Monetary Policy and Crude Oil

The Impacts of the Financial System on Economic Stability and Environment

Thesis

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by

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Abstract

The thesis investigates the effects of monetary policy on the global crude oil market. A theoretical monetary analysis reveals two main mechanisms of transmission, of which one works through economic fundamentals and the other through financial markets. Expansive monetary policy is argued to raise the oil price through the impact of speculative activity in the crude oil futures market. As a reaction, oil industry investment increases which pulls the oil price down to a lower level than the initial one. Oil consumption grows and the economy ends up with a higher oil intensity. Empirical analysis is broadly in line with our suggestions. Two main problems arise from this context: first, the monetary policy impact on the crude oil market enhances financial and economic instability; second, higher oil intensity implies an ecological problem due to increased pollution. In order to address both issues, a new policy design is developed on the base of already existing political instruments. It is called the 'oil price targeting system'.

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ADF test	Augmented Dickey Fuller test
AIC	Akaike information criterion
BIS	Bank for International Settlements
BP	British Petroleum
BTU	British Termal Units
CEA	Commodity Exchange Act
CFD	Contract for Differences
CFMA	Commodity Futures Modernization Act
CFTC	Commodity Futures Trading Commission
CMA	Calendar Monthly Average
EFP	Exchange for Physicals
EIA	Energy Information Administration
Fed	Federal Reserve System
FOMC	Federal Open Market Committee
FSB	Financial Stability Board
HWWI	Hamburgisches WeltWirtschafts Institut / Hamburg Institute of International Economics
ICAPM	Intertemporal Capital Asset Pricing Model
IEA	International Energy Agency
ITF	Interagency Task Force on Commodity Markets
MA	Moving average
NYMEX	New York Mercantile Exchange
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of Petroleum Exporting Countries
OTC	Over the counter
OTF	Organized trading facility
SFC model	Stock-flow consistent model
SIC	Schwarz information criterion
SOMA	System Open Market Account
SVAR	Structural vector autoregression
VAR	Vector autoregression
WTI	Western Texas Intermediate

Introduction

“Soaring gas prices have turned the steady migration by Americans to smaller cars into a stampede. […] ‘The era of the truck-based large S.U.V.’s is over,’ said Michael Jackson, chief executive of AutoNation, the nation’s largest auto retailer. […] there are some indications that the trend toward smaller vehicles will reduce the nation’s fuel use.”

Vlasic (May 2, 2008, New York Times)

“Americans are buying more new cars than ever before. […]As gas prices fell, Americans upsized. This fall, small SUVs became the largest segment of the market, at 14 percent, beating out small and midsize cars.”

The Associated Press (January 5, 2016)

To date, the twenty-first century has been marked by large fluctuations in global commodity prices. Among different commodities, crude oil plays a dominating role and represents, to a certain extent, an indicator of the overall development. It is not presumptuous to consider the oil price hike in 2008 and its preceding and subsequent strong variations as one of the outstanding global economic phenomena aside from the financial crisis, itself likewise erupting in 2008. At the moment of completion of this thesis, crude oil is still the most important energy source in the world. It has a benchmark function with respect to other fuels, notably natural gas and coal. The role of crude oil in the world economy reveals its importance with respect to both the economic performance and the natural environment, that is, specifically, the world climate. On the one hand, oil contributes to prosperity and powers industrial production in the truest sense of the word. On the other hand, carbon emissions drive climate warming and hence are a long-run threat to the world’s and people’s well-being. Thus, the two citations above represent only a small sketch of the far-reaching impacts of oil market developments.

Against this background, the driving forces of the crude oil market become an issue of great interest. It is undoubted that crude oil shares many features with a conventional goods market with conventional feedback mechanisms between supply, demand and price. Yet, it would be too shortsighted to stop the analysis there. Our specific interest in this thesis is in the impact that monetary policy, that is, US monetary policy in our case, has on the crude oil market. The investigation of monetary policy effects requires a clear conception of the role of money in the economy. If it is neutral, as neoclassical economists and specifically monetarists argue it to be at least in the middle to long run, changes in monetary conditions do not produce lasting effects. Oil price changes are in proportion to changes in the general price level and thus the economic structure remains unaffected. On the other hand, if money is not neutral but, instead, allowed to have lasting impacts on both the supply and demand sides of the economy, an investigation of the connection between monetary policy and the crude oil market is not trivial anymore. Without anticipating the following analysis, it is obvious that ruling out any impacts of monetary policy by theory is a much stronger assumption than allowing for them.

There is a specific reason to suggest that the crude oil market is different from other goods markets with respect to monetary policy. In particular, crude oil has a dual character: it is both a physical commodity and a financial asset. Its first nature makes it resemble to a conventional goods market. The second one is due to trading of futures contracts in commodity exchanges. As a consequence, monetary policy has the potential to affect the oil market through both aspects, that is, once through fundamentals in the spot market and once through ‘paper oil’ in the form of a financial asset. Hence, the same thing is traded in two different markets, which are nevertheless closely connected. Moreover, complex interdependencies between both mechanisms of transmission may arise. The spot and the futures markets compose the crude oil market as a whole.

In connection to the issue of money, the understanding of economic processes as such is crucial. In neoclassical theory, economic activity is embedded in a general equilibrium framework where the result is determined by utility and profit maximization. It is founded by microeconomics by means of aggregating individual behaviour linearly to the macro level. However, one may doubt about the usefulness of the aggregation procedure by simply summing up all individual magnitudes. The total of individual actions, including complex interactions, may give rise to unexpected and sometimes paradox outcomes at the macroeconomic level. The aggregation problem is subject to uncertainty (Keynes, 1936/1997, pp. 161–162). Uncertainty is the idea that makes economic activity a radically indeterminate issue. In such an environment of uncertainty where money is allowed to exert lasting effects, the crude oil market may be influenced by monetary policy through various ways. Specifically, speculation is allowed to become a crucial feature and a kind of connection between monetary policy and the oil market by impacting on the oil price. As an example of the meaning of uncertainty that will become important in this analysis, individuals in the crude oil market may behave fully rational from their microeconomic perspective. But exactly their actions may lead to price, production and consumption of oil that are neither optimal nor rational from a macroeconomic point of view.

To line it out briefly, we argue that expansive monetary policy leads to speculation in the futures market. The resulting higher oil price triggers overinvestment in the crude oil spot market pulling down the price eventually to a lower level than the initial one. There are two main problems arising. First, the dual nature of crude oil raises economic and financial instability in the crude oil spot and futures markets as well as, to some extent, in the rest of the economy. Second, overinvestment raises oil supply. The lower oil price has a positive influence on consumption, which amounts to a threat of ecological sustainability in general and climate in particular. It is these challenges that an economic policy design must address. More concretely, stable financial and economic conditions in the crude oil market must be achieved that take the ecological dimension into account and provide a path towards sustainability. We will see that we can make use of the preceding insights into the workings of money, monetary policy, the crude oil market, and the relationships in between. In this regard, our policy proposition is unconventional. Instead of aiming at eliminating any harmful effects of financial markets (the crude oil futures market in our case) on the real economy (the crude oil spot market in our case), we suggest a way how financial market mechanisms may be *used* to achieve a better economic outcome.

The analysis is divided in three parts. Part I contains the detailed theoretical analysis of our issue and emphasizes the crude oil market as well as a background from monetary theory to the extent that is required for our analysis. Chapter 1 starts with embedding the issue of crude oil in the currently existing environment and literature. Specifically, the importance of crude oil is outlined regarding the development of production and consumption of crude oil, the oil or, respectively, energy intensity of the economy as well as the share of crude oil in total energy consumption. Beside of these stylized facts, there are three principle domains concerning the crude oil market on which academic literature is focused. One of them is the debate about crude oil as an exhaustible resource and a fossil fuel. Both characteristics ask for substitution of other energy sources. In this context, the oil price is often argued to rise continuously due to increasing scarcity. It is a controversial question to what extent oil reserves around the world are effectively exhausted and what this means for the structure of the crude oil market. Another issue of great interest in economic research is the existence and effectiveness of speculation in the oil market. Opinions are still widely diverging in this regard, while the view that there is some extent of speculation having a significant impact on the oil price has, in tendency, gained ground in recent years. As a third topic, the role of the Organization of Petroleum Exporting Countries (OPEC) is debated. Analytical arguments and empirical evidence in the literature are mixed. Some contributors suggest OPEC to be effective in controlling the oil price and market share while others deny any crucial influence or judge it to be quite limited.

Chapter 2 begins by emphasizing the nature and role of money in order to derive the functioning of monetary policy from it. Monetary theory can be broadly separated in a perspective that considers money as exogenous, that is, as a kind of commodity used for the exchange with goods and the quantity of which is controlled by the central bank. In contrast to this mainstream view inherent to neoclassical economics, the theory of endogenous money analyses money as being created *ex nihilo* in the process of credit granting. Since money is demand-determined, the monetary authority cannot control its volume. While the exogenous-money view takes the economy as a composition of real forces to which money is just added without having an influence on real quantities, considering money as endogenous does not allow for separate monetary and real forces in the production process. Monetary policy can maximally have short-run effects on economic activity when money is exogenous. With endogenous money depending on demand conditions, the final outcome becomes indeterminate, which opens a space for monetary policy to become effective. In the same way, the understanding of financial markets differs depending on the conception of money. Neoclassical economists rule out bubbles and endogenous distortions in financial markets by assuming the efficient market hypothesis. The existence of money does not affect the relationship between economic fundamentals and financial markets. By contrast, endogenous money, coupled with uncertainty, allows for a financial market evolution that is independent from the real economy to some extent. Speculation may become effective. According to the requirements of the subsequent analysis of the oil market, these two principal approaches are presented and appraised.

With the necessary insights into monetary theory, the oil market then is analyzed in light of the dual nature of crude oil. The role of oil inventories is examined against the background of intensive debate in research. The common argument that the crude oil price cannot deviate from its fundamental value as long as there is no accumulation of inventories is put into question. Extending monetary analysis shows that speculation that raises the oil price may well be rational for the agents involved since it is likely to be profitable for both producers and financial investors. Monetary policy enters the stage by affecting the crude oil market both through fundamentals and the futures market. The analysis is extended by investigating the transmission channels of monetary policy in detail with regard to both fundamentals and financial market aspects. Out of these effects, numerous mutual impacts between the spot and the futures market emerge that can only be suggested but not separated numerically. Yet, we can conclude unambiguously by theoretical analysis that monetary policy has an effect on the oil price as well as oil quantities, to wit, production and consumption. Finally, in this part, we investigate the idea that speculation may not only take place in the crude oil futures market but also in the spot market. We do not rule out any impact thereby produced but suggest it to be limited.

Part II is engaged in putting the theoretical analysis into the context of the actually existing policy and market structures and examining the issue empirically. In Chapter 3, the practice of US monetary policy is presented first. The period covered in our empirical investigation, that is, in general, from 2000 until 2014, is marked by a radical change of how monetary policy is conducted. Conventional policy by manipulating the federal funds rate was the rule prior to 2008. In the course of the crisis, the target rate reached the zero lower bound so that “unconventional” policy, mainly in the form of asset purchases, was adopted. Several new transmission channels have emerged, which contribute to influence market rates. Moreover, unconventional monetary policy intervenes quite directly in financial markets as against conventional policy, which affects financial markets more indirectly.

The third chapter investigates then the global crude oil pricing system. Contrary to the widely held belief that a market price is a definite numerical value resulting from exchange, there is in fact no single price because every deal between two parties yields its own price. In order to get a unique market price, it has to be calculated out of single deals. This is a complicated procedure, which reveals that despite many other imperfections in the real world, even the assumption of a single price is a simplification of reality. Calculation procedure reveals that there are numerous influences that impede the realization of market efficiency. Especially, futures markets are not just a reflection of the spot market but are actually needed to calculate spot prices. Nonetheless, crude oil market data show that the market is integrated with regard to the geographical and the temporal dimension: Prices of different types of crude oil around the world are almost perfectly correlated and so are spot and futures prices of different maturities. It is thus fair to talk about a globally integrated crude oil market. Going a step further, market integration exceeds crude oil as a relatively homogenous good. In particular, natural gas and coal seem to follow a remarkably similar price pattern in the middle to long run. Developments in the oil market therefore tend to go along with analogous developments in the other fossil fuel markets. Policy measures therefore may have effects that reach further than merely to the crude oil market.

The finding of empirical significance is hampered by a dichotomy that marks the analysis: we investigate monetary policy of a single country, the United States, and relate it to a global market. The question arises whether one country's policy can influence the crude oil market. Research suggests that US monetary policy spreads to other countries through various international transmission channels. Transmission is neither perfect nor unlagged but sufficient in its existence to support the investigation at hand.

The impact of monetary policy on the crude oil market is analysed by econometric methods in Chapter 4. To summarize, clarify and represent the results of the theoretical analysis as well as for the purpose of the isolated effects that are going to be estimated, we construct a stock-flow consistent (SFC) model of monetary policy and the crude oil market. This model reveals the main effects and supports intuition for the remainder of this thesis. Even though the theory developed in the course of the thesis tells us that economic effects use to take place simultaneously, two stages of proceeding are distinguished to enable a helpful interpretation. First, the effect of a change in monetary policy on the oil price is considered. Second, we investigate the impact of an altered oil price on oil production and consumption, using vector autoregressive models, cointegration, and Granger causality tests. All in all, empirical estimates suffer simultaneity problems that are especially obvious in the context of fast evolving financial markets on the one hand and slowly reacting fundamentals on the other hand. Moreover, we argue that speculation is too complex a phenomenon in order to be represented by a single variable. Monetary policy, as a third important inconvenience, is difficult to be represented by a variable that is not anticipated by agents. To support empirical evidence, we consider the role of inventories as an approximation for speculative activity.

Two problems with monetary policy and the crude oil market arise from the preceding analysis: economic and financial instability and a higher oil intensity of the economy implying a threat for the natural environment. In Part III, we address political answers for these problems. Chapter 5 debates existing policy propositions that are already partially realized in some cases. Some approaches address only the stability issue while others take only the ecological problem into account. In particular, we discuss futures market regulation and the use of the US strategic petroleum reserve in order to ensure price stability. With respect to environmental policy, a carbon emission trading system and an energy tax use to be proposed. We apply both ideas to the crude oil market and assess the resulting implications. All these propositions are successful in achieving the policy goals partially. However, they share shortcomings as they are not sufficient to guarantee stability and sustainability, and sometimes even may give rise to new problems.

For these reasons, a new approach is taken in Chapter 6. It aims at bringing together the advantages of each of the existing policy propositions while avoiding their drawbacks. Specifically, it must be an approach that is able to establish economic and financial stability as well as ecological sustainability without creating new macroeconomic problems. The idea we present in this chapter is unconventional. It does not try to eliminate financial market disturbances. Rather, a design of coordinated monetary and fiscal policy makes use of the existence of futures markets to lead the crude oil market and, in some measure, the economy as a whole to a stable and sustainable environment. We call it the ‘oil price targeting system’. The idea is illustrated in the framework of the SFC model. The chapter outlines how the system may be implemented within a single country without causing harm to the national economy. Finally, some potential critical arguments are addressed.

I FACTS AND THEORY OF MONETARY POLICY AND CRUDE OIL

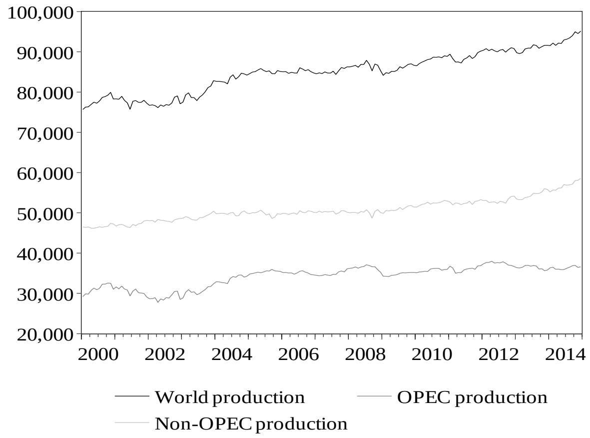
1 The Crude Oil Market and Its Driving Forces

The global crude oil market has some specific features that are often debated and of which some are of primary and some of secondary importance. In order to understand the oil market throughout this work, we briefly consider these issues, review the corresponding literature and locate them with respect to our specific research goal.

1.1 The Importance of Crude Oil: Some Facts

The global market for crude oil can be characterized by several features worth mentioning. They concern production and consumption patterns, price development and the importance of oil as an energy source. We briefly refer to each of them in turn. Oil production with data from the Energy Information Administration (EIA), from which most data are taken, is depicted in Figure 1.1. Obviously, worldwide crude oil output has featured a more or less steady long-run increase since 2000. While OPEC production features several fluctuations, production of the rest of the world follows a rather stable path. At the end of 2014, OPEC accounted for about 38 percent of total world oil production.

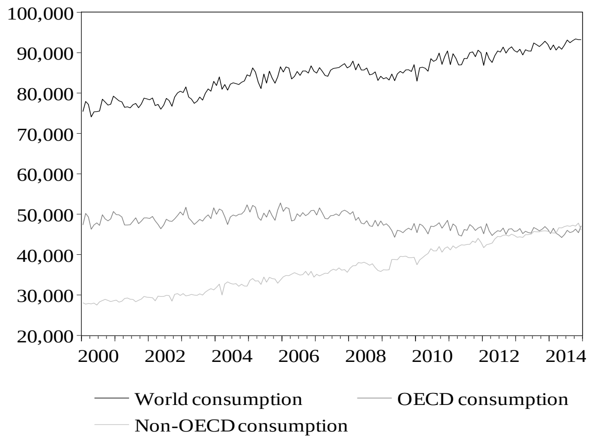
Figure 1.1 World, OPEC, and non-OPEC crude oil production (in thousand barrels per day)



Source: Energy Information Administration (2015b). International Energy Statistics.

Figure 1.2 exhibits monthly EIA data (accessed through Datastream) of the demand side, that is, crude oil or petroleum consumption, respectively. Global consumption has as well continuously risen since 2000. There seem to be strong seasonal effects. The separation of oil consumption of OECD[1] and non-OECD countries shows that seasonality arises from OECD rather than non-OECD data. This may be due to the fact that OECD countries are those with stronger weather fluctuations during the year implying higher energy consumption in winter. OECD countries consumed slightly less oil in 2014 than they did in 2000. Conversely, non-OECD countries faced a strong and constant increase during the same time span and even outpaced OECD consumption in 2014.

Figure 1.2 World, OECD and non-OECD petroleum consumption (in thousand barrels per day)



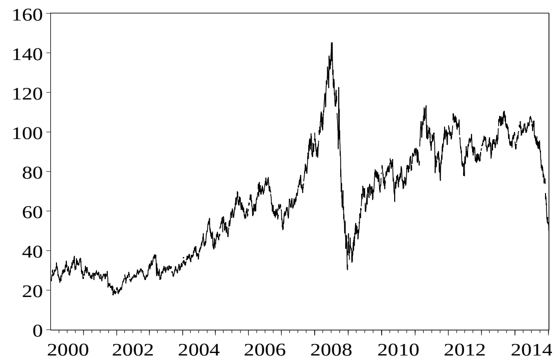
Source: Energy Information Administration (2015b). International Energy Statistics.

One might be surprised by the decrease in OECD consumption, especially in the presence of continuing population growth (OECD, 2015b). Yet, pure numbers tend to give a wrong impression. There is evidence that international trade significantly helps to explain countries carbon emissions (see for instance Peters et al., 2011). This means that many energy-intensive industries have moved from developed to developing countries in past decades. Meanwhile, consumption in developed countries increased with emissions in developing countries (ibid., p. 8907). Hence, developed (in our case OECD) countries consume in fact more fossil fuel than is plotted in Figure 1.2 because fuel is consumed outside of country borders. Consequently, non-OECD consumption is overestimated from this point of view. Oil consumption of non-OECD countries is therefore not unrelated to that of OECD countries and *vice versa*.

[1] The notion includes member countries of the Organisation for Economic Co-operation and Development (OECD).

Daily crude oil spot prices of type Western Texas Intermediate (WTI) are plotted in Figure 1.3. As will be seen, the crude oil market can be considered as globalized even though there exist several different main types. We will justify the use of WTI instead of others later. In 2002, the price started to rise continuously until mid-2008 aside from an interrupt in 2006. The price peak at 145.31 US dollars per barrel on July 3, 2008, is the central issue of ongoing debates about the driving forces of the crude oil price. The sharp price drop thereafter coincides with the outbreak of the global financial crisis. However, at the beginning of 2009, the price started rising again and stayed around 100 dollars. In the second half of 2014, it sharply decreased and has oscillated within 40 and 65 dollars since then. Even though our data window already ends in 2014, the last phase of the price decline will be of great analytical interest. At the moment of completion of the thesis, the price persists to be low.

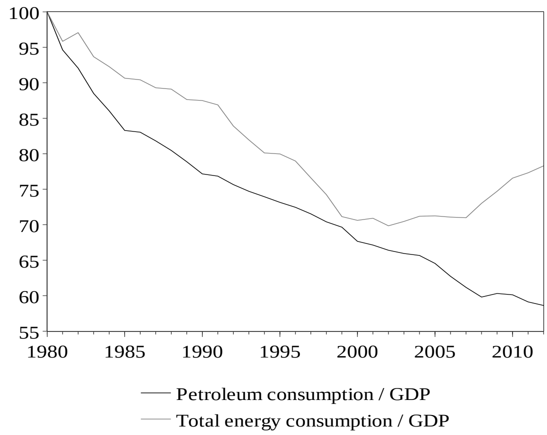
Figure 1.3 WTI crude oil spot price per barrel, 2000–2014



Source: Energy Information Administration (2015a). Petroleum and Other Liquids.

After having found that global oil consumption has been steadily rising in the past in absolute terms, there is no clarity about relative changes. Consumption may have changed merely due to growing economic output such that the fossil fuel balance of a unit of produced output might not have worsened. Relating oil consumption to total output, we get a measure of the oil intensity of the economy. Thereby, both the supply and the demand side of the economy are included: total oil consumption contains the one occurring in the use of (durable) consumption goods as well as the burning of petroleum in production processes. Considering a longer time horizon since the 1980s, it can clearly be seen from Figure 1.4 that the oil intensity of output has decreased since. Remarkably, it has not only declined slightly but by considerable 40 percent as the index shows. The pattern of total energy intensity of output, to wit, the intensity after including natural gas, coal and electricity beside of oil is much less clear. It features a declining path from 1980 until 2000. From then on, intensity stagnated first and has again risen since. Without investigating this trend further, there are two remarks to make. First, like the graphs with oil production and consumption, the indexes of oil and total energy intensity only identify the crossing point of the supply and demand sides of the oil and total energy market, respectively (once we consider the denominator of the ratio, to wit, GDP, as given). The long-run decline of oil intensity does neither say that the demand side of the oil market has become weaker relative to total output evolution nor that the supply side has faced fixed constraints holding oil consumption down. Since data only reveal the final market result, we cannot say anything about the underlying market forces. It may be that with different stances of energy, economic, or monetary policy, respectively, oil intensity would have declined much more or much less over this time. Second, the recent rise in total energy intensity of output shows that a decrease in relative energy consumption over time is far from being the predetermined outcome. It is in this place that economic analysis is required to detect underlying forces that are not visible in data. In this regard, the connection of crude oil to other energy sources plays a crucial role.

Figure 1.4 Global petroleum and total energy intensity of output, 1980–2012 (1980 = 100)



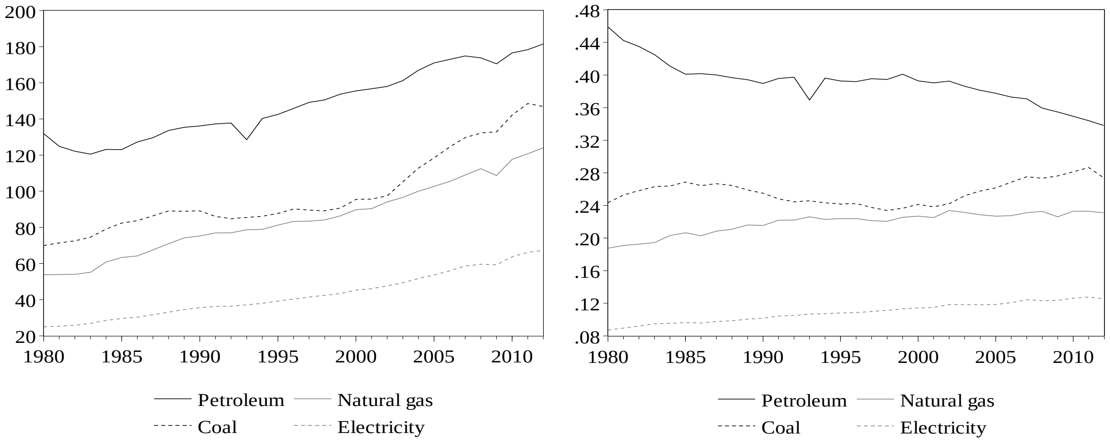
Sources: Energy Information Administration (2015b). International Energy Statistics; World Bank (2015). World DataBank.

While it is generally not denied that crude oil is a central fuel driving the global economy, Figure 1.5 exhibits its importance compared to the other main energy sources in more detail. Electricity data exist in kilowatt hours and is conformed to British Thermal Units (BTU) (for the transformation scale, see for instance Wilcoxen, 2015). Panel a) shows that oil was and still is the most important fuel. All listed energy sources, that is, petroleum, natural gas, coal, and electricity feature a rising path. However, growth rates are different over time. Panel b) shows that the share of petroleum in total energy consumption has declined since the 1980s. Meanwhile, the share of electricity has risen while gas and coal give a more ambiguous picture. A look at panel a) shows that such increases took place mainly after 2000, which may explain the rising magnitude of the total energy intensity of GDP. In the following, we can act on the fact that crude oil still has a dominating role in the energy market as it accounts for about one third of total energy consumption in 2012. Moreover, changes in the crude oil market tend to affect markets for other energy sources, too, as we will explain.

Figure 1.5 Global importance of energy sources, 1980–2012

Panel a) Consumption in quadrillion BTU

Panel b) Share of energy sources in total consumption



Source: Energy Information Administration (2015b). International Energy Statistics. Own calculations. Note that the shares of the four energy sources do not add up to 100 percent but usually to a value between 94 and 100 percent. We can therefore say to roughly cover total energy by these four fuels.

A large body of literature has been and still is produced concerning the role of crude oil not only in comparison to other energy sources but also with respect to the whole macroeconomy. As this is not the centre of our work, we just give a very short summary of how research judges the importance of crude oil in the economy. In general, a rising oil price is associated with distorting effects on economic production of oil-importing countries. It is argued that GDP declines while inflation tends to increase (see for instance Sill, 2007). Yet, this is too absolute a conclusion as the combination of missing economic growth and high inflation was observed in the 1970s but not after anymore. As Kilian (2010b, p. 14) remarks, an isolated recessionary oil price shock is expected to lead to deflation rather than inflation. Yet, the central question is whether such an effect is significant and, if this is the case, whether it is large or not.

High oil prices can affect the economy on both the supply and the demand side as summed up by Kilian (2010b, pp. 5–10). A higher oil price raises input costs for producers and as such represents a supply-side constraint. On the demand side, households face a tighter budget constraint after having paid the bill for energy consumption such that there is less money left to spend for other goods. An additional and specific channel is argued to lie in monetary policy. Thereby, recessionary effects are not directly produced by high oil prices but rather by contractionary monetary policy aiming at stopping inflationary pressures that are themselves due to the change in oil prices (see for example Bernanke et al., 1997). Yet this argument is criticized to hold only if monetary policy is not anticipated (see for instance Carlstrom & Fuerst, 2005). Otherwise, accommodating actions by the central bank are suggested to bring about the same results.

Most researchers find that the effects of oil price shocks on the economy have decreased in the 2000s compared to the 1970s (see for instance Blanchard & Galí, 2007; Kilian, 2010a).[2] However, the explanations for this observation differ. Blanchard and Galí (2007) consider a high oil price as an exogenous shock. According to their analysis, first, the shocks went along with different additional effects in the 1970s than in the 2000s. Second, unsurprisingly in face of their neoclassical or, respectively, new Keynesian background, reduced wage rigidities have lowered the effect on output and inflation. Third, monetary policy has become more credible and thus more able to keep inflation expectations low. Fourth, the share of oil in production, that is, oil intensity, has decreased, which limits potential effects of an oil shock *a priori*. This view is basically confirmed by Figures 1.4 and 1.5. However, it rules out other energy sources and their probable connection to crude oil. Segal (2011) argues that the pass-through of the oil price decreased over past decades, which lowered the need of contractionary monetary policy and hence reduced harmful effects on the economy.

Kilian (2010a, 2010b) strongly criticizes the assumption of exogenous oil price shocks. Their effect on the economy and the way the monetary authority should respond to them depend on the cause of the oil price change, which is itself an endogenous variable. If it is a supply disruption due to, say, a war in an oil producing country, the high oil price effectively tends to affect economic performance negatively to a certain extent. In this case, the central bank should loosen monetary conditions despite potential inflationary pressure in order to counteract a recession. Otherwise, it would just deepen it. On the other hand, if it is a high oil demand at home or abroad leading to a higher oil price, there is no recession to expect since the oil price is itself just a symptom of a boom period. It is in this case that inflation should be treated by contractionary monetary policy. The recession follows once the demand boom decelerates (ibid., 2010a, p. 81). The need for different monetary policy responses to different

[2] Barsky and Kilian (2004) argue that even the recessionary effects of the oil shocks of the twentieth century are overestimated in economic debates.

kinds of oil price shocks is confirmed, for instance, by Bodenstein et al. (2012). The decreasing effect of high oil prices therefore is to ascribe to their different origins. While they consisted more often of supply disruptions in the 1970s, it was strong global aggregate demand in the 2000s that drove oil prices up (Kilian, 2010a, pp. 79–80; 2010b, pp. 15–18).

Even though literature finds a decreasing impact of oil price changes on production, it does not mean that the relevance of crude oil is declining as well. Beside its impact on GDP growth rates, its character as a non-renewable fuel and the fact that fossil energy sources still account for more than 80 percent of total energy consumption make it highly important to analyse the market for crude oil, specifically against the background of climate change.

1.2 Crude Oil as an Exhaustible and Fossil Resource

The first question asked in common discussions about oil is the one about how much of it is left in the world. Crude oil is exhaustible. This is the characteristic standing in the focus of research on and political debates about climate change and resource security (see for instance International Energy Agency (IEA), 2012, pp. 97–101). Oil – together with other non-renewable energy sources like natural gas and coal – is the central fuel driving global production. The limitation of oil reserves in the underground and the numerous threats of climate change will require humanity to search for new sources. A large part of debate and policy measures concern the promotion of renewable energy sources through subsidies or financing of research and development. It is against this background that the basic task is considered as a technological one requiring the replacement of fossil fuels by renewables (see for example Hamilton, 2012; Murray & Rubin, 2012). Others, like Fontana and Sawyer (2015), suggest some macroeconomic and financial system conditions that must be fulfilled in order for the economy to move on a stable path in direction of environmental sustainability. Many voices go much further by suggesting that the need for more energy efficiency and saving in energy consumption will require fundamental changes in social and economic organization. According to these arguments, the difficulty is not primarily of a technological nature the resolving of which would allow business as usual. As the best-known among other institutions and individual scientists, the Club of Rome identifies permanent growth in economic output as the most important cause of rising energy consumption and worsening environmental damages (Meadows et al., 1972, pp. 38–44, 54–87). In its original and famous book *The Limits to Growth* (Meadows et al., 1972), it predicts the collapse of the existing world economy and the current way of living in developed countries if no change in the organization of human living takes places. The reason for this sinister perspective is the contradiction between economic growth and natural limits given by ending resources. One day, the world will reach peak oil, that is, the maximum possible crude oil production. From that point onwards, it cannot but follow a steady decline sooner or later owing to diminishing oil reserves. Once the last drop of oil is burnt, the economy breaks down.

This prediction has not become reality up to now and we do not know the time horizon of the further development. Even though such analyses address problems of greatest seriousness, which should not be ignored even though the collapse has not become reality yet, the base of the Club of Rome's and others' predictions is not able to overcome some complex economic issues. Predicting linearly or exponentially increasing energy consumption ignores price effects. If fossil fuels become scarcer, their price is likely to rise which leads to new factor allocation. For instance, alternative energy production replaces crude oil partially. This has a declining effect on the oil price. As another example, higher expenditures for research and development in the field of renewable energy and energy efficiency may make alternatives to fossil fuel less expensive and hence more competitive. As market investors build expectations about the future and the amount of oil reserves, reallocation might take place before there is any sign of the oil price to move upwards. Hence, whether the end of fossil resources ever takes place and, if this should be the case, whether the passing over to a new way of energy production takes the form of chaos or collapse, is highly uncertain.

Despite uncertainty, such reflections are important, especially from a normative point of view. In positive economic analysis, the role of resource limitation is somewhat different. It can be seen as an outermost constraint within which the economics of the crude oil market take place. Once this constraint becomes binding, we face a situation where varying demand meets constrained supply. In the case of demand growth, this leads to a – potentially strongly – rising oil price. It is this case to which the well-known 'Hotelling rule' of the optimal consumption rate of exhaustible resources is applied (Hotelling, 1931). Moreover, already the classical economists reflected about price building when the object of interest is limited. This led to the definition of the rent, to wit, a form of extra profit earned by the owner of such a resource, which used to be land or metals in the eighteenth and nineteenth centuries (see for instance Marx, 1894/2004, pp. 602–788; Ricardo, 1821/1923, pp. 52–75; Smith, 1776/1976, pp. 160–275). In post-Keynesian literature, in line with classical economists, limited natural resources are as well distinguished from other, unconstrained, goods. While the latter are argued to face a horizontal long-run supply curve, the former behave differently since rising demand is not necessarily satisfied by equally increasing supply at a stable price (Kalecki, 1987, p. 100). This is due to the limitation of the supply side by the reserve constraint. Importantly to note, this constraint cannot automatically be set equal to all proven reserves in the world. On the one hand, not all reserves are profitable at all oil price levels. Those reserves that are difficult to access face higher production cost and thus are only extracted if a sufficiently high oil price guarantees profits to producers. On the other hand, a high oil price makes hitherto uninteresting oil reserves profitable. Moreover, a rising price may give an incentive to intensify exploration activities. Both effects, if the latter is successful, shift the constraint outwards even though it might have been considered as fixed before. It is therefore not possible *a priori* to determine the definite total volume of oil reserves that is relevant for our economic investigation. Furthermore, it may happen that the constraint of exhaustion becomes partially binding. Oil might still be geologically available in abundance but it is only accessible if the oil price reaches a specific minimum level. The resource then is partially exhausted in the sense that it does not exist at the hitherto low prices anymore. This gives the supply curve again another form.

However, the great effort of research employed on price behaviour of exhaustible resources does not automatically imply that this outermost constraint of reserves is always binding. As long as demand can be satisfied by oil production without requiring a higher price, the limitation of total existing reserves is not relevant for market participants at that moment. Hence, within this constraint, there are other limits that are relevant in the shorter term already before oil reserves run the fear of exhaustion. These are production capacities that can be fully utilized in a given situation such that higher demand raises the price. Additionally, oil companies and households may possess inventories that they use as a (personal) reserve in order to hedge against price changes. Once all inventories are sold or consumed, respectively, they cannot serve as a buffer against price fluctuations anymore. Another reason for rising prices may lie in market power on the producer side. We can therefore say that as long as oil reserves suffice to satisfy existing demand, crude oil shares the same features as any other product market.

For the reasons mentioned above, price changes should not precipitately be attributed to exhausting oil. Even though this is relevant without doubt in the long run, it is not necessary that the state of absolutely shortening reserves and exhausting supply has already become acute in a situation of high prices. A case of absolute exhaustion occurs if the oil price keeps rising without there being a reaction on the supply side. Which variable is the one to represent the supply side best will be discussed later. Partial exhaustion is much more difficult to assess and requires the long-run examination of the oil price in order to see whether the oil price is stationary or follows some positive autocorrelation pattern. The former observation would be a sign of plenty oil abundance. The latter would denote a case of partial exhaustion as oil demand can only be satisfied with a continuously rising oil price. Yet, this aspect goes beyond the analysis at hand.

Concerning the present-day degree of absolute exhaustion of oil reserves, opinions differ widely. The IEA (2013, pp. 3–4) forecasts a declining production of conventional oil requiring the extraction of unconventional sources on the one hand and a high oil price in 2035 on the other hand to fill the gap between supply and demand. In contrast, for instance, the Statistical Review of World Energy of British Petroleum (BP) (2015, p. 7) estimates that the ratio of global total oil reserves to annual global production has not only been constant but even slightly rising since the middle of the 1980s. In 2014, this ratio states that proven reserves are sufficient for 52.5 years of global production. Being aware of the wide area within which the technical and economic debate about long-term prospects takes place, we will have to find out in how far they are of relevance when analysing the connections between monetary policy and the global market for crude oil.

1.3 The Issue of Speculation

Let us now turn to the central debate where monetary policy comes into play as will be discussed in abundance in this work. This concerns the driving forces of the crude oil market. It may be fair to say that the largest fraction of literature concerned with this topic concentrates exclusively on the oil price and leaves the effects away that the price-driving forces have on oil quantities. Thereby, it centres on the question whether the oil price is only determined by supply of and demand for physical oil or whether speculation has a significant impact, too. The important point lies in our interest of how monetary policy affects the crude oil market through financial markets.

First of all, it is not easy to get a definite meaning of speculation. This may be one reason why a considerable part of research omits it. Yet, another one might be that the existence of speculation is not equally acknowledged by all economists. It will be seen in more detail in the next chapter that neoclassical economics in its proper sense does not leave room for speculation. Or, to put it at a little more length, it may be allowed to exist but it does not have significant effects on other variables. However, being convinced or not of the existence of speculation, it needs to be defined so that it can be tested. Kaldor (1939, p. 1) provides a definition in an influential paper: "Speculation […] may be defined as the purchase (or sale) of goods with a view to re-sale (re-purchase) at a later date, where the motive behind such action is the expectation of a change in the relevant prices relatively to the ruling price and not a gain accruing through their use, or any kind of transformation effected in them or their transfer between different markets. […] What distinguishes speculative purchases and sales from other kinds of purchases and sales is the expectation of an impending change in ruling the market price as the sole motive of action." As another, contemporary source, Kilian and Murphy (2014, p. 455) determine speculation, in the specific case of crude oil, by "treat[ing] anyone buying crude oil not for current consumption but for future use as a speculator from an economic point of view. Speculative purchases of oil usually occur because the buyer is anticipating rising oil prices." These definitions should basically not be too controversial even though the authors mentioned belong to different schools of economic thought. They probably coincide well with popular ideas of speculation.

Yet, opinions differ with regard to the impact that speculation has on prices, quantities, economic activity, employment, and economic stability. The issue becomes controversial at this point because it moves from the definition of speculation to its embedment into the economy. This act may still be positive but it is close to the somewhat normative judgement of whether speculation is beneficial to the economy and society or not. Kaldor (1939, pp. 2, 10) argues that speculation can be both price-stabilizing and price-destabilizing depending on the magnitude of speculative activity and the range within which the price of the asset is moving beside of speculative influences. He outlines several conditions to be fulfilled in order for an asset to be traded speculatively. It must be fully standardized, durable, valuable in proportion to its bulk and it must be an article of "general demand", that is, it must be an important good in the economy (ibid., p. 3). If so, then it becomes possible to bet on changing prices by accumulating or reducing the stocks of the relevant asset. The more speculators build stocks when they expect a higher price, the more speculation finally affects the actual price (ibid., p. 7). Additionally, the more speculators change their price expectations in face of a change in the current price, the more they raise or lower their stocks (ibid., pp. 8–9). By means of these two elasticities, the influence of speculation is assessed.

This theory is contradicted by other, mainly neoclassical, economists. Defending the 'efficient market hypothesis', yet to be discussed in more detail, they deny a significant impact of speculation on other variables. It is the efficient market as a whole that determines prices. Speculators who swim against the storm make a losing deal for sure, that is, they cannot beat the market (see for example Malkiel, 2003, p. 77). If anything, speculation is argued to be beneficial because speculative investment provides the liquidity necessary to allow not only faster price discovery but even guarantees the functioning of financial markets (Fattouh et al., 2012, p. 4). Financial stability is therefore enhanced.

One may think that it is more appropriate to take newer conceptions of speculation than those of the first half of the twentieth century. However, this controversy is not new. Indeed, Kaldor's (1939, p. 1) starting point is exactly that the "traditional theory of speculation viewed the economic function of speculation as the evening out of price-fluctuations due to changes in the conditions of demand or supply". It is therefore not possible to state that new research results have definitely abandoned older explanations. Even though Kaldor's (1939) theory is rather mechanical in some aspects and without ruling out other approaches in this place, we can keep it in mind for the remainder. It does not insist on the inevitable and permanent presence of speculation nor does it eliminate it *a priori* by theoretical assumptions. It just draws the mechanisms through which it may become effective. By testing for the existence and effectiveness of speculation, most authors follow more or less Kaldor's line of thought independent of whether they consider it as realistic or not.

Yet, in fact, assessing speculation empirically is quite difficult. In the case of producing companies, for instance, it is seemingly clear that any intertemporal considerations or any exposure in financial contracts serves the purpose of hedging against future price fluctuations. Concerning crude oil, a corporation may accumulate inventories in order to smooth price hikes when sudden supply interruptions or demand growth take place. But what is the appropriate level of stocks in such a situation? The corporation's stock building may as well have the effect of keeping the oil price higher than necessary. The line between hedging and speculating thus may often be difficult to draw. Another aspect of Kaldor's theory that is not fulfilled nowadays anymore is the argument that speculation is done by accumulating stocks. That is not wrong. We will as well argue that a high price tends to go along with higher inventories if it is to be driven up by speculation. Yet, as will become clear throughout our theoretical analysis, stocks do not necessarily have to be the cause of the speculative price change. They may as well and even more likely be the result of speculation. In our highly financialized economies, oil futures contracts are the object of interest for most speculators. Such financial assets are used by financial investors in a way that they are completely disconnected from the physical aspects of the underlying real asset. Hence, their owners are not at all concerned with the accumulation of stocks.

In contrast to other commodities, crude oil as a fossil fuel requires another specification. Kaldor (1939, pp. 10–11) argues that commodity prices are determined by "supply price" in the long run, that is, by production cost and a certain profit share. To the degree that this supply price is known, the actual price should sooner or later come back to this level once it deviates from it. Yet, crude oil is not infinite and its possible exhaustion in the future may lead speculators to drive their price expectations upwards so that – if speculation is effective – the actual oil price is as well higher than it would be otherwise. Such expectations might be justified or not. But they have the potential to be relevant in both cases. Moreover, exhaustion does not allow acting on the assumption of a constant supply price. The limitation of oil sources is thus an issue that makes speculation even more difficult to assess.

Before we start the detailed analysis on monetary policy, speculation and its impact on the market for crude oil, let us get an overview of the existing literature on these issues as a preliminary. Indeed, this literature has the same (or similar) starting points of our analysis. Some contributions emphasize monetary policy explicitly. The outstanding feature of the past years that turned special interest on the crude oil market is the price peak in 2008. Even tough research on this single event may appear as quite specific, it contains nevertheless many features that help understand the market in general. In the course of our analysis, we will have a closer look to many of the following contributions.

The view that the crude oil market is merely driven by fundamental forces, to wit, supply by oil producers and demand by oil consumers, is briefly explained by Fattouh (2010, p. 14), who calls this rather simple approach the 'conventional framework': changes in the crude oil price trigger feedbacks from the supply and demand sides. For instance, a high oil price induces supply to increase and demand to fall such that the price does not move beyond a certain corridor. The effectively resulting oil price depends on price elasticities of oil supply and demand. The lower they are, the higher the oil price can rise or fall, respectively, without being counteracted by supply and demand responses (ibid., p. 16). Among those contributors who deny any significant speculative influence on the oil price during the price hike of 2008, opinions differ again with regard to fundamentals. Some see the major cause of the price increase on the supply side, others on the demand side. One of the most influential articles published in the line of the fundamentals view is Kilian (2009b). By constructing a vector autoregression (VAR) model consisting of a constructed demand variable, oil production as the supply variable and the crude oil price, he finds that the price peak of 2008 is almost entirely explained by increasing demand. Such an approach allows the author to endogenize the oil price. The demand variable is modelled by a differentiated, deflated and detrended index of shipping freight rates, which is suggested to be an indicator of global economic activity. Thereby, the variable is free of problems concerning exchange rates, output aggregation or changes in output composition (ibid., pp. 1055–1058). Historical decomposition of the oil price reveals the influence of three different shocks: the demand shock, the supply shock and the so-called 'oil-specific demand shock', which in fact is the residual between the oil price and the explanatory power of the other two shocks. It is given the greatest impact by the VAR result.

As Figure 1.2 shows, growth in global petroleum consumption since 2000 is exclusively due to increasing consumption of non-OECD countries. In the context of demand-side considerations, the oil price peak is often ascribed to the fast rising need for energy of emerging economies like China or India. In another paper, Kilian (2009a) tests for the impact of these two countries by taking GDP forecasts as the basis of the approach. Forecasts have to be corrected up- or downwards in face of effectively realized GDP. The study finds that forecast error corrections as the causal variable historically explain the oil price development remarkably well. However, the two emerging economies are by far not the only source of the price increase since forecast error corrections of OECD countries explain a comparable fraction of the price. Mu and Ye (2011) sharply contradict the view of emerging economies' demand growth as a significant source of the relevant oil price increase. They focus on China as the most important of these countries. By means of a VAR, they provide evidence that an increase in China's oil imports does not have a significant effect on the real oil price. Tests for longer-run impacts show that oil imports raised the oil price only between 11 and 23 percent between 2002 and 2010, while the real oil price increased by 96 percent in the same period (ibid., p. 89).

The stance that the high oil price was caused by supply-side shortages is taken up much less. Kaufmann (2011) starts his analysis by strongly criticizing Kilian's (2009b) shipping freight rate index, which should represent demand conditions. Kaufmann (2011, pp. 106–108) shows that, by employing different price variables, all in all, the index is Granger caused by the crude oil price rather than the other way round. With respect to the supply side, he divides oil production into OPEC and non-OPEC output. By assuming that non-OPEC production takes place under competitive conditions while OPEC follows some strategic behaviour, production shares of both country groups become relevant. The higher the OPEC share in oil produced, the higher the oil price tends to be, because OPEC can be seen as the 'marginal supplier' (ibid., p. 108). After 2004, OPEC production increased slightly. Non-OPEC countries were not able to continue past production growth even though the price was rising. Overall capacity utilization increased such that the supply constraint was more and more approached.

While hardly any author denies the existence of strong fundamental forces, feedback mechanisms and the role of elasticities, a growing body of literature considers the pure fundamentals view as insufficient. Another fraction denies any speculative influence but changes the approach in order to have a theoretical background on the basis of which speculation can be tested empirically. A theoretical model of speculation with an undefined asset is provided by De Long et al. (1990). As a crucial feature, they distinguish three types of investors and hence differ from basic neoclassical assumptions of homogenous agents or a single representative agent, respectively. There are rational informed investors who build expectations about the true value of the asset, which is postulated to be defined well. Passive investors buy when the price is low and sell when it is high. Feedback traders consider the price history of the preceding periods, invest when the price was rising in the past, and sell otherwise. The authors show how the price then can deviate from the asset's fundamentals value such that a speculative bubble emerges. Tokic (2011) extends the De Long et al. (1990) model and applies it to the crude oil market. Agents now change their behaviour depending on price developments. Producers and consumers basically have a price-stabilizing effect as they regulate oil inventories in order to smooth fluctuations. Passive investors who are in search of portfolio diversification and inflation protection, however, do not consider oil market fundamentals but rather inflation rates and stock market risk as indicators to decide on oil purchases. They might hence thereby move the oil price, which attracts feedback traders. In a situation where the price is increasing, those agents who act on the assumption that the price always reverts to its fundamental value cannot but participate in the speculative bubble. If they continued pursuing their strategy of selling oil, that is, going short, they would suffer growing financial losses. Once feedback traders realize that the price is above the fundamental value, they start selling and the bubble bursts (Tokic, 2011, pp. 2057–2058).

Fattouh and Mahadeva (2012) present a neoclassical model with speculators, producers and consumers that extends over two periods. Owing to agents' awareness of this fact, it becomes harder for large price deviations from fundamentals to occur, since changes in period 1 are counteracted in period 2. The term structure of the oil spot price can be tilt but it cannot be shifted (ibid., p. 16). Basically, however, the model allows for financialization when speculators raise their oil market exposure. Calibration with real data leads the authors to the conclusion that speculative activity may of course exist but that it affects the oil price only marginally. According to the model, the increasing presence of financial investment is the result of changes in market fundamentals. This means that speculation is almost exclusively caused by other forces and has itself hardly any causal effects. In contrast to this, Cifarelli and Paladino (2010) apply an Intertemporal Capital Asset Pricing Model (ICAPM) to the crude oil market and include the possibility of feedback trading. Empirical tests confirm significant positive feedback trading, which has itself a significant impact on the oil price.

Another theoretical model is developed by Alquist and Kilian (2010): a higher risk of futures supply shortfalls raises the incentive to hold additional inventories today. This raises the oil spot price in relation to the futures price. Even though one may allow speaking about speculation in this case, the authors prefer the term of ‘precautionary demand’ indicating that inventory accumulation merely serves hedging needs (ibid., p. 540). A precautionary demand component econometrically determined in Kilian (2009b) is tested for correlation with the futures spot spread and exhibits remarkable results but also fails for a part of the period considered (Alquist & Kilian, 2010, p. 566).

Knittel and Pindyck (2013) construct a simple model of constant price elasticities of supply and demand, and test for the possibilities of speculation as well as its implied effects on the price of oil and inventories. They find that the actual pattern of the oil price can be replicated by fundamentals data so that there is no room for speculation.

A series of purely empirical contributions examines Granger causalities between the speculative activity and the crude oil price (see for instance Alquist & Gervais, 2011; Büyükşahin & Harris, 2011; Interagency Task Force on Commodity Markets (ITF), 2008). They usually employ net long futures positions of different categories of investors. It is assumed to be an appropriate measure of speculation. The studies get similar conclusions, namely, that changes in the crude oil price Granger cause changes in futures holdings of investors but that there is no significant Granger causality in the reverse direction. Stoll & Whaley (2010) investigate the impact of index investment on non-energy commodity futures prices and end up with an analogous conclusion.

Another study leads to opposite results. Tang and Xiong (2011) analyse the connection between different commodities with a focus on commodity indexes. Index investors are likely to behave according to Tokic (2011, p. 2056) in so far that they do not aim at exploiting the expected price change of a single asset but rather invest in commodities to diversify their portfolio and to protect against inflation. First, Tang and Xiong (2011) find that correlation between different commodity prices, for instance between crude oil and some selected non-energy commodities, was about zero until 2004 and increased thereafter (ibid., pp. 7–10). Second, they observe by means of regression analysis that the increase in correlation after 2004 is even more pronounced for commodities that are traded in commodity indexes (ibid., pp. 22–23). These findings favour the view that speculation affects commodity prices. The evidence that prices of index commodities move even closer together suggests that they are able to deviate from market fundamentals. The latter differ with respect to each single commodity such that prices would differ as well, if fundamentals were the only determining variables.

A similar result is obtained by Büyükşahin and Robe (2011). They have access to disaggregated non-public data and test for comovement of energy commodity and stock prices. The results suggest that correlation between the prices of the two markets increases with the presence of hedge funds that are active in both markets. If groups of financial investors are able to influence market performance of assets, then it is likely that these asset prices can deviate from fundamental values.

Lombardi and Van Robays (2011) use a VAR and introduce the oil futures price in addition to the spot price. Moreover, the fundamental supply and demand variables as well as oil inventories are part of the model. A change in the futures price is denoted a speculative shock due to ‘destabilizing financial activity’, while a change in inventories is interpreted as an ‘oil-specific demand shock’ (ibid., p. 18), which has the same qualitative reasoning as Kilian’s (2009b) precautionary demand. As such, it is assigned to fundamentals rather than to speculation by assumption. The speculative shock is found to contribute between 12 and 23 percent to the spot price increase between 2000 and 2008 depending on alternative variable specifications (Lombardi & Van Robays, 2011, pp. 25, 26).

In the same paper already mentioned above, Kaufmann (2011, pp. 109–114) tests for the presence of speculation in the oil price by testing for the law of one price. He observes that the prices of two different types of crude oil, that is, the WTI five-month forward contract and the spot price for Dubai-Fateh, exhibit a cointegrating relationship. The law of one price is defined to break down when the residuals of the cointegrating equation deviate far enough from their given distribution. This is mostly found to be the case in the period of strong price growth in 2007 and 2008 (ibid., p. 112).To confirm this approach, an oil price estimation regression model with fundamentals, inventory, and futures price spread variables is taken. Residuals again strongly deviate around the price high. Similarly, the same model is used to make one-period-ahead forecasts of the oil price. The model performs generally well but fails again when the price moves towards its peak in 2008 (ibid., pp. 112–114). Evidence of such explanation gaps is not a direct confirmation but at least a hint of speculation.

Fan and Xu (2011) test for structural breaks in order to find evidence of how the price-determining variables of the crude oil price might have changed in the course of the 2000s. They employ a regression model with an ocean freight rate index as a fundamental demand variable, two differently specified variables of futures long positions of suggested speculators and a set of control variables. The overall result states that futures position variables are significant during the oil price growth before 2008 while the fundamentals variable is insignificant. After the price sharply drops, the fundamentals variable becomes significant while the speculative variables do not have any explanatory power anymore.

Lammerding et al. (2013) construct a bubble state-space model. They assume the oil price to switch between two regimes, where in one it follows its true fundamental value while in the other it departs from that value, meaning that a speculative bubble is accumulating. A bubble is defined to exist if the probability of the bubble regime is larger than 0.5 (ibid., p. 500). Application of the model to real data shows that bubble probabilities indicate price bubbles in the course of the running up to the price peak in 2008 and again in 2009 when the price starts rising again.

In literature where monetary policy is directly involved, speculation is often only implicitly discussed. A theoretical body to which debate often refers is provided by Frankel (1984, 2006, 2014) and Frankel and Rose (2010). It says that interest rates affect the oil price through three channels both on the supply and the demand side of the crude oil market. First, a rise in the interest rate level raises the incentive to produce and sell oil today rather than tomorrow. Second, it reduces the incentive to hold oil inventories. Both channels make use of arbitrage activity of oil producers. Once (expected) prices are given, they compare the benefit of having oil physically available today and selling it tomorrow to the opportunity cost of selling it today and invest the return at the given interest rate level. Third, for speculators, it becomes more attractive to hold bonds instead of oil futures contracts. All three channels have the effect of loosening market conditions such that the oil price falls (see for instance Frankel, 2006, p. 5). Some papers test the theoretical implications and find mixed evidence (see for instance Anzuini et al., 2013; Arora & Tanner, 2013). An event-based study tests for the same effects of unconventional monetary policy on prices of commodity indexes between 2008 and 2010 and does not find significant results in favour of the underlying theory (Glick & Leduc, 2011). Other studies employ high-frequency data to investigate intra-day responses of oil prices to monetary policy shocks (see for example Basistha & Kurov, 2015; Rosa, 2013). The motivation is that price responses within few minutes have a greater chance to be free of noise from other shocks. There are significant results suggesting that a negative interest rate shock raises oil prices. However, the results usually become insignificant when enlarging the framework to daily or monthly responses (Basistha & Kurov, 2015, pp. 95–102). This may either be due to effective insignificance or to econometric difficulties in isolating longer-term effects.

1.4 The Role of OPEC

As a last short discussion before starting our theoretical analysis, the role of the Organization of Petroleum Exporting Countries has to be enlightened so far as it is possible at this stage. The issue has lost importance in the most recent past but still appears in literature. Even more, OPEC strategies are subject to public policy debates (see for example Reed, 2014).

The organization was founded in 1960 and currently includes twelve countries, that is, Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela. This number was variable in the decades of OPEC's existence. According to the own words of the organization, its mission is "to coordinate and unify the petroleum policies of its Member Countries and ensure the stabilization of oil markets in order to secure an efficient, economic and regular supply of petroleum to consumers, a steady income to producers and a fair return on capital for those investing in the petroleum industry" (OPEC, 2015). In most publications outside of OPEC countries, the organization is simply denoted a 'cartel' (see for instance Griffin & Vielhaber, 1994) aiming at controlling the global crude oil market. Bandyopadhyay (2009, pp. 14–29) provides a helpful overview of a great volume of research contributions produced in the past four decades. The central questions of research are if OPEC is really able to influence the oil price by means of cooperation between its member countries and the agreement on production quotas. Kaufmann et al. (2004) present evidence of Granger causality from OPEC utilization of production capacities and production quotas to the real oil price. Yet, they find no Granger causality in the opposite direction. On the other hand, Brémond et al. (2012) argue that OPEC has been acting as a price taker for most periods since 1973. Smith (2009, p. 152) differentiates by suggesting that OPEC has failed at agreeing on lower utilization of existing extraction capacities but succeeded at limiting the building of capacities by constraining efforts to explore new reserves. According to Alhajji and Huettner (2000), it is not OPEC as a whole but rather Saudi Arabia as a single country that acts as a dominant producer.

There are numerous claims that OPEC's strength in affecting oil prices has overall decreased over the decades of its existence. For instance, decreasing OPEC spare capacities, especially during the 1980s and again after 2002 may be seen as a sign of declining market power (see for instance Bandyopadhyay, 2008, p. 20). However, it may in contrast as well be considered as a demonstration rather than weakness of the working of the OPEC cartel in Smith's (2009) sense that the organization agrees as well on the building of new capacities.

All in all, literature remains inconclusive. The difficulty might be found in the complexity to model real-world strategic behaviour of a cartel like OPEC. Strategic behaviour is normally discussed in a microeconomic context. In the case of OPEC, however, it can be traced back to human decisions that have a more or less direct impact at the macroeconomic level. Therefore, there are probably even less linear, calculable and repeating effects than one might hope to find in other economic problems. As Bandyopadhyay (2009, p. 13) puts it, "it is rather unusual to expect a rigid behavioural conduct from OPEC consisting of members with divergent views and interests. Thus, it would be unrealistic to predict the behavioural nature of the OPEC by making use of a single economic model".

A common approach, as well adopted in this work, is to assume non-OPEC oil producing countries as price takers (see for instance Kaufmann, 2011, p. 108). This means that oil companies in these countries behave like competitive firms in a global market, that is, a real market with its various imperfections that we will discuss later. As the average of studies characterizes OPEC neither as a perfect price maker nor as a perfect price taker, we have to be aware of a still unresolved problem when analyzing the global crude oil market. It does not make investigation impossible. However, a potential influence of strategic behaviour on the crude oil price – what its extent may ever be – tends to complicate the analysis.

2 Monetary Policy and Crude Oil: A Theoretical Analysis

The discussion in the previous chapter outlines the topics that surround the issue of the thesis at hand. Some of them will be at the very centre of our analysis, as is the case for the debate about speculation, while others will be background conditions that are not in the primary focus but should not be forgotten, either. The discussions about peak oil or the role of OPEC are examples of the latter. We will return to selected studies and either use them as a base or criticize their approaches. As a priority, a large fraction of this work will be dedicated to the theoretical analysis. It is especially in empirical papers that the underlying theoretical reasoning remains confuse or relies on unquestioned assumptions. Specifically, first, the examination of the working of our contemporary monetary system and of financial markets – in general as well as in connection to crude oil – is of distinguished importance. Second, the far-reaching implications of crude oil's dual nature as a physical commodity on the one hand and as a financial asset on the other hand require further analysis. In particular, the dual nature aspect should be considered in connection with monetary policy. The fundamental side of the crude oil market is much better understood since it is an almost perfect case of a textbook goods market. Without justifying all common textbook conclusions, it becomes nevertheless clear that it is the financial aspect of crude oil that needs specific consideration. For these reasons, we start with the issue of money, monetary policy and financial markets in general. Thereby, we refer to financial assets that are not further specified. After, we apply our preliminary conclusions to our specific financial asset of interest, to wit, crude oil futures.

2.1 On Money and Monetary Policy

The analysis of the relationships between monetary policy and the crude oil market requires a foregoing investigation of some basic issues. It will be seen that the characteristics of money play a crucial role for the understanding of those processes that take place in economic reality. Different conceptions of money yield different conclusions. Moreover, the role of financial markets in monetary policy should be debated. Crude oil has specific features and its strong connection to financial markets is one of them. Financial markets and financial assets are analyzed in their basic form and then with regard to the oil market. Throughout this section, we start in each case with neoclassical explanations as the dominating paradigm and confront them with criticism. Exogenous money is criticized by means of endogenous-money concepts. Endogenous money then is used to develop an alternative view of financial markets, which takes criticisms of neoclassical financial theory into account. For the understanding of the central issues of this section, it is sufficient to emphasize monetary policy in its conventional form. “Unconventional” policy is introduced later.

2.1.1 Monetary Policy with Exogenous and Endogenous Money

When talking about monetary policy and monetary economics it is essential to be aware of the issue of money. This section discusses an elementary aspect of monetary theory so far as it is necessary for the further understanding of our analysis. It is about the nature, source and effects of money. Economists can be roughly divided into two fractions, one of which interprets the origin of money to be exogenous. The other considers money to be endogenously determined in the course of economic activity.

2.1.1.1 Exogenous Money

The conception of exogenous money is strongly associated with neoclassical economic theory. It claims that money is emitted by the central bank. While it had the character of a commodity money during the time of the gold standard, it is nowadays created out of nothing and hence called *fiat money* (see for instance Friedman, 1986; Ritter, 1995, pp. 134–135). The regulation of the stock of money is part of monetary policy. The monetary authority can decrease or increase the quantity of money in expectation of a higher or lower inflation rate, respectively. Thus, the meaning of exogeneity is that money is injected into the economy as if it had, so to speak, fallen from heaven (Davidson, 2006, p. 146).

Commercial banks use the money issued by the central bank (to wit, central bank money) as reserves, which allow them to give loans to the economy. Payments financed by these loans give rise to deposits in the same or other banks, which are thus in a position to grant new loans. By this process, the initial reserves are multiplied and give rise to the stock of money effectively observed in the economy. The so-called money multiplier may change from one specific situation to another but is assumed to be fairly stable over time such that the central bank is able to control the total amount of money by managing central bank money (Friedman, 1959, p. 527). Money supply depends on a policy decision. The supply curve of money is therefore vertical with respect to the market rate of interest (see for instance Blanchard & Illing, 2006, pp. 145–148).

This monetarist view, strongly influenced and spread by Milton Friedman, has the quantity theory of money at its centre (see for instance Friedman, 1956). It argues that under the assumption that the velocity of money circulation is stable, the money stock should grow proportionately to GDP. A rise in the amount of money which is in excess of the economic growth rate leads to a proportional increase of the general price level in the middle or long run. There is a unidirectional causality from the quantity of money to nominal output owing to the exogeneity of money (Palley, 1993, p. 79). Consequently, all else equal with respect to money velocity and GDP, expansive monetary policy leads to a higher rate of inflation, which is equal to the growth rate of the money stock. Since real variables in the market are given at a certain moment of time, monetary policy can only influence monetary variables. A higher money supply raises demand for goods, which again results in higher prices. Meanwhile, the supply side of the economy is supposed to remain unchanged (Lavoie, 2006b). Inflation is exclusively a demand phenomenon (see for instance Barro & Grossman, 1974; Brunner et al., 1973). To say it in often used words, there is no (long-run) trade-off between output and inflation that monetary policy could exploit (see for instance Barro & Gordon, 1983, p. 590; Bernanke & Mishkin, 1997, p. 104). A conduct of monetary policy that is either too contractionary or too expansive with regard to what real market forces require will necessarily lead to corresponding changes in the price level. Monetary policy can control nominal variables but not real variables (Friedman, 1968, p. 11). The only sustaining effect of monetary policy is a price effect. This position is represented in the Friedman aphorism that "Inflation is always and everywhere a monetary phenomenon", supported by a large fraction of neoclassical economists (see for instance Mishkin, 2007, p. 2).

Considering money as exogenous makes it similar to a commodity.[3] Its price rises or falls depending on its scarcity. When the central bank aims at stimulating investment by strongly raising money supply, the value of money drops and inflation increases. Increasing investment without accelerating inflation in the long run is only possible if savings have increased first. It is only higher savings that allow for higher investment. Savings and investment are themselves equilibrated by the real interest rate. However, daily monetary policy may influence the interest rate level such that it differs from the level corresponding to the equilibrium. Thus, there is one observable rate of interest, regulated by monetary policy, and one unobserved rate. The latter equilibrates savings and investment in real, that is, non-monetary, terms. It depends on productivity growth and savings behaviour of economic agents. This unobserved interest rate is called the natural rate and is part of the monetary analysis of Wicksell (Rochon, 2004, p. 2). It

[3] In this respect, see Clower's (1967, p. 5) famous dictum: "A commodity is regarded as money for our purposes if and only if it can be traded directly for all other commodities in the economy. […] money buys goods and goods buy money; but goods do not buy goods." It has served as a foundation for many influential contributions to neoclassical monetary theory, as for instance Kiyotaki and Wright (1989).

needs to be mentioned that some approaches rely on the theory of the natural interest rate even though they have basically incorporated the endogenous-money view. The New Consensus approach to monetary policy is a prominent example of this.[4] It pursues monetary policy targets by setting the short-run interest rate rather than trying to control the money stock (see for instance Woodford, 2002, p. 86). The aim of policy conduct, however, is not to set the rate freely but to shadow the natural interest rate (Goodfriend, 2007, p. 29). This strategy is incorporated in the famous and widely adopted 'Taylor rule', where the interest rate policy follows the natural rate by correcting for deviations in the inflation rate from the target rate and actual output from potential output (Taylor, 1993, p. 202). With regard to the theoretical background and the practice of monetary policy, the New Consensus approach resembles in many aspects the paradigm of treating money as exogenously given. In particular, monetarism has based on the Wicksellian concept of the natural interest rate since its earliest days (Friedman, 1968, pp. 7–8). It is therefore not necessary for the remainder of the analysis to treat it separately now.

The natural interest rate is a reference point that should be obeyed at least in the long run. When the stock of money is too high as a result of expansive monetary policy, the observed nominal interest rate is below the natural rate. This will lead to a higher rate of inflation because the stock of money is in excess of what is needed for economic transactions at a given output and price level. The opposite happens when the nominal interest rate set by monetary policy is above the natural rate. The only sustainable solution in the long run is the equivalence of both rates. Monetary policy has to react in an equilibrating way (see for instance Romer, 2000, p. 156).

Even though the approach of exogenously controllable money is historically tightly connected to monetarism and the quantity theory of money, it should be taken into account that the neoclassical paradigm has been developing since the 1960s when monetarism became influential. On the one hand, new Keynesian economics introduced imperfect competition and nominal rigidities, which made the influence of monetary policy stronger in the short run (see for instance Ball et al., 1988). On the other hand, real-business-cycle models became popular. They consider the economy as a perfectly competitive system that responds to exogenous productivity shocks in a way that equilibrium is reestablished. Money is a simple addition. The combination of these developments, new Keynesianism and real business cycle theory, is sometimes referred to as the "new neoclassical synthesis" (Goodfriend & King, 1997). Monetary

[4] See Romer (2000) for an elaboration, and Lavoie (2006b) and Rogers (2006) for a critique of the New Consensus on monetary policy.

policy is suggested to react to exogenous shocks by setting the interest rate such that the economy is led back to its equilibrium. Hence, monetary policy's task is to enable the economy to work as much as possible like a perfectly flexible system. It is therefore basically effective but only useful if it corrects harmful deviations from the equilibrium path. It does not have the potential to create a positive outcome by departing from an equilibrium point determined by nature (ibid., p. 280). Moreover, even this result is questioned by other authors. They argue that nominal rigidities only delay the neutrality of money but restore it as soon as prices have adjusted (see for instance McGrattan, 1997, p. 286). Monetary policy is therefore still influenced by monetarism, in the sense that it is mainly effective in controlling inflation (Woodford, 2009, pp. 272–273). Effects on real variables are constrained by general equilibrium with flexible prices. It is the optimal outcome that cannot be further improved. Wrong conduct of monetary policy is condemned to result in inefficient distortions. Fluctuations in output and unemployment are due to exogenous shocks to the real business cycle. They should not be counteracted by monetary policy (Goodfriend, 2007, p. 26). To conclude, these new evolutions in theory do not allow monetary policy to become much more powerful. They still judge the creation of money as inflationary because of its exogenous nature.

2.1.1.2 Endogenous Money

The endogenous-money view faces some crucial differences. It is part of the post-Keynesian economic theory and intensely debated within this strand of literature. But it cannot be said that endogenous money is exclusively a post-Keynesian approach. According to this theory, developed to a great extent by Kaldor (1970, 1982) and Moore (1988), neither the central bank nor any other authority is able to determine the total stock of money in the economy. Of course, money is created somewhere and has a specific origin. But it does not come from outside the system nor does it fall from heaven. It is created in the course and out of economic activity itself. Money is created *ex nihilo* when banks provide loans to firms and customers. Every loan represents a purchasing power, and endogenous money is credit money. Each unit of money corresponds to a debt in the same amount (see for instance Rochon, 1999, pp. 8–9).

Banks grant loans to borrowers if the latter fulfill the criteria of a creditworthy customer. Being aware of this fact and given that money is the result of the credit creation process, it is evident that the stock of money is driven by the same forces that drive the demand for credit.[5] Demand for credit depends crucially on the state of the economy. The stronger economic activity and the better future perspectives, the more credit is demanded in order to finance activities. As an important first result, money is demand-led (Moore, 1988, p. 19).

The central bank may try to raise the stock of money by supplying reserves at easier conditions to commercial banks, which transmit this policy by enlarging the volume of their loans. However, the effective quantity of money only increases if there exists a demand for credits. If future prospects are bad and investment activity lies down, no credit is needed, no more money comes into existence, and monetary policy becomes nearly powerless. The ‘money market’ thus features a demand function but not a clearly identifiable supply function, since money supply is itself demand-driven (Moore, 1988, p. 19).

These arguments do not mean that monetary developments are completely independent of monetary policy. But the endogeneity of money gives rise to the fact that the central bank cannot determine the money stock by policy decision. It can merely regulate short-run interest rates, which represent an exogenous variable (Lavoie, 1984, p. 777). The short-run rate affects the price of loans and therefore impacts on the profitability of investment projects. But it cannot influence the demand side of credit creation, because that is determined by economic activity. The condition for monetary policy to have an effect on economic variables like activity, output and employment is that there is large enough a demand. It needs to be sufficient such that investment profitability, altered by an interest rate change, gives effectively rise to a change in the granting of loans. It is sometimes argued that the interest rate is somehow also endogenous, because monetary policy can in substantial part be a reaction to the state of the economy (Woodford, 2001, p. 232). This argument is even strengthened by the adoption of a Taylor rule as a monetary policy compass. However, short-run rates of interest do not automatically respond to economic developments but rather remain being set by the central bank. Hence, their exogeneity is still given (Gnos & Rochon, 2007, pp. 380–381). Taken together, the finding is that demand-determined money and exogenous short-run interest rates do not necessarily correlate in contrast to the view of exogenous money.

[5] Cencini (2003a, pp. 313–314), as a representative of the theory of money emissions, even rejects the notion of a ‘stock of money’, since he argues that money is immaterial. We agree but may nevertheless use the notion in some places for convenience where it is helpful to explain the endogenous character of money.

The setting of the interest rate has been and sometimes still is the issue of a big debate among proponents of endogenous money. According to one fraction, called structuralist and strongly influenced by Minsky (1957), the interest rate curve is an increasing function in the volume of loans given to borrowers (see for instance Dow, 2006; Palley, 1991, 1996; Pollin, 1991). Investment grows in the course of economic activity but the central bank does not ease interest rate conditions infinitely. Hence, commercial banks have to manage their liabilities and therefore raise lending rates of interest. Since the central bank limits the availability of reserves, there is not only a demand constraint but as well a supply constraint on credit creation (see for instance Le Heron & Mouakil, 2008, pp. 421–424).

A second fraction, the so-called horizontalists, assesses the interest rate curve as a horizontal line (Kaldor, 1982, 1985; Lavoie, 2006a; Moore, 1988). The central bank sets the rate at a certain level. At this level, the whole demand for reserves is accommodated. The monetary authority can determine the price of credit but it cannot freely decide to limit supply when demand is high. If it refused to provide all required reserves, it would have to fear that banks get into financial distress. Turbulence may affect the real economy negatively. In analogy to the central bank, commercial banks grant loans according to demand and under the condition that the borrower is creditworthy (Lavoie, 2006a, p. 24; Rochon, 2006, pp. 171–173). The thought that the central bank behaves fully accommodative is an important feature and in strong contrast to the theory of exogenous money as will be seen later (Rossi, 2008, pp. 189–190).

There are other theories of endogenous money like the circuitist approach (see for instance Gnos, 2003, 2007; Parguez & Seccareccia, 2000) or the theory of money emissions (see for instance Cencini, 2005; Rossi, 2003, 2006b, 2009b; Schmitt, 1960). They focus on the circulation of money from the beginning when a loan is granted, through production of output, to income destruction and repayment of the loan.[6] Rather than a contrast to the structuralist and horizontalist conception of money, they are, despite differing focus and some theoretical dissension, related as they share the theory of endogenous money (Rochon & Rossi, 2003, pp. xxv–xxvi). Further, there is the New Consensus approach to monetary policy. It treats money as endogenous but it does not provide a distinct theory of endogenous money. As mentioned, its basic logic and the consequences drawn out of it remain attached to the above described theory of exogenous money and the neoclassical school or the neoclassical synthesis, respective-

[6] The fundamental difference between the theory of the monetary circuit and the theory of money emissions consists of the meaning of money. The former considers money as a stock in circulation, that is, being in a flow. The latter argues money itself to *be* the flow (Rossi, 2009b, p. 39).

ly (Gnos & Rochon, 2007, p. 383). Again, it is therefore not helpful to treat this approach more in detail, as it does not contribute much to the understanding of the issue here. It should be noted that the importance of the horizontalists has increased in the past. Leaving the New Consensus approach aside, horizontalism can now be seen as the dominant view within the endogenous-money paradigm (Rochon, 2007, pp. 4–6).

Some theoreticians suggest that the endogeneity of money is a relatively new phenomenon, because its nature is distinct from commodity money in contrast to the epochs when metal and other objects served as money. This view is strongly contradicted, as endogenous money is argued not to be a matter of time in history but a matter of logic. In a monetary economy, every production activity has to be financed. Thus, a means to exert purchasing power is required. Money is created by loans for this purpose. Since this is a phenomenon observed all through history, it can be said that money has always been endogenous (Rochon & Rossi, 2013, p. 225).

If money is demand-driven, the concept of the money multiplier does not make any sense. Once the central bank has set the short-run interest rate at a certain level, borrowers demand a certain volume of credit that they need in order to finance their activity. If economic activity is weak for whatever reasons, few loans are issued, the stock of money remaining low. An ever increasing supply of reserves by the central banks helps very little in this situation. Thus, it is not money reserves that drive the stock of money by means of a multiplier. It is rather the demand-determined stock of money that drives the amount of reserves that banks need to hold (see Lavoie, 2003, pp. 523–524). Even if the multiplier idea is potentially confirmed by empirical investigation, it does not have any causal meaning, since it is *a priori* wrong from an analytical point of view (Moore, 1988, p. 85).

As outlined above, in a world of credit money, all money is created by loans. Consequently, all money is mirrored in debt in the same amount. Loans are issued to finance investment. The newly created money enters into circulation through the purchase of equipment, the employment of labour force, direct consumption or the purchase of financial assets. Sooner or later, this money results as someone's income. It is deposited in a bank account and functions as saving. By logic of accounting, the deposits equal the issued loans. This is an important aspect of endogenous money theory: first, investment and savings are always equal as a rule of accounting (see for instance Cencini, 2003a, pp. 304–312). Second, causality goes from investment to savings and not the other way round. From a macroeconomic point of view, investment determines savings, that is, loans create deposits (Howells, 1995, p. 90; Moore, 1988, pp. 3–4;

1989, p. 55). This is not a question of personal opinion but comes out of the logic of double-entry bookkeeping, which holds independently of the number of commercial banks or whether or not there exists a central bank (Lavoie, 2003, p. 506). Neoclassical arguments according to which too low an interest rate reduces deposits such that banks are constrained in issuing loans appear as rather fallacious (see for instance Creel et al., 2013, p.10).

In contrast to the exogenous-money view, endogenous money has a fundamentally different character. The money stock cannot be determined by the monetary authority, as it depends on various factors in the real economy. Money is not something that is produced exogenously: it is rather a result coming out of economic conditions. It is not money that determines nominal output through its possible short-run and long-run effects on real output and the price level. It is economic activity itself that induces a stock of money needed for all transactions. Hence, as particularly highlighted by Davidson and Weintraub (1973, p. 1117) in a wage-bargaining model – even without explicitly assessing the endogeneity of money –, money is not a cause but an effect. And as money creation intimately corresponds to the monetary requirements of the economy, there basically cannot exist an excess money supply. Moreover, since the stock of money increases in response to the rate of inflation rather than the other way round for this reason, money does not cause inflation (Arestis & Sawyer, 2003, p. 9). This does not mean that monetary policy cannot have any influence on inflation. A low policy rate of interest can lead to strong credit creation. If the thereby induced high demand exceeds production capacities, the price level increases.[7] Especially in Kaleckian models, capacity utilization is argued to be below unity (Lavoie, 2014, p. 360). While it is often agreed on spare capacities in the short run, considerations about long-run capacity utilization differ (Lavoie, 2014, pp. 387–390). Hence, it is to a large part an empirical question and depends on the state of the business cycle or the degree of competition in the market. As long as production capacities are not fully utilized, the source of inflation lies in cost pushes coming from higher commodity prices, more expensive imports as a consequence of a depreciated exchange rate, wage bargaining, and so on (see for instance Kaldor, 1985, p. 10; Rochon, 2004, pp. 8, 19). Even more, expansive monetary policy can as well be linked to a falling price level. The so-called 'Gibson's paradox' is dubbed as "one of the most completely established empirical

[7] Rossi (2001, pp. 139–145) argues that this kind of inflation is not cumulative over time. Excessive credit creation leading to demand exceeding production capacities and hence rising prices is reversed once credits have to be paid back. Instead, structural and cumulative inflation arises from the working of the contemporary monetary and banking system and is not caused by monetary policy (Gnos, 2007; Rossi, 2001, pp. 145–153, 160–169). In this place, we limit the investigation to changes in the general price level that are potentially caused by monetary policy.

facts within the whole field of quantitative economics" by Keynes (1930b/2011, p. 198). While he then explained the phenomenon by recourse to the natural interest rate that he abandoned later (ibid., pp. 203–206), the paradox may get an alternative explanation in our specific context. One the one hand, a price puzzle might be present in Gibson's paradox to which we will refer in the empirical analysis. From a theoretical point of view, however, there is a more interesting idea. Interest payments represent a share in production cost of corporations. The lower the interest rate, the lower is the production cost that transmits to lower prices (Sawyer, 2002a, p. 42). In the same way, expansive monetary policy may accelerate economic activity. Previously installed fixed capital is more charged to capacity. More units of output share the cost of fixed capital. The price of each unit thereby falls (Arestis & Sawyer, 2009, p. 42). On these grounds, monetary policy has an influence on output but does not necessarily raise the price level. The creation of money itself is not inflationary. Moreover, by influencing investment, monetary policy may also affect the supply side and hence the productive capacity of the economy, which again reduces the inflationary effects of monetary policy (Colander, 2001; Lavoie, 2006b, pp. 178–181).

The theory of endogenous money in its proper sense rejects the idea of a natural interest rate. The latter is indeed unobservable and thus hypothetical (Smithin, 2013, pp. 244–246, 252). To apply it to monetary policy, it can only be estimated by crude approximation (see for instance Taylor, 1993, p. 202). As such, the natural interest rate is merely an assumption. Since it is just part of a theory without any evidence of real existence, there is no reason to accept this existence. This has far-reaching consequences that will also be important for our further investigation.

To sum up, there are four central features of endogenous money: it is demand-determined, investment is always equal to savings, the emission of money is non-inflationary by its nature, and there is no natural interest rate. Moreover, there is the dominant view within endogenous-money theory that the central bank behaves in an accommodative manner after having set the short-run interest rate. Taking these features together means that the quantity of money can in principle rise and fall by large amounts without having any causal effects. When the demand for credit is high, loans are issued. The accommodative behaviour of the central bank provides demanded reserves. There is no requirement that savings have to increase first for the loans to be financed. It is in fact loans that create deposits. The money stock grows without necessarily giving rise to a higher inflation rate. Different stocks of money can correspond to different economic outcomes. For instance, when the economy is stagnating, the stock of money tends to be lower. But as outlined above, it is not money that is at the root of stagnation. A low money stock is rather the consequence of it. These characteristics reveal that, in contrast to the exogenous-money view, money is something completely different from a commodity. It is not scarce. Given the rate of interest, money is available in abundance. The only condition to create it by issuing loans is the creditworthiness of the borrowers appraised by the banks.

It is rarely the case that two concurring paradigms are in opposition to each other over long time without dominance of one over the other. Nevertheless, it is not easy to assess whether money is more often acknowledged in the literature as exogenous or endogenous. As exogenous money and the quantity theory take an important part in neoclassical economics, it may be argued that it is as dominant as neoclassical economics itself. However, the New Consensus as a new Keynesian or neoclassical synthesis approach, respectively, is also very close to the dominating paradigm but treats money basically as endogenous (although it does not explain this on theoretical grounds). Moreover, exogenous money as such does not have the same importance for neoclassical theory that endogenous money has for, by way of example, post-Keynesian economics. Neoclassical models tend to be constructed in merely real terms. Money is normally introduced in a further step as a kind of commodity. In that way, money is predetermined as exogenous. Endogenous-money theories, however, include money as a crucial part of their analysis from the beginning. Money is stronger emphasized as an integral part of any economic activity. This arises from the fact that monetary theories tend to incorporate all economic processes from financing production to final consumption. They refer to ‘economies of production’ and criticize neoclassical ‘economies of exchange’ where only the phase of exchange in the market is enlightened and the origin of money remains unexplained (Graziani, 2003, pp. 25–26). From this point of view, endogenous money might be put to the forefront.

Definitely responding the question by empirical analysis is not an easy task but tends to come out in favour of endogenous money. Significant results for the existence of a stable money multiplier can be interpreted as a causal link from monetary policy to the stock of money and thus as evidence for the exogeneity of money, as already noted above. Similarly, a correlation between the stock of money and nominal income can be and has effectively been seen as evidence for the causal link from money to prices. Critics do not necessarily deny the existence of such correlations (see for instance Kaldor, 1970, p. 5). But as anywhere, correlation is not the same like causation. Simple correlation does therefore not yield a clear result because whether money is exogenous or endogenous depends on the direction of causality. A study about the evolution of money over time by Schularick and Taylor (2009) finds that while monetary aggregates developed in proportion with total bank assets before World War II, they did not thereafter. The authors do not postulate money endogeneity by a theoretical analysis. However, they find that credit creation and thus money creation in a proper sense are not driven by an exogenous money supply. Another paper by Berger and Bouwman (2010, pp. 23–24) is even clearer, though it is merely empirical and does not make any conclusions for monetary theory, either. It finds that the impact of monetary policy on bank liquidity creation is limited and in many cases even found to be insignificant. Moreover, the reaction of banks' liquidity creation to monetary policy seems to depend on the state of the economy. These results correspond to the theory of money endogeneity and confirm it implicitly. Howells (2006) provides an overview of empirical literature about endogenous money and finds clear support for its existence. Furthermore, he argues that money is accepted as endogenous in the practice of monetary policy implementation even if it is not always emphasized theoretically as such (ibid., p. 25). Yet, as an example from practice, economists from the Bank of England explain the mechanism of money creation through the issue of loans by commercial banks and thus confirm the endogeneity of money from an analytical point of view (McLeay et al., 2014, pp. 14–25). So all in all, it seems fair to say that if the theory of endogenous money is not yet supported by a majority of theoreticians, its importance is at least growing fast.

The confrontation of the two paradigms yields some first insights that will be useful for our analysis. Within the framework of exogenous money, monetary policy leads to price changes without having a sustaining effect on quantitative variables like output, production capacities or employment. In the long run, the only suggestion for the monetary authority is to aim at a path following the evolution of the natural interest rate or the corresponding real business cycle, respectively. In contrast, endogenous money implies that monetary policy does not inevitably impact on prices but may influence quantities. The latter takes place under the condition that there exist sufficient demand and spare capacities (or capacity-enlarging investment) such that there is an effective reaction of borrowing in response to a change in monetary policy. Active monetary policy deviating from a hypothetical equilibrium path does not categorically have lasting destructive effects. Thus, under the endogenous-money paradigm, the amount of money is allowed to react much more elastically to changes in the interest rate level. Under a given monetary policy stance, the stock of endogenous money can basically grow interminable as demand for credit increases. This finding strongly contrasts the view of an exogenously determined – and hence limited – stock of money. The elasticity of endogenous money and its nature as a reaction to rather than a cause of economic activity will be a crucial feature in the examination of the role of financial markets in the next section.

2.1.2 The Role of Financial Markets in Monetary Policy

Financial markets and the role they play in light of monetary policy is an issue that has rarely been debated as intensely as in the years since 2008. This section introduces two different views of financial markets. The first is the neoclassical view dominating nowadays. However, as will be shown, there are many reasons for criticism. Neoclassical theory provides in numerous respects explanatory tools that are not satisfying. This is why a second, alternative view of financial markets is introduced. It is based on endogenous money and is used thereafter in the remainder of our investigation. Emphasizing the role of financial markets is important for the subsequent analysis of the crude oil market. The insights gained here are therefore useful for our research work.

2.1.2.1 The Neoclassical View

According to the neoclassical view, economic outcomes are determined by consumers' utility function and firms' production function.[8] They are of a purely technical nature and do not take into account any endogenous monetary dynamics. Money is only introduced as an additional, exogenous entity. In the case of perfect competition, not even social relationships like the balance of strength between employers and workers play any role. They are only considered when market imperfections or nominal rigidities are introduced, as is the case in new Keynesian models, for instance. But still then, these features are treated in a rather static way. Thus, in the long run, the economy is driven exclusively by real forces, the so-called fundamentals. According to the theory introduced above, these fundamental forces determine the natural interest rate. At this rate, the only sustainable one, the economy is in equilibrium. Neoclassical general equilibrium analysis does not leave much space left for money to play a role. Hence, money is added as exogenous to the basic real forces and treated like a commodity (see Bénicourt & Guerrien, 2008, p. 241).

Even though the theoretical background is missing a clear idea of money, it does not imply that money is completely meaningless. At this point, financial markets should be examined. Neoclassical theory postulates two main hypotheses in this respect. The first one is the rational expectations hypothesis (see for instance Lucas, 1972; Sargent, 2008). As its notation says, agents build their expectations about the future on rational

[8] For detailed elaboration, see for instance Frank (2008) and Jehle and Reny (2011).

grounds. They learn from results in the past and adapt their expectations in order to avoid errors. This is an ongoing feedback process. As a consequence, agents forecast their variables of interest without bias. All forecast errors are only randomly. The second postulate is the efficient market hypothesis. It can be considered as an application of the rational expectations hypothesis. According to the idea of efficient markets, all available information about an asset is incorporated in its price (see for instance Fama, 1970, p. 383; Jones & Netter, 2008). For example, when a new promising production technology enters the equipment of a company, higher future dividends can be expected. The stock price of this firm increases. The hypothesis is equivalent to a no-arbitrage condition. Any new available information is immediately reflected by the corresponding asset price. Speculative profits are not completely excluded but they are random. Every reaction of a price to new information brings random profit to some agents. However, random profit is the condition for the no-arbitrage condition, as it eliminates the possibility of any further, systematic profit. This corresponds to the well-known saying that it is impossible to beat the market. Many studies reveal that professional investment managers are not able to reach systematically higher returns than the average of all stocks in the market (Malkiel, 2003, pp. 77–78). There is a weak, semi-strong and strong form of the efficient market hypothesis. They differ in the degree to which public and costless information is available.

It is in the credit and capital market where capital demand and supply meet. Financial markets are therefore useful to improve the efficiency of capital allocation. Especially when capital is made marketable in the form of stocks, bonds and other securities that are traded in primary and secondary markets, it is most likely that capital finds its optimal investment opportunity. The more liquid financial markets are, the better and faster price discovery is achieved (see for instance Jones, 1999, pp. 1506–1507). In this sense, a growing volume of transactions in financial markets can be interpreted as an evolution towards perfectly-working market mechanisms.

The economic fundamentals as the independent and only driving forces of economic outcomes on the one hand and the financial sphere with exogenous money on the other hand are given. The efficient market hypothesis is a crucial tool to understand the relationship between them. It makes all movements of asset prices directly depend on changes in fundamentals. For instance, considering the stock market, we know that high stock prices tell us about higher profit expectations, themselves a sign of well-working fundamentals. Thus, financial markets are a reflection of the real economy. Causality goes from fundamentals to financial markets. Financial assets do not have any intrinsic productive force, so they are not a key determinant of fundamentals. That is why there is no causality from financial markets to the real economy. Deviations from this standpoint are due to market imperfections. These may be rigidities or costly information as will be seen below.

The neoclassical stance of exogenous money does not admit a positive significant role to monetary policy, as outlined in the previous section. Coming from the quantity theory of money, a change in money supply leads to a proportional change in the price level over the long run. Following the further evolution of neoclassical theory after the 1970s by including new-Keynesian market imperfections and real business-cycle approaches, monetary policy becomes partially more effective but the basic proposition of the quantity theory with exogenous money still holds. The hypothesis that expectations are rational is not affected by any action of the monetary authority. Thus, the efficient market hypothesis remains valid, even if one allows for some imperfections by assuming only the weak or semi-strong form of that hypothesis. The relationship between fundamentals and financial markets does not change in the course of active monetary policy. In the long run, the latter has only a nominal effect on the economy. Consumers' utility function remains the same owing to their rational behaviour. Production technology does not change either. Hence, real forces are not influenced. It is still real variables that determine real profits and it is the expectation about real profits that financial markets react to. As a corollary, since monetary policy does not affect the fundamentals, it does not have an impact on financial markets performance. Financial volatility is the symptom of real business cycle fluctuations. In cases of crises or even depressions, the sources do neither lie in financial speculation nor in distortions inherent to the economic system. They are triggered by exogenous shocks in productivity, labour or capital, which are in general caused by misled public interventions (Kehoe & Prescott, 2007, p. 15). Woodford (2002, p. 87) even argues that efficient financial markets support the conduct of monetary policy without distorting efficient capital allocation, to wit, without affecting fundamentals.

Nevertheless, empirical evidence is found in favour of a significant effect of monetary policy on asset prices, in particular stock prices (see for instance Ehrmann & Fratzscher, 2004; Rigobon & Sack, 2002). There are several explanations to reconcile these observations with neoclassical theory. It can be due to imperfections with respect to the efficient market hypothesis or to short-run effects on economic fundamentals, which are then reflected by a corresponding response of stock prices. Furthermore, time lags are certainly larger in the real producing economy than in financial markets. A change in real stock prices in the course of monetary policy might then be explained by the fact that the changed money supply impacts first on financial asset prices and is offset by a corresponding change in consumer prices later. This corresponds to the results found by Bordo et al. (2007, pp. 18–23). They argue that for the period since World War II, stock market booms have occurred when interest rates and inflation rates were low. Booms tend to bust when the rate of inflation increases. From this exogenous-money view, monetary policy necessarily cannot have a lasting effect on real stock prices, because it is clear from the beginning of any policy activity that it will affect the general price level in the long run. Expansive monetary policy raises liquidity. This leads to a higher demand for assets, which causes stock-market booms. Inflation in the real economy is still low, since the reaction of consumer prices is delayed. But eventually, the general price level increases for the same reasons like stock prices: the increased supply of money has exerted its effects; the initial impact of monetary policy is neutralized. Thus, any increase in stock prices as a response to monetary policy is a sign that inflation will increase soon and real stock prices will be back to their initial level.

An additional explanation is implicitly given by Christiano et al. (2010, pp. 2–3, 7). Exogenous productivity shocks alter expectations about future profits. This raises stock prices irrespective for the moment of whether the magnitude of the rise is rationally motivated or exaggerated. An inflation-targeting central bank expects lower prices because of higher productivity. The policy rate of interest is therefore reduced to hit a given inflation target. A further discussion would then concern whether the interest rate cut promotes itself a further stock price growth that is not justified by fundamentals. But, basically, this model is able to explain the correlation between monetary policy and stock prices. It does so by reversing causality, such that expansive monetary policy is triggered by changes in fundamentals rather than the other way round.

To sum up, money is neutral in its relationship to the real economy as well as to financial markets. Some conditions have to be satisfied for this approach to be useful. First, money neutrality should not be distorted too much by market imperfections and nominal rigidities, as we already noted in the previous section. More distortions mean less money neutrality. The second, even more crucial condition is the stability of the relationship between fundamentals and the financial sphere. If expectations are rational and markets are efficient according to the two hypotheses at the core of neoclassical economics, this relationship should be stable. Then, financial markets do not feature any independent dynamics that could spill over to fundamentals.

However, many economists within the neoclassical paradigm disagree about the efficient market hypothesis on empirical grounds (see for instance Summers, 1986). Beside of doubts as to whether a fully rational behaviour is realistic from an analytical point of view, there is the problem of measurability. The so-called joint-hypothesis problem is recognized among both proponents and critics of the efficient market hypothesis. For instance, Fama (1991, p. 1575), a founding economist of the efficient market hypothesis, states that “market efficiency per se is not testable”. To define rational behaviour and efficiency, a theoretical model is needed. Deviations from such a model found in empirical tests then are due either to existing market inefficiency or to the incompleteness of the model. But it is not clear where to attribute the measurement errors. For example, testing whether stock prices adjust to the information of an innovation is not necessarily helpful, if efficiency is to be measured. Stock price changes may be very different across individual firms of a certain industry. This leaves room open for irrational over- and undershooting of single stock prices (ibid., p. 1602). On the other hand, one might see this as a proof for an efficient market mechanism and assign measurement errors to random noise. In this sense, the joint-hypothesis problem makes the efficient market hypothesis hardly attestable as well as hardly falsifiable.

An early important criticism was articulated by Grossman and Stiglitz (1980). In a world with imperfect, costly information, informed agents face arbitrage opportunities. The information spillover to non-informed agents through price changes is imperfect. Arbitrage profits are therefore a necessary condition for an efficient market. They give agents an incentive to produce costly information, which is again necessary for the market to find the equilibrium price. As widely recognized, this distortion of the efficient market mechanism is more realistic than the assumption of perfect information.

Shiller (2003, p. 86) argues that if the efficient market hypothesis held, stock prices should be equivalent to expected dividends, that is, the present value of dividends. However, data show that while expected dividends follow a stable trend throughout the twentieth century, stock prices were much more volatile and deviated over long periods from expected dividends. These observations of seemingly irrational behaviour gave rise to intensive research in behavioural finance (see Olsen, 1998). Investors may not only react to information about fundamentals but as well be just feedback traders who react to past price developments (Shiller, 2003, pp. 91–101). Proponents of the efficient market hypothesis tend to share the view that potential misguided price changes caused by feedback traders are offset by well-informed agents who benefit from this arbitrage opportunity. But even this view is challenged. There are models where rational behaviour has a destabilizing rather than stabilizing effect on stock prices. For instance, in De Long et al. (1990), rational investors buy assets and thereby raise prices. They know that feedback traders will follow them and raise prices further.

Rational investors can now sell at a higher price. Hence, they exploit the arbitrage opportunity that they have themselves created before.

In general, these critiques originate from economists who do not leave the neoclassical paradigm but broaden it. The more imperfections there are, the longer it takes for asset prices to adjust to fundamentals and the more influence monetary policy can therefore have. It is questionable up to which degree of market imperfections or irrational behaviour it is adequate to assume the correctness of the efficient market hypothesis. The claim that asset prices will finally revert to their fundamental value loses its significance the more imperfections distort the equilibrium pattern. The short run may effectively become very long. During the period when asset prices deviate from real economic conditions, the causality between fundamentals and financial markets can become bidirectional. Asset prices then are not a simple reflection of real forces but are also driven by other factors. Hence, financial market performance appears to fundamentals as a partially exogenous variable: it is influenced by fundamentals but may as well have an impact on fundamentals. These characteristics are notably important for two transmission channels of monetary policy – Tobin's *q* and the wealth effect – to be effective.[9]

2.1.2.2 An Alternative View

Neoclassical theory provides an explanation of financial markets and the role of monetary policy that is basically consistent. To arrive there, however, strong assumptions are required. They are useful for the completeness of theory but not necessarily for the description of economic reality. As an example, the existence of stock market bubbles is partially acknowledged by proponents of the efficient market hypothesis, for instance during the internet boom at the end of the 1990s. But they still hold up their support of the hypothesis since there was no evidence of any systematic arbitrage opportunities during that bubble (see for instance Malkiel, 2003, p. 75). So, if bubbles occur even if markets are efficient, it remains to ask what the efficient market hypothesis should be useful for. The fundamental question from the beginning was and still is whether financial markets perfectly reflect the real forces of the economy or whether they feature their own dynamics. Asserting the correctness of the efficient markets hypothesis is considered as sufficient evidence that financial markets follow a neutral pattern. Yet, evidence for both efficient markets and bubble building jeopardizes the comfortable findings of neoclassical financial theory. This is in fact argued to be a central weakness of the efficient markets hypothesis: market efficiency on the one

[9] Tobin's *q* and the wealth effect will be discussed in relation to the market for crude oil.

hand and the condition of no arbitrage in financial markets or the non-predictability of asset prices, respectively, on the other hand are not at all the same thing. However, they have been taken as the same thing or at least as two inevitably connected issues for decades by proponents of the efficient markets hypothesis (see for instance Guerrien & Gun, 2011, pp. 25–26).

In what follows, we emphasize an alternative view of the role of financial markets in monetary policy. It is a view that does not rely crucially on the microeconomic assumptions of how individuals behave. Moreover, we do not assign all potential deviations of nominal variables from fundamentals to rigidities. Rather than a wedge in the otherwise smoothly working economy, price and wage rigidities are a basic characteristic of capitalist production. With complete flexibility of all variables, it would be impossible to plan production (see for instance Cottrell, 1994, p. 591). The perspective we adopt in this regard is a macroeconomic one. Of course, all macroeconomic phenomena are the composition of microeconomic behaviour. But building a macroeconomic theory by simple aggregation of individual actions usually requires strong assumptions and simplifications in order to allow any aggregation at all. Human behaviour and microeconomic market mechanisms are extremely complex. Summing up individuals and their economic actions in a mathematical way ignores interactions between them. Macroeconomic results can thus get rather far from reality. This phenomenon, which is well known in economics, seems also very likely to occur in financial markets: the famous fallacy of composition (see for instance Lavoie, 2014, p. 17). The above presented hypotheses of rational expectations and efficient markets are symptomatic. According to the theory, given that all individuals behave rationally, asset prices react immediately to new information and are therefore a mere reflection of changes in fundamentals. As Cencini (2003b, p. 8) puts it, perfect competition and rational behaviour are the necessary assumptions allowing the distinction between micro- and macroeconomics to be only “a matter of size and not of substance”. However, rational behaviour from an individual point of view is not necessarily rational nor is it necessarily efficient from a macroeconomic perspective. In a financial market boom, investors may behave fully rationally if they speculate on irrational behaviour of others.[10] They believe that prices will rise because of other investors’ enthusiasm and therefore purchase assets. If a sufficient number of investors act like this, prices will effectively increase. Perhaps even nobody at all behaves irrationally, because what has been expected before is reality now. Moreover, it is difficult to obtain a higher than average market return, that is, it is unlikely to beat the market. Nevertheless,

[10] For a review of the theoretical and empirical literature on herding in financial markets, see for instance Bikhchandani and Sharma (2001).

asset prices have probably moved away from their real intrinsic value. A bubble might build up and burst sometime.

Investors build their expectations about the future. But the future is uncertain. This view is related to the principle of uncertainty as developed by Keynes (1936/1997, pp. 161–162). It says that uncertainty is not just a set of possible outcomes with an exact realization probability for each. The future is fundamentally different from the past and the environment is too complex and in permanent change. Mathematical probabilities as a tool to make uncertainty more certain are therefore doomed to failure (Keynes, 1937, pp. 213–214). An investor has to build a belief of what other investors believe, while the belief of other investors is built on what they believe that the other investors believe that they believe, and so on. This is an important mechanism how investors build their short-run expectations in an uncertain economy (Keynes, 1936/1997, pp. 154–158). This means that macroeconomic outcomes in financial markets cannot be traced back linearly to the behaviour of individuals because of dynamic interdependences. It is not useful to base the theory on the assumption that individuals behave either rationally or irrationally. Whether the former or latter holds true, uncertainty does not allow to derive a macroeconomic theory from a simple summation of suggested individual behaviour. In Cencini's (2003b, p. 13) words, the rational expectations hypothesis has to be rejected owing to "the logical impossibility to derive macroeconomics from microeconomics". The conclusion for the efficient markets hypothesis is analogous. Moreover, it is likely that rational as well as irrational behaviour occurs numerously in economic reality where human beings are manifold.

In an economy with uncertainty, expectations and behaviour of individuals can shift macroeconomic variables in principle anywhere. Thus, financial market performance may or may not correspond to the state of fundamentals. In addition, the latter can in principle be determined in retrospect but never in prospect (Hayes, 2006, p. 421). This gives rise to saying that in a world of uncertainty, the conception of equilibrium to which the economy converges is meaningless (Weintraub, 1975, p. 535). Such equilibrium does perhaps not even exist and if it exists, it is hardly possible to determine its level. Assuming a doubtful equilibrium path of the economy may impede a realistic analysis.

The macroeconomic approach in this chapter is based on the principle of endogenous money. Demand-determined creation of money provides large flexibility to the financial system. In combination to an economy with uncertainty, endogenous money brings about a more autonomous financial market evolution. Given the expectations of investors, endogenously created money influences asset prices. In contrast to the neoclassical paradigm, financial asset price changes do therefore not necessarily have to be in correspondence with changes in real forces. These impacts may even last in the long run, because there is no equilibrium to which asset prices should converge together with the real economy. Since financial markets are not just a simple reflection of fundamentals, this approach allows for a bidirectional relationship between the real economy and the financial system. Financial markets can have a positive impact on the producing economy by providing liquidity. But they can as well build bubbles that may be disastrous at the time of their bust. Davidson summarizes these characteristics in the allegory of the “double-edged sword of financial markets” (Davidson, 2002, pp. 104–105). If flexibility is an outstanding feature of financial markets, fragility must be added as another property. It is in this environment of uncertainty that Kaldor’s (1939, pp. 1–2) definition of speculation applies: financial investors make use of expected price changes and thereby may themselves affect the price.

Even though money is not considered as neutral and financial markets are not assumed to simply follow the pattern of fundamentals, it should not be claimed that the real economy and financial markets are entirely unrelated. The performance of production is the basis of present and future profits. Agents’ expectations therefore depend on fundamental data. However, this relationship is neither linear nor does it follow any predetermined time pattern. Fundamentals and the financial system affect each other and can beyond this be altered by other forces. Specifically, monetary policy can influence the connection. It acts as an exogenous force by setting short-run interest rates. This exogenous force has the – imperfect and sometimes quite limited – capability of distorting the relationship between fundamental and financial variables. The means of distortion is endogenous money.

The Nature of Financial Assets

When a commercial bank grants a loan to a company, an asset is created. The new money goes to a bank deposit. From there, it will be used to buy production equipment. In a world of endogenous money, loans create deposits. Loans and deposits are therefore always equal as we already explained. While debt represents a financial asset for the lender, purchased real goods are real assets. Money has a payment function. Financial assets are the counterpart of bank deposits. And money is, owing to its endogenous nature, a measure of produced output and thus it embodies purchasing power by raising a claim on output (Rossi, 2008, pp. 38–39). The principles of double-entry bookkeeping should be emphasized for the present purpose.

Table 2.1 shows the balance sheet of an individual company. Its assets are on the left-hand side. The right-hand side represents financial assets possessed by those investors who fund the company equipment by providing capital. From the view of the company, however, the right-hand side is not assets but liabilities. In this respect, equity can be considered as a debt of the company to its owners. For a bank, the balance sheet looks basically the same. However, its assets are the company's borrowed capital as well as optionally corporate bonds and the company's equity in the form of stocks. Its liabilities are bank deposits held by the public, equity, and, in the exemplary case of Table 2.1, advances from the central bank.[11]

Table 2.1 Balance sheets of a production company and a commercial bank

Company

Assets	**Liabilities**
Cash	Borrowed capital
Bank deposits	Corporate bonds
Equipment, real estate, etc.	Equity

Bank

Assets	**Liabilities**
Loans	Deposits
	Advances from the central bank
	Equity

Source: author's elaboration.

At first, let us consider the case of a pure production economy. The financial market exists merely as a result of the fact that banks create money through the issuance of loans. According to the theory of endogenous money, loans are demand-determined and so is money. The latter is needed to finance production. The quantity of money depends on production. Money is therefore a measure of output. The existence of the financial market is a direct cause of real activity rather than a proper autonomous force. In Table 2.1, equipment, real estate, property rights and the like are real assets. The liability side consists of financial assets. The difference between real and financial assets is made up by money in cash and deposit form. In our production economy, this money can be spent to purchase a corresponding share of output. Alternatively, given that output is already produced and sold such that cash and deposit represent sales earnings, money can be used to repay debt. In both cases, the balance sheet is altered in a way that real assets are equal to financial assets. When output is destroyed by pur-

[11] It may as well be the case that the bank's deposits exceed its loans such that it possesses a net deposit with the central bank's balance sheet.

chase and consumption the money stock decreases by the same amount through debt repayment. This is a logical and necessary outcome when the economy only produces real goods. All money is the reflection of debt in the same amount. Moreover, money corresponds to output in a stable relationship, since it is caused by output. Therefore, debt and real assets are equal from a macroeconomic point of view. This is shown in Table 2.2, where debt entirely consists of bank credit.[12] The equality is measured in units of money. Inflation is nevertheless possible, for instance, when additional demand in the form of credit creation exceeds short-run production capacities. However, this is not the central topic of the present examination.

Table 2.2 Balance sheet of the production economy

Assets	**Liabilities**
Real assets	Bank credit

Source: author's elaboration.

In the case of a pure production economy, bank loans are the simplest expression of the relationship between the borrower and the lender. Credit is granted and paid back at the agreed time. Nothing happens in between. Yet, in reality, debt is securitized to a large degree. Stocks and bonds are not only a borrower–lender relationship like bank loans used to be; they are tradable papers (Lavoie 2003, p. 518). An investor who buys stocks becomes the lender of somebody he probably does not even know. As soon as debt becomes tradable, it is measured twice. First, it has its original, so-called nominal value, which is the sum that has been borrowed from the lender. Second, it has a market price, depending on demand and supply. This gives rise to the existence of a market for financial assets. It is through securitization of debt that financial markets get an autonomous role with their own dynamics, which have the potential to influence other markets. In the following analysis, the focus will be on financial assets that are traded in the stock exchange or over the counter. If not denoted differently, we generally mean tradable securities when discussing about financial assets. All other debt is either denoted as bank loans or non-tradable securities.

To begin with, the supply side and demand side of the financial asset market are highlighted. Financial assets are supplied by producing companies. When a company plans new investment that is not financed out of its own means, it demands a loan at its commercial bank. Alternatively, it issues new stocks or bonds. While the firm requires

[12] Note that Table 2.2 as well as Table 2.3 below show the simplified economy from the production instead of the income side. The income side consists of bank deposits that are claims to purchase total output.

capital on the one hand, it provides a debt title either in the form of a loan or security papers on the other hand. The capital is used to purchase real goods like equipment, real estate and more. Like this, the company builds the potential for future profits. Parts of these profits are distributed to the owners of financial assets in the form of interest and dividends.

Financial asset demand is generated by investors. The term 'investors' includes commercial banks as well as (private) non-bank investors. They are similar in many aspects but fundamentally different in others. In contrast to private investors, banks have access to central bank reserves. Hence, they play the role of money creators. Investors aim at earning a fixed interest in the case of loans and bonds or a variable dividend in the case of stocks.

Financial asset demand depends on two main factors: expected profits of assets and liquidity preference of investors. Profits are composed of future security earnings, that is, dividends and interest as well as the change in the market price of financial assets. In neoclassical theory, the latter component is a simple reflection of the former. The higher dividends, the higher the fundamental value of the security and the higher therefore its price. In the alternative view, financial asset prices have their own dynamics owing to uncertainty. Investors build beliefs about the others' beliefs, which influences individual asset demand and eventually total demand. Demand affects prices. Price changes again impact on future demand.

Liquidity preference means that investors weigh the advantages of having wealth in a liquid form against the return prospects of investing it in a riskier, less liquid asset.[13] The idea of liquidity preference is closely related to the existence of uncertainty in the economy (Lavoie, 2014, pp. 238–250). The higher liquidity preference, the less investors are willing to provide capital for investment, that is, to purchase assets. When risk in financial markets is suggested to be high, investors substitute financial assets with money, the most liquid form of wealth. In times of low liquidity preference, demand for securities increases. Changes in liquidity preference are related to changes in expected profits. But they are not synonymous as we will point out when discussing it in relation with monetary policy.

[13] Note that we do not use the term of liquidity preference as it is used by Keynes (1936/1997, p. 241) against the background of a vertical money supply curve. Rather, we apply it as a concept integrated into the horizontalist perspective of money (see for instance Erturk, 2006, p. 466; Kaldor, 1985, p. 9; for an overview of the discussion, see Cardim de Carvalho, 2013).

Assume a certain state of the business cycle as given. It determines the level of investment, to wit, total funding requirements. Thus, debt of firms is given, too. A fraction of debt is securitized. Hence, we are not in a pure production economy but in an economy with financial markets where financial assets are traded. While financial asset supply is given, financial asset demand is assumed to increase. Securities prices rise. It is further assumed that demand augmentation is strong enough such that prices are above their nominal value. Demand cannot become effective out of nothing. It is reflected in a corresponding amount of money, which is used to purchase financial assets. To create this money, new loans have to be issued. There is now a higher money stock but also a higher stock of total debt. However, production is still the same. Table 2.3 exhibits the total balance sheet of the economy. In contrast to the pure production economy in Table 2.2, total debt is now larger than total real assets. As a second difference, liabilities are not only credit owed to banks. There are in addition stocks and bonds, which are owned by investors. They appear therefore both on the assets and liabilities side of the economy. While companies have debt in the amount of the nominal value of stocks and bonds, investors possess them as financial assets at market price. The difference between market price and nominal value of the assets is caused by increased security demand, which is itself financed by new bank credit.

Table 2.3 Balance sheet of an economy with securitization

Assets	**Liabilities**
Real assets	Non-tradable stocks and bonds (nominal value)
Non-tradable stocks and bonds (market price = nominal value)	Tradable stocks and bonds (nominal value)
Tradable stocks and bonds (market price)	Bank credit

Source: author’s elaboration.

Higher demand in the financial asset market does not raise the rate of inflation in the economy, that is, inflation of consumer prices, as long as the additionally created money remains in the financial sphere and is not spent on the real goods market. Otherwise, prices of financial assets fluctuate at least partially independently. In the case of a falling volume of loans, financial asset demand would fall and therefore trigger asset sales and further price drops. This happens to be a financial crisis. The balance sheet in Table 2.3 grows shorter. For now, it is just to be said that in this kind of economy, as long as consumer prices are stable, total money cannot raise a claim on total output. A part of the claim is devoted to financial assets.

The supply and demand aspects of financial assets reveal that the notion of investment should be clarified. Corporations want to invest but it is not them who finance investment. They raise capital by borrowing or by issuing stocks and bonds. Financial investors are only interested in pursuing their investment strategies. Whether the investment leads to the installation of additional production capacities is of second priority from their view. In contrast, companies need capital in order to buy equipment, increase output and obtain profit. It is only in this way that investment has a direct effect on the real economy. Hence, we shall refer to 'real investment' when companies use it to buy production capital. On the other hand, we refer to 'financial investment' when investors purchase financial assets that bring them a certain annual return in the form of interest or dividends and asset price changes. Real investment corresponds to the supply side of financial assets while financial investment reflects the demand side.

How Monetary Policy Impacts the Financial Asset Market

Given the basic anatomy of the financial asset market, we shed light on the role of monetary policy. Let us consider the case of expansive monetary policy. A fall in the level of the interest rate triggered by the monetary authority reduces the investment cost of corporations. The latter raise their demand for capital to increase investment. Additional bank loans are therefore issued. From the perspective of an individual firm, the emission of tradable securities depends likewise on the level of the interest rate even if mainly through indirect channels. Corporate bonds can be issued at lower cost because financial investors require lower remuneration in the face of a lower general interest rate level all over the economy. New stocks can be emitted at easier conditions, too. Companies are confronted with investors who leave fixed-rate investment, which brings lower earning when interest rates are low. They change to stock market investment. All in all, expansive monetary policy lowers investment cost and thus raises the supply of financial assets (see Mishkin, 1996, p. 2).

The demand side is influenced by monetary policy in a similar way. A lower interest rate does not necessarily raise expected profits at the beginning. But it lowers liquidity preference. Banks can refinance themselves at easier conditions on the interbank market. For private investors, it becomes more lucrative to use their saving deposits to purchase financial assets. Bank loans and securities are less liquid and riskier than cash but they generate a higher return. For professional investors, more capital can be borrowed at a lower interest rate and be invested in securities. Hence, lower liquidity preference induced by an expansionary monetary policy raises demand for financial assets. Resulting price changes may boost profit expectations of speculative investors. As a repercussion, asset demand grows further. To briefly link this argument to the criticism of the efficient market hypothesis above, this outcome is possible whether investors behave rationally or irrationally. In a world of uncertainty, speculating on a certain behaviour of other investors in the market can be absolutely rational. Higher demand for securities reflects higher demand for credit and thus larger money creation. It can again be reasonably assumed that banks behave accommodatively under the condition that borrowers are judged as creditworthy (Lavoie, 2006a, p. 24). Thus, demand for assets is in principle allowed to grow without limit as a reaction to expansive monetary policy. The supply and demand side reactions to monetary policy will have to be elaborated in more detail later.

It is both a theoretical and an empirical question whether nominal or real interest rates are relevant to argue about the effects of monetary policy. Neoclassical theory clearly suggests the use of real rates and, consequently, considers nominal rates at least partially as irrelevant. Since monetary policy can only have nominal effects in the long run, it is only potential changes in the real rate of interest that can have lasting impacts. Indeed, Greenwald and Stiglitz (1987, p. 121) state that is "real, not nominal, interest rates that should matter for investment". However, from the endogenous-money viewpoint, all money that is created defines a claim on output produced while output is itself measured by monetary units. Therefore, "economic magnitudes such as prices, income, profits, capital, interest rates and so on are simultaneously monetary and real and cannot be determined separately either in purely monetary or real terms" (Cencini, 2003a, pp. 303–304). This is the argument we will apply in the remainder. It is only nominal interest rates that can be measured. Real rates have to be calculated first and do not exist as an objective observable indicator. It is thus not wrong to rely on nominal rates.

The motives to purchase assets can be manifold. Most investors seek profits. Expansive monetary policy lowers their liquidity preference. Expectations of future profits and dividends increase. In such an environment, investors with profit purpose raise their demand for financial assets. Other investors want to diversify their investment portfolio in order to reduce risk (see for example Markowitz, 1952). In an environment with low interest rates, diversification can be achieved at lower cost; it is easier to finance a well-diversified portfolio. Furthermore, those investors may expect a higher inflation rate, whether these expectations are justified or not. They increase their diversification efforts. In particular, efforts for diversification can lead to a spillover of price changes from one asset class to another. A third motive is the store of wealth. Possessing money in its liquid form brings some advantages. But money is also vulnerable to changes in the price level. When the monetary authority lowers interest rates, liquidity preference decreases while inflation expectations increase. Thus, transferring wealth to a less liquid but safer form, that is, financial assets, becomes more attractive (see for instance Berck & Cecchetti, 1985). In all these cases, expansive monetary policy raises the demand for assets.

However, it is important to be aware of some limitations and specifications. One should generalize analytical results only with a sufficient portion of caution. Owing to the endogeneity of money, it does not exist a linear relationship between the setting of short-run interest rate and money demand. A drop in the interest rate tends to accelerate money creation but this does not occur in an exogenous mechanical way. Money grows only if there is sufficient demand from the public to react to a change in the interest rate. This was already outlined in the first section. Hence, the degree to which monetary policy can effectively change demand for money depends on many factors related to the business cycle, market structures and investors' expectations. The relationship can therefore change over time. This same issue applies to the demand for financial assets: lower interest rates tend to stimulate asset demand but the magnitude of this effect depends on a multitude of factors. We will analyze this in more detail later on.

As a second specification, we should draw a distinction between different asset classes. Not all financial assets are the same. Stocks and corporate bonds are tradable in exchanges and over the counter. They are relatively liquid since they can be sold for money. However, their liquidity depends on the state of the business cycle. As argued by Davidson (2002, p. 105), in time of recession or stock market crashes, severe liquidity crises occur. Government bonds that are classified as safe tend to play the role of a safe haven in times of financial crises. Their liquidity is therefore more stable. In a stock market downturn, prices fall. Debt repayment and investors' bankruptcy make the money demand fall, too. However, many investors prefer to hold government bonds rather than pure liquid money. Bond prices then may rise. Thus, there can be opposing trends in the evolution of stock market and bond market as, for instance, remarked by Keynes (1930b/2011, pp. 83–84). Higher bond prices are the counterpart of larger money demand in the economy and therefore a larger volume of credit as illustrated in Table 2.3. This backlash cushions the drop in the money stock when a financial crisis occurs. Reversely, money grows more slowly when the crash is over and financial markets start moving towards a new boom, because there is a tendency to shift away from safe havens, which lowers bond prices in a first step. While this effect sustains the stability of the quantity of money, the volatility of prices may be even stronger. Investors exploit arbitrage opportunities by weighing returns and risk and move to the assets where prospects are best. The effect of monetary policy on the market for financial assets may therefore be actually enhanced. When a lower interest rate exerts its stimulating effects on demand for securities at a given supply, price changes in the stock market may trigger substitution of stocks for bonds and raise prices further. Yet, this does not give rise to generally falling bond prices in stock market booms. Higher liquidity in the course of expansive monetary policy is likely to raise bond prices as well in the medium run. Correlation between stock and bond prices may be positive or negative (as well as insignificant in between) depending on the state of the business cycle (Li, 2002; Terzi & Verga, 2006, pp. 1–2, 5–6). All in all, there are complex interactions between different classes of financial assets. One should be aware of them when introducing crude oil futures contracts in the next section.

Another specification to be made is the identification of asset demanders and asset suppliers. While above asset supply was assigned to producing corporations and supply to banks and private investors, the matter is in fact not that clear. Companies supply financial assets by funding their investment. But they may as well become asset demanders. For instance, when profits are not fully distributed, they are often reinvested. This can be investment in the company's equipment. However, in many cases reinvestment is realized by purchasing financial assets, either by the repurchase of the company's own stocks or by acquisition of other securities in financial markets. The increasing weight of the financial sphere in the economy has made the structure of financial institutions rather confusing. Securitization has raised the number of so-called shadow banks, that is, various forms of investment funds. They are not banks in the strict sense of the word, since they do not have access to central bank reserves and therefore need a private or public financial backstop (Claessens & Ratnovski, 2014, pp. 4–5). On the liabilities side of their double-entry bookkeeping, they fund their investment volume by issuing shares, to wit, by supplying financial assets. On the assets side, they use their funding capital to demand financial assets in the market. Their final purpose is to invest capital in financial assets, to wit, they are asset demanders. The issue of financialization and its effects in respect to our analysis has to be investigated later in some more detail.

Quantity Effects and Price Effects

Recall that, in the neoclassical view, investment requires saving: investment is only possible if a sufficient fund of capital has been saved before. Saving increases and investment decreases in the interest rate, respectively. The intersection of the investment and saving curves determines the natural equilibrium rate of interest. This paradigm does not make sense in the presence of endogenous money: loans create deposits and therefore investment is always equal to savings. Demand for capital determines the supply of financial assets. Supply of capital, on the other side, represents demand for financial assets. It is credit creation that satisfies capital demand by generating capital supply. Based on this logic, supply of financial assets is always equal to demand for financial assets. This is a necessary and always valid principle rather than an equilibrium condition. Issuance of loans and thus the volume of deposits tend to be larger when the interest rate is low. In the same sense, both financial asset supply and demand grow when the rate of interest falls. The level of the interest rate influences the quantities in the market of financial assets but it cannot distort the equality between demand and supply.

Yet, the necessary equality of financial asset supply and demand does not imply that the price of financial assets is stable. There are different forces on the supply and demand sides of the market that exert their influence through changes in price. It may then be argued from a neoclassical perspective that this is exactly an equilibrium analysis, which states that the price is the tool to bring supply and demand together. To reply, first, it always applies that what is sold by an agent is purchased by another agent, and *vice versa*. The equilibrium condition is therefore always fulfilled. Second, the equilibrium can in principle be placed at every price and quantity level (see for instance Asensio et al., 2010, p. 9). Equilibrium is thus everywhere and disequilibrium is nowhere. The equilibrium approach loses its utility. This implies the rejection of Say's Law, which states that all supply is met by an equivalent demand under profit maximization of all individuals (Davidson, 2002, pp. 19–21). The thereby resulting general equilibrium in real terms is predetermined. Yet, in reality, the economy is a monetary one; there is uncertainty and expectation building. The cross point realized within the output-price space is not a static one determined by production and utility functions but crucially depends on effective demand (see for instance Davidson, 2002, pp. 21–25; Hartwig, 2006). In Keynes's (1936/1997, p. 55) own words, "the effective demand is simply the aggregate income (or proceeds) which the entrepreneurs expect to receive […] from the amount of current employment which they decide to give". This means in few words that production is determined by expected sales. Once those sales take place, the intersection of the supply and demand curves determines price and output finally realized. In a world of uncertainty, the price thus cannot be predetermined and it can in principle take any value. With respect to financial assets, uncertainty is enhanced further. In contrast to a pure production economy where credit creation corresponds to the funds needed for production, there is no natural limit when speculation is introduced. Investors may raise their investment funds and raise demand for stocks without contributing to production. Therefore, supply and demand sides of the market can be subject to quite different and independent changes. The conclusion that supply and demand are therefore unequal in the end is nevertheless wrong. The only ever existing thing in reality is the cross point where supply and demand are necessarily equal in, notably, monetary terms.

By the way, even if we consider the general equilibrium concept as questionable, this does not mean that it is absent in all critical analyses. Empirical investigations may require a preliminary definition of a kind of 'equilibrium' as a benchmark against which significant effects can be estimated. This will be seen in the empirical part of this thesis.

The equivalence of financial asset supply and demand is expressed in the following simple formula:

$$I = q*p \qquad (2.1)$$

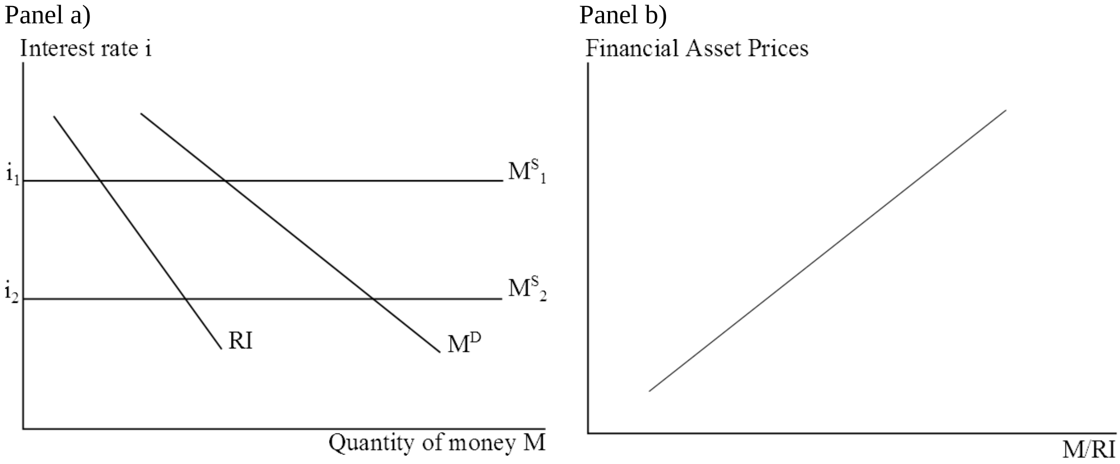
where I is the total amount that financial investors invest in financial assets, that is, it represents the demand side; q is the number of financial assets emitted by corporations; p is the price of financial assets. While the discussion is still centred on securities that are traded in exchanges, the formula covers basically all financial assets, tradable or not. In the case of non-tradable assets the price is stable at the nominal value of the investment. Financial investment I is always equal to real investment q at its current price p. This equivalence allows distinguishing between quantity and price effects. Taking again the same example, an increase in the demand for financial assets I can either translate into an equal growth in real investment q or in an increase of price p. A higher q is tantamount to the emission of new securities by firms. They imply an investment in the same amount in new equipment. If firms do not react to higher demand for financial assets, asset prices necessarily have to climb because assets are scarce.

The central questions to assess the role of monetary policy are the reactions of each financial asset supply and demand to a change in the interest rate. As shown, both respond positively (negatively) to expansive (restrictive) monetary policy. It is not *a priori* clear, however, whether financial or real investment changes stronger when the rate of interest changes. Financial market performance is determined by the relative strength of the responses of supply and demand sides. If expansive monetary policy leads to powerfully widening money creation because investors raise their demand for financial assets but generates only a weak emission of new financial assets by firms, securities prices increase. Conversely, if firms start issuing a large number of new financial assets while financial investors raise their investment funds by a smaller amount, prices fall. Interactions between supply and demand complicate price effects. Supply is likely to rise when demand is high or even when it is just expected to be high. Similarly, a high supply of new financial assets at a low price may attract financial investors to raise their demand. These are the conventional feedback mechanisms of demand and supply. When transmission channels of monetary policy are investigated in the next section, it is, among others, these feedback mechanisms that support the effectiveness of monetary policy. By Tobins' *q* and the wealth effect, high prices of financial assets induce the emission of new securities, which implies real investment and thus an effect on output and consumption. Yet, there is no reason to assume that the feedback mechanisms always lead back to a hypothetical equilibrium price level. Thus, monetary policy effects can be persistent over an undefined time span.

Figure 2.1 reveals how the hitherto pursued analysis is embedded in the horizontalist theory of endogenous money. The well-known diagram (see for instance Rossi, 2008, p. 190) draws the money demand curve, M^D, as an inverse relationship between the interest rate set by the central bank and the demand for money. The money supply curve is a horizontal line. Once the monetary authority has determined the short-run interest rate, it fully complies with money requirements from the demand side. Panel a) in Figure 2.1 extends this feature by taking supply and demand aspects of financial assets into account. Total money demanded is the amount of credit that investors borrow to purchase financial assets. The second falling curve is real investment (RI). It is the share of total money that is invested in newly issued securities measured by the securities' nominal value. Assume a drop in the interest rate from i_1 to i_2. The money stock grows as higher money demand is accommodated by the central bank. Real investment grows, too, because of lower investment cost. If the quantity of total money increases stronger than real investment, excess demand translates into higher prices of financial assets. This is exhibited in panel b). The larger the proportion of money to real investment the higher financial asset prices grow. Figure 2.1 shows how much of a monetary policy intervention arrives at the real economy and how much merely goes to financial markets.

Further, Figure 2.1 reveals that the findings so far are consistent with the theory of endogenous money. It indicates that the nature of endogenous money is elastic such that the money stock can in principle grow to infinity. Constraints exist from an empirical rather than a theoretical point of view. It should be noted that the graphs are only descriptive and do not say anything about the direction of causalities.

Figure 2.1 Money creation and financial asset prices



Source: author's elaboration.

Whether the ratio of total money to real investment – that is, financial asset demand relative to supply – grows when interest rates fall is an empirical question. Financial asset supply is enhanced by expansive monetary policy because investment costs decrease. The magnitude of the enhancement depends on the profitability of additional investment. Expenditures for equipment have to be reimbursed by higher sales quantity. Moreover, the latter must be sufficient to cover interest cost plus a profit margin that goes either to the holders of stocks or to the company in the case of bank credit and corporate bonds. Ample sales are only guaranteed if sufficient demand is assured. Effective demand includes only demand for real goods and services but not for financial assets. Its sufficiency is a condition to be fulfilled if monetary policy should be effective in stimulating the economy through investment. Interest rates account only for a certain fraction of production cost. Expansive monetary policy reduces that fraction. Economies of scale can help reducing production cost. On the other side, investment expenditures contribute to higher effective demand. Then, however, it is still not sure that demand increases in a sufficient amount to compensate total investment cost. Even if there were no interest cost at all, effective demand might remain too weak to afford the purchase of a larger number of goods. Companies' decisions on investment rely on profit prospects, which themselves depend on effective demand. Effectiveness of monetary policy in raising real investment is determined by the situation in the real economy. This is in line with the basic theory of endogenous money.

Demand for financial assets depends essentially on two features, that is, investors' profit expectations and liquidity preference. With respect to the former one, motivation for financial investment is largely analogous to motivation for real investment. Financial investors claim a sufficient profit margin. If they recognize that effective demand is weak and that firms are not able to raise their sales revenues sufficiently to cover investment cost and profit requirements, they do not purchase securities. Given that monetary policy does not improve conditions of the real economy from the perspective of companies, it does not so either in the view of financial investors. However, even when effective demand is weak and production is in a slump, the second feature, liquidity preference, may still respond to changes in monetary policy. It still is valid that a lower interest rate makes saving in a bank deposit less attractive. For banks it is easier to refinance themselves so that they can take more risk. Professional investors can increase their leverage at lower cost. These mechanisms may lead to a rise in demand for financial assets even when economic prospects are doubtful. The interest rate level serves as a kind of reference benchmark. Dividends and bond rates stagnating at a certain level become more attractive the more the benchmark interest rate falls. Growing asset prices triggered by a drop in liquidity preference is a signal to attract more financial investment so that prices climb further.

The magnitude of the reaction of financial asset supply and demand to changes in monetary policy can be considered as elasticities. In our case, they are the interest rate elasticities of financial asset supply and demand. While the elasticity of financial asset supply depends almost exclusively on the state of the real economy, the elasticity of financial asset demand relies in addition on liquidity preference. Real economic conditions change according to the business cycle. This means that supply and demand elasticities are not stable but fluctuate over time and so does the effectiveness of monetary policy. When the economy enters in a boost, expectations are optimistic and effective demand grows. Monetary policy is able to support this upsurge by lowering the interest rate level. The more the economy converges to full capacity utilization at the summit of the business cycle, the less effective monetary policy becomes, since output cannot be larger than full-capacity output. In a downswing or outbreak of a crisis it becomes harder for the central bank to confront worsening performance. Referring to Table 2.3, this happens when prices of financial and real assets start falling and holders go bankrupt while others made profits before. Employment decreases and effective demand weakens. A too depressed economy is hardly possible to revive only by means of monetary policy.

The case of liquidity preference is more complicated. It is affected by monetary policy as well as by the business cycle. In booms, dividends are high, risks of financial assets are judged to be low by investors and therefore their profit expectations are optimistic. Agents have low preference for liquidity. The latter grows as soon as financial markets turn down. The effect of monetary policy on liquidity preference is likely to be larger when economic conditions are stable and to be smaller when fluctuations of securities prices are high. High price increases come along with waves of optimism. Crashing prices occur together with strong pessimism and a run into safe money or government bonds. In such situations, the central bank faces troubles in counteracting these waves by bringing down or raising liquidity preference, respectively. In contrast, when financial asset prices are stable, that is, either at a low level in a recession or depression as well as in a time of permanent good performance, a change in the interest rate should have a stronger impact on liquidity preference.

All in all, it can be stated that the strength of the impact of monetary policy on financial asset supply and demand depends on the state of the real economy. But the sign of the impact is positive if monetary policy is expansive. Since interest rates are in general positively correlated with liquidity preference, expansive monetary policy tends to raise demand for financial assets by lowering liquidity preference. Thus, beside of profit prospects of financial assets, financial investment is influenced by monetary policy through a second driving force, which is effective at a stronger or weaker magnitude depending on the state of the real economy. Under these conditions, demand for financial assets, that is, financial investment, tends to react stronger to monetary policy than supply of financial assets, to wit, real investment. In the case of a cut in the interest rate, financial asset demand grows more than supply. For supply and demand to be equal, asset prices have to increase. This is the central result of this alternative approach: prices of securities can in principle rise even when there is no change in economic fundamentals. We arrive at a conclusion that is at odds with the efficient markets hypothesis in neoclassical theory. Given that the economy is in a slump, real investment increases only marginally in response to a lower interest rate. For investors, it becomes nevertheless more attractive to purchase financial assets in response to a fall in liquidity preference.

In this sense, the financial asset market and its relationship with monetary policy can be characterized by an exogenous constraint given by real economic conditions. Once firms have decided on their investment volume, supply of financial assets is given. From this point onwards, securities prices are determined by demand from financial investors.

This examination considers financial asset prices in a relative rather than absolute way. For instance, a constraint in financial asset supply raises their prices if demand rises. This does not mean, however, that financial asset prices are higher in an economic slump where supply is more constrained than in boom times. In the latter case, economic prospects use to be so bright that asset prices climb even higher. Moreover, we do not make predictions of securities price changes over time. We just emphasize the reaction of the financial asset market to a given monetary policy action. Final outcomes depend on interactions between fundamental factors but also between the real economy and liquidity preference. In addition, supply and demand changes affect each other in well-known feedback mechanisms. This is why relationships between variables are too complex to build a reliable exact prediction of asset market behaviour in every point of the business cycle. Furthermore, these interactions are necessary for monetary transmission channels, that are, in particular, Tobins' *q* and the wealth effect, to become significant.

Rising demand for financial assets in light of expansive monetary policy may sometimes be overshadowed by an opposite effect. Active attempts of the central bank to influence the economy are sometimes interpreted in a contrary manner by investors. For example, a sharp cut in the interest rate might be a signal that the economy needs support, that is, that its outlook is worsening. This can induce investors to sell securities and to let prices fall. In that case, a lower interest rate leads to lower demand for some financial assets (Neely, 2011, p. 23). Yet, these effects occur at short horizon. In the longer run, prices drop more owing to actual downturns. They do not jeopardize the alternative view of financial markets but confirm it, by stating that demand and supply sides of financial assets evolve partially independently from each other.

It can be stated that the alternative view gives an explanation of financial market development and enlightens why financial asset prices are not just a simple reflection of fundamentals. While the quantity theory of money implies that an increase in the money stock leads to a proportional increase in the level of consumer prices, the concept of endogenous money allows representing reality more appropriately. The elasticity of money, when it is recognized as endogenous, reveals that money is not necessarily created merely for the needs of the real economy. Financial markets have an autonomous role, where money can flow without being employed in production. It is thus a logical argument that enhanced liquidity induced by expansive monetary policy gives rise to increasing prices of financial assets. This is likely to happen in any situation of a depressed or booming economy.

Increasing Financialization

Obviously, the alternative view is derived against the background of financial market developments of the past two decades from the mid-nineties until today. The keyword of financialization is a widely discussed issue. While it is not of great concern from a neoclassical perspective, it is investigated here for its effects on the connection between monetary policy and financial markets. Financialization is a subject with many aspects and a proper definition of it is not easy. A broad definition is given by Epstein (2005, p. 3), who characterizes financialization as "the increasing role of financial motives, financial markets, financial actors and financial institutions in the operation of the domestic and international economies". It is a rarely doubted fact that financialization has taken place in the past two to three decades. Profits and income shares of financial institutions have increased in the past (Epstein, 2005, p. 4). The importance of shadow banks has clearly augmented. Net liabilities of shadow banks multiplied by more than four from the early 1990s until the breakout of the financial crisis in 2007 (Pozsar et al., 2013, p. 7). As mentioned above, shadow banks are not actual banks, as they do not have the power to create money. Since their liabilities are not accepted as a means of payment in contrast to traditional banks, they cannot create deposits by issuing loans. They can only collect existing savings and recycle them by providing new loans out of these savings (Sawyer, 2013, p. 233). The quantity of money remains constant and there is no additional purchasing power. Shadow banks have the role of a financial intermediator. As such, however, they can well exert a significant influence on financial market performance. Money creation is enhanced indirectly. By mobilizing savings that would otherwise just function as passive deposits, they raise demand for financial assets. A commercial bank that is confronted with a drain of deposits then has to demand additional central bank reserves. Since many of these non-bank financial institutions aim at highly profitable and risky investment, they employ high-leverage strategies. This requires a higher volume of bank loans that would otherwise not have come into existence. A second probable effect is that shadow banks raise the volume of bank credit indirectly by providing and marketing investment opportunities. This makes financial investment more attractive and might lead investors to riskier behaviour. Enhanced shadow banking activity may also be a symptom and thus a proof of larger credit creation. When the balance sheets of traditional banks grow too long, they run the risk of violating reserve requirements or growing short of liquidity.

They intensify liquidity management by removing assets and liabilities from the banks' ledgers. The new vehicles where assets are sourced out represent a kind of shadow banks.

In practice, many shadow banks are provided with contingent lines of credit or credit put options like wraps guarantees or credit default swaps by commercial banks (Pozsar et al., 2013, p. 4). These services constitute a private backstop for shadow banks and are a reason for large credit creation in good times.

Further evidence of increasing financialization is given by expanding stock repurchase programmes of large corporations. For example, Exxon Mobil, the biggest petroleum producer in the world, spent 174.5 billion US dollars between 2001 and 2010 to buy back own stocks (Lazonick, 2012, p. 21). The management is partially remunerated in stock options. Manipulating stock prices raises manager's income. Using profits for stock buybacks instead of real investment reduces long-run output potential (ibid., p. 27). This aspect of financialization shows that short-run maximization of manager incomes has more and more become top priority of corporations (see for instance Cappelli, 2009, pp. 6–7). These companies change from real investment to financial investment and from financial asset supply to demand.

Financialization enhances the mobility of liquidity. It makes capital allocation more efficient, however in a quite limited sense of the latter word. Changes in monetary policy are therefore faster and more rigorously exploited. Together with highly leveraged investment strategies, overreactions of financial markets to changes in the interest rate are more likely. The long-run process of financialization in the past decades implies that the results of the present alternative view of financial markets have got more weight. The relationship between monetary policy and financial markets should therefore have become tighter over time.[14] This should be kept in mind for the remainder of our analysis.

Contradictions and Crises

The findings of this chapter are kept in a synthetic manner to stress its main features. It yields a pattern to draw a simplified but basically adequate picture of reality. For in-

[14] Interestingly, Estrella (2002) finds that securitization of assets has made the pass-through of the monetary policy target rate of interest to market rates stronger. On the other hand, policy effects on economic activity seem to have decreased. This may strengthen the view that financial markets, whose weight has increased in the course of financialization, may evolve remarkably independently of economic fundamentals.

stance, the relatively strongly growing US economy of the noughties of the twenty-first century was marked by a high and still growing degree of financialization, well-performing financial markets as well as rising inequality of incomes (see Tomaskovic-Devey & Lin, 2011). The latter was a threat for economic growth, since falling incomes in income classes where the propensity to consume is high drag down effective demand. To avoid a drop in consumption, lower and middle classes started getting indebted (Stockhammer, 2012, pp. 14–15). The best-known result of this was a market full of subprime mortgages that has been discussed in abundance. Low income and growing debt on one side of the social spectrum was growing income on the other side. Owing to the equality between loans and deposits, consumer credits turn out to be profit income once they are spent. Those profits were reinvested by purchasing financial assets. Hence, inequality was a source of increasing money creation that was finally not used to purchase real goods but financial assets. The steady tendency of corporations to participate in financial speculation, instead of investing in innovation and equipment (Lazonick, 2012), helped building a growing constraint on supply of financial assets while financial investment, that is, financial asset demand, was growing permanently. Monetary policy of that period kept interest rates at a permanently low level. While this ought not to be the only, or principle, source of rising asset prices, as claimed for instance by representatives of the Austrian school (see for instance Murphy, 2008), it was at least a contributing factor. Inequality and indebtedness were only allowed to last so long and to climb so high because purchasing power in the form of consumer credits and mortgages was accessible at easy conditions. The economic crisis put at least temporarily an end to these trends.

In this chapter we have explained how monetary policy can lead financial markets away from their fundamental values. Central bank actions can distort the relationship in between. Since there is no reason to assume a certain equilibrium path, monetary policy impacts do not necessarily fade out fast. Securities prices can rise without there being necessarily a rationale in the real forces of the economy. Such effects may occur for many years, as is revealed *ex post* by the run-up to the crisis in the noughties of the twenty-first century. Given such persistency, it is not adequate to merely talk about short-run effects. However, high profits in financial markets cannot be realized forever, if the real economy's long-run growth potential is stagnating or increasing only slowly. Sooner or later, there will be a lack of effective demand and production profits drop. At this point, the neoclassical explanation would refer to the efficient markets hypothesis, which guarantees that asset prices always adapt efficiently to changes in fundamentals. Fluctuations in fundamentals, that is, in the business cycle, are treated best if they are not counteracted (Goodfriend, 2007, p. 26). An economy without nominal rigidities reacts to exogenous shocks in the most efficient way. For the current crisis breaking out in 2008, neoclassical proponents recommend, likewise, that public interventions generally worsen the situation by distorting otherwise efficient resource allocation (see for instance Fernández & Kehoe, 2009, pp. 6–7). The alternative view suggests a less harmonic mechanism. The periodic occurrence of financial crises reveals a contradiction between financial markets and real forces. It can be traced back to the basic contradiction between effective demand and profit acquisition that is inherent to capitalist economies. This approach allows for volatile and discontinuous economic processes where distortions and disruptions are endogenous features rather than exogenous shocks.[15] Policy interventions may be required since the economy is possibly not able to find its way out of these contradictions. This will matter in the remainder of this research work, as we know that past decades were characterized by discontinuities that need also to be explained in the investigation of the oil price evolution.

2.2 Monetary Policy Effects on the Market for Crude Oil

The general analysis of money and financial markets provides a consistent explanation and a useful basis for further research in this thesis. To apply the findings to the crude oil market, some extensions and modifications have to be made. Yet, keeping the focus on the monetary mechanisms of the economy, as has been done before, allows for detailed insights into the building of oil prices. As a specific issue of the second part of this chapter, we emphasize monetary policy transmission through each transmission channel. Finally, interactions of monetary transmission through fundamentals and financial markets, respectively, are investigated.

2.2.1 Crude Oil as a Commodity and a Financial Asset

The investigation of the oil market reveals that the economics of oil are specific. As has been noted by several authors (see for instance Fattouh, 2010, p. 13), crude oil has a double nature. On the one hand, it is a common commodity among others, serving as a raw material mainly in energy production. There is a world market where supply and demand, that is, production and consumption of oil, meet. On the other hand, oil is the underlying object of a financial asset that is traded in commodity futures exchanges and over the counter. Futures are standardized contracts that refer to the exchange of predetermined units of an object at a predetermined price on a predetermined date in the future where account settlement takes place in a clearing house (Volkart, 2008, pp.

[15] For an analysis of how capitalism produces endogenous crises, see for instance Minsky (1982; 1994).

938–942). In the case of crude oil, the producer commits to the delivery of a unit of oil on the said date while the consumer commits to purchase it. The delivery position is called 'short', the purchasing position is named 'long'. In the practice of complex financial markets, however, there can be many intermediate steps such that it is neither necessarily the original producer on the short side nor the final consumer on the long side. Moreover, a holder of, say, a long position may buy an additional short position to offset her liabilities. In that case, no delivery takes place. This will be seen later in more detail. Thus, as a general notation, short positions refer to the supply side while long positions represent the demand side of futures contracts.

Owing to the dual nature of crude oil (both a commodity and a financial asset), there exist two markets for one and the same good. In the spot market where oil is a commodity, it is exchanged in physical quantities. It is embedded in the real world economy and thus influenced by industrial production, consumers' income, geopolitical conflicts and wars, market structure, and new oil discoveries. As additional factors, there are considerations with regard to time. Oil is an exhaustible, fossil resource. All participants in the market have conjectures about global oil reserves and therefore take partially precautions (see for instance Kilian, 2009b). They might build oil inventories. Moreover, technological progress may give rise to changes in industrial production, to a reduction in the use of motor fuels or economization of house heating. Trends in the opposite direction may materialize as well (see for instance Anger & Barker, 2015). In the long run, the oil intensity of economic output can change.

In the futures market for crude oil, oil is traded in the form of contract papers rather than physically. Someday, however, a futures contract eventually has to be fulfilled by the delivery of the agreed quantity of oil. The futures market can in principle be divided in several couple of markets depending on the time span of contracts. At the New York Mercantile Exchange (NYMEX), the world's largest energy futures exchange, futures time horizons lie between one month and eight years where longer-horizon contracts use to be rather illiquid (Alquist & Kilian, 2010, p. 544; NYMEX, 2014). In general, at all horizons, the crude oil futures market has some distinct features. Paper trade is more flexible than trade of physical oil. The futures market reacts therefore faster to new information. This is why trading activity is likely to be more volatile. Considering futures as financial assets means that they are in the focus of financial investors who do neither have an interest in the consumption of oil nor in its physical trade. The market for crude oil futures is in many aspects analogous to financial markets analyzed in the preceding chapter. In the same way, the driving forces of the spot market are certainly also relevant for the futures market. Yet, some additional features of the futures market need to be taken into account.

The futures market reflects the future of the crude oil market. As such, however, it is already present currently. It exists next to the spot market where oil is physically traded. The futures market of today is the spot market of tomorrow and the spot market of today was a futures market yesterday. Spot and futures markets cannot be separated from each other. Yet, given a specific point in time, there are always both a spot and a futures market. Hence, they cannot be the same. As will be seen, a futures market is different today compared to tomorrow when it will be a spot market. Oil producers sell oil and issue financial assets in the form of futures contracts. Financial assets other than futures are issued by corporations on the one hand while they sell their produced goods on the other hand. In the case of oil futures, the produced good for sale and the financial asset is one and the same object. Correspondingly, investors consume or at least trade oil and purchase financial assets at once. They often do these two things with different motives but they rely on the same object, which is crude oil.

In analogy to the preceding chapter, the spot market reflects the fundamentals of the oil market. The futures market, on the other hand, has financial market features. Referring to the efficient markets hypothesis, neoclassical approaches suggest that the futures market is a simple reflection of the spot market. Changes in oil market fundamentals cause changes in futures prices but trading activities in the futures market do not influence the spot price of crude oil. They help producers and consumers to hedge their future production and consumption at a specific price in order to avoid the risk of price fluctuations (Fattouh et al., 2012, p. 15). Speculation in the futures market, according to neoclassical theory, is helpful and necessary to support efficient price discovery and risk transfer (ibid., p. 7). In contrast to this view, we will argue that the futures market has an autonomous role. It is not independent from fundamentals but there exist complex two-sided interrelations between futures and spot markets. The dual nature of crude oil brings about even stronger interdependences. They give rise to complex dynamics to be discussed in the remainder of this chapter. In this respect, altered characteristics of supply and demand of crude oil futures should be taken into account.

Since futures short positions are, unlike stocks, not only liabilities to buyers but represent as well the produced good in the same object, supply of futures is also supply of crude oil. Higher prices give firms an incentive to increase oil supply either in the form of real oil deliveries or by contracting new futures. Total supply of physical crude oil is constrained by present and future production capacities. The amount of oil ready for delivery within a horizon of, say, up to one year, finds its upper limit when all oil produced at full capacity utilization and all inventories built in the past are either sold physically or securitized. In contrast, the supply of futures contracts, to wit, the number of short positions, is basically unconstrained. It does not make sense from a macroeconomic point of view to contract the delivery of 80 million barrels of crude oil on a particular day in the future if only 70 million barrels are available. But from the microeconomic perspective of a single oil company or an investor, going short when prices are high is profitable. If they want to avoid physical delivery, they have to offset their short position by the purchase of a long position.

On the demand side, purchase of physical oil is constrained by demand in the real economy. Yet, demand for futures is potentially unlimited. Investors can in principle raise their long positions infinitely. In contrast to stock markets, demand for oil futures does not depend on profit expectations of firms because there is no dividend. But likewise, investors build expectations about price changes. Another motive is again liquidity preference. Lower liquidity preference means *ceteris paribus* higher demand for futures. Hence, in analogy to our financial market analysis, demand for futures can increase without having a preceding change in fundamentals, that is, the oil spot market and the rest of the economy.

The number of futures contracts can grow infinitely since every position can be evened up by a new counterbalancing contract either by an oil company, a gasoline producer, a financial investor or whoever. The simple formula (2.1) presented in the previous chapter still holds. Demand for financial assets is always equal to supply of financial assets; long positions are always equal to short positions since all futures contracts require two contracting parties. As a difference to conventional financial assets, supply and demand sides of the futures market are more flexible. This means that unlike stock or bond supply, the supply of futures is not constrained by real forces. Given a higher demand level and thus a higher price of futures, supply can increase without limit such that the number of contracts is basically allowed to rise to a higher and higher level. It is, however, wrong to claim that since long and short positions are always equal, supply and demand behave necessarily equally. This would imply a permanently stable price. The logical equality of long and short positions does not say anything about underlying market developments (see for instance Irwin et al., 2009, p. 379). If a sufficient number of investors expects a higher spot price in the future, they raise their demand for long positions. By purchasing a futures contract at a given price, they hope to sell it at a higher price before the delivery date or to receive delivery of a certain oil quantity that has a higher spot market price than the contracted price they have to pay for it. Prices offered by demanders increase with the number of investors in order to get matched with a supplier. Futures suppliers receive the signal of a higher price and therefore have an incentive to raise their short positions. The equality of supply and demand is not distorted in any moment. In the other direction, if a sufficient number of agents expect a decreasing spot price, they raise their short positions. If the price effectively decreases, they can deliver crude oil at a higher contracted price than the actual market price. Thus, depending on whether a change enters the futures market either on the supply or the demand side, the price reacts in a different way. On the demand side, there is the feature of liquidity preference in addition to pure price expectations. It can as well exert an influence on price and is emphasized when introducing monetary policy to the futures market.

These reflections reveal that participants in the futures market must be heterogenous. For two parties to contract on long and short side, respectively, they must diverge in their expectations of future price evolution, in their risk aversion as well as investment strategy. Once this is recognized, it becomes harder to maintain the efficient markets hypothesis. Given that investors pursue counteracting investment strategies, a wide field of possible price and quantity outcomes opens. Of course, fundamentals in the oil market are not irrelevant at all. Investors build their expectations based on developments in the real economy. Finally, all oil that is produced must be sold physically. Oil can only have a price if it is of practical use. Somebody must have a need for oil for futures contracts to make any sense from a macroeconomic point of view. To agree on a contract on the long position without having an interest in the consumption of oil or being able to sell it to somebody else is a losing deal for sure. Total sales of oil are constrained by effective demand in the spot market. But uncertainty in the futures market and the large elasticity of futures markets in their number of contracts as well as contracted prices allow for a high variety of evolutions that can be closer to or further from fundamentals. This is to be investigated more in detail.

Classifying market participants is a difficult task. Data of the Commodity Futures Trading Commission (CFTC) (2014) show that net positions of oil producers, that is, the difference between long and short positions, is strongly short over time. Consuming entities, for example gasoline producers, should go long. However, they are not separately registered. Moreover, there are swap dealers, market makers, index funds, and more. These financial investors usually go distinctly long most of the time but their net position may change depending on the situation. Moreover, futures spreads, to wit, long positions that are offset by short positions in an equal amount held by a single agent, are not mirrored in net position data but they can nevertheless give a hint of investment strategies and therefore of prices. The total number of futures contracts, that is, open interest, may therefore play a significant role. The classes of participants are emphasized in our empirical investigation later on. For a theoretical analysis, it is not essential to specify all classes in detail. However, one should be aware of the highly elastic and undetermined nature of the oil futures market. There are surely hedgers as well as speculators present in the market but their share or dominance of ones over the others, respectively, is likely to be very volatile over time.

2.2.1.1 The Connection between the Futures Market and the Spot Market

The basic mechanism that connects the futures market to the spot market is shown in Figure 2.2. Yet, it is not without problems to represent a financial market and especially a contract market in this way. The futures market in the left-hand panel exhibits both rising supply and demand curves. This can be justified by the above argument that suppliers and demanders of futures send and receive price signals. A higher futures price makes it more attractive for suppliers to contract future oil deliveries. Investors may on the other hand expect a rising price and react by increasing their long positions. The causality may also be the other way round such that a higher futures price gives an incentive to raise long positions. But, in principle, reality might also prove different. If behaviour on the supply side is speculative, an expected price drop will raise short positions such that there is a negative correlation between price and the number of short positions. Thus, the structure of the futures market – like any market – depends on the motives of market participants and their expectations (see for instance Pilkington, 2013, pp. 13–22). Past performance may as well impact on investors' behaviour as an additional factor. All these features change over time. The oil futures market can therefore be considered as a typical case of radical indeterminacy in capitalist economies (see for instance Varoufakis et al., 2011, pp. 294–298). For the purpose at hand, the proposed modelling seems to be the most appropriate one. In contrast, it is conclusive to assume that the oil spot market is in a large number of cases composed of a rising (or vertical) supply curve and a declining demand curve. The conventional feedback mechanisms between oil price, supply, and demand are at work. A higher price lowers demand, raises supply, and so on. But even in the spot market, expectations may change the slopes of curves in the short run. So both in spot and futures market, feedback mechanisms can be the conventional ones but they can as well go in the opposite direction depending on agents' expectations. Our presentation is a specific choice out of many alternatives.

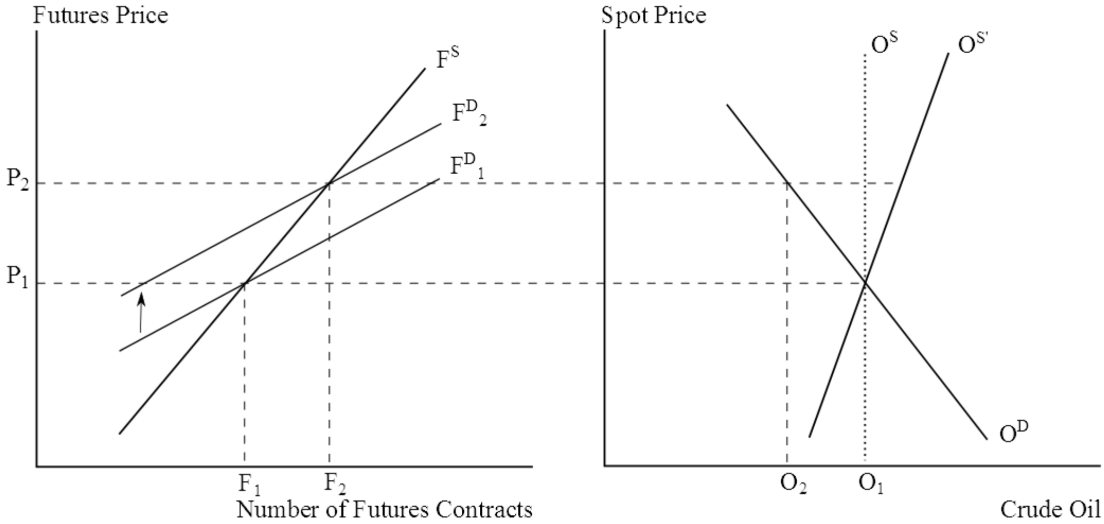
Another problem arises with regard to the issue of time. As explained, the futures and spot markets take place at the same time but refer to a different time period. The futures market in the left-hand panel will become the spot market in the right-hand panel tomorrow. Our consideration of the relationship between them must therefore take place in a single point in time and thus not only in the short run but rather in a single production period. Supply and demand curves in the diagrams cannot be long-run curves since as such the spot market would include present as well as future behaviour of suppliers and demanders. For example, if we assumed a horizontal supply curve in the spot market as an expression of oil producers' ability to fulfill all demand in the long run would imply that the spot market in the future, that is, the futures market today, is contained in the spot market diagram. This would confuse our analysis since we want to map the future spot market separately in the left-hand diagram. The supply curve in the spot market hence is a vertical line, O_S, because production is fixed in a given period. Assuming that firms supply existing inventories when the price is high and accumulate additional inventories when the price is low turns the vertical line to an increasing supply curve, O_S'. The problem of this particular case reveals the general failure of the neoclassical equilibrium approach to deal with real time. These diagrams do not have a time dimension and thus are not able to illustrate how equilibria are reached.[16]

For our purpose, however, Figure 2.2 is a tool to show a particular mechanism rather than a complete theoretical model. The general equilibrium view has already been criticized and rejected in the previous chapter. In spite of almost absolute uncertainty, the diagram can help to enlighten the financial market impact in the oil market. Assume a demand increase in the futures market such that the demand curve shifts from $F^D{}_1$ to $F^D{}_2$. Where such a shift may come from is of secondary interest now and will be investigated in relation with monetary policy. Higher demand for financial assets will raise the price from P_1 to P_2 but also enhance short positions. The demand shift translates into both a price effect and a quantity effect in the form of larger open interest. Assuming away real complications, the futures price and the spot price are equal. Deviations create arbitrage opportunities that are exploited. In the current case, the higher price in the futures market gives producers an incentive to raise supply in the futures market. All oil that is sold in the spot market at a price lower than P_2 is a losing deal for producers, as they have the opportunity to offer it favourably in the futures market. Demand in the spot market decreases therefore but is offset by higher demand in the

[16] For a general critique of neoclassical trouble with time, see for instance Varoufakis et al. (2011, pp. 156–158).

futures market. In face of higher demand in the futures market and lower demand in the spot market, companies adapt respective supplies of futures and physical oil just to maximize expected profits. Hence, supply and demand sides in both futures and spot markets behave such that futures and spot prices are equalized.

Figure 2.2 Connection between futures and spot markets



Source: author's elaboration.

In reality, futures and spot prices are not necessarily always exactly equal. As outlined by Kaldor (1939, p. 6), they normally use to differ structurally. The variables that make the difference are the interest rate level, the risk premium, the convenience yield, and the carrying cost of the commodity. Kaldor (1939) shows that under normal circumstances, that is, in a non-speculative environment, the expected future spot price is equal to the current spot price since expectations about the future are transferred to the present as shown in Figure 2.2. The futures price is lower than the expected price by the amount of a certain risk premium. The risk premium is the compensation of the risk of future price fluctuations that moves from the seller to the buyer when the uncertain future spot price is fixed by the current futures price. The futures price also differs from the current spot price. The difference is made up by the interest rate level and the net convenience yield. The purchase of a futures contract in contrast to a purchase in the spot market has the advantage that the purchaser only has to pay at the delivery date in the future. For the remaining time, the investor can invest the capital at the current rate of interest. On the other side of the contract, the seller does without immediate payment and therefore loses potential investment returns at the current interest level. The net convenience yield, that is, the convenience of having a commodity physically available at any moment minus the cost of storing it, lies on the seller's side because the commodity has to be delivered only in the future rather than today. The buyer on the other hand does without the net convenience yield until the delivery date. The futures price is therefore determined by the spot price plus the return of an alternative investment at the current interest rate minus the net convenience yield. At this point it can easily be shown that since the risk premium is always positive, the futures price is always lower than the expected price and therefore lower than the spot price in a non-speculative environment. Hence, the convenience yield is larger than the interest rate and the futures price is lower than the current price. This is what Keynes (1930b/2011, p. 143) calls 'normal backwardation' as the futures price uses to be lower than the spot price under normal conditions.

However, nowadays the case is less clear. Given that some financial investors do not have any interest in possessing oil physically, they do not require a compensation for escaped convenience yield. It is not just that they purchase futures contracts, which of course existed already when Kaldor wrote his paper in 1939. Now, these contracts are often not seen as a symbol of oil as a commodity that is behind it anymore but simply as a financial asset. As such, futures are completely disconnected from the physical properties of oil when traded by financial investors. The difference between futures price and spot price then is only made up of the positive return of interest. The futures price is thus higher than the spot price; the market is in 'contango'. Additional features complicate the situation. The spot price may as well be higher in a situation where there is an acute delivery bottleneck that will be relaxed in the future. Where this argument may become regularly real in the case of seasonal crops, the supply of crude oil is not likely to have any seasonal deviations. Moreover, if there is permanently a certain amount of oil inventories that can smooth short-run fluctuations of this kind, such distortions are unlikely. On the other hand, supply of a specific type of crude oil may be tight in a given moment, for example owing to constraints in transport capacities. Alquist and Kilian (2010, p. 562) present a model where the convenience yield varies over time depending on expectations about future supply disruptions. When uncertainty about the future is pronounced, the convenience yield increases such that demand in the spot market increases relative to the futures market. The spot price increases relative to the futures price. The model seems to fit data remarkably well from the late 1980s until 2003. But thereafter, the model fails to draw a coherent picture of reality (ibid., p. 566). Even though correlation values are rather impressive, the model does not uncover all possible causalities. The existence of financial investors who consider oil exclusively as a financial asset is suppressed.

Whether one observes 'contango' or 'backwardation' in the oil market depends on various factors. There are the traditional influencing variables remarked by Kaldor

(1939). Furthermore, the motives and expectations of market participants play a role. Time delays in the spot market may be the source of additional differences. The difference between the futures price and spot price does not allow drawing any premature general conclusions about causality. Neither does ‘contango’ necessarily imply an influence of the futures market on the spot market nor does ‘backwardation’ state the opposite to be true. The price structure is undetermined and can take various forms depending on the situation. In fact, crude oil futures and spot prices use to move together quite closely as data show. While the market tended to be in ‘contango’ around the price peak of 2008, ‘backwardation’ dominated in the years before (EIA, 2015c).

Several studies empirically estimate the relationships between the crude oil futures and spot markets (see for instance Kaufmann & Ullman, 2009; Silvapulle & Moosa, 1999). The general result is bidirectional causality between the futures price and the spot price. Changes in the futures price impact on the spot price as well as the other way round. Empirical studies of this kind use to test for Granger causality, that is, whether a change in one variable helps predict a change in another variable in a statistically significant way (see for instance Granger, 2004, p. 425). Such definition of causation is quite generous and leaves large room open for further analysis since it is not immediately clear which forces effectively drive one price to influence the other. Moreover, especially in the presence of bidirectional causality, dynamic interdependencies between the futures and spot market arise.

For the remainder, it seems to be more productive to accept the existence of numerous simultaneous factors that impact on the connection between the futures market and the spot market without trying to quantify and assess each of them. Deriving essential results from the spread between the futures price and the spot price and relying on them in the further analysis seems to be a rather unstable way of proceeding. The price spread changes over time and so do its driving forces in a complex way. What can be concluded from a logical point of view and from empirical data is that the futures price and the spot price follow a common pattern owing to arbitrage and mutual influences between both markets. These tight connections are especially due to oil being a commodity and a financial asset as one and the same object. In contrast to a large part of existing literature, we choose an approach that goes in the opposite direction. We do not start with the analysis of the difference between spot and futures prices since they are not crucial for the general price development. Rather, we start by taking their equality on analytical grounds and then allow for distortions.

2.2.1.2 The Role of Inventories

In an influential paper, Hamilton (2009, pp. 234–240) shows by means of a simple model that the effect of a demand shock in the futures market on the spot price depends on the price elasticity of gasoline demand. The interpretation is analogous when referring to the demand elasticity of crude oil and is also reflected in Figure 2.2. If the demand elasticity is zero, the demand curve is a vertical line. Oil consumption is constant at all price levels. A price increase originating in the futures market as simulated in Figure 2.2 then does not change the quantities in the spot market. Since oil production of that period is as well given by a vertical line, O^S, inventories do not change. The price can in principle grow to infinity without any reaction on the demand side of the spot market. In fact, demand elasticity is rather low. Most estimates range from between –0.005 and –0.02 (Krichene, 2002, pp. 568, 570) to values of about –0.1 (Cooper, 2003, p. 4) depending on the time horizon of consideration. Kilian & Murphy (2014, p. 474) get a larger estimate of –0.24. Despite probable challenges for each estimation method, elasticity of demand is different from zero. The demand curve in the right-hand panel in Figure 2.2, O^D, may be close to a vertical line but has still a negative slope. Thus, all price increases lead to a fall in spot market demand. While the situation may be still profitable for producing firms as they can sell oil in the futures market, real oil quantities sold in the spot market decrease.

As Hamilton (2009, p. 238) argues, for the spot price to stay at the level induced by higher demand in the futures market, oil inventories have to be accumulated. It is, following this logic, only with growing stocks that there is sufficient scarcity in the market to keep the spot price high. In Figure 2.2, inventories have to increase by the distance between the continuous demand curve, O^D, and the dotted vertical line of oil production, O^S, at the level of the upper dashed line, P_2. The larger the price elasticity of demand, the larger is the required quantity of oil to accumulate in stocks in order to keep the oil price at a given level. This finding leads Hamilton to the conclusion that too large an elasticity of demand makes any potential speculative influences from the futures market to the spot price insignificant (ibid., p. 238). All futures price increases induced by financial investors generate a strong reaction of demand in the spot market. Investors then recognize that their price betting is irrational and does not correspond to fundamentals. They stop purchasing long positions since this behaviour yields them financial losses for sure.

There are good reasons to criticize this view, which is based on the efficient markets hypothesis. It is true that oil producers finally rely on effective demand in the spot market. Financial investors know that. However, due to uncertainty, speculating on an increasing oil price without there being changes in the real economy can nevertheless be rational from the perspective of a single agent. In this respect, the futures market works analogously to stock markets. But there is an additional feature that supports the effectiveness of speculation. It is due to the dual nature of crude oil as a commodity and a financial asset at the same time. It is obvious from a macroeconomic point of view that effective demand is rooted in the spot market. From the microeconomic perspective of an oil company, in contrast, effective demand occurs in the futures market as well as in the spot market. Higher demand for futures brings as much profit for companies like selling oil at the same price (or small differences due to 'contango' or 'backwardation') in the spot market. Hence, as a crucial conclusion, companies do not mind accumulating oil inventories. In their view, these inventories are not reserves. They are already sold. A high elasticity of demand is therefore not *per se* a barrier to the effectiveness of speculation.

In the previous chapter we pointed out that contradictions between financial markets and the real economy cannot be carried on without ending in disruptions. The same applies for the market of crude oil. Inventories cannot grow forever, as we will show in more detail below. But individual investors do not share the macroeconomic perspective. They face uncertainty and cannot escape competition. An oil company that continues supplying oil in the spot market at a lower price without benefiting from increased demand for futures behaves irrationally. It is again the fallacy of composition stating that what is rational from a microeconomic perspective is not necessarily rational from a macroeconomic one. Given the complexity of real markets, it is not helpful to minimize possible speculative influences by arguing that they occur only in the short run. The duration of the short run is rather flexible depending on specific conditions.

Let us suggest as a counter-argument that if speculative influences should be significant in the spot market, a corresponding increase in oil stocks must necessarily be observed. Any failure to assess rising inventories in times when the oil price increases means that speculation cannot be the source of the rising price (see for instance Alquist & Gervais, 2011, pp. 8–9; Krugman, 2008). However, this empirical exercise is impeded by several difficulties. First, the acquisition of inventory data suffers from the lack of a clear definition of inventories and from political influences. Firms that benefit from going short in the futures market even if demand in the spot market decreases store produced barrels of crude oil as shown in Figure 2.2. Beside of that, they may also leave more oil in the ground, which may help them save carrying costs. Both are in some sense inventories. Official inventories include produced oil and petroleum products but ignore underground 'stocks' (EIA, 2014). To illustrate this point, assume that oil futures financial investment drives up the price so high such that supply growth required to lead the oil price back to its initial level exceeds existing production capacities. This is the case when oil producers sell oil in the futures market that cannot be produced at the moment owing to capacity limits. It is then clear that a part of the relevant inventories still lies underground.

Secondly, a part of inventories is made of strategic reserves. The political nature of these reserves implies that their amount is not necessarily transparent. Moreover, oil stock data use to be merely about OECD countries and thus exclude other important countries like the BRICS[17]. Kilian and Lee (2014) employ an alternative broader estimate of inventories. However, it faces potentially reduced but similar concerns.

Thirdly, models are not reality. In the real world many effects take place simultaneously. Assume that a geopolitical conflict sharply reduces oil supply. The spot price of oil increases. Oil companies without any attitude to pursue speculative purpose may reduce their inventories in order to satisfy consumption needs required by given demand. If other companies and financial investors in the futures market behave speculatively, they induce stocks to increase. Hence, there are both stock-increasing and stock-lowering effects. The net effect may have any sign and does not allow drawing direct conclusions.[18]

Fourthly, uncertainty can in principle lead to paradoxical results. If accelerating demand by financial investors for futures raises the oil price, all market participants start building expectations. If oil consumers extrapolate past development to the future, they may increase demand in the spot market today even though the price is higher than it was yesterday. This happening occurs when the demand curve in the spot market temporarily takes a positive slope. Such a mechanism is not likely to be of long duration since demand is constrained and cannot react to all possible expectations. However, inventories might then decrease albeit the source of the price boost is of speculative nature. Kilian (2009b, p. 1059) defines a so-called oil-specific demand shock as a driving force of the crude oil price that reflects precautionary demand by consumers in the face of an uncertain future. As such, it should have nothing to do with speculation. The author justifies this arbitrarily by assuming *a priori* that all pre-

[17] The BRICS notion contains Brazil, Russia, India, China, and South Africa.
[18] Structural econometric models may allow an identification of isolated effects. Yet, they rely on assumptions of considerable strength.

cautionary demand only serves hedging needs. It does not allow for the possibility that such precautionary demand may be only a response to foregoing speculative activities in the futures market that are responsible for the price change. Thus, it is not only the existence of precautionary demand that should be taken into account but as well its connection to speculation.

Fifthly, after all the above arguments, there is another aspect that relativizes Hamilton's suggestions and potentially strongly reduces its relevance. In neoclassical theory, firms use to produce at full capacity utilization.[19] Implicitly, Hamilton (2009) accepts this claim. It is only in this case or in the case where producers have constant spare capacities that a speculative price increase leads to higher inventories (given that demand elasticity is negative). If oil producers vary the degree of capacity utilization while speculation in the futures market affects the oil price, the inventories can basically reach any volume and do not necessarily have to increase. This is similar to the issue of leaving oil under the ground. We will come back to it.

Finally, Hamilton's (2009) view is incomplete. A price elasticity of demand of zero or close to zero is neither a necessary nor a sufficient condition for speculation to be effective. It is not necessary because it can take place with a larger range of elasticity values. On the other hand, the condition is not sufficient because it only takes the demand side into account. However, it is not only demand but as well supply that reacts to a higher oil price. While demand falls to a larger or smaller extent, supply is likely to rise owing to investment in additional production capacities. This aspect is quite important when investigating long-run speculative impacts on oil spot market quantities.

2.2.1.3 A Monetary Analysis of the Futures Market

Let us now emphasize the interdependencies between the futures market and the spot market for crude oil in a monetary analysis. It will be seen that the endogeneity of money plays a crucial role. Table 2.4 displays two balance sheets of an oil-producing company and a financial investor, respectively. For the simplification of accounting, other market participants are not assumed away but excluded in this particular exami-

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[19] To be exact, capacity utilization is not necessarily permanently equal to unity in neoclassical models. But distortions in full utilization are due to exogenous shocks that affect the real business cycle and nominal rigidities that delay adjustment to the general equilibrium state (see for instance Greenwood et al., 1988; Svensson, 1986). Hence, once the business cycle is modelled and since the markets always clear by model construction, there is no way how inventories can be accumulated and how capacity utilization may be varied by entrepreneurial decision owing to effects like speculation in financial markets.

nation. Complications are added after but do not change the basic results. In the initial point, (1), the oil company holds *x* barrels of oil as inventories. For further simplicity, we ignore other balance-sheet values like equipment, real estate, and the like. Moreover, the company is fully self-financed by assumption. This means that all liabilities consist of equity E. The equivalence of assets and liabilities implies that oil inventories valued at their current market price are equal to equity, that is, $x*p_1 = E$. Now, the company goes short in the futures market and contracts on the delivery of crude oil in the amount of current inventories *x*. The contracted price is p_1 in order to keep it simple. On its assets side, the well-known and certain return of future oil delivery is anticipated and considered as a balance-sheet value. One may discount these future returns by some interest rate but it is needless for this analysis. On the liabilities side, there is the equally well-known future oil delivery commitment, which is in fact a kind of debt.

The other side of the futures contract is met by a financial investor. She goes long by the same quantity *x* valued by p_1. It is an asset since it provides her with a real good in the future, to wit, crude oil. On the liabilities side, there is debt because the investor owes a price p_1 for each barrel of oil to the company. If many financial investors purchase futures long positions, demand pressure raises the futures price and the spot price to a level of $p_2 > p_1$. The investor does not have an interest in real oil delivery. Therefore, she has to offset the long position before the expiring date of the contract. A short position of equal size is purchased. The financial investors' balance sheet lengthens by the new book-entry (2). Future sales earnings are added to the assets while the commitment to future oil delivery enters on the liabilities side. The offsetting short position has been sold by the oil company. Under (2) in the balance sheet of the latter, the deliberation from the future delivery commitment enters the assets side. This balance-sheet item is greater than the short position earlier on, because oil is now priced at p_2. On the liabilities side, missed future earnings from oil delivery enter. Crossing out the short position and its annulment yields an increase on the assets side by $x*(p_2 – p_1)$. This is due to the higher pricing of crude oil inventories, which remain stocked rather than being sold. On the other hand, crossing out future sales earnings and their subsequent cancellation yields a debt of $x*(p_2 – p_1)$. Under (1), the oil company had a balance at the futures market clearing house of $x*p_1$ due to its delivery commitment. Under (2), the selling of the short position at the new market price means that the company pays $x*p_2$ to the purchaser of the short position for being deliberated from a future oil delivery. Thus, it remains an obligation of $x*(p_2 – p_1)$ at the clearing house. As can be seen under (3), clearing-house debt is offset by crude oil inventories on the assets side of which each barrel of oil is now valued at a higher price.

For the financial investor, crossing out future sales earnings and initial debt as well as the long position and the offsetting short position brings a clearing-house balance of $x^*(p_2 - p_1)$ in the form of cash in (3). It represents a speculative profit. In this example, offsetting occurs by the purchase of the company's short position. The financial investors and the company might, in an analogous way, as well close a new contract where the financial investor goes short and the company goes long. The result would be the same.

Table 2.4 Balance sheets of an oil company and a financial investor

Oil-producing company

	Assets		**Liabilities**	
(1)	Crude oil inventories	x^*p_1	Equity	E
	Future sales earnings	x^*p_1	Short position: future oil delivery	x^*p_1
(2)	Selling short position: no future oil delivery	x^*p_2	No future sales earnings	x^*p_2
(3)	Crude oil inventories	x^*p_2	Equity	E
			Debt	$x^*(p_2 - p_1)$

Financial investor

	Assets		**Liabilities**	
(1)	Long position: claim on oil in the future	x^*p_1	Debt	x^*p_1
(2)	Future sales earnings	x^*p_2	Short position: future oil delivery	x^*p_2
(3)	Cash	$x^*(p_2 - p_1)$	Profit	$x^*(p_2 - p_1)$

Source: author's elaboration.

Table 2.4 explains in the framework of Figure 2.2 how speculation can impact the price of oil to the benefit of the speculator. On the other hand, speculation is not to the damage of the oil company. In our example, losses in the futures market are compensated by the higher price of oil inventories. Hence, the higher oil price does not directly result in larger cash holding but inventories can be sold in the global liquid crude oil market. The price increase suffices exactly to pay back the debt. The oil price is now at a higher level without a single barrel of oil having moved anywhere, that is, without any change in fundamentals.

Some extensions reveal the mechanisms even more drastically. Assume that the oil company offers only a part of its inventories in the form of futures contracts or, similarly, only contracts for a fraction of future oil production. All else equal, the price increase again involves a loss for the company's short position in the futures market clearing house. But now, there is a benefit given by the higher oil price multiplied by the total stock of inventories and future oil production. Not only contracted oil barrels are valued at a higher price but rather all existing inventories and all future oil production. This is a revenue larger than the loss in the futures market. Thus, the company has a net profit even though it is once more in the form of oil inventories rather than realized cash.

As another extension, assume that financial investors' expectations are very optimistic. They expect a higher future spot price such that they accept a present futures price that is higher than the current spot price. One barrel of crude oil at a spot price of, say, 50 US dollars is purchased in a futures contract for, say, 75 US dollars. Recalling Figure 2.2 it is clear that both prices have to equalize apart from potential 'contango' and 'backwardation' situations. Further demand pressure in the futures market drives the oil price even higher. At the delivery date, the spot price is, say, 100 US dollars. The offsetting of the contract brings a clearing house loss of 75 – 100 = –25 US dollars for the oil company and a profit of 100 – 75 = 25 US dollars for the financial investor. However, the new valuation of the company's inventories brings a non-realized gross profit of 100 – 50 = 50 US dollars. The company's net profit is 25 US dollars. The effect of financial speculation therefore brings benefits to both long and short positions of futures contracts. Contract relations in the futures market are more complex in reality. There are companies that do not only go short and financial investors who do not only go long. But since long and short positions finally offset one another, remaining net effects are those outlined in Table 2.4.

Neoclassical economists certainly would appeal against these findings. According to their view, supply and demand curves allow for one possible equilibrium price. Deviations from equilibrium will therefore evoke reacting forces that lead back to equilibrium at a certain speed and within a certain time span (see for instance Stadler, 1994). There are only exogenous but no endogenous forces that may affect the price. Our alternative analysis, in contrast, shows that market outcomes can in principle be placed anywhere in the quantity–price space. The true reference point is not an unknown hypothetical equilibrium but only the equivalence of financial asset supply and demand, to wit, the equivalence of short and long positions. The formula (2.1) in this chapter constrains oil futures only in the quite logical way that both sides have to be equal. But it does not state at which price level the equivalence is satisfied, because it is satisfied at all price levels. When a price change in the futures market transmits to the spot market, the equivalence formula for the spot market is not violated, either. A change in the price alters demand in the spot market while production is given in the period of consideration. However, demand is still equal to production and the change in inventories. Inventories are not a market imperfection that drives a wedge between supply and demand. They are a logical outcome in a capitalist economy where there exist financial markets and where market participants build future expectations. At a given price, oil companies decide not to supply inventories to consumers but to financial investors in the form of futures contracts to which inventories are the underlying real asset. Thus, spot market demand is equal to spot market supply.

The functioning of the futures market shows quite plainly that money is endogenous. The clearing system allows investors to accumulate their open interest without limit. Opposite positions are offset by double-entry bookkeeping. Monetary payments are only required at the date of delivery or expiration of the contracts, respectively. At this point in time, existing open interest that is not offset by an opposite position is settled by delivery. In the case where futures are evened up, the financial investor gets the resulting profit or owes a loss. This is the only effective payment taking place in the course of futures transactions. In our example, the investor would be paid its profit of $x^*(p_2 - p_1)$ while the oil company has to pay a debt of the same amount. The only real capital that the investor has to invest at the beginning is the initial margin that serves as a guarantee that final payment obligations are fulfilled. If these obligations increase during the term of the futures, a margin call is carried out and investors have to raise their initial margin (Volkart, 2008, p. 941).

In our example, speculation has driven up the oil price. The oil company has to pay its debt while the financial investor is looking forward to his profit. However, the company's debt is covered by the higher oil price. For all open accounts to be settled, oil has to be sold. A consumer, for instance the processing industry, or an oil trader has to bring up a larger amount of money than before in order to purchase the same quantity of crude oil. It is thus the higher price level that requires a higher amount of money. This confirms the nature of money as being demand-determined.

But this is only one part of the story. There is only one final settlement in the futures market where, in the case of offsetting positions, only the change of prices that occurred during the futures term has to be paid for. In the stock market, in contrast, the total amount of investment involves much more capital. One cannot get stocks for free and receive the return in form of the price increase in the end. An investor has to purchase a financial asset at the current price and hopes that she will benefit from a growing price. The profit rate is given by the ratio of the price change to invested capital, that is, to the initial price of the asset (ignoring dividends). In the same way, betting on an increasing oil price requires the purchase and resale of oil even though only in the form of paper. However, a financial investor who goes long in a crude oil futures contract for one unit of oil does not pay anything at the day of contracting except the initial margin. The bill will only be met at the expiration date. Evening up the long position will not require any payment at all except in the case of a fallen spot price of oil in the meantime, which gives rise to a negative investment return. But even so, over the duration of the contract the investor is in possession of a futures position that has the power to purchase a unit of oil at the predetermined future price. The futures contract is counterbalanced by debt at the same level, shown in the financial investors' balance sheet in Table 2.4 under (1). The other side of the coin is the oil company's future sale balance in (1) that is in turn outweighed by its short position. The analogy to the process of money creation is obvious: a futures contract creates a claim on a real good in the form of a unit of crude oil. Thus, it is endowed with purchasing power. And like money created by loans, this claim reflects an equal amount of debt. The oil company's future sale balance is a kind of loan while its short position is the balance of the investor and thus reflects a kind of deposit.

In practice, however, futures cannot be considered as a means of final payment since they are not accepted as a currency. If physical delivery of crude oil takes place, the contract obligations will have to be settled in official money. But during the contract term, increased purchasing power in the form of futures contracts is effective in influencing investment. Paying only the initial margin rather than the total futures price allows investors to pursue speculative profits with low investment requirements. The clearing-house system makes it possible to trade paper oil with a relatively small amount of capital. Futures trading is therefore highly leveraged. The profit rate is given by the ratio of the change of the oil price to the initial margin instead of the whole futures price. Commodity speculation is therefore quite risky as it can yield high returns as well as large losses (see for instance King, 2014).

This is basically not surprising because leveraged investments are a widely observed phenomenon in financial markets. They are usually debated from a microeconomic perspective. When a single financial investor pursues a risky investment strategy, she borrows by funding in the capital market or by taking credit from a bank. The leverage is financed by other investment entities. One investor's debt is other investor's balance. A loan is held as a deposit by somebody else in official money form. The debtor pays interest for her borrowed amount of capital. If she is not considered as creditworthy, she will not be granted a loan. Interest payment and creditworthiness are factors that use to restrain the issuance of credit by some degree.

In the futures market, however, the leverage is a microeconomic as well as a macroeconomic one. By contracting for a future oil delivery, new debt and a new claim on real output, that is, crude oil, are created. The debt does not pay any interest and required creditworthiness is not different from the creditworthiness of a conventional oil purchaser. The number of futures contracts is independent of the underlying quantity of crude oil available for delivery. This form of money, that is, open interest, can therefore grow to infinity as long as investors are willing to bear the risk that futures contracts contain. The price mechanism brings the demand and supply sides together for the necessary equality of long and short positions. The leverage can either grow in the form of higher futures prices or the number of futures contracts. The macroeconomic relevance is that it is not only the stock of official money in the economy that grows. Even more than that, new capital, an unofficial form of money, is created out of nothing by futures contract conclusions. It exists outside of the official payment system and is added to conventional money as the official means of payment. The underlying debt represents a leverage that is fully unregulated since it does not bear any interest. The only connection between leveraged capital and conventional capital is the initial margin that is required to access the futures market. This shows that money – in its official form as the means of final payment or in any form – is purely endogenous and highly elastic. Money requirements of financial investors are satisfied by credit creation, whether this credit creation takes place through bank credit or through other ways.

As we argued in the previous chapter, financial markets cannot permanently evolve independently of developments in the real economy. The same applies for futures markets. The price of oil futures is not at all exclusively determined by fundamental forces. There are many important additional factors from the financial sphere that impact on futures. But in the long run, all oil that is produced must be consumed in order to have a positive price. Even though expectations are likely to be quite heterogenous, limitless accumulation of inventories because of missing spot demand is not possible. Let us first consider the demand side. Total demand for futures must grow to have a longer lasting speculative effect on the price. A fraction of total open interest on the long side is held by non-speculative consumers. Their demand decreases sooner or later if the price continues to rise and so does their long position. Speculative futures demand has to grow stronger than non-speculative futures demand decreases for the price to rise. This means that the demand shift, illustrated in Figure 2.2 by highlighting a single point in time, has to occur many times. Changing to the supply perspective, a higher oil price is likely to raise supply by means of higher inventories from past periods and investment to raise production capacities. The oil supply curve thus shifts to the right from period to period. Oil companies therefore raise supply of futures such that not only the demand curve in the futures market shifts to the right but likewise does the futures supply curve. The number of contracts induced by demand for long positions has to grow continuously in order to cover increased oil supply. Hence, both demand and supply reactions to the high oil price are forces that tend to lower the oil price. A high price of oil while the level of stocks is high and effective demand is weak is a contradicting issue. This will sooner or later trigger counteracting movements of financial investors changing from net long to net short positions, which will lead the futures price and thus the spot price back to lower levels. Yet, it is impossible to generalize within which period of time and at which price level such a countermovement occurs, owing to complex reality and uncertainty, to wit, radical indeterminacy.

In the neoclassical view, economists suggest that, since speculative price changes do not have any rational underlying justification through changes in fundamentals, they do not occur or happen only in the very short run. It may be true that financial investors do not have any motivation to invest in oil futures if there are no expected changes in the oil market and in global economic performance. But first, changing expectations might nevertheless lead to increasing prices by way of speculation without expectations having become reality in the real economy. Second, if financial investors change their liquidity preference, they change size and composition of their investment portfolio. Monetary policy is a factor that tends to change liquidity preference. Thus, it should be considered as an exogenous force that drives a wedge between the oil futures market and the fundamental forces in the spot market. Such an exogenous impact opens a space in which speculation gets the potential to exert a lasting influence in the market for crude oil.

The strength of speculative impacts is likely to be affected by financialization. This issue has been intensely debated with respect to the market for crude oil. The degree of financialization is usually identified by the amount of open interest. It is unquestioned that open interest strongly increased since 2000 (CFTC, 2014). From time to time, financialization is said to be triggered by commodity market deregulation in the form of the US Commodity Futures Modernization Act (CFMA), which was signed into law in 2000. Kloner (2001) provides a short overview of this more juridical than economic debate. Some commentators consider the correlation between the oil price and open interest as a proof of how speculation in the futures market raises the oil price (see for instance Masters, 2008, pp. 5–6). Even though this conclusion may be premature and is often missing an adequate underlying theory, financialization deserves to be studied more in detail. It is often argued that total open interest has grown to a volume over time that is a multiple of global daily oil consumption. To infer from this finding that more oil is traded in the futures market than in the spot market with physical delivery is however wrong. Open interest is a stock variable and oil consumption is a flow variable. If open interest is coherently split according to the delivery dates of the futures contracts, open interest corresponding to a certain delivery day is only a fraction of daily oil consumption (Alquist & Gervais, 2011, pp. 3–4). Nevertheless, even though stock variables and flow variables may have a different nature, this does not allow for ignoring them. The larger the number of futures contracts of whatever duration, the more opportunities oil companies have to go short in the futures market rather than selling oil in the spot market. It has been shown that the equality of futures demand and supply is satisfied at any amount of open interest and at any price. Larger open interest does not necessarily induce a higher price. Open interest may increase because oil firms prefer to raise their short positions. In this case, open interest is supply-driven and may lead to a lower price. Yet, as shown in Figure 2.2, the futures market is the channel through which speculation can exert an influence on the spot market. If demand increase is weak, the spot price increases only little. Thus, a sufficient amount of open interest is a precondition for a large demand increase so that speculation is even allowed to become effective. The comparison between open interest and daily consumption is not helpful. Speculation is expected to increase oil inventories, which reduces supply in the spot market. Hence, if the price elasticity of demand for crude oil is low, a relatively little increase in futures market demand suffices to raise the spot price even though open interest may only be a fraction of real oil consumption. Financialization in the form of growing open interest is thus not an automatic proof of a rising oil price but it enhances the potential for speculation to manipulate the spot market. We will argue that financialization becomes even more important when connecting it to the presence of expansionary monetary policy.

Based on the elaborated alternative view of financial markets, this chapter has applied these findings to the market for crude oil. As a crucial difference, there is the complication of the double nature of crude oil as a commodity and a financial asset that needs to be taken into account. But in accordance with stock markets, futures prices can change without changes in the real economy. Conversely, they can well exert an influence on fundamentals rather than merely being a reflection of the latter. This is in contradiction to neoclassical theory. While changes in the stock market are suggested to have an influence through Tobin's *q* and the wealth channel, the connection between the oil futures market and the spot market is much closer and more direct owing to the dual nature of oil. The alternative view takes complexity of real economic relationships into account and does not rely on a general equilibrium approach. It suggests dynamic interrelations between the real economy, the spot market for crude oil, financial markets or the futures market, respectively, and monetary policy. They are analyzed in the next section in order to enlighten the effects that monetary policy has on the crude oil market.

2.2.2 Monetary Policy Effects through the Real Economy and Financial Markets

The hitherto conducted analysis shows that monetary policy exerts impacts through economic fundamentals as well as through financial markets. The former is well known as the traditional way of how monetary policy affects the economy. The latter required to be elaborated more in detail since it is due to the specific characteristic of crude oil as both a commodity and a financial asset. The mechanisms of the working of monetary policy will be emphasized later, when discussing its transmission channels. Fundamental and financial market effects both have distinguished features that should be outlined first.

2.2.2.1 Effects on Fundamentals

Neoclassical theory and our alternative view differ with regard to monetary policy insofar that mainstream economics assesses monetary policy impacts to merely concern the price level while hardly having any effects on real variables. Namely, it assumes a supply-side-determined equilibrium as given to which the economy reverts over the long run instead of accepting for both supply- and demand-side dynamics (Colander, 1996, pp. 28–29; Sawyer, 2002b). In the following, investigation of both supply and demand sides will show that monetary policy may yield a much greater variety of outcomes than only a change in the price level. The endogenous-money approach allows monetary policy to have quantity effects without necessary price effects. Monetary policy may be inflationary when it induces demand that exceeds production capacities. Otherwise, changes in the price level may be due to cost pushes with regard to commodity price changes or altered wage levels. Despite the analytical strength of the endogenous-money view, we will argue that the dual nature of oil is a specific issue even in this regard. On the other hand, expansionary monetary policy may as well lead to falling prices owing to lower interest rates entering production costs. Changes in the general price level leave the real price of oil unchanged and are therefore not in the centre of interest in the current analysis of monetary policy.[20] Inflation does not affect real variables and thus only has the effect to drive a wedge between the nominal and the real oil price while fundamentals in the spot market remain the same. This should at least be valid for inflation rates that are low but at least weakly positive, which is generally considered as a normal situation. In the cases of very high inflation rates or deflation, things may be different since they impede resource allocation that may give rise to additional effects on the price of crude oil (see for instance Lavoie, 2006b, pp. 176–178). Since 1990, the OECD countries have featured moderate average inflation rates constantly below 8 percent, which have even been falling over this time (OECD, 2014). For the moment, owing to these reasons, we abstract therefore from changes in the general price level as a result of monetary policy.

The endogeneity of money gives rise to the fact that the effectiveness of monetary policy depends on effective demand in the economy (Sawyer, 2002a, p. 42). The general way how a lower short-run interest rate affects the economy is through an increased demand for credit. This can be credit for real investment, private and public consumption or, similarly, for mortgages (see for instance Gnos, 2003, pp. 325–326; Mishkin, 1995, p. 4). The strength to which credit creation reacts to monetary policy depends on expectations of future profit that such an investment will induce and on future household income. A corporation decides to invest only if expected sales quantity is sufficient to cover investment as well as profit requirements. Households (should) only take a credit for consumption or mortgage if they are able to bear interest cost and credit repayment out of future income. Thus, for future expectations to be bright, effective demand must be sufficient. At a moment of monetary policy action, effective demand is given. New investment creates new demand since equipment has to be produced and real estate to be constructed. But likewise, new investment creates

[20] Even though we still agree with the argument that monetary and real terms cannot be divided in a monetary economy (Cencini, 2003a, pp. 303–304), the comparison of the oil price to the general price level is useful. In fact, it is an *ex post* comparison of two monetary terms and hence is in line with our monetary analysis. In contrast to neoclassical economics, we do not use the ‘real’ price of oil to make predictions or to measure causalities. Indeed, in economic reality, only the nominal oil price is visible.

new supply by increasing production capacities (Lavoie, 2006b, pp. 178–190). Expansive monetary policy thus raises output by a small or large amount according to existing effective demand (see for instance Forder, 2006, p. 232).

The argument that monetary policy is effective through a quantity effect is made with regard to the whole economy: total output is affected by monetary policy without there being a necessary impact on the general price level. This does not mean, however, that quantity effects caused by monetary policy are neutral to the structure of the economy. Some branches might react stronger to a change in the interest rate level than other branches (see for instance Keynes, 1930a/2011, p. 211). If the composition of total output changes, relative prices may change, too, even though the overall price level does not necessarily alter. In our examination, the relevant issue is how crude oil production or the oil industry, respectively, reacts to monetary policy compared to the rest of the economy. The oil industry can be considered as the supply side of the oil market while the non-oil economy represents the demand side. If the non-oil economy grows more than the oil industry in response to a drop in the interest rate, oil demand rises stronger than oil supply, which requires the oil price to increase in tendency. The term 'tendency' means that prices change to the extent that demand exceeds production capacities. If the utilization rate is below unity, stimulation by monetary policy raises oil production and output of the non-oil economy by a certain amount without any price changes to expect. In the case where the non-oil economy responds stronger to monetary policy than the oil industry, the oil intensity of economic output shrinks. The opposite applies for the case when the oil industry reacts more to monetary policy actions than the non-oil economy. There are many indirect effects between the oil industry and the non-oil economy that take simultaneously place. Growth in oil demand induces an increase in oil supply and *vice versa* by conventional feedback mechanisms. The amount to which supply and demand side reactions allow to prevent extreme price hikes depends on the magnitude of price elasticities of supply and demand.

2.2.2.2 Financial Market Effects

The above sections about financial markets in general and the futures market in particular lay the basis for the analysis of how monetary policy affects the economy or the market for crude oil, respectively, through these financial mechanisms. Conversely to the consideration of monetary policy effects on fundamentals, this section abstracts from any changes in fundamentals that may take place while monetary policy affects the futures market. The interaction of fundamental and financial market effects is emphasized later on.

We show in this thesis that financial markets can in principle evolve without corresponding developments in the real economy, that is, without changes in real quantity variables. Changes in the oil futures market take place through changes in the futures price and, analogously, the spot price. Thus, to make a preliminary summary, monetary policy exerts quantity effects through fundamentals and price effects through the futures market. Let us focus on the latter, that is, the price effect.

Monetary analysis exhibits that speculation is the mechanism through which monetary policy materializes in financial markets. Our alternative approach assesses the potential of speculation to exert influences in financial markets. In the case of crude oil, owing to the strong connection between the futures market and the spot market, speculative impacts necessarily transmit to the real economy. But speculation requires a motivation of financial investors in order to effectively take place. They may have optimistic expectations that overshadow the effective demand constraint given in the real economy. There is the immediate question where this optimism comes from. Hence, while it is not realistic to assume any speculative effects away by means of an efficient markets hypothesis, it is as well unlikely that strong speculation activity comes out of nothing. Monetary policy is suggested to be a crucial factor.

Assume that the central bank cuts the short-run interest rate. Liquidity preference falls for the reasons already explained. A lower interest rate level changes investment perspectives. Bonds and bank deposits become less attractive. Investors would have to correct their profit expectations downward. They increase demand for higher-return and riskier financial assets in order to prevent a lower profit rate. Investors' motivation being either profit purpose, wealth store or portfolio diversification, monetary policy gives rise to stronger activity in favour of these goals. Monetary policy acts as an exogenous force by setting the interest rate and affects liquidity preference in this way. Liquidity preference is based on the relative attractiveness of assets (see Bibow, 2006, p. 334; Lavoie, 2014, pp. 238–250). Interest rates influence the latter, which reveals that liquidity preference is an endogenous issue. But from the point of view of the real economy and financial market performance, liquidity preference appears as partially exogenous, because it is not only an outcome of conventional market forces but as well directly influenced by the central bank. Hence, liquidity preference can fall and speculation activity can accelerate even if there are no changes in the real economy and even if the economy is in a recession or even in a depression.

Profit purpose, wealth store and portfolio diversification are important issues that enable us to explain how a rising demand for financial assets spills over from the stock market to the futures market for commodities and specifically crude oil. Profit purpose is likely to be the main driving motive. Commodity indexes have been shown to face a lower standard deviation than conventional stock market indexes but with a comparable return over decades (Gorton & Rouwenhorst, 2006, p. 74).[21] This characteristic makes crude oil futures, either indexed with other commodities or individually, a welcome investment alternative. They are considered as a hedge against inflation (ibid., p. 75) and can thus serve as a store of wealth and for the diversification of the investment portfolio.

Monetary policy becomes effective in the futures markets because it motivates investors to raise financial investment. The contradiction between economic fundamentals and an ever increasing oil price persists. But effective demand constrains futures market speculation only indirectly, because the number of contracts is unlimited. Hence, the oil price can increase even if the economy is stagnating.

Basically, expansive monetary policy may lead financial investors to go short rather than long, which would bring them a certain return under given expectations, too. However, this scenario is not very plausible. First, lower interest rates use to have a positive effect on expectations about future economic performance, which tends to be linked, if anyhow, with a higher rather than a lower oil price. Second, it is probably easier for speculators to move the price upwards rather than downwards. Betting on a rising oil price without a change in fundamentals is easier done, because the simple reaction of oil companies is to raise short positions while a higher or lower quantity of additional inventories is accumulated. Speculating for a lower price would require oil producers to offer lower-price short positions even though they can sell oil at a higher price in the spot market. They certainly prefer the latter option. Third, inventories can accumulate infinitely but they cannot decline infinitely. At least when they are at zero, the price cannot be pressed down any further by raising oil supply beyond current oil production. Fourth, it is a fact that financial investors hold net long positions most of

[21] Concerning the issue of portfolio diversification, many studies beside of Gorton and Rouwenhorst (2006) investigate the correlation between equity returns and the oil price. Both negative and positive correlations are found (see for instance Kolodziej et al., 2014; Lee & Chiou, 2011; Miller & Ratti, 2009; Tang & Xiong, 2011). In the studies, correlation is shown to change over time. While a negative correlation confirms crude oil futures to be effective diversification opportunities in addition to stocks, positive correlation is interpreted as a sign of increasing financialization that links equity and commodity markets. We do not judge these results in this place. It is only to mention that a change in the correlation is not a theoretical contradiction. In fact, the positive sign may just be linked to the negative one: Investors might exploit the negative correlation for portfolio diversification. Demand for assets thereby exerted may produce a positive correlation. Fluctuations in the empirically measured relationship between commodity and equity prices thus should be the rule.

the time (CFTC, 2014). This empirical evidence is strengthened by the growing importance of index speculators (Masters, 2008, p. 6). Therefore, it is reasonable to associate lower interest rates in tendency with higher demand for oil futures long positions.

As we pointed out, each signing of a futures contract creates an unofficial form of money. It is backed by debt of an equal amount in analogy to conventional money creation. But since this debt does not bear any interest, no limits can be set to money creation in the form of futures contracts. The central bank uses the short-run interest rate as a tool to influence economic performance and to pursue its declared targets. Yet, this tool applies only to official money, which is created by commercial banks. From this point of view it may be argued that monetary policy does not have the power to affect the futures market, because unofficial money contained in futures contracts is fully independent of interest rate setting. This would amount to saying that monetary policy is not a driving force of speculative activity in the futures market.

In fact, it is more appropriate to consider it the other way round. It is true that futures contracts are not directly affected by changes in the interest rate. But to participate in the futures market, an initial margin (complemented by the maintenance margin) is required to guarantee the liquidity of investors, because it is only official money that can serve as a means of final payment. The initial margin triggers the creation of an amount of unofficial money far larger than itself. Expansive monetary policy lowers financial investment cost. Investors have more liquidity available such that they can enhance their initial margins and thereby raise open interest. For clarity, assume for once that all futures contracts require immediate payment of the total contracted price instead of only the price difference that occurs over time. Financial investors would have to borrow much more interest-bearing capital. A given amount of capital could exert much less demand power in the futures market. Financialization of the commodity markets would be at a lower level. Yet, expansionary monetary policy does not only boost demand for futures by accelerating credit creation. It triggers additionally a high leverage in the futures market, which raises hitherto existing futures demand by a multiple. Hence, the actual working of the futures market clearing system and the nature of futures contracts make monetary policy more rather than less effective. In this context, the word ‘effectiveness’ should be considered in a very strict way. It does not mean that the central bank’s ability to control its targeted variables is improved. It just suggests that a certain monetary policy action has further reaching impacts owing to the leverage in the futures market. The endogenous character of money is strengthened by this consideration and reveals even more explicitly that the monetary authority cannot control the quantity of money in the system.

We may enlighten the issue by a further aspect. The leverage in the futures market raises the elasticity of the financial system. But since unofficial money cannot be used to settle open positions, it must necessarily be destroyed one time after creation. It is therefore a kind of money that never leaves the financial sphere and does not exert demand for real goods, which would potentially generate inflation in the real economy. By the mechanism of speculation, it can well have an impact on the spot price and on fundamentals. However, it shows once more that monetary policy, money creation, and inflation are far from being connected by simple linear relationships.

The alternative approach to financial markets and its application to the crude oil futures market can briefly be summarized by the following notion: speculation is the mechanism through which the futures market has an impact on the crude oil spot price. And it is monetary policy that drives this mechanism to become effective. Such a price effect does not require changes in fundamentals.

2.2.3 The Transmission Channels of Monetary Policy

The identification of fundamental and financial market effects gives rise to various interrelations when investigating the transmission channels of monetary policy. It is necessary to distinguish between the whole economy on the one hand and its division into the oil industry and the rest, the non-oil economy, on the other hand. Consequently, there is total economic demand, specific demand for crude oil, total supply as well as oil supply. Each is important in a particular context. Moreover, in some respect we are interested in the whole of financial markets including stock, bond and other securities and derivatives markets. In other contexts, we consider the crude oil futures market in particular. This brings a lot of mutual impacts. Monetary policy influences both the oil industry and the non-oil economy, which both affect one another again. Financial markets in their entirety have an impact on the real economy, that is, on both the oil industry and the non-oil economy. The oil futures market specifically affects the real economy and primarily the market for crude oil. Depending on the particular effect to be enlightened, a specific relationship between some of these various variables is emphasized.

For the analysis of monetary policy transmission channels in the context of crude oil, it is essential to be aware of the dual nature of oil. Hence, each channel has two aspects: a fundamental one and a financial one. The fundamental aspect comes into play when monetary policy affects crude oil as a real commodity. The financial aspect is relevant when the oil market is influenced by way of crude oil as a financial asset, that is, a futures contract.

The interest rate channel, the exchange rate channel, Tobin's *q*, the wealth effect, and credit channels are the well-established channels generally identified in the theory of monetary policy. It would be wrong to take these channels as complete and perfectly complementary to explain the entire transmission mechanism of monetary policy. The theoretical identification of the individual channels took place at different times in the past (Mishkin, 1996, p. 1). Hence, they reflect different approaches and arguments that help detect the ways through which monetary policy is effective. This does not allow us to add up all channels to find the total impact of monetary policy. For example, the interest rate channel may contain features that are also taken into account by other channels. A part of monetary transmission runs the risk of being measured twice. The partial overlap of transmission channels requires a careful interpretation of the impact of monetary policy. Nevertheless, all channels are useful in the sense that they reveal many arguments and yield each important insight for the understanding of monetary policy transmission. Current literature about the connection between monetary policy and the oil price emphasizes additional transmission channels, which we shall call oil-specific channels in the following. They are treated separately in a coherent way corresponding to the hitherto elaborated analysis.

2.2.3.1 Monetary Policy Transmission through Fundamentals

When monetary policy transmission mechanisms are discussed conventionally, it is their working through fundamentals that is meant. The debate uses to be about how monetary policy influences output and the price level through changes in investment and consumption behaviour of firms and households, respectively. This examination is now made for the market for crude oil.

Interest Rate Channel

The interest rate channel is often argued to be the principle one, since its influence on economic variables is quite direct and since it is the interest rate itself that is directly set by the central bank (see for instance Taylor, 1995, pp. 22–23). On the other hand, it is the most general and least specified channel and thus may as well be considered as a residual channel next to all other channels. As such, it is closely related to the other transmission channels and shares many basic characteristics with them. Some insights about the interest rate channel can therefore be applied to explain the remaining channels. Usually, the interest rate channel is described in the following way: an expansionary monetary policy leads to a lower level of interest rates, thus decreases the capital cost, which raises investment. Higher investment means higher aggregate demand that results in higher output (Mishkin, 1996, p. 2). Yet, for our purpose it is not sufficient to know how the interest rate channel is linked to the whole economy taken as a single object. We are interested in the specific issue of the oil market and how it is influenced by monetary policy compared to the rest of the economy. Hence, we suggest a definition of the interest rate channel that is consistent with the existing literature but broader: the interest rate channel is the way how the supply and demand sides in the economy are affected by monetary policy when all market participants react to an altered level of interest rates.

Interest cost is a part of total production cost. Falling interest rates allow firms to finance production at better conditions and thus to produce at lower cost, which transmits to lower prices generally speaking (Sawyer, 2002a, p. 42). Lower prices will raise demand. The firms, in expectation of higher profits to realize, raise the quantity produced. To the extent that effective demand allows for higher returns, firms take additional credit at the more favorable interest rate and enlarge their supply capacities by productive investment. This is the supply-side reaction of the economy (see Lavoie, 2006b; Sawyer, 2002b).

On the demand side, it is investment of firms that exerts additional demand by purchasing new equipment. For private households, consumption wishes can be satisfied by getting indebted more easily when the central bank lowers the interest rate. Similarly, for savers opportunity cost of consumption decreases because saving account returns fall, too. For instance, serving interest payments of a mortgage loan then takes a smaller share in future income of a household. Total demand increases therefore when monetary policy is expansionary. If rising demand has a significant effect on the price level at all, it leads to rising prices. It is argued that real estate and consumer durables represent principally investment-like expenditures for production equipment (see for instance Mishkin, 1996, p. 2). This is true in the sense that all expenditures create effective demand in the same way. However, it is essential to distinguish supply and demand sides and their responses to monetary policy. All expenditures on the market for produced goods and services contribute to effective demand and thus raise output. But not all expenditures raise production capacities. Hence, the character of expenditures has an influence on total production capacity, on the degree of capacity utilization and thus on the price level. This shows again that, given a certain monetary policy action, it is not possible to predict the change of prices. Therefore, money cannot be the object that is itself responsible for inflation.

Whether the interest rate channel has a stronger or weaker effect on the oil industry than on the non-oil economy depends on various factors on both the supply and demand sides. All product prices, including the oil price, consist of a number of components. A price divides into production cost and a profit share. Production cost itself is composed of equipment depreciation (including machines, real estate, and so on), expenditures for commodities and other raw material, salaries, and interest payments. Interest cost is unavoidable for a company, because it requires capital to finance production. Depending on the performance of a specific company, borrowed capital takes a larger or smaller share in total capital.

Hence, a decrease in the interest rate lowers production cost to the extent that production of a company is financed by borrowed capital instead of equity. A higher share of borrowed capital makes the interest rate channel more effective. The interest rate effectuates the same influence in upstream industries, which transmits to the purchase prices of downstream companies. Hence, the effect is enhanced by cheaper raw material.

The profit share is a two-sided issue. The higher profits, the more companies are able to finance production out of their own resources and the higher is thus the share of equity. On the other hand, assuming that the profit share is a mark-up of a certain percentage rate of production cost as is often done in many models of various origins (see for instance Blanchard & Illing, 2006, p. 194; Kalecki, 1987, p. 104), the profit is larger, the larger production cost. A lower interest rate then not only lowers production cost but also absolute profit per production unit. The total effect of monetary policy on the price level is thus enhanced. The degree of competition that influences the size of the mark-up is therefore a further influence factor. The crude oil market is a distinguished case in this respect. The OPEC produces about 40 percent of total crude oil (EIA, 2014). A cartel of this size is likely to influence the market with respect to the price level, production quantities and investment. Even though its effectiveness in agreeing on production quantities is often doubted (see for instance Smith, 2009, pp. 151–154), its existence is to be taken into account as it probably raises the profit share in the oil price and the possibility of self-financing investment.

Given that the price elasticity of demand is different from zero, every decrease in sales prices that is due to lower production cost will raise realized profits of firms. Of course, this only holds true if lower production cost is not owed to wage cuts. The latter would reduce effective demand and thus probably diminish profits. Lower interest cost, however, has an exogenous source and leaves total effective demand unchanged at least in the short run. The more a cut in the level of interest rates alters production cost and the price level, the more companies borrow additional capital to raise their production capacities because their profit expectations increase.

These supply-side considerations concern both the oil industry and the non-oil economy. In general, investment is an expenditure and as such represents demand. However, what is crucial in the longer run is that it enhances production capacities and therefore *ceteris paribus* increases supply. Perspectives change when oil production is considered. Expenditures outside of the oil industry raise demand for oil even if they are an investment of the type described above and hence would appear as an increase in supply from the point of view of the whole economy. This is not valid for all expenditures in the same way. For instance, a haircut of one hour duration hardly raises oil consumption. But since oil is a central fuel of the today existing world economy, higher expenditures, to wit, higher output, raises demand for oil, either directly or indirectly. It can be argued from a macroeconomic point of view that a given increase in total expenditures or in total non-oil investment in a given moment raises oil demand by a specific degree (see Hamilton, 2009, pp. 216–217). This allows us to leave aside long-run developments in production technologies and structures for now.

For the reasons emphasized here, the interest rate channel tends to give rise to higher rather than lower absolute oil production in the course of expansionary monetary policy, since both supply and demand sides are positively affected. The quantification of the effect in comparison to the rest of the economy is less clear. It depends on the relative strength of monetary policy impacts on the oil industry and on the non-oil economy, respectively. For an analytical proceeding, we start again from the equivalence of supply and demand in the oil market. Oil supply and oil demand are equated by the oil price in every moment of time. The interest rate channel does not distort this equivalence, but it alters some relevant variables. When demand (left-hand side) changes, either supply or the oil price (right-hand side) or both have to change, too. This is illustrated by equation (2.2):

$$\Delta(\mathit{consumption}) + \Delta(\mathit{non\text{-}oil\ investment}) = \Delta P_O + \Delta(\mathit{oil\ industry\ investment}) + \Delta(\mathit{capacity\ utilization}) \qquad (2.2)$$

Equation (2.2) is only a rough approximation of the supply-demand equivalence in percentage changes and covers the variables that are relevant with regard to the interest rate channel. Consumption expenditures, that is, purchase of real estate and consumer durables and non-durables, and non-oil economy investment represent the demand side in the oil market. If one or both demand components increase, the supply side responds either by investing in equipment or by raising the capacity utilization rate. Under the condition that lower capacity utilization does not offset enhanced investment, both of these supply-side reactions increase supply. If the oil industry does not react at all or only insufficiently, the oil price has to increase in order to re-equate supply and demand in the oil market. The reason why the price variable as the balancing variable is on the right-hand side instead of the left-hand side of equation (2.2) is that both supply-side components are technical variables. They determine actual physical supply measured by quantity rather than price. In contrast, the demand components express purchased quantities measured in units of money. Hence, they are monetary variables. They divide into a price variable and two supply variables.

Equation (2.2) reveals two effects of the interest rate channel, that is, changes in production cost and in investment behaviour. As regards price effects, we are interested in relative instead of absolute changes of the oil price. This is how we consider the variable ΔP_O. This means that potential changes in the general price level are ignored. If a drop in the interest rate level lowers production cost and hence prices more in the oil industry than in the rest of the economy, ΔP_O is negative. This triggers an increase in oil demand even though it may be very small owing to its low elasticity. The left-hand side of equation (2.2) is therefore at least weakly positive. Oil supply responds by either increasing additional investment or by an augmentation in capacity utilization. Oil supply grows more than oil demand owing to the drop in P_O. This is due to the logic of the equation as well as to increased profit expectations of oil companies outlined above. The effect might be dampened by a partial re-increase of the oil price due to higher demand for oil.

In the same way, if investment in the oil industry triggered by a lower interest rate is larger than the sum of investment in the non-oil economy and consumption growth, oil supply *ceteris paribus* grows larger than oil demand. This requires the oil prices to fall. Alternatively, capacities increased by investment may be evened up by lower capacity utilization. However, this is not to be expected, since it is unlikely that companies invest without using created capacities.[22] In both these cases – a fall in relative oil production cost and relative rise in oil industry investment– oil production increases more than output in the rest of the economy. The lower oil price re-equates both sides. Higher oil supply therefore transmits to higher oil consumption. Oil intensity of total output is now larger than before.

[22] This may well occur but is based on strategic behaviour in monopolistic markets rather than triggered by monetary policy (see for instance Varoufakis et al., 2011, pp. 345–346).

Conversely, if oil production cost falls by less than production cost in the non-oil economy, the oil price increases and demand falls relatively. Equally, if oil industry investment grows less than investment in the rest of the economy, oil supply in tendency rises less than oil demand. Given the case that oil industry investment is fixed, increasing demand requires a higher rate of capacity utilization. If capacities are fully employed, the oil price starts growing. This means that increased oil demand translates in a higher price while supply is constrained. The oil intensity of the economy shrinks in this case.

In general, we have to distinguish between two different types of inflation, that is, demand-pull and cost-push inflation (see for instance Rochon, 2004, pp. 8, 19; Setterfield, 2006; Vernengo, 2006, p. 471). The term ‘inflation’ might go too far, because our interest is on the oil price rather than the general price level. Yet, it nevertheless serves to describe this particular case. Demand-led inflation occurs when demand exceeds production capacities. Cost-push inflation takes place when production costs rise and transmit to prices. Gibson’s paradox is an approach that explains price changes from the cost perspective. Since interest is a part of production cost, expansive monetary policy lowers prices through a reduction of production cost. Demand-pull inflation is the preferred explanation of neoclassical theory, where cost aspects play merely a marginal role (Barro & Grossman, 1974; Brunner et al., 1973; Gnos & Rochon, 2007, p. 374). In our investigation, both approaches should be taken into account. Cost-push inflation has been examined by the decomposition of price components. As regards the first principal effect, a cut in the level of interest rates lowers production cost and therefore represents a negative cost push. In the case where oil industry investment reacts more to a cut in the interest rate than the rest of the economy, the oil price is expected to fall owing to rising supply. In principle, one may consider this reaction as a negative demand pull. However, this phenomenon is more likely to be linked to another (negative) cost push. It shows that the two aspects of the interest rate channel, that is, lower production cost and higher investment, are tied together in many cases. Investment does not grow out of nothing. Oil companies decide to invest if profit expectations are bright. Assuming away strategic behaviour, they raise investment if they know that it will augment profits. Hence, newly created capacities are used and effectively raise oil production. The profitability condition is sufficient effective demand. The increased quantity of oil must therefore be supplied at a price low enough for existing effective demand to clear the market. Companies only accept a lower price if production cost is lower, too. For a given level of effective demand, the interest rate channel raises investment in the oil industry only if the lowered interest rate reduces production cost sufficiently. Increased oil supply that is induced by an expansionary monetary policy is therefore, if not identical, at least closely linked to a negative cost push.

In the opposite case, where the oil industry reacts less to an expansionary monetary policy, the cost push is directly effective, too. But since production cost falls less than in the non-oil economy, the cost push is positive in relation to production cost in the rest of the economy.

The second principal aspect, investment behaviour, refers to a classical type of demand-pull inflation. As mentioned, the oil price only increases if excess demand rises above production capacities. Hence, while the price is expected to fall if oil industry investment grows relatively stronger, the opposite price effect is more ambiguous if non-oil investment and consumption demand grow more. One should be aware that what appears as a demand pull in the oil market may be the counterpart of a cost push in another market. Strong investment in the non-oil economy may be due to lower production cost. Thus, a negative cost push in the non-oil economy indirectly creates a demand pull in the oil industry.

The issue of monetary policy, quantity effects, and price effects is complex. The separation of changes in production cost and investment behaviour does not suggest that they are easy to separate in reality. They are not only tied together empirically but share many similarities in theory as well. In the greatest part of economic literature about monetary policy transmission, the economy is investigated as a whole. The inspection of a single economic branch additionally complicates the issue by introducing relative rather than only absolute variable changes within the whole economy. Relative quantity and price effects reveal how mutual impacts within the economy work. Individual effects tend to be overlapped by other cost pushes or demand pulls. Expectations under uncertainty may induce investments that yield different final results. Moreover, the production cost effect and the investment effect might in principle also be opposing. For instance, production cost of the oil industry may be stronger affected by a lower interest rate than the rest of the economy. Conversely, oil companies might observe performance in the non-oil economy, build expectations and then constrain their investment. The former effect would render the economy more oil-intensive, the latter less. Opposing effects offset one another partially. This complicates analysis even though the strong connection between the production cost and investment aspects suggests them to go in the same direction.

Exchange Rate Channel

Monetary policy transmission through the exchange rate is a well-recognized channel and has a specific connection to the price of crude oil. A cut in the interest rate by the US central bank lowers the return of holding deposits in US dollars relative to returns of other currencies. Demand for dollars decreases and so does its exchange rate against other currencies.[23] Depreciation makes US exports cheaper abroad and raises the price of US imports. Net exports increase and so does US output (Mishkin, 1996, p. 5). The US dollar and the price of crude oil share a specific feature assessed in a cointegrating relationship. A US dollar depreciation, for instance against the euro, leads to a higher oil price while an appreciation lowers it (Zhang et al., 2008, pp. 981–982). World trade in crude oil is denominated in US dollars. A lower value of the US dollar threats profits of oil companies producing outside of the United States. They raise the oil price to avoid shrinking revenues measured in their currencies. In the same way, oil demand from outside of the United States increases, because oil can be purchased cheaper owing to the weak US dollar.

Determining the effects of a change in the US dollar exchange rate against, say, the rest of the world from a global point of view is more complex. In addition to the already mentioned reactions of foreign oil production and oil demand, a depreciating US dollar lowers domestic oil demand and raises domestic oil supply on the one hand. On the other hand, boosting exports of goods and services increase oil demand while decreasing imports reduce oil demand.

The definitions of domestic and foreign country change when some countries decide to peg their currency to the US dollar. For instance, this applies for six oil-producing countries in the Arabian Gulf (Cevik & Teksoz, 2012, p. 3). Such shifts in borders of pegged currency areas alter supply and demand effects. These partial effects have supplementary and adverse impacts on the price, production, and consumption of crude oil. The direction of the resulting net effect can hardly be identified and depends on a considerable number of price elasticities of supply and demand. On the other hand, Lizardo and Mollick (2010, p. 405) observe that a higher oil price depreciates currencies of significant oil importers like Japan relative to the US dollar. This means that a US dollar depreciation against an average world currency basket is partially reversed

[23] It may seem as a contradiction to the idea of an accommodative supply of money since demand is not expected to have an influence on the ‘price’ of money (that is, in this case, the value of the domestic currency in terms of the foreign currency, that is, the exchange rate). For an explanation of exchange rate changes against the background of endogenous money, see Cencini (2000, pp. 11–14). For the purpose at hand, the conclusion about interest effects on the exchange rate does not change.

and takes mainly place relative to significant oil exporters and large economies where oil imports have a lower share in total imports, such as in the euro area. What remains from the depreciation in the US dollar exchange rate, in spite of all additional impacts, is the higher oil price. These findings suggest that the exchange rate effect on the oil price is well established. In contrast, effects on crude oil quantities, that is, production and consumption, are more ambiguous.

Based on the above reasoning, the fundamental aspects of transmission channels use to reveal both relative quantity effects and relative price effects with regard to crude oil. The exchange rate channel is an exception in this respect. In its conventional interpretation in the framework of the whole economy, it is expected to mainly yield quantity effects by altering domestic output, while potential effects on the price level are not neglected owing to changing import prices. However, this is the point of view of an individual country. As the market for crude oil is globally integrated, a worldwide perspective should be taken. At this level, many counteracting effects occur as we have just shown. There is no reason to assume that changes in relative prices of currencies around the world affect the global levels of oil production and consumption aside from the potential case that an exchange rate change strongly affects economic output of a country. It is only the price effect that remains for certain. The latter arises from the fact that oil is traded in US dollars.

Tobin's *q*

Even though we are still analyzing the fundamental aspects of transmission channels, the role of financial markets in monetary policy transmission is already involved by the approach of Tobin's q. Tobin (1969) developed a coefficient, q, which aims at capturing the effect that a change in the level of interest rates has on investment behaviour by ways of companies' capital prices. q is defined by the ratio of the market value of a firm's capital to replacement cost of that capital. The market value is given by the liabilities that the firm commits to in order to finance production multiplied by the market price of liabilities. Replacement cost of capital has to be estimated by the cost that would have to be afforded if the firm had to substitute new production equipment for the existing one. The higher the ratio, the more attractive is the condition at which a firm can raise new capital. If q is larger than one, a company benefits from issuing new stocks or bonds, because it can obtain capital at lower cost than its market value will be. Thus, the firm is induced to increase investment. Variation in q can have numerous reasons of which one is monetary policy. A cut in the interest rate leads investors and savers away from deposits to alternative investment opportunities. Demand for financial assets rises and so does their price. Hence, an expansionary monetary policy raises investment by an increase of Tobin's *q*.

A varying value of Tobin's *q* is incompatible with the efficient markets hypothesis. In a world where prices of financial assets move exactly along fundamental developments, *q* should be 1 (Tobin & Brainard, 1990, pp. 547–549). Anything else would imply that factor allocation is not efficient. As mentioned, the existence of Tobin's *q* as a transmission channel of monetary policy requires at least nominal rigidities, imperfect information, or other market imperfections. Even though Tobin (1969) justifies a flexible *q* by means of a general equilibrium model and exogenous money, he applies a central feature that is also included in the concept of endogenous money and in our alternative view: the interest rate is set exogenously (Tobin, 1969, p. 26). Demand and supplies of assets therefore adapt to monetary policy. Tobin (1969) does not elaborate further the relationship between assets and real output but at least assigns to the financial sphere a certain independence from fundamentals (ibid., p. 16). This is a necessary condition for the financial market and hence Tobin's *q* to have any influence on real variables.

Often, *q* is approximated by the ratio of the price of a stock to its nominal value (see for instance Honda, 2013, pp. 11–12). This is not *per se* wrong but for a more exact measure, it is not only stocks but also corporate bonds that should be taken into account. Basically, the value of a firm is determined by the market valuation of its productive assets, however they are financed (Lindenberg & Ross, 1981, pp. 10–11). This is important, because the structure of company financing affects the strength of the Tobin's *q* transmission channel.

The higher the price of stocks and debt of a corporation, the higher this corporation is valued by the market. The prices of these financial assets must be variable so that the value of *q* is allowed to change over time. A condition for price variation is tradability of assets. A firm credit that is not securitized and therefore not tradable in the stock exchange will always have the same price, which is equal to the nominal value of the debt. Tobin's *q* of a small firm that does not issue any securities and whose production is financed only by bilateral credit from a bank has a constant value of 1. The formula for Tobin's *q* of an average company in the economy is given by equation (2.3).

$$q = \frac{\textit{tradable securities} + \textit{non-tradable liabilities}}{\textit{replacement cost of assets}} \tag{2.3}$$

A larger share of tradable securities thus implies a larger variation of q over time. The more a company is financed by tradable stocks and bonds, the more monetary policy can become effective through the transmission channel of Tobin's q.

The market for crude oil exhibits large corporations whereat almost all are listed on the stock exchange.[24] Even though not empirically assessed yet, this opens the potential for Tobin's q to have an impact on the oil market. In comparison to the rest of the economy, this channel is likely to be more effective in the oil industry. We know without investigating the structure of the non-oil economy in detail that a large share of its output is produced by small firms not quoted on the stock exchange. This is in contrast to the oil industry, which consists for the most part of large companies. From a macroeconomic perspective, the share of tradable securities should therefore be larger in the capital of the oil industry than in that of the non-oil economy. Hence, q grows stronger in the oil industry than in the rest of the economy in response to an expansionary monetary policy. This induces relatively stronger investment in the oil industry. The consequences should then be those of the corresponding case analyzed with regard to the interest rate channel: higher investment in the oil industry than in the non-oil economy is likely to lower the oil price and to raise the oil intensity of the economy. Like a lower interest rate, easier capital acquisition owing to a higher q is reflected in lower production cost.

Wealth Effect

In some sense, the wealth effect is for private households what Tobin's q is for firms. While the latter raise investment in response to an increase in q, the former augment consumption when the market value of their assets increases. This transmission channel is based on the argument by Ando and Modigliani (1963) that consumption not only depends on current income but also on current assets and expected future income, that is, total lifetime wealth. The asset portfolios of households may contain stocks and bonds but are usually dominated by real estate (Rossi, 2008, p. 265). By the same mechanism as with Tobin's q and as examined in the alternative approach to financial markets, an ease in the conduct of monetary policy raises demand for assets. Higher prices of financial assets transmit to real assets directly or indirectly. The case of real estate is similar to crude oil, since it is not only a real asset but as well a financial asset in many cases. A higher price of assets makes household feel richer and thus they raise

[24] In the United States, for instance, there is a large number of small oil producers. However, they make up only for a small fraction of total output (Meyer, 2014).

consumption. The strength of this particular effect is quite controversial (see for instance Ludvigson et al., 2002).

From equation (2.2), which shows how monetary policy affects the oil market from supply and demand sides, it becomes obvious that the wealth effect is exclusively a demand factor. In the course of a drop in the interest rate level, households raise their expenditures for consumer durables or real estate and thereby indirectly increase demand for oil. The wealth effect is not supply-driven, because it does not contribute to the increase of production capacities except in an indirect way by the conventional feedback of the supply side in face of increased demand. Hence, the wealth effect leads to higher change of demand for oil relative to oil supply and thus tends to raise the oil price depending on spare capacities in the oil industry. In the same tendency, oil intensity of economic output falls.

Credit Channels

The credit view is an extension, specification as well as critique of the traditional interest rate channel. It considers that it is not merely the level of interest rates as such that transmits to the economy and affects consumption and investment decisions. It is rather that monetary policy in the same way also alters the conditions for firms to have access to capital. In this sense, it is an “enhancement mechanism” of the conventional transmission channels (Bernanke & Gertler, 1995, p. 28). The literature distinguishes between the bank lending channel and the balance sheet channel, which are also called the narrow and broad credit channels respectively.

The central requirement for the existence of credit channels is that external and internal financing of firms are not perfectly substitutable (Rossi, 2008, p. 266). External financing means borrowing in the credit market while internal financing occurs in the form of firms’ own profit reinvestment or emission of new stocks and corporate bonds. According to the assumption, external and internal financing are subject to different conditions. Some companies do not have access to capital markets and thus exclusively rely on bank credit. The lender is not fully informed about the financial situation and creditworthiness of the borrower (see Stiglitz & Weiss, 1981). Owing to this asymmetric information, the loss risk for a bank by granting a loan is larger. Hence, it imposes a premium in addition to the given general interest rate in order to compensate for the risk. The premium is variable. The higher the general interest rate level, the higher is the risk of an investment failure and so is the loss risk of the bank.

The bank lending channel takes the perspective of the lender, that is, the bank (see Kashyap & Stein, 2000; Kishan & Opiela, 2000; Stein, 1998). Owing to the basic assumption, the firm does not have the unrestricted possibility to change from bank credit financing to self-financing or emission of financial assets in response to a change in the interest rate. This allows emphasizing the entity of the commercial bank as a loan supplier that is different from other financing sources. Thus, the firm's capital volume is constrained by the bank's credit. Even if money is demand-determined and hence basically not limited by the supply side, the issue of loans is constrained by the creditworthiness of the borrower. A further condition for the bank lending channel is, first, the requirement for banks to hold minimum central bank reserves and, second, the impossibility to avoid these requirements by liability management (Rossi, 2008, p. 270). An expansive conduct of monetary policy is effective either by lowering the share of required reserves with respect to the total volume of loans or by making access to reserves easier, or both. A loosened constraint allows the bank to raise the issuance of loans. Lower interest cost decreases risk of investment projects such that the risk premium shrinks, too. The bank lending channel thus strengthens the impact of the interest rate channel.

Unlike other countries, banks in the United States are required to hold positive minimum reserves. These reserves make banks incapable to act unless they hold sufficient liquidity.[25] Thus, the first condition is fulfilled. Indeed, banks that hold little liquidity are found to be significantly more affected by changes in monetary policy, because the loosening of the reserve constraint has a greater impact on them (Kasyhap & Stein, 2000, pp. 408, 425). As a limiting influence, however, increasing financialization in the last decades is likely to have facilitated liability management. It allows enhanced money and credit creation by banks without violating their reserve requirements. The reaction of bank lending to a change in monetary policy is thereby reduced. Yet – and this may also be important as an influence factor on the price of crude oil –, financialization and the bank lending channel seem to have a double-edged relationship. Circumvention of reserve requirements leads to larger credit volumes and risk exposure. Shadow banks do not create money by loan issuance but rely on financial resources that have their origin in the money creation process of conventional banks. The interconnectedness of shadow banks and traditional banks can amplify systemic risk in the course of growing financialization (Financial Stability Board (FSB), 2013, p. 21). A higher leverage deepens bank troubles in times of crisis and thereby financial instabil-

[25] Minimum reserves do not contradict the horizontalist argument of accommodative central bank behaviour. Reserves are supplied according to demand (see Rochon & Rossi, 2011). However, interest rates on minimum reserves involve higher costs for banks.

ity, and thus worsens banks' liquidity situation. The cost of deposit funding is more stable owing to the stability of the deposit rate of interest than the cost of volatile funding in the market by emission of securitized financial assets. Banks that fund themselves to a high degree by market sources reduce credit supply stronger in crisis periods than other banks (Gambacorta & Marques-Ibanez, 2011, pp. 15, 17). The dependence on monetary policy action becomes larger. Hence, the bank lending channel plays an increased role in loosening liquidity during periods of financial instability. Ironically, this appreciation may be promoted by financialization, which is suggested to have contrary influences in normal times.

The balance sheet channel approaches credit effects from the point of view of the borrower. It does not concentrate only on commercial banks as a source of credit but includes as well market funding. The effect of a change in interest rates is augmented by two variables: firm cash flow and collateral (see for instance Angelopoulou & Gibson, 2009; Bernanke & Gertler, 1995; Bernanke et al., 1996). A cut in the interest rate lowers firms' financing cost, especially if it is short-run financing. In response, cash flow increases by a considerable amount in the short run. This improves the financial situation of a firm and mitigates the loss risk of the lending entity. The finance risk premium in addition to the general interest rate decreases. Firms react by increasing investment expenditures. Better financial conditions of firms raise their market value and thereby the net worth of assets that serve as collateral in credit agreements (Bernanke & Gertler, 1995, pp. 35–36, 38–39). Firms can offer more and higher-worth collateral, which reduces the lender's risk and has a decreasing effect on interest cost. Again, the effect of monetary policy is assumed to be weaker, the easier companies have access to internal financing. The approach therefore takes the heterogeneity of borrowers into account. The balance sheet channel is usually found to be significant and more important than the bank lending channel (see for instance Aysun & Hepp, 2013). This is not a surprising result since the bank lending channel is argued *a priori* by theory to be narrower and to cover fewer features than the balance sheet channel.

The issue of financialization has not been investigated but the findings with regard to the bank lending channel are likely to be valid for the balance sheet channel, too. An aspect of financialization is securitization of financial assets. Corporations that finance a larger share of production by market funding instead of bank credit may be more independent of interest rate changes by the central bank, but might rely on it even more heavily than other firms in the case of a financial crisis. Increase of corporate bond rates and fall of stock prices when a crisis breaks out reduce cash flows and liquidity. Moreover, the value of assets drops even further owing to troubles in capital markets and contributes to the worsening financial situation of a company. The balance sheet channel then should become more effective.

The credit view from the borrower side usually concentrates on firm borrowing. Even though this is not done regularly, balance sheets of private households should consequently also be taken into account. An expansionary monetary policy raises financial asset prices. This improves the financial and liquidity situation of households and reduces their risk to get in financial distress (Mishkin, 2001, p. 4). Households can afford more consumption and are imposed a lower premium for external financing by banks. Credit volume for consumption expenditures increases. The mechanism is closely related to the wealth effect.

The structure of the oil industry, mainly consisting of large corporations, implies that it has a good access to internal funding sources. This is in contrast to small firms, which are suggested to fully depend on bank credit. By the same argument that states a stock exchange listing of oil companies above average, the oil industry has a better access to capital markets than the rest of the economy. Thus, under normal circumstances, we expect investment in oil production to react less to a change in monetary policy than expenditures in the non-oil economy. According to equation (2.2), this implicates a stronger reaction of oil demand relative to oil supply and requires a higher oil price in tendency. However, the capital structure of the oil industry may be riskier than that of the non-oil economy. The balance sheet of oil companies directly depends on sales prices of their sales product, to wit, crude oil. It strengthens when the oil price climbs high and contracts when it falls. It is easily shown by comparing the price of crude oil to the consumer price index in the last decades or just by anecdotal evidence that the oil price fluctuates much more than the prices of most other goods (see for instance Kilian, 2010b, p. 4). Oil companies' capital funding may be less constrained by monetary policy in boom periods, when the oil price tends to be high. Conversely, the constraint becomes tighter when financial instability occurs, owing to a falling oil price. The tighter the borrowing constraint, the larger is the effect of a change in the interest rate by the central bank. Financialization is suggested to exacerbate fluctuations not only of the oil price but also of the financial performance of the oil company. Effects of monetary policy on the price of oil thus affect the balance sheet channel by an additional mechanism. This issue is revisited in the next chapter as part of the investigation of the price effects of monetary policy in connection with financial markets.

In a given situation where capital availability for the oil industry and the balance sheets of oil companies are less constrained than those of the non-oil economy, the latter expands investment relatively more, because it is stronger affected by monetary policy. This means that oil demand increases stronger compared to oil supply. This effect tends to raise the oil price and to lower the oil intensity of the economy. In another situation, for instance in a financial crisis, the oil industry's access to credit is likely to be more constrained. The opposite effects should occur then. These impacts are certainly quite difficult to assess empirically. The fact that the non-oil economy reacts stronger to an expansionary monetary policy does not necessarily increase non-oil investment more than investment in the oil industry, because the oil industry can use its access to capital markets to raise investment in correspondence with profit expectations.

2.2.3.2 Monetary Policy Transmission through Financial Markets

Financial markets play an important role for monetary policy transmission, in particular for Tobin's *q* and the wealth effect. Nevertheless, we investigate these channels now in the chapter about monetary policy transmission through fundamentals even though financial markets are involved. The reason for treating the financial markets aspects still separately is due to the dual nature of oil. The fundamental aspects are about the real economy, where oil serves as a physical consumption good. The chapter at hand is about the monetary policy transmission to crude oil when it is traded as a financial asset instead of a commodity. It is shown that this aspect leads to mere price effects in contrast to quantity effects through fundamentals. For instance, despite the influence of financial markets on Tobin's *q*, we still refer to fundamentals because we are interested how real investment reacts to a change in Tobin's *q*. In the next part about financial market aspects, we will examine how a change in Tobin's *q* affects financial investment.

A change in the interest rate by the monetary authority has its effects on supply of and demand for financial assets as argued above. A lower interest level decreases liquidity preference and thus increases demand for financial assets even if the economy is stagnating. Crude oil futures contracts represent an asset, too. Increasing demand for futures implies purchases of long positions. Their price is likely to rise in the course of an expansionary monetary policy, which transmits to the spot price of oil. In opposition to the mere consideration of fundamentals in the previous section, the financial market effect through the interest rate channel implies that it is not only firms or consumers who react to an altered interest rate but as well financial investors. Likewise, there is not only investment in real assets in the form of equipment, real estate, and the like. Investment can also take place in the form of purchases of financial assets in general and of crude oil futures in particular.[26] The financial aspect of the interest rate channel shows that financial investment and hence the oil price increase. The fundamental part of the channel leads to a certain quantity effect by influencing oil production and consumption, while the financial market aspect exclusively yields a price effect.

In the same way that the exchange rate channel is different from the point of view of fundamentals, it differs from the other channels when considering its financial market impacts. Assuming that financial investors know that the oil price and the US dollar exchange rate are correlated, they build their corresponding expectations. When the US Fed lowers the interest rate, which leads to a depreciation of the US dollar, investors anticipate a higher oil price and start betting by purchasing oil futures long positions (Zhang et al., 2008, p. 982). Consequently, the oil price increases.

Similarly, when an expansionary monetary policy raises Tobin's *q* of firms, the improved opportunity to invest does not necessarily lead to the purchase of production equipment. Emission of new stocks and corporate bonds under favourable conditions raise the capital needed for either real or financial investment. Moreover, a higher net worth of companies induces riskier behaviour concerning financial investment. If a certain share of additional financial investment goes to the crude oil futures market, the oil price increases.

In analogy, increased private wealth in the course of monetary policy may lead households not only to enhance the purchase of consumer durables and construction of houses, respectively. Households might increase their financial portfolios and thereby increase demand for crude oil futures contracts. This is the financial market aspect of the wealth effect.

The credit channels have the same price effect. An expansionary monetary policy loosens the constraint of banks' and companies' balance sheets. Increasing issuance of bank loans serves to fund financial investment. Improving balance sheets of companies allow them to get more credit granted. They decide whether to invest it in real production equipment or in stocks, bonds, and futures contracts. One should also con-

[26] Owing to financialization, it becomes even more likely that production companies do not supply financial assets by the emission of stocks and bonds, but become more and more demanders of financial assets by participating in financial investment (see for instance Lazonick, 2012).

sider the specific relationship of oil companies to the balance sheet channel. The effects of transmission channels through financial markets alter the price of crude oil and, in doing so, the latter affects the balance sheets of oil producers, whose oil inventories and sales represent an important part of real assets. Their cash flows and collaterals improve therefore not only by means of a lower interest rate but as well by the financial market effect owing to the dual nature of oil. An expansionary monetary policy is therefore likely to relax the financial situation of oil companies more than that of the rest of the economy. In contrast, a contractionary monetary policy constrains oil companies' balance sheets more and threats their creditworthiness more than those of the non-oil economy.

2.2.4 The Interaction of Fundamentals and Financial Markets

Obviously, the fundamental and financial market aspects of monetary policy transmission are related. A first link is given by the mutual fundamental and financial effects of the balance sheet channels. But there are more general and comprehensive connections. The quantity effects of monetary policy through fundamentals are ambiguous. This means that it is basically obvious that oil quantities, that is, production and consumption of oil, increase when monetary policy is expansionary even though the absolute magnitude of this increase cannot be predetermined and depends on many additional factors. The ambiguity arises from the fact that it is not completely clear if oil quantities increase relatively to the rest of the economy and hence if there is a change in the oil intensity of total economic output. The interest rate channel does not give clear *a priori* results whether the oil industry or the non-oil economy reacts more. The exchange rate channel is an exception in the sense that it represents a mere price effect rather than a quantity effect from a global perspective, whereas the price effect is unambiguous. Tobin's *q* of the oil industry is likely to respond relatively stronger to monetary policy than that of the rest of the economy. In contrast, the wealth effect is merely a factor that enters the economy from the side of the non-oil economy, since it raises consumption and thus demand for oil. The credit channels allow even less for a clear statement about relative strengths in responses to monetary policy. They depend on the state of the business cycle. Moreover, oil companies are specifically affected, because the oil price directly enters their balance sheets. Whether the oil industry or the non-oil economy, that is, the oil supply or demand side, respectively, reacts more to monetary policy is determined by the complex aggregation of the channels of transmission through fundamentals. The sign of the result is an empirical issue. What can be said is that monetary policy can affect fundamentals of the economy and in particular of the market for crude oil without a reason to expect a significant price change of a certain sign. Given a certain change in oil production and consumption following a change in monetary policy, existing spare capacities and capacity-increasing investment tend to prevent a climb in the oil price.

On the contrary, price effects resulting from monetary policy transmission through financial markets are unambiguous. Each particular transmission channel contributes to a rising oil price when monetary policy is expansionary. This occurs since financial investment tends to enter the futures market on the demand side by purchasing long positions. Once the direct effects of monetary policy on fundamentals and futures market are assessed, many interactions emerge that have to be taken into account. We enlighten them against the background of a cut in the interest rate by the central bank. Let us start with the influence that transmission effects through fundamentals have on the futures market. Quantity changes in oil market fundamentals that take the form of higher demand by consumption expenditures, higher non-oil production or higher oil industry investment, respectively, can basically result in almost any possible oil price level. We concluded above that this case of indeterminacy does not raise expectations about significant systematic price changes. Given that there is no price change, financial investors do not adapt their asset portfolio, which they have chosen in response to a change in monetary policy. In the potential case of a drop in the oil price, either due to large investment or a strong negative cost push in the form of lower interest rates, speculators hesitate to bet on a price increase and thereby purchase less long positions. In the opposite case of a price increase, motivation for financial investment grows even stronger and net long positions are likely to increase. While the financial market price effect of monetary policy is weakened in the former case, it is strengthened in the latter. Additionally, even if changes in oil market fundamentals, that is, growth in production and consumption, do not generate any price change, financial investment might nevertheless increase because investors expect that oil becomes scarcer in the future such that they will benefit from speculating for a rising oil price.

Next, let us have a look at the effect of monetary policy transmission through financial markets on oil market fundamentals. The one-directional effect of financial markets on the oil price has its impacts on oil market fundamentals that are more pronounced since its sign is quite unambiguous. A higher oil price caused by financial investment lowers demand and increases supply in the spot market. The magnitudes of reaction depend on the price elasticities of demand and supply. One may argue that mutual feedbacks between supply and demand regulate the oil price and keep it within certain ranges in the medium run. However, the dual nature of oil does not permit us to treat the oil market like a conventional goods market as it is usually presented in textbooks.

The financial market trade of oil futures represents an exogenous influence factor to supply and demand forces in the spot market. Figure 2.2 showed how financial speculation affects the oil spot market without preceding changes in fundamentals. Consequently, a thereby accelerated price does not necessarily revert back to its initial level when supply and demand in the spot market adapt to this exogenous impact. Moreover, we explained that a higher oil price induced by financial markets can also be profitable for oil companies even though it reduces demand in the spot market. Decreasing oil sales are overcompensated by increasing open interest in the futures market, which is, measured in US dollars, equivalent to spot sales from the point of view of oil companies. Hence, the oil price is not inevitably reduced even if oil demand decreases. As a usual reaction to higher prices, the oil industry increases supply by extending production capacities. This will pull the oil price down over a longer period despite its current high level. How much oil supply is increased by the oil industry, how low the oil price eventually falls and within which period of time depends on the relevant elasticities as well as on the strength of the financial market impact and its continuance. Persisting expansive monetary policy actions have the potential to keep the oil price high for a longer time period despite counteracting movements in fundamentals.

The crucial difference between price climbs induced by speculation in the futures market and those caused by excess spot demand can be explained as follows. Assuming away financial markets, the oil price increases either when supply decreases while demand is stable or when demand increases while supply is stable or both, respectively. In any case, supply fails to satisfy existing demand at the existing price. In contrast, a speculation-caused price increase is driven by demand from the futures market. It is not that spot demand grows in excess of spot supply. Rather, growing financial asset demand makes it profitable to sell oil in the futures market by going short by an increasing amount. Hence, it is not that a supply constraint in the spot market is the cause of the higher price, since oil production is confronted with spot demand that is falling rather than rising. As a consequence, oil companies respond by higher investment and raise production capacities. But increased oil production does not necessarily lower the oil price immediately as it would be the case if excess demand in the spot market was the origin of the price hike. Owing to the exogenous demand force, that is, demand for futures contracts, the oil price may last at the higher level even when demand in the spot market decreases. Once monetary policy becomes less expansionary, the price effect of financial markets starts disappearing and the oil price necessarily decreases.

The fact that the financial market effect involves higher oil production through oil industry investment is rather intuitive. The influence on oil consumption is less obvious and should be emphasized. Even though oil supply and oil production on the one hand and oil demand and oil consumption on the other hand are often taken as practically the same thing, respectively, they differ in some important aspects. Supply and demand extend to the futures market, while production and consumption are limited to the spot market. When expansive monetary policy raises the oil price by means of speculation, both oil supply and oil production increase because they react to the same incentive. Total oil demand increases, too. However, it increases not uniformly as its composition changes. Demand in the spot market shrinks but is replaced or overcompensated, respectively, by demand in the futures market. Falling spot demand means falling oil consumption. Growing total demand and decreasing consumption are reflected in rising inventories as explained in detail in this chapter. Speculation contributes to falling oil consumption whereby the extent of the reduction depends on the price elasticity of (spot) oil demand.

At the present point of analysis, neoclassical theory would probably argue that the financial market effect, if it ever exists, has its distorting influence on fundamentals before it vanishes again. The economy goes back to its long-run equilibrium path. However, there are many reasons to suggest that monetary policy transmission through financial markets has long-term persisting impacts. On the supply side, one might suggest that rising oil production will go back as soon as the oil price falls back owing to the fading out of the financial market effect. A lowering oil price will reduce oil supply by the same amount as it had raised supply when it was increasing. Yet, to be realistic, real investment in oil production is hard to be withdrawn once it is realized. Since a large share of it consists of fixed cost expenditures, oil sales are required to cover fixed cost beside of variable production cost. Constructing a whole new production plant might be unprofitable when the oil price is low. In contrast, given that the production plant exists already (considering fixed investment as sunk cost), producing oil is profitable as long as the return of a unit exceeds its variable production cost (see for instance Vickers, 1960, pp. 407, 409). Thus, existing increased production capacities tend to be used even if the existing lower level of the oil price in a given moment does not induce any investor to raise oil industry investment owing to missing profitability. Therefore and crucially, we conclude at this point that real oil industry investment induced by the high price, which is itself due to monetary policy and speculation, lowers the oil price again and probably to a lower level than at the beginning of the causal chain due to larger production capacities. At this point, the economy ends up with a higher oil production than before.

Oil demand may as well be argued to go back to its initial level after the disappearance of the financial market effect. But there is an aspect that has been in the background so far and that mitigates the hitherto conclusion. We have assumed that technology and technological progress, respectively, are given in a specific point in time, so that the effects of monetary policy can be examined without having to take into account such long-run developments. At this place now, the neutrality of technological process should be abandoned. It may be true that consumption expenditures react symmetrically to oil price changes in the sense that oil consumption is the same before a price climb and when it drops back to its initial level. For example, consumers might in average buy smaller and more efficient cars when the oil price is high and move back to more wasteful motors after the reversion of the price.[27] In contrast, it is more likely that in many areas, such as industrial production or house heating, producers and owners start looking more intensively for alternatives. This should promote technological innovations in favour of more efficiency and non-fossil energy sources. For instance, Bayer et al. (2013) show that a high oil price has a significant positive influence on renewable energy innovation. Once new production technologies are invented, applied and established, they are likely to sustain even after the fall of the oil price. The demand curve then shifts downwards; oil consumption is *ceteris paribus* lower than before the price climb. This effect is less obvious and more unforeseeable than supply-side effects. So it should be considered as an aspect that mitigates the hitherto arguments but does not replace their basic logic. This can partially be seen from Figure 1.5, which reveals that the share of renewable energy (as a fraction of electricity) is hardly ever 10 percent of total energy consumption, so that demand-side effects are empirically limited. If real investment in the oil industry, triggered by the speculative increase of the oil price, lowers that same price to a lower than the initial level, oil consumption is likely to be higher than initially as well. The oil intensity of the economy therefore increases. This issue will be subject to central discussions in the empirical and economic policy parts of this work.

It is a difficult task to assess whether monetary policy affects the oil market more through fundamentals or through financial markets. The fundamental aspect of transmission channels requires sufficient effective demand to become significant. When the economy is in a slump and does not react to cuts in interest rates, the financial market aspect is likely to be stronger relative to the fundamental aspect. In the opposite case of a recovering economy that raises investment expenditures and credit creation in response to monetary policy stimulation, the relative impact of the futures market may

[27] Remember the anecdotal citations in the introduction.

be smaller. Futures prices might still increase in this latter case but they may be to a larger share a reflection of well-performing fundamentals than in the former case.

What seems to be clear and is generally argued equally by neoclassical and heterodox economists is that financial markets are more flexible than the real economy. They gather new information faster and contribute in this way to efficient price discovery according to neoclassical theory. Even though our alternative view does not support this proposition without restrictions, we confirm that financial markets react faster to new conditions whereas fundamentals exhibit more lags. The impact of monetary policy on financial markets is therefore likely to happen before changes in fundamentals start working. Financial investors aiming at exploiting small arbitrage opportunities use to adapt investment strategies rather immediately in the face of changing conditions. Investment decisions in the real economy take longer time to evolve and to be implemented. This difference in reaction time appreciates the importance of financial markets. The price effect in form of a higher oil price exerts its impact on the real economy and particularly the crude oil market before oil companies and the rest of the economy have decided how much to invest in light of a lower interest rate. A partial effect that might take place relatively fast in the real economy is lower production cost owing to lower interest. But even Gibson's paradox is expected to materialize only gradually until the new interest rate level is established in all branches and companies.

The price effects that emanate from the oil futures market alter supply and demand in the spot market and can therefore have lasting impacts on fundamentals. The time difference of monetary policy transmission through financial markets and through fundamentals additionally supports the view that financial markets are not simply a reflection of what happens in the real economy. Rather, they can also have substantial impacts on production and consumption of oil, potentially even in the long run. By applying the conception of general equilibrium, this analysis implies that the equilibrium is not stable but moves permanently (see for instance Moore, 2008). The fact that the equilibrium is not only determined by real forces but as well by monetary factors radically calls the general equilibrium approach in its neoclassical meaning into question.

The overall analysis conducted so far suggests that the effects of monetary policy are not symmetric. When the central bank raises the short-run interest rate, monetary policy transmission through fundamentals is expected to take place conventionally by entering production cost and affecting investment decisions. The relevant variables take a path just conversely in the case of an expansionary monetary policy. The financial market aspect, however, is different. First, it is more difficult to speculate for a falling oil price. This would be the symmetric opposite to betting on an increasing price, which is suggested to happen in the course of an expansionary monetary policy. Such speculation might be profitable if a lower oil price is expected. But inducing a lower oil price by financial investment without a change in fundamentals is unlikely for reasons outlined above. The difference between expansionary and restrictive monetary policy is not that the former leads to higher demand for financial assets while the latter triggers higher supply for assets. The difference is that an expansionary monetary policy raises speculative activity while restrictive policy actions reduce it. Higher interest cost makes investment capital more expensive and profitable investment riskier. Investors' motivation shrinks and money creation for the purpose of financial market investment decreases. Smaller investment capital cannot exert the same demand power and hence financial asset prices tend to fall. Thus, a change from more expansionary to more restrictive monetary policy does not mean that speculative activity turns into its opposite. It rather implicates that speculative activity declines. The higher the level of interest rates, the less monetary policy transmits through financial markets. The fundamental aspect of transmission remains. In the environment of a restrictive monetary authority, the oil price therefore tends to be determined more exclusively by fundamental forces.

The price effect that originates in the futures market reveals that crude oil has a specific link to inflation. Monetary policy transmission in its conventional understanding occurs through fundamentals and is argued to lead to a quantity effect. Insofar that it leads to rising demand for financial assets, prices of stocks and securities start rising. So-called asset price inflation (see for instance Dalziel, 1999-2000; Schwartz, 2002) is not directly linked to the consumer price level and therefore does not lead to a higher inflation rate in the economy. Stock prices can basically fluctuate without corresponding changes in the general price level of the producing economy. Its dual nature makes once more a particular case of crude oil. Asset price inflation includes the asset of crude oil futures. Its character as an asset and a commodity at once automatically and necessarily transmits price changes caused by financial investment to the spot market. The spot price of oil enters the measured rate of inflation. Even if core inflation is taken instead of overall inflation in order to exclude energy and food prices, the oil price should still affect the general price level, because oil is a widely used raw material input for production (see for instance Cavallo, 2008). Whether this accelerating impact on inflation rates is a demand-pull or a cost-push case depends on the point of view and corresponds to Kalecki's (1987, p. 100) distinction of cost-determined and demand-determined prices: prices of raw material increases when demand increases owing to inelastic supply in the short run. However, from the perspective of a single company that uses oil as an input, the higher oil price appears as a cost push that is reflected in prices of finished goods.

Figure 2.2 has shown how higher demand in the futures market raises the spot price owing to the almost vertical short-run supply curve. Demand in the spot market decreases, but the oil price remains at a higher level and thus raises production cost. In this respect, monetary policy does not only lead to higher inflation rates to the extent that higher demand exceeds production capacities in the real economy. It has a second link by affecting commodity prices in financial markets. If the higher oil price induces higher investment and higher capacity utilization and thus raises oil supply in the long run, the inflationary effect might be reversed or even more than reversed when the expansionary monetary policy is brought to an end. The resulting falling oil price does not only stabilize the general price level but should rather have a lowering influence on the latter. The importance of this inflationary impact is an empirical question. Literature usually finds rather limited evidence for higher prices of oil and other commodities to be a source of headline inflation (see for instance Cavallo, 2008; Cecchetti & Moessner, 2008). Chen (2009) argues that the pass-through of the oil price into inflation has decreased since the 1980s in most industrial countries. However, the financial market effect on the oil price is a theoretically founded channel about how monetary policy can influence the general price level.

To conclude this chapter, one can argue that the impact of monetary policy on the oil market through fundamentals affects the strength of the financial market effect while the latter influences real forces in the spot market by a price effect. The effects can be persistent, both on the supply and the demand side of the oil market. Their magnitudes and duration depend on the state of effective demand and on the persistency of a specific strategy of monetary policy. The relative importance of fundamental and financial market aspects of monetary policy transmission is therefore not stable. Moreover, the relationship between both ways of monetary policy transmission determines to what extent the price effect from the futures market is reflected in a higher rate of inflation in the real economy. Finally, it should once more be taken into account that beside of elasticities and market structures, monetary policy is implemented against the background of various additional variables. The effectiveness of monetary policy in its different aspects depends on the state of the business cycle, existing underground oil reserves and the long-run technological trend. On the other hand, the effects that monetary policy has on the market for crude oil might also influence at least some of these background and long-run variables.

2.2.5 Speculation in the Oil Spot Market

A large fraction of the literature about monetary policy and commodity prices focuses on a kind of transmission channels that are specific to the oil market (see for instance Anzuini et al., 2013). This approach has mainly been developed by Frankel (Frankel, 1984, 2006, 2014; Frankel & Rose, 2010). It is based on a no-arbitrage condition that contains the interest rate, the price of crude oil, storage cost and convenience yield, and is thus similar to the above discussed model of Kaldor (1939). The framework takes the form of an overshooting model and thus departs from the assumption that there is an equilibrium price of oil to which the actual price tends to revert in case of deviation. In particular, it is assumed that oil companies have to decide between selling produced oil and holding it as inventories. Sales revenues can be invested at the risk-free interest rate. Alternatively, storing oil brings the net benefit of convenience yield and carrying cost as well as the expected price change. The condition of no arbitrage implies that both opportunities yield the same expected return. A change in the interest rate, say, a cut, requires therefore that the oil price is expected to fall for the equation to be satisfied. For this to become possible, the oil price has to shoot up first such that gradual reversion to the equilibrium price justifies expectations of a falling price. Hence, a falling interest rate leads to a higher oil price. The intuition is given by three transmission channels (Frankel, 2006, pp. 5–8). First, lower returns from investment of sales profits owing to a lower interest rate make it attractive to hold more inventories. Secondly and analogously, it is relatively more profitable to leave oil under the ground. In this sense, underground reserves are a part of inventories. Thirdly, speculators shift their portfolio from now lower-return bonds to oil futures contracts. While we already incorporated the latter one of these channels by our emphasis on monetary policy transmission through financial markets, the former two add a new aspect to our issue.

Yet, the assumption of the arbitrage condition in question is not without criticism. On the one hand, it may rely on basically logical aspects, but, on the other hand, it runs the risk of being a theoretical consideration not linked to practice. For instance, Frankel (2014, p. 96) assumes that the storage cost rises linearly with the level of inventories while storage capacities do not change. There are no data for the latter. Furthermore, it might be true that oil companies hold realized profits in bank deposits or in riskless bonds. However, it might as well be true and maybe even more likely that large corporations like those in the oil industry invest their liquidity in other investment alternatives. It is argued that oil sales revenues (the so-called ‘petrodollars’) use to flow systematically into stock markets rather than only being invested in government bonds (Varoufakis et al., 2011, p. 326). Moreover, there is more than only one interest rate. Hence, the arbitrage condition requires a preceding assumption about the choice of the specific interest rate to rely on. Producers might also adapt their behaviour to other prices like the exchange rate. Referring to this finding, it seems that the interest rate is not a key benchmark for oil companies to decide on their inventories. The arbitrage condition that is at the base of the commodity-specific channels is thereby insufficiently verified. Concern about the stability of the arbitrage condition challenges monetary policy transmission through these channels.

Furthermore, it should be mentioned that Frankel's approach does not only apply to commodities but likewise to many other sectors where goods stocks are held and where supply and demand are not fully elastic. This would imply that restrictive monetary policy raises inventories and thus contributes to a higher general price level. If this effect held true, the understanding of monetary policy would heavily be shaken, particularly from a monetarist perspective. While such an arbitrage condition is helpful to give some hints about possible 'contango' and 'backwardation' situations in the oil market, it is more critical to use it as a starting point to investigate monetary policy transmission.

Despite the probable weakness of the arbitrage condition, this approach raises a question that deserves to be discussed. It is about whether or not oil companies actively alter inventories in response to monetary policy. In other words, do oil producers behave speculatively by raising or lowering the volume of stocks? The instrument of speculation would be oil in its physical form instead of 'paper oil'. Our hitherto conducted investigation concentrates on speculation in the futures market while the issue at hand refers to speculation originating in the spot market. It has been shown above that as long as the price elasticity of oil demand is larger than zero, inventories inevitably have to increase in order that speculation can have an effect on the oil price. Stock accumulation in this case is driven by increasing demand for futures contracts in the futures market. It has equally been shown that inventory building is not a condition that makes price speculation impossible, since it can be profitable for both oil producers and financial investors. Oil corporations raise inventories because they sell an increasing share of oil in the futures market instead of the spot market. This happens owing to rising demand coming from the futures market. Hence, speculative activity in the futures market is the force that causes oil stocks to augment. Inventory accumulation is a reaction to a higher oil price. Frankel's assumption of no arbitrage and the suggestion that oil producers may themselves behave speculatively turn causality around: it is argued that inventory accumulation is the reason for a higher oil price, because the behaviour of oil companies produces scarcity in the spot market.

There are some ways how oil companies might autonomously decide on the level of inventories in response to a change in monetary policy. Let us assume again that the central bank cuts the interest rate. Then, oil producers may anticipate an increase in the price of oil according to monetary policy transmission through the futures market. In order to realize speculative profit, they shorten supply by raising stocks, which they can sell at the higher price later. This strategy has an additional positive influence on the price of oil. Expected depreciation of the US dollar should raise the oil price and induces oil corporations to the same behaviour. On the other hand, producers might as well be aware of increased speculative activity in financial markets when monetary policy is expansive. Hence, it results not only a higher oil price but higher prices of most financial assets. Oil companies might therefore be induced to enhance stock market investment. To raise investment capital, profits should be increased by larger oil sales, which tend to lower inventories. This potential second effect mitigates the others.

Speculation rooted in the spot market is different from speculative activity in the form of financial investment. Speculation in the futures market is demand-determined. Increasing inventories and decreasing spot demand are results of overcompensating demand for oil futures contracts. Speculation in the spot market is supply-driven in the sense that the supply side of the crude oil market (oil companies) is the origin of the price change. They constrain oil supply by increasing stocks. Financial speculation in the futures market appears as an exogenous force to the spot market such that the price increase is not *a priori* reversed by reactions in the spot market. Speculative behaviour of oil producers is an endogenous factor. Supply shortening has – among other impacts – an effect on demand that redounds on supply owing to its endogeneity. Raising the oil price by lowering supply might reduce demand to an extent that profits of oil companies decline. No firm would probably be willing to do that. In the futures market, speculative demand pushes up the price. But since the number of contracts is not limited and as an increasing price does not lower demand but raises it further because of investors' profit expectations, there are no direct correction factors that would lead the futures price automatically back to its initial level. It is only over time that speculative price hikes in financial markets require corrections owing to its contradiction with the real economy. In the oil spot market, however, speculation has direct constraints owing to conventional supply and demand feedback mechanisms.

The likelihood that oil companies behave speculatively is determined by a number of factors. First, price elasticity of demand must not be too large. A small elasticity estimate allows a price increase to persist without being fully reversed by lower demand. Secondly, competition in the oil spot market cannot be perfect. There must be a certain degree of monopoly. Otherwise, speculative supply cuts of one oil company are compensated by another. Perfect competition would imply full capacity utilization (see for instance Kalecki, 1987, pp. 71–82). Thirdly, in the case of a high degree of competition, the price elasticity of supply should be sufficiently low. This means that competition takes a certain time to evolve such that supply cuts by some companies are not evened up immediately by others. A fourth factor might be the amount of existing reserves. In expectation of exhausted global oil reserves in the near future, oil companies should tend to raise oil inventories. Inducing a price increase by the augmentation of inventories is easier to afford when oil producers expect that the oil price will anyway rise soon. Competition in the market may penalize speculative behaviour by a loss in market shares in the short run. But strategic behaviour will bring longer-run profits when oil reserves become scarcer.

The more these factors apply to reality, the more the oil spot market is able to affect the oil price by speculative manipulation of inventories. If they do not apply, apart from some certainly existing time lags, a higher oil price – in the absence of speculation in the futures market – leads to lower inventories, because the only thing non-speculative oil producers aim at is the satisfaction of a growing demand for oil. As usual with respect to the issue of speculation, these factors probably apply to some – though limited – degree but they do not allow the manipulation of the oil price in the long run. If accumulated inventories are not sold, they do not contribute to oil companies' cash profits. To realize profits, sufficient effective demand requires a sufficiently low price level. Hence, the oil price cannot stay at too high a level for too long.

Dvir and Rogoff (2014) show that there is a long-run cointegrating relationship between supply, demand, and inventories. They argue that under the condition that supply is inflexible, higher demand leads to higher inventories. This means that producers and traders behave speculatively as they expect that this will raise the price further. Supply inflexibility is suggested to have lasted since 1973 (ibid., p. 114). Even though this is only a long-run result without any indication about the direction of causality, its intuition can analogously be applied to our short-run considerations. Given high demand, supply constraints in the short run can take the various forms outlined above: either competition is imperfect, which gives producers a certain power to limit supply, or supply elasticity is sufficiently low owing to time lags. Or supply is inflexible as producers are aware of shrinking oil reserves.

The argument that a higher oil price is correlated with higher inventories if the former is driven by speculation is well accepted. While we claim that the causality goes from the oil price to inventories owing to financial speculation in the futures market, we shall not fully reject that an additional impact of speculation might be exerted by causality from stocks to price. However, we suggest financial speculation to be stronger and longer-lasting, because the futures market does not face the same constraints that the spot market does. The variable to which oil companies adjust speculative behaviour in the sense of Frankel (Frankel, 1984, 2006, 2014; Frankel & Rose, 2010), be it interest rate, stock market performance or future oil price expectations, is indeed even less obvious.

We argue that the interaction between the financial market and the fundamental aspects of expansive monetary policy transmission to the oil market induces oil producers to raise supply: a higher oil price originating in futures market speculation raises profit expectations of oil companies. Production should therefore grow. This may appear as a contradiction to the argument of speculation in the spot market, where oil companies reduce rather than raise oil supply. Yet, there is heterogeneity in the oil market and producers may have different strategies according to different time horizons. Heterogeneity means that some companies might speculate while others may behave simply competitively. Moreover, a company may reduce oil supply at short horizon but simultaneously raise investment to be able to increase production in the future. Hence, both possible outcomes are compatible as we suggest speculation in the spot market to be effective only in the short run.

II MONETARY POLICY AND CRUDE OIL IN THE REAL WORLD

3 US Monetary Policy and the Global Crude Oil Market

The first part provided a sufficient introduction of the general financial market mechanisms and contributed a theoretical detailed analysis of the working of the spot and futures markets for crude oil. For analytical clarity, however, the investigation was conducted in an abstract way without being embedded in the frame of a real-world economy or an actually existing monetary policy institution. In this part, we connect the results to current practice of central banking. Furthermore, we enlighten the crude oil market in its geographic and temporal integration and present the practice of crude oil pricing. Briefly, crude oil is connected to its closest substitutes in the energy market. And finally, we investigate how monetary policy of a single country can affect the global crude oil market.

3.1 US Monetary Policy in the Twenty-First Century

Until now, we represented monetary policy by simple manipulation of the short-run interest level. Yet, practical implementation is more sophisticated. Moreover, and crucially for the empirical analysis, the so-called "unconventional" monetary policy should be emphasized.[28] It works partially analogously to conventional policy but features as well specific mechanisms and specific transmission channels. They are treated now for a proper understanding of monetary policy practice and how it is integrated into the hitherto framework.

3.1.1 Basic Mechanisms of Monetary Policy Implementation

The Federal Reserve System of the United States pursues three main long-run goals of monetary policy, that is, "maximum employment, stable prices, and moderate long-term interest rates" (Federal Reserve System, 2014b). While the goal of price stability is quantified by a targeted inflation rate of 2 percent, the Fed does not locate fixed long-run values of employment and interest rates, as they depend on respective economic circumstances. In the short run, daily monetary policy actions have the target of the federal funds rate at the centre. The fed funds rate is the interest rate at which fi-

[28] The term "unconventional" monetary policy is criticized by some authors outside of the neoclassical school since it does not affect the endogenous nature of money (see for instance Lavoie, 2014, pp. 226–229). However, since the literature largely referred to uses the term, we accept it for convenience.

nancial institutions with access to central bank reserves – which use to be commercial banks – lend those reserves to one another. This kind of interest rate targeting corresponds well to the approach of endogenous money, which argues that the interest rate rather than monetary aggregates is the exogenous variable. It was the troubles in the 1970s and 1980s that led away from money supply targeting to inflation and interest rate goals (Lavoie, 2014, p. 218).

The federal funds rate is the result of supply and demand in the market for reserves. It consists of reserves from the central bank, which are generally referred to as 'borrowed reserves' (see for instance Ennis & Keister, 2008, p. 241). Borrowed reserves are granted to depository institutions at the discount rate. Reserves that are exchanged in the interbank market are 'non-borrowed reserves'. It is changes in reserves or in the discount rate that allow the central bank to reach the targeted level of the federal funds rate in particular and thereby influence interest rates across the whole economy. Arbitrage activity connects the target rate and market rates of interest. The transmission does not lead to exact equalization of different rates but only determines the direction of changes (see for instance Atesoglu, 2003-4; Payne, 2006-7). Market rates are, naturally, further influenced by exchange rates and financial market factors.

In practice, there are three tools that the US Federal Reserve can use to realize the target funds rate (for details about practical implementation, see, for instance, Krieger, 2002, pp. 73–74). First, it determines the quantity of open-market operations. By means of these so-called repurchase agreements (repos), the central bank lends reserves to depository institutions under the agreement to pay them back within a time span of a few days up to several weeks during normal times. Open-market operations are backed by securities, which serve as collateral and are offered by the borrowing institutions. The second instrument is the setting of the discount rate. It transmits to the interbank market and hence has an influence on the federal funds rate. Nevertheless, it is – taken alone – not sufficient to guarantee the achievement of the target funds rate level as will be seen. Thirdly, banks are required to hold at least a minimum level of reserves. They use to be measured as a fraction of total transaction deposits of banks and must be fulfilled as an average over respective maintenance periods of two weeks (Ennis & Keister, 2008, p. 238). In case of non-fulfillment, banks have to pay a proportional penalty fee (ibid., p. 239). Reserve requirements are on the one hand suggested to reduce risk in the banking sector, because they lower the probability that a specific bank gets into liquidity shortage when depositors raise demand and take off their balance in an unexpected moment. On the other hand, this tool is suggested to control loan issuing of banks to the public through the restriction of the minimum share of reserves in balance sheets. Reserve requirements are clearly subject to the exogenous-money approach, as they rely on the concept of the monetary base and the money multiplier. Thus, they are naturally often an issue of criticism. Rochon and Rossi (2011) argue that reserve requirements would only be an effective instrument to control the volume of money creation if the central bank did not behave in an accommodative way and if reserve payments were not exclusively settled in the accounts of the central bank by exclusive means of central bank money. As long as these conditions hold, reserve requirements are neither useful nor necessary. As outlined at the beginning, accommodative supply of reserves is a realistic feature, since otherwise banks would get into financial trouble quite often owing to missing liquidity. The central bank is well aware of this fact. It endeavours not to risk a banking crisis and thus satisfies any demand for reserves. Hence, banks know that they have access to central bank reserves at all times. This suffices to prevent banking crises of this kind. Moreover, it shows that given the demand for credit in the economy, the central bank does not really have the power to stop loan growth.

Yet, accommodative monetary policy does not imply that banks have unconditional free access to reserves. Accommodation of reserve demand only takes place under reconsideration of the targeted federal funds rate. Given that the funds rate target is met, depository institutions can basically resort to reserves in an unlimited amount. Once the monetary authority has set and reached an interest rate target, the quantity of reserves is determined by demand. The second condition postulated by Rochon and Rossi (2011) is as well satisfied by the fact that the central bank balance sheet is the one and only place where reserve payments are finally settled. Reasonably, therefore, reserve requirements are an ineffective tool to regulate monetary conditions.

Institutionally, the US Federal Reserve System consists of twelve regional Federal Reserve Banks that coordinate the conduct of monetary policy. The Federal Open Market Committee (FOMC) meets regularly and decides about open-market operations. A fraction of the FOMC, the Board of Governors of the Federal Reserve, is responsible for the setting of the discount rate. Finally, the FOMC determines the target level of the federal funds rate. The decisions are communicated to the public. These basics about monetary policy implementation are generally applied. However, when distinguishing between conventional and unconventional monetary policy, some additional features should be taken into account.

3.1.2 Conventional Monetary Policy

The conduct of conventional monetary policy implementation in the United States in the twenty-first century exhibits a distinct change in the year 2008 as explained, for instance, by Lavoie (2014, pp. 221–223). Prior to 2008, the FOMC used to set the federal funds rate target somewhere between zero and the discount rate. Arbitrage between borrowed and non-borrowed reserves tends to equalize the funds rate and the discount rate. Banks prefer to borrow in the interbank market, if the federal funds rate is lower than the discount rate and *vice versa*. But equality between the rates is not effectively reached. The federal funds rate is the endogenous result of supply of and demand for borrowed as well as non-borrowed reserves. The discount rate, contrastingly, is exogenous and sets the condition for borrowed reserves. The existing amount of reserves is reflected in the federal funds rate. The central bank can lead it to the target level by setting the discount rate, that is, the interest rate for additional reserves, above the target level. This prevents borrowed reserves to grow further. In this way, the federal funds rate is consolidated at its level. Even though arbitrage does not result in the equivalence of interest rates, it is responsible for the transmission of changes in the exogenous rate to the endogenous rate. This system reveals a basic problem: the central bank aims at realizing the interest rate target. For this purpose, it has to manipulate the supply of reserves by setting the discount rate. At the same time, it is effectively obligated in practice to accommodate changes in reserve demand so that the financial system is not jeopardized. Hence, there is a trade-off that complicates the successful achievement of the federal funds rate target. In contrast to the system after 2008, the central bank faces more difficulty to reach the target rate as it has only one benchmark to manipulate, that is, the discount rate. This has changed since then.

In the course of the financial crisis in the second half of 2008, the Fed modified its monetary policy implementation and adopted a corridor system (Lavoie, 2014, pp. 223–225). The first crucial difference is that the deposit facility rate, to wit, the rate at which banks can deposit their reserves at the central bank, became positive while it had been zero before. Logically, it is always lower than the discount rate. This implies that the federal funds rate target inevitably lies between the discount rate and the deposit facility rate. Arbitrage prevents the climbing of the federal funds rate above the discount rate. In the same way, if the federal funds rate were lower than the deposit rate, the interbank market would break down, because all banks would deposit their excess reserves at the central bank, which would guarantee them a higher profit. The discount rate and the deposit facility rate are therefore the upper and lower bound of the target rate, respectively.

The second change in 2008 was the choice of the federal funds rate target. There are basically three different systems: the floor, the ceiling, and the symmetric system (Lavoie, 2014, pp. 223–225). They set the target rate of interest at the lower bound, the upper bound, or symmetrically in between, respectively. The US Federal Reserve adopted the floor system. It means that the target rate and the deposit facility rate are equal. The system implies a large supply of reserves to bring down the federal funds rate sufficiently. This brings the advantage that the central bank is more flexible. Before, reserves were demand-driven to the extent that the federal funds rate target was not violated. Under the floor system, even this last constraint on reserves is removed. Given the large supply of reserves that equalizes the federal funds rate and the deposit rate, reserves can be acquired in the interbank market without any loss, because they can be deposited at the same rate at the central bank in case of excess reserves. Banks do not have to optimize reserves to a minimum anymore. Hence, monetary policy can be made without facing any trade-off between the target rate and stabilization purpose when the financial system is in need of reserves. Open-market operations and reserve policy are now two completely independent policy instruments (see for instance Goodfriend, 2002, p. 6). Corresponding changes in the deposit rate and the target rate can realize the pursued interest rate level while reserves do not necessarily have to change. Just as well, the amount of reserves can alter without triggering a change in the interest rate level (Borio & Disyatat, 2009, p. 3). One might argue that the central bank can now control the supply of reserves beside of the control of the interbank rate (see for instance Lavoie, 2010, p. 18). However, given that the supply of reserves must anyway be sufficiently large to keep the target rate at the deposit rate, the quantity of reserves that finally comes into existence is determined by demand for reserves. No more reserves can exist than depository institutions want to borrow. The need for reserves is itself dependent on credit demand from investors in the economic system. Under a floor system, banks might borrow quite large reserves and deposit them at the central bank. Such reserves exist but they are in fact unemployed. Their employment is again driven by demand. In this sense, it is reasonable to conclude that the adoption of the floor system has completed the demand-determined nature of endogenous money.

3.1.3 Unconventional Monetary Policy

The outbreak of the financial crisis in 2007 has led to fundamental changes in how central banks make monetary policy. In particular, it was in 2007 when the US Federal Reserve started taking unconventional measures to provide financial markets with liquidity. In general, unconventional monetary policy is perceived as offering open-market operations at extraordinarily low discount rates or as large asset purchases by the central bank. Defining the term reveals that not all aspects of such activity are unconventional. An extensive analysis of the basic features of unconventional monetary policy by Borio and Disyatat (2009, p. 5) reminds that policy interventions in foreign exchange markets share most of the characteristics of asset purchases but were common rather than unconventional in the past in numerous countries. Thus, even though we keep referring to it as unconventional monetary policy owing to the generally accepted terminology, in the following it may as well be seen as a kind of balance-sheet policy in a broader sense.

Quantitative easing is the most common term for asset purchases. Depending on the type of assets, Borio and Disyatat (2009, pp. 7–8) distinguish exchange rate policy, quasi-debt management, credit policy, and bank reserves policy. The former three types refer to the purchase of foreign currency, government bonds, and private sector assets, respectively. Bank reserves policy corresponds to a policy stance where the monetary authority targets a specific amount of reserves. The US Federal Reserve unfolded its activity in quasi-debt management and credit policy.

Asset purchases can be neutralized by counteracting actions (like repos). This is what the Fed did in 2007 and partially in 2008 (Lavoie, 2010, p. 3). In this case, the balance sheet of the central bank remains constant in its length. What took place after quantitative easing without neutralization has lengthened the central bank balance sheet to a hitherto unseen volume. The change of the implementation framework from the original system with a reserve deposit rate of zero to the floor system with a positive deposit rate took place at about the same time. On the one hand, it allows the monetary authority to separate the interest rate and the reserves instruments and to use them independently as explained above. This enhances the opportunities offered by unconventional monetary policy, because it can principally be executed without affecting the interest rate target. On the other hand, the federal funds rate approximated zero in December 2008 (ibid., p. 8). Expansive monetary policy in its conventional form of manipulating the federal funds rate found its limits and became ineffective. Hence, the change to quantitative easing was not a free choice but rather a necessity from the perspective of the central bankers.

Unconventional monetary policy is often understood in the public as a flooding of the economy by huge amounts of free money. As McLeay et al. (2014, pp. 21, 24–25) explain, central bank purchases of financial assets, say, government bonds, compensate the original bond holder by an equal amount in the form of money that the latter holds as a bank deposit. The thereby increased liabilities of the commercial bank are rebalanced by a corresponding increase in central bank reserves that the bank holds. Reserves enter the central bank balance sheet on the liabilities side and thus equate it as its assets side has grown owing to government bonds purchases. Hence, while the balance sheet of the original asset holder remains constant, the balance sheets of the commercial bank and the central bank both increase by the sum of the assets' market value. Net wealth has not increased for anybody; quantitative easing creates no free money. The only change in this respect may occur by an increase of asset prices that takes place when the central bank exerts demand for a limited number of assets.

Central bank reserves use to be demand-determined. Under the unconventional condition of a federal funds rate close to zero, however, there is no further cut in the rate that would trigger higher demand for reserves. The central bank tries nevertheless to raise the amount of reserves in order to relax tight liquidity conditions in the interbank market and in the rest of the economy. Even though reserve demand stagnates, quantitative easing raises the amount of reserves. Under these extraordinary circumstances, reserves are supply-driven (Lavoie, 2014, p. 226). Since depository institutions do not demand additional reserves, the monetary authority injects them into the economy by circumvention of the banking sector and direct asset purchases from the non-bank sector (Borio & Disyatat, 2009, p. 16).

In this sense, quantitative easing serves as an important tool to the central bank, since it can in principle expand the balance sheet of the whole banking system by injecting reserves into the economy independently of the commercial banks' will. However, there is also a specific limitation with regard to quantitative easing that does not apply to conventional monetary policy: the monetary authority has the monopoly in setting the short-run interest rate, which transmits to the economy through various channels. Balance sheet manipulation, in contrast, can basically be made by any market participant. Even though the central bank has unlimited means and is a powerful agent, balance sheet policy is not its exclusive property. Control of interest rates and price variables by means of quantitative easing is more difficult than in the case of conventional monetary policy (Borio & Disyatat, 2009, p. 14).

Yet, the fact that reserves may become supply-determined in the case of a floor system and in the presence of expansive monetary policy does not imply that the amount of money is as well driven by supply. Reserves themselves do not necessarily increase proportionally to the supply intended by the central bank. They may be traded on the interbank market and be used to reduce overdraft reserves by some commercial banks (Lavoie, 2014, p. 228). But it can at least be said that once banks do not aim at optimizing reserve holdings anymore, they just cannot get rid of reserves, so that the central bank has a wide field open to influence the reserve market. In the case of broad money, things are less easy to control. Asset holders who sell their assets to the central bank might use the newly created money in their possession to repay debt. Hence, while reserves increase by a specific amount, the quantity of money may rise only by a fraction of it (ibid., p. 228). Money thus remains demand-determined even in presence of unconventional monetary policy.

Quantitative easing is doubtlessly the most important feature of unconventional monetary policy. However, it should be mentioned at this juncture that the Fed applied a series of additional measures in recent years as shown by Borio and Disyatat (2009, p. 10). Among them, terms for some open-market operations were exceptionally extended. Moreover, the number of accepted collateral securities in repurchase agreements was increased. Operations became executed *vis-à-vis* a broader set of counterparties, that is, more depository institutions. These measures took place in the frame of conventional open-market operations but were nevertheless extraordinary.

Quantitative easing or, more broadly, unconventional monetary policy may be seen just as another form of expansive policy since they share the same purposes in what concerns inflation, output, employment, and other potential target variables. Yet, strategies of conduct differ in important aspects. Specifically, unconventional monetary policy by definition only takes place in unconventional circumstances. In recent years, quantitative easing suggested itself on the one hand because the federal funds rate reached the zero lower bound. On the other hand, the transmission mechanism of monetary policy seemed to be broken: market interest rates diverged from the rates targeted by the central bank (Joyce et al., 2012, p. F276; Pollin, 2012, pp. 67–68). Risks in the market were judged as too high for policy stimulation to have any further influence. Unconventional monetary policy is therefore often seen as a tool to reestablish the transmission mechanism in order for conventional policy to work again (ibid., p. F272). Quantitative easing takes place against the background of a two-stage transmission of monetary policy. The first step aims at reconnecting the target interest rate and market rates. The second stage consists in the transmission of altered interest rate levels to economic activity. Since the second phase is largely seen as analogous to the transmission of conventional monetary policy, studies about quantitative easing use to concentrate on the first phase. This does not mean, however, that unconventional monetary policy does not have any effect on real economic variables, the price level, or financial markets (see for instance Kapetanios et al., 2012). These effects can be direct as well as indirect and will be important for our specific issue of the oil market.

But the outstanding features of unconventional monetary policy require the enlightening of the first stage of its transmission.

Quantitative easing is argued to exert effects mainly on interest rates and asset prices. Asset purchases should raise their prices. Higher prices of securities directly translate into lower interest rates. This helps to lower the general level of market rates of interest and to lead it closer to the target rate, which is zero in the present case of examination. Research literature has elaborated specific transmission channels for the first stage, that is, from policy action to market interest rates. As in the case of transmission to the real economy, first-stage transmission channels are based on different arguments and thus are not perfectly complementary but rather overlapping. Summing them up is not an appropriate way to detect the overall effect, since there is no clear separation of channels. According to authors, as those referred to in the following, they differ in names and numbers. Each of them can only give an argument and thus enlighten the effectiveness of unconventional monetary policy. The following listing includes the transmission channels generally referred to in the literature. The ordering does not reflect their respective importance.

The first channel is the often mentioned portfolio balance channel, portfolio substitution channel, or scarcity channel, respectively (see for instance D’Amico et al., 2012, pp. F424–F425; Joyce et al., 2012, pp. F277–F278). It is based on the rather realistic assumption that assets in private balance sheets are not perfectly substitutable. By purchasing illiquid assets against newly created money, private sector balance sheets are relaxed, which mirrors in altered behaviour of the owners who are ready to accept lower interest rates on their other assets. Given that investors have a preference for an asset class of specific duration and degree of liquidity, purchases by the central bank affect relative scarcities of asset classes and thereby raise the price of focused assets, because they are not (perfectly) substitutable. The price increase of securities lowers their return and thus supports the reduction of the interest rate level (D’Amico et al., 2012, p. F425). Portfolio rebalancing of investors spreads the effects to other interest rates. Beside of this assets-side effect, the portfolio balance channel may as well be effective on the liabilities side of balance sheets: improvement of the financial situation of the private sector by ways of asset substitution raises the number of accepted collateral and thus facilitates access to new loans in the sense of the credit channel discussed in the previous chapter (Borio & Disyatat, 2009, pp. 13–14).

A second way of transmission is the expectations or signalling channel, respectively (Borio & Disyatat, 2009, p. 13; D’Amico et al., 2012, p. F424). As agents build expectations that are among other things based on what the monetary authority communicates, they may anticipate future policy conduct. Asset purchase announcements by the central bank convince investors that interest rates will stay low or at zero, respectively, for a long time. This lowers long-run rates of interest and hence contributes to the reestablishment of the relationship between short-term and long-term interest rates.

Furthermore, D'Amico et al. (2012, pp. F425–F426) suggest a duration channel. The interest rate of long-term assets is composed of the short-run rate plus a term premium that reflects the higher failure risk during the longer term. Higher demand for such long-term assets exerted by the central bank raises their price and liquidity, and thus lowers their risk. In the case of high initial risk in specific asset markets, this channel brings the long-run rates closer to the target rate and thereby improves the possibilities to affect the overall interest rate level by monetary policy.

Risk does not only have a time dimension but materializes as well between assets of different classes. Similar to the purchase of long-term securities, central bank purchases of riskier assets *ceteris paribus* raise their price and lower the yield relative to safer assets. Thus, not only the risk-free share of the interest rate falls but as well the premium assigned to riskier securities (Joyce et al., 2012, p. F279). This channel may generally be denoted as a risk premium channel. Krishnamurthy and Vissing-Jorgensen (2011, pp. 222–223) distinguish a prepayment risk premium channel and a default risk channel. They refer to different asset classes (mortgage-backed securities and corporate bonds, respectively) but the mechanism is basically the same.

Borio and Disyatat (2009, p. 14) suggest not only a higher demand for riskier assets due to the portfolio balance channel but identify a distinct risk-taking channel. Investors face a lower interest rate level owing to quantitative easing. This incites them to search for yield and hence invest in riskier assets. This has the corresponding effects of higher prices of other assets, be they securities, stocks, or commodities.

While any channel is likely to affect the degree of liquidity of the asset classes concerned, quantitative easing may have the basic impact of providing any liquidity at all in an acutely dried-up market. Gagnon et al. (2011, p. 8) therefore mention a liquidity channel. It might principally be seen as a respective part of all other channels. However, changes in interest rates and prices through the retrieval of liquidity in a specific asset market can be seen as a proper mechanism.

Joyce et al. (2012, pp. F278, F281) argue that an additional channel consists in the multiplier effect of additional reserves supplied by the central bank that enter the economy. Unsurprisingly, from the point of view of endogenous money, this channel cannot but be rejected (Lavoie, 2014, p. 228). It is not that the counterpart of higher reserves, namely higher deposits, allows banks to raise loans. We know well enough that causality goes the other way round, notably, loans create deposits. The fact that reserves are supplied does not imply that they are demanded by the real economy. Thus, especially when the central bank behaves accommodatively, more reserves cannot trigger more loans if effective demand is missing.

These transmission channels exhibit the outstanding features of unconventional monetary policy. The two stages of transmission are distinguished in favour of a precise analysis. In practice, however, it may be hard to identify them separately. For instance, Krishnamurthy and Vissing-Jorgensen (2011, pp. 223–224, 240–243) define an inflation channel that specifically relates to quantitative easing. It works by ways of an increase in expected inflation due to expansive monetary policy. Inflation expectations then enter market interest rates by lowering real long-run rates. Should this inflation channel really exist with regard to unconventional monetary policy, then it should as well exist in the context of conventional policy. Changed inflation expectations in the course of interest rate cuts by the central bank should have their additional effects on market rates of interest. Yet, the neoclassical school of thought suggests exactly the opposite. It argues that it is inflation as well as inflation expectations that render an active expansionary monetary rather ineffective (Friedman, 1968, pp. 5–7). We know that monetary policy does not automatically raise the inflation rate by augmenting reserves. On the other hand, market participants may nevertheless potentially build their expectations on grounds that are not necessarily appropriate. Thus, neoclassical theory seems to be somewhat contradicting with regard to the inflation channel, while our alternative view raises fundamental doubt about the existence of that channel.

Be that as it may, we do not explicitly list such channels since they involve second-stage transmission from market rates of interest to the real economy: they apply if the first-stage channels have been successful. Hence, inflation expectations should alter only if manipulation of market rates of interest by the other channels of quantitative easing has been effective (D’Amico et al., 2012, p. F426). It is merely from this point that the real economy, where inflation finally takes place, is influenced. The impact of quantitative easing on the real economy is an *a priori* condition for the inflation channel to exist. Whether the channel exists once this condition is satisfied is indeed another question. These suggestions show at least that quantitative easing measures may well have an effect on the real economy. Even though it should be seen as a two-stage transmission for analytical clearness, the two phases are hard to distinguish in practice.

Moreover, it seems appropriate to say that the effects of unconventional monetary policy finally materialize through the same transmission channels as in the case of conventional policy, that is, the interest rate channel, exchange rate channel, Tobin's *q*, wealth effect and credit channels.

Against this background, the effect of unconventional monetary policy on the market for crude oil can be seen in analogy to the case of expansive conventional monetary policy, which has been extensively treated in the previous chapter. Even more than that, the financial market effect of monetary policy should have actually a larger importance than in the light of conventional policy. First, quantitative easing takes place in extraordinary circumstances: it applies when the economy is threatened by a crisis, a depression or a severe recession once the effectiveness of conventional policy has faded out. Secondly, quantitative easing in its first stage of transmission is primarily effective through financial markets, be it through the portfolio balance channel, signalling channel, premium channel, risk-taking channel, or liquidity channel. We suggested above that the financial market effect can exist even without a change in the real economy. This is the reason why the efficient markets hypothesis is misleading. Prices of financial assets can well evolve apart from developments in economic fundamentals. Quantitative easing reveals this more clearly: the effect of asset purchases by the central bank is shown to be significant in the above mentioned literature. This means that financial markets react by higher asset prices and lower yields before any impact of the policy actions has reached the real economy. Let us take the portfolio balance channel as an example. Investors will react to large asset purchases by rebalancing their investment portfolios irrespective of whether the real economy responds to these purchases or not. Assuming that fundamentals do not react at all to quantitative easing measures, investment flows may go, at least relatively, even more to financial markets than if the real economy grew soundly. This has been shown in Figure 2.1. A stagnating economy implies a stagnating volume of issued stocks and corporate bonds as shown in formula (2.1). Higher demand for assets, while asset supply is constrained, necessarily leads to higher prices. The higher these prices, the more investment waves will spill over to the oil futures market as a result of profit seeking, portfolio diversification, or wealth store purposes. Futures supply is not constrained but the inflow of capital nevertheless has its impact in the form of a higher futures price.

The impact of quantitative easing on financial markets should be more pronounced than that of conventional monetary policy owing to a structural difference in the character of implementation. By manipulating the interest rate level in the course of conventional monetary policy, the central bank sets the general framework for the economy. A cut in the interest rate affects the real economy and financial markets comparatively more or less depending on endogenous variables like effective demand, expectations, liquidity preference, and others. It prefers neither real nor financial investment *a priori*. Quantitative easing, in contrast, has its direct focus on financial markets. The monetary authority takes itself the role of a financial investor; not just a common investor but the one who dominates all others. It directly exerts demand power in financial markets, while conventional policy only sets a precondition for it by cutting the interest rate. We argue that conventional expansive monetary policy leads to larger financial investment through many mechanisms that induce investors to do so. In the case of quantitative easing, larger financial investment is simply a fact. This finding is far from postulating a linear relationship between unconventional monetary policy and demand for financial assets. In a crisis time, it may be that investors are just glad to get rid of illiquid assets and use the monetary sales return to repay debt. Thus, we only apply this argument to the concrete action of the central bank. Obviously, however, the entrance of the central bank into financial markets improves expectations of speculative investors and hence is likely to trigger further financial investment. This is again analogous to the effects of conventional policy.

Owing to the omnipresence of uncertainty in the economy, there is an important limitation to quantitative easing. By means of the signalling channel, the monetary authority tries to convince the public of its policy strategy. The commitment to take extraordinary measures to stimulate the economy may make investors more optimistic. In specific uneasy situations, however, market participants may also interpret unconventional monetary policy measures as a sign that the state of the economy is worse than expected. Hence, the announcement of new measures might trigger a strong movement towards safe bonds and away from risky assets (Neely, 2011, p. 23). Long-run lending rates of interest thereby may increase even further. Reasonably, longer-lasting asset purchases by the central bank are likely to overcome such counteracting capital flows.

Hitherto suggestions about unconventional monetary policy reveal quite clearly that effective demand is finally the crucial variable. The conventional transmission channels may be at work or reestablished and the financial market effect may have its impact on fundamentals. Whether the final impact on economic output and employment in general and on oil market quantities in particular is really significant depends on effective demand. Sooner or later, insufficient demand in the real economy will also draw back the prices of financial assets to a lower level, because investors have to revise their expectations downwards.

The neoclassical school of economic thought might suggest that quantitative easing is a guarantee to raise inflation rates. Even though usually considered as harmful, an inflationary effect can be welcome in an environment of potential deflation. Kapetanios et al. (2012, p. F316) argue that quantitative easing in the United Kingdom aimed at "inject[ing] a large monetary stimulus into the economy, to boost nominal expenditure and thereby increase domestic inflation sufficiently to meet the inflation target". There is the assumption that a higher amount of money translates into a proportional increase in the rate of inflation measured in the goods market. We reject this assumption, in light of the endogenous-money perspective, because an increase in reserves does not affect the general price level if additional demand flows into financial markets only. Quantitative easing is only inflationary in the goods market, if its transmission leads, first, to higher lending to the real economy instead of only financial markets. Secondly, higher lending has to lead to effective demand that increases production capacities. If these conditions are not fulfilled, any inflationary effects are due to price increases in financial markets that transmit to fundamentals. We have treated this argument above.

3.2 The Globalized Pricing System of the Crude Oil Market

In the hitherto analysis, the oil market has been considered as a model market where there is a spot price and a futures price, both uniquely identified by market supply and demand forces. On this foundation, we have criticized neoclassical theory and, specifically, the efficient markets hypothesis according to which futures prices are a simple reflection of spot market conditions. As we will show in this section, the global oil market does not only consist of single prices in the spot and in the futures market, respectively. Rather, it is a complex set of interlinked prices and production quantities. We will point out that the reality of the crude oil market does not contradict our investigation results but, in contrast, reveals many features that challenge the neoclassical assumptions of efficient markets even more. Fattouh (2011) provides a detailed study of how oil prices materialize worldwide to which we largely refer now.

In the 1970s, the global market for crude oil heavily relied on the power of OPEC countries, which set the so-called 'posted price' of oil according to which producers had to pay government taxes. This system can be seen as an administered pricing system (Fattouh, 2011, pp. 15–18). Most oil was sold with long-term contracts. Under these conditions, oil-producing countries had a large influence on the quantities produced. In the 1980s, higher oil prices led to higher oil production in non-OPEC countries, which was additionally supported by new non-OPEC oil discoveries and new technologies. This forced OPEC countries to abandon administered pricing and allow the market to determine the oil price (ibid., pp. 18–19). The influence of OPEC has not completely vanished since. Regular agreements about building or non-building of new production capacities are suggested to have considerable influences on world oil market conditions (Smith, 2009, p. 152). We treated the controversial role of OPEC in the first part.

There exist at least as many different types of crude oil as there are oil producing countries and regions in the world. The most important among them are WTI in the United States, Brent in the North Sea, Dubai and Oman as representatives in the Gulf region. They serve as a benchmark on which other crude oils rely. Concretely, the benchmarks set the price level and the dependent types of oil set the price differential, which is largely made up of differences in quality, that is, density and sulfur content. The differentials can, however, change temporarily as supply and demand conditions of a certain type of crude oil alter relative to other types (Fattouh, 2011, p. 21).

Neoclassical economic theory assumes an efficient market mechanism that sets the price of a good where supply meets demand. In reality, yet, things are less clear. Supply and demand are not curves given by nature and the crossing point is not unique. Rather, there are many individual suppliers and demanders who agree on the transfer of goods at a bargained price. Since many such deals take place, many different prices exist. The market mechanism leads in fact to an indeterminacy of price (see for instance Bénicourt & Guerrien, 2008, pp. 27–28). This exactly applies to the global market for crude oil, where prices of trades differ across different types of oil as well as within them. The single market price does not fall from heaven but has to be assessed by calculation based on individual deals. This is the task of price reporting agencies (see Argus, 2015; Platts, 2015). The calculation methods are not the same for all agencies. They consider a time window of distinct length and take into account the deals that take place within this window. Some also include undone deals, that is, the corresponding bids and offers (Fattouh, 2011, p. 31). A method where deal prices are weighted and averaged over several hours a day faces the problem that the price resulting at the end of the day is biased since it contains many past prices rather than merely the actual price at the close. In contrast, short time windows at the end of the day do not fear great lags but may suffer insufficient liquidity such that few great traders may lead to distortions in the price result (ibid., p. 32). Different methods hence imply different price assessments for one and the same type of crude oil. Moreover, there are limits to the participation of traders in time windows of price reporting agencies. On the one hand, it requires high qualification so that trading in the time windows is made up of a relatively small group of participants. On the other hand, a participating trader has to report all deals according to regulatory obligations in the United States. But participation itself is voluntary (ibid., p. 33).

All in all, price reporting agencies try to cover market developments as careful as possible. But there is also an impact in the reverse direction. The particular pricing system chosen influences the market and participants in their buying or selling decisions, which may have an additional effect on the price (Fattouh, 2011, p. 30). Finally, price reporting agencies hold a key position in the market and might think about manipulating it by changing the pricing formula. However, Fattouh (p. 35) argues that they have a strong interest in self-regulation owing to competition among agencies and hence need for reputation.

The need of price assessment shows that it is doubtful whether a true market price ever exists, since the market consists of individual deals such that a single price is quite hypothetic. Once allowing for the abstract assumption that there is a unique equilibrium price, the process of oil price calculation shows that there are many ways for the assessed price result to deviate from the invisible true price. We agree that supply and demand forces do, of course, have their respective impact on prices and quantities. But exact crossing points in a mathematical sense do not reflect reality. This gives rise to the conclusion that if the spot price of crude oil is allowed to deviate from its own theoretical market price, then the futures price should at least as well be allowed to deviate from it. This argument supports the view that the efficient markets hypothesis fails in the face of economic reality. The pricing systems of the dominant benchmark oil prices show that there is even more doubt to consider the futures price as a simple reflection of the spot market.

The WTI will be at the centre of the forthcoming analysis. It is not the only dominant benchmark but has nevertheless some outstanding characteristics. Almost all oil imports to the United States are priced with reference to WTI. That is, they are not all of WTI type but they take it as a benchmark and set a specific price differential that covers qualitative differences of crude oils. The United States consumes a narrow quarter of total worldwide oil consumption (Fattouh, 2011, p. 52). Moreover, and crucially, the Light Sweet Crude Oil Futures Contract is one of the largest traded commodity futures contract and is based on WTI. Its trading volumes on NYMEX have grown exorbitantly in the decade from 2000 to 2010 (ibid., pp. 54–55).

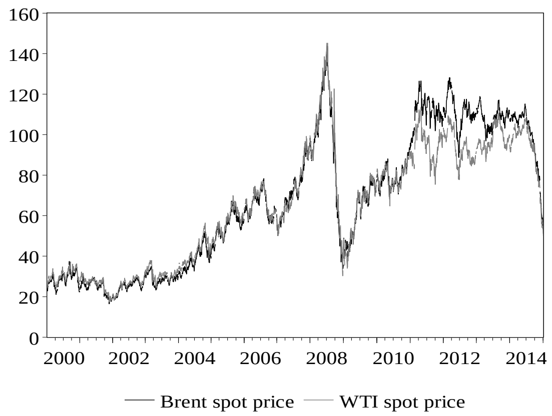
In practice, identification of the WTI spot price is done by taking the level of the WTI futures price as the starting point. The spot price comes into play by the posting plus (P-Plus) and the differential to NYMEX Calendar Monthly Average (CMA) markets, which are both spot markets. Both use the futures price as a reference, so that what is effectively traded in these markets is the differential to the futures price (Fattouh, 2011, p. 58). Without going too far into details, this price assessment reveals two important aspects. First, the futures price is the basis of calculation, that is, it sets the price level. The spot market only sets the difference. Secondly, the spot price contains an element of forwardness (ibid., p. 20). Futures prices are real-time prices since they suffer hardly any time delay. In contrast, physical deliveries usually do not take place immediately. Time inconsistency is likely to arise for the reason that the spot price is fixed for a quantity that is only to be delivered in the time to come. Thus, it is probably not a perfect reflection of supply and demand conditions in the spot market at the time of delivery. This means that the spot price may already be different from the equilibrium value in the sense of neoclassical theory before we start any examination of the issue.

The Brent and the Dubai-Oman benchmarks are assessed similarly. Especially the case of Brent that exhibits larger production quantities than WTI but a less liquid futures market is somewhat more complicated. The futures price is again the initial point. By adding an Exchange for Physicals (EFP), which is a swap of a futures against a forward contract, the Forward Brent price is assessed. By further addition of a Contract for Differences (CFD), a kind of swap of spot Brent (so-called Dated Brent) against Forward Brent, the Dated Brent results. The characteristics of the WTI pricing formula apply to Brent, too (Fattouh, 2011, pp. 39–51).

It is quite hard to derive clear causalities from these findings. The price level is provided by the futures price but this does not necessarily imply that the futures price is the principal determinant variable of the spot price. Expectations of investors can react to the evolution of fundamentals by entering the futures price in such a way that it changes simultaneously with the spot price. This has been shown in Figure 2.2. It appears nevertheless as a criticism of the assumption that the futures market is fully determined by developments in the spot market. The fact that the futures price is given while the spot price has to be assessed by reference to the former leaves additional room open for changes in the futures market to materialize in the spot market. Many companies even use the NYMEX futures contract as a direct price index (Fattouh, 2011, p. 58). This is in full accordance with our analytical proceeding.

It is this complex network of price levels and differentials that brings the distinct types of crude oil together and forms a world market for them. Regional distances and different methods in price assessments may limit arbitrage between crude oil benchmarks. However, worldwide oil transportation connects regions and requires benchmarks to follow the same long-run paths. A comparison between the two main benchmarks exhibits this fact quite convincingly. Figure 3.1 exhibits the WTI and Brent spot price evolution of past years. They used to move closely together. The only lasting differences are found between 2011 and 2013, when there was a WTI discount of up to 25 US dollars. This gap is mainly explained by supply constraints due to limited pipeline infrastructure to the US Gulf Coast. Higher cost of alternative transportation required a lower WTI price. This shortage was finally overcome by higher capacities (EIA, 2013). As we noted, price differentials can vary over time. Nevertheless, the correlation between both prices from 2000 to 2014 at daily frequency is 0.98. This allows us to assume in the following that the oil market is globally integrated. It is thus fair to refer to WTI, thereby covering the world market. We should, however, be aware of the potential limitations and noise that this approximation can bring to our results. Furthermore, we should also be aware that the need of price assessment is a source where deviations from fundamentals may already be priced in *a priori*.

Figure 3.1 WTI and Brent spot prices, 2000–2014, in US dollars

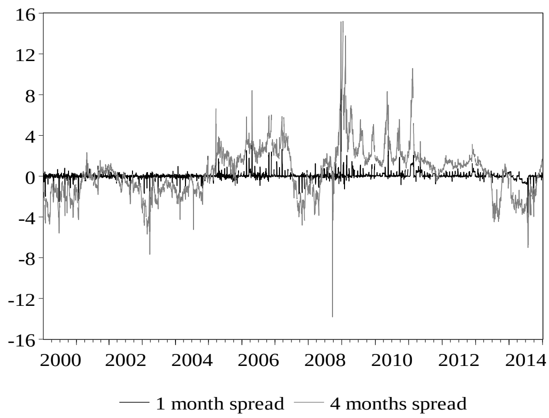


Source: Energy Information Administration (2015a). Petroleum and other Liquids.

Mutual interdependencies in the global crude oil pricing system exist not only in the geographic but as well in the time dimension. Figure 3.2 draws the spreads between the WTI one-month and four-month futures price, respectively, and the spot price in the past fifteen years (futures – spot). They use to move within a +/–8 US dollar-range. These borders were broken around the price peak in 2008. Intuitively, the one-month spread is much less volatile than the four-month spread. We do not suggest the reasons for 'contango' and 'backwardation' situations, as they may be due to various reasons like time delays, acute supply shortages, motives of holders of long and short positions, and more. We argued in the previous chapter that it is improper to derive any causality of futures-spot spreads with respect to price building.

Daily data of futures and spot prices in this time span reveal a clear-cut relationship. The correlation of the one-month futures price and the spot price is 0.9999. Four-month futures price and spot price correlate at a value of 0.997. Thus, both values are hard to distinguish from 1. Since open interest in futures contracts is strongly concentrated within contract lengths of one to four months, we can say that futures and spot prices closely follow the same path. In accordance with Figure 2.2, arbitrage opportunities between futures and spot prices are exploited such that they are equal beside of the suggested structural differentials.

Figure 3.2 One-month and four-months WTI futures–spot spreads, 2000–2014, in US dollars

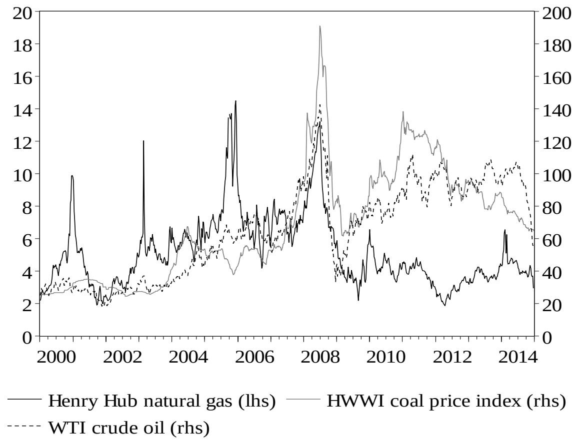


Source: Energy Information Administration (2015a). Petroleum and other Liquids.

3.3 The Relationship between Crude Oil and Other Fossil Energy Sources

Beside of the geographical and temporal dimensions, the degree of global integration of the crude oil market is also determined by its relationships to other sources of energy. It is relevant to know if an event in the crude oil market is limited owing to its isolation or if it affects the market for energy as a whole. Let us consider the other two fossil fuels, that is, coal and gas. Figure 3.3 shows their weekly prices in comparison with the crude oil price pattern. Price data of natural gas of the Henry Hub type is provided by the EIA (2015c). The global coal price index is calculated by the Hamburg Institute of International Economics (HWWI) (2015). The overall impression is that fossil fuel prices move more or less together. The relationship between the coal price and the oil price seems to be closer than that between gas and oil. While all three series tend to move closely along with one another from 2000 until 2008, a large discrepancy between coal and oil on the one hand and natural gas on the other hand opens. A small set of numbers can give an impression of how the price series might be connected. The coefficient of correlation between crude oil and natural gas prices is 0.12 for the whole sample. This is positive but quite small. If we take only the period from 2000 until 2008 into account, the coefficient considerably rises to 0.72. Correlation between crude oil and coal is 0.87 for the whole sample.

Figure 3.3 Natural gas, coal and crude oil prices, 2000–2014, in US dollars



Sources: Energy Information Administration (2015a). Petroleum and other Liquids; Energy Information Administration (2015c). Natural Gas; Hamburg Institute of International Economics (2015). Coal Price Index, Datastream.

These relatively strong correlation values open a space for a couple of arguments about how the relevant prices may be related. The connection of oil and gas prices is investigated in much more detail in the literature than that of oil and coal prices. Villar and Joutz (2006, pp. 4–5) argue that, from a demand perspective, a higher oil price leads to substitution of natural gas for oil, thereby raising gas demand and consequently the gas price. On the supply side, there are several counteracting effects. Depending on the specific source of a certain production plant, natural gas can be a co-product of crude oil. A growing oil price induces higher oil production, which thereby may raise the supply of associated natural gas and hence lowers the gas price. On the other hand, a higher oil price caused by increasing oil demand increases the need for production factors like labour or drilling rigs. Higher prices of the latter raise production costs and lead to a higher price of natural gas. Finally, a higher oil price has a positive effect on cash flows of oil producers. They may invest it in new gas extraction projects raising gas supply and lowering the price of gas.

By investigating the time period from 1989 until 2005, Villar and Joutz (2006) find a stable cointegrating relationship between the WTI crude oil price and the Henry Hub natural gas price. Moreover, the oil price seems to be weakly exogenous, implying that oil influences gas rather than the other way round. This means that the price-raising factors in the transmission from the crude oil to the natural gas market seem to dominate. However, this estimate does not cover the period when natural gas and crude oil prices start separating. Erdös (2012, p. 717) argues that a strongly rising supply of shale gas production took place from 2009 onwards, so that liquefying and export capacities got scarce. This prevented global arbitrage and gas price re-equalization and hence led to a drop in the Henry Hub price relative to the oil price. According to this idea, it is only a question of time until cointegration between oil and gas prices is restored, that is, a question of how long it lasts for transport capacities to adapt to production. The drop of oil and coal prices towards the end of 2014 may be a first sign of this tendency. Brigida (2014) allows for switching between different states in the relationship between crude oil and gas prices and thus takes the temporal deviation into account. The cointegrating relationship is found to be strengthened.

Applying all these time series tools to the relationship between oil and coal would be beyond the capacity of this chapter. We rely on Figure 3.3 for the basic argument that crude oil and coal prices seem either to be causally connected or at least to be affected by a common third variable. This suggestion is confirmed by the rather high correlation coefficient. Yet, the case of coal should be considered more cautiously, since it is not as close a substitute for crude oil as natural gas.

It can be concluded that crude oil is not an isolated issue. Changes in the crude oil market are likely to have effects on prices and quantities of other energy sources. For instance, a high oil price probably triggers substitution of other energy sources for oil. Consequently, impacts of monetary policy on crude oil has further-reaching influences, notably on other energy markets. These effects might take place in the short or in the long run depending on the speed of market reactions.

3.4 The Dichotomy between US Monetary Policy and the Global Crude Oil Market

The geographic and temporal integration of the oil market results in a complex price network where new developments can enter the market from many angles. A supply change in Russia transmits to the price of oil consumed in the United States while expectations of a future event may affect the spot price through the futures market. The interest at hand is in the effect of US monetary policy on the global crude oil market. Enriching the interrelations of the pricing system with causalities needs a theoretical explanation that we provide in this research work. Assessing the practical relevance of these findings, however, requires the fulfillment of further conditions.

The US economy is the largest in the world. Its monetary policy has worldwide implications. Nevertheless, there exists a dichotomy between monetary policy and the market for crude oil. While the former takes place within the frame of individual countries, the latter is globalized. There is thus the basic question whether monetary policy actions of a single country can have a significant influence on a market that stretches over the whole planet.

The leading role of the US economy makes its monetary policy as well a leading one. Changes in US monetary policy stance are argued to transmit to the rest of the world. It is observed that monetary variables like interest rates and asset prices have become more correlated across emerging market economies in past years, specifically in the course of US quantitative easing (Mohanty, 2014, p. 3). US monetary policy seems to have international effects that give rise to the existence of certain transmission channels to other countries. In general, five main channels are identified (see for instance Caruana, 2013; Takáts & Vela, 2014). The first one is the exchange rate. It is the same mechanism that we already addressed in the previous chapter. Among the conventional transmission channels, it is the only one that has an immediate international impact, as it can only exist if there is more than one country. Expansive US monetary policy in general and quantitative easing in particular lead to a depreciation of the US dollar against other currencies. This brings the respective effects on exports, output and other variables of these countries. Nominal and real exchange rate appreciations of emerging market economies have been modest during quantitative easing programmes in the United States (Mohanty, 2014, pp. 4–5). Some countries, especially several oil-exporting countries, have pegged their exchange rate to the US dollar. Hence, the transmission of US monetary policy effects to these currency areas is a logical consequence, even though the implications are not inevitably proportional to those in the United States.

Another channel is the setting of policy rates of interest. Takáts and Vela (2014, pp. 54–56) show that target rates of many emerging economies are considerably correlated with the US federal funds rate. This means that the central banks of these countries react to interest rate cuts in the United States by lowering their policy rates proportionately. Obviously, this transmission channel counteracts the exchange rate channel. By reducing their interest rates, emerging market economies prevent their currencies from appreciating. This is why Mohanty (2014, p. 5) observes that not only policy rates of interest of countries with pegged exchange rates but also those with flexible exchange rate systems follow US monetary policy conduct. This relativizes the notions of pegged and flexible exchange rates as such.

Long-run interest rates, reflected by long-term government bond yields, represent a further international transmission channel. The difference to the policy rate consists in the fact that correlation of long-term yields is not up to central bank reactions but takes place through financial markets: lower yields in the bond market of one country spill over to other countries (Takáts & Vela, 2014, pp. 57–58). Hence, the effects that US expansive monetary policy and especially quantitative easing have on US bonds, apply analogously to foreign bonds. Asset prices increase and long-run interest rates fall.

Cross-border bank lending constitutes a fourth transmission channel. It gives a picture of how monetary policy conditions set in the United States lead to worldwide expansion of US dollar bank loans. A low interest rate does not only give an incentive to demand a credit denominated in US dollars in the United States but as well abroad. There has been strong co-movement of foreign credit to emerging market economies since 2001. However, it has lost shares to domestic financing (Takáts & Vela, 2014, pp. 61–62).

The portfolio channel is similar to the bank lending channel. Corporations in emerging market economies have strongly raised emission of securities at the cost of bank lending in past years (Mohanty, 2014, p. 7). Low interest rates in the United States promote carry trade: low-cost credit denominated in US dollars is invested abroad. This is also facilitated by corporate securities that are issued in US dollar denomination.

Importantly, the international transmission channels do not only lead to a spillover of monetary conditions from one country to another but let as well spread financial risk. An expansive monetary policy stance in the United States is suggested to have a similar financial market effect in impacted foreign countries. The balance sheets of banks and corporations grow longer and so do risk exposures. Once US monetary policy becomes more restrictive, the transmission channels work in the opposite direction. A sudden outflow of capital from emerging market economies jeopardizes the stability of their financial systems. Currencies depreciate and inflation is on the way to increase. The countries have to raise policy rates, too (Caruana, 2013, p. 2).

Takáts and Vela (2014, p. 66) suggest further channels. One is a psychology channel, saying that international capital flows and uncertainty about countries' economic performance can lead to herding behaviour. Capital in- and outflows then may not be proportionally distributed around the world but might concentrate on few countries. An additional channel is argued to be a commodity price channel. It says – only vaguely – that expansive monetary policy might spill over to other countries through altered commodity prices. It is not useful to discuss this channel further at this juncture, as it is the basic issue of investigation in this thesis.

The mere existence of international monetary transmission does not say anything about its empirical relevance. Moreover, its importance may change over time. For instance, the short-run interest rate channel seems to have become less significant in the course of the financial crisis that began in 2008 (Takáts & Vela, 2014, pp. 55–57). Meanwhile, there is evidence that transmission through long-term rates has become more important (ibid., pp. 58–60). The studies use to investigate a considerably large selection of countries. So we should expect that individual country characteristics impede a clear-cut result about international monetary policy transmission. Indeed, the above mentioned significant results normally only apply to a fraction of the countries under investigation. Ramos-Francia and García-Verdú (2014) employ an impressive number of empirical tests and find mixed evidence about how international transmission has evolved in the course of the financial crisis that burst in 2008.

Empirical results taken alone are not a proof of the existence of transmission channels. While the international effect of US monetary policy is seen as a push factor that raises liquidity, there are also pull factors, reflecting the comparative performance of countries and their ability to attract foreign capital (Mohanty, 2014, p. 10). This shows again the demand-determined nature of money, saying that demand for credit in foreign countries is a precondition for capital to flow there. Interpretation of cross-country correlations of interest rates and capital flows thus becomes more difficult. The pull factors of capital flows may imply that countries are in a similar phase of the business cycle or face common economic growth prospects. This is a possible reason for correlation of interest rates and capital flows. Conversely, the degree to which interest rates and capital flows differ across countries may reflect the differences in economic performance. These sources of variation in interest rate and capital flow variables are at least not directly linked to monetary policy. Adding the push factor, that is, monetary policy in the United States, gives us an indication but no definite evidence. Interest rate correlation and capital flows may be due to monetary policy or they may not. They may also be parallel phenomena without a causal link. On the other hand, monetary policy may be internationally effective but clear-cut correlations are masked by country-specific differences. Thus, even though the empirical results allow for some suggestions about the international effect of US monetary policy, they should not be taken as absolute.

The presented evidence is about emerging market economies, including Asian, Latin American, Eastern European and few other countries. While this selection covers many economically important countries, it leaves out advanced economies other than the United States. It is even argued that US monetary policy serves as an approximation for advanced economies as a whole (Takáts & Vela, 2014, p. 51). On the one hand, this is increasingly appropriate, because advanced economies contribute now less than half of global output (Adams-Kane & Lim, 2011, p. 2). However, it is as well reasonable to argue that advanced economies conduct monetary policy more independently from each other in comparison to emerging market economies. This would limit the international impact of US monetary policy. As Borio et al. (2011, p. 45) show, foreign credit denominated in euros and yen has grown since 2000, too, especially in the years prior to 2008. But US dollar credit flows still are clearly much larger and their growth rate exceeds those denominated in euros and yen. Nevertheless, monetary policy in the euro area and Japan probably exerts analogous effects on other countries. This again opens room for many counteracting effects. Yet, monetary policy in advanced economies in recent years has in general been quite expansive and thus points basically in the same direction. The ambiguity of monetary policy transmission between advanced economies leads us to suggest that it is at least not entirely absent. Neely (2011) examines the effect of US unconventional monetary policy on several advanced economies, to wit, the United Kingdom, Germany, and Canada. His results show that quantitative easing in the United States had no effects on these countries' short-run interest rates but rather strong effects on their long-term rates.

Overall, these considerations about international transmission of US monetary policy give us many hints and indications but also leave us with several indeterminacies. We do not have explicit causalities, though it is likely and reasonable that monetary policy in the United States has effects beyond country borders. Being led by such reasoning, we may state that there is at least partial international transmission of monetary policy: on the one hand, if other countries do not follow US monetary policy, the US dollar exchange rate is likely to change so that there is at least one channel of international transmission. This is due to the fact that crude oil is traded in US dollars internationally. On the other hand, if countries seek to avoid currency appreciation against the US dollar, they implement their monetary policy in accordance with the United States'. In one way or another, US monetary policy should have international effects. This will help us finding significant empirical results. Given such results, we will have another source of uncertainty: if developments in the oil market can be traced back to monetary policy, we may not be sure if this means only US monetary policy or monetary policy of various countries. The latter would be the case if not US monetary policy is at the source of other countries' policies but if countries react analogously to other common features. As a minimum result, we suggest that monetary policy in the United States has international effects albeit its strength is hard to assess. Having international aspects of monetary policy in mind allows us to deal with the dichotomy between global oil market and national monetary policy. International transmission probably cannot make this contrast disappear but mitigates it.

4 Empirical Evidence: Monetary Policy Impacts on Oil Market Variables

The aim of empirical analysis is to test the quality of theoretical ideas. It is useful to put abstract concepts into the specific historical context of real economies. However, it cannot be seen as an act of proving or disproving hypotheses with mathematical precision. Econometrics is rather a further argument in favour or against an economic theory. It does not describe physical laws but the real world where humans live. Humans are not mechanical but conscious beings. As such, they have individual behaviour that varies over time and which depends on other individuals' behaviour (see for instance Bénicourt & Guerrien, 2008, p. 72). Uncertainty thus crucially limits the success of econometric measures. Estimating final economic outcomes can be done only with some – and usually considerable – degree of imprecision. The argument can be strong or weak depending on resulting evidence. On the one hand, it is hard to defend an economic idea if all existing empirical results deny it. On the other hand, we cannot be sure that a theory which does not find support in real data does not have any grain of truth. Likewise, seemingly convincing evidence does not guarantee the overall correctness of the underlying conception. There are many factors that complicate the finding of clear-cut estimation results or make it even impossible. Some are of a general nature; some are particular to our case of monetary policy and the global market for crude oil.

4.1 Measurement Problems: Quantitative Analysis Requires Qualitative Background

A first and omnipresent measurement problem in economics consists of time lags. Most if not all effects materialize with a certain delay in the rest of the economy. Detecting causal effects requires appropriate selection of lag time and number (Gollob & Reichardt, 1987, pp. 81–82). Yet, our knowledge is not precise. Moreover, we are not only interested in monetary policy effects on fundamental variables but as well on financial markets. Impacts on the latter should have smaller lags. In our case, we have seen in the analytical part of transmission channels that it is important to distinguish between monetary policy effects on the oil sector and on the rest of the economy. An increase in investment in the oil sector is likely to take longer than in the remaining economy, as the former consists of complex production technologies and hence requires large fixed investment. Oil supply and oil demand may therefore react with different speed to changes in monetary policy. Adding the financial market effect, the issue of time complicates the analysis further. We argue that speculation in the futures market raising the price of oil triggers investment in the oil sector. This occurs with an additional time lag. Additionally, we have at the back of our mind that monetary policy also affects the global oil market through international policy transmission from the United States to the rest of the world. All these specific transmission channels provide many sources of additional time lags, be it the policy reactions of foreign central banks, long-run interest rates, or cross-border lending. Consequently, monetary policy effects on prices and quantities in the oil market take place within different lengths of time, which makes it even more difficult to detect the total impact of central bank actions. Time lags impede empirical estimates, as we do not exactly know when a specific effect takes place and whether it occurs once in a point in time or only gradually.

A second difficulty in econometrics is the building of expectations by agents. This is what we say to give rise to uncertainty in economics. With regard to empirical analysis, it brings the problem that the impact of a variable change may not be found to be significant because individuals anticipate it. They already adapt their behaviour before the change in the variable occurs. The effect then exists but it cannot be assessed from data. Monetary policy gives a famous example of this problem. In the United States, the setting of the interest rate target is published after FOMC meetings. Most investors inevitably build their expectations in advance. Anticipating a cut in the target rate, they may expect higher asset prices in accordance with our detailed reasoning at the beginning. In order to benefit from price increases, they may already purchase stocks, bonds and futures contracts before the Fed has decided anything. Hence, the financial market effect may at least partially take place previous to the shock that we consider as causal. Modelling a monetary shock that yields significant results is therefore part of an ongoing debate. For instance, Bernanke and Mihov (1995) favour the federal funds rate of interest as a generally appropriate measure of monetary policy. Indeed, it has become the most conventional one. Another measure is proposed by Romer and Romer (2004), who try to filter out endogenous movements of the federal funds rate. They argue that changes in the interest rate target are in large part responses to economic conditions as well as future expectations. The newly created data series is supposed to be relatively free of endogeneity and anticipation problems (ibid., p. 1056). Its drawback is that by extracting presumed endogenous components of the federal funds rate, a part of the monetary policy effect is extracted, too. For instance, if investors anticipate a future change in monetary policy conduct and thus adapt their investment portfolio, the effect is forestalled. It is hard to detect it in data. But it is nevertheless an effect of monetary policy. The concerns about measuring conventional monetary policy apply equally to unconventional policy, as anticipation also occurs in view of asset purchases by the central bank.

Even further-reaching problems with respect to expectations arise in connection with supply, demand and price mechanisms. We can suppose the slope of supply and demand curves but we cannot detect them definitely owing to uncertainty. As we argued in the context of Figure 2.2, the curves can basically have any slope (see for instance Pilkington, 2013). Especially in financial markets where no physical quantities are traded, it is likely that the demand curve is rising instead of falling in price. In the oil spot market, the supply and demand curves are reasonably rising and falling, respectively, in the long run. In the short run, however, uncertainty allows basically for any form of the curve. It thus becomes harder to find significant results as middle- or long-run developments to be tested are disturbed by erratic short-run noise in the data. An example of this is liquidity preference of investors. We expect expansive monetary policy measures to stimulate economic activity and asset prices to some degree. Yet, as noted, announcement of extraordinary monetary policy conduct may give agents the signal that economic performance is worse than they thought. They might react by a flight into money or liquid assets like government bonds. Prices of other assets fall therefore. Even if monetary policy is effective in reaching its goal of stimulating the economy, empirical data may reveal a counteracting short-run slack. Another example is the pattern of oil inventory accumulation that will be emphasized further.

Beside of any troubles with time lags and expectations, we have to deal with the problem that some parameters that are normally treated as well-recognized are in fact not that easy to handle. There are methods to estimate elasticities. These can be price elasticities of supply and demand or the elasticity of substitution between fossil and renewable energy sources, for instance. But there is no agreement on their values (see for instance Cooper, 2003; Krichene, 2002; Kilian & Murphy, 2014). Moreover, we have to act on the assumption that elasticities change over time depending on price and income levels, technological progress and the structure of the economy.

Furthermore, we have limited access to data on crude oil trade. On the one hand, we will have to restrict data selection and choose, as argued, data of the Western Texas Intermediate type of crude oil. This is reasonable but brings some restrictions as it cannot cover potential regional events concerning particular types of oil. What weighs possibly even more is missing data on over-the-counter trade. Data inquiries are bounded to semiannual acquisition contributed merely by a fraction of central banks and cover only a total of commodity derivatives instead of providing separate crude oil data (Bank for International Settlements (BIS), 2013, pp. 9, 12). We may suggest that NYMEX Light Sweet Crude Oil Futures data are representative of the oil derivatives market, as global integration eliminates arbitrage opportunities. This is an appropriate working assumption. But we should be aware that over-the-counter trade leaves potentially important information in the dark.

A specific characteristic of the crude oil market is its globalized competition on the one hand and its connection to political issues on the other hand. It is in general difficult to find stable relationships in complex economies. In our particular case, it becomes even more difficult as the oil price may be directly affected by political decisions in OPEC countries. These decisions depend on specific strategies and historical circumstances. It is thus nearly impossible to model them. As a consequence, the oil supply curve gets a changed form. In particular, the price-quantity feedback mechanism may not be symmetric with regard to oil supply. Oil production of OPEC countries might react fundamentally differently to a price increase than to a price drop. As argued by Smith (2009, pp. 151–154), the OPEC is successful in agreeing on the construction of production capacities. This helps to keep the oil price at the desired level. On the other hand, the OPEC may aim at competing against non-OPEC countries by influencing production quantities. This would imply a rise in production in order to drive private competitors insolvent. Such may be the case in the second half of 2014, when OPEC countries did not decide to cut production even though the price was falling by about 50 percent within few months (see for instance Krauss & Reed, 2015; Reed, 2014, 2015). Hence, for instance, OPEC production might stay constant when the oil price is rising or it may rise when the oil price is falling. This reaction or non-reaction, respectively, is not primarily due to low production flexibility but to political strategy. Yet, OPEC countries may also decide differently on production quantities according to specific strategies under given circumstances. Such asymmetries complicate any empirical analysis, because they cover or partially replace the market mechanism, which is quite often suggested to follow a regular pattern.

A further, similar, problem about the oil supply curve arises from the fact that crude oil is a natural resource. Oil reserves differ in quality and accessibility. The final commodity supplied has therefore been produced at different costs (IEA, 2008, pp. 217–219). As such, we cannot assume that all oil demand can be satisfied at equal conditions, that is, it does not exist a horizontal long-run oil supply curve. The higher demand, the more easily accessible oil reserves are exhausted and the more oil with higher production cost has to be explored. This means that the oil supply curve is probably not linear. Within a particular range of the oil price, oil supply may not at all react to a price increase, so that the curve is vertical in this range. In another range, where we assume that the price reaches a level where a production technology for a specific type of oil becomes profitable, a small price rise may trigger a quite large increase in production. Investment behaviour of oil companies therefore is probably non-linear, too. Modelling supply-side behaviour of the oil market becomes an even more difficult task.

To draw a conclusion that brings us a step further, we need assumptions and simplifications to overcome empirical measurement problems. These assumptions may hamper the finding of significant results. So, beside of the advantages that empirical models bring, there are the disadvantages of missing details. It is only a theoretical analysis that is able to make sense of a complex issue without having to make strong assumptions. Thus, in the course of our empirical investigation, the theoretical analysis remains our benchmark. Some results may not be what theory would predict. This does not automatically falsify the theory as long as the whole explanatory framework remains logically consistent. The hitherto analysis offers many aspects to be tested empirically. Each approach can yield a part of the explanation about the whole issue of monetary policy and the market for crude oil.

4.2 A Stock-Flow Consistent Model of the Crude Oil Market

Complexity of the real world requires simplification, if one wants to draw empirical conclusions. In this chapter, a stock-flow consistent (SFC) model of the crude oil market is presented in order to crystalize the main effects and principal variables. We follow the basic principles of modelling discussed by Godley and Lavoie (2012). The outstanding characteristic of this kind of models is that they are truly macroeconomic in the sense that model results are not based on strong assumptions of individual behavior that determine an aggregate equilibrium. In SFC models, deviations from stationary points merely induce reactions whereby the economy adapts to new conditions. This reflects the fact that market participants make their decisions in a world of uncertainty (Godley & Lavoie, 2012, p. 16). Hence, room is left open for a large set of possible outcomes. Moreover, SFC models are consistent with reality in that they take the double-entry characteristic of all economic stocks and flows into account. This allows for an appropriate monetary approach, because it is money that implies the relationship of all financial assets to an equal amount of debt. For instance, by this proceeding, we respect the fact that financial investors do not just behave according to developments in fundamentals or asset prices. Their investment decisions are also affected by the cost of investment, that is, the interest rate on borrowed capital that is used to purchase assets.

The model at hand serves as a summary of the theoretical analysis and yields a rationale before we start with our empirical examination. The modelling of the oil market takes place at the cost of details that we have emphasized above. Nevertheless, it is able to reach an integration of the futures and spot market with dynamic interactions. As such, it serves as a tool to show basic mechanisms. Moreover, it gives us an impression of the results to which indeterminacy in capitalist economies can lead. We will see that the variation of model parameters can yield different results that hamper econometric testing. Therefore, the model shows us also which empirical approaches promise to be successful and which do not lead to meaningful results. Since it merely wants to give an idea of complexity, it does not aim at giving a numerical solution of the effect of monetary policy in the market for crude oil. Beside of reliance on general principles of SFC modelling, this model that contains monetary policy and its relationship to an integrated crude oil market is new and has, to our knowledge, no forerunner model in the literature.

As a first crucial feature of the model, money is endogenous. The central bank sets the interest rate while the quantity of money is determined by demand for credit. Loans are granted either to producers for real investment or to financial investors for the purchase of futures. Hence, there is real as well as financial investment. Money either flows to the real economy or into financial markets. Demand is the crucial final variable that drives economic evolution. Since the SFC model does not have a single and ever valid equilibrium as a gravitation centre and since decisions are made under uncertainty, the efficient markets hypothesis loses its reference point. As a second feature, therefore, the model gets along without the efficient markets hypothesis.

The running of models requires them to be closed. In order to arrive there, rather strong assumptions have to be made with regard to how expectations are built. We will see that there is ‘passive’ as well as ‘active’, or rather speculative, expectation building. Different types of expectations have in common that they are based on the values of variables one period ago. These assumptions are critical. But probably all other types of expectation modelling would require even stronger assumptions without necessarily leading to fundamentally different outcomes. The chosen proceeding is thus reasonable for the purpose at hand.

The model itself does not provide empirical results. The parameters are set according to economic reasoning concerning their sign but do not reflect exact values achieved by empirical calibration. Hence, the model is constructed rather than estimated. It thus serves as a starting point for the econometric analysis and lines out the individual relationships that have to be estimated.

4.2.1 The Model Structure

The SFC model contains 43 endogenous variables and hence consists of 43 equations.[29] It starts with the equation of the crude oil spot market. Demand for oil is assumed to depend on two variables, that is, economic output and the oil price:

$$C_{oil,d} = \delta_0 + \delta_1 {*} C_s - \delta_2 {*} p_{spot} \tag{4.1}$$

where $C_{oil,d}$ is demand for oil, C_s is non-oil output and p_{spot} is the spot price. C_s is taken as exogenous. A variation in non-oil output thus represents a change in oil demand that is rooted in economic fundamentals. The equation shows how the oil market evolves if there were no futures market distorting fundamental developments. We implicitly assume that the demand curve is falling, that is, δ_2 is positive. This assumption may be reasonable both in the short and long run but may as well be violated temporarily. We will come back to this aspect.

Oil production is divided into oil sales and accumulation of inventories. This is a logical fact: oil production amounts to a given quantity. Oil supply, in contrast, is only what is effectively offered at a given market price. Therefore, it is equal to oil sales. The difference is the change in oil stocks:

$$\Delta IN = \delta_3 {*} K_{-1} - \gamma {*} IN_{-1} - C_{oil,s} \tag{4.2}$$

where IN is inventories. K is the capital stock in the oil industry at the end of the last period that has become operative in the current period. Consequently, δ_3 is a measure of production technology that creates a relationship between capital and crude oil produced. This simple modelling of oil production does not mean that we leave labour out of consideration. It will be shown in another equation that capital and labour input both grow proportionally to oil output. The concentration on capital in equation (4.2) facilitates the modelling of oil industry investment.

One should be cautious about the term $\delta_3 {*} K_{-1}$. It does not represent effective oil production but rather production capacities. The amount to which capacities are used is

[29] For the stock and flow matrices as well as an overview of the model, see Appendix I.

determined by the level of inventories of the previous period in equation (4.2). The higher the stock of inventories, the easier an oil company can react to unforeseen changes in oil demand. If existing oil stocks are already high, there is no need for a company to accumulate any further. Production capacities then do not have to be fully utilized. Production in excess of oil sales is hereby reduced. The coefficient γ thus determines the degree to which the inventory level translates into capacity utilization.

As discussed in abundance, supply and demand are always equal in any market. This means for the oil market and for the rest of the economy that

$$C_{oil,s} = C_{oil,d} \tag{4.3}$$

$$C_d = C_s \tag{4.4}$$

The equality between oil supply and oil demand always holds. This signifies in connection with equations (4.2) and (4.1) that demand is the driving variable and determines capacity utilization and inventory accumulation.

The sum of non-oil output and oil production yields total output. The model is based on an unfamiliar notion of GDP, Y, which is taken in both nominal and real terms. In particular, it is real with respect to economic output other than crude oil but nominal with regard to crude oil production. It consists of

$$Y = C_s + p_{spot} {}^* C_{oil,s} + I_s + p_{spot} {}^* \Delta IN \tag{4.5}$$

Hence, exogenous non-oil output, C_s, and oil-industry investment, I_s, are in real terms. Oil production, that is, effective oil supply and the change in inventories are measured in terms of the current price. It follows that we are not interested in the absolute oil price level but in the oil price in proportion to the prices of the rest of the economy. In other words, we assume the prices of non-oil production and oil investment goods to be constant but allow for the oil price to vary. This is in line with the framework applied in the theoretical analysis of the monetary transmission channels in Chapter 2, as it gives rise to oil price changes relative to the general price level. Importantly, let us recall that we have a variable of total output, Y, but that the focus of the model is on the oil industry. The fact that non-oil output is exogenous means that all associated non-oil variables are exogenous, too. Indeed, we ignore not only non-oil prices but as well non-oil investment, non-oil wages, non-oil capital, non-oil loans, and so on. There is no logical inconsistency about this. All research is forced to concentrate on a limited issue and to ignore circumstances. In the following, all variables beside of C_s concern the oil industry rather than the whole economy.

Investment demand in the oil industry depends on expected profits of future oil sales and risk exposure:

$$I_d = \frac{\alpha_1 * PP_P^e}{1 + \alpha_2 * L_{P,-1}} \quad (4.6)$$

The higher expected profits, PP_P^e, the stronger is the incentive to enlarge production capacities, to wit, to raise investment spending. L_P is bank credit taken to finance production. The larger the amount of credit, the higher is leverage and the higher thus the risk to go bankrupt. Producers hesitate to increase risk without limit. Additional investment, however, requires further credit and thus raises risk even more. Hence, high indebtedness constrains investment in order to prevent leverage to keep growing to infinity. Expected profits are simply given by profits of the preceding period:

$$PP_P^e = PP_{P,-1} \quad (4.7)$$

Production profits are obtained by simple subtraction of cost from return. A share *s* of them is reinvested while the rest is distributed to the owners of oil-producing firms:

$$PP_P = Y - C_d - W_d - r_{-1} * L_{P,-1} \quad (4.8)$$

$$PPU_P = (1 - s) * PP_P \quad (4.9)$$

where PPU_P represents distributed profits. Even though the interest rate level is not an immediate determinant of investment in equation (4.6), it has nonetheless a strong influence as it directly impacts on profits in equation (4.8). Thereby, expected profits are equally affected, so that the interest rate finds way to the investment equation. This is the effect of monetary policy through the fundamentals of the oil market. Investment demand is, naturally, equal to the supply of investment goods. Moreover, investment consists of the equipment that is added to the capital stock. We abstract from capital depreciation.

$$I_s = I_d \quad (4.10)$$

$$\Delta K = I_s \quad (4.11)$$

Wage rates, denoting wages in proportion to total output, are assumed to be constant. Labour input, W_d, and thus total wages paid increase in proportion with oil production. δ_7 in equation (4.12) summarizes the labour share of income and a technology measure transforming labour into oil produced. Demand for labour is again equal to supply of labour, W_s.

$$W_d = \delta_7 * (C_{oil,s} + \Delta IN) \quad (4.12)$$

$$W_s = W_d \quad (4.13)$$

Let us now turn to the oil futures market. While the spot market is more determined by middle- and long-run developments, the futures market is quite short-lived. Hence, as a fact to be well aware of, making assumptions about speculative behaviour is not an easy task. Futures contracts are traded by a long side and a short side. Short positions, F_S, and long positions, F_L, are equal in every moment:

$$F_S = F_L \tag{4.14}$$

We assume that producers exclusively go short while financial investors only go long. On the one hand, this assumption is strong, as we will emphasize later. On the other hand, real data show that net positions are as we argue (CFTC, 2014). If we cover all futures market traders other than producers by the term ‘financial investors’, we are not too far from reality. Even though this idea will not be that easy to obey in econometric tests owing to the composition of datasets, it is logically consistent with our theoretical analysis: what matters is demand pressure exerted by financial investors. Furthermore, we cross out offsetting positions that producers and investors hold among themselves.

Another equality has been derived in our theoretical analysis. We argued that oil prices in the spot market and in the futures market are equal. We abstract from ‘contango’ and ‘backwardation’ situations, since we do not assign them causal power in driving prices. Thus, developments in the spot market have a direct impact on the futures market and *vice versa*.

$$p_{spot} = p_{fut} \tag{4.15}$$

where p_{fut} is the futures price of crude oil. It is driven by the amount of open interest, by developments in market fundamentals, and by the propensity of producers to rely on futures market demand:

$$p_{fut} = \frac{\delta_4 + \delta_5 * (F_L + C_{oil,d})}{\delta_6 * K_{-1}} \tag{4.16}$$

In equation (4.16) the term within brackets measures total demand force that acts on the futures price. δ_5 thus is a parameter of price sensitivity. Intuitively, the futures price increases with demand power exerted in the futures market, F_L. The second term, spot demand $C_{oil,d}$, is less clear at first sight but as well quite intuitive. We know and argued in detail that price-driving speculation in the futures market is likely to reduce spot demand for oil. This occurs since the futures price is equal to the spot price while the spot price exerts its effect on oil demand in equation (4.1). This has a price-lowering effect. The reduction in spot demand that we model by the variable $C_{oil,d}$ can in reality materialize by two ways. Either financial investors recognize it by observing the spot market such that they reduce their long position bids. Or consumers hold long positions with a hedging instead of a speculative intention. By reducing consumption demand, they reduce their futures position held. In both cases, demand increase by financial investors in the futures market has to exceed the decline in spot demand in order for the price to keep rising. The supply side has a decreasing effect on the price, too, because producers are willing to accept a lower price for futures contracts in the face of decreasing spot demand. By introducing $C_{oil,d}$, we model these effects in an indirect way. Equation (4.16) is indeed the key equation connecting the spot and futures markets. F_L is determined in the futures market but has an effect on the spot market through the futures price, which is equalized by the spot price. On the other side, $C_{oil,d}$, is assessed in the spot market but has an impact on the futures market, because its change promotes or hampers speculative behaviour. It is the double nature of oil as a commodity and a financial asset that closely links both markets.

Price changes are mitigated to a certain degree by installed production capacities, K_{-1}. Oil producers have to decide whether they accept the price bids of speculators in the futures market. Let us assume the case where oil is available in abundance and any further unit can be supplied with little additional effort, respectively. In this case, competition makes producers accept relatively low bids. In the opposite case, where oil is scarce, the more producers have difficulties to supply additional units of oil, the higher is the price they require. The lower production capacities, the harder it is to satisfy any demand. This leads to a stronger futures price reaction in the face of increasing demand. If production capacities are large, that is, K_{-1} is high, growing demand has a smaller effect on the price since more oil can be supplied in the short run.

Financial investment in the futures market is highly leveraged. We argued that the trade of futures contracts creates high amounts of debt owing to the fact that the trader is currently in possession of an asset but the commitment to pay is given for a specific date in the future instead of the present. All one has to pay in advance is a maintenance margin. The leverage then consists of the debt – or, as we argued, a virtually created unofficial form of money – over the maintenance margin. The rates of margin requirements usually are between 10 percent and 20 percent of the contract value (see for example Investopedia, 2015). The maintenance margin to be held for trading a given number of futures contracts therefore depends on the price level in the futures market.

$$F_L = \frac{M_I}{m^* p_{fut,-1}} \tag{4.17}$$

where M_I is the amount of the maintenance margin held by financial investors. *m* is the rate of margin requirement. The higher the futures price, the less futures contracts an investor can buy with a given amount of margin. We ignore details about how many barrels of oil a standardized contract contains.[30] Beside of this simplification, equation (4.17) is a logical accounting equality and does not require further modelling assumptions. However, we leave away the maintenance margin of producers when they go short in the futures market in order to hedge their sales. The loss of model quality is limited. Equation (4.17) would have exactly the same form for producers apart from F_L becoming F_S. One may argue that producers, that is, the short side in the futures market, only have a passive role and automatically accommodate financial investors' demand for futures owing to equation (4.14). Thus, they would participate in the futures market according to investors' wishes irrespective of the potential losses that futures trading may bring them. This is not true. The willingness of producers to agree on futures contracts depends on the futures price that investors are willing to pay. The conditions of producers' futures supply are expressed in equation (4.16) by parameter δ_5 and K_{-1}. Moreover, we suggested in Chapter 2 that, from a microeconomic perspective, speculative gains of financial investors do not necessarily have to be harmful to producers, because their inventories are valued at a higher price.

Every purchase of a futures contract requires a corresponding margin balance. Consequently, continuing from equation (4.16), financial investment in the futures market is expressed by an increase of the maintenance margin. Financial investment depends on expected profits, the interest rate and risk exposure:

$$\Delta M_I = \frac{\beta_0 + \beta_1 {*} FP_I^e - \beta_2 {*} r}{1 + \beta_3 {*} L_I^2} \qquad (4.18)$$

where FP_I^e is expected financial profits of investors and *r* is the interest rate. The effect of the interest rate has two complementing interpretations. First, a lower interest rate makes borrowing cheaper. Investment in futures contracts can be made at lower cost. Second, the interest rate affects liquidity preference. On the one hand, a drop in the interest rate makes liquid forms of value store like bonds or bank deposits less attractive. On the other hand, a lower interest rate level brightens prospects of future economic performance and hence raises the willingness to invest in assets other than only the most liquid forms. L_I is bank credit for financial investors. The larger the indebtedness of investors, the higher is risk exposure. The argument fully corresponds to failure risk of oil producers in equation (4.6): given a high risk exposure, investors become more cautious of taking additional credit. Raising the weight of risk by squaring

[30] A crude oil futures contract at the NYMEX contains 1000 barrels (NYMEX, 2015a).

the variable is an issue of modelling but has a reasonable explanation. Real investment in the oil sector creates a real asset that backs investment expenditures. In contrast, financial investment is only backed by paper oil, which consists in large parts of an uncovered leverage. Loans granted to financial investors are therefore more risky than those granted to producers. This is why we square investors' debt but do not do so with producers' debt. All in all, equation (4.18) replicates the financial market effect of monetary policy on the oil market.

The amount of credit that speculators have to borrow is given by the desired capital to invest and the fraction of it that can be contributed out of own means:

$$\Delta L_I = \Delta M_I - FPU_I \qquad (4.19)$$

FPU_I is realized and undistributed financial profits of investors that are available for reinvestment. The need for credit is reduced by the same amount. Total financial profits are calculated by changes in the level of long positions and changes of the spot price in comparison with the agreed futures price. Borrowing cost is subtracted.

$$FP_I = (p_{spot} - p_{fut,-1})*\Delta F_L + \Delta(p_{spot} - p_{fut,-1})*F_{L,-1} - \frac{r_{-1}}{52}*L_{I,-1} \qquad (4.20)$$

The first two summands in equation (4.20) reflect how changes in the number of futures contracts and prices yield financial profits. The formula and the proof of why they represent all sources of asset returns are given by Godley and Lavoie (2012, pp. 134–136). If the spot price has grown higher than the futures price of the past period when the contract was made, financial investors make a profit given that new contracts have been made, that is, ΔF_L is positive. The second summand in equation (4.20) represents how the difference between the futures price and the spot price has changed for positions that existed already in the last period or have been rolled over, respectively. The last summand in equation (4.20) is the interest cost for the credit that was necessary to finance financial investment. The interest rate is divided by 52, because we run the model in weekly frequency and rely on the convention that interest rates imply a payment once a year.

Expected profits are defined analogously:

$$FP_I^e = (p_{I,spot}^e - p_{fut,-1})*\Delta F_{L,-1} + \Delta(p_{I,spot}^e - p_{fut,-1})*F_{L,-1} - \frac{r_{-1}}{52}*L_{I,-1} \qquad (4.21)$$

where $p_{I,spot}^e$ is the spot price expected by financial investors. Expectations are built at the beginning of the period. We thus assume that investors base them on the number of futures contracts of the past period. The expected spot price relies also on past price developments:

$$p^e_{I,spot} = p_{spot,-1} + (p_{spot,-1} - p_{spot,-2}) \tag{4.22}$$

This means that investors take the spot price of the previous period as the initial point but build as well an expectation of the direction in which it may move. The expected price change is given by the actual change that occurred between the two preceding periods.

We assume that financial profits are fully reinvested, that is, undistributed profits are equal to total financial profits. This may appear as a strong assumption. But if a positive fraction of financial profits were redistributed, this would hamper financial investment only to the extent that it reduces expected financial profits. Financial investment is basically determined by equation (4.17). However, we note for completeness that

$$FPU_I = FP_I \tag{4.23}$$

where FPU_I represents undistributed profits of financial investors.

Financial profits of oil producers are calculated the other way round. They benefit if the spot price has fallen below the level of the agreed futures price one period ago. In analogy to investors' financial profits, we assume that producers fully reinvest financial profits.

$$FP_P = (p_{fut,-1} - p_{spot})^* \Delta F_S + \Delta(p_{fut,-1} - p_{spot})^* F_{S,-1} + CG_P \tag{4.24}$$

$$FPU_P = FP_P \tag{4.25}$$

We leave away credit cost in equation (4.24) since we ignore the maintenance margin of producers above. To remind, their credit needed for production is taken into account in the profit equation (4.8). In contrast, producers' capital gain, CG_P, is introduced. It accrues from a change in the valuation of oil inventories:

$$CG_P = \Delta p_{spot}^* IN_{-1} \tag{4.26}$$

It is a question of definition whether to assign capital gains to production profits or to financial profits. On the one hand, inventories concern oil in its character as a real commodity. On the other hand, capital gains are independent of actual current production.

After this, the producers' need for credit can be determined. It is the sum of what is needed for production and investment minus own financial means out of undistributed profits.

$$\Delta L_P = I_d + \Delta W_s - PPU_P - FPU_P + CG_P + p_{spot}*\Delta IN \qquad (4.27)$$

Oil production requires credit to finance wages. The change of credit therefore changes to the extent that labour employed changes compared to the previous period. Production and investment spending can partially be financed out of production and financial profits. Capital gains enter equation (4.27) positively, because they are contained in FPU_P but do not effectively contribute to liquid cash for expenditures. Capital gains rather appear in the illiquid form of inventories. The same applies to the changes in the level of inventories.

Let us turn to the banking system. Total loans that banks grant to customers are determined by the sum of loans to oil producers and loans to investors:

$$L_B = L_P + L_I \qquad (4.28)$$

where L_B is the total volume of loans granted by banks. They yield a rate of return equal to the market rate of interest. Bank profits are therefore given by the difference between the interest payments received from borrowers and interest payments that banks have to pay on central bank reserves:

$$P_B = r_{-1}*L_{B,-1} - r_{T,-1}*R_{B,-1} \qquad (4.29)$$

where $R_{B,-1}$ represents central bank reserves, which are held on the central bank account. r_T is the interest rate on them. We assume that the futures market clearing house is part of the banking system, so that the maintenance margin of financial investors is a kind of deposit that does not bear interest earnings. Credit taken for oil production is suggested to circulate in the form of cash in the hand of workers and consumers as will be seen in a moment. Banks' need for reserves is thus given by

$$\Delta R_B = \Delta L_B - \Delta M_B \qquad (4.30)$$

M_B is the maintenance margin of investors that takes the form of a kind of deposits in the view of banks. Hence,

$$M_B = M_I \qquad (4.31)$$

Monetary policy is made by targeting r_T. The proceeding is to be imagined in analogy to the setting and implementation of the federal funds rate target. Central bank profits are simply given by the return on reserves paid by banks.

$$P_{CB} = r_{T,-1}*R_{B,-1} \qquad (4.32)$$

As equation (4.29) shows, banks' profitability is traditionally determined between the interest rates on their loans and the interest rates they have to pay on deposits and central bank reserves. Equation (4.33) thus defines an interest differential that we argue to be realized in the market:

$$r = r_T + D \tag{4.33}$$

We assume that the interest differential D is exogenous. This is realistic in the sense that as long as the transmission mechanism of monetary policy works, the difference from the interbank rate to market rates of interest should be more or less constant in order to guarantee profits.

Consumers are the remaining group in the model. They generate income by working in the oil industry and by receiving profits distributed by producers, banks and the central bank. Both banks and the central bank distribute their profits completely to the public, so that they end up in the pocket of individuals who also have the role of consumers. We call the sum of these profits the 'profits of consumers':

$$P_C = s{*}PP_P + P_B + P_{CB} \tag{4.34}$$

Consumers hold cash at the end of the period to the extent that income exceeds expenditures for oil consumption:

$$\Delta H_C = W_s + P_C - p_{spot}{*}C_{oil,d} \tag{4.35}$$

where H_C is cash held by consumer households.

For formal completeness, two accounting equations have to be added. First, cash created by the central bank is equal to cash held by consumer households, since there is no cash held by another entity. Analogously, the reserves provided by the central bank are equal to the reserves held by commercial banks.

$$H_{CB} = H_C \tag{4.36}$$

$$R_{CB} = R_B \tag{4.37}$$

Finally, producers, financial investors, banks, the central bank, and consumers have a certain amount of wealth at the end of every period. Producers' wealth consists of the capital stock and inventories net of bank credit. Financial investors' wealth is given by the volume of capital invested, that is M_I, also reduced by debt. The wealth of banks is zero. This is intuitive, because central bank reserves must be of an amount such as to fill any gap between loans and deposits, as shown in equation (4.30). Moreover, we assume that they distribute all profits so that no past profits contribute to the growth of equity. The wealth of the central bank is equal to reserves to banks minus cash held by consumers. Cash is central bank money that represents a fraction of reserves. Since this fraction of central bank money is therefore not in the hands of the monetary authority, it has to be subtracted from the total of reserves. Consumers' end-of-period wealth is the cash they hold. Summing up the wealth of all groups yields total wealth in the oil industry, which obviously consists only of real rather than also financial wealth. The only nominal element is the oil price, because of the notion of GDP adopted in our model.

$$V_P = K + p_{spot}*IN - L_P \tag{4.38}$$

$$V_I = M_I - L_I \tag{4.39}$$

$$V_B = L_B - M_B - R_B \tag{4.40}$$

$$V_{CB} = R_B - H_C \tag{4.41}$$

$$V_C = H_C \tag{4.42}$$

$$V = V_C + V_P + V_I + V_B + V_{CB} = K + p_{spot}*IN \tag{4.43}$$

To point it out again: this model is of a closed character. There are 43 unknown variables and the same number of equations to solve it. Despite its considerable volume, it remains a theoretical model and is not able to incorporate complexities of the oil market sufficiently. Its strength lies in the ability to show basic mechanisms, to visualize key effects that have been elaborated upon in the preceding analysis. The model lays the basis for econometric analysis. Moreover, its weaknesses exhibit the actual difficulties to handle with complexity.

For instance, the model suffers a certain time inconsistency. We divide the interest rate by 52 in equations (4.20) and (4.21) by the argument that we run the model in weekly frequency. There would also be arguments to adopt daily frequency, owing to fast moving events in financial markets. In other equations (equations (4.8), (4.18), (4.29), and (4.32)) concerning oil production, bank lending and monetary policy, we leave the interest rates unchanged. This is appropriate from the point of view that production takes place over a longer time horizon. Moreover, financial markets react, in contrast to fundamentals, to the smallest short-run price movements. Similarly, banking that only consists of granting loans is not that exciting, as that developments would have to be documented weekly. The same applies to monetary policy. Yet, a problem arises, because yearly interest rates are nonetheless applied to a model run at weekly frequency, which is a contradiction. By trying to integrate fast-evolving financial markets with longer-lagged production we have to make this concession. It does not make a crucial difference to model results, because the patterns of variables differ only in the lengths of the time lag according to whether interest rates are divided or not.

Financial investors do not have but crude oil futures (net) long positions as an investment opportunity. Once the price falls, they inevitably end up with losses and uncovered debt, because they cannot rearrange their portfolio beside of varying the total volume of invested capital. However, we are not interested in profitability of speculation but rather in the effects speculation has on the oil market.

Two limitations concern the financial sector. One is that the model has an exclusive focus on conventional monetary policy. Nevertheless, we shall overcome this shortcoming as we argue unconventional monetary policy to be analogous in its effect on the oil market. Econometric testing will require more detailed separation. Second, consumers cannot save in bank deposits. Missing savings deposits enhance banks' need for central bank reserves but leave the oil market unchanged.

As another potential shortcoming, the character of crude oil as an exhaustible natural resource is neglected. Indeed, oil production behaves like the supply side of any goods market reacting accommodatively to changes in demand. The long-run supply curve is considered as horizontal. Criticism in this respect is justified. But as will be seen in the empirical part, accommodative oil supply is not an assumption too far from reality. The model thus can continue doing its work.

The effect of economic growth is described separately. For instance, it is relevant in the case of the financial crisis involving a drop in global output and hence in the oil price. Even though applied with a positive growth rate of GDP, the results in Figure 4.2 show that the model is able to reproduce the impact of an economic crisis on the oil market. It is this growth effect that is suggested to take place as well in response to a change in the conduct of monetary policy. It would be easy to incorporate a reaction of C_s on a changed interest rate. But since monetary policy transmission through fundamentals is argued to have ambiguous effects on the oil price, the sign of the model result would depend on parameter calibration and hence would suggest a clear outcome that, in fact, is not justified. Separating this effect thus allows more transparency and easier interpretation of the model solution.

As regards monetary policy, the exchange rate uses to be taken into account. In our model, however, we leave it away, since we consider the crude oil market in its global extension where exchange rates of single countries in general do not play a great role.

We argued with respect to the exchange rate channel of monetary transmission that beside of an induced change in the oil price denominated in US dollars, there is no significant change in global crude oil production and consumption. Changes in exchange rates produce effects in a national economy that are counteracted by the rest of the world, whose currencies *ceteris paribus* face the exchange rate change from the opposite perspective. Once the dichotomy between national monetary policy and the global oil market is analyzed – this is what we have done in the third chapter –, neglecting the exchange rate in our SFC model seems appropriate.

Since the model is of a macroeconomic nature and describes a particular sector of a capitalist economy, strategic behaviour and geopolitical strategies like those of OPEC are ruled out. This may appear as an important drawback in light of OPEC's potential influence as described before. Especially regarding the falling oil price in the second half of 2014, the fact that OPEC decided to keep oil production at a high level to keep market share (Krauss & Reed, 2015; Reed, 2014, 2015) seems to lie out of the reach of monetary policy. This may be true, but one may as well argue that the need for raising OPEC production only emerged as a reaction after increased global oil production had made the price already falling. If so, then the essential mechanism is captured by the model. It is strengthened by the OPEC strategy. In addition, strategic behaviour is by definition irregular and thus hard to reproduce by a macroeconomic model. To reproduce basic effects of monetary policy on the crude oil market, we find it justified to leave OPEC aside.

4.2.2 Running the Model

Despite the rejection of the general equilibrium approach, calibrating a model requires the assumption of a stationary starting point. This is necessary to detect the isolated effects on which our investigation focuses. A stationary starting point has inevitably the characteristics of equilibrium. However, once the starting point is passed, we are interested in the direction, length, and strength of occurring effects rather than in perfect convergence to a new equilibrium. As we do not attest our model to be able to reproduce real data outcomes, it is calibrated with arbitrarily chosen values of variables. The signs of parameters are chosen as intended in each equation by economic theory but their numerical values are constructed rather than estimated empirically. However, the exact numbers of results are not the object of interest. What we want to reveal is the actual existence of effects.

The model is run from 1990 until 2014. The time window is arbitrarily chosen. If we decided to run it at daily instead of weekly frequency, the same number of periods would be concentrated within about two or three years. In the equilibrium at the start of the time period, there is no futures market investment, producers' profits, real investment, and inventories are zero. This may appear too artificial. However, this state may also be transferred to the real world in the sense that producers realize a minimum profit rate that is just sufficient to keep up production with neither investment nor disinvestment. Likewise, there may be inventories that oil companies hold in average to hedge against future risks. They are just carried over from the past and thus do not imply any price effects. Setting these values to zero at the beginning implies that our interest is in the deviation of the variables from a given initial point.

In the next step, a cut in the interest rate target from 3 percent to 2 percent at the beginning of 1991 is simulated. Figure 4.1 shows the evolution of important model variables arranged in an order in which variables cause other variables. Open interest, to wit, total long or short positions, respectively, is presented in panel a). When the interest rate falls, investors start investing, which is mirrored in an increase in open interest. The mechanism is defined in equations (4.17) and (4.18). Lower interest rates lower the opportunity cost of oil futures investment and reduce liquidity preference, too. Panel b) exhibits oil industry investment sharply increasing after the cut in the interest rate. It soon reaches its peak and falls a little below zero, so that it is hard to recognize it in panel b), in order to converge to the initial level of zero investment.

It is important to know that open interest in panel a) shows the total volume of financial investment in the form of oil futures. Panel b), in contrast, shows the amount of investment expenditures being spent again and again every period. Hence, open interest is a stock of capital while oil industry investment is a flow of capital. This means that total capital does not fall back to its initial level when investment reverts to zero. The picture rather shows that the capital stock of oil producers first grows strongly, then declines a little as long as investment is below zero, and eventually converges to a value above the initial one. As already mentioned in the context of equation (4.8), a lower interest rate raises expected profits and thus makes investment profitable. According to equation (4.6), the capital stock increases until expected profits again reach zero, owing to large and perhaps even excess production capacities.

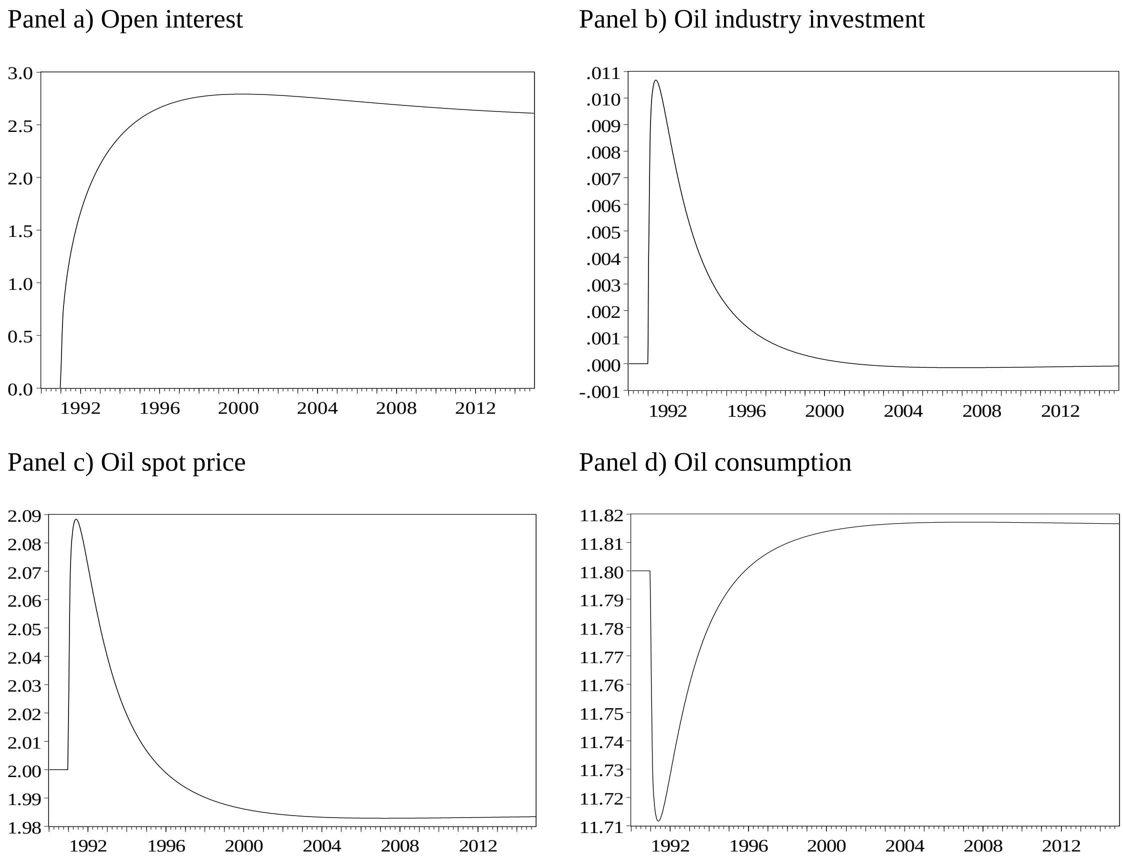
Panels a) and b) represent the two broad ways of monetary policy transmission: the financial market effect and the effect through fundamentals, respectively. Yet, they are not the isolated effects directly caused by monetary policy. They include also mutual impacts on each other.

Panel c) in Figure 4.1 gives a picture of the oil spot price evolution. Increasing demand in the futures market due to investment in futures contracts raises the price sharply as shown in equation (4.16). From equation (4.1), we know that spot demand decreases when the oil price increases. Declining spot demand affects in turn the futures price in equation (4.16) owing to financial investors becoming more cautious and producers being ready to accept a lower price in futures contract agreements. Moreover and crucially, investment takes place, and this increases production capacities. The supply side of the oil market becomes more and more relaxed such that oil companies are willing to drive up oil sales even at lower prices. This is expressed in the denominator of equation (4.16). All these factors pull down the oil price from its peak and let it converge to a new stationary level even below the initial one. This can simply be explained by the fact that the oil industry ends up with higher production capacities that have been installed during the high-price period. They do not vanish – or merely to a small extent – after the price has come down. Note that there is a kind of slight overreaction: the price falls deeply and then converges very slowly to the new level from below.

In panel d), oil consumption is plotted. Consumption is what is effectively purchased in the market and not what is produced. It is thus the value of supply and demand of oil in every period. The higher oil price lowers oil demand, while price reversion pulls it up to a quantity larger than at the beginning. The pattern is explained by equation (4.1). In reverse correspondence to the oil price, oil consumption decreases slightly in direction of the new convergence level. Since output of the rest of the economy is exogenous and remains constant during the whole time span considered, oil intensity of GDP depends uniquely on the absolute volume of crude oil consumption. In this case, the economy ends up with a higher oil intensity.

One may ask why the number of futures contracts is higher at the end, even though the oil price is lower than at the beginning. Common sense potentially might suggest that speculative activity declines in line with decreasing profit expectations, so that the futures market should eventually face a lower level of open interest than at the starting point. This is only one part of the issue. The other part is the permanently changed liquidity preference due to the lower interest rate. While diminishing profit expectations lower the level of long positions held by financial investors, reduced liquidity preference has a converse effect. At the new stationary level, open interest is thus lower than when the oil price is on the peak but higher than at the beginning. Changing weights assigned to expected profits, liquidity preference, and also risk affinity would reproduce the same basic course of the curve but with different strengths of individual effects.

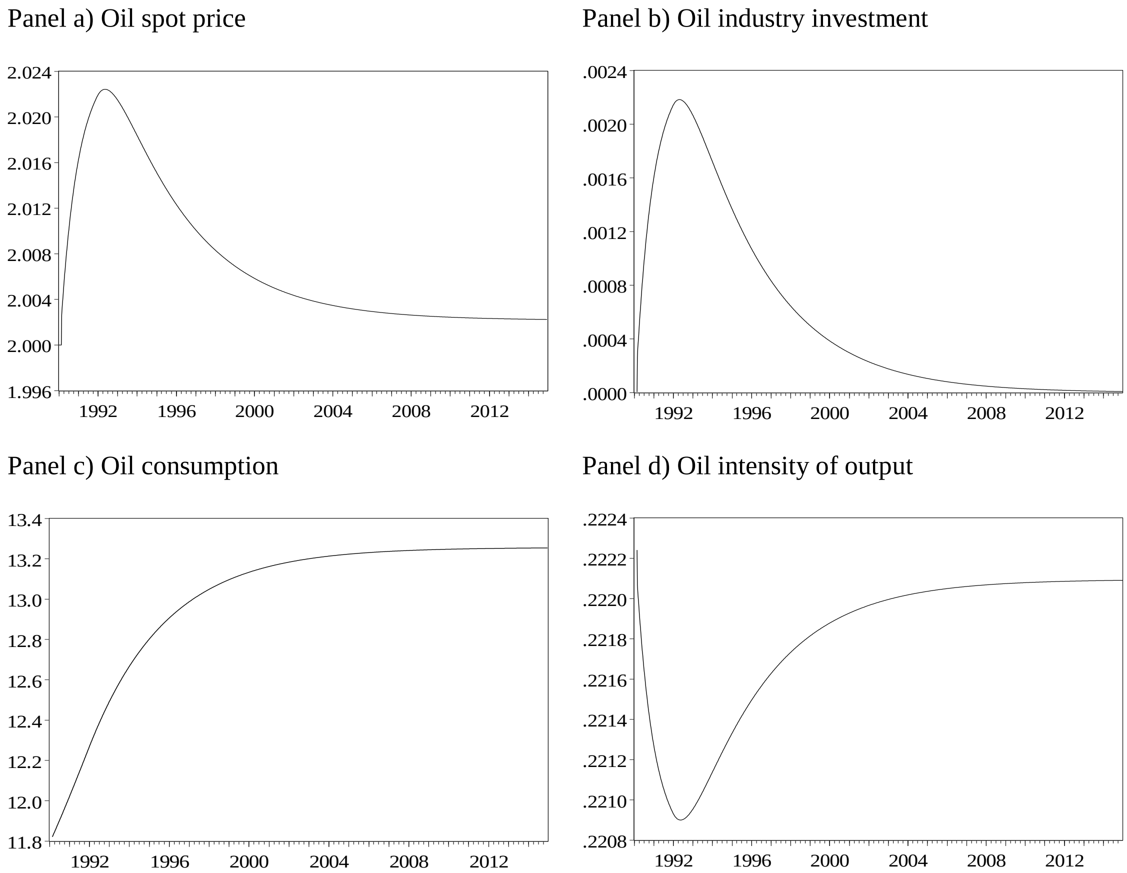
Figure 4.1 Effect of a 1-percent decrease in interest rates



Source: author's elaboration.

The effect of monetary policy on total GDP is neglected in this simulation, because we assume output of the rest of the economy to be exogenous. We do so because we are interested in the effects of monetary policy on the oil market beyond its impact on the economy as a whole. Arguing that expansive monetary policy has a larger or smaller positive effect on output taking a specific time span to materialize, the oil market is affected by increasing demand. We reproduce this separate effect by assuming that the economy grows by 0.0004 percent in a week, which amounts to about 2 percent in a year. This happens for two years, that is, from 1990 to the end of 1991. After, the economic growth rate declines gradually and converges to zero in 2014. The growing variable is non-oil production C_s. Monetary policy conduct can remain unchanged for this. Figure 4.2 shows the evolution of the oil price in panel a). As long as annual GDP growth is 2 percent, the oil price increases. This is due to rising oil demand in equation (4.1), which transmits to equation (4.16). Oil industry investment, presented in panel b), rises in light of a growing oil price. Since oil producers base investment decisions on profit expectations, which depend on realized profits in the preceding period, oil investment is lagged (equations (4.6) and (4.7)). Output growth is one step in advance of existing production capacities. Once the economic growth rate diminishes, investment is again lagged and thus in excess of output growth in a given period. The price thus starts decreasing and so does lagged investment. This corresponds well to common explanations of business cycles. When output growth converges to zero, oil price and investment do likewise.

Figure 4.2 Effect of economic growth



Source: author's elaboration.

Panel c) of Figure 4.2 exhibits oil consumption. It grows in correspondence to output growth of the rest of the economy corrected by the effect of the fluctuating oil price. When output growth diminishes, oil consumption grows at a flatter rate. Oil intensity of output that we calculate by dividing oil consumption by total output, Y, is shown in panel d). When the oil price rises owing to rising output, oil demand also rises but slower. The oil intensity shrinks. When output growth drops, oil intensity rises again to the initial level. Note for all panels that the curves do not reach the exact starting values in the end. Diminishing growth is a convex pattern, so that the process of convergence is in principle never finished.

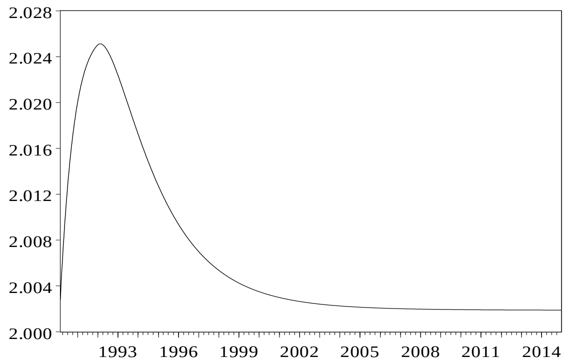
It arises from Figure 4.2 that economic growth affects the oil industry. But with respect to the proportion of the oil industry to the non-oil economy, that is, oil intensity of output, higher output has no influence. It is only the process of economic growth that lowers oil intensity temporarily. If there were permanent output growth, the model would produce an outcome of steadily falling oil intensity. This case would assume away output volatility of business cycles. Moreover, if economic growth is considered as permanent, oil producers would start raising investment stronger, because they fear less risk of investment loss. This is a case not modelled in this framework.

We may extend the model by assuming that financial investors start anticipating output growth. They conclude that the oil price will rise and thus raise demand for futures. Equation (4.18) then is modified to become:

$$\Delta M_I = \frac{\beta_0 + \beta_1 * FP_I^e - \beta_2 * r + \beta_4 * \Delta C_{s,-1}}{1 + \beta_3 * L_I^2} \qquad (4.18')$$

where $\Delta C_{s,-1}$ represents economic growth during the last period on which financial investors base expectations about the future. The same pattern of output growth then leads to a quite similar movement of the oil price, exhibited in Figure 4.3.

Figure 4.3 Effect of growth on the oil spot price in the presence of financial speculation



Source: author's elaboration.

Figure 4.1 on the one hand and Figures 4.2 and 4.3 on the other hand separate monetary policy effects. The first simulation merely shows the effect of monetary policy on the market for crude oil in proportion to the rest of the economy. This is the central issue of the whole analysis. The second simulation and the subsequent extension reflect the impact of absolute output levels on the oil market. It brings various dynamic effects between the oil industry and the rest of the economy. Of course, total output growth has a price effect as demand for crude oil increases. However, there are no lasting effects on the oil intensity of output, that is, on the distribution between oil and non-oil output. Figures 4.2 and 4.3 do not offer the guarantee that absolute changes never affect relative changes. This aspect would especially become important if we included long-run changes of technology. They use to develop, however, not only over years but rather over decades. Nevertheless, the figures all in all yield an argument that isolating the effects of monetary policy on the crude oil market from general monetary policy effects on the economy as a whole is an appropriate way of proceeding. Hence, the results of Figure 4.1 continue to be at the centre of our interest. Yet, short-run fluctuations should not be forgotten with regard to neither general nor oil-market specific effects. They make up for an important part of economic phenomena. Short run and long run are well separable in a closed model but rarely so in reality. The short run can become considerably long as we argued. Beside of this, we explicitly allow short-run events to have an effect in the long run in some way. But again, it is just in this case of economic growth that model results suggest no permanent change.

Model results presented here are quite intuitive. Even though calibration of starting values is an arbitrary issue, the model is able to reproduce what has been concluded in the theoretical investigation. First and crucially, financial markets do not only affect prices temporarily, they influence them permanently. As a consequence, not only price variables are impacted but also quantities. This reveals the topic of our starting point about the nature of money and financial markets. Fundamentals and money should not be seen as two separated and parallel objects. The model confirms the suggestion that economic analysis should be made from a monetary perspective. It is through money that fundamentals and financial markets interact dynamically. The transmission mechanism of monetary policy has both an effect through fundamentals and a financial market effect whose interrelations can lead to unforeseen outcomes. This is shown in the model. Given this background, there is no rationale to think about a general equilibrium to which the economy regularly reverts. Referring to the market for crude oil, it would be a much stronger assumption to suppose that financial impacts do not affect fundamentals than to allow that they do.

4.3 Proceeding in Two Stages

Our theoretical analysis and the SFC model reveal many steps that take place when monetary policy affects the market for crude oil. The initial point is a change in the short-run interest rate by the central bank modelled as a one-percent cut in the SFC framework. We argue that monetary policy then affects the oil market through fundamentals, on the one hand, and through financial markets, on the other hand, producing price and quantity effects. To be more exact, according to theory, the level of the interest rate influences the volume of trading in the futures market, which we suggest affects the oil price. With more delay, it has also an impact on investment in the oil market as well as in the rest of the economy, whose relative net effect is ambiguous from a theoretical point of view. Fundamentals and financial market effects are expected to interact. We suggest the impact of policy-induced changes in fundamentals on the futures market to be not very clear-cut. In contrast, the effect of changes in the futures market on fundamentals should be quite significant, as shown in abundance in the reasoning above.

We know, of course, that all these effects take place simultaneously at a given point in time. They occur at different frequencies and with different time delays. Sometimes, they cannot be separated from each other. For instance, there should be two effects of fundamentals on the oil price of which one is caused by a change in the interest rate on oil supply and demand and the subsequent impact on the price; the other consists of the response of the futures market to changes in fundamentals, which again should affect the oil price. It is hardly possible to distinguish both effects numerically from each other. In general, we must accept that monetary policy has quantity and price effects that are closely linked in a complex way and cannot be separated. We cannot start by only taking the impact of an interest rate change into account and keeping resulting interactions between quantities and price away. Moreover, it is inevitable to account not only futures market variables when we want to estimate financial market effects: we also have to integrate fundamentals variables to control for the currently existing supply and demand conditions in the spot market. This calls for integrated measurement methods.

For these reasons, the following steps of proceeding are proposed. In the first stage, we estimate the effect of monetary policy on the futures market and on spot oil supply and demand as well as the impact they have on the oil price. By this, the fundamental and the financial market effects of monetary policy are covered as well as the interactions between them. Yet, the focus lies on the price variable, because the price effect, especially through financial markets, materializes faster than quantity effects. Reasonably and as argued above, quantity effects take longer to realize than price effects. Hence, they should be emphasized separately. In the second stage, therefore, we investigate the longer-run impact of the oil price on quantities, that is, oil production and oil consumption. A central variable of interest will be how a change in the oil price influences real oil industry investment.

Our two-stage proceeding is therefore as follows: the first stage investigates the transmission of monetary policy from the interest rate to the oil price, while the second stage examines the impact that the oil price itself exerts on oil quantities. The second stage can be seen as the indirect effect of monetary policy that follows the direct effect of interest rate changes. Despite their probable simultaneity, we analyze the two stages separately, because they differ in lag length and data frequency. This strategy may be affected by the risk to measure the same impacts twice. As suggested, however, it is hardly possible to separate price and quantity effects as well as direct and indirect effects in the sense that we cannot assign a definite numerical value to each of them. It is by splitting one empirical model into two that there is even a chance not to find numerical results but to detect the mere existence of price, quantity, direct, and indirect effects as well as their interdependencies. By this method, we aim to test the results of the SFC model shown in Figure 4.1 empirically.

While it is theoretically easy to argue in favour of or against a causal relationship between two variables, empirical confirmation is more difficult. There are several concepts of how a causal relationship from one variable to another may be estimated (see for example Hoover, 2008). The best-known and mostly applied one is the idea of Granger causality. It claims that if a change in variable *a* occurs before a change in variable *b*, and if variable *a* bears information that is not contained in any other variable, then variable *a* has some causal effect on variable *b* (Granger, 2004, p. 425). Yet, causality can be suggested but there is no obvious way how it can be proven. This is why this concept is called ‘Granger causality’ and not just ‘causality’. We will refer to Granger causality, too, when analyzing relationships between data. But it is necessary to be cautious: while data may reveal a relationship saying that one variable is able to forecast another one, it is not possible to find out from available data why the information that a variable yields should be unique. It is at this point that we have to rely on economic theory. So again, theoretical considerations inevitably have to lie behind empirical analysis for the latter to have a meaning.

In this respect, let us recall the principle that correlation does not mean causation. Together with the need of econometrics for a theoretical background, we have a tool to argue causal relationships out of correlations even though we cannot prove it. Take two variables, *a* and *b*. Theory suggests that there is a positive feedback between them, that is, if *a* increases, *b* increases, too, and if *b* increases, *a* increases, too. This may be the case with financial investment and financial asset prices: higher demand for financial assets leads to higher asset prices, while higher asset prices attract additional financial investment. The futures market is likely to be a specific example of this case. If regression analysis detects a significantly positive coefficient connecting the two variables, there is no statement about the direction of causality between *a* and *b*. In a different case, however, theory may suggest that an increase in *a* leads to a rise in *b*, while a rise in *b* lowers *a*. The relationship between the oil price and real oil industry investment serves as an example of this. A higher oil price is an incentive to raise oil production capacity by increased investment, which in turn has a negative impact on the oil price. The resulting parameter estimate yields an indication of the direction of causality. Theory suggests it to go in both directions. But if the coefficient should be significantly different from zero, one causal relationship must dominate the other one. If it is significantly positive, it suggests that causality mainly goes from *a* to *b*. If it is negative, it primarily goes the reverse way. However, such a result is not clear-cut. In a regression analysis where only contemporary variables are included, delayed effects of one variable on another one are ignored. This argument is not a proof of what kind of causality a regression analysis reveals. It just helps to make sense out of the estimation results. This is a more proper approach than arbitrarily taking a correlation as a given causal relationship, as it is done in a large part of economic literature.

Hence, there are three tools helping to confirm or reject suggestions made in this thesis: the more detailed suggestive results of the theoretical analysis, the hints of the SFC model, and econometric methods.

4.4 From Monetary Policy to Oil Price[31]

This section concerns the first stage of our examination. By investigating almost exclusively the effects of monetary policy on the oil price, we largely ignore the impact on oil quantities for the moment and refer to it later. First, monetary policy and the oil market are simultaneously treated in VARs. The results will not be sufficient, so that a

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[31] Some of the following ideas are taken from my term paper "Monetary Policy, Oil Price and Speculation" developed in a time series analysis course at the Summer School of the University of St.Gallen in June 2014.

more detailed analysis of causal relationships will be required. The outcomes, whether significant or insignificant, then can be used for further, more sophisticated, investigations of causalities. Finally, the oil inventory argument is taken into account in order to test the phenomenon of speculation. We criticized those numerous explanations that use oil stock data to assess whether price effects of speculation exist or not. By taking this criticism as a base, we employ a new approach to inventories showing how they can be productively used in order to have some explanatory power.

4.4.1 Some Basic Estimations

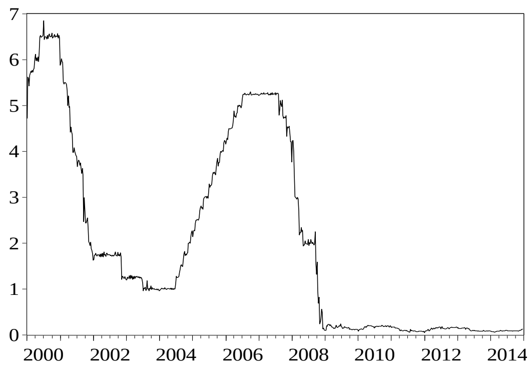
Monetary policy in the time period of investigation, that is, from 2000 until 2014, is marked by the already discussed change from conventional to unconventional monetary policy. The latter started taking place at the beginning of 2009, when the federal funds rate reached zero in the United States. The US Federal Reserve had already begun taking action by purchasing financial assets in large quantities. Therefore, the period is separated into two at the end of 2008. The first one is referred to as the period of conventional monetary policy, the second one as the period of unconventional monetary policy. We start by estimating a structural VAR (SVAR) for each period (see for instance Enders, 2014, pp. 313–317). This approach is in general judged to be convincing, as it allows detecting various causal relationships and estimating counteracting effects among many variables. It is thus just a common method to apply to issues like the present one. However, we will see that this approach is not without criticism. It is a part of our econometric analysis but is not sufficient to yield robust results. Further steps are needed, as we will show.

VARs face the same trade-off of any regression analysis in a stronger form: more variables and lags are potentially able to include more effects but reduce the quality of the model at the same time. Hence, a selection of variables is necessary and has to be founded on economic criteria. We want to include both financial and fundamental variables as well as a monetary policy variable. The financial market effect is suggested to materialize faster than changes in oil supply and demand. To cover them, the SVAR is run with weekly data.

4.4.1.1 The First Period, from 2000 until 2008

In the SVAR for the period of conventional monetary policy, we choose the federal funds rate as the policy variable provided by the US Federal Reserve (2015). Figure 4.4 shows that it runs through ups and downs before it approximates zero at the end of 2008. It is not perfect, as argued above. On the one hand, it can be anticipated. On the other hand, the impact of a change in the rate of interest is likely to occur only gradually over time. For instance, financial investors may raise their exposure only if interest rates are not only low but have been low for a sufficient period, so that they have confidence that the level will continue to be low. In the case of an increasing interest rate, refinancing costs of financial investors rise only step by step the more credits have to be renewed. As a contrary argument, the federal funds rate is the one and crucial variable by which monetary policy influences monetary conditions. Investors rely on this rate when making decisions rather than imagining some artificial constructed variable. Hence, despite these limitations, we try to generate significant estimates by including lags.

Figure 4.4 The US federal funds rate in %, 2000–2014



Source: Federal Reserve (2015). Selected Interest Rates.

The second variable is the WTI crude oil spot price from EIA (2015c). Its pattern has already been presented in Figure 1.3. One may deflate it by the US consumer price index to have the real price of oil. This is what theoretical considerations – investigating the oil market in proportion to the rest of the economy – would suggest. But, first, data on inflation rates are only available at monthly frequencies. Interpolating them would bring no additional information. Second, US inflation has not exhibited specific features since 2000 despite the fall in the price level after the outbreak of the financial crisis. The correlation between the nominal oil price and the real oil price deflated by the US consumer price index (OECD, 2015a) is 0.993. So we cannot make great estimating errors in applying nominal instead of real data. It is intuitive that weekly changes in the oil price are hardly due to a change in the general price level. Third, we argue that in a monetary economy, the nominal and the real sides of the economy are integrated and cannot be split up (Cencini, 2003a, pp. 303–304). We thus employ the nominal oil price at least for the first stage, where data are considered at weekly frequency.

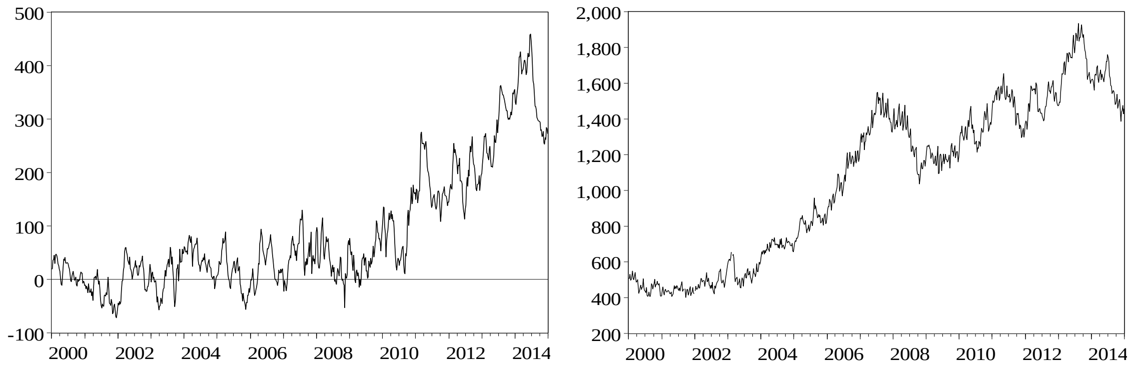
To include the financial market aspect, a variable of speculative futures trading is added as a third variable. In particular, we use non-commercial net position data surveyed by the CFTC (2014). The CFTC (2015) defines commercial traders as those "involved in the production, processing, or merchandising" of crude oil. Another criterion to qualify as a commercial is the incentive to hedge by holding a futures contract (CFTC, 2014). Non-commercials make up for the residuum of trading activity and consequently do not have contact with and probably no interest in physical quantities. They do not aim at hedging and hence can be considered as speculators. Yet, such a classification is not easy to make and has also been criticized. Masters (2008, pp. 7–8) complains that so-called index speculators enter the futures market by contracting commodity swaps, which are classified by the CFTC as commercials rather than non-commercials. The non-commercial category is therefore more a guideline than a clear-cut indicator. Their net positions, that is, non-commercial long positions minus short positions, are a variable that is often applied in the literature (see for instance Alquist & Gervais, 2011; Büyükşahin & Harris, 2011). Moreover, it is confirmed as an indicator by the theoretical analysis above: if systematic speculation takes place, it almost certainly tends to bet on a rising rather than a falling price. Speculating on a lower price would require non-commercials to go net short in order to benefit if their expectations become true. Given that there is no change in fundamentals, oil producers then prefer to sell on the spot market, where the oil price does not fall, as there is no change in oil market fundamentals. Moreover, if non-commercials go short in a significant amount, there remains the question of who goes long. Commercial producers and consumers probably only do this if they expect a future spot price lower than the current one. Hence, we take non-commercial net positions as an approximation of speculation. The larger net positions are, the stronger is speculative activity. A case of negative net positions then indicates a situation where financial investors in total effectively go net short, because they expect the oil price to fall further owing to changing fundamentals. The path of this variable is drawn in panel a) of Figure 4.5. While non-commercials tend to have positive net positions, the difference between long and short only takes off after 2008. Negative values may also be due to the imprecise definition of the category of non-commercials. Panel b) shows the evolution of total open interest on a clear move upwards.

There is another inconvenient about net positions to be an indicator of speculation. High demand of financial investors on the long side may be offset by short positions of other non-commercials. Even though this does not raise net positions, it may nevertheless have an effect on the price, because it is a sign of strong demand pressure to which futures supply adapts by ways of an increasing price. Despite imperfections, we employ net position data to get an impression of a change in financial investment in the futures market that may be caused by monetary policy. Later on, this measure will be extended to include more potential indicators of speculative activity. We will see that it is insufficient to cover potential influences of financial investment. Other approaches to deal with speculation will be required.

Figure 4.5 Non-commercials' net positions and total open interest, 2000–2014

Panel a) Non-commercials' net positions in thousands

Panel b) Total open interest in thousands



Source: CFTC (2014). Commitment of Traders: Historical Compressed.

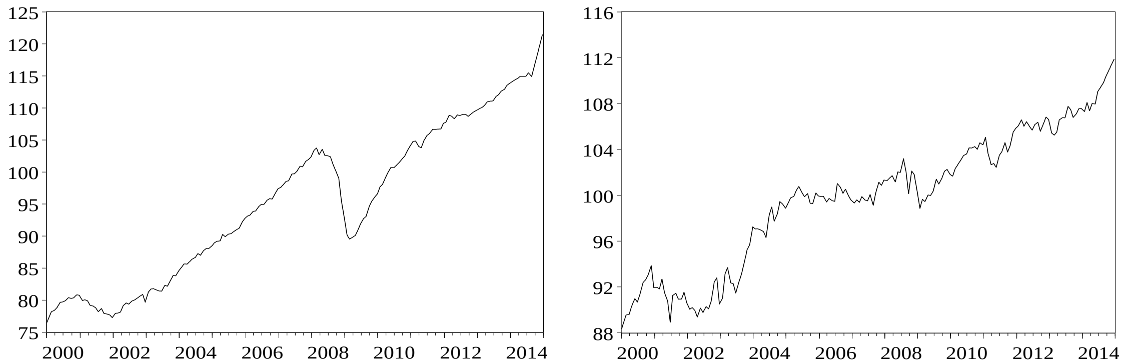
Fourth, the fundamental side of the oil market should be included as well. The supply side of the oil spot market can be modelled by global oil production provided by the EIA (2015b). Herein, we follow a common path of the literature (see for instance Kilian, 2009b, p. 1058; Lombardi & Van Robays, 2011, p. 16). Yet, we will see later that this variable is not free of any problems. For oil demand, global industrial production data from the World Bank (2015) are chosen. Fossil energy being an important input, we suggest that an increase in industrial production raises the demand for crude oil. There are also other studies where this variable is applied in this sense (see for example Lombardi & Robays, 2011). Unfortunately, these variables are only available at monthly frequency. They are interpolated linearly at the expense of information content of the series. Yet, the only alternative would be to leave them away and thus to ignore oil market fundamentals in the SVAR.

To keep the model parsimonious, the supply and demand sides of the oil spot market are merged into the ratio $\frac{industrial\ production}{oil\ production}$. If oil demand rises in proportion to oil supply, this ratio tends to increase. By the way, this reflects changes on supply and demand sides and does not distort the discussed necessary equality of oil supply and demand themselves. The composition of the two variables bears the danger that it cannot distinguish demand and supply shocks individually. This potential loss of information is justifiable, in particular because our theoretical analysis is interested in changes of fundamentals of the oil market in relation to the rest of the economy. If the oil industry reacts stronger (less) to monetary policy than the rest of the economy, the denominator should change more (less) than the numerator. The fundamentals ratio should thereby be capable to take the spot market into account. Both variables are shown in Figure 4.6. Industrial production exhibits a growth path that is only interrupted by the financial crisis. Global oil production grows as well but less steadily.

Figure 4.6 Indices of global industrial production and global oil production, 2000–2014

Panel a) Global industrial production index (2007=100)

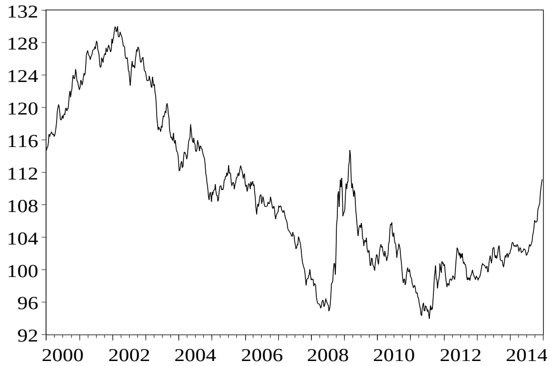
Panel b) Global oil production index (2007=100)



Sources: EIA (2015b). International Energy Statistics; World Bank (2015). World DataBank.

The final variable is the exchange rate taken from the Board of Governors of the Federal Reserve System (2015d). It is an index of the US dollar against a broad group of important US trading partners. The numbers are in indirect quotation, meaning that an appreciating US dollar leads to a higher index value. In Figure 4.7, one notices that the US dollar depreciated in the long run over the total time window under consideration. Recently, there has been a partial re-appreciation. It may be surprising why the exchange rate as a particular transmission channel is modelled with a single variable while other channels are not included explicitly. The exchange-rate channel has – in contrast to the other channels – a quite direct link to the crude oil price, since the latter is traded in US dollars. As such, many other effects express themselves in a change of the exchange rate, which is expected to find its way to the oil price. This variable choice, of course, does not mean that all other transmission channels are ignored. Since the US federal funds rate is a central variable of the model, its transmission to the oil market implies the existence of transmission channels. We argued in abundance that transmission channels are theoretical arguments and therefore difficult to measure. And specifically, they cannot be clearly separated from each other because they are overlapping.

Figure 4.7 The US dollar exchange rate against a broad currency basket, 2000–2014



Source: Board of Governors of the Federal Reserve System (2015d). Trade Weighted US Dollar Index: Broad.

The five variables are tested for cointegration by the Johansen procedure (Johansen, 1991). There are two cointegrating relationship at the 5 percent level of significance both concerning the trace and the maximum eigenvalue test statistics. The precondition for running a VAR is thereby fulfilled. The specification takes the following form:

$$B_0 X_t = C + \sum_{i=1}^{2} A_i X_{t-i} + \varepsilon_t \quad (4.44)$$

where X_t is the vector containing the federal funds rate, ffr_t, the oil spot price, $oilpr_t$, non-commercials' net positions, $noncom_t$, the fundamentals ratio $ip\_oilprod_t$, itself containing industrial production and oil production, and the exchange rate variable, $exch_t$. These are the variables that we have just presented. C is a [5x1]-vector of constants, A_i and B_0 are [5x5]-matrices where i denotes the lag. The lag length of 2 is suggested by the Schwarz information criterion (SIC). The Akaike information criterion (AIC) suggests more lags.[32] We decide in favour of parsimony and choose two lags. ε_t is the vector of innovation shocks. It is assumed that ε_t fulfills the conditions of $E(\varepsilon_t) = 0$, that its covariance matrix is positive-semidefinite, and that it does not face autocorrelation.

B_0 allows the innovation shocks of the variables to have an effect on another variable within the same period. This requires an ordering of the variables to determine which variable affects another variable contemporaneously and which one does not. Chole-

[32] For details about information criteria, see for example Enders (2014, pp. 69–70).

sky ordering is helpful in this place. As argued in the outline of the empirical proceeding, we mainly want to know how the oil price is affected by the other variables. It is therefore influenced by all other variables in the same period but affects other variables only with a lag. The rest of the order is chosen such that the more volatile variables are more impacted by other variables than they influence other variables. These relationships are expressed by means of the structural shocks u_t in the following decomposition matrix $u_t = B_0^{-1}\varepsilon_t$:

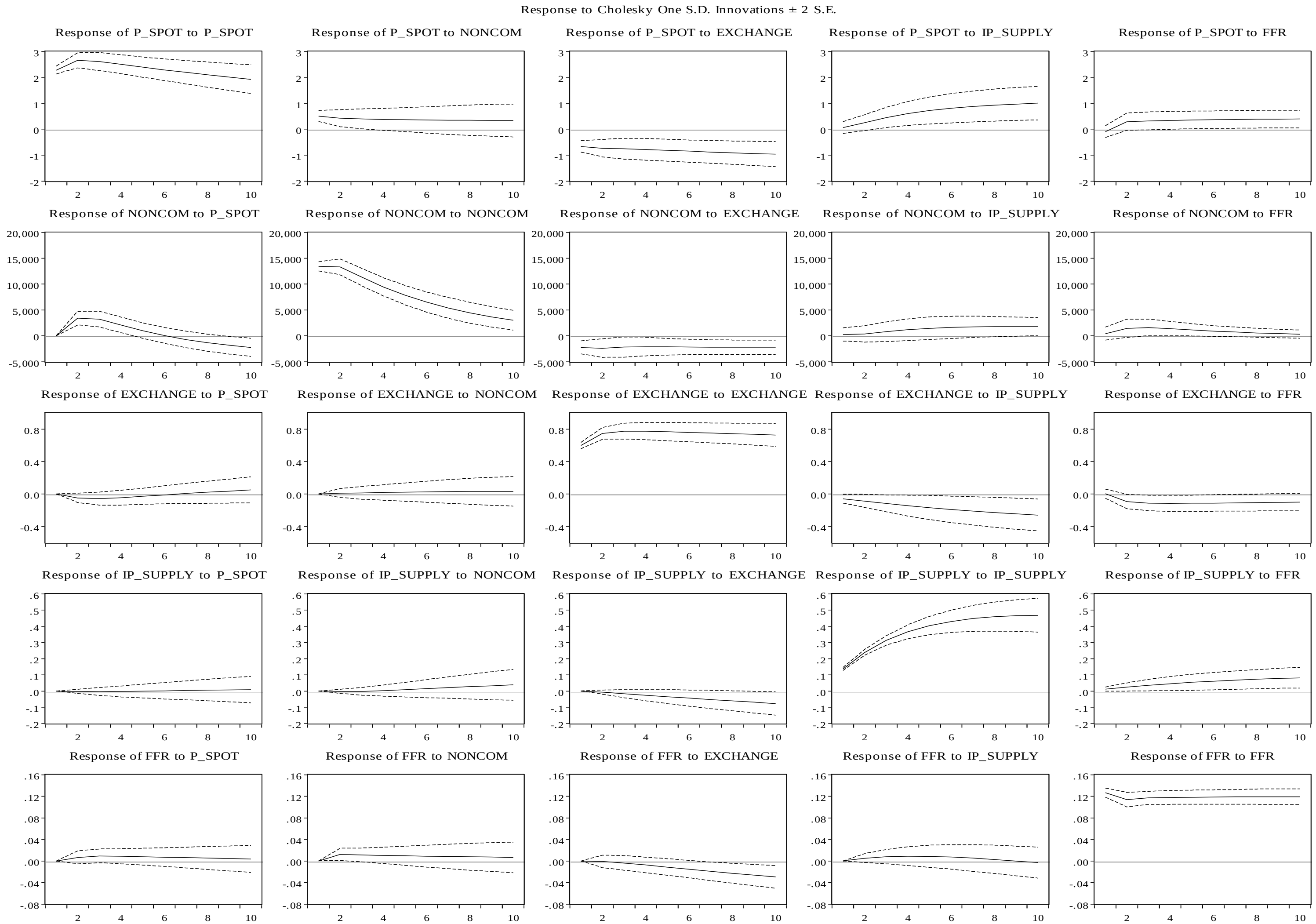
$$\begin{bmatrix} u_t^{ffr} \\ u_t^{ip\_oilprod} \\ u_t^{exch} \\ u_t^{noncom} \\ u_t^{oilpr} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{ffr} \\ \varepsilon_t^{ip\_oilprod} \\ \varepsilon_t^{exch} \\ \varepsilon_t^{noncom} \\ \varepsilon_t^{oilpr} \end{bmatrix} \tag{4.45}$$

Hence, the fundamentals variable is only affected by the oil price or the exchange rate with a lag. The federal funds rate is allowed to have the greatest immediate impact on other variables because it is the only variable that is at least to a great part exogenous.[33] The fundamentals variable is in the second place, because it is suggested to react more slowly to changes in the environment than the financial market variable, to wit, $noncom_t$.

The impulse responses of this SVAR are shown in Figure 4.8. The result is not spectacular at all. First of all, the federal funds rate features no significant impact on other variables except a scarce effect on the fundamentals ratio, suggesting a weaker reaction of the oil demand side to an increase in the interest rate than the supply side. The signs of the impulse responses of the oil price, net positions and the exchange rate are even in the opposite sign of what the theory suggests, even though they are not significant. The significant results are on the one hand the negative relationship between the US dollar strength and the oil price, where causality seems to go from the exchange rate to the oil price. On the other hand, there seems to be a significant but quite small positive two-sided causality between the oil price and net positions. The clearest result arises with regard to the fundamentals variable: the oil price increases in response to an increase in industrial production relative to oil supply. Moreover, the US dollar seems to depreciate in response to an increase in the fundamentals ratio. This might be due to a rising US current account deficit associated with stronger global economic growth.

[33] We regard the federal funds rate as exogenous as argued by the theory of endogenous money. The partially endogenous character arises from central bank reactions triggered by economic developments.

Figure 4.8 Impulse responses between monetary policy and the crude oil market, 2000–2008



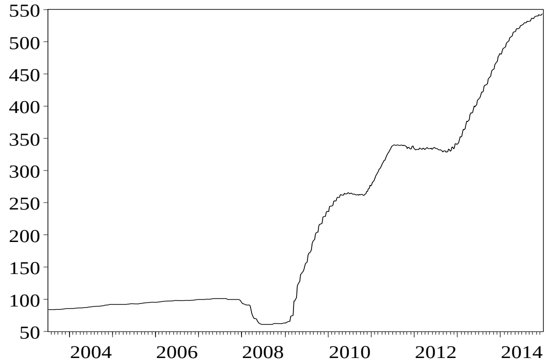
Source: author's elaboration.

4.4.1.2 The Second Period, from 2009 until 2014

The period from 2009 until 2014 is considered in a separate SVAR owing to the change in the US monetary policy stance. Modelling the impact of unconventional monetary policy is not easy. The advantage in comparison to the federal funds rate is that the effect of asset purchases should immediately be visible in prices and not only gradually, as is probably the case with the policy rate of interest. On the other hand, a change in the federal funds rate is only announced at the end of the FOMC meeting and thus unknown before, even though there are trials to anticipate it. Unconventional measures are announced as well but then executed only step by step. For instance, the Fed communicated on September 13, 2012, that it would purchase additional mortgage-backed securities of 40 billion US dollars per month (Fed, 2012). While this information is probably new for market participants, subsequent monthly purchases are not new. Thus, a large part of unconventional policy can almost certainly be anticipated once it is announced. By this argument, it is the shock at the announcement date that should be included in the investigation (see for instance Gagnon et al., 2011; Gilchrist & Zakrajsek, 2013). However, it is an open question whether or not asset purchases are anticipated effectively. Assuming that they are perfectly anticipated after the announcement is an implicit assumption of the efficient markets hypothesis that we consider to be too strong an assumption. Only modelling the announcement shock as an exogenous dummy in the SVAR is thus likely to prove insufficient. Moreover, it is not clear how to consider a single announcement. Including all dates since the outbreak of the financial crisis where the FOMC signalizes a change in its stance on unconventional monetary policy would require the inclusion of at least 15 dummies (Fed, 2014a). Since the efficient markets hypothesis is hardly able to isolate 15 separate effects, the result may be that competing dummies mutually reduce the chance of significant outcomes when they follow one another with high frequency. It is, in addition, not clear how a dummy variable should be built. It may be only a short-run event or it might leave its trace until the end of the considered time window.

For these reasons, an alternative approach is chosen. It suffers the inconvenient of being anticipated but qualifies insofar that it can take longer-run effects into account and that it is a set of real data. We take the holdings of the System Open Market Account (SOMA) of the US Federal Reserve. It contains the securities purchased by the Fed in open-market operations. Data are available at the Federal Reserve Bank of New York (2015). It allows drawing a rather exact picture of the central bank’s implementation of the asset purchase programmes. The sum of total assets features a very slowly growing and stable pattern from 2003, when the series started being published, until the end of 2008. In 2009, it soon starts rising to levels that are multiples of the initial ones, as Figure 4.9 shows. SOMA changes thus reflect monetary policy changes from the beginning of the financial crisis onwards and especially against the background of a policy rate of interest that has reached the zero lower bound.

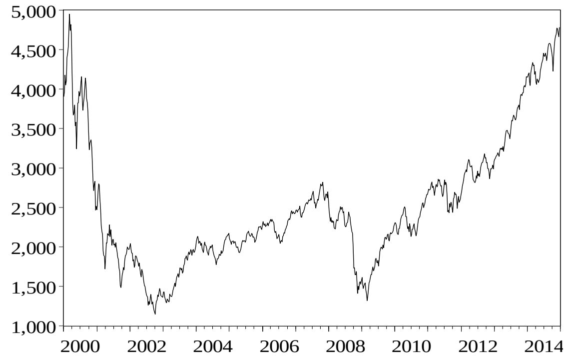
Figure 4.9 The Federal Reserve System Open Market Account (SOMA) index mid-2003–2014 (2007 = 100)



Source: Federal Reserve Bank of New York (2015). System Open Market Account Holdings.

The SVAR keeps its form beside of two changes. First, the variable $soma_t$ replaces ffr_t. Second, since the central bank now acts not only by setting the policy rate of interest but rather by directly intervening in financial markets, we add a stock market variable reflecting financial market conditions. We argue that higher stock prices spill over to commodity markets owing to investors' purposes of profit, wealth store or portfolio diversification. It makes the model less parsimonious but has the potential to test an essential aspect of the theory, namely how monetary policy practically transmits to the oil price. The corresponding data series is the NASDAQ Composite Index (2015) containing more than 3000 equities either in the form of stocks or private non-derivative securities. Figure 4.10 shows the rather turbulent pattern of the index. For simplicity, we refer to it as p_stock_t. It is placed between $exchange_t$ and ip_oils_t in the Cholesky decomposition. The Johansen cointegration test suggests three and one cointegrating relationships at the 5 percent level for the trace and the maximum eigenvalue statistics, respectively.

Figure 4.10 NASDAQ Composite Index, 2000–2014

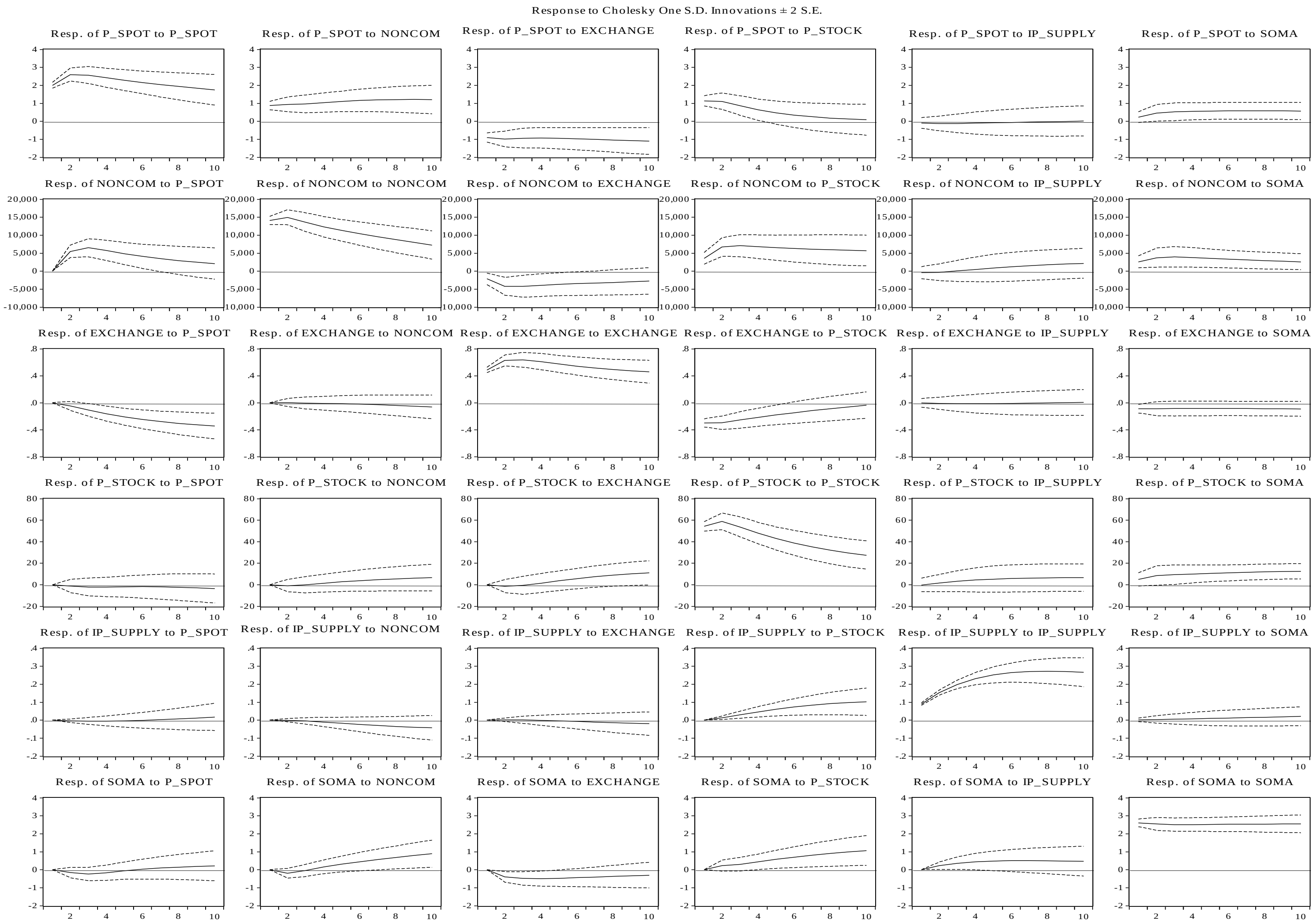


Source: NASDAQ OMX Group (2015). NASDAQ Composite Index.

The result of this second SVAR is shown in Figure 4.11. It is much more promising in what concerns significance. The SOMA variable has small and scarcely significant but lasting impacts on the oil price, on net positions and on stock prices. This corresponds to the preceding analysis: asset purchases raise the oil price, because investors react by purchasing stocks and futures contracts. It is insofar remarkable that it is hard to find an appropriate monetary policy variable and $soma_t$ is not a perfect one, either. Moreover, there seems to be a two-sided positive causality between the oil price and non-commercial net positions. Higher net positions, that is, more financial investment, raise the oil price, whereby a higher oil price gives an incentive to raise investment in futures contracts. These effects are confirmed by the significant and positive impact that rising stock prices have on net positions and the oil price. While the effect on the oil price occurs only in the short term, the effect on net positions remains positive for the ten-week window considered. This might be due to the fact that the spillover from stock markets affects net positions directly and thereby the oil price indirectly. The impact of an exchange rate change is about the same as between 2000 and 2008.

The fundamentals variable does not react significantly to any other variable and affects only stock prices. Intuitively, higher industrial production leads the stock market index upwards. The relative passivity of this variable in reacting to other variable changes might partially be due to the need of interpolating monthly to weekly data and partially to more lagging changes in fundamentals than in financial variables.

Figure 4.11 Impulse responses between monetary policy and the crude oil market, 2009–2014



Source: author's elaboration.

While one VAR hardly exhibits any significant result, the other is rather well in line with our theoretical analysis. Yet, the latter cannot belie that the VARs have fundamental weaknesses. Cholesky decomposition has been chosen and the resulting ordering is plausible. However, a change in the ordering or another structural decomposition might make even strongly significant impulse responses insignificant. There is thus the likely problem of missing robustness. But, additionally, there is another, probably much more serious criticism: our theoretical analysis draws a picture of the oil market consisting of a spot and a futures market both evolving simultaneously. There are complex relationships that materialize in a different degree and take more or less time to occur. Our theoretical analysis takes radical indeterminacy into account that capitalist economies are confronted with. VARs require summarizing a complex system to some few standardized variables. A fatal drawback of VAR models hardly ever discussed in the literature can be summarized as follows: all variables are obliged to have the same frequency and the same number of lags. Hence, effects of oil market fundamentals are assumed to have the same speed as an exchange rate change or an interest rate change. If not, they do not exist. However, it is obvious that financial variables are more flexible than real variables. We argue that a change in the US federal funds rate has an effect on the oil market that is hard to measure, because it might be anticipated and probably occurs not in the form of a shock but rather gradually. It thereby becomes quite difficult for the US federal funds rate to prove its importance if the number of lags is given exogenously from the perspective of a single variable, because it is actually determined by the model as a whole.

4.4.2 A Cointegrating Relationship of the Crude Oil Market

For the reasons summarized in the previous section, we must find a way to test our theoretical analysis while allowing for indeterminacy and complexity. Let us start with a cointegrating equation over both periods from 2000 until 2014 containing the variables that we argued to be the central ones. We leave monetary policy aside for a moment and merely consider the crude oil market separately. The oil price is represented as explained by the fundamentals, to wit, supply and demand, non-commercials' net positions in the futures market, and the exchange rate. Since the need for parsimony loses its urgency partially, supply and demand components are taken separately as $oilprod_t$ and ip_t respectively. The basic equation is as follows:[34]

[34] The choice of the fundamentals variables, that is, supply and demand as well as the exchange rate variable, is probably unchallenged owing to their unambiguous theoretical role in the crude oil market. The speculative variable is more controversial. We conducted the estimation of equation (4.46) with different futures market variables such as total open interest. Since we did not get meaningful results, we concentrate on the particular specification of the equation that is going to be presented now.

$$oilpr_t = \beta_0 + \beta_1 * noncom_t + \beta_2 * ip_t + \beta_3 * oilprod_t + \beta_4 * exch_t + \varepsilon_t \qquad (4.46)$$

Estimation of equation (4.46) yields results that are shown in the first column of Table 4.1. To base the starting point of the following proceeding on stable grounds, it is as well estimated in logs. For this purpose, net positions have to be transformed, because log values can only be built with positive numbers. As a simple solution, we index the series with the first data point being set to 100. Then, we linearly transform it by adding the lowest value to each data point such that all values are at least zero. Finally, we raise data by 1 in order to have only positive values. This approach may appear as arbitrarily but it is the simplest one possible. To broaden the basis of equation (4.46) further, we replace data of $noncom_t$ by another indicator: instead of net positions of non-commercials, we take their total long positions. The so-called spread, that is, the number of non-commercial long positions being evened up by own short positions, is included in the dataset. Now, as we argued, net positions might be an insufficient variable to cover all potential speculative effects. Total long positions are thus a trial to approach speculative activity from another viewpoint. The higher long positions – including the spread – the higher demand power is suggested to be exerted in the futures market. The result should be a higher price. Likewise, we conduct the same estimation in log values whereby a transformation of total long positions into positive values is not necessary anymore, as they are naturally already positive. We thus end up with four equations.

It can be seen that the most clear-cut significant results are given by the spot demand side, that is, industrial production, and the exchange rate. Both coincide with economic theory. The higher industrial production, the higher is the oil price. As argued before, the positive sign is a hint that dominating causality goes from oil demand to the oil price. If there would be reverse causality, that is, from price to demand, the sign should be negative. The exchange rate variable is negatively correlated with the oil price. The stronger the US dollar, the lower is the oil price. As both possible causalities are suggested to be negative by theory, nothing can be said about whether causality goes from the exchange rate to the oil price or *vice versa*. The oil supply variable is significantly negatively correlated to the oil price, indicating that higher oil production lowers the price of oil. However, this applies only to estimations 1) and 3): the log estimates are positive but insignificant. The financial market variable, $noncom_t$, is only significant when it represents total non-commercial long positions.

Table 4.1 The oil price explained by fundamentals and financial variables, 2000–2014

	1) net positions	2) net positions, logs	3) total long positions	4) total long positions, logs
constant	266.43*** (20.76)	10.53*** (1.20)	277.52*** (20.24)	10.90*** (1.19)
ip	1.69*** (0.13)	1.60*** (0.16)	1.40*** (0.16)	1.32*** (0.17)
oilprod	-1.70*** (0.22)	0.41 (0.30)	-1.62*** (0.22)	0.29 (0.30)
exch	-1.77*** (0.08)	-3.33*** (0.11)	-1.74*** (0.07)	-3.17*** (0.12)
noncom	7.80E-06 (5.48E-06)	-0.01 (0.18)	1.33E-05*** (4.02E-06)	0.05*** (0.02)
R^2	0.90	0.94	0.90	0.94
DW statistic	0.068	0.11	0.07	0.10

Standard errors are in parentheses. Coefficients with *, ** or *** are significant at the 10%, 5% or 1% level, respectively.

Source: author's elaboration.

Despite some hints about causal relationships, the regressions in Table 4.1 are correlations that do not provide reliable information about how variables cause one another. Tests for cointegration show that all regressions consist of cointegrating variables. This can be seen from the Augmented Dickey–Fuller tests applied to the residuals shown in Table 4.2.

Table 4.2 ADF test statistics for cointegration residuals

	1) net positions	2) net positions, logs	3) total long positions	4) total long positions, logs
t-statistic	-4.04***	-5.25***	-4.16***	-4.95***
p-values	(0.00)	(0.00)	(0.00)	(0.00)

Coefficients with *, ** or *** are significant at the 10%, 5% or 1% level, respectively.

Source: author's elaboration.

Yet, Table 4.1 shows that the regressions feature impressive R^2s but as well strong autocorrelation exhibited by the Durbin-Watson statistics. Being aware that any correlation cannot stand for itself but rather needs an economic background, this should not disturb our further analysis. It may well be that autocorrelated error terms are due to behavioural anomalies and indeterminacy that may produce short-term disturbances. They do not necessarily falsify our investigation. Anyhow, autocorrelated error terms raise the likelihood that the regression model is wrongly specified. The four regressions are modified by introducing a moving average (MA) component (see for instance Enders, 2014, pp. 50–51; Hamilton, 1994, pp. 48–52). This means that the dependent variable also depends on the error terms of past periods. Potential anomalies can be eliminated by correcting current outcomes by past ones. The result is shown in Table 4.3. Including residuals lagged by two periods suffices to eliminate autocorrelation.[35] R^2s approximate 1. Note that the estimated coefficients do not greatly change except that they have become even more significant, now at the 1 percent level for almost all variables. The financial market variable has become significant for all four regressions. Though, in the second columns of Table 4.3 it is significantly negative. Let us point out that transformation of net positions to log data may reduce the quality of the data series and make the estimate less credible. The sign of the supply variable is significantly negative, if normal values are taken and significantly positive for log values. ip_t and $exch_t$ are still significantly positive and negative, respectively.

Table 4.3 The oil price explained by fundamentals and financial variables in a moving average representation, 2000–2014

	1) net positions	2) net positions, logs	3) total long positions	4) total long positions, logs
constant	278.87***	11.11***	287.83***	11.46***
	(5.39)	(0.38)	(5.28)	(0.37)
ip	1.66***	1.57***	1.37***	1.30***
	(0.03)	(0.05)	(0.04)	(0.05)
oilprod	-1.76***	0.36***	-1.67***	0.21**
	(0.06)	(0.10)	(0.06)	(0.09)
exch	-1.81***	-3.37***	-1.77***	-3.2***
	(0.02)	(0.04)	(0.02)	(0.04)
noncom	9.81E-06***	-0.01***	1.41E-05***	0.06***
	(1.41E-06)	(0.00)	(1.04E-06)	(0.01)
resid(-1)	1.16***	1.12***	1.16***	1.11***
	(0.04)	(0.04)	(0.04)	(0.04)
resid(-2)	-0.19***	-0.18***	-0.20***	-0.16***
	(0.04)	(0.04)	(0.04)	(0.04)
R^2	0.99	0.99	0.99	0.99
DW statistic	1.996	1.96	2.00	1.97

Standard errors are in parantheses. Coefficients with *, ** or *** are significant at the 10%, 5% or 1% level, respectively.

Source: author's elaboration,

[35] For reasons of missing space, we renounce to additional steps to test for heteroscedasticity. In view of the quite strong significance of the variables estimated after removing autocorrelation, we suggest that the relationship is sufficiently stable and should not be greatly reduced by further corrections.

These regression results are useful to our further examination. All in all, we can argue that most results are rather stable whether taken as logs or not. The financial market variable and oil production require further analysis. Moreover, the coefficients are almost identical in the basic correlation in comparison to the MA representation. Thus, it hardly makes a difference whether to choose the coefficients of Table 4.1 or those of Table 4.3.

4.4.2.1 Assessing Causalities

The next step of our analysis focuses on causal relationships. We are interested to know if the financial market variable, oil demand, oil supply, and the exchange rate cause changes in the oil price. The method applied is the concept of Granger causality (see for instance Granger, 2004, p. 425). By investigating relationships between two variables separately, the number of lags can be varied in contrast to the VARs, where the lags of a particular variable are predetermined by the whole model. The number of lags for measuring Granger causality is not definitely given. Often, it is chosen by the number of lags that a corresponding VAR would suggest by applying information criteria. But this is not an exclusive way of proceeding. Finally, the lags should be chosen according to economic reasoning. Fundamentals variables are expected to require more time to have significant effects on other variables than financial variables.

Taking one single number of lags as the true and only one would be arbitrary. Causal relationships might be significant at a given number of lags but insignificant with one lag more or less. To get stable and credible results, we will investigate Granger causalities at different time lags. Granger causality tests naturally involve testing of causality from variable *a* to variable *b* as well as from *b* to *a*. However, in the analysis, the focus is on the causal influence of the explaining variables on the oil price. Causality testing from the oil price to other variables would be interesting but would require too much space. Thus, in the following investigation, causal effects of the oil price usually are not tested. However, we refer to them where necessary to complete an argument.

The Granger causality test takes the following general form. If it is to be found out whether *a* causes *b*, the formula is as follows:

$$b_t = \sum_{i=1}^{I} \beta_i * b_{t-i} + \sum_{i=1}^{I} \alpha_i * a_{t-i} + \varepsilon_t \qquad (4.47)$$

where I is the total number of lags included. Equation (4.47) is held in rudimentary form. It does not indicate whether the variables are in levels or in differences. Granger causality testing requires data to be stationary (Hendry, 2004, p. 205). Table 4.4 tests the time series for their order of integration by means of an Augmented Dickey-Fuller (ADF) test (see for example Enders, 2014, pp. 206–208). It shows that all variables are I(1), that is, they are unit root in levels and stationary in first differences. Hence, Granger causality is tested in first differences. Equation (4.47) is completed by a level variable of *a* and *b* for the first lag. The rest remains the same. This is a usual way of proceeding in practice that is analogous to the formula of the ADF test and does not change the intuition of the equation.

Table 4.4 Augmented Dickey-Fuller tests for oil market data, 2000–2014

	levels		1st differences		Order of integration
Oilpr	-1.80	(0.38)	-22.75***	(0.00)	I(1)
Ip	0.52	(0.99)	-4.71***	(0.00)	I(1)
Oilprod	-0.24	(0.93)	-8.37***	(0.00)	I(1)
Exchange	-1.24	(0.66)	-21.29***	(0.00)	I(1)
Noncom					
net positions	-1.86	(0.35)	-24.59***	(0.00)	I(1)
total long positions	-0.75	(0.83)	-8.54***	(0.00)	I(1)

Tests are executed with intercepts. *p*-values are in parentheses. Coefficients with *, ** or *** feature a stationary process at the 10%, 5% or 1% significance level, respectively. The other variables have unit root.

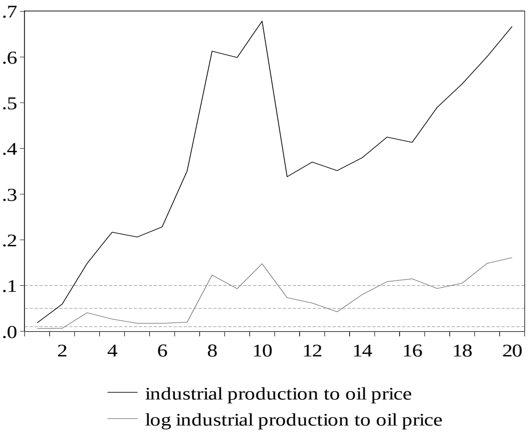
Source: author's elaboration.

Let us start with the fundamentals variable yielding the clearest results in the cointegrating equations, that is, global industrial production. Panel a) in Figure 4.12 draws the patterns of the *p*-values of Granger causality estimates from one to twenty lags. The lower the *p*-value, the more significant is the effect. The dashed lines denote significance at the 1 percent level, the 5 percent level and the 10 percent level, respectively. For instance, where the continuous line is below the highest dashed line, there is Granger causality at the 10 percent level of significance at the corresponding number of lags. If it is below the middle dashed line, causality exists even at the 5 percent level, and so on. Let us remember that one lag corresponds to one week. One graph shows causalities with normal data, the other one with log data. While normal data reveal significant causality from industrial production to the oil price only with one and two lags, log data yield significance at the 1 percent level for one and two lags, at the 5 percent level until seven lags and at the 10 percent level between 11 and 13 lags.

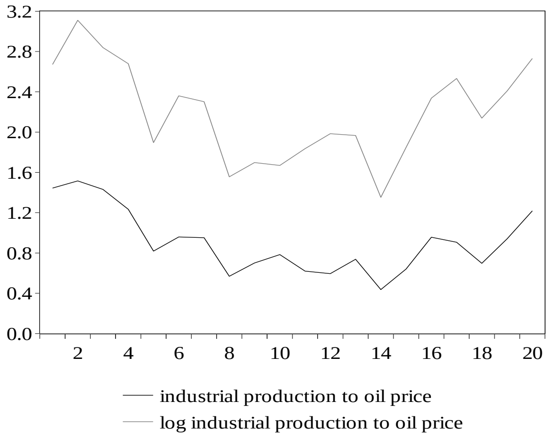
The mere assessment of significant causality is not sufficient as a result in favour of or against our theoretical investigation. It is necessary to know the sign of the causal influence. Panel b) of Figure 4.12 exhibits the sum of the estimated coefficients of the Granger causality test, that is, the sum of the α_i's in equation (4.47). If Granger causality is found to be significant for a particular lag choice and if, say, the sum of coefficients is positive, then it can be said that variable *a* has a positive influence on variable *b* at this specific number of lags. It can be seen in panel b) that for both normal and log data, the impact of industrial production on the oil price is clearly positive. This is found for all lags whether the corresponding effect is significant or not. Taking panels a) and b) together, it can be concluded that there is a positive sum of coefficients that goes along with Granger causality estimates that are in large part significant. Hence, as is to be expected and even though not all *p*-values are significant, there is strong evidence that rising industrial production causes the oil price to increase. The outcome does not consist of a single number but is instead based on a rather large set of tests and can thus be considered as reliably stable. The effect seems to be rather immediate, because the first two lags exhibit the lowest *p*-values and also the highest sum of coefficients. This is quite intuitive, since we suggest that the oil price variable reacts fast on new developments. If we tested the impact of the oil price on industrial production, Granger causality would probably be assessed only with a considerable number of lags, if it is ever found to be significant.

Figure 4.12 Granger causality from industrial production to the oil spot price

Panel a) *p*-values of Granger causality tests depending on the number of lags



Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



Source: author's elaboration.

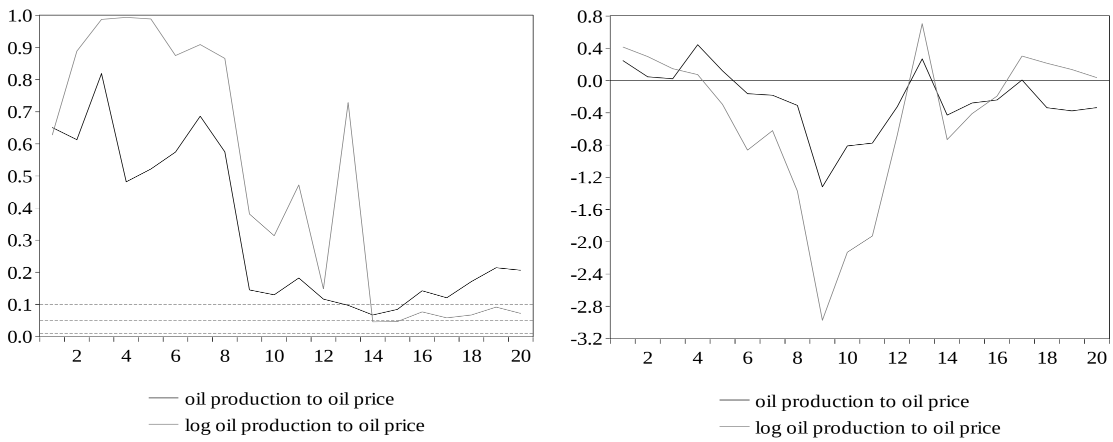
As they are only of secondary importance, Durbin-Watson statistics are not shown here. Yet, autocorrelation does hardly occur in these tests neither with few nor with many lags. This is found for causality tests with industrial production as well as with the other variables.

The next variable, oil production, brings much less distinct results. Panel a) of Figure 4.13 yields hardly any significant values. The only time where the 5 percent level of significance is scarcely reached is for log data with 14 and 15 lags. From 16 until 20 lags, there is significance at the 10 percent level for log data. The same applies to normal data between 13 and 15 lags. However, the combination with panel b) makes the hitherto findings even less convincing. The negative effect of oil production on the oil price, as argued in our theoretical analysis, is only visible between six and twelve lags. However, all these sums of coefficients are found to be insignificant. In the area where there are significant *p*-values, the sums of coefficients are ambiguous: some are positive and some are negative. In total, these results do not allow concluding that oil production has a significant impact on the oil price. Possible reasons for this shortcoming are emphasized later.

Figure 4.13 Granger causality from oil production to the oil spot price

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



Source: author’s elaboration.

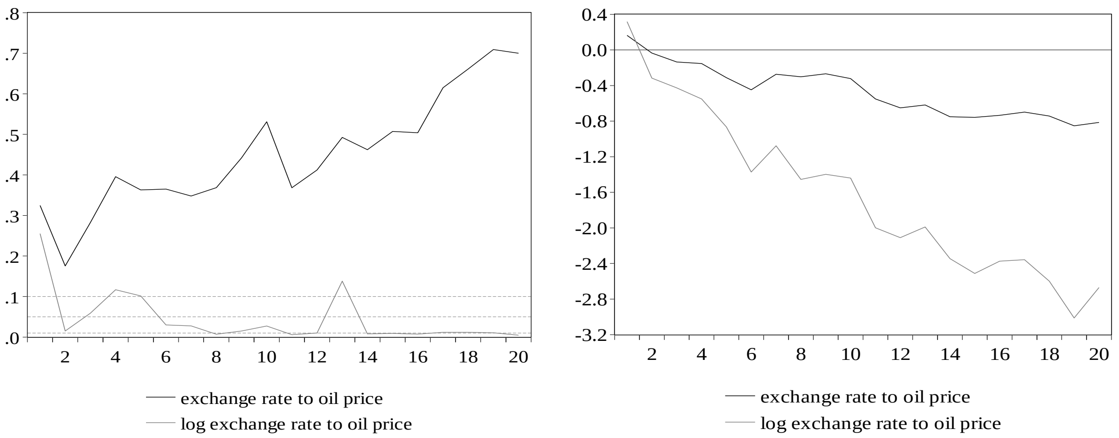
Granger causality from the US dollar exchange rate to the oil price can be found but requires a closer look at the results. Figure 4.14 shows in panel a) that short-lagged tests do not yield significant causality. For higher lag orders, normal data tests never become significant while testing with log data brings strongly significant results at least at the 10 percent level for almost all lag choices. For 14 and more lags, the *p*-value is close to the 1 percent level and sometimes even lower. Panel b) exhibits unambiguously negative sums of coefficients beside of the test with only one lag. This means that a higher US dollar exchange rate lowers the oil price. Even though panel a) does not exclusively provide significant estimates, taking it together with panel b) gives nevertheless a good picture of the effect. Against this background, it is fair to say that the exchange rate has the predicted influence on the oil price. Hence, Figure 4.14 confirms existing research stating that a weaker US dollar exchange rate lowers the oil price (see for example Zhang et al., 2008).

Evidence suggests that the causal effect may take place in the short run as well as in the medium run, that is, up to 20 weeks in our measurement window. This might surprise, as we argued several times that price variables adapt faster to changes in other, causal, variables than for example quantity variables. A closer look at the mechanism of the exchange rate effect is helpful. We have argued that a weaker US dollar threatens profits of oil producers and lowers the price for consumers outside of the United States. Producers reestablish profits either by accumulating inventories or lowering production, which raises the oil price. Higher global demand should as well have a positive effect on the oil price. Hence, the mechanism, through which the US dollar exchange rate affects the price of oil is through quantities – on the supply side just as on the demand side. This explains why the reaction of the oil price to an altered US dollar exchange rate may take some time or, respectively, is visible for a broad number of lags.

Figure 4.14 Granger causality from the exchange rate to the oil spot price

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



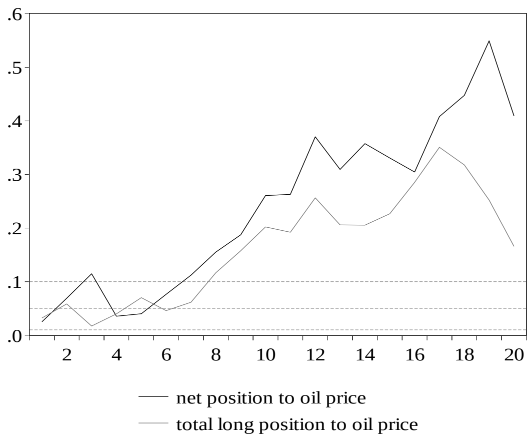
Source: author’s elaboration.

Without going further into details, Granger causality tests show that there is also some evidence of a causal effect from the oil price to the US dollar exchange rate. This is in accordance with the hitherto argument if one takes expectations of producers, consumers and investors into account. Producers and consumers may change their behaviour in the above suggested way in advance, if they expect the exchange rate to change. Moreover, financial investors may invest in crude oil contracts, as they expect to make profits as soon as the US dollar exchange rate changes. This may drive up the oil price further.

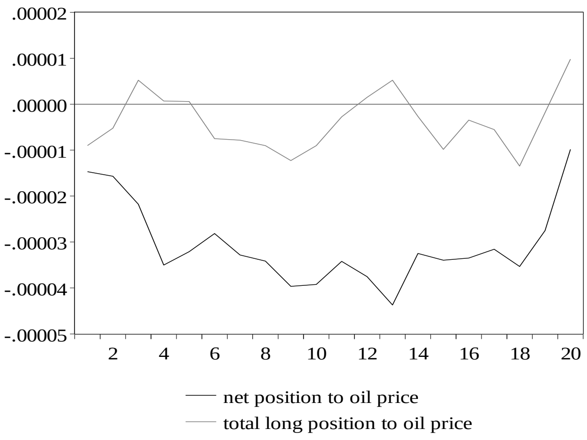
To detect whether this is effectively the case, the financial market variable has to be examined in the same way. Non-commercials' net long positions as well as their total long positions including the spread still are the two variables that should replicate the effects of futures market speculation. In Figure 4.15, panel a) draws the line of *p*-values of the Granger causality tests with normal data. There is Granger causality for both variables from one to six lags (except for three lags with net positions) at the 5 percent and 10 percent level, respectively. With additional lags, no significance is found anymore. Results in panel b) are against any intuition. Total long positions feature a sum of coefficients that is sometimes positive and sometimes negative. The sum of coefficients for net positions is always negative. Log data in panel c) show clearly significant *p*-values for net positions with higher lag numbers, while total long positions are insignificant at any lag. The sums of coefficients in panel d) are clearly negative and tend to get even more negative the more lags are added.

Figure 4.15 Granger causality from non-commercials' futures positions to the oil spot price

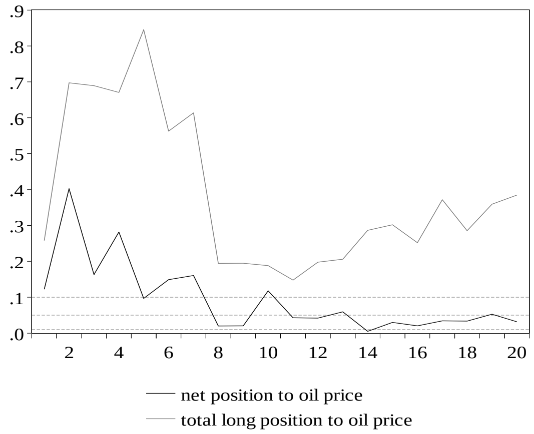
Panel a) *p*-values of Granger causality tests with normal data depending on the number of lags



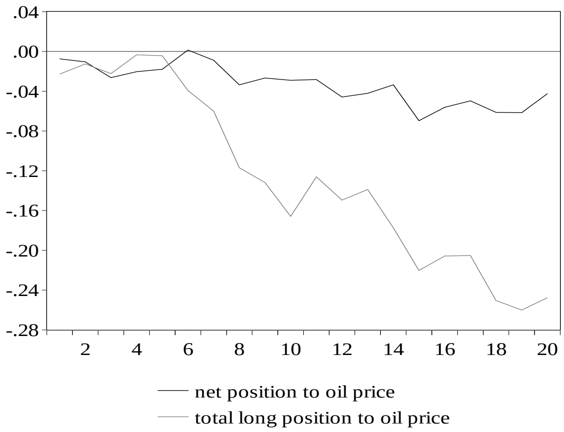
Panel b) Sum of coefficients of Granger causality tests with normal data depending on the number of lags



Panel c) p-values of Granger causality tests with log data depending on the number of lags



Panel d) Sum of coefficients of Granger causality tests with log data depending on the number of lags



Source: author's elaboration.

This is in strong contrast to what our theoretical investigation predicts. If we observe significant Granger causality, we expect the sum of coefficients to be positive instead of negative. There is no logical explanation why higher futures market investment of non-commercials should lead to a lower oil price. Thus, despite the conventional conduct of econometric tests, we have to conclude that with a high probability, Figure 4.15 represents economic nonsense.

4.4.2.2 A Preliminary Interpretation of the Speculation Test Results

Our findings may provide satisfaction to those who deny any influence of speculation on the oil price. For instance, the *Interim Report on Crude Oil* of the ITF (2008), Stoll and Whaley (2010), Alquist and Gervais (2011) as well as Büyükşahin and Harris (2011) apply similar Granger causality tests normally using net long positions to represent speculation. Even though these studies partially differ in the commodity and investor group considered, they draw a generally common conclusion: first, the oil price (or other commodity prices) has a causal effect on futures price investment, to wit, a higher oil price makes investors raising their positions. Second, the volume of futures market investment does not affect the oil price, that is to say, Granger causality tests yield, with hardly any exception, insignificant results. There is no reason to criticize the first finding. Logically and as already discussed, many financial investors use to be trend followers. A price increase in the past attracts new financial capital that wants to benefit from promising returns. It is thus the most natural thing that the oil price has a causal effect on position data. The second result also corresponds in large part to our result in Figure 4.15. The analysis presented here has three advantages in comparison to the studies mentioned above: it investigates two data series that should approximate speculation rather than only one, it is a larger approach as it includes many lag choices, and it takes the sum of coefficients into account instead of only considering *p*-values. The implicit assumption that the above named authors probably make is that the effect of futures market investment is around zero, perhaps also slightly positive, but is not significant. However, we can see in Figure 4.15 that there is significance with some lag choices. Moreover, the sum of coefficient is close to zero for many lag numbers but not always. Often, it is clearly negative.

Hence, is it correct to draw from these results the conclusion that speculation does not have any impact on the oil price? There are two possible interpretations. First of all, one may have full confidence in Granger causality measurement techniques. In this case, it is just consequent to deny any effect of futures market speculation on the oil price. However, this interpretation requires an explanation of why the potential effects of the speculative variables on the oil price – whether significant or not – are in large parts negative rather than positive. There is no intuitive way to make sense out of this. A second way of dealing with unfamiliar results is thinking about the weaknesses of the estimation procedure. While the Granger causality test has the advantage that it allows the variation of lags of a single variable in contrast to VARs, it does not incorporate other control variables, which impedes the assessment of isolated effects. This makes again clear that econometric test results can only be interpreted in connection with an economic theory. They cannot provide absolute truth but merely an additional argument in favour of or against a theory.

In this framework, a third possible explanation arises. The issue of speculation is not easy to define and assess. It has been outlined how the futures market works: expectations of agents are heterogeneous and the number of futures contracts is basically unlimited. Long and short positions are two sides of the same coin: they are necessarily always equal. Yet, supply and demand pressures, entering the market from various sides, assert their effects on the futures price. For instance, high demand of financial investors may raise their long positions. They may either be offset by short positions of commercials but as well by those of other speculators. Net long positions of financial investors thus probably represent only a part of speculative reality and so do their total long positions. Indeed, negative net long positions, that is, positive net short positions of non-commercials, may potentially be a sign that the oil price should fall, because there is nobody who drives up the price by purchasing long positions in large amounts (in this case, however, it is to be explained why commercials consequently go net long; probably since they aim at hedging their sales returns against both low and high price extremes). But, contrastingly, it might as well be that negative net long positions lead to a higher oil price: for instance, this may occur after financial investors have purchased large amounts of long positions leading up the price. Given that the price moves from a specific level further upwards, a growing number of financial investors may expect the price to fall again at some moment. They start offering short positions to the other speculators. If this continues, non-commercials might end up with net short positions. Considering only net positions may give rise to the expectation of a lower price, but it does not take into account the underlying demand pressure that drives the price up. This effect may potentially take place at all levels of non-commercials' participation in futures trade. Whether financial investors' long positions are evened up by other investors' short positions at a high or a low volume does not give a clear-cut indication of what the futures price should be. A particular number of contracts may come into existence by pressure either from the supply side or from the demand side. Assume, first, that some speculators expect the oil price to increase so that they start purchasing long positions or agreeing on new contracts on the long side, respectively. These contracts may be offset by other speculators with different expectations. The exerted demand pressure drives the oil price up; futures supply by other investors' offer of short positions is only a reaction. Assume the second case, where the same market participants expect a falling price and hence purchase short positions. Offsetting by other investors may lead to the same volume of futures contracts. However, since the origin of the futures contracts is in this case to be found in supply pressure rather than in demand pressure, the oil price is likely to fall.

All these stylized cases of what form speculation can take are likely to occur simultaneously in the futures market. Moreover, one single effect is possibly quite short-lived and soon replaced by another one. It is thus the high elasticity and uncertainty of the futures market and of financial markets in general that makes it extremely difficult, if not impossible, to represent speculation by a single variable. Considerations suggest that speculation is too complex to be modelled in this way.

Of the three interpretations of Figure 4.15, the second one and specifically the third one are more plausible than the first one, which implies unconditional belief in econometric estimation results. They ask for other approaches in testing for speculation. In this respect, it is wrong to conclude that if Granger causality tests yield insignificant results for the causality from net positions to the oil price, then there is no speculative effect in the oil market. The mentioned papers therefore should not be seen as a final verdict proving the non-existence, or non-effectiveness, of speculation.

After the criticism of these approaches, an explanation of the SVARs impulse responses in Figures 4.8 and 4.11 is needed. In the first period, from 2000 until 2008, the effect of net positions on the oil price is broadly insignificant, while it is significantly positive in the second period, from 2009 until 2014. We are now cautious with delivering an interpretation. First, the result may indeed be an indication of speculation, saying that it was ineffective in the first period and effective in the second period. Thanks to the SVAR approach that allows isolating individual effects, the effect is as it should be, that is, positive rather than negative. This would also mean that speculation has changed over time and that it is more than one-dimensional such that net positions as a single data series are not sufficient to describe it. Second, the structure of the SVARs may be inadequate and the isolated effect therefore arbitrary. A different specification of the models might bring different results. Third, owing to the complexity of the phenomenon of speculation, the outcomes still cannot be interpreted. A fair and modest conclusion is to say that Figures 4.8 and 4.11 give a hint confirming the effectiveness of speculation. But owing to uncertainty, the result is rather unstable. We thus need an alternative approach.

By the way, the problem of representing speculation does not mean that the variables employed are completely useless. On the one hand, especially the pattern of total non-commercials' long positions shows how financialization has increased in the past. We argued that the latter contributes positively to the influence of speculation. Correlations thus can help to give at least a hint of some tendencies. On the other hand, the cointegrating relationship assigns a certain explanatory power to both variables even though the sign is in line with our theoretical analysis only in six out of eight estimates. Yet, what is still missing is the direction of causalities between the variables. However, since the estimates in Tables 4.1 and 4.3 seem to be rather stable, we leave them unchanged and will use them in the alternative proceeding subsequently.

4.4.3 Assessing Monetary Policy Transmission to the Oil Market

In the previous section, the cointegrating equation (4.46) and the subsequent tests for Granger causality have focused on the crude oil market itself without taking monetary policy into account. Before we take a further step to enlighten the speculation issue, let us consider that the oil market is connected to monetary policy. We will point out that the influence of speculation can be assessed or at least be approximated, respectively, by the analysis of the transmission of monetary policy through financial markets.

To arrive there, we investigate the impact of monetary policy on each of the variables in the cointegrating equation. Testing for Granger causality from monetary policy to the oil price means measuring the total effect with neither distinguishing between fundamentals and financial market effects nor taking any special features of the individual transmission channels into account. Examining the connection between monetary policy and the explaining variables, that is, industrial production, oil supply, the US dollar exchange rate and the speculative variables, then should allow for conclusions about how monetary policy transmits through fundamentals and in how far financial markets play a role. To warn again in this place, the impact of futures market investment will require further analysis.

While the cointegrating relationship of the crude oil market can be estimated for the whole time window from 2000 until 2014, monetary policy again needs to be separated into two periods. We use again the federal funds rate for the period from 2000 until 2008 and the SOMA variable for the second phase, from 2009 until 2014. Note that the approach of varying lag choices brings the advantage of reducing measurement problems of monetary policy shocks. The more lags are included, the higher is the probability that the gradual effects of the US federal funds rate are taken into account.

Again, variables have to be tested for stationarity. In Table 4.5, unit root test results indicate that all variables are I(1) in the first period except industrial production and net positions, which are I(2) and I(0) respectively. For industrial production, the variable has therefore to be taken in second differences. In the second period, orders of integration are I(1) at the 10 percent level for the SOMA variable and at the 1 percent level for all other variables.

Table 4.5 Augmented Dickey-Fuller tests for oil market and monetary policy data

2000–2008							
	levels		1st differences		2nd differences		Order of integration
oilpr	-1.37	(0.60)	-17.82***	(0.00)			I(1)
ip	-2.22	(0.20)	1.40	(1.00)	-7.87***	(0.00)	I(2)
oilprod	-1.32	(0.62)	-9.33***	(0.00)			I(1)
exchange	-0.89	(0.79)	-9.89***	(0.00)			I(1)
noncom							
net positions	-4.72***	(0.00)	-19.65***	(0.00)			I(0)
total long positions	-0.64	(0.86)	-6.50***	(0.00)			I(1)
ffr	-1.59	(0.49)	-4.00***	(0.00)			I(1)

2009–2014					
	levels		1st differences		Order of integration
oilpr	-2.39	(0.15)	-13.87***	(0.00)	I(1)
ip	-0.71	(0.84)	-5.66***	(0.00)	I(1)
oilprod	-0.13	(0.94)	-5.83***	(0.00)	I(1)
exchange	-1.43	(0.57)	-13.28***	(0.00)	I(1)
noncom					
net positions	-1.55	(0.51)	-14.76***	(0.00)	I(1)
total long positions	-1.37	(0.60)	-7.96***	(0.00)	I(1)
soma	-0.37	(0.91)	-2.86*	(0.05)	I(1)

Tests are executed with intercepts. *p*-values are in parentheses. Coefficients with *, ** or *** feature a stationary process at the 10%, 5% or 1% significance level, respectively. The other variables have unit root.

Source: author's elaboration.

4.4.3.1 The Effect of the Federal Funds Rate in the First Period

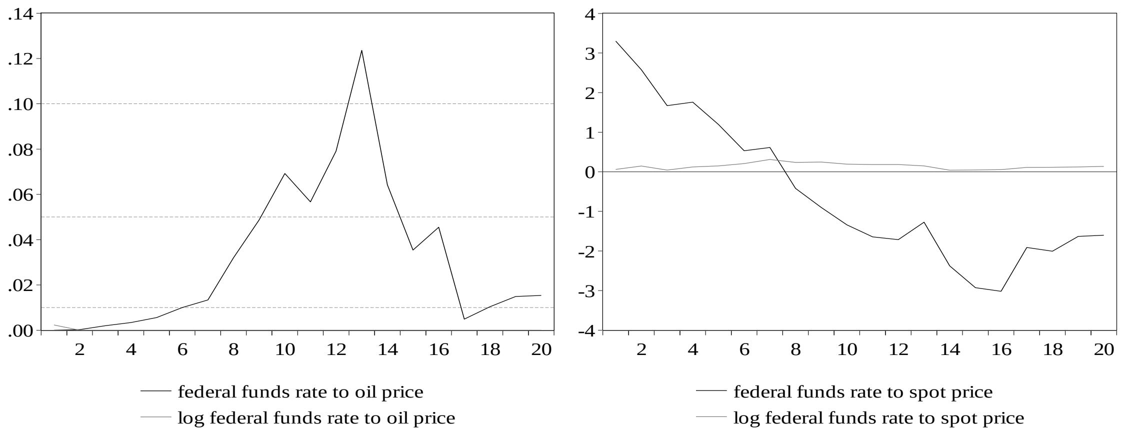
The overall effect of monetary policy on the crude oil price in the first period is shown in Figure 4.16. First, Granger causality tests are considerably significant with many different lag choices for normal data at the 1 percent, 5 percent or 10 percent level, respectively, as can be seen in panel a). For log data, test results are so highly significant that the graph approximates zero and thus is hardly visible. Panel b) draws a less clear picture. Normal data feature a positive relationship between the US federal funds rate and the oil price for low numbers of lags and a negative connection for higher order lags. Log data provide clear evidence for only positive causality. In this context where the numerical values between the sums of coefficients of normal data and those of log data are so large, it should be emphasized again that we are not interested in the magnitudes of the estimates. Our focus here is merely on whether the results are significantly positive or significantly negative. Given the fact that log sums of coefficients mean percentage changes, the causal effect is not so small eventually.

Considering our detailed theoretical analysis, there are some possible interpretations of these outcomes. A positive sum of coefficients means that expansive monetary policy lowers the oil price. Given that the estimate is appropriate, this gives rise to a specific combination of the fundamentals and the financial market effect of monetary policy on the oil price. The financial market effect has been judged to be unambiguous, meaning that expansive monetary policy raises the oil price. It is thus a negative relationship. For the overall effect of Granger causality to remain positive, there must be a strongly positive causation from the US federal funds rate to the oil price through the fundamentals effect. This is the case, if the oil industry reacts stronger to a change in the interest rate than the rest of the economy. Assuming a cut in the interest rate, the oil industry raises oil supply more than the non-oil economy raises oil demand. It is basically not impossible that this fundamentals effect is large enough to outweigh the counteracting financial market effect. However, it is unlikely from a theoretical point of view. While the financial market effect is argued to be rather clear-cut, the impact of monetary policy transmission through fundamentals is likely to be much more ambiguous. Hence, our theoretical analysis suggests an overwhelmingly negative causal effect of the US federal funds rate on the oil price. This is confirmed by strongly significant normal data sums of coefficients with 16 up to 20 lags but not by lower lag orders and not by log data.

Figure 4.16 Granger causality from the US federal funds rate to the oil spot price

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



Source: author's elaboration.

Hence, one may again doubt the outcome of the Granger causality tests. The observation that a higher US federal funds rate leads to a higher oil price is likely to be related to the well-known 'price puzzle'. This phenomenon, intensely debated particularly by Sims (1992) and Eichenbaum (1992), denotes the observation that contractionary monetary policy is followed by a higher general price level (Eichenbaum, 1992, p. 1002). The phenomenon should not be explained by turning theories of monetary policy and its effects upside down. Monetary policy is still suggested to exert its effects but the latter do not materialize in data, because there are other endogenous variables driving the price level. There may be strong economic activity leading to increasing prices. Monetary policy reacts by raising interest rates. The cause of price growth does not fully disappear. So, prices keep rising but less than they would, if there were no reaction of monetary policy (Sims, 1992, p. 988). The price puzzle is one of the sources of the debate about how to model proper monetary policy shocks. It keeps discussions about the effectiveness of monetary policy alive (see for instance Kuttner & Mosser, 2002, pp. 17–18).

The test for Granger causality from the US federal funds rate to the oil price probably suffers a similar problem. Figure 4.12 reveals that industrial production as an approximation of oil demand has a positive effect on the oil price. At the same time, industrial production is also not too bad an indicator of economic activity in general. Rising industrial production thus may raise the oil price as well as the general price level. Therefore, monetary policy is likely to raise the interest rate level in situations where the price of oil is high. Since the underlying price driver, that is, industrial production, may nevertheless grow further, the price is likely to keep increasing for a while, too. Note that we do not at all mean by this argument that the general price level and the oil price move in the same way, so that the real oil price remains the same. Inflation and oil price developments may tend to move in the same direction, but there is no reason to assume that they do it by the same amount. It is for this reason that core inflation and overall inflation are distinguished. Moreover, it has been shown that the correlation between the nominal and the real oil price approximates unity, confirming that inflation is far from explaining a substantial share of nominal oil price fluctuations.

A second effect in the case of crude oil is that not only fundamentals react sluggishly to changes in the conduct of monetary policy. Many financial investors in the futures market probably adapt their decisions – beyond of what concerns ultra-short-run speculative strategies – to an altered interest rate level step by step after the new rate has proved to be stable for a while. A higher interest rate raises refinancing cost more and more, as credits have to be renewed more and more. The price puzzle in the market for crude oil may thus also be due to the fact that the US federal funds rate works only gradually through the financial market effect as it does through fundamentals.

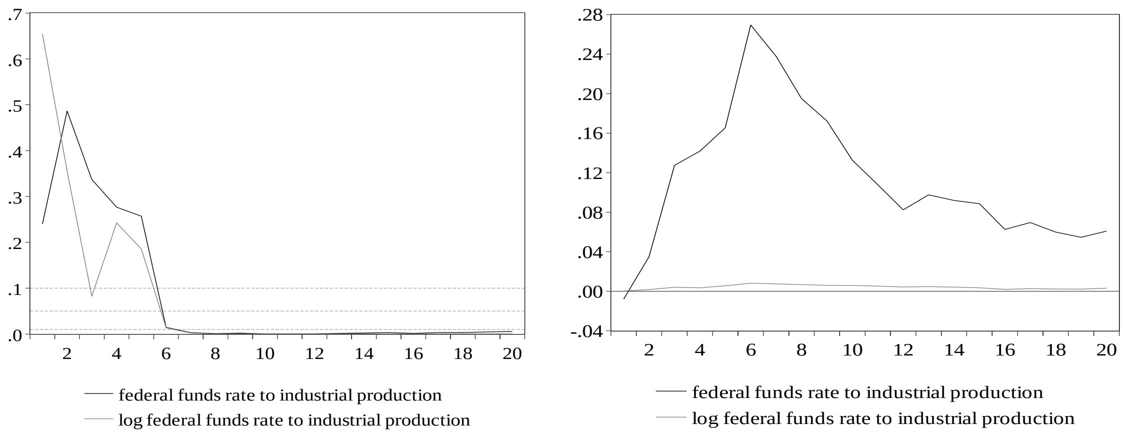
While Granger causality tests with normal data seem to be able to overcome the price puzzle after a sufficient number of lags, the log test series remains positive throughout all lag choices. First of all, this ambiguity asks for a more detailed investigation of the monetary policy impact on the particular transmission effects and channels.

Concerning monetary policy transmission through fundamentals, we first concentrate on the demand side, that is, the non-oil economy. In our setting, it is approximated by global industrial production. Figure 4.17 again shows the *p*-values of the Granger causality tests for causality from the US federal funds rate to industrial production, whereby once normal data and once log data are taken for the two variables. As industrial production is I(2) for this period, it has to be employed in second differences. This means that we test the effect of the US federal funds rate on industrial production growth. Yet, this does not affect the intention of the tests. From 6 lags onwards, we find strong significance at the 1 percent level of significance. However, panel b) again shows that the positive relationship between the US federal funds rate and industrial production seems to dominate all over the sample. Completely accepting this result would lead to a conflict with economic theory. Monetary policy may be significant in that a lower interest rate raises output, or it may be insignificant. But a significant result stating that contractionary monetary policy, to wit, a higher US federal funds rate, raises industrial production is completely counterintuitive.

Figure 4.17 Granger Causality from the US federal funds rate to industrial production

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



Source: author’s elaboration.

Alternative tests can be made with monthly data, where it becomes possible to include a longer time span, as 20 lags then mean almost two years. Additionally, global industrial production data can be replaced by US data. This may help to strengthen the relationship we want to measure. We argued that US monetary policy has international implications. However, the delay and the channels through which the activity of the US Federal Reserve spreads over the world cannot be taken into account in detail. Concentrating on US industrial production data thus might support the finding of significant results. Finally, industrial production is suggested to rise anyway over time owing to the long-run growth path of the economy. Extracting an assumed linear time trend in the data could be a further measure to isolate the component of industrial production that is really affected by monetary policy. There is only a short concluding remark to be made about these modified tests: they do not change the feature that a higher US federal funds rate seems to affect industrial production positively. Test results are not shown here as they do not provide any additional information.

The logical explanation of these shortcomings is that the Granger causality tests suffer from an analogy to the price puzzle. The central bank tends to contract monetary conditions in a situation when industrial production or output in general, respectively, feature a rising trend or even a boom. These are periods when inflation rates use to be higher than in normal or recessive times, or when there are fears of growing bubbles and instability in financial markets. Like prices, output tends to rise further for a while after the monetary authority has raised the interest rate. The opposite happens in a recession: the central bank cuts the interest rate aiming at stimulating the economy, but output continues falling. In the period from 2000 until 2008, there are good examples for both cases. From mid-2004 until mid-2006, the US Federal Reserve raised the federal funds rate continuously. The FOMC justified these measures by the potential threat of inflation owing to high capacity utilization in production and rising commodity prices (Fed, 2006). Later, when the financial market downturn started in mid-2007, the US federal funds rate was cut again and again, until it reached the zero lower bound in the second half of 2008. As is well known, this could not prevent the slump in industrial production. These are just two events that might be sufficient to yield significantly positive Granger causality from the US federal funds rate to industrial production. Again, one should mention that the boom and the recession would have been more extreme, had the Fed not reacted by changing its federal funds rate target.

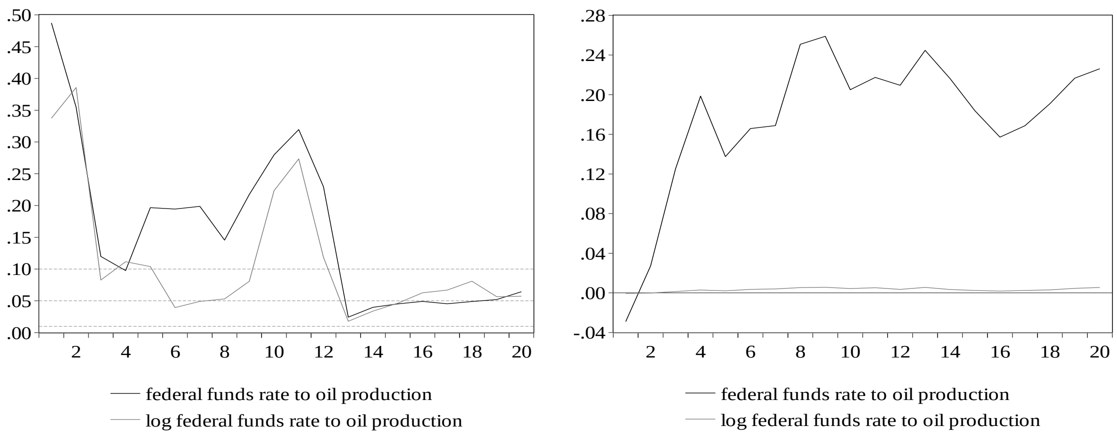
Yet, econometric measurement problems cannot hide the probable fact that the influence of monetary policy on output is limited. Even though it has the potential to affect fundamental variables significantly and permanently without the necessity of bringing them back to some hypothetical equilibrium, monetary policy itself is not always a sufficient condition to set the economic system into motion. We discussed in detail at the beginning that money is demand-determined. Expansive monetary policy is not effective if demand for credit is missing. This leads finally to effective demand in the economy as the crucial condition for lower interest rates to strengthen economic activity. Monetary policy effects exist but their strength and degree of significance change over time so that they are not linear.[36]

The next variable, oil production, is the second fundamental component, since it covers the supply side of the oil market, that is, the oil industry. Granger causality tests for the relationship between the US federal funds rate and oil production do not yield greatly significant results, either. Panel a) of Figure 4.18 shows that Granger causality estimates are – with some exceptions – insignificant for both datasets up to 13 lags. For higher lag orders, *p*-values are sometimes smaller than 0.05 and sometimes only smaller than 0.1. There is no really convincing evidence of strong and stable causality. Panel b) yields positive sums of coefficients for almost all lag choices and definitely for all that are significant. From a theoretical point of view, however, we would expect a negative relationship. Like industrial production, oil production should tend to expand in response to expansive monetary policy. The effect of fundamentals on the oil price then would be given by the relative strength of the reaction of the supply and demand sides. The positive relationship therefore is again a hint of the simultaneity problem analogous to the price puzzle. Scarce significance reminds us of the results in Figure 4.13, where the oil production variable does not seem to have a causal effect on the crude oil price. The oil supply side is investigated in a subsequent section. There are plausible reasons to argue that oil production is a variable featuring a rather specific behaviour.

Figure 4.18 Granger causality from the US federal funds rate to oil production

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



Source: author's elaboration.

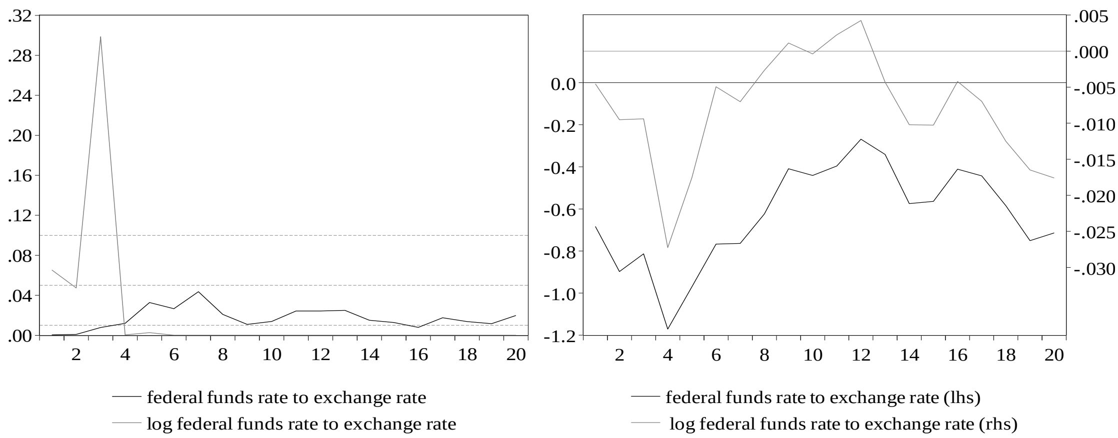
[36] There are views denying any significant effect of monetary policy on output and thus the use of interest rate to govern wealth and income distribution instead of output. For a review of approaches, see Rochon and Setterfield (2011).

Granger causality tests for the US dollar exchange rate variable are exhibited in Figure 4.19. *p*-values in panel a) bear a clear-cut message stating that there is evidence of Granger causality from the US federal funds rate to the exchange rate. Only the three-lag estimate for log data is insignificant. There is no rational explanation for it: probably it is a statistical outlier confirming the usefulness of making causality tests for a broad set of lag numbers. Beside of this particular case, all estimates are significant. Normal data are all significant at least at the 5 percent level while log data yield estimates significant even at the 1 percent level for all lag choices higher or equal to four. Panel b) provides sums of coefficients that are all in all fully consistent with our theoretical analysis. Since the log estimates are quite small values relative to normal data values, they are plotted at a second right-hand-side scale. Otherwise, they could not be distinguished from the zero line. The sums of coefficients are negative except for log data between nine and twelve lags. Altogether, saying that there is a significantly negative causal effect from the US federal funds rate to the exchange rate seems appropriate. This means that expansive monetary policy weakens the US dollar exchange rate.

Figure 4.19 Granger causality from the US federal funds rate to the exchange rate

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags

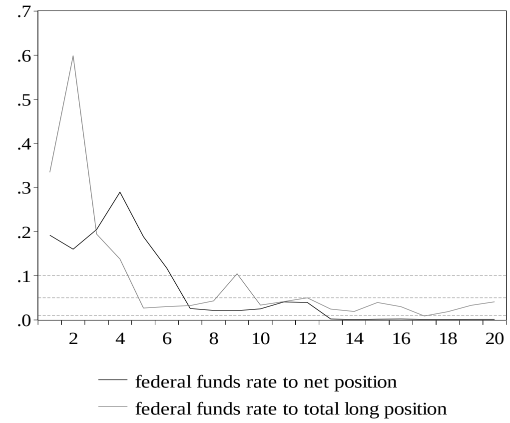


Source: author’s elaboration.

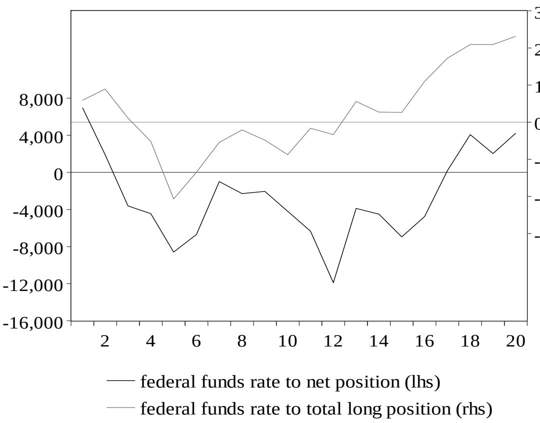
Even though the financial market variables are probably inappropriate to represent speculation, we test for Granger causality from monetary policy to non-commercials’ net positions and to their total long positions. It might at least give a hint of how central bank actions affect trading activity. Panel a) shows impressive significance for higher-order lags with normal data. In panel b), where the two graphs are each plotted against a separate scale owing to large differences in numerical values, the sum of coefficients for net positions is negative for most lags. For total long positions, however, the positive and negative sums have about the same share. Panel c) shows *p*-values for log data and yields only convincingly significant results for net positions. Panel d) is less clear. Sums of coefficients for net positions are quite volatile. Even though they tend to become more negative with the number of lags increasing, the estimates are far from providing a clear-cut conclusion. Total long positions face not the least sign of a sum of coefficients that moves significantly away from zero. It is thus only net positions that give us a rather scarce picture of the effect of monetary policy on speculative activity. Figure 4.20 confirms the preceding argument that the financial market effect of monetary policy needs a specific investigation. Before we get there, the second period of unconventional monetary policy should be analyzed.

Figure 4.20 Granger causality from the US federal funds rate to non-commercials' futures positions

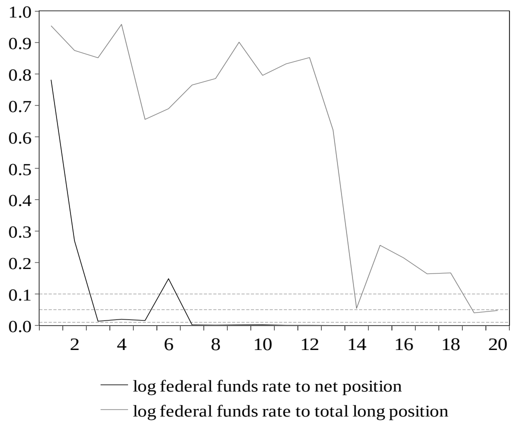
Panel a) *p*-values of Granger causality tests with normal data depending on the number of lags



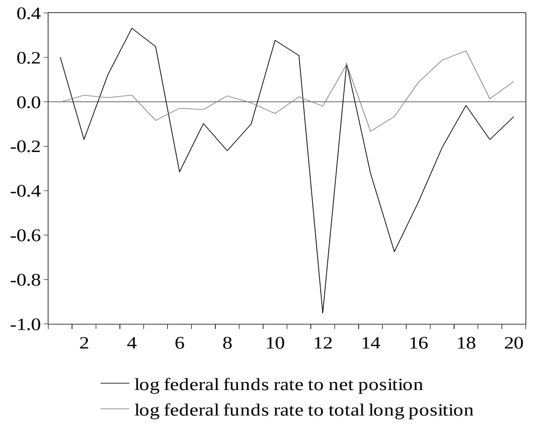
Panel b) Sum of coefficients of Granger causality tests with normal data depending on the number of lags



Panel c) p-values of Granger causality tests with log data depending on the number of lags



Panel d) Sum of coefficients of Granger causality tests with log data depending on the number of lags



Source: author's elaboration.

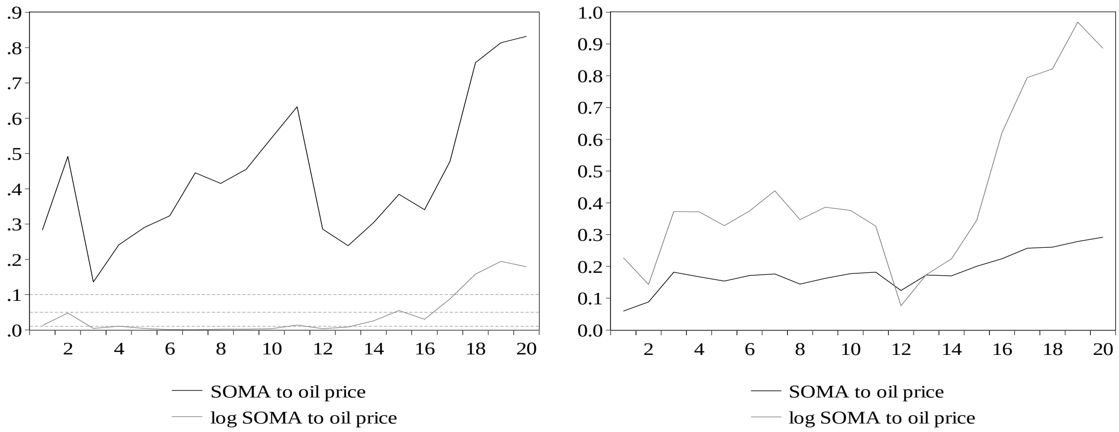
4.4.3.2 The Effect of Quantitative Easing in the Second Period

For the period from 2009 until 2014, the federal funds rate is replaced by the Fed asset purchases. Figure 4.21 shows the test results for Granger causality from the SOMA variable to the oil price. Panel a) reveals that normal data do not yield any causality while the log variable is highly significant for most lag choices. The sums of coefficients are positive for all data points, as can be seen in panel b). This is in accordance with economic theory suggesting a positive causal effect of quantitative easing on the oil price. The SVAR result is thus confirmed. Yet, Figure 4.21 might as well suffer from a kind of pricing puzzle as the estimates of the first period. We thus try again to separate the financial market and the fundamentals effects in the crude oil market. On the other hand, the positive effect of quantitative easing on the oil price in Figure 4.21 is possibly even underestimated, as it is easy to anticipate asset purchases regularly taking place month after month after they have been announced by the FOMC.

Figure 4.21 Granger causality from SOMA to the oil spot price

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



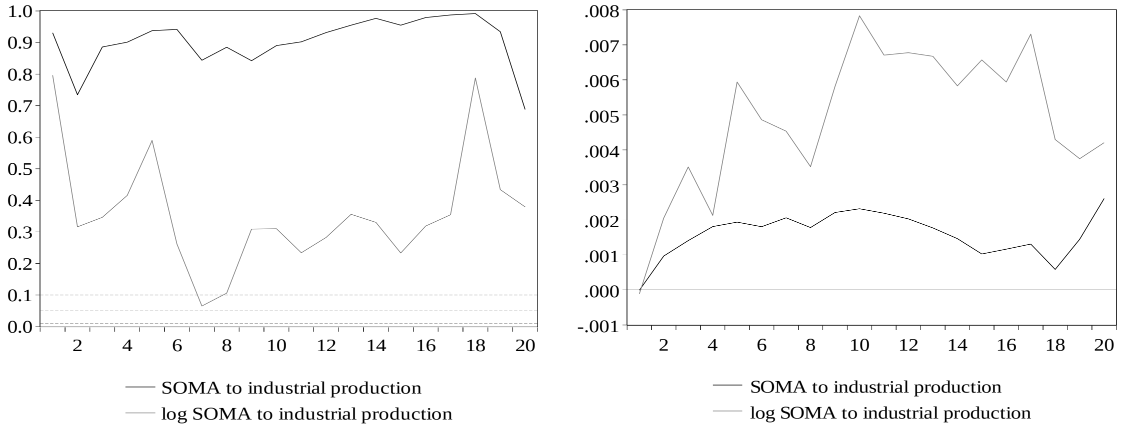
Source: author's elaboration.

Even more than in the first period, Granger causality tests do not reveal causal effects from monetary policy to global industrial production. Panel a) in Figure 4.22 exhibits that there is no reason to conclude that quantitative easing raises industrial production. The sums of coefficients in panel b) are always positive, but this cannot overshadow the exorbitantly large *p*-values in panel a). However, the background is different this time. Quantitative easing measures are applied when the conventional transmission mechanism is broken or if the target interest rate reaches the zero lower bound. Top priority then is to purchase assets in order to bring market interest rates down. The effect of interest rate changes on the real economy comes in a second step. We took this special feature of unconventional monetary policy in account by distinguishing first- and second-stage transmission. The specific recessionary or stagnating environment in which quantitative easing measures are applied might partially be responsible for the absence of a significant effect of the SOMA variable on industrial production.

Figure 4.22 Granger causality from SOMA to industrial production

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



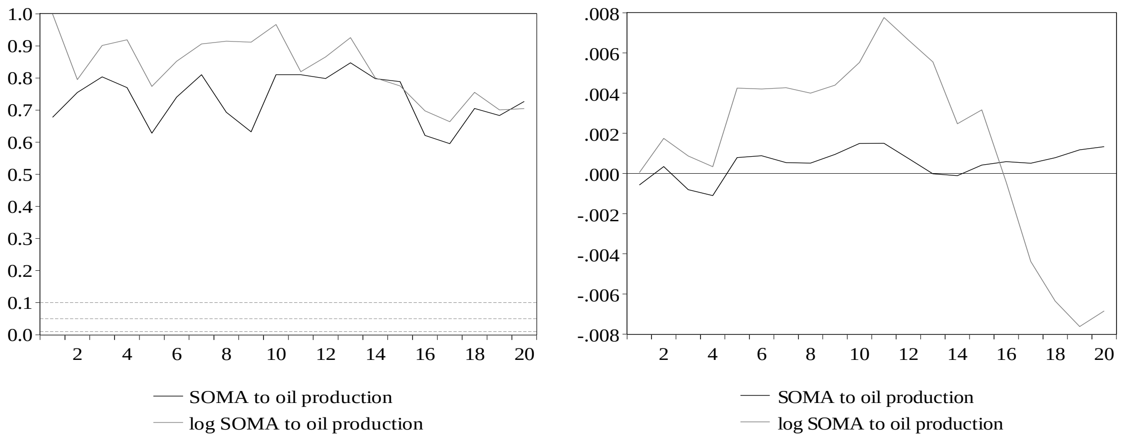
Source: author's elaboration.

Oil production is still an insignificant variable in connection with monetary policy as can be seen in panel a) of Figure 4.23. The sums of coefficients are sometimes positive and sometimes negative, and hence do not allow for a clear-cut conclusion. The supposed reasons for the determination of oil production are still to be explained.

Figure 4.23 Granger causality from SOMA to oil production

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



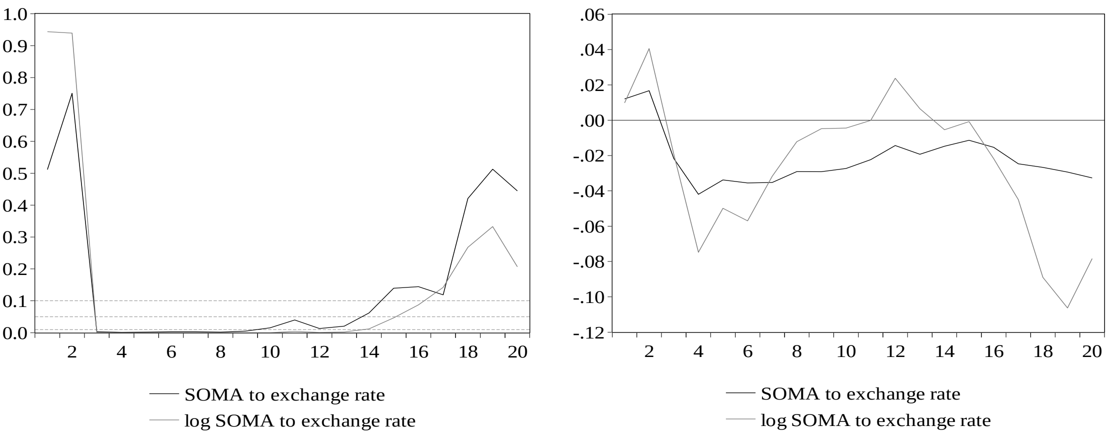
Source: author's elaboration.

The effect of quantitative easing on the US dollar exchange rate is expected to be significantly negative, suggesting that lower market interest rates and increasing liquidity weaken the US dollar. *p*-values in panel a) of Figure 4.24 are considerably significant for most lag numbers but overall significance has decreased compared to the period of conventional monetary policy. The sign of the causal relationship, patterned in panel b), tends to be negative with normal as well as with log data for most lag choices. But here also, the result is less clear since there is a new episode of positive sums of coefficients for one and two lags. This is possibly again due to situations of high financial risk and instability in which unconventional monetary policy usually takes place. Even though large-scale asset purchases tend to ease liquidity conditions at least in the medium run, they might have an opposite effect in the very short run: the Fed announcement of quantitative easing might be taken as a sign of financial stress owing to the extraordinariness of the measure. As a reaction, investors may raise demand for safe assets (Neely, 2011, p. 23; Noeth & Sengupta, 2010). These may take the form of, for instance, government bonds or foreign currency. Since the US dollar is the leading global currency, it is considered as one of the safest assets. Quantitative easing in the United States therefore may paradoxically trigger a run to the US dollar. Yet, once the central bank succeeds in keeping market interest rates constantly at a low level, the depreciating effect on the exchange rate is likely to dominate.

Figure 4.24 Granger causality from SOMA to the exchange rate

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags

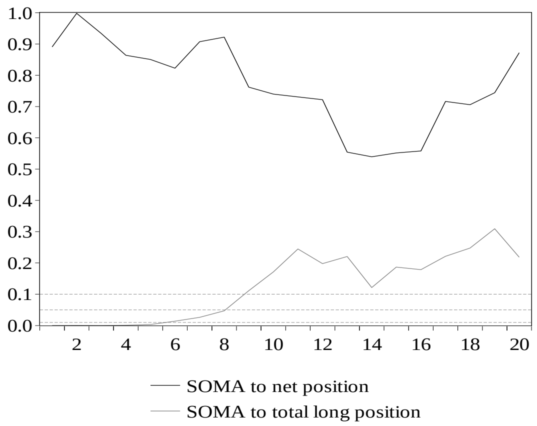


Source: author's elaboration.

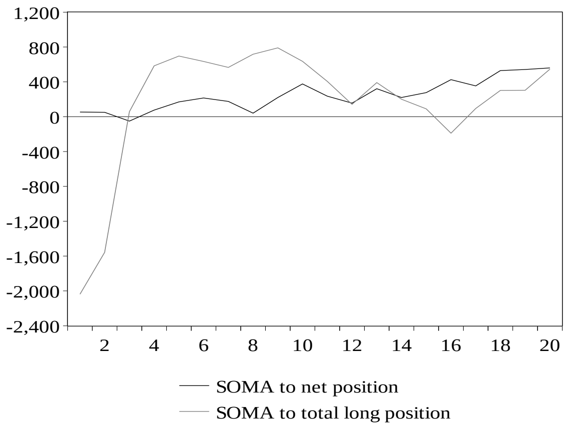
Without expecting great results, the effect of quantitative easing on the speculative variables is tested for completeness. Panel a) of Figure 4.25 shows that with normal data, only total long positions react significantly for low lag numbers to a change in SOMA. In panel b), the sum of coefficients is almost exclusively positive for net positions and also overwhelmingly positive for total long positions. Their negative values for low lag numbers might reflect the flight into safe assets in the short run, implying investors' movement out of oil futures contracts. So far, the signs coincide with the predictions stemming from our theoretical analysis but the evidence is too weak to be largely significant. Panel c) reveals even partial significance for both variables in log specification. Panel d), however, only provides conclusive outcomes for net positions that react positively in response to an increase in SOMA. The sum of coefficients for total long positions is negative for almost all lag choices. We thus again end up with results that do neither fully deny nor confirm economic arguments.

Figure 4.25 Granger causality from SOMA to non-commercials' net positions

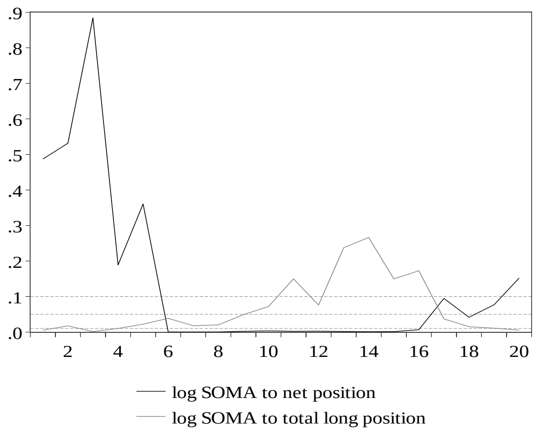
Panel a) *p*-values of Granger causality tests with normal data depending on the number of lags



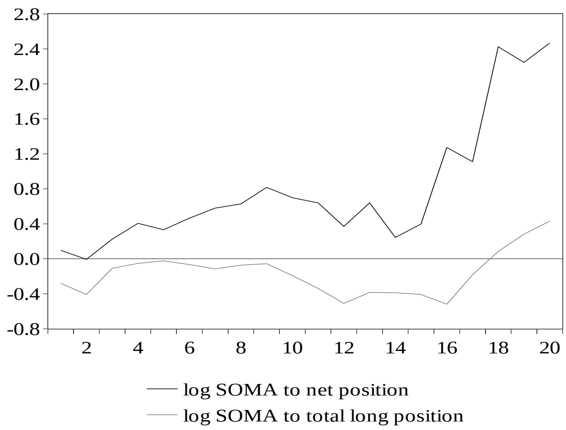
Panel b) Sum of coefficients of Granger causality tests with normal data depending on the number of lags



Panel c) *p*-values of Granger causality tests with log data depending on the number of lags



Panel d) Sum of coefficients of Granger causality tests with log data depending on the number of lags



Source: author's elaboration.

4.4.3.3 Bringing Significant and Insignificant Results Together

Let us now summarize our findings. Concerning the causalities in the crude oil market, we have evidence of a significantly positive effect of industrial production and a significantly negative effect of the US dollar exchange rate on the oil price. Oil production and the futures market variables do not provide conclusive results. The estimates for the period of conventional monetary policy suffer price puzzle problems. The overall effect of the US federal funds rate of interest on the oil price is found to be overwhelmingly positive instead of being negative. The interest rate impact on industrial production and oil production is insignificant, so that it becomes hard to detect monetary policy transmission through fundamentals in accordance to the ambiguity suggested by our theoretical investigation. The exchange rate of the US dollar reacts to a change in the US federal funds rate in accordance with our theoretical analysis, while the speculative variables still are not helpful for yielding intuitive outcomes. The second period gives a similar picture. The effect of SOMA on the oil price is positive, but its validity may again be limited by the price puzzle. Both fundamental variables are still insignificant and so are futures position data. The only significant variable is still the exchange rate.

Even though these results seem to be rather disappointing, we can read more out of them than we might think at first sight. The summary of the hitherto results allows us to find a way of further proceeding. We noticed that growing industrial production raises the oil price. Therefore, the significant Granger causality tests between these two variables lead us to conclude that the significant coefficient in the cointegrating equation (4.46) is probably not just a correlation but in fact represents a causal relationship. Moreover, in the same regression, the coefficient estimate for the exchange rate also seems to reflect a causal effect. We have thus two variables that can explain at least a fraction of the oil price development. The oil supply variable is still to be explained. Yet, oil production is found to be significant in the cointegrating equation for normal data. As it is a fundamentals variable, it is strongly connected to the demand variable, that is, industrial production.

Let us therefore simulate a 'fundamentals component' of the oil price. It is the price that results if it is only explained by the estimated coefficients of industrial production, oil production and exchange rate variables. It may be asked why the exchange rate is taken as a fundamentals variable. Following the distinction of monetary policy transmission channels above, the exchange rate channel of monetary policy transmission is divided in a fundamental and a financial market component. The latter implies futures market reactions to changes in the exchange rate that are themselves due to monetary policy. The way in which the exchange rate variable is employed now follows the reasoning of how it is effective through fundamentals. Without ruling out that it may also contain speculative aspects, we use it, for convenience, as a fundamental variable.

The fundamental price of oil defined now leaves a residual, which is the difference between the true price and the constructed price. Given that the fundamental variables are reliable and more or less sufficient to cover all important effective movements in fundamentals, the residual should represent the financial market component of the oil price. By measuring the causal effect of monetary policy on this residual, we may find out if there is a significant policy transmission through the futures market. As a concession, however, the assumption that the fundamentals and the financial market component of the oil price are numerically separable has to be accepted for this test. ADF tests of the speculative components, p_{fin}, implied by the variants of the cointegrating equation (4.46) with normal data are given by Table 4.6. In both periods, the variables are stationary at the 5 percent level of significance. To have a stronger guarantee for stationarity, they are nevertheless taken in first differences where unit root is rejected.

Table 4.6 Augmented Dickey-Fuller tests for speculative oil price components

2000–2008					
	levels		1st differences		order of integration
p_{fin} (with net position)	-2.87**	(0.05)	-18.52***	(0.00)	I(0) / I(1)
p_{fin} (with total long position)	-2.84*	(0.05)	-18.47***	(0.00)	I(0) / I(1)
2009–2014					
	levels		1st differences		order of integration
p_{fin} (with net position)	-3.38**	(0.01)	-13.28***	(0.00)	I(0) / I(1)
p_{fin} (with total long position)	-3.43**	(0.01)	-13.34***	(0.00)	I(0) / I(1)

Tests are executed with intercepts. *p*-values are in parentheses. Coefficients with *, ** or *** feature a stationary process at the 10%, 5% or 1% significance level, respectively. The other variables have unit root.

Source: author's elaboration.

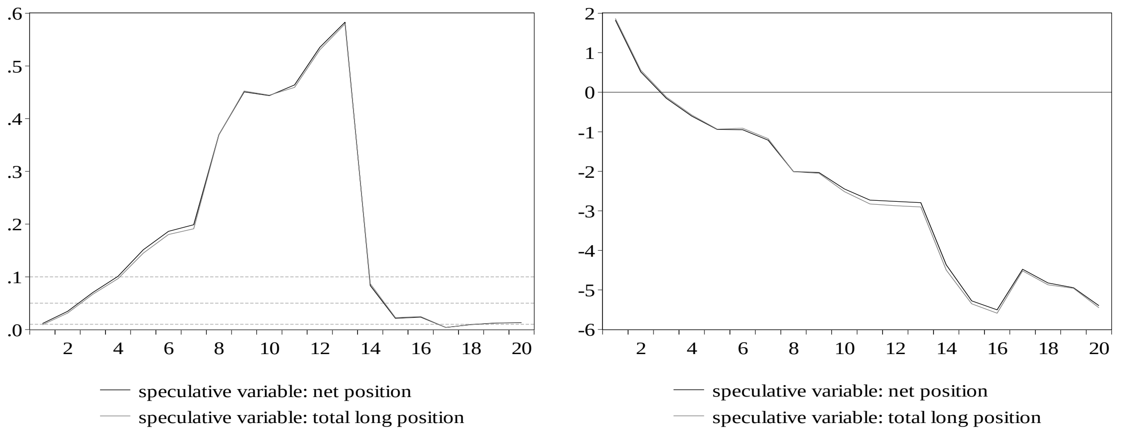
The result for the first period is plotted in Figure 4.26. There are two graphs in each panel a) and b). One graph shows the speculative component of the cointegrating equation with non-commercials' net positions, while the other graph shows the one with total long positions. Log estimates cannot be realized, since the financial market component contains the original residuals ε_t of the cointegrating equation. They are both equally positive and negative owing to their unbiasedness. Transformation to positive numbers bears the risk of unpredictable measurement mistakes. Hence, we take variants 1) and 3) of the cointegrating regression for the following proceeding.

The US federal funds rate of interest has a significant effect on the financial market component of the oil price for small lag lengths as well as for high ones from 14 upwards, as can be seen in panel a) of Figure 4.26. In between, *p*-values move far away from significance levels. Both graphs are almost identical. This is due to the fact that the coefficients of the fundamental variables are rather similar in both equations. Moving from panel a) to panel b), we see that the sums of coefficients are almost perfectly in line with economic theory. While they are positive for small lag numbers, they decrease becoming clearly negative very soon and decreasing further almost steadily. As a reasonable interpretation, the causal relationship between the US federal funds rate and the financial market component of the oil price suffers a kind of price puzzle for small lag choices, which drives the sums of coefficients positive. With higher lag numbers, the price puzzle is overcome and the relationship becomes more and more negative. It is also possible to bring this interpretation in accordance with the *p*-values in panel a). Low lag choices bring significantly positive results. Increasing the number of lags lets the sum of coefficients approach the zero line in panel b). Logically, this yields more insignificant results, since the F-test statistic of the Granger causality test cannot reject the null hypothesis of all coefficients being equal to zero. As long as the sums of coefficients move around zero, the *p*-values are above significance levels. When the former are more negative, causality estimates become significant again.

Figure 4.26 Granger causality from the US federal funds rate to the speculative component of the oil price, 2000–2008

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



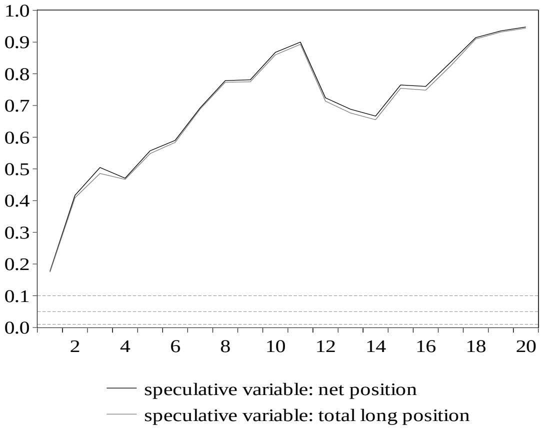
Source: author’s elaboration.

While it was clear from the beginning that monetary policy transmission to the oil price through fundamentals is ambiguous, our theoretical analysis predicts transmission through financial markets to be clear in the sense that expansive monetary policy raises the oil price. By filtering out the fundamentals component in an imperfect but reasonable way we now see that the financial market component behaves as suggested in our theoretical analysis. Lower interest rates seem to fuel speculative activity, which raises the oil price on condition that fundamentals of the oil market remain unchanged. Intuitively, a change in the interest rate level appears to materialize gradually. This is confirmed by the finding that the negative relationship between the US federal funds rate of interest and the speculative component of the oil price strengthens with an increase in the number of lags.

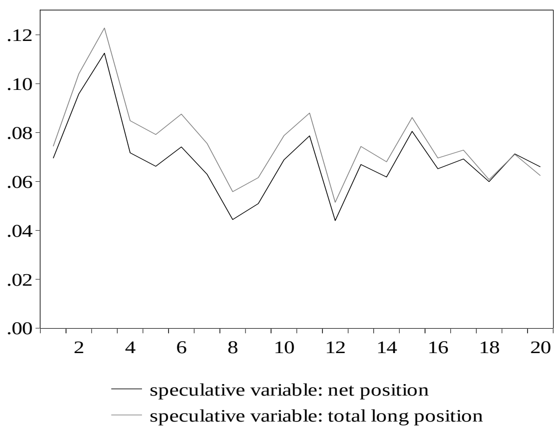
In the second period, from 2009 until 2014, the same Granger causality test with the SOMA variable yields only insignificant results as shown in panel a) of Figure 4.27. Panel b) shows at least that the sum of coefficients is always positive and rather stable. Hence, it is not only positive for the oil price as a whole but as well for the speculative component of that price. Yet, insignificance does not allow drawing a conclusion. An important reason for this might be the strong anticipation of asset purchases by financial investors after the US Federal Reserve announced them. If so, it is quite hard to find significant results.

Figure 4.27 Granger causality from SOMA to the speculative component of the oil price, 2009–2014

Panel a) *p*-values of Granger causality tests depending on the number of lags



Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



Source: author's elaboration.

There are approaches to calculate a 'shadow' federal funds rate of interest. After the policy rate of interest reached the zero lower bound, quantitative easing had the task of depressing market rates of interest further. Thus, unconventional monetary policy can be considered as a measure to pull the US federal funds rate of interest virtually below zero. Wu and Xia (2014) provide a dataset of such a shadow rate. However, it cannot but be developed out of a model that itself requires strong assumptions. Moreover, it only exists at monthly frequency. Granger causality thus can hardly yield any meaningful results, because all shadow US federal funds rates of interest are constructed issues and highly artificial. Therefore, we renounce making any further tests.

After these different tests, we have a result that partially confirms our theoretical suggestions. While significance is impressive for the first period, it is missing for the second one. We must rely on intuition, which tells us that quantitative easing also has a positive impact on the oil price but through ways that are less linear and therefore more difficult to detect. On the other hand, the SVAR of the second period assigns a more significant effect on the oil price and speculative activity. Even though we criticize this approach and the speculative variables, it cannot be said that there is no empirical evidence of monetary policy effects through the futures market in the period from 2009 until 2014. One may argue that the current result even underestimates the influence of speculation and hence the influence of monetary policy. A linear regression tries to maximize the share of the dependent variable that can be explained by the independent variables. The number of the latter is limited. The lower the number of explaining variables, the more weight one single variable gets. Even if there is only one independent variable, the econometric procedure of the least-square method tries to cover the entire explained variable. The effect of the independent variable then tends to be overestimated. In the cointegrating equation (4.46), there are four variables of which we decide three to belong to fundamentals. The remaining financial market variable is significant in most cases but quite small. Moreover, it has been argued in abundance that speculation can hardly be represented by one single variable. For these reasons, non-commercials' net positions and total long positions play only a limited role in explaining the oil price. As a consequence, the fundamental variables tend to be overestimated, as they try to explain the whole oil price and not only its fundamental component. Plotting the fundamentals component of the oil price in comparison to the total oil price in order to have an impression of the speculative component would thus not be careful, since it would provide a biased picture. However, this does not really challenge the above tests, since the signs and order of magnitudes of the variables are likely to be in a reasonable range. The concern is rather about definite numerical outcomes than about basic arguments.

4.4.4 What Crude Oil Inventories Can Tell Us

Another way to assess price-influencing speculation is the investigation of oil inventories. This topic is referred to so often that it deserves being considered more closely. As discussed in our theoretical analysis, many economists take the inventory argument as a proof of whether speculation exists or not (see for instance Alquist & Gervais, 2011; Frankel, 2014; Hamilton, 2009; Krugman, 2008). By stating that inventories did not rise extraordinarily when the oil price peaked in 2008, it is frequently argued that there was no speculation. There are, however, many reasons to criticize this view. In this section, a new approach is presented. It may show how the inventory argument can nevertheless be used productively.

We have found some main weak points in the argument: there are problems to get appropriate data, since the latter probably include also strategic reserves. Moreover, underground reserves should as well be counted as reserves, but it is not clear to what extent. In addition, the assumption that capacity utilization is constant is rather unrealistic. And finally, precautionary demand in the spot market may lower inventory measures but lead to a higher oil price all the same.

Let us start with the latter issue by using the SFC model. To recall, oil demand in the spot market is given by the following equation:

$$C_{oil,d} = \delta_0 + \delta_1 {*} C_s - \delta_2 {*} p_{spot} \tag{4.1}$$

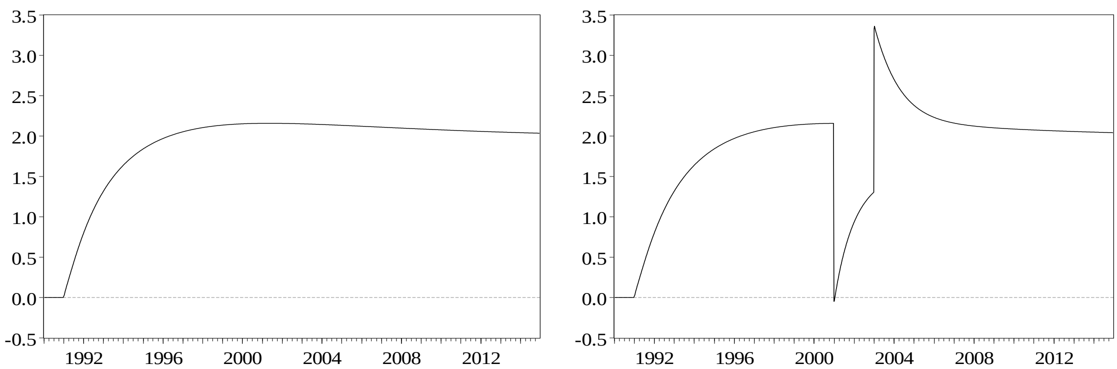
The coefficient δ_2 determines how spot demand reacts to an increase in the spot price. As we argued, the slope of the spot demand curve is likely to be negative over the medium and long run. Speculation in the futures market raising the oil price then requires higher inventories owing to lower demand in the spot market. Measuring inventories and concluding whether there is speculation or not is impeded by uncertainty. At least in the short run – however long the short run might last – the demand curve slope can also be positive. Consumers observe a rising price and hence expect it to rise even higher in the future. As a reaction, they raise demand for oil now in order to save an amount of money equal to the difference between the expected price in the future and the price today. Inventories measured in oil companies stocks then decrease even though speculation raises the price away from fundamental conditions. Such consumer behaviour may be called precautionary demand, as denoted for instance by Kilian (2009b, p. 1053). We do not know whether this behaviour is motivated by speculative or hedging purposes.

In panel a) of Figure 4.28, there is the pattern of inventory accumulation in the baseline simulation of the SFC model where the interest rate target is cut by the central bank. The reaction of the markets has been explained above (see Figures 4.1 and 4.2). Growing speculation raises inventories in the spot market. When the oil price falls below its initial value owing to real oil industry investment, inventories decrease slightly, because they are used to satisfy growing consumption. In this simulation, δ_2 is equal to 1, so that the oil price affects spot demand negatively in equation (4.1). In panel b), we assume that precautionary demand comes into play for a limited time span, from the beginning of 2001 until the end of 2002. δ_2 takes the value –0.1. Beside of this, behaviour is as shown in panel a). We see that inventories react quite confusingly to somebody not aware of the possibility of precautionary demand. Inventories fall sharply and then rise again in a concave way until they shoot up when δ_2 becomes again positive, which has the effect of a shock.[37] The central feature of Figure 4.28 is that changes in demand behaviour affect inventory data. Uncertainty about the slope of the demand curve thus makes it quite difficult to gain useful insights about the evolution of oil inventories. If δ_2 varies continuously producing effects like in panel b), it becomes hard to find significant results.

Figure 4.28 The effect of precautionary demand on oil inventories in the SFC model

Panel a) Inventory pattern in the baseline simulation of expansive monetary policy

Panel b) Inventory pattern with temporary precautionary demand



Source: author’s elaboration.

Let us move from the demand to the supply side. The SFC model characterizes the production behaviour of the oil industry in the following way:

[37] The pattern can be explained by the behaviour of oil producers in the model: the shock to the precautionary demand parameter lowers inventories immediately and raises producers’ profits, giving rise to higher capacity utilization and overshooting investment expenditures. Resulting excess production capacities lead to renewed accumulation of inventories. The second shock of precautionary demand back to the initial parameter value makes inventories jump, since production is adjusted only with lags. From the new point, disinvestment and reduced capacity utilization reduce production and hence inventories step by step.

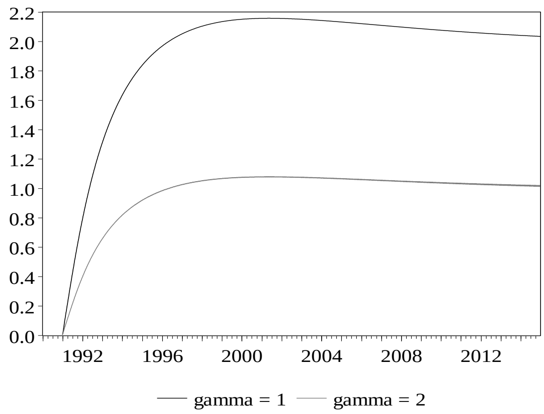
$$\Delta IN = \delta_3 * K_{-1} - \gamma * IN_{-1} - C_{oil,s} \tag{4.2}$$

Inventory accumulation of oil producers is simply equal to crude oil produced minus crude oil sold, that is, $C_{oil,s}$. δ_3 represents the production technology, which translates capital input into oil output. The first term on the right-hand side of equation (4.2) thus represents production capacities. If these capacities remain stable or grow over time, if they are fully used and if the spot demand curve is falling, oil inventories necessarily must increase in the presence of a higher spot price that is caused by speculation. The latter condition of demand behaviour has been discussed just before. The former condition of at least constant production capacities is also reasonable to be taken as given, since there is no reason why these capacities should decrease when speculation occurs. The second condition of full capacity utilisation may even be relaxed for the consequence of rising inventories still to be valid. They also do so if the rate of capacity utilization is below unity but remains stable over time. Yet, there is no reason why capacity utilization should be stable. The second term of equation (4.2) describes the degree of capacity utilization, which is assumed to depend on the existing level of inventories. γ is positive, so that capacity utilization is below unity whenever inventories are greater than zero. When oil companies have built a volume of stocks sufficient to hedge against reasonable unforeseen disturbances, there is no need for them to accumulate oil stocks further. Effective inventory accumulation can therefore be quite variable over time. Oil production is only bounded above by production capacities. But below this limit it can vary widely. Given that inventories of the last period are very large, production in the current period can also be lower than what is sold in the spot market, leading to a decrease in oil inventories.

One may say that this argument does not put Hamilton's (2009) conclusion into question, because lower oil inventories due to lower capacity utilization just imply larger underground stocks of crude oil. This idea is broadly in line with Frankel (1984, 2006) and Anzuini et al. (2013, p. 135). Yet, first, underground inventories can hardly be assessed, because they are not separated from total oil reserves. Secondly, the authors mentioned above make capacity utilization depend on an arbitrage condition that has been explained and criticized in our theoretical analysis. If so, then over- and underground inventory building is theoretically tied to a rule of mathematical precision. Our point here is clearly different. In a SFC framework, inventories are built based on entrepreneurial decisions that are modelled in a macroeconomic manner. The fact that oil inventories evolve according to oil companies' feedbacks to preceding developments means that there is a much wider field open for their pattern. Most likely, oil companies do not leave oil under the ground just because an arbitrage condition tells them to do so. They rather stop accumulating inventories in a situation where they have already enough and they want to save carrying cost. Hence, the feedback coefficient is likely to vary over time depending on the price level as well as price volatility and suggested risk in the oil market. Moreover, geopolitical events may affect capacity utilization, too. And crucially, we do not limit speculation to the spot market in contrast to the arbitrage condition mentioned above. In that theory, it is oil producers who influence the price by holding back oil instead of selling it. Our model also emphasizes speculation in the futures market, in presence of which oil producers adapt their inventories. In this case, the latter merely react to speculation than being themselves the source of it. That financial investment in the futures market probably has a greater price-influencing potential than speculation in the spot market has been argued in our theoretical part.

Figure 4.29 shows how the pattern of oil inventories changes depending on capacity utilization predicted by our SFC model. It is a rather schematic figure, as it takes the feedback coefficient γ to be determined once and forever. In reality, γ changes over time. Inventories then do not inevitably rise in a moment of intensive speculative activity compared to a moment of almost no speculation. Again, temporal variations of translating into inventory fluctuations impede the finding of significant results.

Figure 4.29 The effect of speculation on oil inventories depending on capacity utilization



Source: author's elaboration.

Together with equation (4.3) of the model, this argument explains why we found the oil production variable to be insignificant in almost all tests. Oil supply is necessarily always equal to oil demand. Industrial production has been identified as a significant demand force. From the perspective of the crude oil market, it is largely exogenous. Oil supply is therefore more a reaction to oil demand than an independent force. The difference between oil supply and oil production is given by the accumulation of inventories. As we know, inventories can take a highly uncertain pattern. Oil production thus has hardly the chance to explain a great part of the driving forces of the oil market. It only would have done so on the unrealistic neoclassical assumption of permanently full capacity utilization. It is only then that production really reflects supply-side constraints.

This argument might be surprising against the background that crude oil is an exhaustible variable. We may expect shifting supply-side constraints owing to limited oil reserves in general or certain oil fields being on the decline in particular. In such a case, inventories should come to their lower limits, so that any further supply shortcoming raises the oil price. Even though reserves are certainly declining over decades, we do not find any systematic significant signs of this tendency in oil production over the short run. Likewise, we do not find oil production to be a meaningful and significant variable. In contrast, oil production seems to behave accommodatively to a change in demand (beside of short-run capacity constraints like delays in capacity enlargement). This is an indication that exhaustion of oil reserves is not a binding constraint at this moment.

Any trial to measure how speculation might be associated with crude oil inventories should take these supply and demand side concerns into account. The demand-side problem of precautionary demand could be overcome, if there were a measure of inventories that includes not only those of oil producers, traders, and other important entities. It should also contain stocks of the firms and corporations of the rest of the economy as well as those of households. However, the Energy Information Administration as the main provider of stock data includes only primary stocks, to wit, those in refineries, bulk terminals, and pipelines (EIA, 2015d). Inventories outside of the oil industry are not taken into account. Indeed, the problem of precautionary demand is not that consumers start consuming more oil in expectation of a rising price than they would otherwise. They rather purchase it for future use and thus also build inventories either in business or privately. The core of the issue is that precautionary demand draws oil out of the official inventory statistics, because it is not held by oil producers anymore. There would be a simple way out of this problem by approximating inventories or the change in inventories, respectively, by the difference between global oil production and global oil consumption. Yet, in analogy to inventory data, consumption data do not cover what is effectively consumed but what is purchased and hence disappears from the oil market. Nevertheless, we use this differential. Despite its imperfection, it still has the advantage that it approximates global and not only OECD inventories. This is in line with equation (4.2) of our SFC model and leads to the following equation:

$$\Delta in = oilprod - oilcons \tag{4.48}$$

The supply-side aspect of capacity utilization can be taken into account just by investigating in how far the utilization rate or the rate of spare capacities, respectively, change when the crude oil price changes. Empirically, speculation can be said to exist if a higher oil price is associated with either an increase in our inventory measure, a decrease in capacity utilization, or both, respectively. In total, we want to know whether the difference between production capacities and oil consumption increases when the oil price rises. This is implicitly contained in equation (4.2). What we want to estimate is therefore given by:

$$oilpr \sim capacity - oilcons \tag{4.49}$$

Since capacity utilization is a measure of oil production, both variables can theoretically be considered as the same if they are taken in logs. If capacity utilization increases by one percent (where the existing utilization rate is 100 percent), oil production does likewise (on condition that the production technology has constant returns to scale). By inserting the oil production variable once negatively and once positively into relation (4.49) and then integrating equation (4.48) we get:

$$\begin{aligned} oilpr &\sim capacity - oilprod + oilprod - oilcons \\ &= capacity - utilization + oilprod - oilcons \\ &= capacity - utilization + \Delta in \qquad (4.50) \\ &= spare + \Delta in \qquad (4.50') \end{aligned}$$

Either (4.50) or (4.50’) can be estimated depending on whether total capacities and the utilization rates are investigated separately or summarized in spare capacities (which is just the difference between total capacities and utilization rates). The final equation controls for industrial production, oil production, and the US dollar exchange rate. Even though oil production is hardly a helpful variable, we include it as it is significant in the cointegrating equation (4.46) and it may nevertheless add to the overall quality of the estimation model. The regression gets the following forms:

$$\begin{aligned} oilpr_t = \beta_0 &+ \beta_1 {*} capacity_t + \beta_2 {*} utilization_t + \beta_3 {*} \Delta in_t + \beta_4 {*} ip_t + \beta_5 {*} oilprod_t \\ &+ \beta_6 {*} exch_t + \varepsilon_t \end{aligned} \tag{4.51}$$

or, respectively:

$$oilpr_t = \beta_0 + \beta_1 {*} spare_t + \beta_2 {*} \Delta in_t + \beta_3 {*} ip_t + \beta_4 {*} oilprod_t + \beta_5 {*} exch_t + \varepsilon_t \tag{4.51'}$$

Data are now monthly, since it is the highest frequency available for capacity and global production and consumption data. While the alternative inventory measure, that is, production minus consumption, is global, capacity and utilization data cover only the US economy. However, on sufficiently competitive conditions, they allow for some conclusions about the behaviour of the global crude oil market. Moreover, US capacity and utilization data have the advantage in comparison to global data that they exclude OPEC. The latter may behave strategically and thus complicate the interpretation of the results.

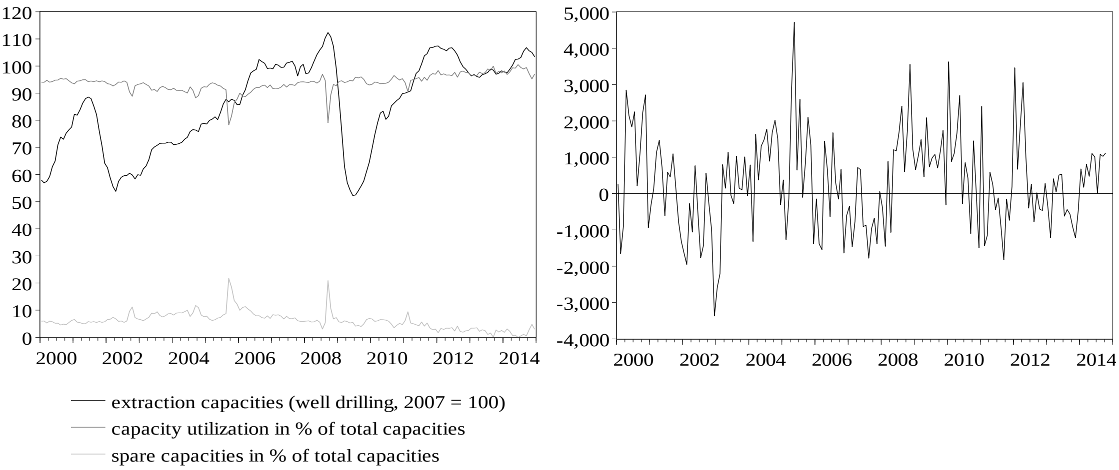
Panel a) of Figure 4.30 shows an index of drilling wells of US oil and gas industry as well as their degrees of capacity utilization and spare capacities, respectively, provided by the Board of Governors of the Federal Reserve (2015a, 2015c). Merging both oil and gas data provides imprecise results. But again, both markets share many similarities, so that test results should nevertheless be useful for interpretation. The dataset does not measure production capacities directly but is an indicator of how capacity evolves. The curve reminds us of the oil price curve. This is a feature to be investigated in the next chapter. The other two graphs are seemingly unspectacular apart from some outliers. Yet, neither capacity utilization nor, necessarily, spare capacities are constant over time. Given that we have low price elasticities of demand, a higher oil price affects oil consumption not too strongly. Consequently, if the price increase is due to speculation, it goes along with only a small change in capacity utilization. Considering it the other way round, a small change in capacity utilization can be associated with a large speculative price increase. Panel b) plots the alternative global inventory variable based on data of the EIA (2015b) whereas its monthly consumption data have been accessed through Datastream. Without running an econometric test, it can be seen that the difference between global oil production and consumption is not stable at all nor is it randomly distributed around zero. There are longer-lasting phases of both inventory accumulation and reduction.

Log specification allows giving variables with small values their appropriate weight. This is particularly relevant for utilization and spare capacity data that are given in percentage points. On the other hand, the alternative measure of inventories is a variable in first differences as it provides the change in stocks in each period. The series thus contains positive as well as negative values. In order to prevent the transformation of the series that potentially jeopardizes important information, we just transform it linearly to an index with the value 100 in the first month. Hence, the series is at least partially adapted numerically to the other series.

Figure 4.30 US oil and gas well drilling, capacity utilization and spare capacities and change in global inventories, 2000–2014

Panel a) Extraction capacities, capacity utilization, spare capacities

Panel b) Difference between global oil production and consumption (in 1000 barrels per day)



Sources: Board of Governors of the Federal Reserve System (US) (2015a). Capacity Utilization: Oil and gas extraction; Board of Governors of the Federal Reserve System (US) (2015c). Industrial Production: Mining: Drilling oil and gas wells; Datastream (2015); Energy Information Administration (2015b). International Energy Statistics.

Table 4.7 exhibits the estimation results of regression equations (4.51) and (4.51’). The results are quite clear. The rate of capacity utilization decreases significantly when the oil price is high. Likewise, oil inventories grow meanwhile. The fact that the coefficient is small compared to the others does not mean anything, since it is the only non-log variable. Moreover, the coefficient does not say anything about the effective historical weight of a variable. A small coefficient can still make a big difference if the changes in the estimated variable are large. Both estimates confirm the presence of speculation: if fundamentals were the only source of oil price changes, oil inventories and capacity utilization should be constant. Or even to the contrary, inventories should decline while capacity utilization should rise in tendency. The oil and gas wells index, briefly denoted as *capacity* in the table, does not change significantly with the oil price. This shows that lower capacity utilization is probably not due to a strong increase in capacities while oil utilization remains the same in absolute levels. This would, in relative terms, lead to a drop in capacity utilization, that is, the capacity utilization rate. The result rather suggests that capacity utilization decreases not only in relative but also in absolute terms when the oil price is high. Estimates of regression (4.51’) confirm the interpretation as spare capacities increase significantly with the oil price. The control variables yield familiar results with significant estimates for industrial production and the exchange rate and insignificance for oil production. All in all, if there exists the phenomenon of precautionary demand, the results tend to be underestimated. In this case, inventories grow in fact more than is recognized by data. This is due to the inability of petroleum consumption data to include inventories accumulated in the non-oil industry or in private households. We have already argued above in this sense.

Table 4.7 Correlation between the oil price and capacity utilization and oil inventories, 2000–2014

	(4.51)		(4.51')	
constant	12.63***	(2.95)	5.70**	(2.88)
capacity	0.03	(0.07)		
utilization	-1.21***	(0.29)		
spare			0.05***	(0.02)
Δin	5.48E-05***	(1.95E-05)	5.64E-05***	(1.99E-05)
ip	2.50***	(0.40)	2.56***	(0.37)
oilprod	-0.45	(0.66)	-0.30	(0.66)
exch	-2.68***	(0.26)	-2.55***	(0.28)
R^2	0.95		0.95	
DW statistic	0.54		0.50	

Standard errors are in parantheses. Coefficients with *, ** or *** are significant at the 10%, 5% or 1% level, respectively.

Source: author's elaboration.

One may argue that both regressions are potentially meaningless owing to considerable autocorrelation detected by the Durbin-Watson statistic. As in any econometric test, this case is not ruled out. Recall, however, that we are not in search of a significant outcome that would prove that one variable of the regression explains another one. Rather, results in Table 4.7 describe a correlation in its most proper sense. We do not explain the oil price by an increase in oil inventories or a decrease in capacity utilization. Suggestions and arguments have been made in our theoretical analysis as to whether causal speculative effects originate in the futures market or in the spot market. But they are not included in this regression. Table 4.7 just shows that a higher oil price seems to be associated with lower capacity utilization and inventory growth. This – nothing more and nothing less – is what we suggested theoretically in preparation of these estimations. It is now confirmed empirically. Therefore, despite autocorrelation, our significant results are useful. Moreover, the residuals of both regressions are stationary (with test statistics –5.21 (p-value 0.00) and –4.97 (p-value 0.00), respectively, each being significant at the 1 percent level). The variables are cointegrated so that there is no sign of spurious correlation.

But indeed, data selection and results in Table 4.7 yield a strong argument in favour of speculation mainly originating in the futures market rather than in the spot market. The observation that a high oil price is associated with lower capacity utilization is made with US data. We argued that oil production outside of OPEC broadly follows the logic of a competitive market. It is therefore difficult or close to impossible for a single oil producer to manipulate the price of oil by accumulation of stocks. Competition punishes such a company through lower profits. This has been discussed in detail before. As a consequence, in light of our empirical results, it becomes even more likely that speculation affects the oil price rather through the futures market.

By combining this outcome with the preceding investigation of the connection between monetary policy and the oil price and with our SFC model, we get an economic interpretation of it. Without being able to assess every detail, test results are broadly in line with our theoretical analysis. We notably find confirmation for the argument that monetary policy has an effect on speculation, which itself influences the price of crude oil. To sum up, policy transmission through fundamentals is insignificant and thereby indeed corresponding to its ambiguous character as argued in our theoretical analysis. Transmission through financial markets is more clear-cut and seems to take place actually.

4.5 From Oil Price to Oil Quantities

We have found empirical evidence that is in line with theoretical arguments stating that monetary policy impacts on the oil price. As announced from the beginning, we are not only interested in the oil price but also in oil quantities. The effect of monetary policy on crude oil production and consumption can be seen as a two-stage transmission. Price variables in the oil market are more flexible than quantity variables, so that the first stage is the effect of a change in the interest rate level on the oil price. The second stage consists of the impact of an altered oil price on oil production and consumption. To remember, this does not mean that quantities do not play any role in the first stage. We have abundantly investigated monetary policy transmission through fundamentals, that is, through oil supply and oil demand. Yet, the results are mostly insignificant. What is more significant is the direct price effect through speculation, which we call the financial market effect, since we suggest that it occurs through the oil futures market.

The presentation of this chapters’ structure has shown the necessity of distinguishing the numerous effects in order to reduce complexity. In reality, quantity and price effects take simultaneously place. The proposal of the procedure at hand is thus a way to enable a productive analysis of the issue albeit achieved by simplification.

4.5.1 Crude Oil Market Investment Behaviour

In the theoretical part we argued that a high oil price triggers real investment in the oil industry, which pulls the oil price down again. In the presence of speculation, fundamental forces are distorted. There is a contradiction between price-raising financial investment in the futures market and price-lowering real investment in the spot market. Sooner or later, high production capacities and possibly high oil inventories lead to market pressure lowering the oil price. Financial investors are heterogenous. The more supply in the spot market increases, the more speculators become aware of changing fundamentals. Consequently, they stop betting on a rising oil price. More and more of them even expect a falling price and thus raise short positions. The price effectively starts declining. In comparison to the beginning, production capacities are higher. When the intensity of speculation has come down to its initial level, the oil price is therefore lower than initially. Crude oil is now available in abundance, which tends to raise consumption and thus oil intensity of total economic output.

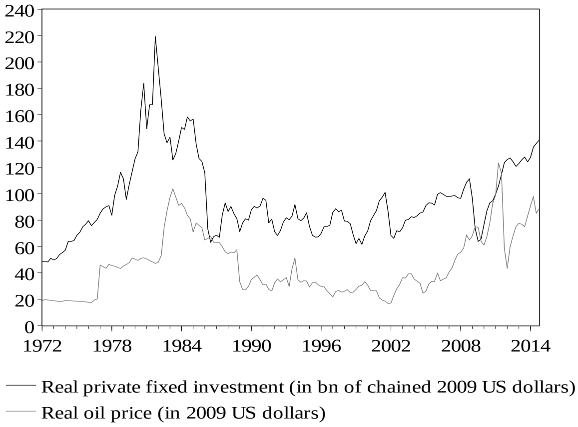
To measure the effect on quantities, it would again be wrong to take oil production as the relevant variable. It is subject to many fluctuations like capacity utilisation or inventory accumulation. Furthermore, the only real supply-side feature that can finally be observed is the crossing point of supply and demand in the spot market, that is, oil sales and oil purchases, respectively. Yet, a given quantity of oil sales can take place at any price level, so that it is not possible to conclude any causal effects between oil price and finally resulting quantities.[38] What we need to investigate are the underlying forces on the supply side that determine the volume of oil supplied at a specific oil price level. For instance, these are investment behaviour and production capacities.

Let us start with investment. Again, there are only US data available. They are provided by the US Bureau of Economic Analysis (2015) and contain investment in mining exploration, shafts and wells. Figure 4.31 plots the data series together with the oil price. Since investment data are quarterly data, we investigate a longer time horizon in order to cover a sufficient number of observations. The oil price is presented in deflated terms as investment data are as well real and since inflation has a greater influence

[38] This is in accordance to the argument that oil production behaves accommodatively as long as exhaustion of reserves is not a binding constraint.

during this long time window than in our usual period of consideration. It is striking that the real oil price and investment are moving relatively closely together.

Figure 4.31 US real private fixed investment in mining exploration, shafts, and wells, 1972–2014



Sources: Energy Information Administration (2015). Petroleum and other Liquids; US Bureau of Economic Analysis (2015). Real private fixed investment: Nonresidential: Structures: Mining exploration, shafts, and wells.

The fact that there seems to be a positive relationship between the two variables is a hint that there is causality from the oil price to investment. In the case of dominating causality in the reverse direction, the relationship should be negative, as rising investment is expected to lower the oil price. Granger causality tests strongly confirm this conjecture. Unit root tests for the two variables reveal that they are both I(1) for the period from 1972 until 2014, as Table 4.8 shows. The tests for Granger causality thus again have to be conducted in first differences. The capacity variable or, respectively, the index of oil and gas wells is added, since it is used just after for the same purpose.

Table 4.8 Augmented Dickey-Fuller tests for real oil price and real private fixed investment, 1972–2014

	Levels		1st differences		order of integration
real oilpr	-2.21	(0.20)	-10.26***	(0.00)	I(1)
investment	-2.13	(0.23)	-11.36***	(0.00)	I(1)
capacity	-3.06**	(0.03)	-5.32***	(0.00)	I(0) / I(1)

Tests are executed with intercepts. *p*-values are in parentheses. Coefficients with *, ** or *** feature a stationary process at the 10%, 5% or 1% significance level, respectively. The other variables have unit root.

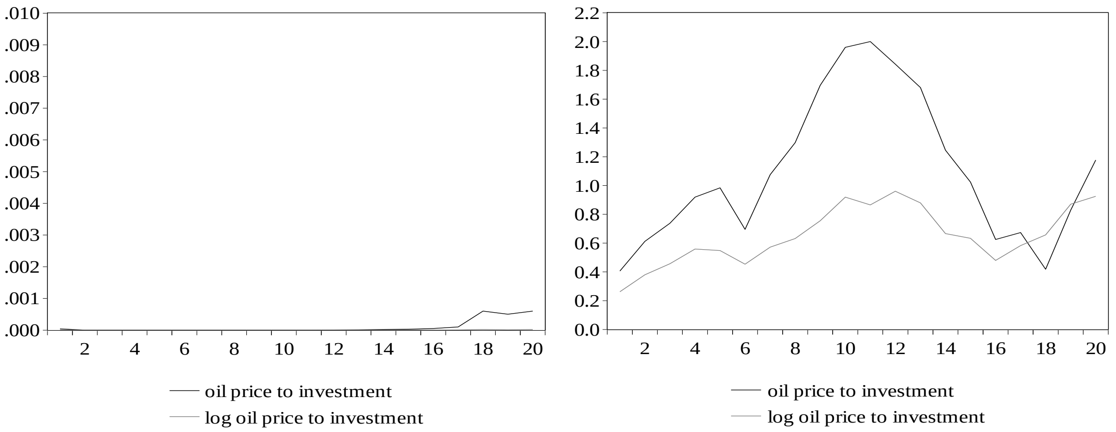
Source: author’s elaboration.

Panel a) of Figure 4.32 shows that all causality tests yield highly significant results for causality from the oil spot price to investment at the 1 percent level. The highest lag length of twenty now corresponds to five years. Panel b) provides exclusively positive sums of coefficients for both normal and log data. We can therefore convincingly say that our theoretical analysis is validated by our empirical investigation up to this point.

Figure 4.32 Granger causality from the oil price to US oil industry investment

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



Source: author's elaboration.

4.5.2 The Role of Production Capacities

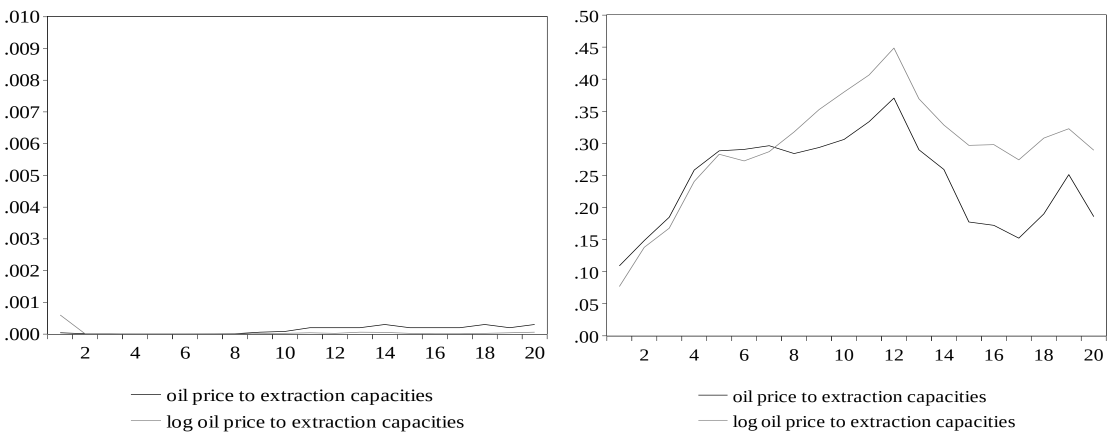
A similar outcome is generated by examining the effect of the oil price on the index of drilling oil and gas wells. The latter are monthly data, so that we can come back to the common time window from 2000 until 2014. The data series is integrated of order zero at the 5 percent level and of order one at the 1 percent level, respectively, as shown by Table 4.8. It cannot be wrong to take it in first differences, too. The advantage of this index is its short-term flexibility and, hence, its ability to react to changes in the short run, as Figure 4.30 shows. We may instead use, say, a variable that covers total capacity in the crude oil market by measuring total US oil output or potential output, respectively (global data at useful frequency are anyway hard to find). But it would be potentially biased severely by middle- or long-run developments like changes in the US share in total global oil production or technological progress. Our interest concentrates on the reaction of production capacities to changes in the oil price rather than other potential sources of change. The index has the outstanding feature that it measures well drilling as a particular economic activity, that is, the effort of investors, devoted to increase production capacities. It is therefore suggested to be least biased by other influences, since it does not measure final productive potential but rather the newly allocated resources in reaction to the price signal. We will have a look at final installed production capacities below.

The investigation of crude oil inventories showed that a higher oil price is not associated with significantly higher production capacities. It would nevertheless be a mistake to conclude that the oil price and production capacities are independent of one another. Correlation implies simultaneous effects and does not account for time lags. However, production capacities require time to be realized. A higher oil price first raises investment expenditures that are used to install additional production plants. Figure 4.33 exhibits the same Granger causality tests with extraction capacities and corresponds very well to Figure 4.32 with investment behaviour: extraction capacities increase in response to a higher oil price. The test results are highly significant at the 1 percent level. Investment and capacity data show that we are able to find empirical evidence of a causal chain from monetary policy to oil market quantities.

Figure 4.33 Granger causality from the oil price to US oil and gas well drilling

Panel a) *p*-values of Granger causality tests depending on the number of lags

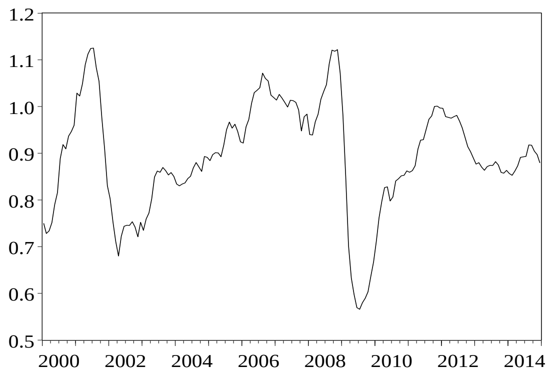
Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



Source: author's elaboration.

A counter argument may now claim that investment triggered by an increasing oil price just takes place to the extent that it is required by an accelerating oil demand. It might be growing industrial production that raises the oil price in order to give an allocation signal to the supply side. Investment then takes the oil price back to its initial level. Investment is nothing extraordinary and therefore does not have an effect on the oil intensity of the economy. To assess this argument, extraction capacities are put in proportion to global industrial production. We call this ratio *cap/ip*. Figure 4.34 plots its pattern. This series is now stationary (the test statistic (–3.91) of the ADF test is significant at the 1 percent level for the series at levels). Yet, it is far from following the path of industrial production. This may be due to never-ending feedbacks between the oil price and drilling activity: from a neoclassical or, rather, a new Keynesian perspective, the market does not come to equilibrium, because feedback mechanisms face lags and hence are at work in every moment in order to adapt to past changes. Alternatively or additionally, respectively, one may suggest that the oil price contains a speculative component. As a consequence, real investment in the oil industry also reacts to other effects than only a change in spot oil demand. This idea is tested in Figure 4.35. There is significant Granger causality at least at the 5 percent level but mostly at the 1 percent level from the oil price to the *cap/ip* ratio. The sums of coefficients are all positive for both normal and log data. Even though this is not a proof, it enlarges the potential of the financial market effect further. At least, there are significantly more interrelations between oil price and quantities than fundamentals would suggest.

Figure 4.34 US well drilling index to industrial production ratio *cap/ip*, 2000–2014

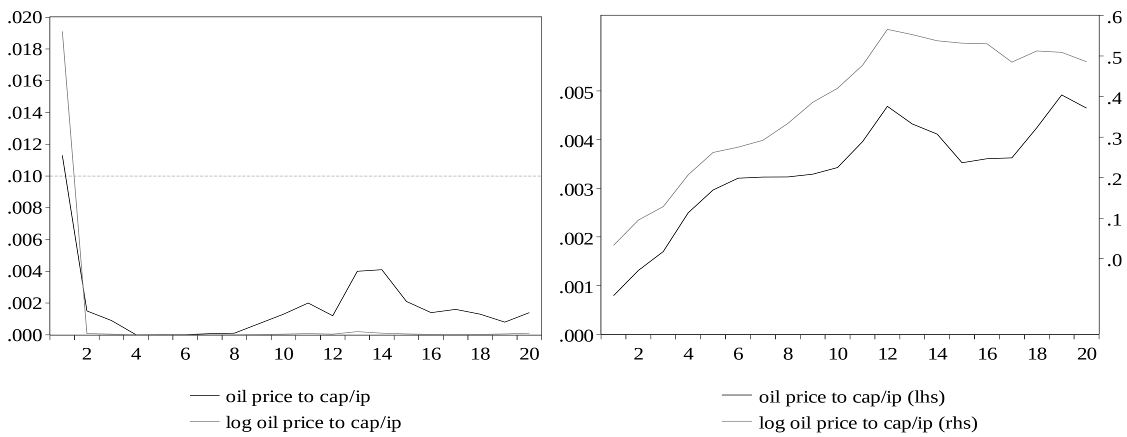


Sources: Board of Governors of the Federal Reserve System (US) (2015c). Industrial Production: Mining: Drilling oil and gas wells; World Bank (2015). World DataBank.

Figure 4.35 Granger causality from the oil price to *cap/ip*

Panel a) *p*-values of Granger causality tests depending on the number of lags

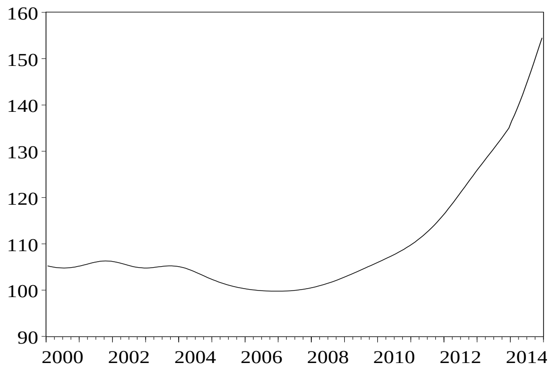
Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



Source: author’s elaboration.

Notice that a lower value of drilling activity does not mean an actual decrease in total production capacities. Such a decline is only given if, in a given moment, more exhausted wells are closed than new ones are drilled. Total installed extraction capacities therefore depend on many factors, particularly on the volumes of reserves. Reasonably, easily accessible reserves are opened up first, so that each additional well tends to provide less oil. On the other hand, higher price levels make new reserves profitable and thus even accessible. And finally, technological changes affect total production capacities as well. While investment behaviour and drilling activity are flow variables, total installed capacities is a stock variable. The latter is the final result of the former. Its magnitude therefore reacts with more delay to changes in other variables. Moreover, as installed capacities consist of heavy industry equipment, they probably do not respond at all to short-run disturbances in the crude oil market.[39] Econometric analysis thus becomes nearly impossible, and it is more promising to rely on qualitative arguments. Effectively installed US oil and gas extraction capacities from the Board of Governors of the Federal Reserve System (2015b) are plotted in Figure 4.36. The dataset is seasonally adjusted but its relative smoothness would probably also remain if there was no adjustment. Obviously, extraction capacities strongly increase from 2006 onwards. Accounting for time lags of capacity construction, this coincides well with the increasing oil price and its persistently high level until mid-2014. The sharp price drop in the course of the financial crisis and the corresponding decline in investment and drilling activity are not mirrored in total capacities installed. This may be due to the inflexibility of existing extraction plants and to the fracking boom since about 2008.

Figure 4.36 Total installed US oil and gas extraction capacities, 2000–2014 (2007 = 100)



Source: Board of Governors of the Federal Reserve System (US) (2015b). Industrial Production: Mining: Drilling oil and gas wells.

[39] For instance, while drilling activity may react fast to a price decline, installed capacities are not shut down immediately.

Figure 4.36 is broadly in line with the hitherto findings and the argument that the extended period of the high oil price has raised real oil industry investment and drilling activity so that we end up with impressively large extraction capacities installed. Relating the data series to industrial production would not be helpful, because all resulting short-run fluctuations would be due to volatility in industrial production rather than to smooth capacities. There would be no additional information.

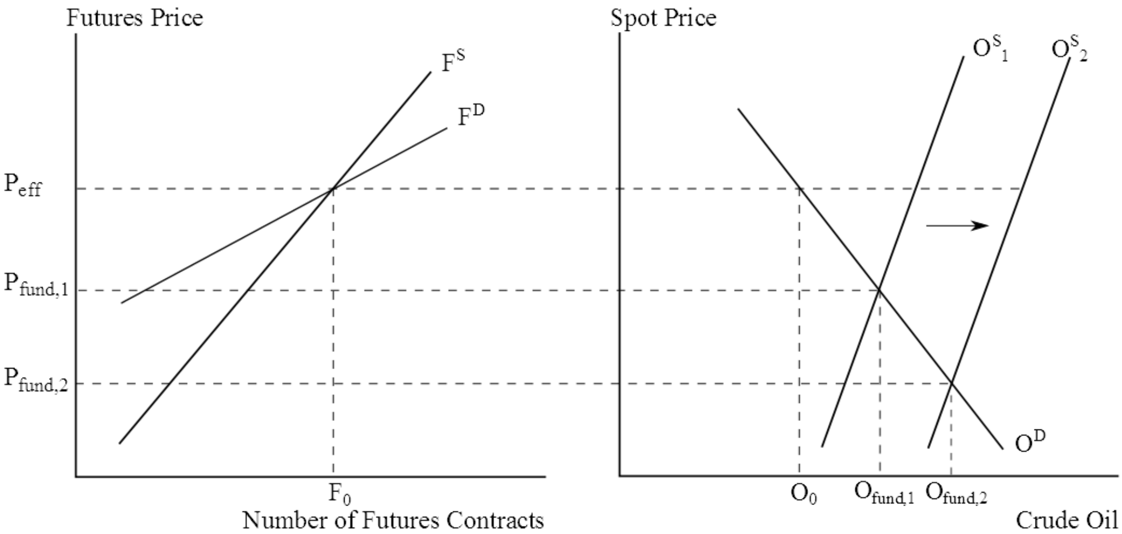
To conclude the argument, it should be tested whether additional investment and production capacities pull the oil price down from its high level, which we suggest to be determined by financial investment in the futures market. There is a difficulty to measure an effect of the supply-side variable on the oil price. We assumed from the beginning that the oil price contains a fundamentals component and a financial market component. Even though these two components can hardly be separated in reality, we had to find a way to deal with them. The fundamentals component has been estimated by the three variables 'industrial production', 'oil production', and 'exchange rate'. The financial market component is the residual.

At this point, we must come back to the dual nature of crude oil as a commodity and a financial asset. Let us show this in Figure 4.37, which is closely related to Figure 2.2 discussed in abundance in our theoretical analysis. We leave the slopes of supply and demand curves unchallenged for now, because any reasonable modification would not affect the argument. Assume the situation where financial investment in the crude oil futures market has driven up the futures price, which directly translates to the spot market. The analysed underlying arbitrage condition guarantees the close connection between the futures and the spot price, to wit, between the futures and the spot market. The effective price in the crude oil market, P_{eff}, is therefore different from what fundamentals would suggest. If it were only real forces in the spot market determining the oil price, it would realize at $P_{fund,1}$. This is the fundamental component of the effective price. In response to this discrepancy, real investment in the oil industry increases. This would lead to a decline in the price from $P_{fund,1}$ to $P_{fund,2}$ if there were no speculation. Yet, as long as financial investors keep up capital invested and do not revise their expectations downwards, the effectively observed oil price stays above the level dictated by fundamentals. The resulting discrepancies between oil demand that corresponds to P_{eff}, O_0, and the respective supplies according to the supply curves O^S and $O^{S'}$, respectively, are compensated by inventory accumulation and capacity underutilisation. This is confirmed by our econometric examination. It is intuitive and logic that this situation cannot last forever. Relaxed conditions in the spot market pull the oil price down. Financial speculation has to increase further in order to keep the price at

P_{eff}. Sooner or later, financial investors change their expectations and move more and more to short positions. This will bring the oil price definitely down. But uncertainty tells us that there is neither a rule nor a stable relationship that would make it possible to forecast when this turnaround in the futures market happens.

This raises the econometric problem that the price effect of real oil industry investment cannot be measured as long as speculation keeps the oil price at the elevated level. In contrast, there should be a direct and measurable effect on the fundamentals component of the oil price, provided that the fundamentals component is itself measureable. For this reason, the imperfect but hitherto useful calculated fundamentals price is employed again.

Figure 4.37 Real oil industry investment and the connection between the spot and futures market



Source: author's elaboration.

Consequently, we test for a causal effect from production capacities or drilling activity, respectively, to the fundamentals component of the crude oil price. Table 4.9 verifies their order of integration depending on whether the fundamentals component is calculated with the coefficients of the cointegrating equation with net position or total long position, respectively. They are both I(1), so that we employ them in first differences.

Table 4.9 Augmented Dickey-Fuller tests for the fundamentals component of the oil price, 2000–2014

	levels		1st differences		order of integration
p_{fund} (with net position)	1.23	(0.66)	-7.91***	(0.00)	I(1)
p_{fund} (with total long position)	-1.31	(0.62)	-8.11***	(0.00)	I(1)

Tests are executed with intercepts. *p*-values are in parentheses. Coefficients with *, ** or *** feature a stationary process at the 10%, 5% or 1% significance level, respectively. The other variables have unit root.

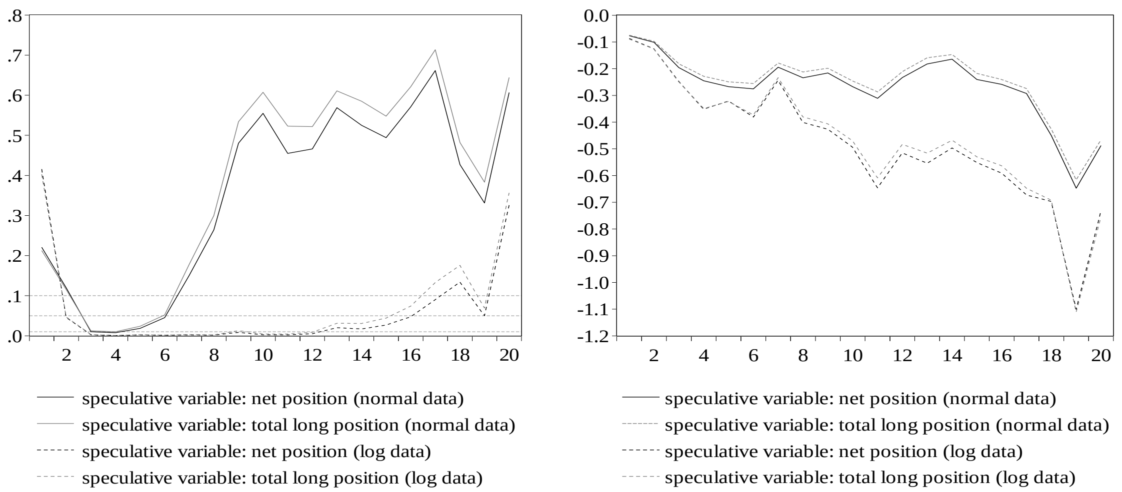
Source: author's elaboration.

Figure 4.38 makes a quite clear statement. *p*-values in panel a) are very low for small lag lengths with normal data and for almost all lag length with log data. Again, both fundamentals components of the oil price with either non-commercials' net or total positions as the speculative component (see cointegrating equation (4.46)) yield rather similar results. Evidence of Granger causality is therefore obviously given. Sums of coefficients in panel b) go well along with our prediction. They are all negative without any exception. Hence, the expansion of extraction capacities by enhanced drilling activity significantly lowers the fundamental component of the oil price.

Figure 4.38 Granger causality from US oil and gas well drilling to the fundamentals component of the oil price

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



Source: author's elaboration.

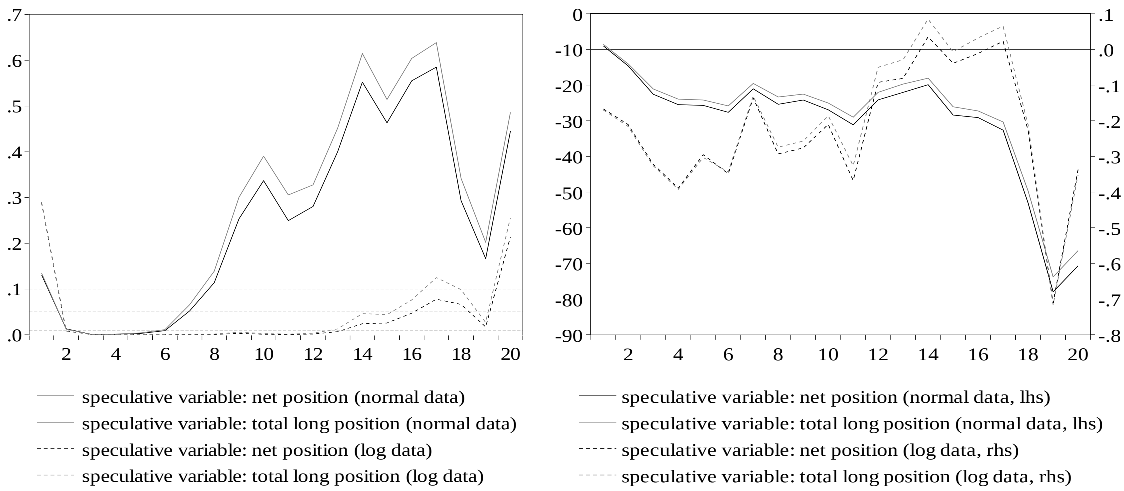
Once again, the argument may arise that this conventional feedback effect from production capacities to a price variable is only the expression of evolving fundamentals.

As a little test to investigate the effect of real oil industry investment in excess of what is demanded by fundamentals, we employ again the *cap/ip* ratio. Granger causality tests from this ratio to the fundamental component yield almost the same results exhibited in Figure 4.39. There are only two lag choices with log data where the sum of coefficients is positive and hence in contradiction to our theoretical investigation. However, this does not change the overall conclusion that there is a significant impact of real oil industry investment on the fundamental component of the oil price.

Figure 4.39 Granger causality from the *cap/ip* ratio to the fundamentals component of the oil price

Panel a) *p*-values of Granger causality tests depending on the number of lags

Panel b) Sum of coefficients of Granger causality tests depending on the number of lags



Source: author's elaboration.

Given that there is a measurable effect on the fundamentals component of the oil price, we can conclude that there is also an effect on the whole price that cannot be estimated but is nevertheless present. The financial market effect produces a lot of noise and may go in the opposite direction than the fundamental component in a specific moment. Nevertheless, the negative impact of real oil industry investment on the oil price exists *ceteris paribus*. The price effect through fundamentals affects futures market investment. Relaxed conditions in the spot market lower the attractiveness of crude oil futures for financial investors. Therefore, when the fundamental component of the oil price declines, the speculative component will sooner or later decrease as well. It is uncertainty, specifically in financial markets, which does not allow us to have a definite rule of when this happens. The relationship between production capacities and the effective price of crude oil thus becomes non-linear.

4.5.3 Concluding Remarks on the Empirical Analysis

Our empirical analysis has confirmed our theoretical intuitions. Structural VARs have proved to be limited in their ability to model the connection between monetary policy and the crude oil market, in particular the theoretically suggested financial market effect. This has led us to an alternative approach starting with a cointegrating equation of the oil market. The impact of monetary policy has in detail been investigated by testing for bilateral causal relationships between relevant variables. The finding that any single variable seems to be unable to represent the phenomenon of speculation in the futures market required a simplification in favour of measurability. We represented the financial market effect as a residual not explained by market fundamentals. This might be criticized as being rather arbitrary. But the fact that there is a significantly negative effect from the US federal funds rate of interest on this residual coincides exactly with our theoretical prediction, so that the suggested financial market effect is likely to be more than an arbitrary residual. The same effect could not be shown with significance in the period of unconventional monetary policy. A great part of this insignificant result may be due to the problematic issue of measurability of quantitative-easing effects.

As a confirmation, we employed an alternative approach to crude oil inventories by the introduction of fluctuations in capacity utilization in the oil industry. There is strong evidence that inventories accumulate and capacity utilization decreases in times of a high oil price. This is obviously a sign that the crude oil market is not only driven by real forces but also by speculation, to wit, there exists a financial market effect.

A higher oil price gives an incentive for real investment in the oil industry. Our econometric test strongly supports this view. Conversely, higher production capacities lower the oil price. After all, we end up with a conclusion in line with what has been suggested in our theoretical analysis and shown by our SFC model: an expansive monetary policy transmits ambiguously, if significantly, through fundamentals (beside of the unambiguous price effect of a changing exchange rate) but significantly through financial markets. Financial investment in the futures market increases and drives the oil price up when interest rates are low. This triggers real oil industry investment, which raises production capacities and lowers the oil price again. Finally, oil is produced in abundance, thereby lowering the oil price. This is just the situation at the end of 2014: total extraction capacities installed reached unseen levels, as shown with the example of US data in Figure 4.36, and oil price has fallen by almost 50 percent within half a year (see Figure 1.3). Given that the price elasticity of oil demand is larger than zero, this must raise oil consumption and the oil intensity of total economic output.

One may be fully confident in perfect competition and argue that the resulting lower oil price will lead to losses for oil producers and consequently reduce overcapacities again. The character of crude oil as a natural and exhaustible resource implies that oil reserves are accessible at different production cost. A higher oil price makes new sources profitable. But likewise, a falling price makes them uninteresting. This is, of course, not completely wrong. But, first, during which time span is this going to happen? Speculation is a phenomenon that reacts immediately to new events and so does the oil price. Oil market quantities, however, do not adapt that fast to a changed environment. Extraction of crude oil requires high fixed investment. Once these expenditures are made, they count as sunk cost, meaning that they are broadly irrelevant for daily production. In this situation, the difference between the oil price and variable production cost determines whether the extraction of an additional unit of crude oil is profitable. Hence, new investment in the face of a low oil price is not lucrative, since investment expenditures are too high. For existing production industries, however, such as those realized during the preceding oil price boom, oil production continues to be financially interesting, because fixed investment is sunk cost. Even more, they may desperately need to raise oil output, because each barrel contributes to the financing of past investment expenditures as long as the oil price exceeds its variable production cost. The oil price may therefore remain low while oil production continues to be elevated for a considerable time.

Such a situation can trigger additional effects. Contrary to the expectations of many observers, OPEC did not cut oil production to counteract the sharp fall in the oil price since mid-2014 (see for instance Krauss & Reed, 2015; Reed, 2014, 2015). One may speculate about the reasons for this decision. One of them might be that the cartel wants to keep its global market share. In this case, its intention is to keep the oil price sufficiently low for a sufficient time to beat out competitors whose access to reserves is less privileged, so that they have to produce at higher cost. OPEC probably eyes the newly installed wells during the preceding price boom. The resulting overcapacities caused by price-driving speculation then are likely to be strengthened over the medium run.

III ACHIEVING STABILITY AND SUSTAINABILITY: ECONOMIC POLICY MAKING

5 Economic Policy Propositions: An Overview

In this final part, we will analyse the problems resulting from the relationships between monetary policy and crude oil price and quantities. Thereafter, we discuss a set of possible policy propositions. It will be crucial to make use of the hitherto developed insights into the working of monetary policy and the crude oil market.

5.1 Economic and Ecological Problems Arising from the Crude Oil Market

We have shown that through speculation, monetary policy cannot only affect the crude oil price but as well crude oil production and consumption. These are longer-term effects implying far more than a short-run deviation from equilibrium owing to several rigidities. Rather, they are a result of the logic about how the futures and spot markets are integrated. Against this background, two problems arise of which one is of an ecological and the other of an economic nature. The former has already been outlined even though without having been denoted as a problem: a higher oil price induced by speculation raises real investment in the oil industry, which itself enhances oil supply. The price falls to an even lower level than before with the corresponding positive response on the demand side. Oil consumption tends to increase so that the oil intensity of economic output (or the oil intensity of society's consumption in general, respectively) is higher than it would be without speculation. We end up with a higher pollution and the corresponding contamination of world climate (see for example Murray & King, 2012). In the long run, the development of alternative energy sources and improvement of energy efficiency is weakened.

The second problem concerns the issue of both financial and economic stability. While both terms are broad concepts, the former is particularly difficult to define (for an extended debate about defining financial stability, see Panzera, 2015, pp. 8–23). Schinasi (2004, p. 8) chooses the following definition: "A financial system is in a range of stability whenever it is capable of facilitating (rather than impeding) the performance of an economy, and of dissipating financial imbalances that arise endogenously or as a result of significant adverse and unanticipated events." Our interest is not in the whole financial system but rather in the crude oil futures market. To the extent that oil price speculation exceeds the hedging needs of oil producers and consumers, it loses its beneficial impact. By moving the oil price away from what is suggested by the spot market, the futures market starts impeding rather than facilitating the performance of an economy. According to our analysis, price fluctuations caused by financial investment give rise to imbalances in the spot market. This is where financial instability becomes economic instability. Chant (2003, p. 4) clearly distinguishes between financial and macroeconomic instability by characterizing the latter as caused by aggregate demand and supply shocks such as changes in expenditures or technological progress. The term ‘macroeconomic’ requires closer consideration in the context at hand. The common debate about financial stability concerns the economy as a whole (see Panzera, 2015, pp. 8–23). If an event affects the economy as a whole, it is of a macroeconomic nature; if there is only a change within some parts of the economy without changing the total economy, it is a microeconomic one (Cencini, 2012, pp. 54–55). Testing our case against this strong proposition, we find that even though the crude oil market is only a fraction of the economy, it has effects on the whole economy, as we will argue. In accordance to our preceding macroeconomic analysis, the investigation of policy propositions continues to be macroeconomic. For convenience, when it is about stability not in the whole economy but specifically either in the crude oil market or in the rest of the economy, we will talk about ‘economic’ stability in the following.

The instability problem consists of the economic risks of both real and financial overinvestment. On the one hand, speculation may create a bubble in the futures market by moving the oil price away from what fundamentals would suggest it to be. This bears great risks. Financial investors who bet on the long side of the market incur large losses once the price falls again. Private bankruptcies have their corresponding repercussions on the banking system of an economy. Their dimension may be hard to evaluate owing to crude oil futures often being only a fraction of an investment portfolio. On the other hand, the response of oil companies to a high oil price by raising real investment potentially leads to the same bubble in the crude oil spot market. As we pointed out, the price therefore has to fall inevitably. The conventional feedback mechanism would imply oil supply to decrease again. We explained just above why this feedback may not take place so soon and that in the medium term, there may even be opposite effects of rising supply. Yet, if oil production is not profitable, it will not persist in the longer run. According to production costs, different oil sources require a different minimum oil price level for sales to cover those costs. The IEA (2008, pp. 217–219) calculates the production costs of conventional crude oil to be between less than 10 and 40 US dollars while, for instance, those of oil shales range between 50 and more than

110 US dollars depending on the specific source. Those producers, whose costs are below the price or just move around it, will shut production down sooner or later. Going bankrupt, however, is a process that leaves its traces in the form of unpaid credits and suspension of employees. Since in the oil industry all companies depend on the same global price level, a drop of the latter may lead to a crisis in a whole branch of economic activity. In the case of the United States, for example, there are more than 400,000 stripper wells all over the country contributing 11 percent to US crude oil output (Meyer, 2014). This shows that a decrease in the oil price can have far-reaching effects in the sense that a great number of entities are concerned. Beside of crude oil, other energy sources like natural gas are likely to be concerned as well by the high oil price owing to the cointegrating relationship we suggested above. As soon as enthusiasm about the fracking boom entered the stage when the oil price was again around 100 US dollar per barrel in 2009, critical voices rose as well stating that production returns were not sufficient to cover investors' debt (see for instance Ahmed, 2013). After the oil price had dropped in mid-2014, troubles of oil producing regions and companies appeared in the daily press (see for instance Scheyder, 2015).

Finally, fluctuations in the oil price affect the rest of the economy where fossil fuels are an important production input. We already mentioned different investigations in this respect (see for example Bernanke et al., 1997; Blanchard & Galí, 2007; Kilian, 2010a, 2010b). This is the point where the stability issue definitely becomes macroeconomic. Financial and macroeconomic stability are usually separated in terms (see for instance Chant, 2003, p. 4). There are, naturally, connections in between. For instance, rising stock market prices may accelerate expenditures in the real economy. In the case of crude oil, in contrast, the linkage between financial and macroeconomic stability is much closer. An oil price change due to financial investment in the futures market directly affects the real economy. The producing economy usually reacts with more delay to events than financial markets do. But nevertheless, owing to the dual nature of crude oil as a physical commodity and as a financial asset, financial and macroeconomic (in)stability are the two sides of the same issue. Importantly to note, financial stability includes the ability of the financial system to facilitate the efficient allocation of resources (Schinasi, 2005, p. 2). Hence, not all changes in the oil price are a sign of instability. We focus on price changes originating in financial speculation that does not correspond to any need of the oil spot market.

We argue that monetary policy may be a possible origin of such overinvestment in the crude oil market. A similar line of argument is provided by White (2013, pp. 33–36), who denotes it as 'malinvestment' caused by easy monetary policy: low interest rates make investment credit cheap and hence may lead to investment expenditures that are wrong in place and that cannot be afforded anymore when interest rates rise again. However, there are differences to this view. First, the oil price affects the oil industry much more directly and heavily than a change in the interest rate affects a common sector. The potential fluctuations triggered by a change in the oil price are therefore larger. Second, we do not adopt the concept of the natural interest rate nor do we connect our findings to it in any way (ibid., p. 30). Its application in a Wicksellian sense means that a deviation of the financial interest rate from the natural one inevitably leads to a changing price level and malinvestment as we have already outlined in the chapter about monetary theory. Our conclusion does not share this view. On the one hand, the natural interest rate cannot be observed. All conjectures about its level are therefore speculative (Rochon, 2004, p. 16). On the other hand, macroeconomically, expansive monetary policy may contribute to growth in total output without creating imbalances in contrast to what neoclassical theory suggests (see for instance Colander, 1996, pp. 28–29; Sawyer, 2002b). Interest rates enter the supply as well as the demand side, that is, production as well as consumption. This aspect has been elaborated in detail in the framework of the transmission channels. The rate of interest does not necessarily distort the relationship of nominal variables to fundamentals but has as well the potential to move those fundamentals themselves. There is nothing of a harmful disequilibrium herein *a priori*. With respect to the market for crude oil, we do not state that monetary policy inevitably gives rise to overinvestment by deviating from the natural rate of interest. The effects detected in our analysis are due to the possibility of speculation and the dual nature of crude oil as a physical commodity and a financial asset. These two features cause a reaction of the crude oil market price and quantity variables to monetary policy that is stronger than in the rest of the economy. To simplify it by means of a supply-demand diagram, we end up with a shift of the oil supply curve that is not matched by a corresponding shift of the (spot) oil demand curve. Hence, the oil price falls. Oil intensity tends to increase owing to higher oil consumption, which is not caused by a demand curve shift but by a movement along the same demand curve due to higher supply.

Both the ecological and the economic problem arising from our analysis require a policy response. Neoclassical economists may recommend the remove of market rigidities in order to enable the economy to smoothly follow its equilibrium path. Such ideas are motivated by the argument that decreased rigidities have mitigated the impacts of oil price shocks on the economy in past decades (see for instance Blanchard & Galí, 2007). Yet, first, our results are not founded on rigidities of a new Keynesian type. They will always exist in capitalist economies, because they are a precondition of capitalist production (Cottrell, 1994, p. 591). Hence, one cannot say that a competitive market, as it exists in the real world, can overcome the effects of monetary policy and speculation on the natural environment or on economic risks.

If economic policy is to intervene in the crude oil market – be it by government activity, new regulation laws, an improvement of the financial structure of the economy, or a change in the conduct of monetary policy, respectively – it has to be aware of the desirable outcome. Consequently, we first have to determine the optimal level of the crude oil price.

5.2 Which Level of the Crude Oil Price Is Optimal?

Instead of defining an exact optimal oil price, we just distinguish between a high and a low price in this place. In general, one might take the view that prices do not have a normative aspect, since they are determined by market forces and are thereby, so to speak, a natural product. In a similar, more sophisticated way, it can be argued that speculative price effects are harmful but that the fundamental component of the price represents the ‘true’ price. However, as argued above, it is hardly possible to distinguish price components. Alternatively, commentators take the perspective of the supply or demand side, respectively. This can be shown with regard to food commodity prices. There was an analogous debate in recent years similar to the one about oil prices (see for instance Baek & Koo, 2014). Most voices raised great concern about the consequences of high food prices for developing countries’ poor and, especially, urban population. However, high food prices help producers raise their income, which is to the benefit of hundreds of millions of peasants around the world. A conclusion would consider food prices to be optimal at a level that guarantees an appropriate income to producers but, given that this condition is satisfied, is as low as possible so that all people can afford food expenditures. It becomes clear that debates about the optimal price cannot avoid political considerations and motivations.

Even though this concept is still rather abstract, it provides some point of reference. With oil, however, the case is much less clear. One may again come to the same conclusion by only taking producer and consumer welfare into account. But there are two additional aspects specific to crude oil. The first one is of a geopolitical nature. The general public suggests that a low oil price is a central interest of Western countries in order to feed industrial production and to raise social welfare. Yet, this view is contradicted by heterodox authors. For instance, Varoufakis et al. (2011, pp. 321–326) argue that the oil price shocks of the 1970s were not counteracted by political measures by the US government, because it was in its own interest. The United States produce a higher share of crude oil consumption in the own country than (continental) Europe and Japan. A higher oil price therefore improves the US terms of trade relatively to other advanced economies. A more radical analysis is presented by Bichler and Nitzan (2015) saying that there are strong connections of economic and political interests between oil companies, high oil prices, wars in the Middle East, and Western arms industries. A low price of crude oil is therefore not necessarily a univocal objective of energy and industrial politics.

Beside of geopolitics, and more in the centre of the investigation at hand, there is the ecological issue of the oil price. All our arguments and, specifically, the SFC model go in the direction that, despite non-linearity, a high oil price *ceteris paribus* goes along with lower oil consumption relative to a low oil price. Thus, the oil price is relevant for the amount of energy use and pollution. A high oil price may be seen as advantageous, since it gives both producing industries and individual consumers an incentive to raise energy efficiency of buildings and production processes. Moreover, they substitute other, potentially more sustainable and renewable, energy sources for oil. However, this is only the demand side effect of the oil price. The supply side is more often neglected. The higher the oil price, the more oil reserves – also those that are not easy to access – can be developed and extracted. Oil sands and extra-heavy oil face higher production costs than conventional oil (IEA, 2008, pp. 215–216). Moreover, their extraction requires technologies that produce chemical residues, which run the risk of being distributed in the natural environment, especially in freshwater systems (see for example Hodson, 2013). The environment, including climate, benefits from a high oil price with regard to the demand side of the oil market but is damaged with respect to the supply side.

Against this background, it is not easy to characterize a price. Is it a moment's snapshot describing the state of the market? Or is it a dynamic issue reflecting the underlying dynamics that lead to this price as well as the dynamics the price will trigger? In this latter case, a price cannot be understood in a single moment but only in a period of time. From this point of view, not the price level is relevant but rather its change. In fact, this is the only way we can get an idea of what a price really means. A high price cannot be judged as such, because it bears the dynamics in it that will lower it again (if we abstract from exhaustion of oil reserves in our case). With the presence of speculation, these dynamics get an even larger magnitude. This aspect is especially important with respect to the problem of overinvestment in the oil industry in the course of price speculation. The level of the oil price then is of second priority. The crucial issue is the extent of price changes. Stable investment conditions require a stable price.

To achieve the ecological goal at the same time, we have nevertheless to find a level of the price that goes along with sustainable levels of oil quantities, that is, production and consumption. In the face of climate change and environmental contamination, the quantities are desirable to be as small as possible. Thus, while we do not know whether a high or a low oil price is helpful for the environment, the case is quite clear with regard to oil quantities. In contrast, assuming away the ecological challenge and merely focusing on market stability, oil quantities become basically irrelevant. Of course, they influence the oil price and hence can contribute to instability. The key variable for stability is the oil price. Given that it is stable, stability of the crude oil market as a whole is guaranteed whether oil production and consumption are large or small. These reflections are the basic preliminary for the development of economic policy propositions that are able to address the economic or the ecological problem resulting from monetary policy and futures market speculation, or both of them, respectively.

5.3 Several Opportunities for Economic Policy

There are several ways to encounter the above identified problems. We will debate and criticize them according to suggested advantages and drawbacks. Some are better known than others and they rely on different approaches. We will also develop drafts of alternative policy proposals. While some will require smaller steps from the present situation, others are more ambitious. Especially, and this may be new in this debate, monetary policy will be put to the fore. Overall in this work, therefore, not only the role that monetary policy plays today with respect to the crude oil market is taken into account. We go further and ask about the role monetary policy may potentially as well play in an economic framework that intends to overcome the problems of instability and the ecological challenge associated with crude oil. An important aspect will be the implementation of policy propositions either at a global level or within national borders. In the following, the proposals can be divided into two main classes: the first class aims at exerting power by, directly or indirectly, influencing the oil price, while the second focuses on oil quantities.

5.3.1 Enhancing Stability in the Crude Oil Market

We start by discussing policy proposals for the issue of economic and financial stability in the crude oil market. The ecological problem will follow thereafter. The reason for this ordering – which does not imply any valuation – is given by the different natures of the two topics. We will realize that the approaches dealing with the environmental impact of crude oil are further-reaching than those for the stability issue. With each of the environmental policy approaches, we will discuss its aspects, and if and how it can be brought in line with stability measures previously analysed.

5.3.1.1 Financial Market Regulation

When speculation occurs, the call for regulation follows on step. In commodity markets, the conception aims at making speculative trades impossible, so that futures markets only serve the needs of commercial traders, that is, producers and consumers, to hedge their purchases and sales, respectively. The proposed measures are most articulated with regard to food commodities and have got larger public attention since 2008, when food prices climbed and revolts in numerous developing countries erupted. The call for regulation is in great part shared and spread by the altermondialist movement (see for instance Global Justice Now, 2015). Since all important commodity futures markets basically work in the same way, the findings and conclusions can be employed to the market for crude oil, too.

There are a couple of central measures in discussion. Some are integrated fully or partially in the US Dodd–Frank Act. In order to turn to each of the debated propositions in a structured way, we follow Staritz and Küblböck (2013, pp. 16–23), who separate them into six groups. Where it is not specified further, we replicate their arguments as they represent the overall debate of commodity market regulation quite well:

- *Transparency and reporting:* transparency in futures market can be seen as the first step to enable any regulation at all. Reporting is required to have data of different trader groups and strategies. Division in commercials and non-commercials or even dividing the latter again in swap dealers and money managers (see CFTC, 2015) is not sufficient. As, for instance, Büyükşahin and Robe (2011) show, empirical results may differ when data disaggregation is improved. Nobody should be excluded from reporting and it should be guaranteed by national or international authorities rather than single exchanges.
- *Limit/prevent over-the-counter (OTC) trade:* OTC trade is often said to have become especially meaningful after the CFMA entered into force at the end of 2000, since it removed all OTC activity from regulation under the Commodity Exchange Act (CEA) (see for example Greenberger, 2010, pp. 99–100). Market risk therefore tends to increase in many aspects. First, nobody knows the total expo-

sure in the futures market. Second, capitalization of traders may be insufficient. In contrast to official exchanges, there are no definite margin requirements so that trades become even more leveraged. Regulation therefore claims that standardized contracts be only traded on and cleared by transparent exchanges that are themselves also well-capitalized (ibid., p. 112). Outside of the exchanges, only non-standardized contracts should be allowed and they should as well be subject to margin rules and general regulation requirements such as reporting. Moreover, the authorities should work in favour of far-reaching contract standardization in order to concentrate futures trading in a smaller number of exchanges and to minimize OTC trade (Staritz & Küblböck, 2013, pp. 19–20).

- *Position limits:* futures market participants are not allowed to hold a larger amount of contracts than a specific threshold. Such position limits reduce speculative activity. Futures market transactions then should merely be of an amount required to guarantee liquidity for price discovery and to satisfy hedging needs of commercials. Thereby, gross as well as net positions should be taken into account. This claim is supported by our suggestion that the importance of speculation cannot be captured by a single variable. In the same way, position limits should be applied to individual traders as well as to aggregate specific trader classes. There should be no general exemptions for any trader class, not even commercials. Exemptions should only be granted to specific transactions insofar that they serve hedging necessities.
- *Price stabilization instruments:* in most stock exchanges, there exist regulating tools leading to a standstill if prices fluctuate too much within too short a time span. Yet, there is nothing of the sort in commodity futures markets. Speculative trading is therefore free to move futures prices. The regulating authority may use a financial transaction tax between 0.001 percent and 0.1 percent as a price stabilization instrument. Thereby, it defines a price band within which the commodity price is suggested to lie according to fundamental conditions. Once the price leaves the price band, the transaction tax becomes effective. Each transaction in the futures market then is taxed by a given rate, which might vary depending on the degree of price deviation. Financial investors – either on the long or on the short side of the market – who aim at benefiting from very small price changes then lose their profit prospects. They lower the volume of transactions and hence reduce the impact on the price. The latter thereby moves back to the predefined price band.
- *Restriction of certain groups of traders or trading strategies:* high-frequency trade is a strategy where traders hold financial assets only for milliseconds before selling them again in order to benefit from infinitesimal price changes. Another

and closely related problematic issue in this framework is algorithmic or technical trading, respectively. Speculators use technical systems to calculate past price trends and to trigger an automatic purchase of long or short positions depending on the trend these systems perceive (Schulmeister, 2012, pp. 38–40). Such systems may give rise to uncontrolled price fluctuations. Some of these strategies might already be counteracted by a financial transaction tax. Otherwise, they can be restricted or prohibited.

- *International cooperation and supervision:* finally, for regulation to be definitely effective, it should be extended globally in accordance with global commodity markets. International cooperation should be strengthened to harmonize national regulations or to set global minimum standards. In the optimum, there is a global authority with regulatory and supervisory competences.

An advantage of the proposed measures is that they can be directly applied to the place where speculation occurs, that is, in the crude oil futures market. They do not require a full macroeconomic framework to enter into force. Basically, the claims listed here are rather a question of legislation than of economic reasoning once their general idea is given. However, the seeming practicability of the regulation approach is as well a drawback. Beside of well-known doubts, it leaves some important economic issues unquestioned.

The first objection that occurs regularly is the one of legislative effort, which produces a lot of bureaucracy. Especially with regard to the regulation or, rather, strong reduction of OTC trade, it requires a lot of supervision without a guarantee to be fully successful. A possible instrument to limit the supervisory effort may be the creation of arbitrage opportunities by prescribing different maintenance margins to shift futures trading activity from over the counter to organized clearing facilities. However, the economic issue of arbitrage is not easy to employ in the preferred direction. Staritz and Küblböck (2013, pp. 19–20) criticize the EU regulation that allows for the creation of organized trading facilities (OTF) by investment firms beside of the official exchanges. They argue that instead of pulling OTC trade out of the shadow towards OTFs, it may as well be possible that investors move from regulated exchanges to OTFs.

Moreover, regulations tend to leave gaps used by financial investors to circumvent the rules in a legal way. For instance, if financial investors face position limits, they may contract on a physical OTC delivery and hence can claim in the futures market that they have a commercial interest and get rid of the position limits (The Economist, 2013). Regulation may be more or less efficient and effective and thus leaves more or less regulatory gaps open.

Second, regulatory rules use to have legal power. They should thus be able to be applied to every situation where speculative activity requires counteracting measures. Yet, this requirement is a problem, since the optimal setting of regulatory values, that is, for instance, position limits, transaction tax rates, a price band, or margin requirements, changes over time. Two difficulties have their source in this institutional shortcoming. The first one is the inflexibility of a legal framework to circumstances that change as fast as those of financial markets. The second problem is more profound and of an economic nature.

The regulation approach does not ask the question about the oil price level that we sketched above. Therefore, it does not seem to have an idea of the preferred price, whether it should be relatively high or low. The exclusive purpose is to remove speculation from the futures market. The implicit assumption lying therein is the acceptance of the market price driven by fundamental forces to be the ‘true’ price. In order to ensure economic stability and to prevent bubble building in commodity markets, this view may be appropriate. For those prices of food commodities that tend to be driven up by futures market speculation such that food becomes unattainable for great parts of world population, the argument seems to be adequate as well. Yet, for crude oil, which has not only an economic but as well an ecological importance, simple elimination of speculation will not be sufficient as we will show later.

But nevertheless, with respect to the question of the price level, the regulation approach is not without problems for commodities in general. By, directly or indirectly, identifying the fundamentals price as the ‘true’ one, it suggests that the fundamental and the speculative components can be separated. In our theoretical analysis where we distinguished transmission channels of monetary policy through fundamentals as well as through financial markets, we argued that they are closely related and interact dynamically. Their numerical separation is therefore not possible. In the empirical part, a concession in this regard was made to test for basic significance of fundamental and financial market price effects. Yet, we are far from claiming to have found exact numbers attributed to each one.

For these reasons, it becomes quite hard to define an oil price band outside of which a financial transaction tax is to be imposed. Where should the limits be set such that all movements within the oil price band can be attributed to changes in fundamentals while those outside of it are purely speculative? Likewise, where are position limits for financial investors to be set, so that they serve to provide liquidity but do not exceed those needs? Uncertainty about these issues makes regulation in the form of conventional legislative frameworks rather inflexible. Since the speculative price component cannot be detected, the regulatory framework cannot be determined by means of objective economic arguments. It is rather subject to permanent and renewed economic analysis and policy. For regulation to be effective, permanent market supervision and possible adaptation of regulatory values are necessary. The supervising authority should therefore be endowed with a certain degree of flexibility and independence, as it is well established regarding monetary policy.

5.3.1.2 Counteracting Oil Price Fluctuations

Instead of creating a legislative framework to rule out speculation, another approach consists in active intervention in the crude oil market. Whether such actions are executed by the government administration or by some specified regulatory authority is of secondary importance in this place. The basic idea consists of a reaction to price developments that impact the market in the opposite direction. This measure is strongly recommended by Davidson (2008). He mentions the US strategic petroleum reserve. While it fulfills the emergency stocks obligations of the IEA and is argued to serve as a national defense fuel reserve, it mainly “provides the President with a powerful response option should a disruption in commercial oil supplies threaten the U.S. economy” (Office of Fossil Energy, 2015). To get an idea, in March 2015, for instance, the strategic petroleum reserve stocks amounted to about 36 days of US petroleum consumption (EIA, 2015b, 2015d). In a moment when the oil price is very high and speculation is suggested to be a major price driver, a partial release of the strategic petroleum reserve by selling it on the spot market pulls the oil price down as supply conditions are relaxed.

It is an open question whether the oil reserves are sufficient to bring the price of oil to its desired level. According to Considine (2006) and Stevens (2014), the price impact of the use of the strategic petroleum reserve is quite modest, while Verleger (2003) argues it to be strong. On the one hand, one may argue that the public is aware of the strategic petroleum reserve and once it is released to its limits, speculative investment may carry on. On the other hand, financial investors often aim at benefiting from very small price changes, as in the case of high-frequency or technical trading. A one-time release of crude oil reserves may have a sufficiently large effect on the oil price, so that the losses incurred by speculators cannot be compensated by small-scale profits anymore. This might then be sufficient to free the oil market of the main speculative impacts.

The holding of strategic reserves is, however, suggested to be insufficient and inefficient as it implies physical storing capacities and trading infrastructure. Nissanke (2011, pp. 54–56) and Nissanke and Kuleshov (2012, p. 35) propose market intervention through the futures market rather than directly in the spot market. In the case of a high oil price, the political authority should enter the oil market on the short side of it to lower the oil price. In this way, counteracting measures can be taken faster and more flexibly without physical exposure. Moreover, trading crude oil in paper form rather than as a physical object allows better fine-tuning. To be credible, the public trader has to convince financial investors to be ready to make losses if necessary to stabilize the oil price. The more credible the threat, the less intervention is actually needed, since speculators do not want to take too high a risk of investment losses. This not only helps prevent the oil sector from overinvestment; it also contributes to financial stability, as financial investors hesitate to build up too large a leverage.

This approach does not make the claim to be able to distinguish the fundamental and the speculative components of the oil price. In contrast to financial market regulation, it does not make suggestions about the origin of price movements to intervene directly at those origins after their identification. Rather, it lets market forces, in the spot market as well as in the futures market, act freely. It takes the final result, to wit, the crude oil price, as the starting point and then counteracts correspondingly. This way of proceeding is relatively simple and allows flexible and probably effective intervention. However, it has as well its shortcomings. While it tries to stabilize the crude oil price and hence to stabilize overall market conditions, the stabilization effort may also have destabilizing effects. Owing to the indivisibility of the oil price in its fundamental and financial market component, market intervention cannot be precise in the sense that it manages to filter out exactly the speculative fraction of the price. It thus may be insufficient, which means that it only mitigates but does not fully break the speculative influence. Or it might be overshooting, implying that fundamentals are affected more than if only speculation were neutralized. Assume that the political authority releases a large part of its strategic petroleum reserve or, alternatively, goes short in the futures market such that the oil price falls below of what it would be in the absence of speculation (ignoring now that we do not know the price level exclusively implied by fundamentals). Such an overshooting has effects on both supply and demand sides of the spot market by influencing the amount of inventories, production, consumption, and investment behaviour. Such an outcome is more likely if counteraction takes place in the spot market instead of the futures market owing to the greater flexibility of the latter.

To sum up briefly, the approach of direct market intervention has the merit of simplicity and flexibility. On the other hand, it suffers missing precision owing to the uncertainty of the oil price and its components. Therefore, it may have destabilizing effects even though they do not have to be very large. Concerning implementation, sophisticated international cooperation would be required for this approach to be successful. If each country pursued a different strategy of market intervention, effects would probably be more destabilizing than stabilizing.

5.3.2 Reducing the Share of Fossil Energy

The above mentioned policy propositions contribute to economic and financial stability. Given that they are able to ensure that the oil price corresponds to the underlying fundamental developments without containing any other component, a certain degree of ecological stability is established as well. Indeed, in this case we do not face the variation in the oil intensity of output that we identified as a response to a change in the stance of monetary policy in panel d) of Figure 4.1. Otherwise, regulatory approaches and direct market intervention may themselves be a source of smaller or larger disturbances and hence affect oil consumption volatility, too. Whether the instruments are successful or not, would be an empirical question after their potential implementation. In the optimal case, they guarantee economic stability and prevent fluctuations of oil consumption that are harmful to the natural environment in general and to climate in particular. Yet, they do not contribute to a clear improvement of the ecological balance of the economy but rather reestablish the *status quo*. Therefore, we may ask the question how the insights of the hitherto analysis can be employed productively to get a step further.

So far, we established that monetary policy has an effect – mainly through the futures market by means of financial investment – on the oil price and hence on oil quantities. If climate change is to be stopped, production and consumption of fossil fuels and hence of crude oil must decline. There is hardly any serious doubt to this claim in science at the time of writing (see for instance Murray & King, 2012). The question of interest is, therefore, how economic policy can achieve not only economic stability and smoothing of oil consumption but, instead, both economic stability and a reduction in oil consumption. We will develop a way how our analysis may serve these purposes, that is, how monetary policy and futures markets might be used in a helpful way. In the course of this proceeding, different propositions will be presented that are already frequently discussed in the sphere of economic and environmental policy and maybe already implemented in related political fields. We will point out that our own proposition is a combination of already existing approaches that pursue the purposes of economic stability and ecological sustainability.

As a preliminary, let us note that we face a more ambitious issue, since economic policy that should have an ecological impact has to take oil production and oil consumption into account. Supervising or influencing the crude oil price is not sufficient anymore in contrast to the conditions for financial and macroeconomic stability, where oil quantities are mainly irrelevant. In this regard, it is a quite basic fact that economic policy allowing for market forces may either focus on affecting the oil price or oil quantities but can never control both (see for instance Weitzman, 1974). While the preceding approaches to economic stability aim at having an impact on the oil price, we will now turn to a policy proposal that has oil quantities in its centre. It has its merits as well as shortcomings, and will thereby contribute useful insights to the further debate.

5.3.2.1 Oil Supply Target

Acknowledging that oil consumption necessarily has to decrease, to stop, or at least mitigate climate warming, the political authority may simply set targets for oil production. This is well known for public enterprises such as in the context of the crude oil market to those in OPEC countries (see for instance Reed, 2013). In countries, however, where private companies compete in a market, this idea may appear as rather unconventional. But there is a way to implement production targets or, to be more exact, oil supply targets. Similar propositions are made by various voices including economists, think tanks, and journalists (see for instance Barnes, 2008; Boyce & Riddle, 2007; the Foundation for the Economics of Sustainability (feasta), 2008). The reason why it is again important to make a difference between production and supply will easily become clear.

The political authority may set a target either for oil consumption in absolute levels or for the oil intensity. In order to assess the oil intensity of the economy, a ratio has to be defined. The most obvious ones are the proportion of oil consumption to industrial production or to total GDP, respectively. While the absolute level of oil consumption is the only relevant one from the view of climate policy, the intensity ratio takes long-run economic development and business cycles into account. The former features the problem that setting a target without reconsidering the state of the economy can have negative repercussions on output. Using an oil intensity ratio is therefore more appropriate. The political dispute then consists of the level of the targeted ratio. A constant target allows for the stabilization of the oil intensity but implies greater pollution if output grows. If oil consumption is to be decreased in absolute levels, the ratio must therefore fall over time, given that there is a long-run growth rate of output larger than zero. The condition for a falling oil intensity target to lead to a decreasing quantity of oil consumed is given by the following simple formula. The variable of interest, be it industrial production or GDP, is described by Y_t and is assumed to grow by an annual rate g_y.

$$g_y = \frac{Y_t - Y_{t-1}}{Y_{t-1}} \tag{5.1}$$

The oil intensity ratio R_t should fall enough so that crude oil consumption C_t is at least constant or otherwise declining, meaning that

$$C_t \leq C_{t-1} \text{ which implies } C_t/C_{t-1} \leq 1 \tag{5.2}$$

The percentage change of the intensity ratio g_R is therefore given by

$$g_R = \frac{R_t - R_{t-1}}{R_{t-1}} = \frac{R_t}{R_{t-1}} - 1 = \frac{C_t/Y_t}{C_{t-1}/Y_{t-1}} - 1 = \frac{C_t}{C_{t-1}} * \frac{Y_{t-1}}{Y_t} - 1 \leq \frac{Y_{t-1}}{Y_t} - 1$$
$$= \frac{1}{1 + g_Y} - 1 \tag{5.3}$$

The condition is thus given by

$$g_R \leq \frac{-g_Y}{1 + g_Y} \tag{5.4}$$

For small values of g_Y, the nominator can be roughly approximated by 1, saying that oil intensity has to decrease by the same rate at which output grows for oil consumption to remain constant. For the latter to decline, the drop of the ratio has to be larger than output growth. To account for year-to-year fluctuations in output, the target can be set for longer-period averages of, for instance, ten years.

Crude oil or petroleum consumption, respectively, takes place in a decentralized manner, that is, in industries and individual households. Political intervention being employed on the consumption side is thus quite complicated and runs the risk of ending up in more bureaucratic effort than would in fact be necessary. The target hence may be set on the oil production side. Conditions in the oil industry are more or less competitive and thus more or less concentrated depending on the country. But even in the case of the United States, where there is also a large number of small producers present in the market, political intervention is still easier to carry into execution on the production side than on the consumption side (feasta, 2008, p. 4).

Yet, production is not the same like consumption and hence the target of interest, that is, the oil intensity ratio, is distorted. Production includes inventory accumulation, which is *a priori* independent of effective consumption, especially when we take oil imports and exports into account (see below). It is thus more useful to take supply as the target value, to wit, the volume of crude oil that is effectively sold in the market. Supply is equal to demand in any moment. Hence, the targeted ratio is now distorted only by a much smaller gap consisting of oil demand and effective oil consumption, which amounts to inventory building on the consumer side. As oil supply targeting is a medium- or long-run purpose and since it is reasonable to suggest that inventories of consumers follow a stationary pattern, the replacement of oil consumption by oil demand seems to be appropriate. Yet, the approach is called oil supply rather than oil demand targeting, because it is implemented on the supply side of the crude oil market.

Until now, this approach might seem rather abstract and radical to some readers. It is justified to ask how such a simple design of a proposal can be implemented in the real economy. With regard to the latter, however, it becomes clear that this proposal is not as unique as one might suppose. Indeed, its conception is related to greenhouse gas emission trading systems of which the largest one currently exists in the European Union (European Commission, 2015, p. 1). This system basically consists of a ‘cap’ that determines the maximum volume of emissions allowed in one year. The cap is composed of allowances that a company must possess by an amount that covers its annual carbon emissions. While the allowances were allotted to the sectors for free every year in the first two periods of the system’s existence from 2005 until 2012, they have been allocated by an increasing share through auctioning since then (ibid., p. 4). Companies can trade the allowances among themselves in accordance with their emissions arising from production. The limitation of allowances by setting a cap gives them a price. The rationale behind the system is to let market forces work freely, suggesting that allowances are traded in a way that leads to an efficient allocation. If so, then, according to the suggestions, reduction of carbon emissions can be achieved in the most cost-effective way (ibid., p. 2). The system’s basic economic framework can be traced back to Coase (1960), who states that, in the absence of transaction costs, all external effects can be internalized by agents’ bargaining, once property rights are well defined. In this case, emission allowances are made a tradable asset over which companies bargain and thereby find the most efficient level of output and the optimal degree of contamination. A difference is, however, given by the fact that political action is required to provide emission with a price and to determine what the socially optimal, or acceptable, level of overall pollution is. Oil supply targeting could be implemented in an analogous way by emitting allowances according to the targeted level of the oil intensity. They are allotted to oil producers and define the total quantity of oil that is allowed to be sold.

Yet, the European carbon trading system is not at all free of criticism. As Gilbertson and Reyes (2009, pp. 9–12) put it, numerous reasons make carbon trading an inadequate and insufficient strategy to address climate change. For their first criticism, a cap set at too high a level, so that it exceeds effective current pollution of individual industries, does not put any pressure on the latter to improve production processes. Even more than that, they can sell excessive allowances to other polluters and thereby benefit financially from the emission trading system. Second, as far as allowances are allocated to economic sectors for free, historical patterns of industries' carbon emissions are considered. Those industries that face a relatively large volume of emissions are allotted with more allowances than others. This gives rise to a reward for industries that did not make any efforts in the past. Third, the UN-administered so-called 'Clean Development Mechanism' allows emission reductions in developing countries that are not part of the trading system. When a company realizes a project in such a country, it gets emission allowances in the amount of carbon emissions saved by the project. The quantity saved is estimated by the difference between pollution of the actually implemented project and the project that would otherwise have been realized. However, such an estimate mainly consists of guesses of what the alternative project would be. Guesses may in principle be quite generous, so that the success of the system might appear impressive. Yet, what takes undeniably place beside of artificial guesses about emission reductions is the increase in pollution owing to the project realized. At the same time, the company in the north is allowed to augment emissions by the amount of the additional allowances. This offsetting opportunity consequently allows companies in the system to increase the number of allowances according to requirements (Bernier, 2007).

The approach proposed at this juncture should be able to circumvent these critical points. As regards the first one, the cap of permits (in our case permits to sell crude oil) has to be determined tight enough in order to have an effect on oil supply. In this respect, the rule derived above about how to set the target ratio becomes important. This is dependent on political decisions assessing the reduction goals to be reached.

The second problem of allocation of allowances applies differently to the oil market than to the carbon emission market. Once the cap is set, resulting oil supply leads to a specific oil price level, which is the same for all consumers. They decide on the volume of consumption depending on the price of crude oil. Conditions thus are basically the same for all agents on the consumer side. Among producers, however, free allocation according to historical production or sale volumes, respectively, may indeed be considered as a reward of those who produced most in the past. Auctioning the allowances without any prerequisites would therefore be fairer.[40] Larger producers would have the power to purchase more permits but this corresponds to the distribution of market shares already in place. Offsetting emission reductions in countries outside of the trading system, which represents the third problematic point in the European emission trading system, should simply be kept out of the design. To get there, it is crucial to determine the working of the approach within a single country and its relation to crude oil exports and imports.

To be sure, in the real world an economy is not placed in a vacuum but within the borders of a country facing the rest of the world. Implementing the oil supply target globally is the simplest and most effective way. However, in a world were global governance is not developed too far, this possibility is unlikely. In order for an oil supply trading system to be nevertheless employed, the latter must be compatible with the fact that most relevant legislation is national while the crude oil market is globalized. In a carbon trading system, the basic economic idea is to give environmental contamination in general and carbon emissions in particular a price by making it scarce (European Commission, 2015, p. 2). By setting a cap on total emissions, a market is created out of nothing. By contrast, an oil supply target is set in a preexisting global market. This fact may provoke critical objections concerning the viability of such a system in the market for crude oil. However, the setting of this approach allows for quite an elegant realization. The problem would be acute if the target would concern production instead of sales. In the former case, companies could produce not more than what is allowed by the cap. This would leave the problem of determining the level of the target, since it is not clear how oil exports should be weighted. The latter may grow in the future or not be independent of the target set for national oil intensity. Constraining oil exports would come at the cost of national producers while missing exports would be compensated by other foreign producers. With respect to crude oil imports, a production target can, of course, easily be circumvented by oil imports so that there is no in-

[40] The public returns emerging from the auction may be redistributed to people in order to prevent harmful effects on equality or even to improve wealth distribution, respectively (Boyce & Riddle, 2007; feasta, 2008, pp. 13–17). For the use of the revenues, see the further debate in this thesis.

centive to use fossil fuels more efficiently. Focusing the target on crude oil sales resolves the problem: oil producers are allowed to produce in excess of what is allowed to sell in the home economy and to export it. Oil importers, on the other hand, can in principle import as much oil as they want, but they can only sell a quantity that is backed by supply allowances. In this way, producers still have the opportunity to participate in the global crude oil market as they would without a supply target. On the other hand, the target is effective in the national economy and can exert the desired effects on the oil intensity in the country. Hence, there are no (legal) arbitrage opportunities that may be used to circumvent the policy measure. The only potential repercussions a supply target can have on the global market is the reduction in national demand for oil. Yet, this effect is just the intention of this approach. To the extent that it makes consumers employ more efficient and alternative technologies, declining demand pulls the oil price back in direction of the world level.

After all, however, this policy proposition cannot get rid of all problems in the theoretical sphere as well as in the area of practical implementation. First, the tighter the supply target is set, the greater is the incentive of illegal circumvention and hence the greater the effort of supervision required. Second, and more profound, distribution of supply permits that are constrained by the political authority may be subject to speculation. Agents are aware of the number of allowances distributed either freely or by auctioning, and build expectations about market conditions and prices. Expected tightness may induce them to purchase more allowances today, which can be sold at a higher price. However, this argument is limited by the construction of the supply trading system: allowances are emitted anew every year implying that a permit to sell a barrel of crude oil is valid in the current year and cannot be saved for the next period. One may as well envisage a system that allows accumulating permits over more than one year. But as this argument clearly shows, this would probably facilitate and promote speculative activity.

The third problem is the most serious one from an analytical point of view. While oil quantities are influenced by policy intervention, the oil price may continue to fluctuate. Controlling both quantities and prices is a logical impossibility in market economies. In a system with oil supply targeting, the price of crude oil does not only reflect intrinsic fundamental developments of the oil market but is naturally strongly influenced by the supply target, too. To enable a smooth oil price development, the cap should be set according to supply and demand conditions in the crude oil market. In the European carbon trading system, this was found to be a quite difficult task. In the first phase of the system's existence, the price per ton of CO_2 started at a level of about

23 euros in 2005, climbed to 27 euros and fell in almost straight line to zero until mid-2007. In the second phase, from 2008 until 2012, price fluctuations could be mitigated but were still considerable, between 8 and 33 euros per ton of CO_2 (Committee on Climate Change, 2009, p. 68). In the carbon market that was created exactly for the purpose of climate protection, such fluctuations are a sign – especially when the price falls to zero, that is, when the market shuts down – that the cap is set inadequately. The consequences for environmental goals may be severe while those for the economy are limited to changes in production cost of which carbon allowances represent a fraction. In the crude oil market, however, a target that produces high price volatility has direct effects on producers' as well as consumers' behaviour and thus has a much greater potential to harm the economy. The nature of this problem is such that it cannot be resolved by simply setting the cap differently. The assessment by research or the civil society that the European emission trading system is not able to guarantee stable price patterns is basically correct (see for instance Carbon Trade Watch, 2013; Gilbertson & Reyes, 2009, pp. 12–13). But it is insufficient on analytical grounds. Rather than an empirical question, it is a theoretical issue. Indeed, there is no method how to set the target at a level that corresponds to stable prices. Just as little is there a way to follow a predetermined declining path of an emission cap or an oil intensity ratio, respectively, and to achieve a stable price (or a smoothly rising price) at the same time. This is due to an endogeneity problem. For the crude oil price to be stable over time, oil supply has to accommodate to changes in oil demand. Since supply is determined, or at least bounded above, exogenously by the target, it is up to policy to set it in a way that it matches oil demand. On the one hand, future demand for crude oil depends on output growth. The political authority has to make predictions, which can be more or less close to the effective outcome. A prediction bias has its consequences for the oil price. If supply was market-based, producers could overcome a sudden shortage in the spot market by a decrease in inventories, which is not possible if the volume of sales is predetermined. Second, and this is the true endogeneity issue, oil demand depends on the oil price. The oil price is itself, among other factors, dependent on conditions on the supply side. In other words, oil demand is *ceteris paribus* determined by the quantity and the price at which crude oil is supplied. Supply is in turn to be determined by the political authority in light of demand expectations. We end up in a circular reference, which cannot be dissolved by the approach of the oil supply target. The decision to use an oil intensity ratio as a target instead of an absolute level of supply enables to take business cycles and long-run oil demand developments at least partially into account. But it cannot give a response to the endogeneity problem.

The fourth critical point concerns economic stability in the crude oil market. The oil supply target, if announced in public, provides oil companies with information about future production conditions. Given this transparency, they can plan production and investment in a stable environment, since they know the capacities needed to fulfill the cap. Even if the price should rise strongly in a given situation, producers do not have a reason to overinvest, since supply cannot increase despite the high price. This constraint is relaxed and relativized by a number of factors, namely foreign trade, changes in production technology, and business-cycle impacts. However, stability gained in this aspect is jeopardized by other, newly emerging instabilities. First, price instability is enhanced by the theoretical inability of the political authority to exactly match oil demand, so that the oil price follows a stable pattern. Second, the issue of speculation in the futures market is not addressed. Financial investors may therefore still benefit from betting on changing oil prices. The phenomenon may even be intensified: beside of building expectations about distributed supply permits, an issue discussed above and suggested to be limited, information about the target in the future may be an additional source fueling speculative futures market investment. For instance, given that the economy is in a boom and speculators judge the supply target to be too low to accommodate rising demand, they start betting on rising prices. By exerting additional demand power in the futures market, the crude oil price rises effectively and runs the risk of building a bubble. The effects of such a price increase have been analyzed in abundance. While overinvestment should now not be a problem of first priority owing to the reasons explained, exacerbated oil price fluctuations have their effects on the rest of the economy.

Weighing the advantages and disadvantages of this policy proposition in a conclusion yields an ambiguous judgment. It is an effective approach to the ecological problem. However, it does not resolve the problem of economic and financial instability or even worsens it, respectively. In particular, the causal chain identified in our theoretical analysis from monetary policy to price and quantities of crude oil is not distorted in any way. Yet, the discussion of the proposal is nonetheless useful, because there are some insights that can be used in the remainder.

5.3.2.2 Fossil Energy Tax

A policy approach to the market for crude oil that is to guarantee economic stability and ecological sustainability at the same time needs to overcome the troubles arising from quantity regulation detected with oil supply targeting. In this section, we thus consider an approach to the ecological issue that focuses again on the price instead of quantities. With respect to energy and environmental policies, an often debated proposal is a tax imposed on energy consumption, be it energy in general or crude oil in particular. First emphasized by Pigou (1920), it aims at internalizing external effects. Fully integrated in the neoclassical microeconomic framework, the analysis suggests that external effects consist of the gaps between the social marginal net product and the private marginal net product (see for example the summary in Aguilera Klink, 1994, p. 387). This distortion is to be corrected by a tax that, in the case of negative externalities, is imposed on the producer of this external effect. The tax is to be set such that the producer corrects its activity by an amount that re-equilibrates the social and private marginal net products. In the specific case of crude oil or fossil fuels, respectively, the tax would make production more expensive, so that the price realized is higher while output is lower. In the optimum, fuel production is such that the marginal unit contributes a utility that is equal to the damage caused by additional pollution due to this marginal unit.

The concept drafted in this way suffers the problem of applicability to the real world. As Pigou (see for instance Pigou, 1951) himself states, the conception of social and private marginal products requires knowledge about utilities both at the social and individual level, which are not measurable. Baumol (1972, p. 316) argues that externalities may be of a psychic nature and therefore even farther from being measurable. Yet, the need for practicability allows deviating from the exact optimal solution obtained under perfect competition. Baumol (1972, pp. 318–320) proposes a tax that is driven by one or several principal indicators concerning the externality. If the indicator exceeds a specific predetermined limit, the tax is adapted. Thereby, the political purpose is suggested to be reached step by step.

In fact, the instrument of a tax on fuel is not as outstanding as it might seem at first sight, nor is it merely a theoretical idea discussed in abundance but never realized. It is quite the opposite, namely, that such taxes already exist in quite diversified varieties in many OECD countries (see for instance Newbery, 2005, pp. 1–7). It must as well be said that there exist at the same time, for instance in the United States, also substantial tax preferences for producers of crude oil and other fossil fuels (Metcalf, 2007, pp. 158–160, 166–168). Subsidies are the opposite of taxes but, in an economic sense, of an analogous nature. Usually, existing taxes do not serve the purpose to internalize external (environmental) effects but rather take the form of value-added taxes or earmarked for specific public expenditures like transport infrastructure. Consequently, both the subject and the object on which a tax is imposed may differ. It might be raised from the producer, the refining industry, or the final consumer, respectively. Consequently, crude oil, petroleum, or heating oil may be the respective object of taxation. Following the argument from above, implementation should be easier on the production side, as it is more centralized than the consumption side. Let us assume, for reasons that will become clear in the remainder, that the tax is raised from crude oil producers.

A tax on crude oil production, fossil fuels in general, or pollution, respectively, is quite elegant in the sense that it allows for pursuing an ecological goal without being obliged to set prohibitory bureaucratic regulatory controls. The purpose can thus be reached more efficiently (Bernow et al., 1998, p. 193). An additional complication accrues when considering the economy of interest in the context of its international relationships. A tax imposed only in a single country brings losses in competitiveness for the industries concerned, since their production costs increase. Usually, these drawbacks are suggested to be overcome, on the one hand, by putting tariffs in place to protect these industries. Alternatively, the original competitive conditions can be restored by removing the tax on the goods exported and raising it on the same goods imported, to wit, crude oil in our case (ibid., p. 195).

Yet, while this correction mechanism at the country's border eliminates these distortionary effects, it creates new ones, even though they are of a transitory nature. Both measures bring about similar effects, so let us consider the case of where crude oil exports are unburdened and imports are imposed by the tax. We assume further that it is about a small open economy where world prices are given. The oil industry is imposed a tax of, say, 10 US dollars per barrel. One may as well imagine a regime with the tax being a certain percentage share of the oil price. However, this would imply additional dynamics, as tax revenues increase and decline with the oil price (Newbery, 2005, p. 6). We abstract from such effects for now. To speak in simple model terms, the supply curve shifts upwards involving a shift on the demand curve in direction of a higher price and a lower oil quantity. The oil price in the country is now higher than at the global level. Arbitrage does not lead to re-equalization of the two prices, since exports and imports are corrected by the tax. This is the standard explanation of how such a tax can be implemented in a single country against the background of global integration without distortions. However, there are cross-border effects. Under the usual case of imperfect competition, the crude oil tax is raised at the cost of producers' profits. Therefore, it becomes lucrative to export a higher share of oil production instead of supplying it at home. The supply curve thus not only shifts upwards owing to the tax imposed but additionally moves to the left – which is, in fact, the same direction again – owing to a larger fraction of output that is exported. The oil price thereby increases further, while oil demand decreases even more. Arbitrage effects are therefore present and lead basically to a quasi-equalization of the home price and the global price of crude oil corrected by the tax (and other imperfections like transportation cost, which are ignored here). After a shorter or longer period of adjustment, we end up in a new state where the oil price in the small open economy is in a kind of equilibrium with the world price. If the economy is sufficiently large so that the world price is not simply exogenous anymore, which is to some degree for all economies, increasing exports affect the world price. This again has the corresponding repercussions lowering the home price until equilibrium is reached.

Adjustment bears distortion that repeats every time the level of the tax changes. Consequently, this makes it harder to gain knowledge of the effectiveness of the tax. There is a way to smooth distortions. Instead of unburdening exports and imposing imports by the whole amount of the tax, correction at the country border may only be such that it compensates for the difference between the home price and the world price. Focusing again on the simple case of a small open economy, the introduction of the tax affects production costs. The new price guarantees some profits that are lower than before. It becomes more lucrative to export oil if it is fully unburdened of the tax. However, if tax is refunded only by a fraction corresponding to the difference between the higher home price and the lower world price, the producers' profit per barrel remains the same. Exports are disburdened by $\Delta p = p_{home} - p_{world}$, while imports are charged by the same difference. There is no arbitrage opportunity between selling in the national economy and exporting and, hence, there is no incentive to raise exports in a way that would tighten the home market. Some output remains unsold at home owing to decreasing demand in response to the price increase. It can be exported without having distortionary effects in the home market, owing to the new compensation mechanism at the country's border. Once the tax changes, international trade conditions adapt smoothly, since the tax compensation adapts as smoothly because the oil price is a part of its formula. There is no distortionary force. To the extent that the economy's crude oil output is large enough to affect the world price, the usual feedback mechanisms take place. However, this is less the case, since exports rise less in response to the tax introduction as if the tax would be fully compensated at the country's border.

Important to be mentioned, Δp may at the maximum be equal to the tax. This maximum then corresponds to the conventional mechanism of tax correction. If the difference between the home price and the world price is larger, then it is due to other reasons than taxations, such as lacking competitiveness owing to production technologies, exchange rate changes, and so on. Fundamental developments of this kind cannot be taken into account by the political authority.

It is justified to ask why such a smoothing mechanism is necessary. All kind of taxes on consumer goods and services, like value-added taxes, feature the same cross-border problem. However, this problem is usually managed by subtracting the tax completely from exports and fully adding it to imports. Nonetheless, we do not observe substantial distortions that seem to be worth an economic debate. The crude oil market is different in several crucial respects. First, it is highly globalized. Hardly any other sector is as strongly globally integrated as the market for crude oil. By contrast, many national sectors produce goods and services that are not exported and hence are not in global competition. With crude oil, the national economy and the world price are so strongly connected that changes in one place, which is the oil tax in our case, have potentially strong repercussions on the other. A smoothing mechanism is therefore important, especially as the crude oil tax appears to the market as an exogenous impact. Second, for the tax to be effective with respect to petroleum consumption, it ought to be of a considerable level. The currently existing gasoline tax in the United States of 18.4 cents per gallon (Bickley, 2012, pp. 11–12) is probably insufficient. The higher the tax is set, the larger are its potential distortions. Third, an environmental policy that seriously aims at continuously reducing the share of fossil fuels in energy consumption has to increase the tax in regular time intervals. Each change in the tax then may bring about distortions and more and more lasting uncertainty about future market developments. Fourth, in the case that the tax is imposed as a constant percentage share of the oil price, every change in the price affects the amount of the tax and thus bears additional distortionary dynamics. This has to be seen particularly against the background that the price of crude oil fluctuates much more than that of most other goods (Kilian, 2010b, p. 4). For these reasons, a mechanism that allows the smooth introduction of a crude oil tax in a single country gets considerable importance.

While the advantages of an energy tax in general and a crude oil tax in particular are obvious and given by its pure motivation, the disadvantages have to be emphasized in more detail. On the one hand, there is the well-known principal critique that energy taxes would raise production costs, giving rise to a drain of production industries where fossil energy makes up for a large fraction of inputs. This is an argument that concerns all kinds of taxes. Yet, there are numerous other factors that make up for the competitiveness and prosperity of a country (Mills, 2015). This is valid for the manufacturing industries. Crude oil producers themselves do not have to make a decision about which country to produce in. First, drilling wells cannot be moved away, implying that crude oil production is naturally tied to a certain place. Second, oil that is sold in the national economy is taxed whether it is produced at home or abroad. However, tax revenues may be used to either compensate for potential losses in international competitiveness. This issue will be debated further.

On the other hand, what is interesting and more important in our context, a crude oil tax does not contribute to economic and financial stability. To simplify, it is just added to a given price level. Besides of middle- and long-run effects of the higher oil price on decreasing oil demand, search for alternative energy sources, and technology development, the tax affects neither the fundamental nor the speculative forces that drive the oil price. The price thus is basically allowed to follow the same pattern as without the tax. This includes the occurrence of speculative activity potentially giving rise to price bubbles and overinvestment resulting out of it. The crude oil tax may be effective in bringing an ecological benefit. But it is not able to solve the problem of economic and financial instability. To prevent monetary policy from contributing both to instability and higher oil intensity, we need another policy approach. In the next chapter, we will develop a proposition by combining the benefits of the hitherto discussed measures. In particular, critical points will be taken into account in order to keep them out of the policy design.

6 An Economically Stable Way Out of Fossil Energies

To sum up, each of the previously presented policy proposals has its advantages and disadvantages. Financial market regulation by laws aims at determining, for instance, speculative traders' futures positions or a tax that prevents the price to deviate from its fundamental value. This presumes knowledge of the fundamental part of a price, which we suppose being impossible. Hence, legal regulation does not necessarily bring stable market conditions in contrast to what is intended. A constructive solution thus should be independent of the information of the fundamental and the financial market components of the oil price.

Using the strategic petroleum reserve to intervene in the oil market in the presence of speculative activities is effective but features similar drawbacks. Intervention may be overshooting, so that it decreases the oil price to a level lower than implied by fundamentals. The purpose to stabilize the oil price at its 'true' value suffers missing knowledge of what this 'true' value is.

Setting oil supply targets to reduce the (absolute or relative) importance of petroleum in the economy is effective. But while it is able to fulfill the ecological goal, the achievement of this goal comes at the cost of additional price instability, which harms the rest of the economy by increasing uncertainty. Price regulation seems to be more in favour of stability than quantity regulation.

A tax on crude oil production satisfies the requirement of focusing on the oil price instead of quantities. However, by just adding another charge to the previous production costs, it does not affect the oil price evolution, which is itself driven by fundamental as well as speculative developments. The impact of monetary policy on the crude oil market thus remains the same as analyzed in the preceding chapters. Hence, a tax has an ecological effect but does not contribute to economic and financial stability. Price regulation should be implemented in a way that it effectively reduces price volatility.

By means of our theoretical and empirical analysis, we identified a lasting effect of speculation in the crude oil futures market on the oil spot market. Most policy answers of those authors who recognize such effects aim at ruling out any monetary policy and financial markets effect on economic fundamentals (see for example Davidson, 2008; Staritz & Küblböck, 2013). To circumvent the disadvantages of the policy responses, we choose just the opposite way: instead of ruling out the impact of monetary policy and financial markets, we employ a system that is able to *make use* of this mechanism as a tool to achieve a better economic result to provide financial and economic stability as well as ecological sustainability.

What we propose in the following is an approach of macroeconomic governance implying an appropriate coordination of monetary and fiscal policy. General propositions of this type of economic governance are, for instance, provided by Arestis (2015), Arestis and Sawyer (2004), Asensio (2007), Hein and Truger (2011, pp. 214–216). The difference to our case consists in the fact that these general approaches usually focus on total output and the general price level, while we are concerned with oil quantities and the particular price of crude oil, respectively. Even though this policy is only concerned with a specific market instead of the total economy, the methodology is still macroeconomic as it relies on macroeconomic principles of monetary and fiscal policy.

6.1 The Basic Framework

Achieving economic and financial stability requires a stable price of crude oil. One may argue that instead of a stable price, oil quantities should be stable in order to have stable overall economic conditions. However, considering the crude oil market as a market that (once the supply constraint is given) is determined by demand from the rest of the economy reveals that the latter requires a stable oil price. Once the price is fixed, growth in the non-oil economy determines the amount of crude oil purchased at this price. Fixing the quantity first would lead to strongly rising prices in times of high demand and thereby lead to volatile production costs and consumer prices, which again affect demand conditions. Instability would be enhanced.

Let us therefore simply argue that the oil price is determined by policy. The oil price thus becomes exogenous and the oil industry as well as the rest of the economy align production and consumption, respectively, with it. With respect to financial markets, oil futures speculation may occur but cannot have an effect on the oil price anymore. This allows stable conditions in the economy: supply and demand follow long-run patterns and so does investment in the oil industry. Overinvestment does not occur anymore. Since there is no oil price risk, speculative activity in the futures market becomes meaningless and hence no leverage should build up. A price bubble cannot take place anymore due to price exogeneity. This may seem quite radical. However, the debate on whether policy should let asset prices float freely or target them is quite intensive and, besides of *laissez-faire* stances, numerous tools are proposed to affect asset prices (see for instance Bernanke & Gertler, 2001; Brittan, 2009; Palley, 2003; Williamson, 2009).

With respect to the ecological issue, the question of the right price has to be taken up again. Pure science does not provide a result of what the correct price is, since we cannot distinguish the fundamental and the financial market components of the oil price. The price is thus subject to political considerations. In order to reduce pollution, petroleum consumption has to decrease. Therefore, the price should be high. Hence, in addition to the idea of just fixing the price, we may as well say that policy decides to raise the oil price step by step in a transparent manner. Stability is guaranteed, since the price increase takes place smoothly and all actors in the market are aware of the future price development. There is thus a strong incentive for oil consumers to invest in energy efficiency and renewable energy sources. The long-term increase of the oil price guarantees that these technologies remain competitive and become even more so. Logically, a high oil price usually gives rise to increasing oil production. How overproduction can be prevented is emphasized below. Moreover, naturally, it is not inevitable for policy to raise the oil price forever. In contrast, it can define a price level that is considered as appropriate, lead the oil price smoothly to this level, and park it there.

The next two questions suggesting themselves are those about which institution determines the oil price exogenously and how it can be implemented. To address the former, we briefly go back to our theoretical and empirical analysis. We argued that monetary policy affects the crude oil market through both the real economy and financial markets, giving rise to an influence of speculation on the oil price. The central bank is in a dilemma: it may be in a situation where it is necessary to cut the interest rate target in order to stimulate investment behaviour and credit creation. However, credit is not only granted for the purpose of real production and consumption but as well to invest in financial markets, including the crude oil futures market. A speculative bubble with the corresponding harmful effects on the crude oil market is likely to build up. To address both issues, that is, business-cycle development and futures-market evolution, it is not sufficient to have only one instrument in the form of interest rate manipulation at hand. An additional goal, to wit, oil price stability, requires an additional tool for monetary policy.

The basic idea how the oil price target can be realized is provided by Davidson (2008): the political authority intervenes in the crude oil market by selling oil to lower its price and purchasing oil to raise it. However, as argued before, trading in the spot market with physical oil requires large efforts, since storage capacity is needed and transport has to be organized. Moreover, trading physical oil takes more time and thus impedes fine-tuning, which is necessary to meet the price target. It is therefore more appropriate to intervene in the futures market by purchasing and selling oil futures contracts (see for example Nissanke, 2011, pp. 54–56; Nissanke & Kuleshov, 2012, p. 35). Like this, action can be taken faster and much more flexibly. As our theoretical analysis around Figure 2.2 shows, spot and futures prices of crude oil use to be the same beside of partial effects that lead to very small and often only temporary differentials. For policy to be effective, there is hence no disadvantage if it intervenes in the futures market instead of the spot market.

The principle mechanism of how the price can be determined is as follows. The central bank offers to purchase all crude oil futures contracts at the price it has set as a target. There are arbitrage opportunities neither for producers nor for consumers nor financial investors. For instance, if producers wish a higher price than the one set by monetary policy, they may try to sell their oil either in the spot market or in the futures market for a higher price. However, this is not attractive for any buyer, since a futures contract – and hence the quantity of physical oil that is represented by a contract – can be purchased at the targeted price from another producer who is indifferent between selling it to the central bank or to anybody else. Or, as another example, if an investor tries to go long at a lower price in order to benefit from a higher price differential when the contract matures, she does not find any supplier going short. The party on the short side prefers to deal with the central bank or any other trader who accepts a contract at the price target.

When the discussion concerns monetary policy and asset prices, usually it is not about targeting by direct intervention in financial markets. Rather micro- and macroprudential measures applied to bank balance sheets are proposed (see for instance Canuto & Cavallari, 2013; Palley, 2003). Yet, targeting the oil price by futures market intervention is not a completely new approach. Since the abolition of the Bretton Woods system of fixed exchange rates, targeting the exchange rate of the own currency has been widely adopted by central banks and is still subject to ongoing debates (see for instance Engel, 2010). The motives, specifically those concerning the short and medium run, are similar to those in our case: exchange rates fluctuations may lead to financial instability and encourage speculative behaviour (Filardo et al., 2011, pp. 38–40). By purchasing and selling currency reserves in the foreign exchange markets, the exchange rates can be influenced. Without judging these monetary policy objectives, they show that the approach of oil price targeting can be embedded in already existing frameworks.[41]

It is justified to ask if there is no threat of speculative attacks of financial investors who purchase futures contracts to push the oil price beyond the target. This aspect shows another weakness of Davidson's (2008) proposal of using the strategic petroleum reserve. Once the reserve is running short, the government administration runs out of its possibilities. In the case of intervention in the futures market, it is easier for the central bank to accumulate a greater stock of futures long positions, which it can use to counteract price effects of financial investment. Once these positions are reduced to zero, the monetary authority can even go short for a while to lower the oil price further. Of course, the central bank is not interested in neither purchasing nor selling crude oil. Hence, all positions must be offset later or rolled over to contracts of longer-lasting maturity. Thus, given a situation where the central bank holds net short positions, evening them up with long positions tends to raise the oil price again and thus benefits financial investors who just want the oil price to increase. However, the central bank is able to affect the oil price specifically and thereby can prevent investors' profits or even inflict them a loss. Such short-run threats allow the central bank to frighten financial investors of attacking. It now becomes clear why it must be monetary policy to take the task of targeting and determining the oil price: the central bank is the only institution that has unlimited means to act in the crude oil market. Therefore, it is the only institution to make credible threats and hence to guarantee the realization of the target. This is a crucial difference to the use of the strategic petroleum reserve proposed by Davidson (2008).

Naturally, this approach, as it is outlined until now, distorts allocation of resources seriously, since the oil price does not react to changes in supply and demand anymore, be it in the spot or futures market. If the oil price is raised by exogenous monetary policy action, demand decreases while supply reacts, in a quite conventional way, by rising investment and growing oil production. However, the oil price does not fall by ways of the hitherto known feedback mechanism. Oil producers always have a final demander for futures contracts, that is, the central bank. On the other hand, the only way for the central bank to keep up the price at its targeted level is by purchasing an ever increasing amount of futures contracts. Since it does not want to accumulate inventories of physical oil, it has to roll over all contracts. A contract specifies the deliv-

[41] There is an intensive debate beyond simple exchange rate pegging that aims at fixing exchange rates institutionally by an international clearing union (see for instance Gnos, 2006; Keynes, 1980; Rossi, 2006a, 2015; Wray, 2006). Hence, asset price targeting by monetary policy intervention is incorporated within active research and thus far from being an extraordinary proposition.

ery of crude oil at a predetermined date in the future, implying that it is still unsold in the present moment. Hence, stocks then build up with oil producers. They raise oil production in response to the rising oil price and thereby accumulate inventories correspondingly. Consequently, the amount of futures long positions held by the central bank has to increase proportionally. A high volume of inventories would, in normal circumstances and in the medium to long run (assuming financial market effects away), press the oil price down, since it makes the supply side of the market less tight. The only way to prevent a decrease in the price is by raising demand for these inventories. This takes place in the form of the futures contracts purchased by the central bank, which define a claim on those oil stocks.

Inventory building may be mitigated once producers get confidence concerning the path of the oil price pursued by the monetary authority. Being aware that the central bank will never want to settle the claim on oil inventories, they might just reduce capacity utilization to save carrying costs but nevertheless contract with the central bank on the short side. Even though physical stocks are then at a lower level, oil producers are still ready to raise supply physically at the given price level if demanded physically. Hence, inventories still have the same down-pressing impact on the oil price. Monetary policy still has to intervene increasingly in the futures market. The danger of an ever-growing imbalance is thus identified: there is overproduction, which only occurs because the monetary authority subsidizes crude oil by purchasing it at the price it determines exogenously. The problem has to be met by an additional political measure.

Raising the oil price serves the purpose of reducing final oil consumption. However, owing to the relaxation of the supply side in response to oil price growth, we end up with overproduction. Therefore, we are back to the initial reflections in this chapter, where the question of the optimal price was asked. A continuous increase in the oil price is ecologically sustainable from the demand point of view but brings unintended consequences on the supply side. In order to decrease the oil intensity in the long run, a policy is needed that decreases oil consumption as well as oil production. There is a way to achieve this: if oil production is charged with a tax, production costs increase and the oil supply curve shifts upwards or, respectively, to the left. At a given oil price, oil supply is lower than it would be without the tax. Except in the very short run where the supply curve is vertical, the tax is effective in influencing the supply side in the pursued direction whether the supply curve is upward sloping or horizontal in the medium to long run.

Yet, some drawbacks of an energy tax have been outlined above. The principal one is that a tax does not rule out speculative influences on the oil price and hence does not contribute to price stability. In our proposal, however, we can eliminate these shortcomings if we combine the tax with the price target. The cooperation of monetary and fiscal policy becomes the central issue. The tax has to be set in a way that it matches the difference between pre-tax oil production and oil consumption. To put it analogously, the tax should be imposed so that it avoids the accumulation of inventories. Such a system prevents the central bank from being obliged to purchase crude oil futures in an ever increasing volume. The challenge consists of the optimal calculation of the tax rate. Clearly, it has to be flexible over time to account for shocks occurring in the crude oil market. The level of the tax should be aligned with the evolution of oil inventories. When oil inventories increase, oil production is too high with respect to demand at the given price, implying that the existing tax level is too low. Conversely, when oil stocks decline, the tax is too high, because demand is larger than production at the given price. In the following period, the tax should be adapted in the corresponding direction.

In practice, however, oil inventories are inappropriate to be taken as the target variable that determines how the level of the tax should be set. As discussed in several places above, inventories are quite difficult to measure owing to unsatisfying data availability. Raising data would take time, so that they would only be available with considerable time delay. Moreover, inventories do not necessarily need to evolve as suggested by neoclassical theory. There is no reason why production capacities should be used fully or at least at a constant rate, respectively. If it becomes clear that the central bank rolls over all futures contract and does not have an interest in possessing crude oil physically, oil producers may reduce capacity utilization. Stocks do not accumulate at a speed at which they would in the case of constant capacity utilization, but the problem of overcapacities that put downward pressure on the oil price would remain.

It is therefore much more adequate to use crude oil futures held by the central bank as the variable that is to be targeted. They are the relevant issue, since they reflect the state of the crude oil market better than oil inventories: their level incorporates the states of, both registered and unnoticed, inventory accumulation as well as capacity utilization. Moreover, they are of broader public interest, since it is their amount that determines to which extent oil price targeting leads to a subsidy of private oil producers. When the tax is too high, demand is higher than production at the given price level, so that the central bank has to go net short in order to prevent the oil price from rising higher than the target. In an analogous way, when the tax is too low, production is higher than demand and hence monetary policy has to purchase futures long positions in order for the oil price to be kept at the target level so that it does not fall below it. This action guide for the central bank may appear as just the same as if oil inventories were targeted directly. But beside of the drawbacks of oil stock data owing to data quality and capacity utilization, targeting oil futures instead of oil inventories has an additional crucial advantage for practical use: futures data feature much less time lags, since trade in futures market is even reported in high-frequency data (although the latter is, yet, not necessary for the implementation of the price targeting system we advocate here).

There is another advantage that makes this policy proposal practicable. It is reasonable that the oil supply curve is either rising or horizontal in the middle to the long run, while the demand curve is falling over the same time span. However, neither do we know the exact slopes nor are they constant over time. Specifically in the short run, the curves can basically have any slope, leading to radically indeterminate outcomes (see for instance Pilkington, 2013; Varoufakis et al., 2011, pp. 294–298). Investigating the crude oil market in this respect would require hard econometric analysis with probably unprecise results. However, radical indeterminacy or, respectively, radical uncertainty of the crude oil market is not a threat to oil price targeting, because it is already incorporated in the amount of futures contracts that the central bank has to purchase. Assume that a specific event leads to an increase in precautionary demand of consumers who expect the crude oil price to climb in the future. Inventories decrease (or capacity utilization increases) and the amount of futures contracts that oil producers deal with the central bank declines. Oil producers may react by keeping crude oil from the market to raise the price further. The monetary authority then has to counteract by raising its short positions so that the oil price does not exceed the target. Net long positions therefore fall. Analogous shifts occur with changes in fundamentals, be it a technology shock raising supply or accelerating economic growth that leads to higher demand. In all cases, the changes are reflected in the account of central bank futures holdings. Every time such an event takes place, monetary policy has to defend the price target by trading futures contracts in the first step. In the second step, it has to change the tax on oil production so that the account of futures can be kept constant. Of course, futures holdings are allowed to fluctuate over time, since, owing to uncertainty, it is not possible to assess the tax perfectly so that the central bank does not have to intervene in the futures market anymore. Yet, this is not a grave problem, since the central bank has unlimited purchasing power and can afford fluctuation in futures positions. It is in the middle to the long run that futures holdings should be constant in order for the crude oil spot market not to become structurally imbalanced. Such intervention is possible without the knowledge of elasticities and short-run and long-run dynamics in the crude oil market.

This system can briefly be described by saying that the price target is the exogenous variable while the tax is set exogenously as well but has an endogenous meaning, because its optimal size is determined by other market forces. One may argue that it is the tax that has the crucial impact on the price rather than trading with futures contracts by the central bank, because contracts do not increase in the long run and therefore cannot have an effect on the price. This is basically true. However, our approach requires the proceeding described here. It is price targeting and futures trading that guarantee a smooth price and thereby economic and financial stability at first instance. At second instance, it is the tax on oil production that rebalances the oil market. If only a tax were imposed, the oil price would fluctuate as without any political intervention and there would be no hint of the level at which the tax rate should be set.

This two-stage implementation of the oil price targeting system outlines the political organization necessary for it. First, it is monetary policy that sets and realizes the oil price target. It observes the level of oil futures contracts in its account and hence provides an advice of the level at which the oil production tax should be set. Second, fiscal policy implements the tax at the proposed level.

An additional issue concerns the question whether the oil price targeting system affects the other goals of monetary policy negatively. A steadily rising oil price passes through to inflation even though the estimated effect is found to be limited and to have decreased in past decades (see for instance Cavallo, 2008; Cecchetti & Moessner, 2008; Chen, 2009). Nonetheless, one might fear increasing inflation owing to this policy proposition. However, given that price changes from year to year are moderate, the impact on inflation rates is even more so. All in all, oil price targeting may even yield a benefit for monetary policy. Firstly, even though the oil price increases, it does so in a smooth way. In contrast to the volatile oil price pattern until today, which has a corresponding effect on fluctuations in inflation rates, oil price targeting may slightly increase the average rate of inflation but reduces inflation rates volatility. Moreover, of course, the oil price does not necessarily have to rise forever. Once an appropriate level is reached, the price can be parked there. A constant and stable oil price then definitively does not accelerate inflation. To sum up, oil price targeting affects inflation targeting to the extent that the former creates an 'oil price transmission channel', which transmits monetary policy action to the general price level. Its importance is an empirical question that suggests it to be quite limited. On the other hand, the oil price transmission channel may from time to time even be a useful tool for monetary policy to stabilize inflation rates.

Further concerns may arise pointing at the fear of inflation in the course of rising money supply owing to futures purchases. This is the monetarist idea that growing money feeds more or less directly into higher prices (see for instance Mishkin, 2006, pp. 2–4). Yet, money is still endogenous. The central bank does not raise money supply by its own force, which then leads to a rise in the general price level. Rather, it sets the oil price target. At this level, the quantity of money is a result of the number of futures traded with the monetary policy. To be exact, the largest part of the purchasing power created by futures trades does not take the form of official money but rather of a large leverage, as explained in our theoretical analysis. Moreover, since the futures account of the central bank is targeted to be stable, there is no rising quantity of money by an ever increasing number of contracts to be expected. Money demand increases to the extent that more money is needed to make transactions with crude oil that is now more expensive. Still, money is the result rather than the cause (in this regard, see Davidson & Weintraub, 1973). Hence, any influence of the oil price targeting system on inflation is given by the changed and smoothed price pattern of crude oil. Monetary concerns are misconceived.

For the balance sheet of the central bank, there is no risk of loss that the public is charged with. If the tax on oil production is set adequately, the account of crude oil futures at the central bank does not increase in the medium and long term, so that no systematic asset price risk emerges. If anything, there is a benefit for the central bank, because once the number of futures can be kept more or less constant, the rising price of each futures long position yields a return. For a volume of positions sufficiently low, they could even be liquidated without having a lasting impact on the oil price.

It should not be denied that a rising oil price is a challenge for many industries as they need to change production technologies and sometimes even have to develop new ones. However, tax revenue may be redistributed so that the tax is neutral with respect to production cost from a macroeconomic point of view. Importantly, if the redistributed tax fund is not earmarked, it must not directly flow to oil producers in proportion to their output. This would give them an incentive to increase crude oil production as much as possible, since their income from tax distribution would grow accordingly. The tax would lose its impact. Yet, if redistribution is proportional to oil companies' size, the funds should be earmarked in the sense that it must be used for the development and production of sustainable technologies or the exploration of renewable energy sources to avoid any moral hazard.

6.2 Oil Price Targeting in the SFC Model

After having outlined the basic working of the oil price targeting system, the use of our SFC model helps to look at it in some more detail. The model is taken in the same form containing the crude oil market with integrated spot and futures markets, the effects of monetary policy and financial investment as well as real investment in the oil industry. Step by step, it is modified and slightly extended to introduce the oil price targeting system.[42] First, the futures price target of the central bank is defined as an exogenous variable. Since the central bank has unlimited capacity to reach its target by trading crude oil futures, the target can be set equal with the actual futures price.

$$p_{fut} = p_{fut,target} \tag{6.1}$$

Naturally, this is a simplification since, in practice, the monetary authority may fall short of reaching the target in the very short run owing to erratic fluctuations. However, by appropriate reaction, the central bank can approach the target.

Oil producers' profits are now diminished by the production tax imposed on them.[43] Production profit equation (4.8) is thus modified in the following way:

$$PP_P = Y - C_d - W_d - r_{-1} * L_{P,-1} - T \tag{4.8'}$$

where T is the total sum of the tax paid by producers. Since the tax lowers profits, future profit expectations are as well downgraded, which reduces expenditures for real investment. The latter can also be negative, thereby representing the shutdown of production facilities. The resulting shrink in the capital stock implies reduced production capacities. The oil price rises in response. This reaction chain is already contained previously in the model. An additional and more immediate price-rising effect of the tax takes place through increasing production cost. We model this fact by adapting model equation (4.16) to become as follows:

$$p_{fut} = \frac{\delta_4 + \delta_5 * \left(F_L^{tot} + C_{oil,d}\right) + \delta_8 * T}{\delta_6 * K_{-1}} \tag{4.16'}$$

Equation (4.16') shows that the higher the tax, the higher is the price. δ_8 determines the extent to which the tax affects production costs. There could as well be the spot

[42] For an overview of the model modification, see Appendix II.

[43] On the other hand, the rising oil price targeted by the central bank affects profits positively.

price on the left-hand side of the equation instead of the futures price. However, since equation (4.16), and hence equation (4.16') as well, represents the integration of the spot and futures market, and since we had set both prices equal in equation (4.15), this does not matter. As another modification, F_L has become F_L^{tot}. Before, private financial investors were assumed to be the only actors to go long in the futures market. Under the oil price targeting regime, the central bank becomes a futures dealer, too. Yet, what is relevant is not only speculators' positions but rather all long positions in the market, that is, F_L^{tot}, because all futures have the same effect on the price.

Now, the futures price is defined endogenously twice, that is, in equations (6.1) and (4.16'). Since the futures price is given by the realization of the exogenous price target, it enters equation (4.16') as a predetermined variable. The variable that is determined endogenously in this latter equation is total futures positions. Reformulation yields:

$$F_L^{tot} = \frac{p_{fut}{*}\delta_6{*}K_{-1} - \delta_4 - \delta_8{*}T}{\delta_5} - C_{oil,d} \qquad (4.16'')$$

The intuition is now in line with the above argument: the higher the price (which corresponds to the price target), the larger the volume of total futures positions has to be *ceteris paribus*, so that a lower spot oil demand, $C_{oil,d}$, does not pull the oil price down. However, there are counteracting effects. First, a higher capital stock requires even larger futures positions, since overcapacities put downward pressure on the oil price. Second, the tax on crude oil production works in the opposite direction. The higher the tax, the stronger is the supply constraint in the spot market and the stronger is upward pressure on the price. Consequently, the less demand for crude oil futures is required for the oil price to stay at the targeted level.

The fact that there are now two different types of futures contract traders, to wit, private financial investors and the central bank, presupposes two other simple adjustments in the model. On the one hand, (4.17) concerns now not total futures long positions but only those of private financial investors, F_L^I. This is only an adaptation of denomination. On the other hand, total futures long positions are composed, naturally, by private financial investors' and central bank exposures. Central bank positions are therefore calculated as the difference between total and private positions:

$$F_L^I = \frac{M_I}{m{*}p_{fut,-1}} \qquad (4.17')$$

$$F_L^{CB} = F_L^{tot} - F_L^I \qquad (6.2)$$

The maintenance margin that the central bank has to pay, assuming that it participates as a conventional trader without any privileges in the futures market, is then simply given by the multiplication of the rate of margin requirement with the price level (to which the requirement rate is related) and with the volume of futures positions. It is analogous to equation (4.17'), but reformulated. Furthermore, total maintenance margins deposited with the banking system to which, to remind, we assume the futures market clearing house to belong, is the sum of financial investors' and the central bank's margin:

$$M_{CB} = m{*}p_{fut,-1}{*}F_L^{CB} \tag{6.3}$$

$$M_B = M_I + M_{CB} \tag{4.31'}$$

Equations (4.16'') and (6.2) show that the central bank is ready to step in and buy the amount of futures necessary so that the total of contracts in the market is such that the futures price matches the targeted level. The tax now should be set so that the central bank does not have to go excessively net long or net short to realize the oil price target. Moreover, for practicability, the monetary authority should be able to derive the level of the tax by means of reliable and observable indicators. In the model, we define the tax to depend on two indicators, namely the oil price target and the central bank futures positions:

$$T = i{*}(\tau_0 + \tau_1{*}(p_{fut,target} - 2) + \tau_2{*}(p_{fut,target} - p_{fut,target,-1}) + \tau_3{*}(F_L^{CB} - F_L^{CB,target})) \tag{6.4}$$

where i is a policy dummy that takes the value 0 before the oil targeting system is introduced and the value 1 thereafter. τ_1 measures the importance of the level of the price target for the tax to be set. The number 2 signifies the crude oil price before policy intervention. Hence, the numerical value does not have any further meaning but is just given by model calibration. τ_2 reflects the impact of a change in the price level. And finally, τ_3 shows how much the tax should increase (decrease) if the central bank futures account increases (decreases) as the result of the defense of the price target. Here, the central bank may define another target concerning the amount of futures holdings. It might be set to zero, implying that the central bank adjusts the tax in a way that it approaches zero futures holdings. However, it might be better to target a position level above zero, that is, net long. Like this, the central bank has a larger range within which it can act. It then has the possibility to have a lowering impact on the oil price in a given moment without having to go net short. While the first two terms of equation (6.4) represent the basic pattern that the tax has to follow in the face of a rising price, the third term is the short-run guide to monetary policy. It incorporates fundamental and other shocks that affect the oil market and thus crystallize in the central bank futures account.

Obviously, equation (6.4) resembles a kind of Taylor rule (see Taylor, 1993). Indeed, in order to model the behaviour of the central bank, such a mechanic formula is inevitable. This is necessary, on the one hand, because every model requires simplification to be a model. And it is possible, on the other hand, since once model parameters are given, every shock of the same type and the same magnitude has the same effect. In reality, however, the impacts of shocks differ depending on specific historical circumstances. A fixed formula may therefore be helpful in one moment but inappropriate in another. The critique of the Taylor rule (see for instance Rochon, 2004) applies to equation (6.4), too. It should therefore just be seen as a model equation rather than as a reliable monetary policy rule. Reality is too complex in order for the central bank to always respond in the same way to changes in its futures account. By contrast, every adjustment of the oil production tax requires a single judgment. We will see that even in the model, different shocks have different optimal reaction equations. It is, then, more useful to adapt the determining formula of the tax according to requirements than to focus on the same parameters, as if it were an eternal rule. This is what monetary authorities would do as well.

The final equation is basically not necessary, because the working of the crude oil price targeting system can already be shown with the preceding modifications. But to make it more realistic, we adjust equation (4.18) that represents the behaviour of financial investors. Namely, we assume that speculators observe the targeted price pattern communicated by the central bank and build expectations about future oil price changes. They do this now in a much more direct way than if there were no exogenous price setting. The equation thus takes the form

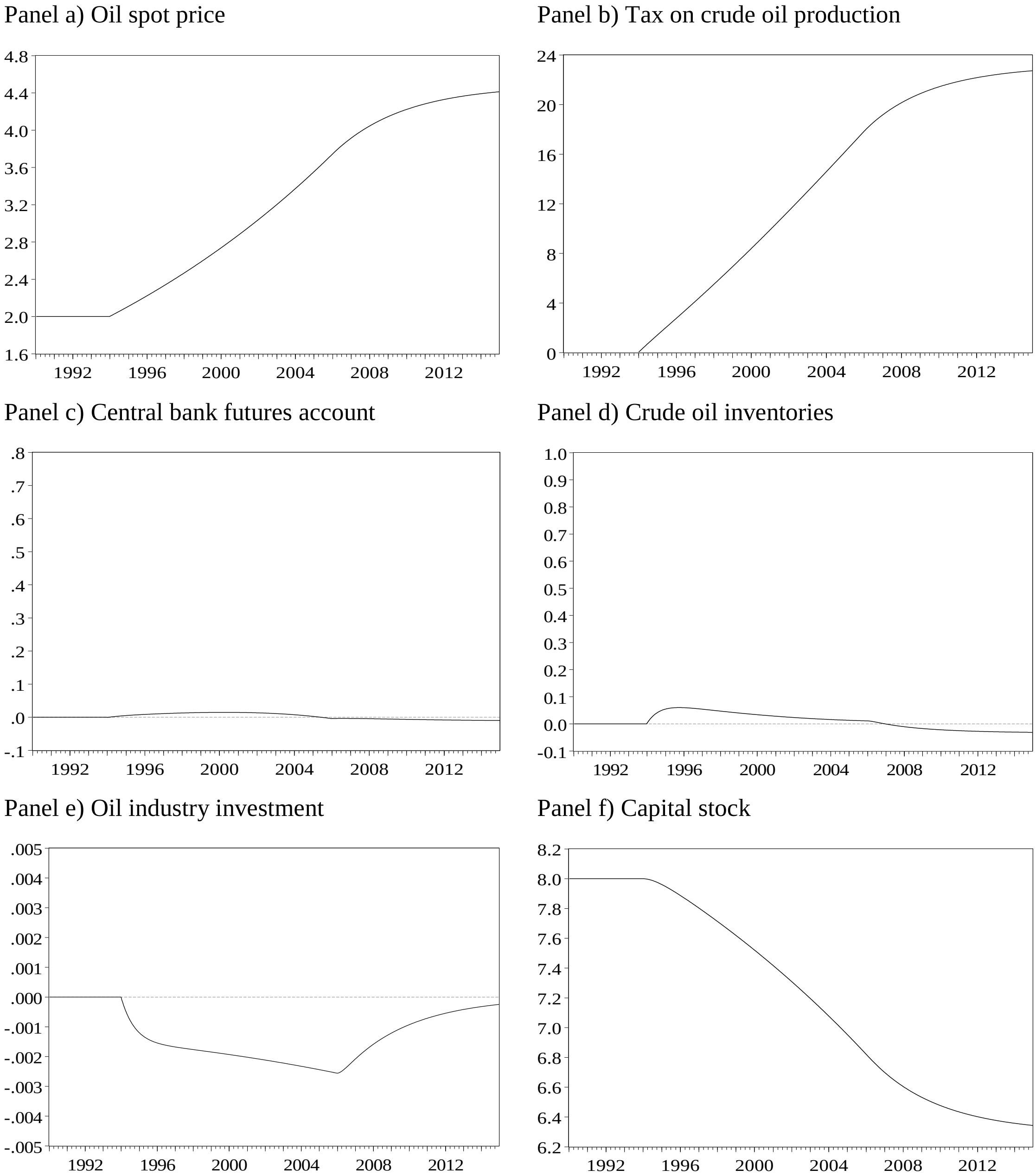
$$\Delta M_I = \frac{\beta_0 + \beta_1 * FP_I^e - \beta_2 * r + \beta_5 * (p_{spot}^e - p_{spot,-1})}{1 + \beta_3 * L_I^2} \qquad (4.18'')$$

showing that futures market investment of financial investors now depends as well on the expected oil price change. The higher the expected oil price, the more capital speculators invest in futures contracts. Remember that M_I still depends on many other variables, that is, past profit performance, the interest rate, and risk exposure.

The running of the model takes again place in the arbitrarily chosen time span from 1990 until 2014 at weekly frequency. Again, the crude oil market is constructed to be in an equilibrium initially, meaning that there is no speculative movement and the oil price is stable. Assume now that the central bank decides to target the crude oil price from the beginning of 1994 onwards. It raises the crude oil price by 0.1 percent in each period until end 2005. Thereafter, the price increase flattens and slowly converges to a new level. Meanwhile, the tax on oil production is needed to keep the oil market in balance. The targeted level of the futures account, $F_L^{CB,target}$, is assumed to be zero for now. Figure 6.1 shows the consequences for a set of variables. Again, the numerical values originate from model calibration and are arbitrary. The pattern of the oil price in panel a) shows that the total price increase amounts to about 120 percent. This may seem extreme. But a doubling of the oil price within 17 years is not at all unrealistic. In contrast, history has featured much stronger price changes. Panel b) exhibits the path of the tax on oil production, which goes straightly upwards. It is just in line with what is expected from the preceding draft of the system. In panel c), the central bank futures account shows that the tax is effective: it allows the central bank to target the oil price and to keep the account of futures positions quite stable at the same time. Note that futures are not exactly equal to zero. This shows that even in a theoretical model short-run fluctuations have to be accepted. However, they are quite small and move closely around zero. Panel c) can be set in relation to panel a) of Figure 4.1, where the effect of a change in the interest rate on futures market speculation is shown. The amount of futures held by financial investors is a multiple of what the central bank has to trade to meet the oil price target. An analogous result is exhibited by crude oil inventories in panel d). They fluctuate around zero (which we have to read as a change in relation to initial stock holdings rather than positive and negative stocks in absolute numbers). Again, they are quite small compared to the amount of inventories accumulated in the face of speculation in the crude oil futures market (see Figures 4.28 and 4.29).

The further reaching effects of the oil price targeting system that occur on the supply side of the crude oil market are presented in panels e) and f) of Figure 6.1. Investment behaviour in panel e) is in accordance with theoretical predictions. Deteriorated profit perspectives lead to disinvestment, that is, shutdown of drilling wells and other production facilities. Once the oil price target grows at a diminishing rate, disinvestment slows down as well and approaches zero again. As a consequence, the capital stock in panel f) that represents the state of production capacities drops first and then converges to a new and lower level.

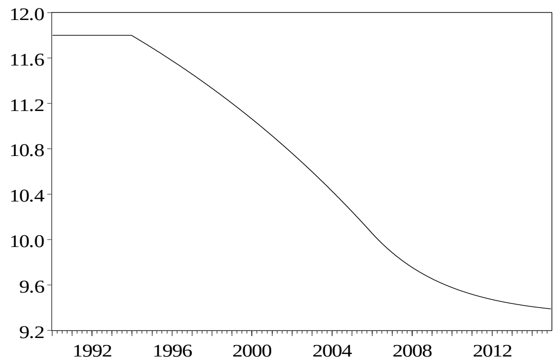
Figure 6.1 Effect of an increasing oil price target



Source: author's elaboration.

The model shows how financial and price stability can be achieved without creating imbalances. To see how the ecological purpose is affected, we look at the final indicator, that is, crude oil consumption in Figure 6.2. It decreases smoothly and then converges to a lower level. Thereby, a smooth pattern is given for the economy to move out of fossil fuel dependence. Analogous to the supply side of the oil spot market, the demand side faces a stable long-run price pattern. There is no reason for precautionary oil purchases by consumers since there is no price uncertainty. They may want to make large purchases when the oil price is still low. But the profitability of such strategies is quite low as storage is costly, storage capacities are limited, and the price increase, which is a condition for precautionary purchases to be profitable, is very slow.

Figure 6.2 Effect of an increasing oil price target on crude oil consumption



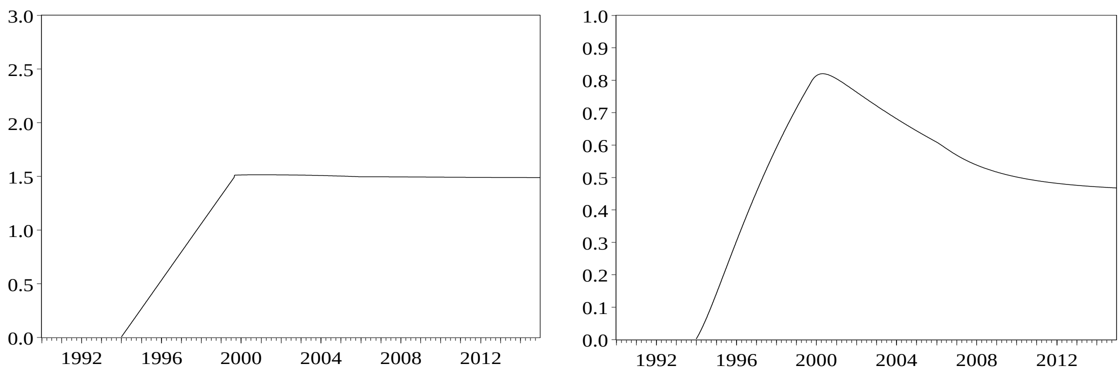
Source: author's elaboration.

Alternatively, the central bank may not aim at holding no futures at all but might rather set a target level above zero in order to have a broader range for short-run intervention. This may be necessary in the case of a speculative price effect that raises the oil price beyond its target. For instance, assume that the target of central bank futures long position holdings, $F_L^{CB,target}$, is growing linearly from 0 to 1.5. This allows the monetary authority to smoothly raise its account without creating short-run distortions. Panel a) in Figure 6.3 reveals that the central bank again is able to hold its futures positions quite close to its target once the latter is reached. This has consequences for oil stocks held by producers. In order for the central bank to raise its futures account, oil supply at the given price must be larger than the sum of demand in the spot market and financial investors' demand in the futures market. It is this gap that the central bank can fill by purchasing futures contracts. The gap can be created by imposing a lower tax on oil production than if the futures target was zero. A lower tax gives rise to higher profits for oil companies. Investment (or disinvestment) is higher (lower) than it would be with a higher tax. This gives rise to partial overproduction and inventory accumulation as shown in panel b). When the targeted level of central bank futures holdings is reached, the tax even overshoots a little owing to time lags in the reaction function. Oil stocks fall back but converge to a positive level that corresponds to the futures account of the central bank. This means that the central bank possesses the claim on these inventories in the form of the futures contracts. If there were developments in either the futures or the spot market that tend to push the crude oil price above the target, the central bank could counteract this threat by selling long positions or by acquiring short positions, respectively. This would raise oil supply and thereby lower the oil price. If the contracts purchased by private traders are not rolled over but settled, inventories would *ceteris paribus* decrease correspondingly. Hence, a reserve in central bank futures holdings is backed by a reserve held by oil producers.

Figure 6.3 Effect of the oil price targeting system when the central bank accumulates futures

Panel a) Central bank futures account

Panel b) Crude oil inventories



Source: author's elaboration.

Until now, the oil price targeting system is tested against the background of a stationary economy without growth, changes in technology or even shortages in supply due to exhausted sources of crude oil. It is, of course, an important issue to investigate how the oil price targeting system can be sustained when there are shocks to economic fundamentals. As an example of such a case, assume that after the oil price target has been set and implemented from 1994 onwards, the economy starts growing in 2000 by 0.0004 percent in a week, which amounts to about an annual growth rate of 2 percent. After 2002, GDP growth decelerates and the economy converges again to stationarity. This is an appropriate way to model a demand shock. The growing variable is again non-oil output, C_s, which approximates total output fairly well. The target of central bank futures holdings is assumed to be zero.

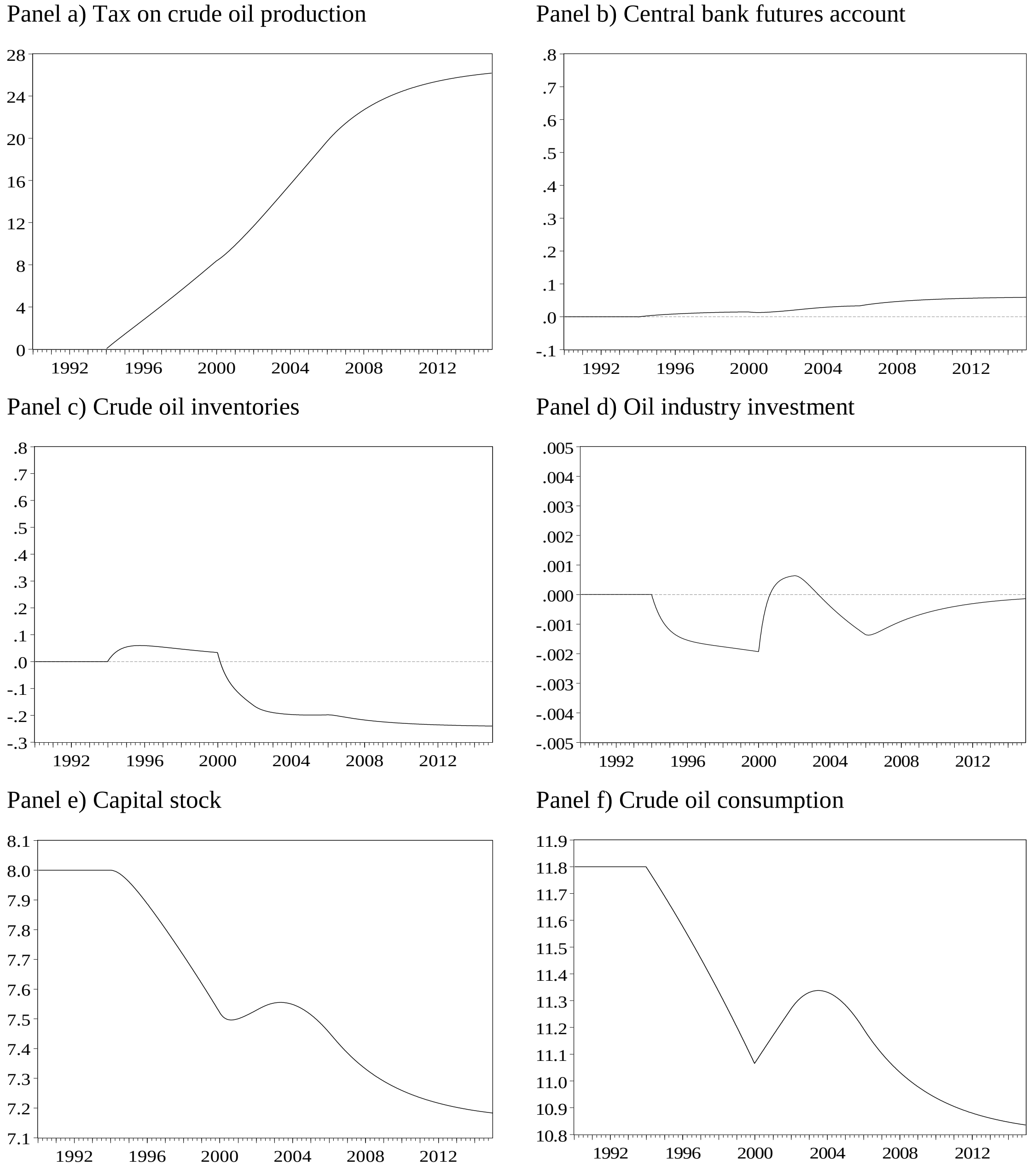
The oil price still follows the same path since the target of the central bank is unchanged. The other variables are shown in Figure 6.4. The tax on oil production in panel a) is slightly lower when the growth period sets in. This can be explained by the price-driving effect of increasing oil demand. If the tax was imposed at a level as if there was no change in fundamentals, oil supply would be constrained further and higher demand would drive the oil price beyond the price target. A relative decline in the tax rate relaxes conditions on the supply side that are necessary to meet additional demand at the given price level. The appropriate tax charge allows for a rather stable central bank futures account in panel b). In contrast to the stationary case, however, it grows a little before it can be kept stable. Even though the outcome is considerably well, time-specific action of the central bank may improve it. Moreover, if the monetary authority targets zero futures holdings, it has to adjust its behaviour. This shows that, in reality, the central bank should not act in the mechanical manner of a reaction function that we are forced to employ in this model. Any kind of Taylor rule is thus too simplistic and therefore not able to keep the oil market balanced in the medium term when different types of shocks occur.

The pattern of inventories in panel c) is now not completely analogous to central bank futures holdings anymore. Before economic growth starts, oil stocks move close to zero and are identical to the stationary case. Thereafter, however, they fall clearly below their initial level. This is not due to a mismatching monetary policy but is rather a result of economic growth: when the oil price starts increasing, production capacities are still the same as in the previous periods. Hence, to satisfy oil demand, inventories have to be released. Even though capacities are increased in response, an observation yet to be explained, the decline in stocks continues. Capacity extension is lagged, so that growing oil demand has to be met by an additional depletion of inventories in every period. Once economic growth converges to zero, inventories tend to stabilize aside from the small and flat variations that were already present in the stationary case.

Panel d) exhibits the seemingly surprising but, in fact, quite reasonable path of oil industry investment. First, investment is negative owing to the increase in the oil price. When the economy starts growing, oil consumption and, therefore, oil sales increase while the price of oil remains at its targeted level or, respectively, grows at its targeted rate. Higher sales against the background of a, *ceteris paribus*, unchanged price means higher profits for oil companies. Taken together, this means that in this phase, the positive effect of economic growth on oil demand is larger than the negative effect of the rising oil price on demand. Hence, production profits increase. Corporations invest and raise production capacities. When GDP growth decelerates, the effect of the oil demand-lowering price rise becomes larger than the demand-driving effect of economic growth. Producers are left over with overcapacities and they start disinvesting. Later, the price target converges to its new stable level and oil investment approximates zero. The same development is mirrored in panel e) with capital stock evolution. It declines owing to falling oil demand caused by oil price targeting. Economic growth causes a temporary re-increase that fades out. The final capital stock is, however, larger than with stationarity since GDP growth leads to a higher final economic output.

Crude oil consumption in panel f) features a rather similar development. Yet, it is less smooth since demand reacts immediately to a change in the oil price or in non-oil output in contrast to investment and capital stock, which change with time delay. It shows that the oil price targeting system does not rule out market mechanisms. Nevertheless, it is able to reach its ecological purpose. Absolute crude oil consumption rises in the course of economic growth. However, over the period of, say, a whole business cycle, it declines. Relative oil consumption, that is, the oil intensity of the economy, decreases continuously over the observed time span.

Figure 6.4 Effect of an increasing oil price target in the presence of economic growth



Source: author's elaboration.

It is important to mention the issue of financial and economic stability. Oil price targeting ensures stable conditions for the rest of the economy in what concerns oil supply. For the oil industry, one may consider fluctuations in inventories, investment, and oil consumption as a sign of instability. First, however, these fluctuations are not caused by policy intervention. They enter the stage whether the oil price is targeted or not. Second, monetary policy can hold the oil price stable according to its target despite shocks to fundamentals. Hence, while both oil consumption and the oil price would vary without intervention, intervention can at least hold the price stable. Thereby, only consumption is left fluctuating. It is true that consumption volatility is greater than otherwise since there is no feedback mechanism from a rising oil price. However, for the non-oil economy, stability is enhanced.

Concerning financial and economic stability within the crude oil market, the oil price targeting system does not allow speculation to have a price effect, so that harmful distortions in crude oil production and consumption are ruled out. There is therefore no reason for financial investors to expose themselves to risks. Economic stability is established as well. Naturally, there are fluctuations in investment behaviour of oil producers. Yet, such investment is just natural, because it is a response to shocks in economic fundamentals. It is investment that corresponds to increased needs by the rest of the economy. Oil produced by thereby created additional capacities serves physical needs of oil. It is the result of resource allocation in a market economy, be it perfect or not. In this sense, such investment is not overinvestment.

6.3 Global Implementation

The hitherto discussion and the SFC model considered a closed economy. Translated to the real world, this implies a global implementation of the oil price targeting system. Indeed, this would be the most effective solution. It requires an international agreement on the design of the system. Oil price targeting is most easily conducted by the US Federal Reserve, because crude oil is mostly traded in US dollars and the best established crude oil futures contract is the WTI Light Sweet Crude Oil (Fattouh, 2011, pp. 54–55). The tax on oil production is directly imposed on oil companies in different countries. If national governments were themselves responsible for tax collection, there would be a moral hazard problem for all countries where oil producers are owned by the state. A higher oil output yields higher tax income. There would thus be an incentive to raise oil production, which would make the tax useless. Hence, there should be an international institution able to impose a tax. Redistribution should be such to compensate oil producing countries – especially developing countries – for escaped benefits. However, as already noted above, it must not create a new moral hazard.[44]

6.4 Implementation within National Borders

Global implementation requires many preconditions, such as the existence of a strong multinational institution. Since important conditions are not fulfilled, the oil price targeting system must be applicable to a single country in order to be viable. Now, it is shown how the system may be drafted for either oil exporting or oil importing countries. Let us start with the case of an oil exporting country. Its central bank determines the oil price by intervention in the futures market. Oil producers at home are taxed at the required rate. Leaving the system like this would raise a twofold problem. First, consumers purchase crude oil from abroad, because the price at home is higher than the international price. The intended reduction in crude oil consumption then cannot be achieved. Yet, at the same time, demand for oil produced in the national economy is immediately zero owing to arbitrage behaviour (if we ignore transportation costs and time lags). This gives rise to economic instability within the crude oil market. Secondly, the oil companies would reduce supply, too, because the tax leads to lower profits and thus disinvestment even if the demand shift did not occur. This is just what is wanted by policy. However, a strong reduction in supply of an oil exporting country has respective consequences for the world market to the extent of the country's importance. The world price of crude oil shoots up, leading to economic instability in the rest of the world. On the one hand, the non-oil economy is concerned. On the other hand, other oil exporting countries would raise oil supply to counteract the oil price increase, so that a strong oil price volatility may be the final result.

For these reasons, a mechanism at the country's border is required to allow for a smooth reduction in oil consumption in the national economy without distorting the world market. The easiest way to do this is the one described above with the oil production tax: when oil is exported, the difference between the home price and the world price should be transferred to oil producers. If so, then the national economy is decoupled from the world market and the oil price targeting system can exert its effects within country borders. Oil consumers are indifferent between purchasing oil at home or abroad while oil producers may export the oil that is not consumed at home at the same conditions like before the introduction of oil price targeting. The remuneration difference again must not be greater than the tax itself. If differences between the

[44] Again, redistributed tax revenues may be used for social security purposes, investment in renewable energy and energy efficiency, and so on.

world and the home price of oil still exist after maximum remuneration, they are due to fundamental differences in oil production costs and, hence, competitiveness. It is not the task of policy intervention to account for them in this case.

Even though a fraction of tax income has to be remunerated owing to exports, net tax income is always equal or larger to zero:

$$T*C_{oil,s} - min(p_{home} - p_{world}; T)*(export - import) \geq 0 \tag{6.9}$$

The tax per barrel of oil produced times oil output yields total gross tax income. The difference between the home price and the world price of oil is usually smaller than the tax per barrel. Otherwise, it is the tax per barrel that can be remunerated at the maximum. For an oil exporting country, oil exports are always larger than oil imports. But net oil exports are usually lower than oil production, since some part of oil is consumed at home. Thus, in practice, tax income is rather strictly than weakly larger than zero. This is important, since additional tax income can be used to support industries that threaten to change their offices and production facilities to other countries where energy costs are lower. Moreover, fairer wealth distribution in society can be achieved by (partial) tax redistribution to consumers (Boyce & Riddle, 2007) and renewable energies as well as energy efficiency may be supported.

In oil importing countries, the oil price targeting system can be introduced, too. Once the central bank of the country has set the oil price target above the world price level, every importer faces an arbitrage opportunity by selling crude oil to the central bank instead of a final consumer. This will last until the crude oil price meets the price target. The tax has to be imposed on crude oil imports to prevent that more and more oil is imported and that the central bank needs to purchase an ever growing amount of crude oil futures in order to keep the oil price at its target. Now, the level of the tax is exclusively determined by the difference between the home price and the world price of oil. Tax income is strictly larger than zero:

$$(p_{home} - p_{world})*(import - export) > 0 \tag{6.10}$$

owing to both factors being greater than zero. Again, tax income might be used to support consumers and the industries most affected by higher energy costs. From now on, when the tax on crude oil production is mentioned, it includes the tax imposed or removed at the country's border according to the needs of the specific country.

Until now, the case seems to be clear that the country described is the United States, because crude oil trade is denominated in US dollars and the most important futures exchange is the NYMEX. If every country in the world or, respectively, every currency area with a central bank should be able to adopt oil price targeting, the system must not depend on the US dollar. A short outlining shows that this policy proposal basically can work with whatever the currency in the country considered is. If there exists no futures market in that country, yet, the central bank can nevertheless contract on future oil deliveries, that is, it can 'issue' futures. Even if the market's liquidity is low, the arbitrage opportunity created by offering a higher price than the existing price level will do its job. The price target can therefore be realized. There are now two possibilities to achieve the purpose. The central bank may trade these futures contracts in its own currency. Oil price targeting and the setting of the tax on crude oil production then has to take changes in the exchange rate of the home currency vis-à-vis the US dollar into account in order to prevent arbitrage exports and imports. Alternatively, the monetary authority may trade the futures in US dollars by using currency reserves.

The concern that foreign oil producers and financial investors may make profitable use of the central bank's intervention activity is unjustified. As for speculators from abroad who are interested in benefitting from price increases generated by the home central bank, the same applies to financial investors originating in the national economy: the higher level of the oil price compared to the world price does not make any difference in this respect. What is relevant for speculative profits is the price change over time, which is given by the central bank. With oil companies that want to contract on the short side with the central bank to be able to sell at a higher price, there is no way to make extra profits, either. Once the contract is fixed at the oil price that the central bank has determined and should be settled, the seller pays the tax when he exports oil to that country. Since the tax is, in this case of interest, exactly equal to the difference between the targeted price and the world price of oil, there is no higher profit for the oil producer than if he would sell it in the rest of the world at the world price.

6.5 Critical Arguments

It is not possible to draw a policy design in great detail in this place. The oil price targeting system is a political idea that requires more elaboration. At this stage, some counterarguments and assumed failures of this approach should nevertheless be addressed. Let us show that they are either misconceived or, if they are justified, how they can be taken into account by modifying the approach.

- *Feasibility:* there is a relationship of power between the central bank and private futures market traders. This is not exceptional but rather usual when monetary policy has to defend a target by direct market intervention. The more credible the central bank can communicate to defend its target, the less potential attacks will be. We already mentioned the case when financial investors try to push the price beyond the target by purchasing futures long positions. The central bank may use its futures reserves and let the price fluctuate. This accrues losses to financial investors who cannot sustain them over a longer period owing to the high leverage contained in futures deals. The central bank should be able to hold off such speculative attacks. However, there is another possibility how the power relationship between the central bank and other agents may become relevant. Imagine that the contracts held by the central bank roll out in a specific moment. Since it has no interest in possessing crude oil physically, the central bank aims at rolling over its long positions. Assume further that neither are the dealers on the short side willing to continue contracting nor is anybody else in the market ready to take over the short positions. The motivation may be that oil producers want to lower their inventories to save storing costs and to realize a profit instead of only having the value of crude oil in its material and illiquid form. Is the central bank now obliged to purchase physical oil and to store it somewhere? It is not, if its power of intervention against such behaviour is sufficient. The central bank may just resell the short positions to another agent in the market. If, as we assume, there is not any consumer or financial investor to buy it at the given price, the monetary authority may simply offer these futures at a slightly lower price. There is now an arbitrage opportunity for traders to purchase the long positions of the futures offered by the central bank instead of those at the otherwise higher market price. The central bank's action lowers the crude oil price market-wide and thereby devaluates all existing inventories held by oil producers. Moreover, future profit prospects are deteriorated should the price development take place at a lower path than it would otherwise. There is, on these grounds, no reason for oil producers to challenge the central bank by not rolling over the futures contracts. On the other hand, to mention it again, it is the task of monetary policy to apply its instruments – price targeting and the tax on crude oil production – appropriately to avoid excessive futures accumulation with the central bank's account.
- *Dealing with speculative waves:* there may be the risk that the central bank runs out of its futures reserves when it has to counteract a speculative wave that pushes the oil price upwards. There are several responses to such a situation. To keep this risk low *a priori*, the oil price target changes from year to year should it not yield more attractive yields than those of the risk-free interest rate, say, the returns of

government bonds. Like this, there is no specific reason to invest in crude oil futures, since the path of the price is determined exogenously and does not yield more than government bonds. This does not mean that the percentage price change has to be exactly equal to the risk-free rate at the maximum. There are transaction costs and market imperfections making arbitrage imperfect as well. In addition, risk-free rates may vary over time, thereby contributing to uncertainty. Furthermore, the development of the crude oil price is not completely risk free. As described just before, the central bank may choose to let the oil price deviate from its target in the short run to hold off financial market price effects. In this respect, it may be useful not to target a single price level but rather a price band within which the oil price is allowed to fluctuate. Going even further, the central bank may set a target but allow for uncommunicated small fluctuations around it. This strategy is related to the concept of 'constructive ambiguity' that is debated in many fields of monetary policy (see for instance Chiu, 2003). In the case that a financial market effect lasts longer time and outlives those counteracting measures, the tax on oil production and the remunerations on exports and imports of oil may be adjusted. In times of an oil price that threatens to be driven upwards by financial investment, the central bank may lower the tax that relaxes supply conditions. Open interest in the futures market increases and since it is driven by supply it helps keep the oil price at its target. All these instruments can be applied quite flexibly and hence should be able to prevent large distortions owing to futures market investors.

- *Strong fundamentals shock:* as a similar scenario, there may be a demand shock in the spot market that is due to strong global economic growth. The central bank may react by lowering the tax and its futures account. However, the shock may be so large that it still continues when all oil reserves are exhausted. This case is unlikely, because the central bank has time to accumulate oil reserves on the one hand. On the other hand, a fundamental shock is now not strengthened by speculation as it would probably be otherwise. But if this scenario realizes nevertheless, the central bank may suspend oil price targeting for a while and only intervene if further price increases are found to be more due to futures market investment than to the real economy. The central bank may re-establish the target in due time. Such partial free floating gives rise to instability. Yet, it is only of a temporary character and just reminds of the volatility that exists without any policy intervention.
- *Substitution of other fossil fuels:* when the oil price increases continuously owing to targeting by monetary policy, oil consumers may easily substitute other energy sources for petroleum. The most important substitutes are, as shown in Figure 1.5,

coal and natural gas, to wit, fossil fuels as well. The goal of pollution reduction is missed. Substitution of natural gas is an ecological improvement while substitution of coal implies an aggravation: the burning of a BTU of petroleum produces more carbon dioxide than that of natural gas but less than that of coal (EIA, 2015a). The cointegrating relationship suggested above does not hold anymore, because the oil price is determined exogenously. However, there are still endogenous responses from the coal and the natural gas markets to changes in the crude oil price. But the reverse does not hold anymore. The solution to this problem lies in an analogous proceeding with coal and gas. Their financial asset forms as futures contracts can be held by the central bank in order to target coal and gas prices. They exist already at present, for instance, at the NYMEX (NYMEX, 2015b).

- *Central bank independence:* there is a great body of literature about central bank independence. The proponents of a high degree of monetary policy independence from governments argue that independence allows central bankers to pursue the goal of price stability without being constrained by other competing purposes (Alesina & Summers, 1993, pp. 151–152). Empirical evidence as to whether independence effectively reduces inflation rates is both found to be positive (see for instance Alesina & Summers, 1993; Cukierman et al., 1992) and negative (see for example Campillo & Miron, 1997). Other authors criticize the concept of central bank independence on theoretical grounds, since it lacks democratic justification. As a consequence, concentration on a single objective ignores the population's welfare, specifically in terms of output growth, employment, and wealth distribution (see for instance Rochon & Rossi, 2006; Rossi, 2009a). In our context, this debate becomes relevant insofar that if the oil price should be targeted, the central bank would be endowed with an additional instrument of economic and political power. From a democratic point of view this is problematic, since it leaves the central bank with a large autonomy of action, which is required by the nature of the oil price targeting system. However, there are ways to deal with this concern as is already done with the conventional tasks of monetary policy. The US Federal Reserve is obliged to pursue the goals of "maximum employment, stable prices and moderate long-term interest rate" (Fed, 2014b). In contrast, the European Central Bank (ECB) is instructed to promote merely one objective of first priority, that is, price stability (ECB, 2015). In addition to the existing goals, the central bank may be endowed with a mandate to target the oil price at a path that is determined by the democratic process. This means that it is politics that decides whether or not to allow for this additional objective in general. In analogy to the other monetary policy objectives, it is important to allow the central bank to act within a certain range in order to react to short-run events once the overall objective is given. Since oil price targeting is a long-term proposition, the mandate given to the central bank should not be restricted by daily short-run issues of the political sphere. The central bank may be endowed with it or not. But once this is decided, the monetary authority should be independent of daily political influences. Central banks that are not guaranteed a sufficient space of free action may have difficulties to implement the oil price targeting system.

- *Credibility:* the oil price targeting system may appear as a contrast to today's theoretical framework and practice of central banks. In fact, it can be implemented in broad complementarity rather than in rivalry to the other objectives of monetary policy. However, monetary policy, as is usually practiced currently, is based on a supply-determined neoclassical background considering money as (more or less strictly) exogenous. This framework is exclusive in the sense that it tends to focus on a single policy objective, that is, price stability (see for instance ECB, 2015). General equilibrium theory suggests that only prices should be affected by monetary policy. Oil price targeting, in contrast, aims at influencing quantities in the crude oil market as well in the long run. As we argue, this additional goal can be pursued by an additional instrument without impeding the inflation targeting policies. Mutual impacts are given interdependencies since the oil price is part of the general price level and hence affects inflation targeting policies. Yet, we suggest those interdependencies to be limited. All in all, to be credible in targeting the oil price, a central bank has to ground its policy on a theoretical framework that incorporates the endogeneity of money. In order to recognize that monetary policy has the power to affect the real economy, the general equilibrium models have to be abandoned.
- *Economic order:* other questions may arise concerning the economic order of a country. A commodity price that is determined by a political authority may have the appearance of central planning from the perspective of some observers. The accusation usually is that "targeting an asset price is tantamount to fixing prices, almost certainly to cause misallocations and dislocations that could destabilize asset markets and perhaps the economy" (Sinai, 2009, p. 15). Yet, the oil price targeting system does not reject resource allocation that is driven by market forces. In general, allocation signals of prices trigger complex reactions. Even though market forces without political intervention do not necessarily yield an optimal final outcome, replacing them by political decisions bears considerable risks and difficulties. Finding an optimal price for all goods in the economy is a task that can be traced back to the debates about the transformation problem, which is concerned of the mere existence of such a price system (see for instance Baumol, 1974; Meek, 1956; Seton, 1957). However, the case of crude oil is different. We

do not claim to have found the optimal price by a scientific proof. Rather, it is found by political considerations. The price should be set so that it gives rise to the optimal quantities of oil production and consumption. In general, this would be hard to find if it was about, for instance, a food commodity. We discussed this above. With crude oil, however, there is a simple political purpose or, respectively, a proposition of environmental science. This reasoning argues for a reduction in oil production and consumption in order to reduce pollution. It is by ecological justification that the oil price should increase in the future and be combined with a tax on crude oil production. All other prices and quantities react correspondingly by adjusting allocation, which is still driven by market forces.

- *Taking account of business cycles:* reducing fossil fuel consumption is an economic, technological, and organizational challenge. In a recession, it may be argued that the burden of the increasing oil price be too heavy. Like this, it might raise costs of production inputs, thereby reducing the share of wages in total output, which finally dampens effective demand. In principle, the central bank may also make the oil price target depend on business cycle conditions. This implies that the oil price is allowed to grow slower, to stagnate, or even to drop to a certain degree in times of a recession. On the other hand, keeping the oil price at its target instead of letting it falling in the course of economic stagnation may be a useful tool for monetary policy. When the economy runs the risk of deflation, targeting the oil price at a moderately growing level may counteract this danger. Owing to transparency in the prospected path of the oil price, even expectations of inflation may be lightened up and thus contribute to a normalization of the changes in the general price level.

Conclusion

The global crude oil market is a multilayer issue. On the one hand, it is a well-integrated market and thus may just represent a textbook model. On the other hand, it includes a financial market component that makes it a complex building with various relationships. The importance of crude oil is given by its share in total energy consumption, which detects it as the key fuel driving the global economy. Disruptions in the crude oil market thus have far-reaching impacts throughout the economy. Likewise, the importance of crude oil as the main fossil energy source makes it a driver of climate change. Understanding the crude oil market is crucial to the implementation of sustainable policies regarding climate change in particular and ecological sustainability in general. The specific interest of this analysis is the impact of monetary policy on the global crude oil market. The insights gained thereby can be used to address the challenges arising from the economic mechanisms identified throughout our investigation.

Allowing monetary policy to have lasting impacts on the economy, which amounts to saying that money is non-neutral, gives rise to complex dynamics. Monetary policy effects exerted in an environment that is recognized to be uncertain open a space for financial speculation to become effective. The financial market aspect of the oil market leads the oil price and oil production and consumption to a different level compared to what they would be in the absence of a futures market.

In Part I of our analysis, after having embedded the crude oil market in its global environment of ecological and natural resource issues, financial speculation, and geopolitical aspects with respect to OPEC, the character of money has been discussed. The nature of money as demand-determined credit money goes along with its non-neutrality. Endogenous money thus admits a potentially significant role to monetary policy. Importantly, the insight that economic dynamics are better grasped by monetary economies of production than by supply-determined economies of exchange requires that the relationships between monetary policy and the oil market is explored through the lens of a monetary analysis. In the same way, we have discussed the role of financial markets if money is either exogenous or endogenous. It has been judged to be more realistic to allow financial asset prices to deviate from their fundamental, unobservable, value than to act on the assumption of the efficient markets hypothesis. Deviation is not motivated theoretically by time lags owing to nominal rigidities. The latter may add to distortions but the fundamental cause is uncertainty, which is especially present in financial markets. Monetary policy has been argued not only to have an impact on investment, production and consumption behaviour, but as well on prices of financial assets. Lower interest rates tend to raise asset prices by influencing liquidity preference and profit expectations of financial investors. Through a change in liquidity preference, monetary policy may have an effect on asset prices even if the real economy is stagnating. Thereby, strong price fluctuations may be due to uncertainty, when speculators follow other speculators. Distortions are endogenous in contrast to neoclassical real-business-cycle models, where crises are exclusively caused by exogenous shocks.

In this respect we have found the most particular feature of the oil market to be the dual nature of crude oil as a physical commodity and a financial asset. By ways of financial investment in the futures market, the oil price may be influenced. A monetary analysis has revealed that speculation may be to the benefit of both speculators and producers from a microeconomic perspective and hence, owing to uncertainty, may take place even under the assumption that all agents are rational. The transmission of monetary policy through fundamentals and financial markets materializes in one and the same good, giving rise to complex interactions between both aspects of transmission. To say it in other words, we have suggested in the introducing part that monetary policy affects the real economy and financial markets. Financial assets have not been specified further. With crude oil, fundamentals and financial assets are not two distinct issues anymore but unified in crude oil. The same good is traded in two different but closely connected markets. The spot market and the futures market aggregate to the crude oil market as a whole. The narrative of the theoretical analysis is the following: expansive monetary policy triggers speculation in the crude oil futures market, which raises the oil price. Policy transmission to the spot market is quite ambiguous (beside of the unambiguous price effect of a change in the US dollar exchange rate) and does not give rise to significant changes in relation to the rest of the economy. The higher oil price improves profit prospects of oil producers, who increase investment expenditures. Rising oil production capacities bring the oil price down sooner or later to a lower level compared to the beginning. Overinvestment keeps the oil price low for a longer time, leading to higher oil consumption and therefore a *ceteris paribus* higher oil intensity of the economy.

Part II has intended to relate the hitherto, partially quite abstract, analysis to the real-world institutions and to test it empirically. The time window considered is marked by a change in the conduct of US monetary policy from conventional to unconventional implementation. The global oil pricing system is an indirect criticism of the efficient markets hypothesis and shows that there are many ways how imperfections and deviations of the oil price from its fundamental value may occur. Moreover, we have embedded the crude oil market in its current structure by showing that it is integrated with respect to both the geographic and the temporal dimensions as well as with regard to other fossil fuels. As a consequence, this has raised the question of whether it is possible that monetary policy of a single country, the United States in our case, can influence a global market. By referring to numerous international transmission channels, we have argued that US monetary policy has global effects.

To support the empirical analysis, an SFC model has been constructed that is able to show the isolated effect of monetary policy on the crude oil market. Empirical evidence was not easy to find within a single econometric model. Firstly, speculation is a complex phenomenon and very difficult to represent by individual data series. Secondly, by integrating the spot and the futures markets of crude oil in the same model, two markets are merged that work with different speeds, which hampers the finding of significant results. However, using different econometric tools has revealed an overall picture that allows a meaningful interpretation. Structural VARs, cointegrating relationships and Granger causalities have confirmed the ambiguity of monetary policy transmission through fundamentals and provided some evidence of significant transmission through the futures market. The insignificant oil supply variable suggests that the exhaustion of oil reserves is not a binding constraint to date. To support the robustness of the evidence of speculation, a new approach with oil inventories and capacity utilization has been introduced. It provides evidence that speculation is present in the oil market in times of high oil prices. The second stage of estimation yields robust evidence that a higher oil price raises oil production capacities and finally lowers the oil price again. The causal chain from monetary policy to the crude oil market is thus complete.

Finally, Part III identified two main problems arising from the influence of monetary policy on the crude oil market. The first is economic and financial instability triggered by speculation in the crude oil market. The second consists of the ecological threat by overinvestment resulting from the financial market impact. A lower oil price raises *ceteris paribus* oil consumption and thereby the oil intensity of the economy, implying an additional load for the environment. These challenges ask for a political solution. Since they are themselves a market outcome, simple reference to market correction mechanisms is not an adequate answer. We have discussed a series of existing economic policy approaches that are already in force in several countries in some cases. The first, and most often mentioned, proposition is futures market regulation. The basic idea behind it is the ruling out of financial market distortions that harm the spot market. It thus mainly serves stability purposes. The regulation measures presented may be successful in keep speculative influences down. However, they require an assumption about the true fundamental value of crude oil, which we argue to be unobservable. Regulation may run the danger of bureaucracy, which may again be circumvented by actors. Moreover, if the assumption of a fundamental price is wrong, regulation may also trigger additional instability. The second approach, intervention in the crude oil market by means of the strategic petroleum reserve, may be quite effective but unprecise and thus may as well contribute to instability in the oil market.

Other policy proposals are a kind of oil supply target that resembles in many characteristics the carbon emission trading system of which the largest one exists already in the European Union. In contrast to the others, it takes the ecological issue into account. However, by setting the quantity, it has to let the price fluctuate freely. Owing to the cap exogenously set, the price becomes quite volatile according to the state of demand. Economic and financial stability is jeopardized. Another well-known approach to address the environmental problem of fossil energy consumption consists of taxing that energy. It is in favour of a decreasing use of oil, but does not prevent fluctuations originating in the futures market.

We have outlined a policy proposal that takes both the stability and the ecological sustainability issue into account by combining the currently existing policy ideas. In particular, monetary policy is coordinated with fiscal policy. An oil price target is set and achieved by intervention of the central bank in the futures market along the lines of the use of the strategic petroleum reserve. As a difference, trading futures contracts instead of physical oil allow for more flexibility and better fine-tuning. Once the oil price target is achieved, stability in the oil market is guaranteed and speculation is ruled out. By increasing the oil price target step by step to a higher level, oil consumption can be decreased, which is in favour of climate protection. Stability is as well established for the rest of the economy, since it becomes clear that investing in oil-consuming equipment will not be profitable anymore in the future. Uncertainty with respect to the oil price is removed and it is obvious that investment in renewable energy sources and energy efficiency is sustainable in an ecological as well as economic sense. To avert that supply and demand of oil diverge as a consequence of the exogenous price setting, a tax is to be imposed on oil production. It lowers oil supply and thus avoids overproduction and, as its counterpart, infinite accumulation of futures contracts with the central bank account. The insight that the futures and spot market are integrated, so that spot and futures prices move closely together, allows the use of the futures market for economic policy. The futures account of the central bank gives real-time information as to whether the tax on oil production is set correctly or not.

We have further shown how the oil price targeting system may be introduced in a single country, distorting neither the oil market nor the rest of the economy. Additionally, questions concerning the economic order, the impact on inflation, the feasibility of the system as well as democratic concerns have been addressed.

The idea of an oil price targeting system may appear as quite radical at first sight. However, closer examination, like the one we have conducted, shows that it arises from existing and quite conventional approaches. Implementation can take place within existing institutional infrastructure. Moreover, we do not deny the utility of the hitherto proposed policy approaches. They may well be applied and unfold their beneficial effects. The oil price targeting system is just considered as the ultimate consequence of accounting for shortcomings and incompleteness of current policy proposals. Combining the general ecological benefit of a rising oil price with a stable pattern over time is a way of great effort but it may nevertheless be the most comfortable and efficient way to get out of fossil energies.

For the future, there is a considerable amount of work to be done. Regarding political intervention in the oil market, institutional details should be enlightened. For instance, be it with the oil price targeting system or with an energy tax in general, the rule of redistribution to the economy so that it does not risk a loss of competition but without either creating a moral hazard for oil production calls for additional research. Moreover, what oil price targeting means for overall inflation has been debated. Yet, how the oil price target has to be set under conditions of general inflation should be investigated closer. While it is not a difficult thing to deflate a price *ex post* by dividing it by a consumer price index, it is more difficult to determine *ex ante* what the oil price ought to be relative to the overall price level. Research in this field may be helpful. More general, literature on the macroeconomic effects of oil price shocks has been produced for decades. What is important to know is the impact that a changing oil price, specifically if the change is lasting, has on the composition of economic output and hence on the structure of employment. Another issue from the macroeconomic perspective is the impact of a rising oil price on income and wealth distribution in the economy. Some groups of the population may be stronger affected than others depending on their consumer basket and on the remuneration scheme of the tax on oil production.

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Appendix: SFC Model of Monetary Policy and the Crude Oil Market

Appendix I: The Basic Structure

Model Variables

C_d	Consumption goods demand
CG_P	Capital gain of inventories
$C_{oil,d}$	Oil demand
$C_{oil,s}$	Oil supply
C_s	Consumption goods supply (exogenous)
F_L	Net long positions of investors, futures demand
$FP^e{}_I$	Expected financial profits of investors
FP_I	Financial profits of investors
FP_P	Financial profits of producers
FPU_I	Undistributed profits of investors
FPU_P	Undistributed financial profits of producers
F_S	Net short positions of producers, futures supply
H_C	Cash held by consumers
H_{CB}	Cash issued by central bank
I_d	Investment demand
IN	Oil inventories
I_s	Investment supply
K	Capital stock
L_B	Loans issued by banks
L_I	Loans granted to investors
L_P	Loans granted to producers
M_B	Maintenance margins at banks
M_I	Maintenance margins of investors
P_B	Profits of banks
P_C	Profits distributed to consumers
P_{CB}	Profits of central bank
$p^e_{I,spot}$	Expected spot price of investors
PP^e_P	Expected profits of producers
p_{fut}	Futures price of oil at the moment of contracting, expiring in the next period
PP_P	Production profits
PPU_P	Undistributed profits of producers
p_{spot}	Spot price of oil
R	Bank lending rate

R_B	Reserves demanded by banks
R_{CB}	Reserves provided by central bank
r_T	Interest rate target (exogenous)
V	Total wealth
V_B	Wealth of banks
V_C	Consumer wealth
V_{CB}	Wealth of central banks
V_I	Wealth of investors
V_P	Wealth of producers
W_d	Wage demand
W_s	Wage supply
Y	Nominal GDP

Model Equations

(4.1) $C_{oil,d} = \delta_0 + \delta_1 * C_s - \delta_2 * p_{spot}$

(4.2) $\Delta IN = \delta_3 * K_{-1} - \gamma * IN_{-1} - C_{oil,s}$

(4.3) $C_{oil,s} = C_{oil,d}$

(4.4) $C_d = C_s$

(4.5) $Y = C_s + p_{spot} * C_{oil,s} + I_s + p_{spot} * \Delta IN$

(4.6) $I_d = \dfrac{\alpha_1 * PP_P^e}{1 + \alpha_2 * L_{P,-1}}$

(4.7) $PP_P^e = PP_{P,-1}$

(4.8) $PP_P = Y - C_d - W_d - r_{-1} * L_{P,-1}$

(4.9) $PPU_P = (1 - s) * PP_P$

(4.10) $I_s = I_d$

(4.11) $\Delta K = I_s$

(4.12) $W_d = \delta_7 * (C_{oil,s} + \Delta IN)$

(4.13) $W_s = W_d$

(4.14) $F_S = F_L$

(4.15) $p_{spot} = p_{fut}$

(4.16) $p_{fut} = \dfrac{\delta_4 + \delta_5 * (F_L + C_{oil,d})}{\delta_6 * K_{-1}}$

(4.17) $F_L = \dfrac{M_I}{m * p_{fut,-1}}$

(4.18) $$\Delta M_I = \frac{\beta_0 + \beta_1 * FP_I^e - \beta_2 * r}{1 + \beta_3 * L_I^2}$$

(4.19) $$\Delta L_I = \Delta M_I - FPU_I$$

(4.20) $$FP_I = (p_{spot} - p_{fut,-1}) * \Delta F_L + \Delta(p_{spot} - p_{fut,-1}) * F_{L,-1} - \frac{r_{-1}}{52} * L_{I,-1}$$

(4.21) $$FP_I^e = (p_{I,spot}^e - p_{fut,-1}) * \Delta F_{L,-1} + \Delta(p_{I,spot}^e - p_{fut,-1}) * F_{L,-1} - \frac{r_{-1}}{52} * L_{I,-1}$$

(4.22) $$p_{I,spot}^e = p_{spot,-1} + (p_{spot,-1} - p_{spot,-2})$$

(4.23) $$FPU_I = FP_I$$

(4.24) $$FP_P = (p_{fut,-1} - p_{spot}) * \Delta F_S + \Delta(p_{fut,-1} - p_{spot}) * F_{S,-1} + CG_P$$

(4.25) $$FPU_P = FP_P$$

(4.26) $$CG_P = \Delta p_{spot} * IN_{-1}$$

(4.27) $$\Delta L_P = I_d + \Delta W_s - PPU_P - FPU_P + CG_P + p_{spot} * \Delta IN$$

(4.28) $$L_B = L_P + L_I$$

(4.29) $$P_B = r_{-1} * L_{B,-1} - r_{T,-1} * R_{B,-1}$$

(4.30) $$\Delta R_B = \Delta L_B - \Delta M_B$$

(4.31) $$M_B = M_I$$

(4.32) $$P_{CB} = r_{T,-1} * R_{B,-1}$$

(4.33) $$r = r_T + D$$

(4.34) $$P_C = s * PP_P + P_B + P_{CB}$$

(4.35) $$\Delta H_C = W_s + P_C - p_{spot} * C_{oil,d}$$

(4.36) $$H_{CB} = H_C$$

(4.37) $$R_{CB} = R_B$$

(4.38) $$V_P = K + p_{spot} * IN - L_P$$

(4.39) $$V_I = M_I - L_I$$

(4.40) $$V_B = L_B - M_B - R_B$$

(4.41) $$V_{CB} = R_B - H_C$$

(4.42) $$V_C = H_C$$

(4.43) $$V = V_C + V_P + V_I + V_B + V_{CB} = K + p_{spot} * IN$$

Stock Matrix

	Consumers/ households	Producers	Investors	Banks	Central Bank	$\sum$
Capital		$+K$				$+K$
Loans		$- L_P$	$-L_I$	$+L_B$		0
Cash	$+H_C$				$- H_{CB}$	0
Maintenance margin			$+M_I$	$- M_B$		0
Reserves				$- R_B$	$+R_{CB}$	0
Inventories		$+p_{spot}*IN$				$+ p_{spot}*IN$
Open interest		$+p_{fut,-1}*F_S$	$- p_{fut,-1}*F_L$			0
Oil balance (due to futures contracting)		$- p_{spot}*F_S$	$+ p_{spot}*F_L$			0
Net wealth	$\boldsymbol{- V_C}$	$\boldsymbol{- V_P}$	$\boldsymbol{- V_I}$	$\boldsymbol{- V_B}$	$\boldsymbol{- V_{CB}}$	$\boldsymbol{- K - p_{spot}*IN}$
$\sum$	0	0	0	0	0	0

Transactions Matrix

	Consumers/ households	Producers		Investors		Banks		Central Bank		$\sum$
		Cu	Cap	Cu	Cap	Cu	Cap	Cu	Cap	
Oil consumption	$- p_{spot}*C_{oil,d}$	$+p_{spot}*C_{oil,s}$								0
Other consumption	$- C_d$	$+C_s$								0
Real investment		$+I_s$	$- I_d$							0
Wages	$+W_s$	$- W_d$								0
Net profits	$+P_C$	$- PP_P$	$+PPU_P$			$- P_B$		$- P_{CB}$		0
Loan interests		$- r_{-1}*L_{P,-1}$		$- r_{t-1}*L_{I,-1}$		$+r_{t-1}*L_{B,-1}$				0
Interests on reserves						$- r_T*R_{B,-1}$		$+r_T*R_{CB,-1}$		0
Stock accumulation		$+p_{spot}*\Delta IN$								$+p_{spot}*\Delta IN_P$
Futures investment / open interest		$+(p_{fut,-1}- p_{spot})* \Delta F_S - \Delta(p_{spot} - p_{fut,-1})*F_{S,-1}$		$+(p_{spot} - p_{fut,-1})*\Delta F_L +\Delta(p_{spot} - p_{fut,-1})*F_{L,-1}$						0
Financial profits		$-FP_P$	$+FPU_P$	$- FP_I$	$+FPU_I$					0
Change in money	$- \Delta H_C$								$+\Delta H_{CB}$	0
Change in loans			$+\Delta L_P$		$+\Delta L_I$		$- \Delta L_B$			0
Change in margin					$- \Delta M_I$		$+\Delta M_B$			0
Change in reserves							$+\Delta R_B$		$- \Delta R_{CB}$	0
$\sum$	0	0	0	0	0	0	0	0	0	0
Stock accumulation		$+ \Delta p_{spot}*IN_{-1}$								$+\Delta p_{spot}*IN_{-1}$
Capital accumulation		$+ \Delta K = I_s$								$+ \Delta K = I_s$

Appendix II: Model Extension with Policy

Additional variables

F_L^{CB}	Net long positions of central bank
$F_L^{CB,target}$	Central bank target of net long positions (exogenous)
F_L^{I}	Net long positions of investors (existing before as F_L)
F_L^{tot}	Total long positions
M_{CB}	Maintenance margin of central bank
$p_{fut,target}$	Futures price targeted by central bank (exogenous)
T	Tax on oil production

Modification of model equations

(4.8’) $$PP_P = Y - C_d - W_d - r_{-1}*L_{P,-1} - T$$

(4.16’’) $$F_L^{tot} = \frac{p_{fut}*\delta_6*K_{-1} - \delta_4 - \delta_8*T}{\delta_5} - C_{oil,d}$$

(4.17’) $$F_L^I = \frac{M_I}{m*p_{fut,-1}}$$

(4.18’’) $$\Delta M_I = \frac{\beta_0 + \beta_1*FP_I^e - \beta_2*r + \beta_5*(p_{spot}^e - p_{spot,-1})}{1 + \beta_3*L_I^2}$$

(4.31’) $$M_B = M_I + M_{CB}$$

(6.1) $$p_{fut} = p_{fut,target}$$

(6.2) $$F_L^{CB} = F_L^{tot} - F_L^I$$

(6.3) $$M_{CB} = m*p_{fut,-1}*F_L^{CB}$$

(6.4) $$T = i*(\tau_0 + \tau_1*(p_{fut,target} - 2) + \tau_2*(p_{fut,target} - p_{fut,target,-1}) + \tau_3*(F_L^{CB} - F_L^{CB,target}))$$