ETLA
ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B 00120 Helsinki Finland Tel. 358-9-609 900
Telefax 358-9-601 753 World Wide Web: http://www.etla.fi/

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Paavo Suni

OIL PRICES AND THE RUSSIAN ECONOMY:

Some Simulation Studies with NiGEM

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ABSTRACT: Russia has greatly benefited both from exporting more energy commodities in volume terms and from the improvement of it's terms of trade due to the rise in oil and other commodity prices in the 2000's. To study the impacts, the counterfactual simulation for the years 2001-2006 and the "usual" oil price rise simulations for the future were made. According to the counterfactual simulations, the role of oil has been a key driver in the recent Russian economic development in the 2000's. The average GDP growth in 2001-6 would have been around 4 per cent, around 2.5 percentage points lower than in the actual case. The effect was strongest in the last years of the period bringing the growth even below one per cent in 2006 instead of more than 6 per cent. The strong effect is due to large and rising price difference between the actual and counterfactual oil prices especially in the years 2003-6, which would have meant pronouncedly smaller oil income into the economy than actually took place. In the other simulations, the effects of the permanent 20 USD price rise to the baseline was compared. The economy reacted initially strongly to the shocks with e.g. raising GDP growth and current account strongly. The effect was, however, quickly vanishing after the rise. The temporary end of the current commodity boom would cause serious difficulties in the Russian economic development as the fuel for the engine would dry. The more robust growth would necessitate drastic changes in the economic structure from resource based economy towards more normal economic structure. Given the short and rather undeveloped Russia time series and from this reason also rather undeveloped models, the results contain large uncertainty. However, simulations provide one useful benchmark on the size of the effects of the energy price rise on the Russian economy.

KEY WORDS: Russian economy, simulation, oil price

JEL-codes: Q32, Q43, F47

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TIIVISTELMÄ: Venäjän talouskasvu vauhdittui tuntuvasti raaka-aineiden ja etenkin energian hinnan rajun nousun seurauksena 2000-luvulla. Hintojen nousu vaikutti sekä vaihtosuhteen paranemisen että raaka-aineiden viennin määrän tuntuvan lisäyksen lisäämien vientitulojen kautta. Hintojen nousun vaikutusta tutkittiin ns. "counterfactual" -simuloinnein eli verrattiin toteutunutta Venäjän talouskehitystä vaihtoehtoiseen maailmantalouden mallilla laskettuun kehitykseen toteutunutta selvästi alhaisemman öljyn hinnan vallitessa. Mallilla tehtiin myös "tavanomaisia" eteenpäin katsovia öljyn hinnan muutossimulointeja. Simulointien mukaan öljyn hinta on ollut keskeinen Venäjän talouskehityksen taustatekijä vuosina 2001–6. "Counterfactual" -simulointien perusteella Venäjän BKT:n keskimääräinen vuosikasvu olisi ollut vuosina 2001-6 noin neljä prosenttia eli noin 2.5 prosenttiyksikköä toteutunutta hitaampaa. Ero oli suurin periodin loppuvuosina, koska tuolloin öljyn hintaero oli suurimmillaan ja siten öljytulot olennaisesti pienemmät. Muissa simuloinneissa verrattiin tilannetta, jossa öljyn hinta nousi pysyvästi 20 dollaria tynnyriltä perusvaihtoehtoon verrattuna. Venäjän talous reagoi nopeasti ja voimakkaasti muutokseen. Kertaluontoisen nousun vaikutus kuitenkin vaimeni verraten nopeasti. Näin ollen raaka-aineiden hinnan pudotus heikentäisi talouskehitystä nopeasti, koska talouden kehitystä tukeva tulokehitys olennaisesti supistuisi. Kestävä nopean talouskasvun jatkuminen edellyttääkin talouden olennaista rakennemuutosta raaka-aineriippuvaisuudesta normaalimpaan rakenteeseen. Tuloksiin liittyy luonnollisesti suurta epävarmuutta, koska Venäjän aikasarja-aineisto ja siten myös sen varaan rakennetut mallit ovat vielä kehittymättömiä. Simuloinnit tarjoavat kuitenkin yhden lisävertailukohdan raakaöljyn hintavaikutusten arvioimiseen.

ASIASANAT: Venäjän talous, simulaatio, raakaöljyn hinta

JEL-koodit: Q32, Q43, F47

1 INTRODUCTION

During the past several years, the Russian economy has been outperforming well and the development has beaten the forecasts since the Russian crisis in 1998. The economy opened up rapidly after the crisis in terms of exports per GDP. In early 2000's, the trend started to reverse. However, the export to GDP share stabilised to above 30 per cent thanks to Russia's most important export product, as well as other energy commodities and raw materials in general which Russia also exports.

Russia has thus benefited both from exporting more energy commodities in volume terms and from the improvement in its terms of trade due to the rise in oil and other commodity prices. As a result, domestic demand has received a strong growth impulse. This development has been initiated and reinforced by the lagged effects of the 1998 collapse in the value of the Russian rouble, which drastically improved the international price competitiveness of Russian products. Also public sector revenue has increased considerably due to, among other things, the taxes imposed on oil exports. However, we will not discuss the significance of the oil fund that the Russian government has been cumulating, while the use of it is very important in creating the future of the Russian economy.

An oil price shock, whether a rise or decline, affects economies by changing the relative prices of oil-intensive goods and services. Shocks also transfer wealth between oil producers and oil consumers and may affect the expectations of the economic agents (Barrell and Holland 2006). Oil prices obviously also affect asset markets and changes international net asset positions. Economic policy plays a role, too, as it may strengthen or smoothen the impact, see for example Euroframe (Euroframe 2005) and IMF (2000). Finally, the impact will depend on the length of the shock that is whether it is thought to be temporary or permanent. In the long term, substitution effects will become more and more important. We will not discuss these, however. Using the National institute global econometric model (NiGEM[1]), the importance of the price development of oil and other energy commodities for the performance of the Russian economy is analysed

The year 2001 is used as the base year in some of the NiGEM simulations. This is convenient because the major rise in world market prices has taken place after 2001. This assumption[2] like the other possible oil price assumptions serve as a basis to see what had been the case with this assumption given the model. We will run two separate simulations with NiGEM. In the first so-called counterfactual (Barrel - Magnusson 1996) simulation, the price of crude oil is fixed to its 2001 level for the 2002-06 period and see how Russia's economy would have performed during these five years without the drastic rise in energy prices that has taken place. The second scenarios provide results from permanent 20 US dollars shift in the oil price assumption starting in the beginning of 2007 with backward and forward looking expectations of economic agents.

This paper is structured as follows. In Section 2 the role of energy commodities in the Russian economy and Russia's global role as a producer are discussed. Section 3 shows the simulation results done using this model and. Section 4 concludes.

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[1] NiGEM is a tool used in economic forecasting and simulations of real economic development up to the medium term. The model contains a rich .description of the world economy with a large number of countries.

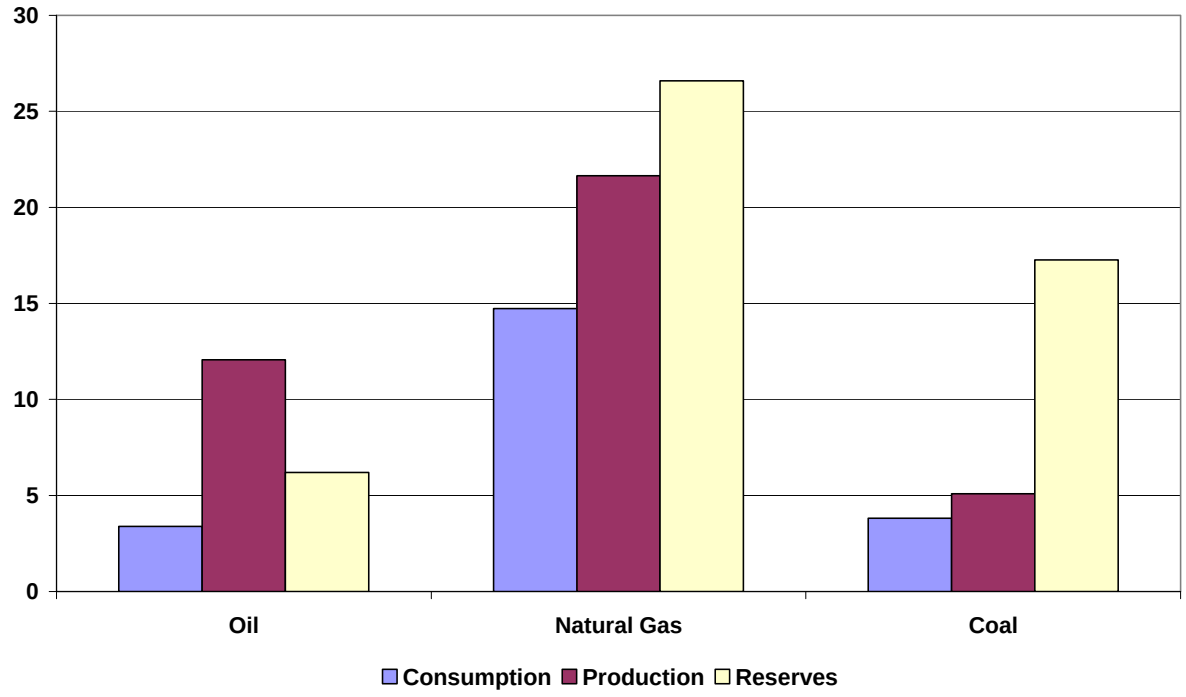
[2] Oil price forecasts and assumptions contain a great deal of uncertainty due to the geopolitical, technological and macroeconomic uncertainties.

2 ENERGY COMMODITIES IN THE RUSSIAN ECONOMY

Russia is a major exporter of energy commodities. Its share in world oil exports was around 14 per cent in 2005. In 2006 both Russian production and exports outstripped the formerly largest producer's production and exports. This made Russia for a while the largest oil exporter and producer in the world. In the long term this cannot continue, because Russia's share in known global oil reserves is relatively small (see Figure 1). Russia's role as a key energy producer will continue, however, as its reserves of coal and gas are very large in international comparison.

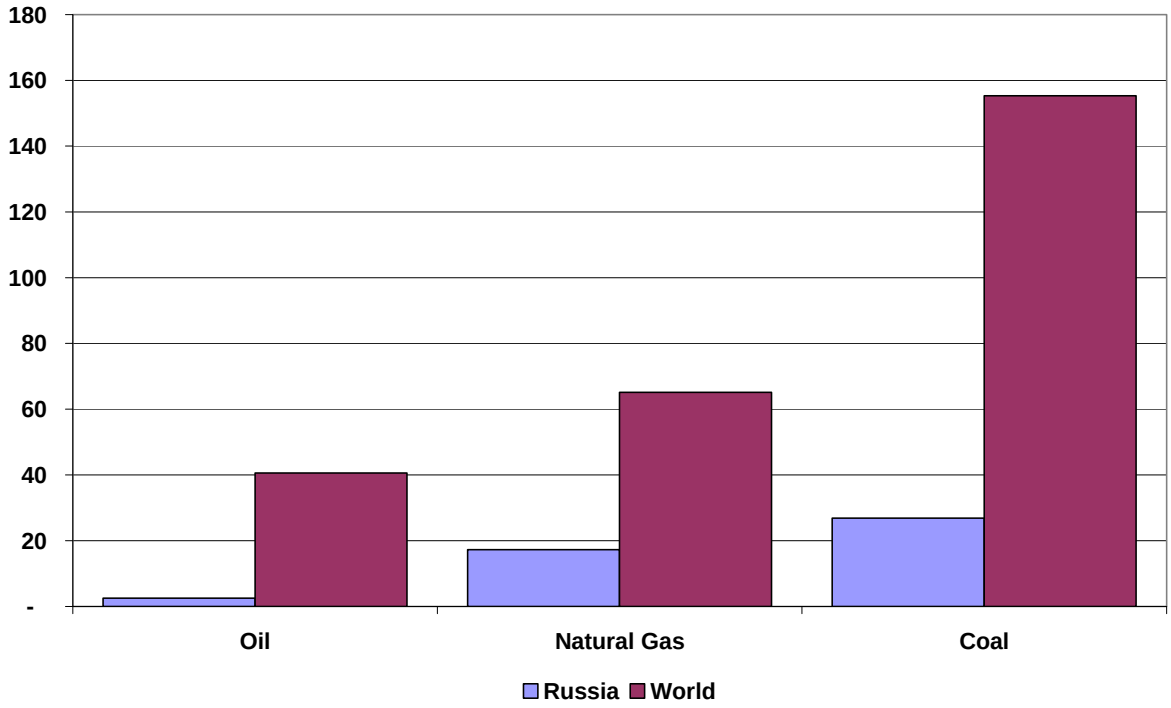
According to British Petroleum (2006), the size of Russia's oil inventories will only last 21 years with its own production rate in 2005. On the other hand, Russia's coal reserves will last over 500 years and its natural gas reserves 80 years. This measurement is not accurate, however. It overestimates the reserves because both production and consumption tend to rise in time. On the other hand, new discoveries, technological advances and especially higher prices will probably raise the reserve estimates as the (proven) reserves are a function of the prices. After the late 1980s, the global oil reserves relative to production have been quite stable instead of declining. (See also Suni, 2007.)

Figure 1a Russia in Global Energy Markets in 2005, % of world total



Sources: British Petroleum (2006), ETLA.

Figure 1b **Fossil Reserve Adequacy for World Production in 2005, reserves per world production in 2005, years**



Sources: BP, ETLA.

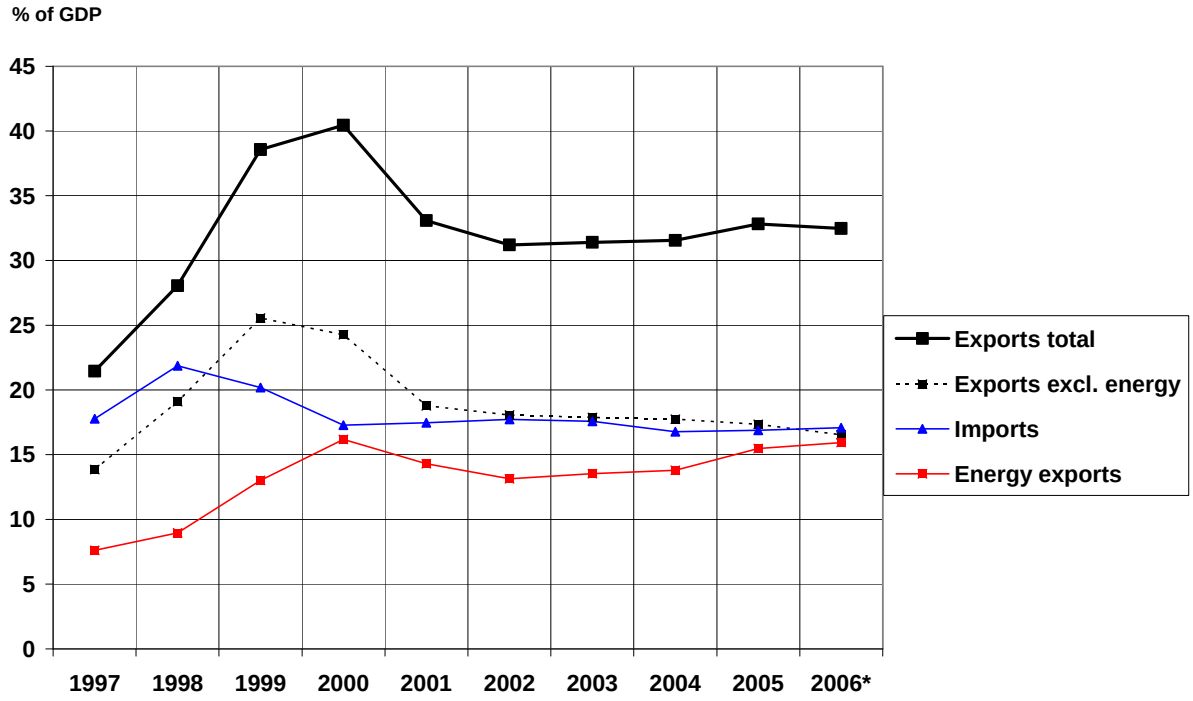
The share of oil and other energy production in Russia's total GDP is difficult to estimate. The official statistics tend to underestimate the share. According to Russian statistics, the share of the fuel industry[3] is some 5.5 per cent of Russia's GDP. According to the GTAP database, fuel industry (i.e. coal, oil, gas and other minerals) accounted for 19 per cent of Russia's GDP at basic prices in 2001 when measured as a share in factor income by sectors. According to World Bank (2004, 2005), the share of oil and gas in Russia's GDP in 2002 was 25 per cent. According to the Russian government, as quoted by Juurikkala and Ollus (2006), the energy sector accounted for 30 per cent of the Russian GDP in 2005. (See also Kaitila and Suni, 2007, for a discussion of this issue.)

Figure 2 shows the value of energy and other exports in relation to the GDP. The total-exports-to-GDP ratio has remained relatively stable in nominal terms since 2001. World energy prices and thus Russia's export prices have risen considerably, but so has Russia's GDP in nominal terms. The imports-to-GDP ratio has fallen slightly. These disguise the development in volume terms.

The value of energy exports is almost the same as the value of total imports, which means that the former can be used to finance the latter. However, it is worth noting that the value of other than energy exports is also equal to the value of total imports. The volume of Russia's oil exports has stabilised (see Figure 3). This is due to increasing domestic demand and too little investment in fuel extraction. Crude oil accounts for 70 per cent of the total value of Russia's crude oil and natural gas exports.

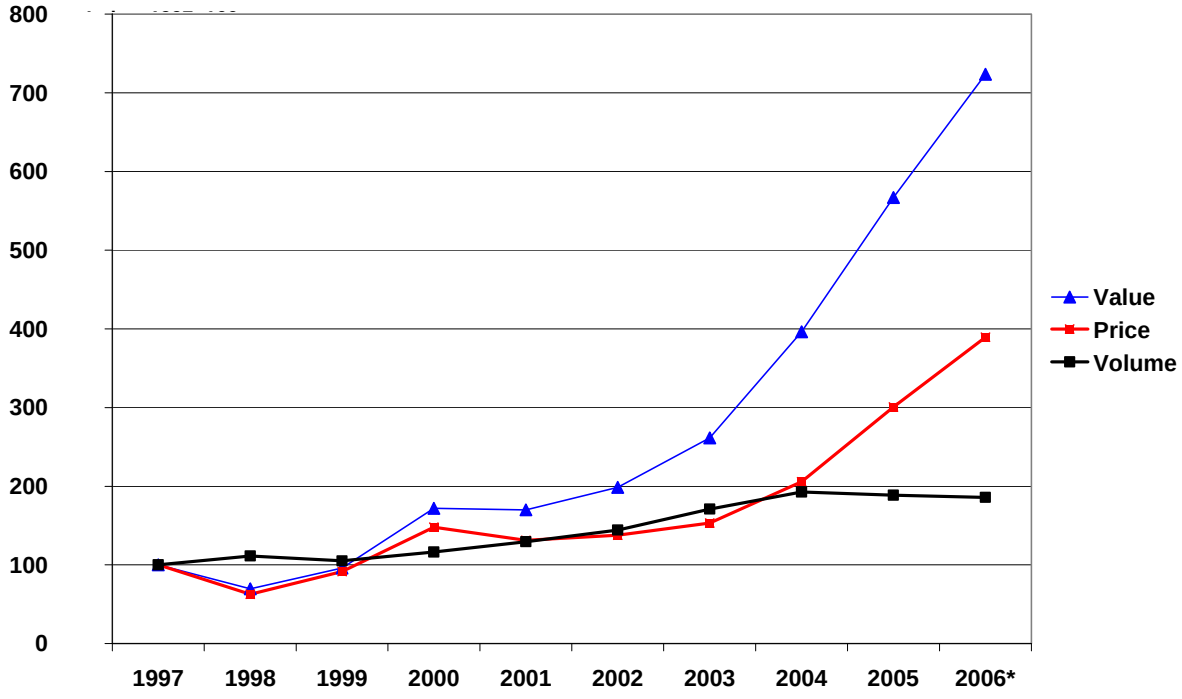
[3] Using industry gross output data.

Figure 2 **The value of Russia's energy and other exports and imports, % of GDP**



Sources: RET, ETLA.

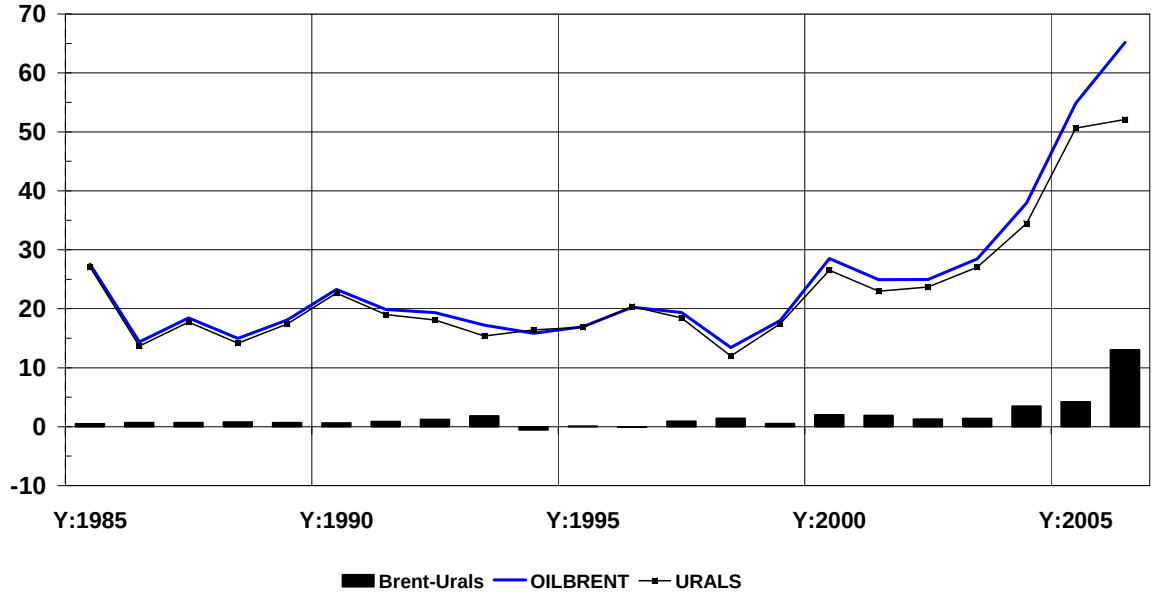
Figure 3 **The decomposition of the value of Russia's oil exports into price and volume, 1997 = 100**



Sources: RET, ETLA.

There is a market price differential between the Russian Urals grade and other oil grades. Figure 4 shows the price differential between Brent and Urals. The differential arises from the technical properties of the Russian oil, which do not fit well to the market needs, which favour the so–called sweet and light oils at the expense of sour and heavy oils like the Urals. This is due e.g. to the tightening environmental regulation.

Figure 4 **The world market price of Urals and Brent and their price differential since 1985, USD per barrel**



Sources: HWWA, IEA, ETLA

Looking forward, Russia's oil production in volume terms is likely to peak during the next decade and the growth rate of production has already slowed down considerably (BP 2006, IEA 2007). Exports are also constrained by rising domestic oil consumption. Consequently, any future effect from energy commodities, positive or negative, will be mostly based on world market price changes, which are notoriously difficult to forecast.

3 NIGEM SIMULATIONS

There exist some interesting studies touching this issue. For example, Bebee and Hunt (2007) study also the effects of oil price rises by the source of the shock. The shock, we have faced in the 2000's can be interpreted as a demand shock and thus according to Bebee and hunt, it may be positive to the world economy as the source is the positive supply shock in Asian economies contrary to the supply shock in the energy supply. This interpretation fits well to the current historically robust global growth period.

Rautava (2002) has studied the effects of oil prices and exchange rates on the Russian economy using VAR methodology and co-integration techniques. He finds that in the long-run a 10% permanent increase (decrease) in international oil prices is associated with a 2.2% growth (fall) in the level of Russian GDP. Respectively, a 10% real appreciation (depreciation) of the rouble is associated with a 2.4% decline (increase) in the level of output with significant short-run effects due to error-correction mechanism. This implies large short-run

GDP effects on Russian economy like in our permanent oil price rise simulations. Effects found here are, however, about the third of Rautava's estimate.

We run two different types of NiGEM simulations. The first is a counterfactual simulation in Section 4.1. There we fix oil prices at their 2001 level and see how differently the Russian economy would have performed in 2002-06 without the huge rise in oil prices during these years. Of course we will have to make assumptions concerning, among other things, Russia's monetary policy in this hypothetical situation. In the second simulations in Section 4.2 we set a 20 dollar price shock above the baseline with different background assumptions in 2007-28 and see how the Russian economy will perform.

3.1 A counterfactual simulation for the beginning of the 2000s

The counterfactual case was constructed as follows:

1. The baseline scenario is the real development in 2001-06 as described in NiGEM.
2. The price of oil (average of WTI[4], Brent and Dubai grades) was fixed at 23.6 dollars per barrel, which was the average price in 2001 according to the NiGEM data base,[5] for the period between the first quarter of 2001 and the last quarter of 2006. The dollar price was thus on average 37.5 per cent lower than in reality (see Figure 5).
3. The dollar value of the rouble was fixed at 29.2 for the same period. This is relatively close to its true average value in 2001-06.
4. The central bank of Russia is assumed to have used a combined nominal GDP and inflation target.

Lower oil prices in the counterfactual case have a positive effect on real GDP growth in oil-consuming countries as can be seen in the case of the EU15, the USA and Japan in Figure 6. The cumulative impact of lower oil prices for GDP growth in these countries is just under one per cent. In the case of Russia the dominant role of oil in the economy makes the effects much larger and naturally negative. According to the results, the level of Russia's real GDP in 2006 would have been 12 per cent lower if the oil prices had not risen since 2001. This would have produced an average GDP growth rate of 4.0 per cent in 2001-2006 instead of the actual 6.3 per cent. Domestic demand in Russia would have been hit harder than this, however (see Figure 7). The simulated real domestic demand is nearly 20 per cent lower than in the actual baseline scenario. The average growth rate of domestic demand would have been 4.5 per cent a year instead of 8.5 per cent in reality. Both real GDP and domestic demand had the similar annual development. During first years, the effect was minimal due to small changes in the oil price. As the oil price increased drastically in an accelerated way, also the negative effects of the oil price had been increasingly larger. In fact, the rise of real Russian GDP declined in 2006 already to below one per cent. The rapidly diminishing growth rates are driven by decreasing terms of trade and decreasing net foreign assets caused by lower oil price.

The very strong positive external balance in the beginning of the decade deteriorated in both real world statistics and the counterfactual simulation. Even with the lower oil price, the current account would still have a surplus in the counterfactual case albeit lower clearly than in the actual case. It would be about 12 per cent of GDP instead of actual around 15 per cent. Lower oil prices mean that nominal export revenue would be smaller, but on the other hand lower domestic demand would also translate into lower real imports. The latter partly

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4 West Texas Intermediate.

5 This is also relatively close to the OPEC target set in March 2000. OPEC set up a price band mechanism, which had as aim to hold the price of the OPEC basket between 22 and 28 dollars per barrel. On 30 January 2005, OPEC decided to temporarily suspend the price band mechanism as the prise had risen much higher (EIA 2006).

compensates the effect of lower oil prices on the current account. In terms of imports, the assumption of fixed exchange rate is of course important especially in cases of oil producers like Russia. However, lower oil prices could justify a weaker rouble, but this would only

Figure 5 **Oil price in the counterfactual simulation and actual development, USD per barrel**

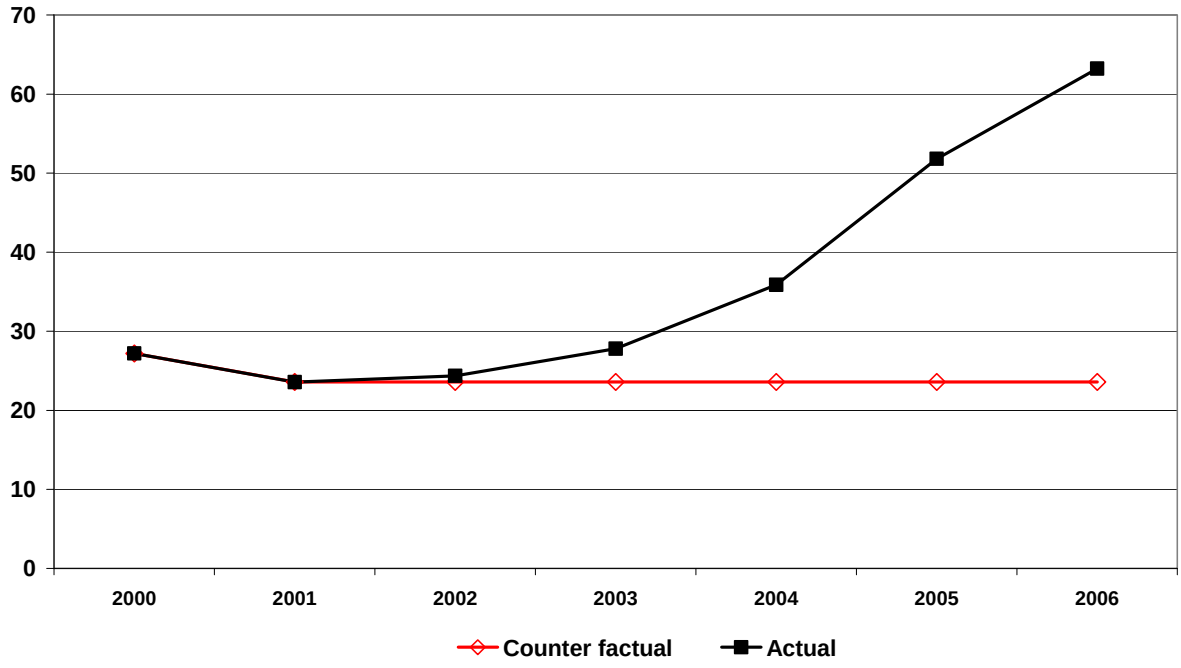


Figure 6 **GDP developments in Russia, the Euro Area, the United States and Japan in the counterfactual simulation, cumulative %-deviation from the base (actual development)**

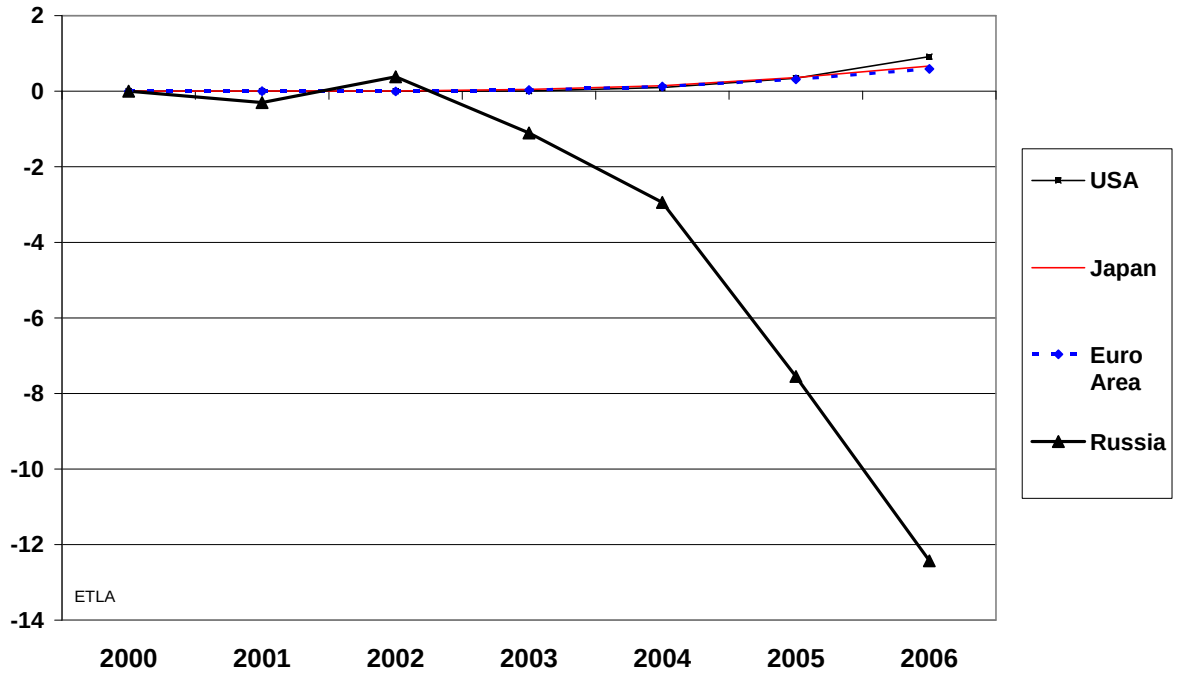


Figure 7 **Russia's GDP and domestic demand, cumulative %-deviation from actual development**

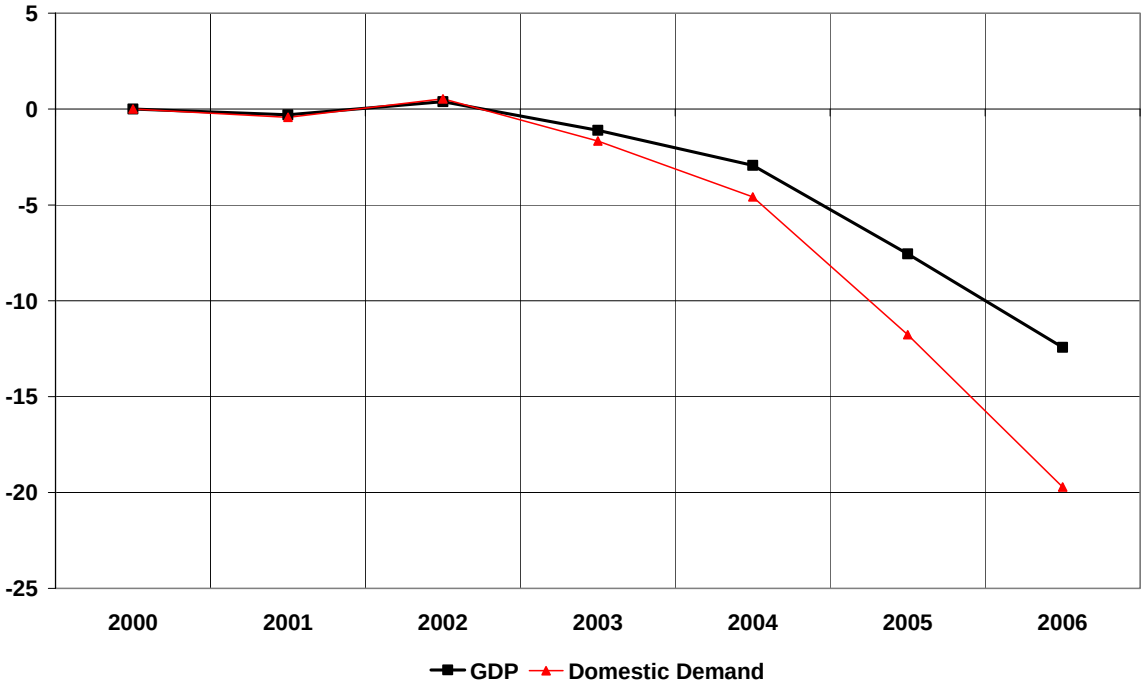
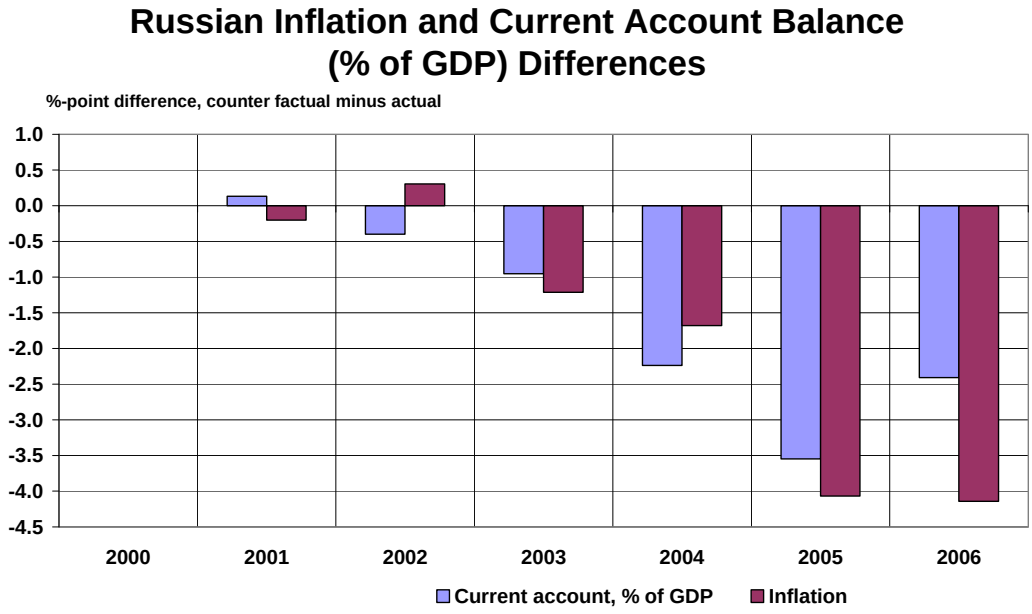


Figure 8 **Russia's current-account surplus, % of GDP, and consumer price inflation, %**



translate into ever lower imports. Anyway the still existing current-account surplus hints that the rouble would not need to be weaker than what we have assumed.

Lower export revenues and weaker domestic demand lead to considerably lower consumer price inflation in our counterfactual scenario than in the actual case. This also means that the rouble would have appreciated less in real terms than in the actual case, which would have supported the trade and current account surpluses. Both lower inflation and GDP growth, on the other hand, lead to lower interest rates, which supports growth.

Output in a commodity producing country is permanently affected by a change in commodity prices, much as is the case for Russia in the simulations. The equilibrium level of unemployment will be reduced by higher commodity prices in such a country, and hence overall output will be higher. The real producer wage (nominal wages deflated by output prices) falls relative to the real consumer wage (nominal wages deflated by consumer prices) because output is more heavily weighted to commodities than is consumption.. The 'wedge' between these two wage rates is an important determinant of the equilibrium level of unemployment as Layard, Nickell and Jackman (1991) show. And this fall in the wedge will raise equilibrium employment and hence the supply capacity of the economy. Although the impacts of oil prices might be less than such an analysis indicates, other commodity production is more labour intensive, and the overall direction of the effect on output is clear. In the case of Russia, the energy, however, dominates the commodity output.

To a large extent, Russia's GDP growth has been fuelled by the rise in Russia's export prices. Here we have only taken into account the price of oil. As many other commodity prices have also risen, our results show a higher bound for the development without the price hikes. Taking into account the higher prices in other commodity, mostly relatively capital intensive, exports would have resulted in even larger negative effects for the Russian economy.

Naturally, the depreciation of the exchange rate could smooth drastically the results in case of a large shock. In the basic simulation, the bilateral rates were assumed to be fixed. This assumption was checked by using an improbable case of real exchange rates, which caused even more severe effects. When the interest rate arbitrage was allowed to determine the exchange rate development, the results for Russia were surprisingly little changed.

The size of the effect bears a significant amount of uncertainty due to poor quality and short strictly comparable time series of the Russian data. That is why also, the description of the econometric model of the Russian economy is also far from perfect. However, the results give a good reason for being careful in evaluating the development of Russian economy in a longer run, even if no big decline in the oil price is in the horizon.

3.2 The long-run impact of a permanently higher oil prices on the Russian economy

There is plenty of oil still available in the world but the potential problems with the supply of oil are significant because investments in oil production have been modest. In fact, this is one of the reasons behind the strong recent rise in oil prices. Supply has not been able to respond to the surprisingly strong and rapid rise in demand in China and other developing countries, see for example IEA (2006), IMF (2006), and Suni and deCarvalho (2005).

The difficulties in increasing the supply of oil in the coming decades are likely to keep the market tight and prices relatively high. Also political tensions and security issues in the producing countries are factors that may still have a potentially major impact on the prices but that cannot really be foreseen much in advance. In long-term scenarios, we should also take into account technological development and substitution away from oil and oil products. This was achieved to a remarkable extent after the first oil crisis of 1973-74. Attempts to decrease the green house gas emissions may play a vital role in this respect in the coming decades. These developments will be further supported by the expensive oil. Changes in economic structure and introduction of both more energy-efficient and non-fossil capacity will take time, however.

In the baseline scenario, the international price of oil is fixed at 59 dollars per barrel between the first quarter of 2007 and the last quarter of 2010. Thereafter the price is set to rise by 3 per cent per year (see Figure 9). The shock scenario is such that there is a permanent rise

in the price of oil by 20 dollars per barrel in the first quarter of 2007 and thereafter prices will remain that much higher compared with the baseline scenario. We ran the simulation with both backward and forward expectations. The Russian and other central banks are assumed to target the combination of value of GDP and inflation.

Figure 9 **Oil price assumptions for 2007-28, USD per barrel**

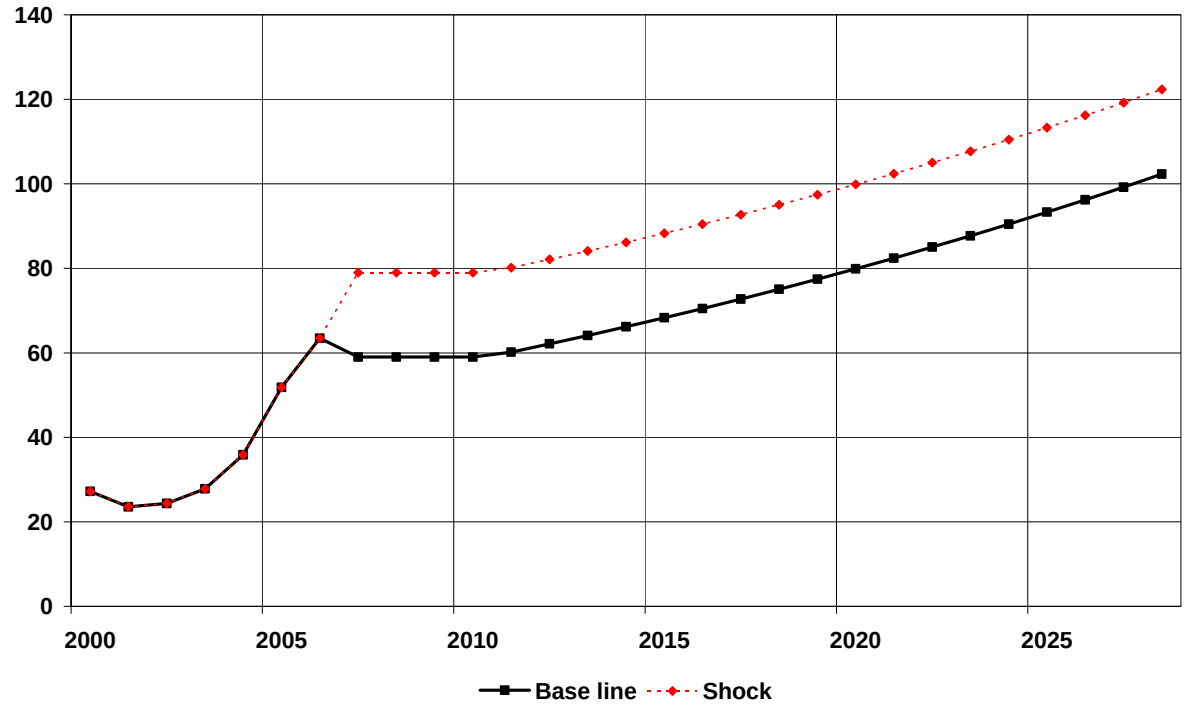
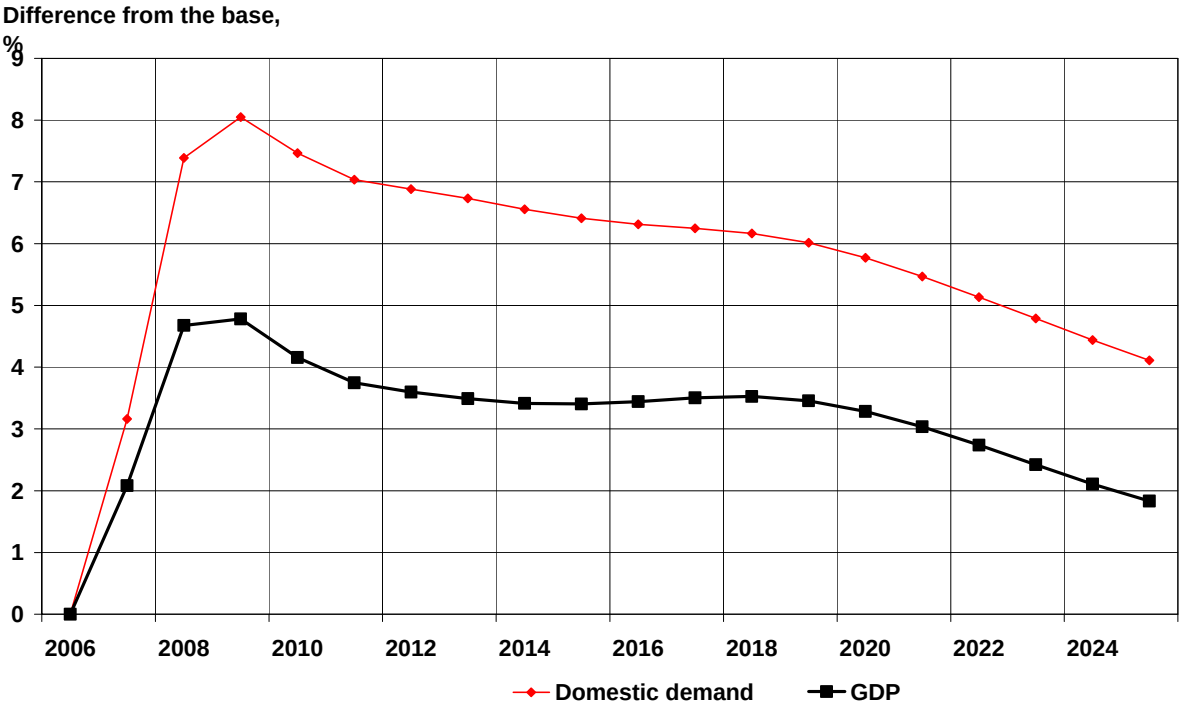


Figure 10 **Russian GDP and domestic demand in the simulation (+20 USD/bbl) with backward expectations, cumulative %-difference from baseline**

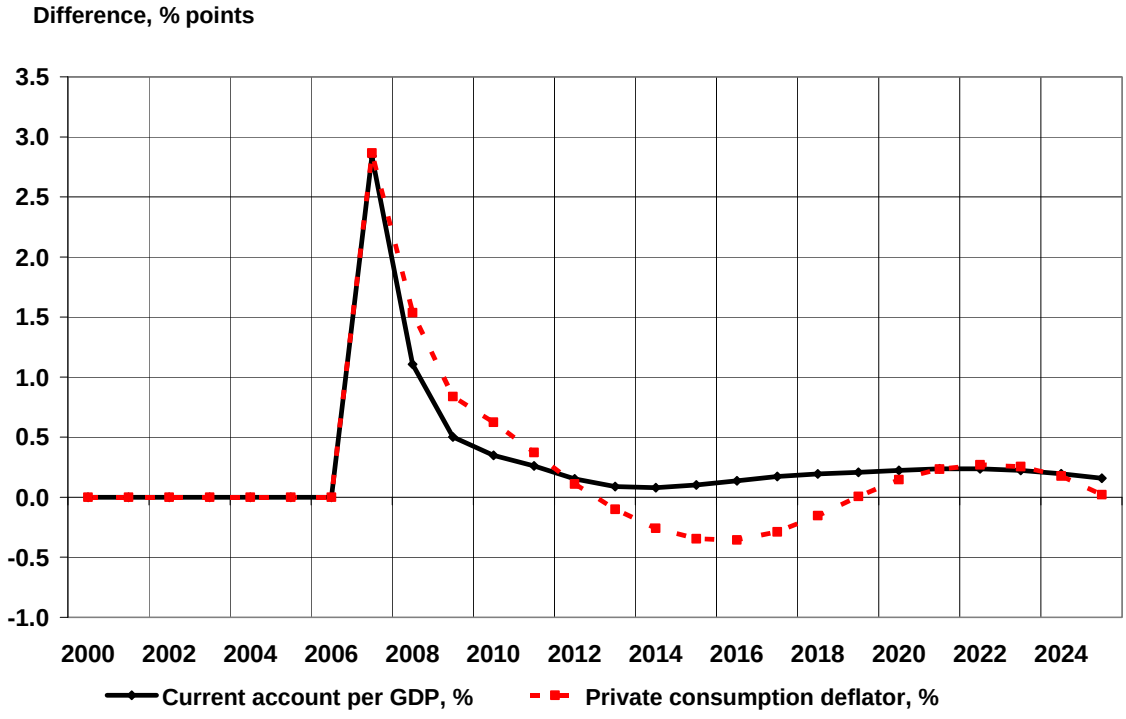


According to the results, the sudden and permanent positive oil price shock will raise Russia's domestic demand and GDP rapidly for the first three years up until 2009. At that point the level of domestic demand will be 8 per cent and that of GDP almost 5 per cent higher than in the baseline scenario. Thereafter the difference with respect to the baseline scenario starts to decline, but it will not vanish completely during the 20-year simulation period. Effects are driven by changes in export income, risen net foreign assets and by the effects of the change in prices on labour market equilibrium. In the long-run output is higher, and the scale of the effect depends on the importance of commodities in output and the size of the increase in prices.

Also as a result of higher oil prices, the current account balance will naturally improve pronouncedly in 2007 but the effect will start to diminish rather quickly as higher domestic demand will increase imports and the value of GDP will grow. The current-account surplus will still remain larger than without the oil price shock. There is also a hike in consumer price inflation, which also will soon start to diminish. In a longer term, the deflator will be unchanged with respect to the baseline by 2012.

These results indicate that any oil price increases will fade relatively quickly if there are no further price increases. The current-account-surplus-to-GDP ratio will also start to decline rapidly after a jump. Thus the economy is vulnerable to a possible decline in oil prices as the process functions, in principle, also the other way around. We checked the effects also using forward expectations. Using forward expectations did not change the overall picture. The size of the effects were fairly similar with some differences in timing, which can be seen e.g. in the Figure 12.

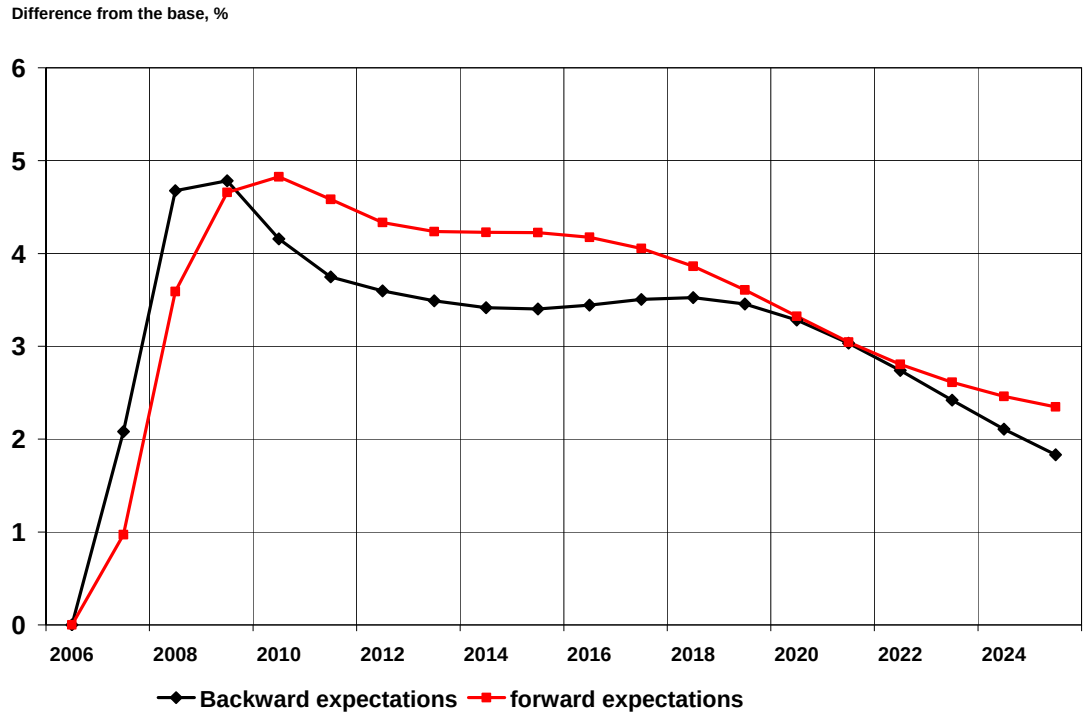
Figure 11 **Russian current-account surplus, per cent of GDP, and private consumption deflator in simulation (+20 USD/bbl) with backward expectations, %-point difference from baseline**



A decline in or just a stabilisation of world commodity prices on a lower level is likely to cause difficulties for the Russian economy as the most important driving force of the econ-

omy would cool down. More robust growth in a longer term would call for significant changes in the structure of the economy away from a resource-based economy and towards a more normal structure. Among other things, more economic openness could serve as a driver for rising productivity and the competitiveness of production outside the energy sector. Openness would also provide the necessary competition to check the price structures and give correct price signals to the non-resource economy for its development.

Figure 12 **Russian GDP in the simulation: permanent oil prise rise (+20 USD/bbl) with backward and forward expectations, cumulative %-difference from baseline.**



4 SUMMARY

According to the counterfactual simulations, the role of oil has been a key driver in the Russian economic development in the early years of this century. Given the short and rather undeveloped Russia time series and from this reason also rather undeveloped models, the results contain large uncertainty. However, they provide one useful benchmark on the size of the effects of the energy price rise on the Russian economy.

So far, the Russians have benefited from the more expensive oil by both exporting more on quantitative basis and the rise in the Russia terms of trade due to hike in the oil price. Consequently, the domestic demand has got a strong growth impulse. This development has been reinforced by the lagged and large effects of the 1998 Russian crisis, when the pronounced depreciation of the rouble drastically improved the international price competitiveness of the Russian products. Depreciation strongly favoured domestic demand and exports at the expense of foreign products. Possible continuing lagged effects of this drastic change have not been taken into account in the simulations. According to the counterfactual simulations, the stabilisation of the oil price on the level in 2001 would have had a significant negative effect on the Russian economic development. The average GDP growth in 2001-6 would

have been around 4 per cent, around 2.5 percentage points lower than in the actual case. The effect was strongest in the last years of the period bringing the growth even below one per cent in 2006 instead of more than 6 per cent. The strong effect is due to large and rising price difference between the actual and counterfactual oil prices especially in the years 2003-6, which would have meant pronouncedly smaller oil income into the economy than actually took place.

To study the future impacts, the effects of the permanent 20 USD price rise to the baseline were compared. In the base line the oil price was fixed near to the current (in the turn of the year 2006/7) implicit OPEC target, around 60 dollars per barrel till the end of 2010 and after that the price was assumed to raise in real terms around 2 per cent in a year. Basically, the main scenario for the oil price given current knowledge is that the price will be expensive in relation to historical prices. The real price of the oil, independent of the way measured, will be much higher than we used to e.g. in the 1990s. However, the recent historical peaks can be interpreted as overshooting, i.e., prices rise soon back to similar levels soon only in a case of shocks. The prices of around 60 dollars per barrel in international benchmark prices still support the Russian development as the prices are higher than a year ago. The strongest support is, however, over and in the future the growth is basing more and more on other fossil fuels "traditional" production and exports of goods.

The first future simulation was made by assuming that the expectations are backward looking, then the effect of the forward looking expectations were studied. In all cases, the Russian Central bank was assumed to follow nominal GDP and inflation targeting in its monetary policy. The economy greatly reacted to the shocks with e.g. raising GDP growth and current account initially strongly. The effect was, however quickly vanishing after the rise. Short-run fluctuation in oil prices affects the Russian economy in many ways, but on the longer-term economic development is not greatly influenced.

The temporary end of the current commodity boom would cause serious difficulties in the Russian economic development as the fuel for the engine would dry. The more robust growth would necessitate drastic changes in the economic structure from resource based economy towards more normal economic structure.

There is a danger that while energy effects dominate the Russian economic development, the need to create fruitful circumstances for the growth of the non-oil sector is seriously underestimated as the short term gains from higher energy prices are so large. Here, more openness in the economy and the use of oil fund would serve as an important impetus to raise the productivity and the competitiveness of the production outside the energy sector in the long-run. Openness of the economy would provide the necessary competition to check the price structures and give correct price signals to the non-resource economy for its development.

The recent success in WTO membership negotiations is a good signal in this direction. However, recent Russian policies to support the monopolistic nature of the energy sector as well as export duties raises the vulnerability of the economy to decline in the raw material prices and especially those of the energy may undermine the ground behind normalisation of the economy.

ANNEX 1. THE NIGEM MODEL

The National institute global econometric model, NiGEM is a Neo-Keynesian model with a rich structure of countries (35) and regions (13) and their economic description. Nominal shocks have a short term impact while the effects are neutral in the long term. The world is closed in the sense that exports and imports as well as foreign liabilities and assets add up to world totals. The behaviour is described using error-correction models, where short-term dynamics are taking place around theoretically justified equilibriums. The model is used extensively in both forecasting and simulations in the short and medium term. The forecast and simulations period end till the end of 2020's to facilitate the use of forward expectations.

Basic model

In the basic quarterly model, there are 3,677 equations of which 448 are estimated. Behavioural equations are error-correction models. Thus in the long-run $Y_t = \alpha + \beta X_t + \varepsilon_t$, while adjustment to equilibrium is given by $\Delta Y_t = \lambda\left(Y_{t-1} - \alpha - \beta X_{t-1}\right) + dynamics + error$.

Nearly all OECD economies and many other countries like China and Russia are described in the model. The largest countries are modelled using around 120 equations, including 20 behavioural equations. Some countries like Russia have smaller models partly due to lack of adequate data and partly due to the shortness of time series. The model for the Russian economy consists of 47 equations with 5 behavioural equations. For example, Russia's GDP on the expenditure side is simply the sum of total domestic demand and the difference between exports and imports. Domestic demand depends on e.g. terms of trade, net foreign assets and exports.

$\Delta DD = f(P_{x,\,t-1}/P_{d,\,t-1}, NFA_{tt}, DD_{-1}, X_{t-1})$

On the supply side, NiGEM uses CES production functions. Production factors are capital and labour. The long-run output determinants are thus labour force, capital stock and technical progress. (See NIESR)

Simulation properties

NiGEM provides a wide range of options to describe the different plausible simulated economic development. The outcome depends on the assumed behaviour of economic agents including backward expectations or forward looking rational expectations in defining the behaviour of wages.

There is a range of forward-looking variables: the exchange rate (fixed either in nominal or real terms or determined by forward-looking uncovered interest rate parity condition), short-term interest rates (with forward-looking inflation), consumption (with one period 'look ahead' on the consumption growth rate), equity prices (with one period 'look ahead' on the equity price and private sector capital stock, which captures discounted expected profits), prices (with forward-looking inflation), wages (with forward-looking inflation), long term interest rates (a weighted sum of future short rates), and long term real interest rates (a weighted sum of future short rates and inflation). Inflation can be either forward or backward looking.

The monetary policy rule can be selected from various kinds of nominal GDP and inflation targeting rules, for example a Taylor rule or a combination of nominal GDP and inflation rules. Interest rates can also be fixed. It is also possible to use different rules for different periods. In countries, where public sector is model, it is assumed to be solvent.

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