Determinants of Crude Oil Prices: Supply, Demand, Cartel or Speculation?

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Understanding the factors driving crude oil price developments is essential for assessing their effects. This paper examines four groups classifying a total of some thirty potential determinants of crude oil prices: fundamental factors, i.e. supply and demand, factors relating to the structure of the crude oil market (OPEC), and factors associated with the behavior of financial market participants (speculation). Bayesian Model Averaging (BMA) allows us to analyze a multitude of potential explanatory variables under model uncertainty and to quantify their robustness in explaining oil price inflation (price changes in percent). The results of our analysis suggest that the significance of individual factors varies over time. While no single factor dominates throughout the entire period under review (1983 to 2008), models explaining short-term movements in oil prices should always include headline inflation indicators and take into account the persistence of oil prices. In the 1990s, also the production quota of Saudi Arabia – a factor relating to the market structure – played a significant role; in the 2000s, both supply and demand (European demand for oil and refining capacities) have been highly important factors. The results of our analysis do not preclude the possibility that determinants other than those discussed here may become significant in the long run. While fundamental shortage conditions play a key role in driving up the price of crude oil, the existence of cartels and speculation can further increase price pressures.

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The recent boom in commodities prices – and even more so its abrupt end – has triggered a debate over the extent to which developments in crude oil markets are determined by the fundamental factors of supply and demand. Alternative explanations cite the market power of crude oil producers and the behavior of investors in the financial markets as drivers. Arguments have been offered both in favor and in opposition of all four theories.

- Many analysts emphasize the dynamic demand by emerging economies, most notably China. However, this growth trend is not new and has hardly changed for decades.
- Advocates of the hypothesis of a fast-approaching global production maximum *(peak oil)* cite supply shortfalls as drivers behind oil price movements. This view is challenged by skeptics who point to the potential of unconventional sources and technological advances.
- The fact that OPEC has experienced a comeback is also beeing put forward, although the production discipline of its member states is not that of a well-organized cartel.
- Another possible explanation rests on the observation that financial market participants are more actively engaging in commodity markets, thereby causing deviations from the equilibrium price. However, "speculation" makes fundamental supply shortfalls more transparent.

Hamilton (2008) and Dees et al. (2008) show that all four theories do not necessarily contradict, but rather may complement one another.

It is possible that the most recent oil price shock was an expression of a fundamental energy crisis which has had a

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severe impact on the world economy. Despite the sudden drop in energy prices brought about by the economic recession, the International Energy Agency (IEA, 2008a) expects crude oil demand – mostly from emerging markets – to increase further in the long run and to rise by an estimated 45% by 2030 (IEA, 2008a). This implies a somewhat slower growth rate than that forecast prior to the financial crisis. Nevertheless, the gap between supply and demand for oil is widening and must be closed by new sources. In the IEA's baseline scenario, the tightening of supply conditions will result in a crude oil price of up to USD 200 by the year 2030, which would equate to approximately USD 120 in real terms (i.e. based on today's purchasing power).

Initially, the oil price boom between 2000 and 2008 gave reason for optimism about its comparatively moderate macroeconomic effects (Blanchard and Galí, 2007). The situation quickly deteriorated when the shock was exacerbated in early 2007 by developments in other commodity markets that are causally related to oil price hikes.[2] While inflation rose to alarming levels, this was soon followed by a dramatic economic downturn triggered by the financial crisis. Like many times before in economic history, oil prices have evidently once again significantly contributed to a recession (Hamilton, 2009).

The question of whether oil price shocks are caused on the supply or the demand side raises debate about their exogenous or endogenous treatment in macroeconomic models. The different impacts of the shocks – depending on the underlying cause – would also have consequences for determining an adequate monetary policy response (Kilian, 2009a). Therefore, it is hardly surprising that oil price determinants have become a popular area of research. The methods and models used vary considerably, which gives rise to the impression that disparate findings are in part the result of the research approach chosen.

This study approaches the subject using a statistical method that allows for an analysis of a multitude of different theories. Contrary to the conventional approach, *Bayesian Model Averaging (BMA)* not only addresses parameter uncertainty, but also accounts for the uncertainty associated with model selection. While the standard approach is limited to a single model and ignores potential findings from other models – and thus model uncertainty – the use of BMA allows us to evaluate a large number of different models and draw conclusions that explicitly quantify model uncertainty.

The Bayesian approach is particularly suited for analyzing the factors determining crude oil prices. Empirical studies that focus on a multitude of possible determinants yield no conclusive results in this regard. This lack of consensus suggests that the simultaneous application of different model approaches would be beneficial.

This study is structured as follows: Section 1 presents some stylized facts about the historical development of crude oil prices. In addition, we discuss four groups of potential determinants in light of the current theoretical and empirical literature: supply, demand, market power and investor behavior. Section 2 presents a detailed description of the determinants used in the

[2] *Put in a context with non-energy commodities, crude oil takes on the role of an input factor (energy), a substitute (biofuels), or a competitor for important investment goods (e.g. excavators). A recent World Bank study (Mitchell, 2008) attracted considerable attention with its discussion of the connection between energy and food crises.*

empirical section of this paper and justifies our choice. Section 3 compares these variables using BMA and quantifies the relative importance of each factor. Finally, section 4 discusses the results and presents conclusions.

1 Fundamental and Market Factors

From the turn of the millennium until mid-2008, the price of crude oil – probably the most important price in world trade – surged fivefold[3] to an all-time high of around USD 145 per barrel. Subsequently – and equally surprisingly – it plunged by more than USD 100 within six months, only to move back up to around the USD 70 mark soon thereafter.

Four groups of explanatory factors can be identified as possible contributors to the development of crude oil prices:

1. fast-growing demand due to high global economic growth
2. declining supply or anticipated shortages in supply
3. coordinated action on the part of crude oil producers
4. the behavior of financial market participants, speculation

These determinants are not necessarily mutually exclusive, but can complement each other or take turns in chronological succession. Hamilton (2008) combines these explanations in a complex, multi-causal interpretation, which can be outlined as follows: Increasing demand encounters stagnating supply, triggering speculation about future shortfalls, which subsequently materialize as the producing countries stockpile oil reserves.

Determining the causes of an oil shock is essential if we are to assess its effects, but conversely, the effects also provide information about the causes. Kilian (2009b) decomposes oil price shocks into three components, concluding that – contrary to the prevailing view – during the last forty years, crude oil supply shocks have played a lesser part than general or oil market-specific demand shocks. The latter essentially stems from precautionary demand driven by fears about future oil supply shortfalls.

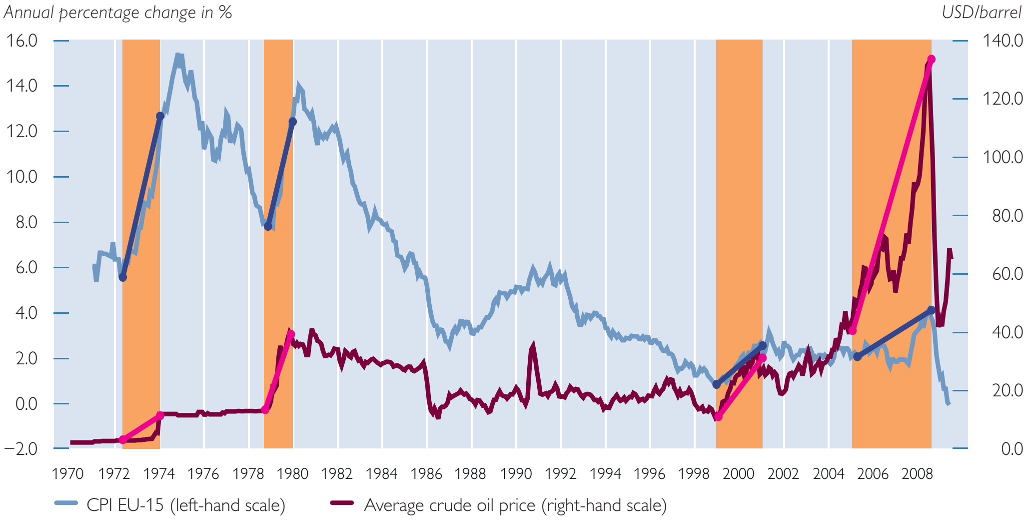
Unlike the historical oil price peaks of the last century, which were associated with stagflation crises, the macroeconomic impact of the most recent oil price upsurge was generally moderate until mid-2007. Kilian (2009b) interprets this reaction as evidence for the key role of the demand side in the recent shock.[4] If, by contrast, the shock had been triggered by supply-side effects, aggregate macroeconomic demand would have fallen, because a negative supply shock incurs the same reaction as imposing a tax on consumers (with a high propensity to consume) in favor of oil producers (with a lower propensity to consume). A supply shock also drives production costs and inflation (at least to the extent that price and wage rigidity is unavoidable), which in turn prompts central banks to raise their interest rates, thereby further dampening economic activity. Conversely, in the event of a demand-driven, endogenous oil price shock, combined with low short-term supply elasticity, inflation rises only temporarily, and there is no sudden decline in economic growth (Kilian, 2009b).

[3] *For West Texas Intermediate, although this statement basically applies to all crude oil types, as any differences in crude oil prices are mainly the result of quality-related premiums and discounts.*

[4] *Blanchard and Galí (2007) cite other reasons for the moderate effects: "good luck" (lack of concurrent adverse shocks), reduced oil intensity of the economy, more flexible labor markets and improvements in monetary policy.*

Chart 1

Crude Oil Price and EU-15 Inflation[1]



Source: OECD, Eurostat, IMF.

[1] *Monthly data; from 1997: euro area inflation.*

In the second half of 2007, however, signs of stagflationary tendencies emerged, which supports the conclusion that the oil shock was in part affected by supply-side factors. One year later, the global economy plunged into the deepest recession in post-war history, while inflation even turned negative at times. Accordingly, Hamilton (2009) adds the economic slump of 2007 to 2008 to the list of recessions that were significantly precipitated by oil prices.[5]

Before examining the four groups of factors in more detail, one other general aspect deserves particular attention: Crude oil is characterized by extremely low price elasticity in both supply and demand, which leads to extreme price fluctuations under market conditions of persistent scarcity (i.e. low levels of reserves held by suppliers and consumers) (Krichene, 2006).

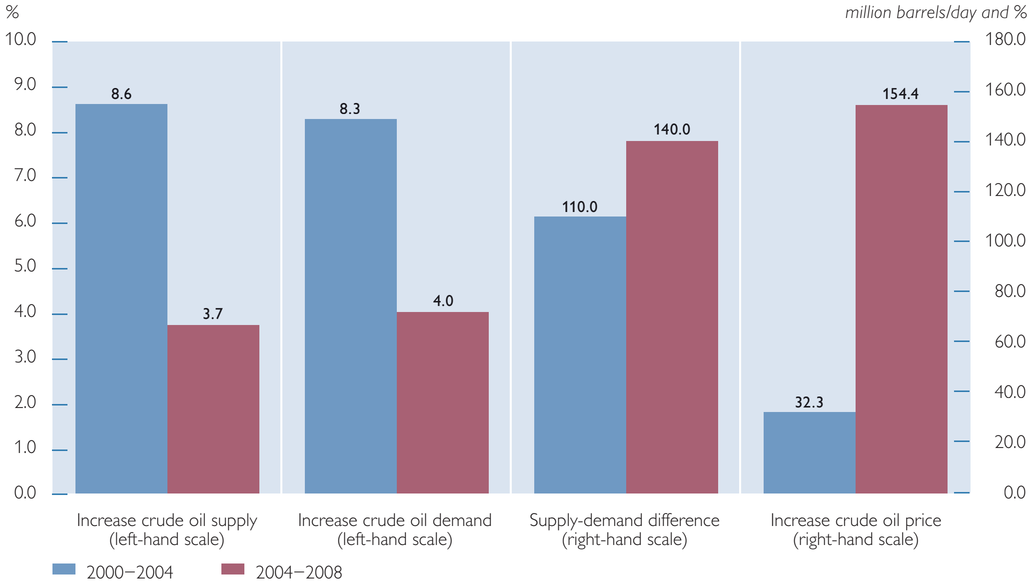
1.1 Demand Factors

The majority of recent studies argue that demand represents a significant – if not the major – driving force behind the latest oil price shock between 2004 and 2008 (Hamilton, 2008; Hicks and Kilian, 2009; Kilian, 2009b; Wirl, 2008). This rationale is supported by the fact that the prices of almost all other commodities skyrocketed along with oil prices. Another fact seems to contradict this view, though: From 2000 to 2004, demand grew more than twice as fast as in the subsequent period, whereas prices showed a converse tendency, increasing considerably more moderately before the shock than in the aftermath (chart 2).

[5] *The chronology of events supports this theory. Some months before the financial crisis reached its worst point (mid-September 2008), economic indicators from around the world had already fallen sharply (Fricke, 2008). The magnitude of the oil shock in comparison with the generally perceived culprit behind the crisis – real estate prices – further supports this theory (Rubin and Buchanan, 2008). Furthermore, there is a possibility that the deterioration of housing prices in the U.S.A. itself was caused by high fuel prices and the resultant negative impact on the disposable income of suburb dwellers (Cortright, 2008).*

Chart 2

Two Phases of the Crude Oil Upsurge 2000 to 2008



Source: IEA.

Nevertheless, the enormous hunger for commodities of emerging markets – mainly China and India, but also the Middle East and Latin America – is a frequently cited element to explain the commodities boom. The decisive factor here is growth and not the level of demand from emerging economies.[6]

The correlation between the sharp price decline in the second half of 2008 and the sudden slump in demand is even more pronounced. In industrial economies, however, concurrent movements of crude oil prices and economic growth tend to be atypical and to date have only occurred for short periods (chart 3). Hamilton (2009) observes that – with one exception – all U.S. recessions were in fact preceded by a surge in oil prices.

Several factors can be identified as exhibiting a causal or final relationship to economic growth and exercising a determining influence on crude oil prices. Frankel (2006), for example, points to the real interest rates as determined by monetary policy, which affect both the demand and supply of crude oil, thereby empirically exhibiting a negative correlation with real oil prices.

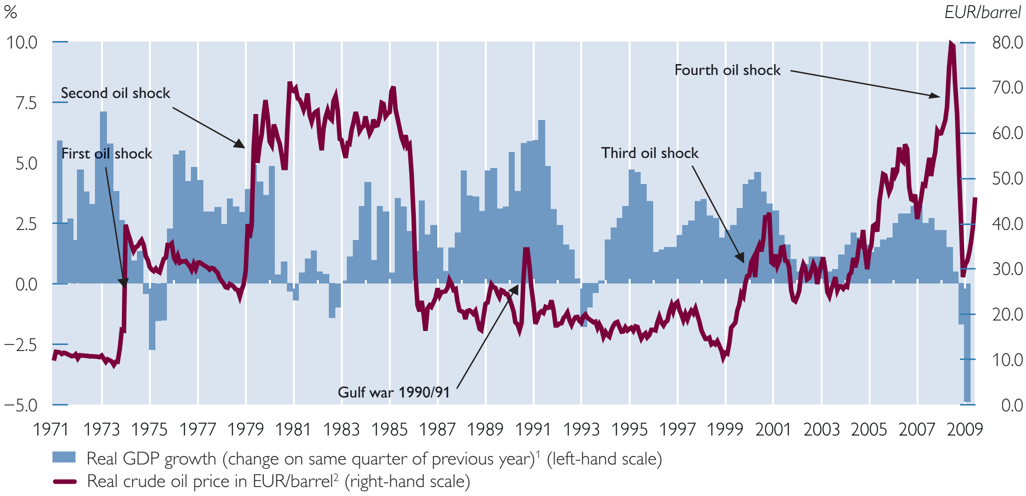
Compared with demand pull, which has exerted a dominant influence over the long term, other short-term determinants – although frequently in the headlines – take secondary importance. Comparatively low inventories in OECD countries, which are symptomatic of a general scarcity in the oil market, may account for a substantial proportion of the recent price surge. Furthermore, weather conditions often play a significant role in the short-term evolution of demand.[7]

6 *The OECD countries still account for more than six tenths of the global demand for crude oil, although consumption already began to dwindle in 2008 as a result of cyclical developments and oil prices.*

7 *Severe weather conditions (e.g. hurricanes) also have a negative impact on supply through the destruction of up- and downstream infrastructures.*

Chart 3

Real Crude Oil Price and Economic Growth in the EA-15



Source: Eurostat, Thomson Reuters, OeNB.

[1] Before 1992: GDP growth in Germany.
[2] Basis: December 2005; adjusted for HCPI (before 1991: Consumer Price Index Germany, EUR in DEM equivalents).

In the medium to long term, high crude oil prices provide an incentive to invest in energy efficiency and alternative sources of energy. This phenomenon had a particularly dampening effect on demand after the first two oil price shocks in the 1980s. It is conceivable that the most recent oil price shock has also set similar processes in motion. However, in emerging economies, rapidly expanding demand can be expected to remain the key determinant of crude oil prices, given the generally high income elasticity of oil demand (Krichene, 2006).

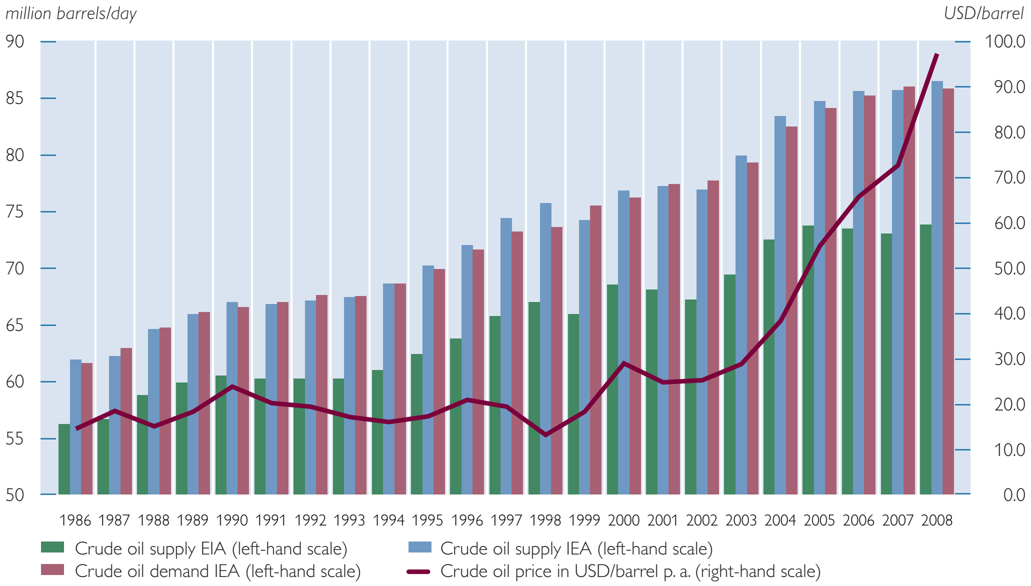
1.2 Supply Factors

There is no doubt about the fact that oil is an exhaustible resource. From an economic perspective, scarcity rents and thus continuously increasing prices are plausible for exhaustible resources.[8] According to Hotelling (1931), the price of an exhaustible resource increases over time in line with the interest rate. If crude oil producers were to sell all of the resources presently at their disposal at the current market price and invest the proceeds, this amount should grow continuously at the rate of interest. Producers are indifferent to the time of sale only if oil prices rise successively in line with interest rates. Empirically, *Hotelling's rule* has neither been convincingly substantiated nor disproven, as it is difficult to separate it from other influencing factors (Livernois, 2009). This is perhaps due to the extreme volatility of oil prices, which react strongly to news without settling on a long-term path that would reflect the growing scarcity of oil and climate costs (Gronwald, 2009). Yet it may be possible that the most recent oil price shock marks the point at which the scarcity rent component of oil prices begins to gain in impact (Hamilton, 2008).

[8] See also David Ricardo's concept of diminishing marginal returns on land (1821), according to which increasing marginal costs of development and exploitation determine the resource price.

Chart 4

Crude Oil: Supply and Demand



Source: EIA, IEA, Thomson Reuters.

During the most recent surge in crude oil prices, growing demand met what was evidently an increasingly scarce supply. The IEA's annual figures reveal that growth in the worldwide supply of crude oil halved between 2004 and 2008, compared to the preceding four-year period, just at the exact time when price hikes offered a significantly greater incentive for increased production (chart 2). According to the U.S. Energy Information Agency (EIA), global oil output actually stagnated between 2005 and 2008 (chart 4),[9] which indicates that supply factors have gained in relevance.

The relatively scarce supply situation lends credence to the *peak oil hypothesis,* which asserts that the point of global maximum production has already been passed and will now be followed by successively declining production quantities (Schindler and Zittel, 2008). According to this theory, the rate of oil production follows a bell-shaped curve named after U.S. geologist M. King Hubbert, who used this curve to accurately forecast the development of crude oil production in the U.S.A. (Hubbert, 1956). According to this curve, the peak of production is reached when approximately one-half of the known reserves have been extracted. In fact, annual discoveries of crude oil have been on a declining trend since the 1960s, despite extended efforts to locate new oil resources, while annual production started to exceed annual discoveries in the 1980s. The historical maximum of oil discoveries must be followed by a maximum of oil production. However, uncertainty exists as to the exact point in time at which peak production will be reached, given the steady increase in proven reserves and the continual improvements in technologies, which include techniques for improving oil recovery from existing fields as well as procedures that reduce the enormous costs

[9] *Unlike the EIA, the IEA also includes liquid gas production in its data on crude oil supply.*

involved in the extraction of unconventional oil resources (oil sand, oil shale, heavy oils, liquid gas, deep sea oil, Arctic oil, etc.). Unconventional production faces a number of significant environmental obstacles, though (Global Forest Watch, 2009).

Today, the theory of peak oil has been widely accepted, even by the IEA (2008), at least regarding easily exploited oil sources. If, in the wake of the financial crisis, investment in the development of new energy sources and technologies falls short of the annually required total of USD 1,000 billion, the world faces a potential supply squeeze after 2015, as the average oilfield production rate is continually increasing and production sources are therefore becoming ever more constrained.

The IEA reports that non-OPEC oil production has stagnated since 2004 and that the increase in the global supply of crude oil is attributable to OPEC countries alone, where production is primarily controlled by government-owned entities. The fact that primary fossil energy resources are concentrated in non-OECD countries amplifies the importing nations' unilateral dependency. Although in part mitigated by a greater reliance on alternative energy sources such as coal, gas and renewables, this dependency is nevertheless set to continue as crude oil will remain the predominant primary energy source for the foreseeable future.

1.3 Market Power in the Oil Market

In their long-term study, Dvir and Rogoff (2009) observe that oil prices were fundamentally high and volatile in the years from the 1970s to the present day – the last phase of the period under review. The onset of this phase coincided with oil production in the U.S.A. passing its peak, thereby facilitating the emergence of an effective oil cartel.

According to OPEC's own data, the twelve current OPEC member states account for 40% of global crude oil production, 55% of crude oil exports, and more than two-thirds of the world's crude oil reserves (OPEC, 2009). The difference between current and potential production suggests that OPEC's influence on the oil market will probably become stronger in the future. In fact, buoyed by the tight supply situation resulting from fundamental factors as outlined above, OPEC has already experienced a revival of its market power. Still, it would be too much of a stretch to cite OPEC as the main driver behind the currently high oil price. *Resource nationalism*[10] (i.e. governments asserting control over the natural resources within their territory) is already considered rational behavior for individual countries – also with a view to safeguarding national wealth for future generations. Additionally, any decrease in the interest yield on oil revenues heightens the incentive to postpone oil extraction from the ground in the hope that the future will bring either price or interest rate increases. Government intervention, which ranges from tax hikes and regulation to full-scale nationalization, directly or indirectly results in reserves being hoarded or investments for the exploration of natural resources being held back. In fact, OPEC countries' (quickly accessible) reserve capacities were below average in the high price years up to mid-2008, which may be a sign that there is less scope for further

[10] *The counterpart of resource nationalism is an equally problematic tendency that we could call resource imperialism: importers attempting to strategically secure access to raw materials.*

production ramp-ups, but may also be a result of delayed *upstream investments*.

With oil output from the North Sea and the Gulf of Mexico shrinking, the responsibility for the world's energy supply increasingly shifts to the shoulders of the OPEC countries (and Russia), which – not surprisingly – do not rank among the world's politically most stable nations. The negative correlation between resource abundance on the one hand and democratization (Acemoglu, 2008) and development on the other is known as the *resource curse* (Sachs and Warner, 2001). This phenomenon is connected to another one labeled *Dutch disease:* Economic activities in the non-commodity sector decline to secondary importance, which in turn creates incentives for *rent seeking,* i.e. economic stakeholders expend (and waste) an ever greater effort on controlling access to their resources.

The interest of crude oil producers in forming cartels can also be linked to the major trends previously outlined. As a general rule, relatively high fixed costs and the associated decrease in average costs facilitate the emergence of oligopolies in the oil market, which – in view of the various quality segments – does not constitute a pure monopoly, however. After years of weakness (triggered, inter alia, by the non-cooperative behavior of Saudi Arabia in the mid-1980s and the development of efficient spot markets), OPEC experienced a revival of its market power driven by surging demand (particularly from Asia). In light of its profit-maximizing behavior, however, OPEC also has an interest in keeping demand stable and therefore takes into account the dampening effects of soaring oil prices.

Finally, negative news about geopolitical tensions – a term typically denoting the risks associated with short- to medium-term exogenous supply shocks resulting e.g. from wars or revolutions – also lead to greater price volatility.

1.4 Investor Behavior

Participants in the *commodity markets* speak of a *commodity cycle* that follows the economic cycle, and even (in regard to the most recent bull run in commodities) of a *commodity super cycle* driven by fundamental data. Traders are not exclusively speculators with a short-term focus on reaping instant profits by successfully anticipating price movements. It is also large energy consumers and producers trying to hedge their physical trade volumes against fluctuating prices. In times of increasing inflationary concerns and financial market turbulence, market participants also include institutional investors seeking refuge in the perceived safe haven of commodities or interested in diversifying their portfolios, as commodity assets show a negative correlation with stocks and bonds.[11]

Opinions diverge, however, on the actual significance of speculation. On the one hand, it is considered to be destabilizing and dangerous, such as in cases where large-scale transactions are used to achieve profits from price changes. On the other hand, speculation is deemed useful in that it allows for transparent and efficient liquidity-based price discovery. Even if speculation drives prices above the fundamen-

[11] *The correlation of oil papers with other asset classes is mainly negative, with causality not being unambiguously established. Just as capital fleeing the stock markets enhances the status of commodities, climbing oil prices usually put pressure on stock prices, with the exception of oil stocks. Bonds are affected by opposed effects, with the inflationary and interest-raising impact (increasing attractiveness of commodities) outweighing the growth-dampening implications (declining crude oil demand) in most cases.*

tal trend, it can nevertheless contribute to optimum resource allocation: High crude oil prices, for example, point to potential future shortages, which in turn sends a signal to consumers to save energy and to crude oil producers to develop new sources.

According to Masters (2008), institutional traders' index speculation in the futures market (the dominant type of speculation today) is more damaging than "traditional speculation."[12] In the five years before spring 2008, the revenue from trading in crude oil derivatives increased exponentially[13] and the prices of crude oil futures[14] are considered to be the benchmark for spot markets and long-term contracts. In the case of the Rotterdam crude oil market, this is in fact explicitly the case. This view stands challenged by the contention that so-called *paper barrels* – unlike physical crude oil *(wet barrels)* – have unlimited availability. Furthermore, no major imbalances between long and short positions occurred during that period, which could have provided an indication about the likely direction of speculation-induced price trends. If the number of market participants increased greatly, it was only because they were following a trend that can be determined through the fundamental equilibrium (ITF, 2008). Models taking into account the interaction of heterogeneous participants (fundamentalists, chartists and portfolio managers) on *financialized* commodities markets allow the possibility of a persistent misalignment of prices away from the fundamental equilibrium (Redrado et al., 2008).

Krugman (2008) contradicts the hypothesis of a crude oil price bubble, arguing that if financial markets were in fact to generate artificial shortfalls over the long term, this would have to be reflected by large stockpiles of crude oil, thereby generating additional physical demand. He claims that the evolution of inventories prior to the oil price peak in mid-2008 did not, at first glance, indicate hoarding. Yet, inventory holdings outside of the OECD region were not at all transparent. In addition, OPEC countries' increasing reserve capacities can be interpreted as underground "stocks" (Hamilton, 2008).[15] Moreover, the findings reported by Stevans and Sessions (2008) and Acharya et al. (2009) do indeed provide evidence of precautionary hoarding on the crude oil market. According to this research, crude oil inventory holdings and futures prices do show a positive correlation and thus also influence prices on the spot market. According to Büyüksahin et al. (2009), fundamental data as well as the increased activity of *hedge funds* and other financial market participants are responsible for the stronger cointegration of futures contracts with near and far terms.

A further argument for a causal relationship between speculation and crude oil prices rests on the fact that the latest oil price upsurge coincided

[12] *Technical trading systems are gaining significance in this process (Schulmeister, 2009).*

[13] *Between January 2003 and March 2008, futures transactions in the American WTI crude oil variety increased sixfold; those in the North Sea Brent variety fourfold (Masters, 2008).*

[14] *In the case of a crude oil futures contract, two parties agree to supply (short position) or buy (long position) a certain quantity of crude oil at a certain price and at a certain time.*

[15] *The change of the pricing structure to contango (i.e. spot prices are lower than prices for later delivery) observed at that time points to the possibility of such "hidden stockpiles." Usually, the price structure curve is in backwardation (i.e. contracts maturing earlier trade higher), which may reflect the fact that producers tend to hedge against their price risk more than potential customers. Storage costs or the lower volatility of futures markets in comparison with the corresponding spot markets may also play a role.*

with the deregulation of futures markets. It is only since 2006 that West Texas Intermediate (WTI) products have been admitted for trade on London's ICE commodities exchange, which – unlike New York's NYMEX – is not regulated by the Commodity Futures Trading Commission (CFTC). This is also one of the reasons for the information gap over actual trade volumes, which is further compounded by the fact that approximately 80% of all derivatives trades take place – equally unregulated – over the counter (OTC).

In all probability, the weakness of the U.S. dollar also contributed to the oil price upsurge (Breitenfellner and Crespo Cuaresma, 2008), a correlation that can be ascribed to the following five channels: First, oil producers aim to regain the purchasing power of their export revenues, which are typically denominated in U.S. dollar. Second, demand increases in countries whose currencies appreciate against the U.S. dollar. Third, commodity investments gain in attractiveness over U.S. dollar investments. Fourth, monetary easing motivated by exchange rate movements stimulates greater demand. Fifth, currency markets reflect fundamental factors that are pivotal for commodity markets.

In summary, we underline that the relationship between the real economy and financial markets is complex. Futures markets help to form expectations regarding future prices, and these expectations in turn determine prices. That investors tend toward *overshooting* is a recognized phenomenon (Dornbusch, 1976). In this sense, the change in the relationship between spot and futures markets observed over a number of years suggests that the long-term uptrend in prices triggered by fundamental market developments has been exacerbated by speculation (Kaufmann and Ullman, 2009). Equally, the altered relationship between real oil prices and stock prices indicates the existence of several price bubbles since the turn of the millennium (Miller and Ratti, 2009). As a result, crude oil prices have almost certainly overshot their fundamental equilibrium values. As to whether speculation plays a role in price formation beyond this and shapes trends, judgment remains reserved.

Table 1

Time Series Data for Individual Crude Oil Price Indicators

Factor group	Individual indicator	Description	Periodicity	Period covered	Source
Crude oil price	West Texas Intermediate	Nominal U.S. benchmark crude price: *Cushing, OK West Texas Intermediate Spot Price FOB* (USD per barrel).	daily	01/1983–04/2009	Energy Information Administration
Demand	Federal Funds Rate	Federal Funds Rate, U.S. base rate	monthly	01/1983–03/2009	Federal Reserve System
	10-year bonds	10-year U.S. bonds	monthly	01/1983–02/2009	Federal Reserve System
	Inflation in the U.S.A.	U.S. Consumer Price Index	monthly	01/1983–02/2009	Bureau of Labor Statistics
	M2 growth	M2 monetary growth, annual growth	monthly	02/1980–07/2009	Federal Reserve System
	EMBI spread	Difference between government bonds issued by emerging economies and U.S. bonds	daily	01/1998–04/2009	Thomson Reuters
	Energy intensity, worldwide	Worldwide energy intensity is calculated by dividing total primary energy consumption in British thermal unit quadrillions (10^{15}) by GDP. For every country and year available from Global Insight, the exchange rate (for the year 2000) in billions of U.S. dollars is applied.	annually	1980–2006	Energy Information Administration
	Energy intensity, North America	see above	annually	1980–2006	Energy Information Administration
	Temperature	Average world temperature	monthly	1983–2009	National Climatic Data Center
	GDP growth China		annually	1983–2008	Chinese Statistical Bureau
	GDP growth euro area		annually	1984–2008	OECD
	GDP growth EU		annually	1985–2008	OECD
	GDP growth G-7		annually	1986–2008	OECD
	GDP growth OECD		annually	1987–2008	OECD
	GDP growth OECD Europe		annually	1988–2008	OECD
	September 11	Dummy variable for September 11		1 for 09/2001	

(continued) Table 1

Time Series Data for Individual Crude Oil Price Indicators

Factor group	Individual indicator	Description	Periodicity	Period covered	Source
Supply	Total oil rigs[1]	Rig count, indicator of drilling activity	monthly	01/1995–04/2009	Baker Hughes BHI International Rig Count
	Total gas rigs	Rig count, indicator of drilling activity	monthly	01/1995–04/2009	Baker Hughes BHI International Rig Count
	Refining capacity[2]	Total refining capacities worldwide	annually	01/1983–03/2009	Energy Information Administration
	Capacity utilization	Rate of refining capacity utilization, could be indicator of shortfalls in the crude oil market. Denotes the rate at which the processing capacities of the available refineries are utilized.	monthly	01/1985–04/2009	Energy Information Administration
	Oil reserves, worldwide	Estimated quantities of energy sources that are recoverable under existing economic and operating conditions with reasonable certainty according to analysis of geologic and engineering data. The location, quantity, and grade of the energy sources are usually considered to be well established in such reserves.	annually	1980–2009	Energy Information Administration
	Oil supply, worldwide	Total oil supply comprises the production of crude oil, natural gas plant liquids, other condensates and products derived in the refining process.	quarterly	Q1/1994–Q4/2009	Energy Information Administration
	Oil stocks, worldwide	Worldwide oil stocks cover crude oil (including strategic reserves), natural gas plant liquids, refinery feedstocks, additives and oxygenates, other hydrocarbons and petroleum products	quarterly	Q1/1973–Q4/2008	Energy Information Administration
	Exploration costs	Real costs of crude oil, natural gas and non-productive wells (dry holes).	annually	1960–2007	Energy Information Administration
	Baltic Dry Index	Baltic Dry Index of the Baltic Exchange	monthly	05/1985–07/2009	Datastream
	Hurric 1	Dummy variable for hurricane Ivan		1 for 09/2004	
	Hurric 2	Dummy variable for hurricane Katrina		1 for 08/2005	
	Hurric 3	Dummy variable for hurricane Gustav		1 for 08/2008	
	Gulf War 1	Dummy variable for the first Gulf War		1 for 08/1990–02/1991	
	Gulf War 2	Dummy variable for the Iraq War 2003		1 for 03/2003	
Crude oil market	Share of OPEC reserves	See worldwide oil reserves, OPEC share	annually	1980–2009	Energy Information Administration
	OPEC quota	Total production quotas of OPEC member states, as agreed at OPEC meetings.	irregularly (depending on the day of the meeting)	04/1982–11/2007	OPEC
	Saudi Arabia quota	Saudi Arabia's production quota, as agreed at OPEC meetings.	irregularly (depending on the day of the meeting)	04/1982–11/2007	OPEC
	Oil supply, OPEC share	See worldwide oil supply, OPEC share	quarterly	Q1/1994–Q4/2009	Energy Information Administration
Financial market	U.S. NEER	U.S. dollar nominal effective exchange rate	monthly	01/1981–02/2009	Bank for International Settlements
	U.S. REER	U.S. dollar real effective exchange rate	monthly	01/1981–02/2010	Bank for International Settlements
	S&P Composition	S&P 500 (Standard & Poor's index of the 500 largest listed companies in the U.S.A.)	daily	01/1981–03/2009	Thomson Reuters
	Net positions	Non-commercial long positions less non-commercial short positions of the NYMEX WTI crude oil futures	biweekly (14 to 16 days)	15/01/1986–31/03/2009	U.S. Commodity Futures Trading Commission

Source: OeNB.

[1] A drilling rig works the drill pipe into the ground and creates a new borehole (or diverts an existing one) to locate, make accessible and exploit crude oil or natural gas.

[2] Capacities that could be mobilized within 30 days in addition to those that are undergoing repair and could be mobilized within 90 days. The capacity refers to the input quantity in barrels that can be processed within a 24-hour day.

2 Selection of Possible Determinants

To accommodate the multitude of factors that potentially determine oil prices, this study examines different variables relating to each of the four groups previously outlined (supply, demand, oil market and financial markets).

On the supply side, the *total oil rigs* and *total gas rigs* variables provide an indication of the current level of production. Most notably, the number of oil rigs has increased significantly over the last ten years, while the rise in the number of gas rigs has been less pronounced. A substitution relationship exists between oil and gas production (especially when it comes to electricity generation).

The worldwide *refining capacities* and their degree of *capacity utilization* describe supply-side factors that should bear a close relationship to short-term shortfalls on the oil market.

If there is a general expansion of refining capacities, bottlenecks caused by growing demand can be countered more quickly. Following this logic, a negative impact on crude oil prices would be the result. On the one hand, if the rate of actual utilization of available refining capacities gets closer to the total capacity limit, this could be interpreted as an increase in shortages on the market. Consequently, a higher rate of capacity utilization would result in rising oil prices. On the other hand, higher capacity utilization at existing capacities leads to a short-term increase in supply. Analysis of the two time series reveals a sharp rise in worldwide refining capacities, particularly between 1997 and 2001 (9.4%). A further, albeit smaller upturn can be observed between the end of 2005 and the beginning of 2007 (chart 5).

Another variable is frequently mentioned in the debate surrounding the subject: available *reserves,* which are hypothesized to contribute to oil price hikes (particularly in the last few years). As outlined in section 1, the relatively low reserve stocks in OECD countries lead to tensions that may translate into upward oil price movements. For their part, the total *reserve stocks* available worldwide represent a significant variable in the determination of oil prices. The time series included in this study are based on geological and technical estimates of existing energy sources. Chart 5 shows that the estimates of worldwide reserves have more than doubled since 1985. The OPEC countries' reserves saw a particularly sharp increase between 1978 and 1988, while the reserves of non-OPEC countries remained at around 200 to 250 billion barrels for a long period. After that, between 2002 and 2003, they experienced a strong surge to almost 400 billion barrels.

The group of supply-side variables also contains the entire *worldwide supply* as a time series, which, in addition to crude oil production, also includes liquids and other refinery products. While the global oil supply has, with some fluctuations, increased moderately since the mid-1990s, the ratio between OPEC and non-OPEC supply has barely changed at all. We expect a negative effect of overall crude oil supply on prices.

The cost of developing new oil wells is a further aspect that is critical in the group of supply-side variables. Upward movements in the costs associated with exploring new oil fields should be reflected in the oil price. Until the 1990s, the costs of exploration remained relatively stable, but increased by more than sixfold over the following 15 years. Finally, this group of factors also includes the time series of the *Baltic Dry Index,* which serves as a measure of the transport costs for commodities.

Based on the assumption that the accumulation of *crude oil reserves* permits greater flexibility in countering short-term supply shortages, we included the worldwide crude *oil inventories* variable in the group of supply-side variables. However, as changes in inventory levels simultaneously create precautionary demand, the direction of this variable on oil prices cannot *a priori* be determined conclusively.

On the demand side, which in the debate on the subject is frequently viewed as being responsible for the most recent surge in oil prices, this study uses time series for economic development (GDP) in the euro area and the EU, China, the OECD and the G-7, as well as the *J.P.Morgan EMBI spread* series. Furthermore, to account for the economic and investment environment, we used relevant monetary and macroeconomic data, such as the *U.S. Federal Funds Rate, consumer price index developments, monetary growth* (M2) in the U.S.A., and the *10-year U.S. bond rate.* Here, too, the net effect of the different variables is a priori not clearly defined. Hotelling's theory, for example, suggests a positive influence of interest rates on the oil price (the price of an exhaustible resource increases in line with the rate of interest). At the same time, however, a fall in interest rates might also lead to increasing demand and thus to a rise in oil prices.

Finally, alongside demand developments that occur as a result of short-term changes in economic activity, the economies' *energy intensity* is another relevant, structural variable. An increase in energy consumption for a given output level has an impact on the demand for oil and thus possibly on the oil price. Energy intensity witnessed a sharp decline before the turn of the millennium; since then, it has fluctuated between 12,400 and 12,600 British Thermal Units (BTU) per U.S. dollar.

We account for the possible impact of oil-market variables – especially of OPEC countries – on the oil price (section 1) by taking account of the frequently cited *OPEC production* quota and the OPEC's share in world crude oil reserves, among others. Given the important role Saudi Arabia plays in crude oil production and thus in price dynamics, this study also examines a separate time series for Saudi Arabia's OPEC quota. For both production quota time series, we expect a negative effect on the short-term development of crude oil prices, as has been empirically demonstrated by Dees et al. (2004).

The group of financial market variables draws upon the time series of the *S&P 500 index*, which is based on the share prices of the 500 largest listed U.S. companies and should therefore be a good indicator of the U.S. financial markets, which have worldwide significance. A positive, investment-boosting atmosphere in international financial markets should also be reflected in the development of oil prices, moving them in a positive direction.

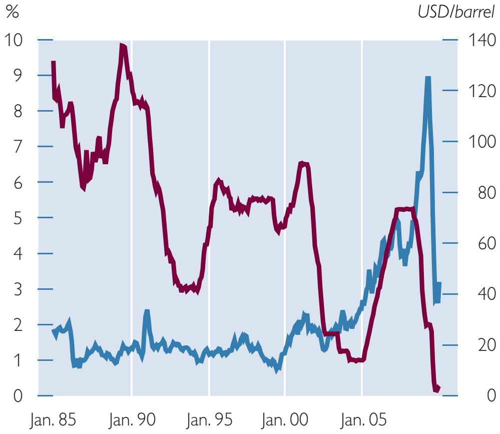
We use the time series of the Commodity Futures Trading Commission's *net positions* in the futures market (noncommercial long positions minus noncommercial short positions) as a proxy for speculative investor behavior, as suggested by Gurrib (2007) in his study on crude oil prices and speculation. Finally, the exchange rate is also included as a significant financial market variable for explaining crude oil prices (Breitenfellner and Crespo Cuaresma, 2008).

Important geopolitical and historical events (e.g. the Second Gulf War from August 1990 to February 1991 and the Iraq War in 2003) are also accounted for by using dummy variables.

Chart 5

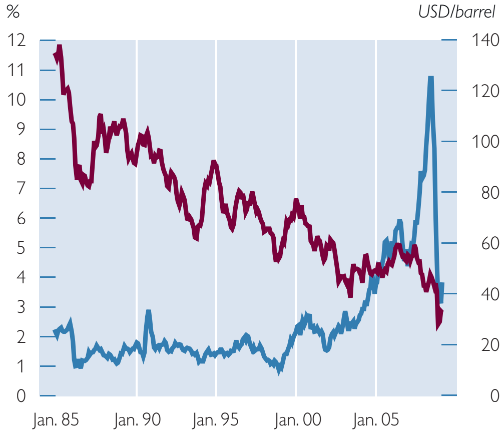
Potential Determinants of Crude Oil Prices

Federal Funds Rate



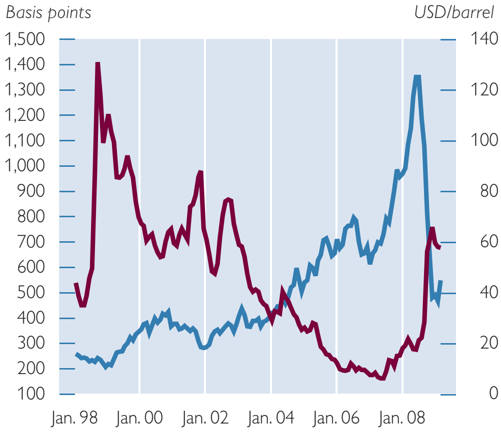
Federal funds rate (left-hand scale)
Crude oil price (right-hand scale)

Interest for 10-Year Bonds



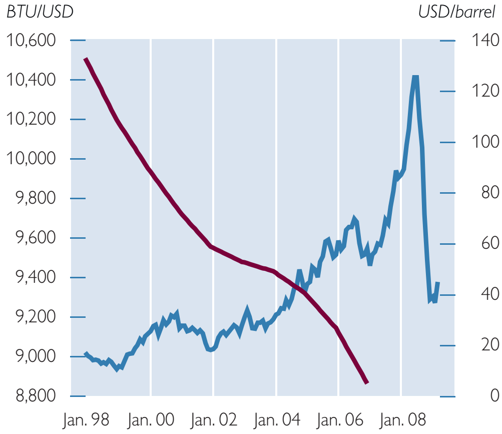
Interest for 10-year bonds (left-hand scale)
Crude oil price (right-hand scale)

EMBI Spread



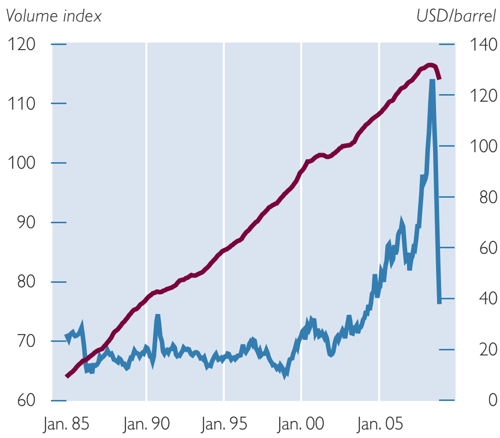
EMBI spread (left-hand scale)
Crude oil price (right-hand scale)

Energy Intensity Worldwide



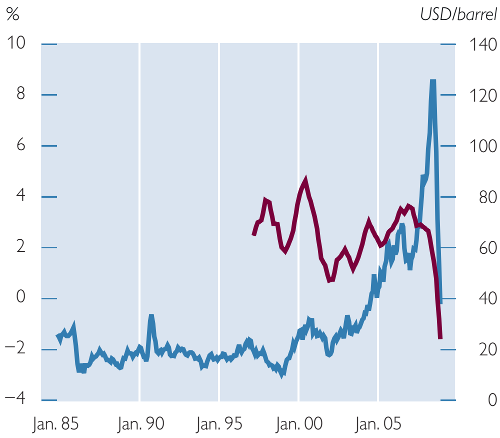
Energy intensity (left-hand scale)
Crude oil price (right-hand scale)

GDP Growth, G-7



G-7 GDP growth (left-hand scale)
Crude oil price (right-hand scale)

GDP Growth, OECD Europe



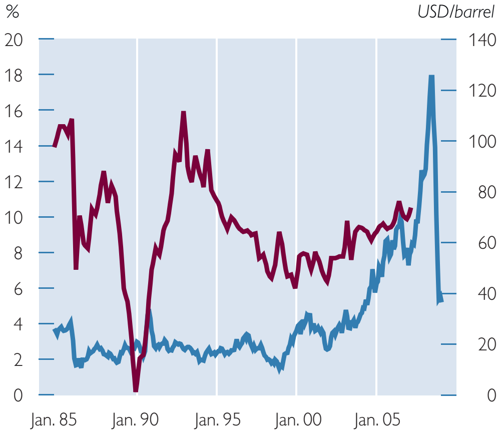
OECD Europe GDP growth (left-hand scale)
Crude oil price (right-hand scale)

Source: Oil Market Report, EIA, Thomson Reuters.

(continued) Chart 5

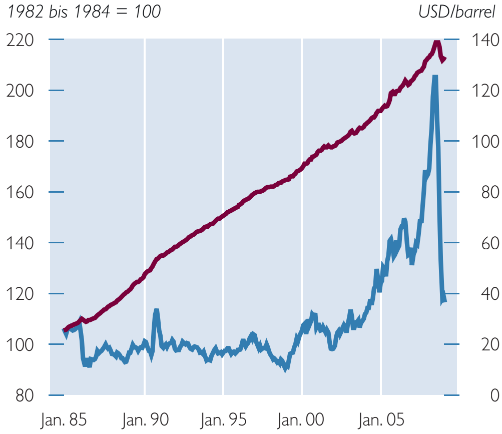
Potential Determinants of Crude Oil Prices

GDP Growth, China



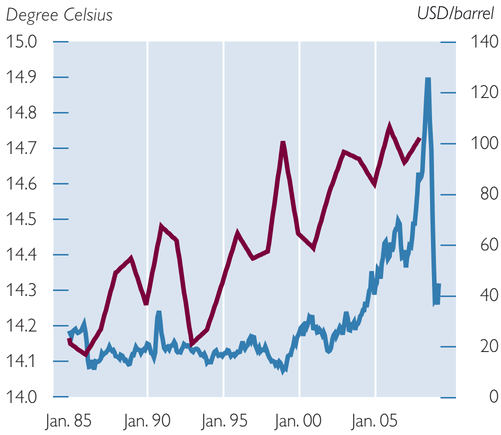
China GDP growth (left-hand scale)
Crude oil price (right-hand scale)

U.S. Consumer Price Index



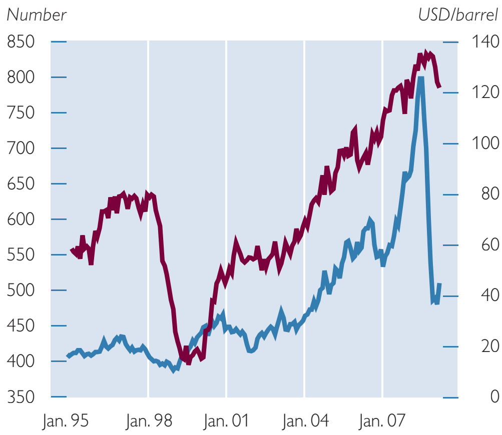
CPI U.S.A. (left-hand scale)
Crude oil price (right-hand scale)

Average World Temperature



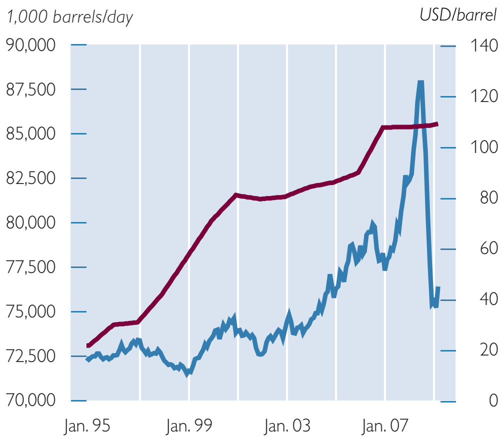
Average world temperature (left-hand scale)
Crude oil price (right-hand scale)

Total Oil Rigs



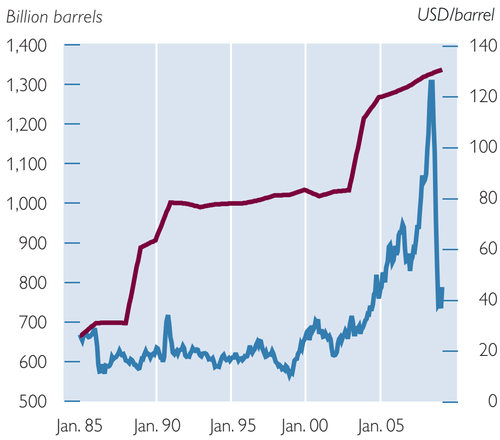
Total oil rigs (left-hand scale)
Crude oil price (right-hand scale)

Worldwide Refinery Capacities



Worldwide refinery capacities (left-hand scale)
Crude oil price (right-hand scale)

Worldwide Oil Reserves



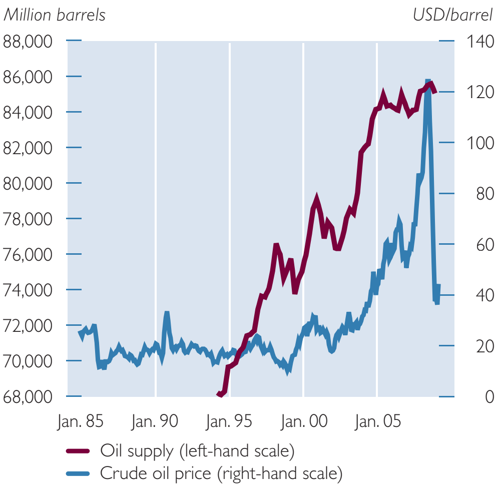
Worldwide oil reserves (left-hand scale)
Crude oil price (right-hand scale)

Source: Oil Market Report, EIA, Thomson Reuters.

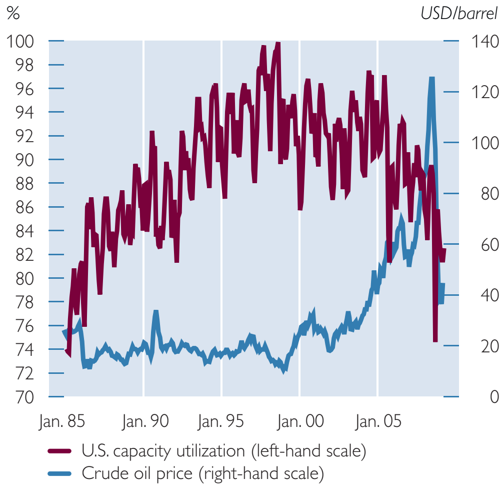
(continued) Chart 5

Potential Determinants of Crude Oil Prices

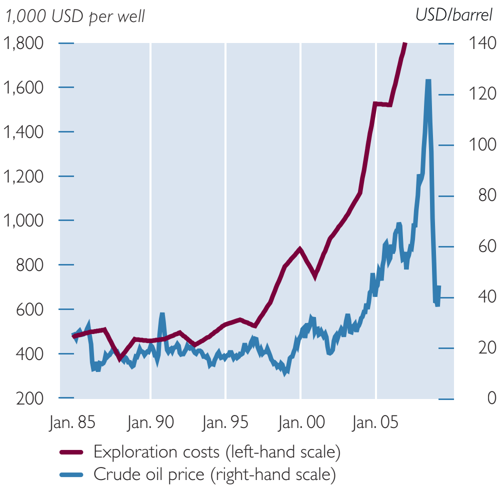
Oil Supply



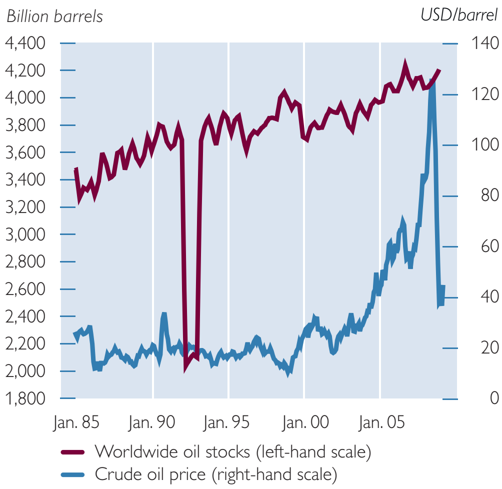
U.S. Capacity Utilization



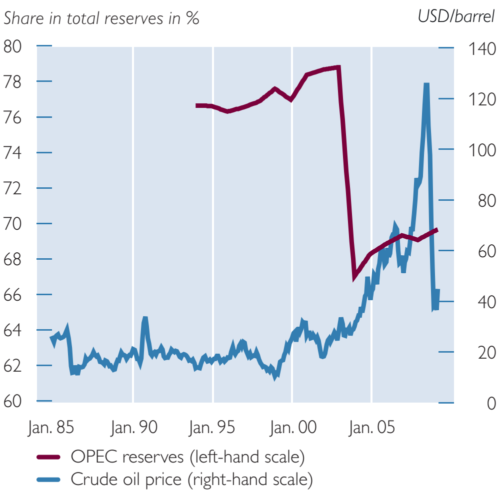
Exploration Costs



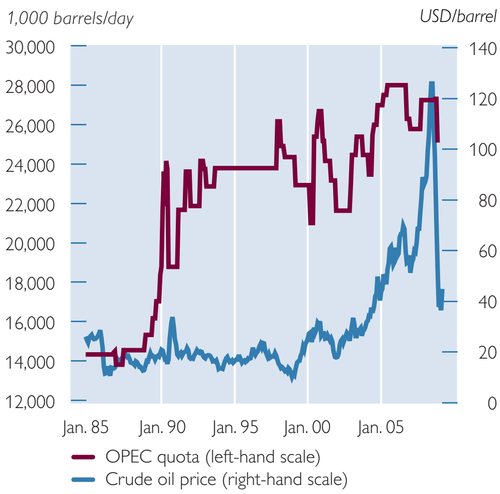
Worldwide Oil Stocks



OPEC Reserves



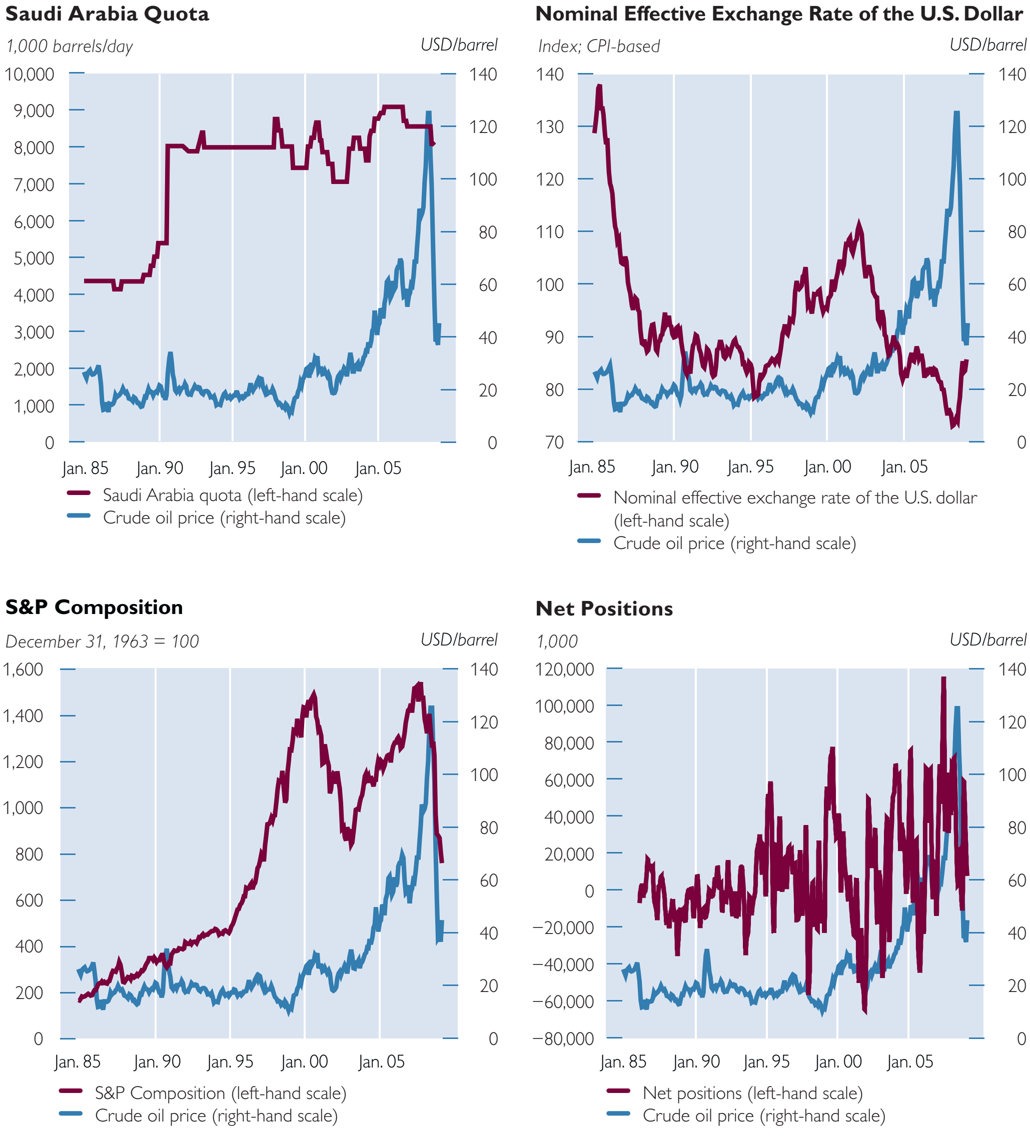
OPEC Quota



Source: Oil Market Report, EIA, Thomson Reuters.

(continued) Chart 5

Potential Determinants of Crude Oil Prices



Source: Oil Market Report, EIA, Thomson Reuters.

3 Applying Bayesian Model Averaging to Oil Price Inflation

BMA is a technique designed to help account for the uncertainty inherent in the model selection process, a factor that traditional statistical analysis often neglects. By averaging over many different competing models, BMA incorporates model uncertainty into conclusions about parameters and prediction. BMA has been applied successfully to many statistical model classes, including linear regression models, generalized linear models, Cox regression models and discrete graphical models. In most cases, using BMA improved predictive performance. In economics, BMA has been applied mainly to economic growth determinants (Fernández et al. 2001; Sala-i-Martin et al., 2004; Crespo Cuaresma and Doppelhofer, 2007). Recently, however, BMA has also been applied to other economic research questions, such as determinants of currency crises (Crespo Cuaresma and Slacik, 2009). A thorough account of the statistical details of BMA can be found in Raftery (1995) and Hoeting et al. (1997). Due to space constraints, we will just provide intuitive aspects of the method and their implementation.

The basic idea behind BMA is to obtain weighted average estimates of parameters of interest across potential models, using the (probabilistic) belief in each model after observing the data as a weight. In our application, the class of models considered can be parameterized as follows

$$p_t = \alpha + \sum_{j=1}^{k} \beta_j x_{j,t-1} + \varepsilon_t \qquad (1)$$

where p_t is the oil price inflation variable and x_{jt} *for* $j = 1, \ldots, K$ are variables which may have an effect on p_t.[16] There are thus 2^K possible linear models that can be considered using this set of explanatory variables. BMA estimates are obtained by weighting each estimate with the posterior probability of the model it comes from, and summing over the whole model space, which is composed by all 2^K models. The posterior model probability is, in turn, a function of the prior inclusion probability of the model and the marginal likelihood of the model, which summarizes how well the model fits the data. In BMA, Zellner's g-prior is the most common choice of prior distribution over the parameters of a given model (Fernández et al. 2001a; Liang et al., 2008; Feldkircher and Zeugner, 2009), while a flat prior probability over models is the preferred choice in the literature. Recently, Ley and Steel (2009) proposed using a hyperprior on model size. They show that this approach leads to more robust inference when applying BMA. In our application, we use the BRIC prior over model parameters proposed by Fernández et al. (2001), and the hyperprior over the model space put forward by Ley and Steel (2009). The *BRIC prior* over the parameter space bridges the use of the Bayesian information criterion (BIC) and the risk inflation criterion (RIC) as an instrument to obtain posterior model probabilities. Using simulated data, Fernández et al. (2001) show that the BRIC prior has the best performance among the different g-priors put forward in the literature.

The lack of a single, consistent theoretical framework in which to frame the choice of explanatory variables for oil price changes makes BMA an optimal method for our application. Table 1 presents the set of variables which are used as potential covariates. The variables are measured at monthly frequency[17] and they represent different oil demand and supply factors, as well as factors related to financial markets and the structure of the market for oil. The strongly persistent nature of the time series of oil price changes implies that the lagged changes in oil price inflation should also be considered as a further determinant.

Results

The results of the BMA exercise are summarized in table 2 for the whole sample, as well as for the subperiods 1983 to 1989, 1990 to 1999 and 2000 to 2008. The breakdown by decades is useful in that it proxies phases of key oil

[16] *All variables in our dataset which have a trending behavior are transformed by taking the annual growth rate so as to ensure stationarity of all covariates.*

[17] *If the source data are not available at monthly frequency, we aggregate the data by taking monthly averages (for higher frequencies) or interpolate the data linearly to monthly frequencies (for frequencies lower than monthly).*

price developments: dropping prices in the 1980s, low prices in the 1990s, and the oil price boom that lasted almost until the outbreak of the financial crisis. Owing to limited data availability, we use different subsets of variables as the potential set of determinants in each subperiod. The number of potential models from which BMA estimates are computed is intractable for most of the settings proposed in our study, so we use the MC-3 method *(Markov chain Monte Carlo model composite)* to compute the necessary statistics. The results in table 2 are based on 2 million Markov chain draws, computed after discarding 1 million burn-in draws. For each exercise, we present the results in terms of the posterior inclusion probability of each covariate and the mean and standard deviation of the posterior distribution of the corresponding parameter in equation (1). Bold print is used for variables with a posterior inclusion probability above 0.5, which we label "robust" determinants. One surprising result is that practically no single explanatory variable is robust for the full sample setting (1983 to 2008). The only exception is U.S. inflation, whose lag is negatively related to oil price inflation. This result, however, cannot be directly interpreted as a causal link, and provides evidence against theories claiming that in the past, oil price shocks were always preceded by inflationary pressure (Barsky and Kilian, 2004). At the same time, the parallel dynamics of oil price inflation and the U.S. business cycle postulated by Hamilton (2009) may also give rise to this type of partial correlation between X and Y. Other than that, only the autoregressive term appears to be robust in the full-sample results. The estimate of the autoregressive parameter implies a very high persistence of oil price inflation, a feature which is also present in the different subsamples studied.

Table 2

Bayesian Model Averaging: Results

	1983 to 2008			2000 to 2008			1990 to 1999			1983 to 1989		
Variable	PIP	PM	PSD	PIP	PM	PSD	PIP	PM	PSD	PIP	PM	PSD
Demand												
Federal funds rate	0.012	0.000	0.000	0.007	0.000	0.001	0.012	0.000	0.001	0.037	0.000	0.002
10-year bonds	0.028	0.002	0.016	0.007	0.000	0.012	0.081	0.014	0.054	0.028	0.004	0.045
U.S. inflation	**0.714**	**−1.926**	**1.395**	**0.970**	**−7.182**	**2.147**	0.017	−0.014	0.290	0.306	−3.552	5.921
M2 growth	0.009	0.000	0.000	0.006	0.000	0.001	0.019	0.000	0.001	0.056	0.000	0.004
EMBI				0.009	0.002	0.028						
EMBI spread				0.247	0.000	0.000						
Energy intensity (worldwide)				0.025	−0.112	0.989						
Energy intensity (North America)	0.030	0.034	0.226	0.014	0.045	0.855	0.011	0.001	0.112	0.183	0.842	1.945
Temperature	0.009	0.000	0.003	0.022	0.004	0.034	0.011	0.000	0.004			
GDP growth China	0.026	−0.011	0.080	0.006	−0.002	0.101	0.013	−0.001	0.066	0.111	0.026	0.083
GDP growth euro area				0.099	1.216	4.398				0.174	−0.269	0.654
GDP growth EU				0.072	1.066	4.230						
GDP growth G-7	0.187	0.356	0.803	0.084	1.127	4.016	0.022	0.041	0.433	0.040	−0.089	1.290
GDP growth OECD				0.040	0.411	2.618						
GDP growth OECD Europe				**0.732**	**11.105**	**6.994**						
Dummy variable for September 11	0.019	−0.001	0.011	0.010	−0.001	0.007						
Supply												
Oil rigs				0.011	−0.002	0.027						
Gas rigs				0.006	0.000	0.008						
Refining capacity	0.015	−0.006	0.076	**0.995**	**−14.515**	**2.629**	0.019	0.016	0.153	0.049	−0.069	1.066
Oil reserves, worldwide	0.043	0.013	0.069	0.077	−0.126	0.469	0.434	1.184	1.456	0.073	0.062	0.282
Oil supply, worldwide				0.023	−0.025	0.195	0.014	0.005	0.060			
Oil stocks, worldwide	0.012	0.000	0.005	0.007	−0.003	0.070	0.029	−0.002	0.013	0.020	0.000	0.014
Capacity utilization				0.005	−0.001	0.022	0.013	0.000	0.018			
Exploration costs	0.018	0.001	0.011	0.014	0.001	0.017	0.014	0.001	0.006	0.050	0.000	0.100
Baltic Dry Index				0.058	0.004	0.016						
Dummy variable Hurric 1	0.009	0.000	0.006	0.003	0.000	0.003						
Dummy variable Hurric 2	0.007	0.000	0.004	0.004	0.000	0.003						
Dummy variable Hurric 3	0.278	−0.041	0.072	0.007	0.000	0.006						
Dummy variable Gulf War 1	0.010	0.000	0.003				0.014	0.000	0.004			
Dummy variable Gulf War 2	0.033	−0.003	0.019	0.012	−0.001	0.008						
Oil market structure												
Share of OPEC reserves				0.027	0.012	0.114						
OPEC quota	0.009	0.000	0.010	0.009	0.001	0.022	0.009	0.001	0.013	0.111	0.139	0.444
Saudi Arabia quota	0.058	0.008	0.038	0.006	0.000	0.014	**0.596**	**−0.301**	**0.298**	0.029	−0.007	0.059
Oil supply, OPEC share				0.013	0.007	0.079						
Financial market												
Nominal effective exchange rate of the U.S. dollar	0.013	0.000	0.029	0.038	0.111	0.704	0.027	−0.008	0.063	0.170	0.179	0.646
Real effective exchange rate of the U.S. dollar	0.013	−0.002	0.038	0.054	−0.170	0.950	0.030	−0.012	0.085	0.141	0.100	0.710
S&P Composite Returns	0.173	0.022	0.052	0.009	0.001	0.016	0.013	−0.001	0.016	0.026	0.004	0.041
Net positions				0.008	0.000	0.000	0.009	0.000	0.000			
Autoregression												
Lagged oil inflation	**1.000**	**0.961**	**0.030**	**1.000**	**0.865**	**0.081**	**1.000**	**0.942**	**0.046**	**1.000**	**0.955**	**0.078**
Number of observations		299			107			119			71	

Source: OeNB.

Note: Dependent variable: year-on-year oil price inflation. PIP stands for Posterior Inclusion Probability, PM for Posterior Mean, which is the mean of the posterior distribution of the parameter for the corresponding variable. PSD stands for Posterior Standard Deviation, i.e. the standard deviation of the posterior distribution of the parameter for the corresponding variable. Results are based on 2 million Markov chain Monte Carlo model composite draws. Bold values indicate PIP>0.5.

While the results of the full sample indicate that there is no single systematic explanation for oil price inflation over the 25-year period under review, the analysis of subsamples reveals that this is the case partly because the importance of the numerous channels put forward above varies over time. During the 1980s, no single mechanism can explain oil price dynamics robustly, and only *lagged oil price inflation* appears robustly related to oil price changes. The analysis of the 1990s, on the other hand, reveals that market structure, and in particular the strategic position of *Saudi Arabia* within the group of oil producing countries played a key role in explaining oil price changes in that period. Our results imply that in the 1990s, increases in the Saudi Arabian quota were systematically related to decreases in oil price inflation, even though the estimate of the quantitative effect is not very precise.

We find new robust determinants of oil price inflation if we concentrate on data for the period from 2000 to 2008. On the one hand, it is only in this period that oil demand proxies appear to be robust determinants. Our results indicate that stronger GDP growth in industrialized countries led to higher oil price inflation over the last decade. The BMA exercise highlights European GDP growth as the key variable in this channel, but we should keep in mind that, given the correlation of all economic growth variables in our dataset, this variable may be proxying global demand-driven pressure on oil prices. On the other hand, changes in refining capacity also appear robustly related to oil price changes in this subsample. The negative, very precisely estimated parameter indicates that increases in refining capacity were indeed successful in accommodating short-run demand changes during the last decade.

The results of our analysis suggest that recent oil price changes were triggered by numerous and time-varying mechanisms. No single channel tends to dominate as an empirical determinant of oil price inflation in the full period from 1983 to 2008. The study of subsamples reveals that demand factors and short-term changes in refining capacity can robustly explain changes in the last decade, while the strategic position of the OPEC, and in particular of Saudi Arabia, seems to be the most relevant factor behind oil price changes in the 1990s.

4 Conclusions

This paper provides an overview and a ranking of numerous short-term determinants of crude oil prices. Essentially, our findings confirm the theoretical suggestions that fundamental factors trigger and dominate price trends, but we do not find evidence to support monocausal explanations. Rather, the price of oil is the outcome of complex processes occurring within the global economy.

Throughout the entire period under examination, our results suggest that of the short-term factors on the supply side, consumer price inflation plays a significant part in modeling crude oil price fluctuations. Moreover, Saudi Arabia's production quota – a factor relating to the market structure – gained increasing prominence in the 1990s, while in the 2000s, both supply and demand factors (European demand for oil and refining capacities) are most prevalent in determining crude oil prices (Wurzel et al., 2009). In addition, our results show that the pricing process is subject to a certain degree of persistence, which Dvir and Rogoff (2009) also confirm from a historical perspective. Once prices move in a certain direction, it can only be reversed with difficulty.

The results of our analysis do not preclude the possibility that in the long run other determinants discussed in this paper may become significant. Provided they coordinate themselves effectively, crude oil producers would certainly be in a position to exercise pricing power in the event of supply shortages. Furthermore, the role of speculation and financial market participants' investment strategies, although not easy to prove, can hardly be excluded. Although financial flows essentially follow fundamental market trends, they can nevertheless determine price developments over the short to medium term.

The econometric results do not necessarily contradict the view that the most recent oil price shock was caused by a chronological sequence of all four groups of determinants (demand, supply, structure of the oil market and speculation). Originally, the demand trend from emerging economies seems to have played a decisive role. This perhaps also accounts for the initially rather moderate macroeconomic effect in comparison with historical oil price shocks, which were primarily caused by (expectation of) short-term scarcity of supply.[18] Evidently, demand shocks have a less severe impact on growth than supply shocks, which incur the same reaction as imposing a tax on oil importing economies. Later on, long-term supply factors have obviously become more significant in comparison with demand factors, considering the worldwide rise in inflation from mid-2007 and the deep recession of 2008–2009. In addition, it is conceivable that interaction between crude oil producers and financial market participants in the most recent phase of the price surge exacerbated the pressure on oil prices (Hamilton, 2008).

This study marks a starting point for investigating oil price determinants by applying the Bayesian approach. It might be interesting to include the time periods surrounding the first two oil price shocks of the 1970s and 1980s in future research, although this would likely entail accepting lower frequency and quality of data. Moreover, to the extent that more frequent (at least weekly) data are available, possible structural interruptions could be analyzed. Finally, the Bayesian approach could be combined with cointegration methods in order to capture long-term determinants. These examples demonstrate promising fields for future research.

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[18] *Other explanations for this benign effect include, for example, a more credible monetary policy and/or more flexible labor markets.*

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