The Impact of Oil Price Changes on Growth and Inflation

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This contribution looks into the impact of oil price changes on growth and inflation. Oil price shocks affect the economy through the supply side (higher production costs, reallocation of resources), the demand side (income effects, uncertainties) and the terms of trade. The effects of oil price shocks have become less intense over time (thanks to technological innovation, the development of cost-effective alternative sources of energy, sectoral change and the structural change of the oil market) and are asymmetric. An increase in the price of oil feeds through to GDP growth to a much larger extent than a decline, a phenomenon that can be attributed to adjustment costs associated with sectoral reallocations, the implications of uncertainties for spending on consumer durables and investment, and nominal wage rigidities. Furthermore, the element of surprise in oil price hikes seems to play a considerable role. Thus, when a rise in the price of oil occurs after a prolonged period of oil price stability, it has a larger impact than a price hike which immediately follows previous cuts.

The role of monetary policy is still a controversial issue.

According to some authors, a tightening of monetary policy following an oil price shock has a much more severe impact than the direct effects of the oil price shock themselves. However, empirical evidence on this matter is ambiguous. Current simulations for the euro area, the U.S.A. and Japan show that a constant oil price rise of 10% generates negative growth effects of some 0.1% a year in the first three years – not taking into account monetary responses. After that, the negative effects quickly fade. The impact on inflation ranges from 0.1 to 0.2 percentage point, with Austria at the lower end of the international spectrum. A simulation of the effects caused by the oil price remaining stable at USD 40 as of the third quarter of 2004 instead of falling to USD 29.2 until 2006 – as assumed in the OeNB Spring 2004 Outlook – would slow down growth in Austria by 0.03 percentage point in 2004 and by 0.2 percentage point in both 2005 and 2006. Inflation would be 0.1, 0.4 and 0.3 percentage point higher in 2004, 2005 and 2006, respectively.

1 Transmission Channels of Oil Prices

Oil price shocks affect the economy through different channels: the supply side, the demand side and the terms of trade. *Supply suffers as production costs rise* in the wake of an oil price shock. Given substitution between production factors, relative price changes result in a *reallocation of the means of production*. This, in turn, cushions the negative effects. The long-term effects on production capacity are thus less pronounced than the short-term effects, which are dominated by frictions arising as a result of resource reallocations and by uncertainties about the subsequent development of oil prices. However, these intersectoral reallocations also generate costs (training expenses, irreversible investments, etc.). The actual impact on investment essentially depends on the expectations about the stability of oil price changes, which tend to vary over time. On the *demand* side, oil price shocks drive up the general level of prices, which translates into lower real disposable incomes and thus reduces demand.

Apart from their direct effects on the general *price level,* oil prices also have second-round effects, as *rigid nominal wages* and *price and wage indexation* add to inflation. Higher wage pressures and weaker demand dampen employment. In addition to that, a deterioration of confidence and stock market reactions can amplify the impact of a shock. Furthermore, economies are hit by changes in the international environment brought about by oil price shocks. Climbing import prices trigger a deterioration of the *terms of trade* and thus precipitate welfare losses. Apart from the channels described so far, the *monetary policy response* plays an important role (see chapter 3). The above findings apply to oil importing countries. *Oil exporting countries* benefit from higher export revenues, which are, however, diminished by a decline in global demand.

2 Asymmetry and Waning of Effects over Time

Virtually every empirical study finds asymmetric effects. An increase in the price of oil feeds through to GDP growth to a much larger extent than a decline. This phenomenon can be attributed to *adjustment costs associated with sectoral reallocations* and the *implications of uncertainties for spending on consumer durables and investment*. According to the so-called *dispersion hypothesis,* oil price hikes lead to a reallocation of resources from energy-intensive to energy-efficient sectors. As this reallocation progresses only gradually due to adjustment costs involved, a short-term decline in output results, which intensifies the economic slowdown. On the other hand, when oil prices shrink, the consequent expansion of aggregate output is dampened by adjustment costs. In this connection, adjustment costs on the labor market play an important role according to the *dispersion hypothesis. Nominal wage rigidities* also help explain asymmetric effects. When oil prices rise, employees will try to compensate the loss of their purchasing power by negotiating wage hikes. However, increases in real purchasing power caused by lower oil prices do not lead to sinking nominal wages. Another explanation for these asymmetric effects is that decisions on whether or not to buy consumer durables and capital goods (cars, real estate, heating, insulation, production facilities, etc.) are often based on energy prices. Oil supply problems fuel *uncertainty* and lead to an abrupt contraction of such expenditures. Therefore, rising oil prices entail a decline in demand, while falling oil prices do not trigger a spike in demand.

Since the 1970s the *correlation* between oil prices and GDP growth *has weakened*. Technological innovation, the development of cost-effective alternative sources of energy and sectoral change have diminished the ratio of oil imports to GDP in industrialized countries.

Modeling the correlation between oil prices and GDP growth is difficult not only because of the reduced impact of oil prices on GDP, but also because of changes in oil market structures. With the Organization of the Petroleum Exporting Countries' (OPEC) influence receding after 1980, oil prices have been increasingly dependent on demand (endogeneity problem). Furthermore, oil prices have become much more volatile since the introduction of forward and futures markets in the 1980s. In addition to that, central banks have changed their ways of reacting over time, which has contributed to the fading influence of oil prices on growth. These altered statistical properties have made it impossible for simple linear models to adequately describe the impact of oil prices on GDP growth. Empirical research thus predominantly uses nonlinear specifications (see e.g. Hooker, 1999a; Hamilton, 2003) and finds a relatively stable correlation between oil prices and GDP growth for the entire postwar period. Lee et al. (1995), for instance, transform the oil price, dividing the oil price change by the current volatility. Their study is also a first step towards measuring the *element of surprise in oil price changes.* Accordingly, when a rise in the price of oil follows a prolonged period of stable oil prices (during which theres is small current volatility), it has a stronger impact than a price hike which comes as an immediate adjustment of previous price drops.

3 The Role of Monetary Policy

When confronted with an oil price shock, monetary policymakers face a fundamental tradeoff. Depending on their monetary policy strategy, they can try to either counter real effects with expansive measures or to fight inflationary effects with restrictive measures. Monetary policy can therefore significantly determine the effects oil price changes have in the short run.

The empirical evidence on effects (and reactions) of monetary policy varies greatly. Some authors describe a *strongly restrictive impact of monetary policy* and weak to nonexistent direct effects. Conducting simulations with Vector Autoregressive (VAR) models, Bernanke et al. (1997) have found that a majority of the real effects of oil price shocks are not caused directly by the shock but by the subsequent *tightening of monetary policy*. According to Barsky and Kilian (2001), the 1970s stagflation was solely induced by monetary policy. The boom at the end of the 1960s was triggered by expansive monetary policy and resulted in price pressures for industrial goods and raw materials. Barsky and Kilian argue that the oil price hikes of 1973–74 (as well as 1979–80) were an endogenous reaction to the expansive monetary policy conducted by the Federal Reserve (Fed). The subsequent tightening of monetary policy led to stagflation. Barsky and Kilian partly based their arguments on leading indicators, which predicted that a recession would hit already in early 1973 (nine months prior to the first oil price shock but shortly after the tightening of monetary policy). Bohi (1989) goes one step further and largely disputes that oil prices by themselves have any significant macroeconomic impact. His claim is primarily based on the finding that no correlation between energy intensity and employment changes can be observed when analyzing disaggregated data from the periods following the oil price shocks of 1973 and 1979. Instead – just like Barsky and Kilian (2001) – he blames the restrictive monetary and fiscal policies of the U.S.A., the United Kingdom, Germany and Japan for the lackluster performance of these economies.

One question immediately arising in this context is how to define a *neutral reaction of monetary policymakers* to oil price shocks. In simulations conducted by Bernanke et al. (1997), the interest rate climbs after oil prices rise, while real GDP shrinks. By comparing these effects with a neutral reaction by monetary policymakers, the authors find that the negative effects of the oil price shock are mostly caused by monetary policy responses. However, this outcome decisively depends on how a neutral reaction of monetary policymakers is defined. Bernanke et al. define it as a constant interest rate after the shock, as opposed to the rising interest rate in the baseline scenario. Stable interest rates are, however, not the only option. Brown and Yücel (1998) examine how the definition of a neutral response determines the stability of the outcomes of Bernanke et al. Using alternative definitions of a neutral monetary policy response (a constant monetary aggregate or unchanged nominal GDP levels), they find that the Fed's reaction to previous oil price shocks has been neutral. Effects on GDP would thus have to be directly attributed to oil prices.

Some authors – such as Hamilton and Herrera (2001) – question a *strongly restrictive effect of monetary*

policy and believe there are stronger direct effects. There are, however, also studies describing an *expansive effect of monetary policy* in the wake of oil price shocks. Hooker (1999a), for example, has studied the impact of oil prices on U.S. inflation. While oil prices strongly affected core inflation prior to 1980, their influence conceivable regressed thereafter. Hooker ascribes this structural break to a shift in the monetary policy response. His VAR simulations, which use empirically estimated reaction functions of the Fed, indicate that before 1980, the Fed always answered oil price hikes with a considerable loosening of monetary policy. Its responses after 1980 were much weaker.

Overall it can be said that empirical evidence varies greatly. Changes in the structure of the oil markets, in demand patterns and in the reaction of monetary policymakers make it difficult to produce reliable empirical outcomes. On top of that, the commonly used VAR models are very sensitive to changes in specifications.

4 Oil Price Developments since World War II

Oil price developments since World War II up to the end of the 1990s can roughly be divided into three stages. Leading up to the 1970s, nominal oil prices were stable, while real oil prices slightly fell. The 1970s and early 1980s were characterized by the two oil price shocks of 1973–74 and 1979–80 with skyrocketing oil prices. After oil prices shrank in the first half of the 1980s, nominal oil prices fluctuated up until the 1990s around a relatively stable value of USD 15 to USD 20, with some temporary deviations. Even the surge in the run-up to the first war in Iraq reversed quickly. In terms of percentage increase the oil price hike of 1999–2000 is comparable to the second oil price shock of 1979–80. In 2001 and 2002 the global economic downturn triggered a temporary plunge in oil prices, which have picked up considerably again since the second war in Iraq was announced.

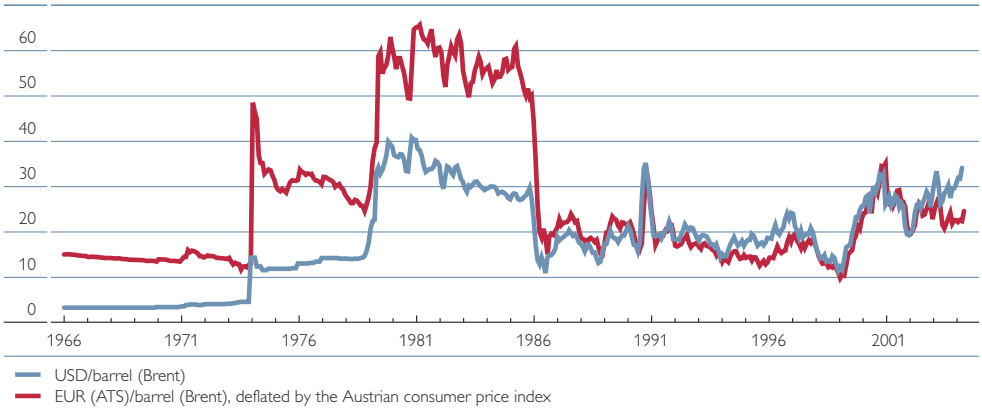
The *first oil price shock of 1973–74* was fueled by several factors. Even before the oil embargo was launched as a reaction to the Yom Kippur War in October 1973, global demand for oil accelerated immensely. The world economy at that time was at a stage marked by strong growth and low interest rates. Currency turmoil led to the collapse of the Bretton Woods System in 1973, ultimately resulting in the abandonment of the previously effective system of fixed exchange rates. The industrialized countries had already posted high inflation rates prior to the oil price shock, and the dollar sharply depreciated. These developments and the production cuts induced by the oil embargo caused oil prices to quadruple within a short time. The recession following the first oil price shock was aggravated by several factors. Monetary policymakers in the industrialized nations at that time were unable to quickly fight inflation. This brought about a change in inflation expectations. The then prevalent wage indexation and the institutional wage formation structures additionally intensified inflation.

The *second oil price shock of 1979–80* hit closely after the Iranian revolution in late 1978 and before the outbreak of the war between Iran and Iraq in October 1980. The international macroeconomic environment was posting solid growth, low interest rates and rising inflation, much like in the early 1970s. Contrary to the first oil price shock, the decline in the

worldwide oil supply was only temporary, as shortfalls in production in Iran and Iraq were offset by expanded output of other oil producers. Most of the price increase took place between the Iranian revolution and the outbreak of the war. At that time global production exceeded prerevolution levels, which means that shortfalls in output cannot serve as an explanation. Rather, current demand expanded as a consequence of heightened uncertainty about possible future shortages and assumed high demand. The monetary policy responses focused on retaining price stability to a much larger degree than during the first oil price shock. In 1979 the Fed started to actively fight inflation. However, inflation expectations, which had risen during the first oil crisis, rendered the real economic costs of containing inflation significant.

Chart 1

Historical Oil Price Movements



Source: IMF, Statistics Austria.

In the *1980s* OPEC's possibilities to intervene in prices dramatically receded. Oil supply of non-OPEC countries picked up as new oil producers came into existence and other countries, in particular the U.S.A., Mexico and the then USSR, stepped up output. At the same time the global slowdown of the economy lessened demand. This served as an incentive for OPEC producers to expand their market share and consequently their revenues by offering low prices. When Iraq invaded Kuwait in August 1990, the *first Gulf War* started. In the run-up to the war there was a notable rise in oil prices triggered by the high level of uncertainty. As soon as the war started, this uncertainty dissolved and prices quickly fell. During the ongoing military operations serious shortfalls in production occurred, which were, however, compensated by an increase in output by other countries. As the war went on, oil prices remained stable. After plummeting amid the Asian crisis of 1997–98, they rose sharply in 1999–2000 when global demand heated up. Simultaneously, OPEC regained some of its market power.

When looking at the real price of oil for Austria in euro or schillings (chart 1), the extent of the first oil price shock becomes much more evident. The second oil price hike in 1979–80 had a long-term effect on Austria because the U.S. dollar appreciated in the wake of the hike. The recent oil price increase has been damp-

ened by the appreciation of the euro. Although the current level of the nominal oil price is comparable to the highest level reached during the second oil price shock of 1979–80, the real price in euro is still considerably below half of that value.

There is continuing controversy about what exactly are the determinants of oil price trends. Hamilton (2003) argues that the political and military actions leading up to oil crises are directly responsible for price hikes, whereas Barsky and Kilian (2001) stress the role of a favorable macroeconomic environment as a prerequisite for price rises. Jones and Leiby (1996) have found that oil price increases in the 1970s can be attributed to OPEC's cartel power rather than to shortfalls.

5 An Overview of Current Oil Price Elasticities

The oil price elasticities of growth and inflation presented here are either based on macroeconomic models (Dalsgaard et al., 2001; Hunt et al., 2001; International Energy Agency, 2004) or on VAR or Structural Vector Autoregressive (SVAR) models (Abeysinghe, 2001; Jiménez-Rodriguez and Sánchez, 2004). Hunt et al. (2001) applied the MULTIMOD model of the International Monetary Fund (IMF). The simulations described by the International Energy Agency (2004) were conducted by the Organisation for Economic Cooperation and Development (OECD), using the Interlink model.

Most macroeconomic models can only be used to a limited extent for analyzing the response of an economy to an oil price shock. For instance, the OECD and IMF models – just like the macroeconomic model of the OeNB – depict the entire supply side of an economy in *one* production function. Therefore, shocks setting off sectoral reallocations cannot be represented adequately. Furthermore, most models fail to depict asymmetries (Jones et al., 2002). Elasticities therefore tend to be underestimated.[1] The intensity of the effects of oil price shocks in macroeconomic models decisively depends on wage and price responses (and in particular on how inflation expectations are modeled), but also on the respective monetary policy reaction function. The simulations conducted by Abeysinghe (2001) and by Jiménez-Rodriguez and Sánchez (2004) are based on VAR models. These time-series models depict the dynamic interaction between a limited number (generally three to four) of macroeconomic variables such as GDP, oil prices and interest rates. Ciscar et al. (2004) used a multiregional static General Equilibrium model for their calculations, which comprises 21 regions of the world and 20 sectors per region. The model calculates equilibrium prices at which the respective markets are cleared. Unlike most macroeconomic models, this model distinguishes between different sectors, permitting not only income effects but also the sectoral reallocations deriving from oil price shocks to be simulated. The model presupposes flexible prices. The effects of price rigidities (especially on the labor market) are therefore not

[1] *Apart from macroeconomic models and VAR models, there are two more types of models for estimating oil price effects: Aggregated production functions, which were already used in the 1970s, define GDP as a function of production factors such as labor, capital and energy. The real business cycle approach attributes the pattern of booms and busts to the response of the economy to random exogenous shocks. Jones and Leiby (1996) provide a detailed overview of studies applying these different types of models.*

Table 1

Effects of a Permanent 10% Increase in Oil Prices in U.S. Dollars[1]

	Model	GPD			Inflation		
		Euro area	U.S.A.	Japan	Euro area	U.S.A.	Japan
	Average deviation of growth rates in percentage points						
Hunt, Isard and Laxton (2001) – IMF	Macro	−0.05	−0.06	−0.01	+0.28	+0.18	+0.08
International Energy Agency (2004)	Macro	−0.12	−0.07	−0.10	+0.14	+0.10	+0.08
Dalsgaard. André and Richardson (2001) – OECD	Macro	+0.04	+0.00	+0.02	+0.04	+0.02	+0.00
Jiménez-Rodriguez and Sánchez (2004) – ECB	VAR	−0.06	−0.17	−0.18	×	×	×
Abeysinghe (2001)	SVAR	×	−0.05	−0.03	×	×	×
Ciscar et al. (2004)	CGE	−0.10[2]	−0.09	−0.10	×	×	×
Average		**−0.06**	**−0.07**	**−0.01**	**+0.15**	**+0.10**	**+0.05**
Average excluding the OECD (2001)		**−0.09**	**−0.09**	**−0.01**	**+0.21**	**+0.14**	**+0.08**
		Austria			Austria		
OeNB (2004)	Macro	−0,02			+0,06		

Notes: CGE: Computable General Equilibrium model. Macro: Macroeconomic model. VAR: Vector Autoregressive model. SVAR: Structural Vector Autoregressive model.

[1] The values listed in the table depict the average deviation of GDP growth rates and inflation rates during the first three years following the oil price shock. The only exception are the results of Ciscar et al. (2004), which are comparative static results, i.e. they show the deviation between the old and the new equilibrium. For reasons of comparability, this deviation was converted into annual growth rates, assuming a three-year adjustment period to the new average.

[2] Result for the entire EU.

depicted. These simulations do not take into account policy reactions.

Given the use of different models and varying definitions of scenarios, the results of the individual studies are comparable only to a limited degree. As the simulations are based on different presumptions about the oil price change, the results have been scaled – assuming linearity – to a 10% increase.

The simulation results shown in table 1 are the average deviations of GDP growth rates and inflation in the first three years following an oil price shock. The simulations show a *deceleration of GDP growth by about 0.1 percentage point a year in the first two to three years*. Subsequent growth effects (as far as reported) can be neglected. On average, the euro area and the U.S.A. are equally affected, with Japan feeling a much smaller impact. The relative effect on the three major economies varies across the studies. The impact on *inflation* ranges from *0.1 to 0.2 percentage point*. In two out of three studies the euro area feels a stronger burden than the U.S.A.

The extent to which various countries or economies are affected depends on several characteristics. Important aspects are energy intensity (oil consumption relative to GDP), the sectoral structure of the economy, disposable stocks, the mineral oil tax system (specific or ad-valorem tax), citizens' preferences, economic policy responses, the existence and amount of oil reserves and the structure of the labor market and the labor market institutions.

In its simulations, the OECD (Hunt et al., 2001) finds oil price hikes to have consistently positive effects on the global economy. It reports a 0.1 percentage point increase in GDP on the initial value within three years for the entire OECD area and an even higher increase (0.2 percentage point) for the euro area. These effects are attributed to expanded demand for imports by oil exporting countries. They have, however, not been confirmed by other studies.

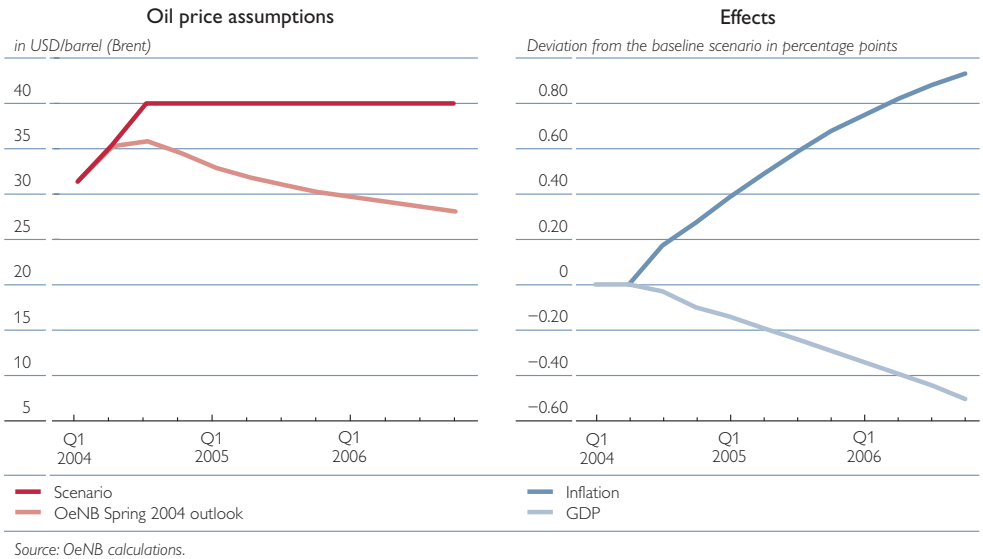
6 An Oil Price Scenario for Austria

With oil prices currently at a high, it seems particularly interesting to investigate their impact on the Austrian economy. The OeNB Spring Outlook 2004 for the years 2004 to 2006 assumes oil prices of USD 34.6, USD 31.8 and USD 29.2 per barrel of Brent oil for each successive year. These projections are based on the futures prices of May 17, 2004. According to the oil price scenario, prices will come to USD 40 as of the third quarter and will remain at this level until the end of 2006. The effects of this assumption have been simulated with the OeNB's macroeconomic model. A series of additional technical assumptions had to be made. In particular, constant monetary policy conditions, i.e. unchanged nominal interest rates, had to be presupposed. Furthermore, the simulation was based on constant exchange rates. An oil price shock is a global shock with repercussions on the entire world economy. Ideally, such a shock is simulated with a global model. The simulation at hand takes reactions of other euro area countries to the oil price shock into account by considering elasticities. However, as it fails to regard global reactions outside the euro area, effects are largely underestimated.

In the model the oil price shock takes effect through different mechanisms. Increasing import prices cause domestic price levels to rise, which diminishes real disposable private household income and thus consumer spending. At the same time Austrian export prices pick up. Whether and to which extent exporters then become less competitive depends on the degree of price hikes by Austria's competitors on its export markets. An increase in domestic prices results, ceteris paribus, in a substitution of domestic goods by imports. Investment is determined by two contrary effects. The sinking general level of activity reduces investment demand, while the rising price level – at unchanged nominal interest rates – lessens the real user cost of capital and thus

Chart 2

The Impact of a Permanent Increase in Oil Prices to USD 40 on Growth and Inflation in Austria



Source: OeNB calculations.

stimulates investment. The simulation shows a small net increase in investment. The model does not capture supply side and sectoral effects.

As the simulations do not start until the third quarter of 2004, growth in 2004 slows down only by 0.03 percentage point. In both 2005 and 2006 GDP growth is expected to fall by 0.2 percentage point. Effects on inflation will be somewhat stronger at 0.1, 0.4 and 0.3 percentage point in 2004, 2005 and 2006, respectively. At the end of 2006 the level of GDP will be 0.5 percentage point below the Spring 2004 Outlook level, while the Harmonised Index of Consumer Prices will be 0.9 percentage point above the level projected in the Spring 2004 Outlook. If a tighter monetary policy is assumed as a response to inflation, price effects would be dampened, while real effects would be even stronger.

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