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The Macroeconomic Effects of an Oil Price Shock on the World Economy

A Simulation with the NIME Model

E. Meyermans
P. Van Brusselen

March 2005

Federal
Planning Bureau
Economic analyses and forecasts

Avenue des Arts 47-49 Kunstlaan
B-1000 Brussels
Tel.: (02)507.73.11
Fax: (02)507.73.73
E-mail: contact@plan.be
URL: http://www.plan.be

.be

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In this Working Paper, we use the nime model to describe the macroeconomic effects of an oil price shock on the world economy. We start with an overview of the nime model and a discussion of the modelling of oil price shocks. Next, we examine the macroeconomic effects of a permanent 25 per cent oil price rise due to an increase in the price mark-up of oil. In the long run, such a shock causes a fall in productivity, thereby reducing output and real wages by about 0.27 per cent in the euro area while leaving the employment rate almost unaffected. In the medium term, various adjustment costs as well as the income transfer from the oil-importing countries to the oil-exporting countries prevent demand from immediately adjusting to its new long-run equilibrium.

The reader should be aware that the short-term forecasts and medium-term projections for the Belgian economy carried out within the Federal Planning Bureau (FPB) do not necessarily retain NIME oil price scenarios in their underlying international economic assumptions.

Keywords: macroeconometric world model, oil prices, euro area, world economy

JEL codes: C5, F4

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Executive summary

In this Working Paper, we use the NIME model to assess the macroeconomic effects of an oil price shock on the world economy. We start with an overview of the NIME model, and a presentation of our modelling of oil price shocks. Next, we examine the effect of a permanent 25 per cent increase in the price of oil, under the assumption that the shock is caused by an increase in the mark-up of the oil price.

The reader should be aware that the short-term forecasts and medium-term projections for the Belgian economy carried out within the Federal Planning Bureau (FPB) do not necessarily retain NIME oil price scenarios in their underlying international economic assumptions.

The simulation results for a permanent 25 per cent oil price shock show that, in the long run, such a shock reduces aggregate private sector output by 0.27 per cent in the euro area, 0.30 per cent in the Western non-euro EU Member States[1], 0.33 per cent in the United States, and 0.23 per cent in Japan. In the long run, the effects on total employment are negligible, though real producer wage rates and the return on capital drop proportionally to the decline in output. The effects on the general price level depend on the conduct of monetary policy. In this paper, we assume that the monetary authorities set the short-term interest rates according to a Taylor rule. Under a Taylor rule, the rise in prices is directly proportional to the decline in volumes, thereby leaving unaffected the current price value of aggregate output, nominal GDP, and the money supply.

In the medium-term, various adjustment costs prevent demand from immediately adjusting to its new long-run equilibrium. These adjustment costs include the cost of implementing the revised expenditure plans of households and enterprises, as well as the menu and information costs associated with price adjustments. As a result, certain components of aggregate demand can deviate significantly from their new long-run solution in the medium-term.

Looking at the results for the euro area, we note that imports are the most severely affected component of demand, as they drop immediately by 0.43 per cent. Moreover, as the impact of the oil price shock becomes stronger, imports pursue their fall and bottom out at 2.21 per cent below baseline in the third year, compared to 1.91 per cent below baseline in the new steady state. Private consumption in the euro area falls by 0.24 per cent in the first year, mainly due to a strong decrease in (expected) disposable income and household wealth, a 0.40 percentage point increase in the short-term interest rate, and a 0.30 per cent increase in the consumer price. Private consumption bottoms out at 0.45 per cent below baseline in the third year. As of the fifth year, as disposable income and household wealth stabi-

1. The Western non-euro EU Member States consists of Denmark, Sweden, and the United Kingdom.

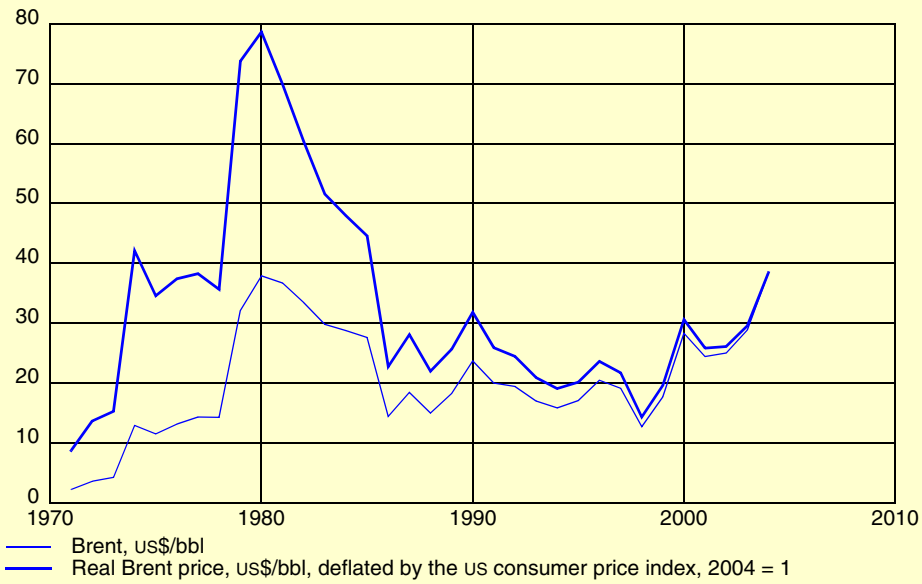
lise and monetary policy is relaxed, private consumption recovers somewhat, and then gradually converges to its new equilibrium level at 0.32 per cent below baseline. Total gross fixed capital formation falls only moderately, down by 0.14 per cent after four years, and by 0.06 per cent in the long run, mainly due to the fact that enterprise investment is almost unaffected. The decline in enterprise investment is small, as the relative price of capital falls in order to reflect the drop in the return on capital. Furthermore, we note also that real producer wages do not adjust immediately to their new equilibrium, leading to a decline in private sector employment in the medium-term.

Apart from the long-run supply effects and the medium-term demand effects in the oil-importing countries, a change in the price of oil also generates a temporary income transfer from oil-importing countries to oil-exporting countries. Indeed, as the price of oil increases, the traded oil volume adjusts only gradually to its new steady state level. This initially raises oil-exporting countries' export revenue above its equilibrium level, allowing oil-exporters to temporarily increase their expenditures. However, as adjustment progresses, oil export volumes will fall proportionally to the rise in oil prices, and drive total oil revenues back to their baseline level.

I Introduction and summary

In recent months, the price of oil increased significantly, with European Brent crude up from 29.81 US dollars per barrel in December 2003 to an average of 49.8 US dollars per barrel in October 2004. The major causes of this recent surge in oil prices have usually been attributed to the strong rise in demand for energy due to high economic growth in the United States and China, as well as fears of disruptions to a tight oil supply following terrorist attacks and political uncertainties in important non-OPEC oil-producing countries. Whatever the reasons behind these price hikes, it is clear that they can significantly affect the medium-term outlook for the world economy[1] and complicate the work of policy makers.

FIGURE 1 - The European Brent crude oil spot price (year average, US$/bbl)



In this Working Paper, we use the NIME model to describe the macroeconomic effects of an oil price shock on the world economy. In the next section, we present the NIME model, and we discuss how we model the effects of an oil price shock by making a distinction between price rises due to an increase in the productivity of oil and an increase in the price mark-up of oil.

1. See Meyermans and Van Brusselen (2004 and 2005) for a comprehensive medium-term outlook for the world economy. Available on the Internet at http://www.plan.be/nl/pub/wp/wp0416/wp0416en.pdf

The reader should be aware that the short-term forecasts and medium-term projections for the Belgian economy carried out within the Federal Planning Bureau (FPB) do not necessarily retain NIME oil price scenarios in their underlying international economic assumptions.

1. Simulation results of a permanent oil price shock: the euro area

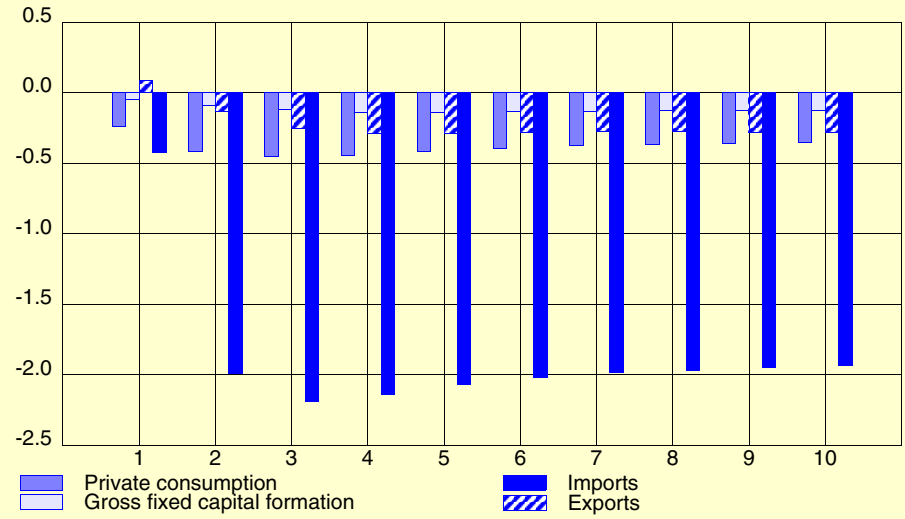
In this paper, we examine the macroeconomic effects of a permanent 25 per cent increase in the price of oil, due to an increase in the oil price mark-up. Before summarizing the simulation results, we highlight here some of the underlying assumptions of the exercise. First, it is assumed that the price of oil (deflated by the producer price) is equal to the productivity of oil plus a mark-up, which are both determined outside the model. Second, in this exercise a shock is only applied to the price mark-up of oil, and not to the prices of the other energy carriers and sources. Third, the NIME model integrates the fact that the euro area and Japan import all the oil they consume, while the United States and the Western non-euro EU Member States[1] produce part of their own oil consumption. Fourth, the enterprise sector production function has a constant-returns-to-scale Cobb-Douglas specification defined over, on the one hand, value added which is produced by capital and labour, and on the other hand (intermediary) imports. The use of the Cobb-Douglas specification implies that the long-run elasticity of substitution between value added and imports is constant and equal to one. Fifth, it is assumed that higher oil revenues earned by the oil-exporting countries are recycled through higher aggregate demand in these countries. Sixth, the monetary authorities set the short-term interest rates according to the Taylor principle. Finally, we wish to emphasize that the appendix of this working paper spells out the major analytical results which follow from these assumptions.

The simulation results show that, in the long run, such a shock reduces aggregate private supply for final demand (henceforth referred to as "output") by 0.27 per cent in the euro area, 0.30 per cent in the Western non-euro EU Member States, 0.33 per cent in the United States and 0.23 per cent in Japan. However, due to the Cobb-Douglas constant-returns-to-scale specification of the production function and the fact that the euro area and Japan import all their oil, the fall in output matches the fall in imports, so that the aggregate value added of these areas, measured as aggregate output minus imports, remains almost unaffected[2]. In the United States and Western non-euro EU Member States, the fall in value added is more notable as the fall in output is not completely offset by a similar decline in imports.

In the long run, the employment effects are negligible, though real producer wage rates and the return on capital drop proportionally to the decline in output. The outcome for the general price level depends on monetary policy. Under a Taylor rule, the rise in prices is directly proportional to the decline in volumes, thereby leaving unaffected the current price value of aggregate output, nominal GDP as well as the money supply.

1. The Western non-euro eu Member States consists of Denmark, the United Kingdom, and Sweden.
2. See Section B of the Appendix for more analytical details on this result.

FIGURE 2 - Selected components of aggregate demand
(deviations from baseline in per cent)



In the medium-term, various adjustment costs prevent demand from immediately adjusting to its new long-run equilibrium. These adjustment costs include the cost of implementing revised expenditure plans by households and enterprises, as well as the menu and information costs to adjust prices. As a result, certain components of aggregate demand can deviate significantly from their new long-run solution in the medium-term.

Looking at the results for the euro area, we see that the most affected component of demand is imports, which immediately fall by 0.43 per cent. Moreover, as the impact of the oil price shock becomes stronger, imports pursue their fall and bottom out at 2.21 per cent below baseline in the third year, compared to 1.91 per cent below baseline in the new steady state.

Private consumption in the euro area falls by 0.24 per cent in the first year, mainly due to a strong decrease in (expected) disposable income and household wealth, a 0.40 percentage point increase in the short-term interest rate, and a 0.30 per cent increase in the consumer price. Private consumption bottoms out at 0.45 per cent below baseline in the third year. As of the fifth year, as disposable income and household wealth stabilise and monetary policy is relaxed, private consumption recovers and gradually converges to its new equilibrium level at 0.32 per cent below baseline.

Total gross fixed capital formation falls only moderately, down by 0.14 per cent after four years, and by 0.06 per cent in the long run, mainly due to the small drop in enterprise investments. The decline in enterprise investments is small as the relative price of capital falls in order to reflect the drop in the return on capital.

The real producer wage rate initially rises by 0.09 per cent, mainly in response to changes in the price of private consumption (relative to the producer price). Indeed, in the first year, private consumption prices increase by 0.30 per cent, while producer prices increase by only 0.20 per cent. This implies that households - who use consumer prices to deflate their nominal wage - attempt to negotiate a nom-

inal wage rate increase that is larger than what producers - who use the producer price to deflate their nominal wage costs - will accept to pay. Initially, the household sector has enough bargaining power to negotiate a nominal wage rise which matches to a large extent the rise in the consumer price. However, the resulting effective increase in real producer wage costs reduces labour demand. This then leads to a higher unemployment rate, and puts downward pressure on wages.

2. Simulation results of a permanent oil price shock: other areas of the world

Results similar to those presented for the euro area are to be found for the other oil-importing areas. In the Western non-euro EU Member States, private sector output falls by 0.07 per cent in the first year, bottoms out at 0.43 per cent in the third year and reaches 0.30 per cent below baseline in the long run. In the New EU Member States, output falls by 0.21 per cent in the first year and reaches 0.71 per cent below baseline in the long run. In the United States, private sector output falls by 0.22 per cent in the first year and reaches a low of 0.55 per cent in the fourth year, before levelling out at 0.33 per cent below baseline in the long run. In Japan, private sector output falls by 0.24 per cent in the first year and stabilises at 0.23 per cent below baseline in the long run. In the rest of the world, output initially increases by 0.28 per cent, as the oil price shock leads to a temporary income transfer from oil-importing countries to oil-exporting countries. However, as oil export revenues start to fall, aggregate demand in these countries also falls and output finally returns to its baseline level.

II The NIME model

The NIME model is a macroeconometric world model developed at the Belgian Federal Planning Bureau (FPB). This model is built to make medium-term forecasts of the international economy and to study the transmission mechanisms of economic policies and exogenous shocks. This section gives a very brief overview of the model. More technical details regarding the model can be found in Meyermans and Van Brusselen (2000.a, 2000.b, and 2001), Meyermans (2003 and 2004) and the appendix of this paper.

The current version of the NIME model divides the world into six country blocs: the euro area, the Western non-euro EU Member States[1], the New EU Member States[2], the United States, Japan and the rest of the world. These country blocs are linked to each other through trade and financial flows. Data for the euro area is aggregated using ECU/euro exchange rates. Data for the Western non-euro EU Member States and the New EU Member States are aggregated in a common synthetic currency unit.

In each of these country blocs, except for the rest of the world bloc and the New EU Member States bloc, we distinguish a household sector, an enterprise sector, a public sector, and a monetary sector. A similar set of behavioural equations and accounting identities is specified for each sector across blocs, while the parameter values of the equations are obtained using econometric techniques applied to the aggregated data of the different blocs[3].

The NIME model makes an analytical distinction between three different time horizons: the short run that is demand driven and during which the plans of the agents are not fully realised due to the existence of adjustment costs, the medium run during which the plans are realised but still changing due to lagging adjustment of the other endogenous variables, and a steady state long run. In the steady state, productivity growth, inflation, the real interest rate, and growth in population and labour supply are exogenous, while the steady state values of the other variables, such as potential output, are determined by these exogenous variables and the structural equations of the model.

The expectations of the agents are partly forward-looking, and partly backward-looking. The forward-looking expectations are quasi-rational in the sense that agents have model consistent expectations about the steady state but the speed of

1. The Western non-euro EU Member States consists of Denmark, Sweden, and the United Kingdom.
2. This bloc includes Cyprus, the Czech republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia plus Bulgaria and Romania.
3. For the rest of the world and the New EU Member States, only a limited number of equations describing overall economic activity is specified.

convergence towards this steady state is determined by a reduced form function rather than by the underlying structural parameters of the model.

The version of the NIME model used in this paper is a modified version of the model described in Meyermans and Van Brusselen (2001) and Meyermans (2003 and 2004). The modifications are described in Appendix A, and they include an explicit modelling of the use of oil in the oil-importing countries and the modelling of the income transfer from the oil-importing countries to the oil-exporting countries due to an oil price shock.

Before we proceed with a discussion of the variants, we will have a brief look at each of the sectors of the NIME model, i.e., the household sector, the enterprise sector, the fiscal sector, and the monetary sector.

1. The household sector

The household sector allocates its total available means over goods and services, real money balances, residential buildings, and other assets as a function of the nominal interest rate, the real interest rate, the user cost of residential buildings, and a scale variable. The scale variable consists of inherited assets, plus current income from assets, plus current and expected future take home labour income, plus transfers. Error correction mechanisms and partial adjustment schemes are used to capture sluggish adjustment in the expenditure plans of the household sector. Moreover, in the short run, the household sector is liquidity constrained so that a fraction of its expenditures must be financed by disposable income.

2. The enterprise sector

The enterprise sector maximizes its profits by hiring production factors and selling its products to the final users. There are three production factors, i.e., labour, capital and intermediary imports which includes oil. Error correction mechanisms and partial adjustment schemes are used to model the short-run demand for production factors. In these demand schemes, the long-run factor demand equations are derived from a Cobb-Douglas production function with constant returns to scale.

In the long run, prices of inputs and outputs clear the markets, but they adjust only sluggishly to their equilibrium value. As a consequence, it is quantities that adjust in order to meet demand in the short run.

3. The fiscal sector

Public sector receipts are determined by endogenous tax bases and predetermined tax rates, while public expenditures mainly determined by the business cycle and trend growth. In the NIME model, the automatic fiscal stabilisers operate on the expenditure side mainly through the unemployment benefits and interest payments on public debt, and on the revenue side mainly through direct labour income taxes, profit taxes, social security contributions, and indirect taxes.

4. The monetary sector

Short-term interest rates are set according to a Taylor principle. This implies that the monetary authorities increase the short term nominal interest rate more than proportionally to changes in inflation, thus increasing real interest rates when inflationary pressures arise. It also implies that the monetary authorities keep the short-term interest rate below (above) the equilibrium interest rate if demand is below (above) potential output. Long-term interest rates are determined by the term structure theory of interest rates. An area's effective exchange rate is determined by a weighted average of the equilibrium exchange rate and the lagged observed exchange rate, by the interest rate differential, and by the expected inflation differential.

5. Oil in the NIME model's production function

As discussed above, there are three production factors in the NIME model, i.e., labour, capital and (intermediary) imports. Here, we assume explicitly that total imports are an aggregate of oil imports, on the one hand, and other imported goods and services (or "non-oil imports"), on the other hand. At the same time, the price of total imports is an aggregate of the price of oil imports and the price of non-oil imports.

In previous versions of the NIME model[1], it had been assumed that importers were price-makers for all imported goods and services in the long run, so that the price of total imports converges to their long-run productivity. Here, we continue to assume that the long-run price of non-oil imports is determined by its long-run productivity. However, we now assume also that the oil-importing country blocs are price-takers with respect to the price of oil. More specifically, we assume that the price of oil is equal to its productivity augmented with a mark-up, whereby the productivity of oil as well as the price mark-up are determined outside the model. As a consequence the price of oil can change due to a change in its productivity (i.e. energy efficiency) or due to change in the price mark-up. In Appendix A, we show analytically that both shocks have a different impact on output. First, if the energy efficiency improves, the price of oil will increase and producers will demand a lower amount of oil. However, because the productivity of oil has improved, the lower oil consumption will prove to be sufficient to maintain the same output level as before the price change[2]. Second, if the price mark-up increases, the price of oil will increase and producers will demand a lower amount of oil. However, because the productivity of oil has not improved, the lower oil consumption prevents producers from maintaining the same output level as before the price change and output falls.

1. See, for instance, Meyermans and Van Brusselen (2001).
2. Remember that potential output is determined by labour productivity and the natural rate of employment. None of these are affected by an increase in the productivity of oil.

III Effects of a permanent oil price shock

In this section, we present the macroeconomic effects of a permanent 25 per cent increase in the price of oil. The shock is modelled as an increase in the mark-up of the price of oil. We start with a discussion of the comparative statics of the shock, followed by a presentation of the medium term dynamics. Though the shock is implemented in all of the NIME model's six country blocs, the main focus of the following text will be on the results for the euro area. However, detailed numerical results for all blocs can be found in the tables at the end of this section. The results for the euro area are shown in Table 1 while the results for the other areas are shown in tables 2 to 6. The numbers in these tables are, unless otherwise specified, percentage deviations from a technical steady state baseline.

A. The comparative statics

1. The euro area

In the long run, the 25 per cent permanent oil price shock reduces through a fall in total factor productivity, the euro area's potential output by 0.27 per cent. At the same moment, the real wage rate falls by the same proportion, while the employment level remains almost unaffected.

As aggregate supply decreases by 0.27 per cent in the euro area, total demand must fall proportionally, in order to maintain equilibrium in the goods market. However, the various components of demand do not all adjust in the same manner. Public consumption of goods and services decreases - by assumption - proportionally to the drop in potential output. Total gross fixed capital formation by the enterprise sector and the public sector does not change, as both employment and the capital to labour ratio are unchanged relative to the baseline in the new steady state. Investment in residential buildings falls by 0.28 per cent, in line with the long-run reduction in real take home wages. Euro area exports decrease by 0.26 per cent, reflecting the overall 0.26 per cent fall in foreign effective demand, and the unchanged real effective exchange rate. Imports drop by 1.9 per cent, due to the 1.9 per cent increase in the import price. Any remaining excess demand is absorbed by a decrease in private consumption, which is triggered by a 0.05 per cent increase in the relative price of private consumption[1].

1. Note also that the fall in the sum of private and public output matches the fall in imports, allowing real GDP to almost return to its baseline level in the long run. See also Section B.3 of the Appendix on this.

The effect of the oil price shock on the price level depends on monetary policy, while the change in the relative prices is independent of monetary policy. In this variant, the monetary authorities follow a Taylor rule. As a consequence, the prices of private sector output, public consumption, residential investment and public investment increase by 0.25 per cent. However, the prices of imports, exports, enterprise sector investment, and private consumption exhibit significant changes in terms of relative prices. In the long run, the price of imports increases by 1.89 per cent in the euro area, reflecting the impact of the exogenous increase in the price mark-up of the oil price, and the share of oil imports in total imports of the euro area. The price of euro area exports rises by 0.24 per cent, compensating for the rise in the foreign effective price level, and the unchanged nominal effective exchange rate. Though the long-term price of enterprise sector investment falls by only 0.02 per cent, the decline is 0.27 per cent relative to price of private sector output. This decline reflects the fall in the capital stock's productivity caused by the long-run 0.27 per cent decline in aggregate private sector output. Finally, the price of private consumption increases by 0.30 per cent, as it adjusts to ensure the long-run equilibrium between aggregate supply and demand. All in all, we note that under a Taylor rule, the rise in prices is directly proportional to the decline in volumes, thereby leaving unaffected the current price value of aggregate output, nominal GDP as well as the money supply. Moreover, the GDP deflator does not change much as the increase in the price of output is matched by an increase in the price of imports.

In the new steady state, the euro area's interest rates are unaffected by the oil price shock. This stems from the fact that the real interest rate does not change and from the fact that the long-run inflation and output gap both return to their baseline level. The equilibrium nominal effective exchange rate (of each country bloc) does not change either, as output and output prices both change proportionally, and in opposite directions[1].

The euro area's fiscal deficit-to-GDP ratio and debt-to-GDP ratio return to their baseline level, although this is made possible after a very modest 0.01 percentage point increase in the direct income tax rate. This tax increase is necessary to keep the fiscal accounts in balance in the face of a change in the relative price of private consumption. As explained above, the price of private consumption increases by 0.05 per cent relative to the producer price, in order to balance aggregate supply and demand. However, as the relative price of private consumption changes, the fiscal balance tends to deteriorate. Indeed, an important part of the tax bases are indexed to the GDP deflator or to the producer price, while important items of public expenditure, such as transfers to the households, are linked to the price of private consumption. As the price of private consumption increases more than the general price level and producer price, public expenditure falls less than government income. Hence, an imbalance appears in the government fiscal accounts, which the authorities must offset by an increase in the current income tax rate[2]. Moreover, this increase in the income tax rate reduces the gap between the reservation wage and the take home real wage, thereby reducing the willingness of

1. See equation (D.16) in Appendix D of Meyermans and Van Brusselen (2001), for the equation of the equilibrium real exchange rate.
2. This is the assumption that is retained in the current simulation. Alternatively, one could impose that the fiscal authorities restore balance by reducing certain expenditure items, such as public consumption of goods and services, transfers to households, employment, or investment. In the default version of the model, public consumption of goods and services simply fall proportionally to private sector output. By assumption, the tax increase does not appear at the beginning of the adjustment process, so allowing for clearer medium-term results.

employees to accept a job offer. This results in a long-run rise in the natural rate of unemployment, albeit by only 0.01 percentage point.

2. The other country blocs

The model generates qualitatively identical long-term results for the other oil-importing country blocs. Indeed, potential output falls by 0.30 per cent in the Western non-euro EU Member States, 0.33 per cent in the US, and 0.23 per cent in Japan, compared with 0.27 per cent in the euro area. At the same time, the price of private consumption increases by 0.43 per cent in the Western non-euro EU Member States, 0.38 per cent in the US, and 0.21 per cent in Japan, compared with 0.30 per cent in the euro area. Imports fall by 0.30 per cent in the Western non-euro EU Member States, 1.88 per cent in the United States, and 2.47 per cent in Japan, while exports fall by 0.21 per cent in the Western non-euro EU Member States, 0.13 per cent in the United States, and 0.23 per cent in Japan. In the long run, the financial variables are all close to their baseline level. In the labour market, the employment levels are almost unaffected, but real producer wages fall proportionally to output. Finally, government fiscal balance is restored after very moderate increases in current income tax rates.

In the oil-exporting rest of the world, long-run aggregate supply is not affected by the oil price shock[1]. However, the components of demand are modified. The export volume falls by 3 per cent, but the export price increases proportionally, leaving the total value of exports unchanged relative to baseline. Similarly, the imports of the oil-exporting rest of the world fall by 0.75 per cent, and import prices increase so as to leave the total value of imports unchanged. Hence, the long-run current account-to-GDP ratio returns to its baseline level.

B. The adjustment process

In this section, we discuss the adjustment path towards the new equilibrium[2]. The adjustment path is to a large extent determined by the speed of adjustment of prices and the adjustment costs incurred during the implementation of revised expenditure plans. Once again, we focus on the results for the euro area. The results for the other main country blocs remain qualitatively similar.

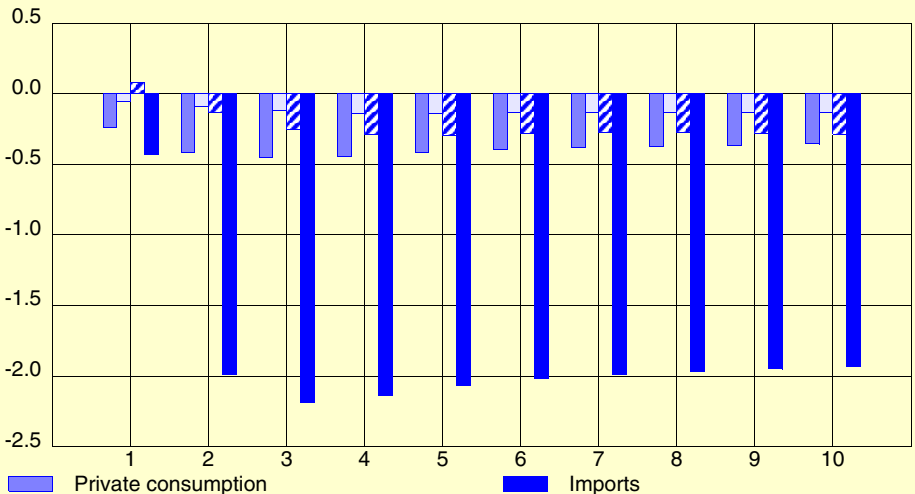
1. This is an assumption. See section E.2 of the Appendix.
2. For comparison, we list at the end of this working paper a number of other studies on the effects of oil price shocks. For example, the European Commission (2003.a, b and 2004.a, b) shows results originating from the Commission's QUEST model. Robinson et al. (2000) and Hunt et al. (2001) report results for the International Monetary Fund's MULTMOD model. The Organisation for Economic Co-operation and Development (OECD) (2000) and the International Energy Agency (2004) discuss simulation results produced with the OECD's INTERLINK model. Comparing these results, we note that model responses to oil price shocks are generally limited and that these responses depend, inter alia, on the size and duration of the shock, on if the countries are oil-producers or not, on the wage-price formation processes, on monetary policy and on reactions of oil-exporting countries to higher oil proceeds. See, for instance, Brook et al. (2004) and Barsky and Kilian (2004).

1. The euro area

The results for the euro area are shown in Table 1 and summarised in Figures 4 to 10.

In the euro area, private consumption falls by 0.24 per cent in the first year of the oil price hike, primarily reflecting the decrease in disposable income and wealth of the household sector, a 0.40 percentage points increase in the short-term interest rate and a 0.30 per cent increase in the price of private consumption. Disposable income falls by 0.07 per cent in the first year, as the take home real wage falls by 0.01 per cent, total employment falls by 0.05 per cent and the (unanticipated) 0.30 per cent increase in the consumer price lowers the real value of interest income. At the same time, the unanticipated inflation erodes the purchasing power of the household sector's nominal assets, while the decline in potential output reduces expectations regarding future labour income. In the second year, as disposable income and the wealth of the household sector fall further, and nominal interest rates remain above their baseline level, private consumption declines by 0.42 per cent below baseline and bottoms out at 0.45 per cent below baseline in the third year. As of the fourth year, disposable income and household wealth stabilise, and private consumption starts to converge towards its new steady state level, which is 0.32 per cent below baseline.

FIGURE 3 - Selected components of aggregate demand in the euro area
(deviations from baseline in per cent)



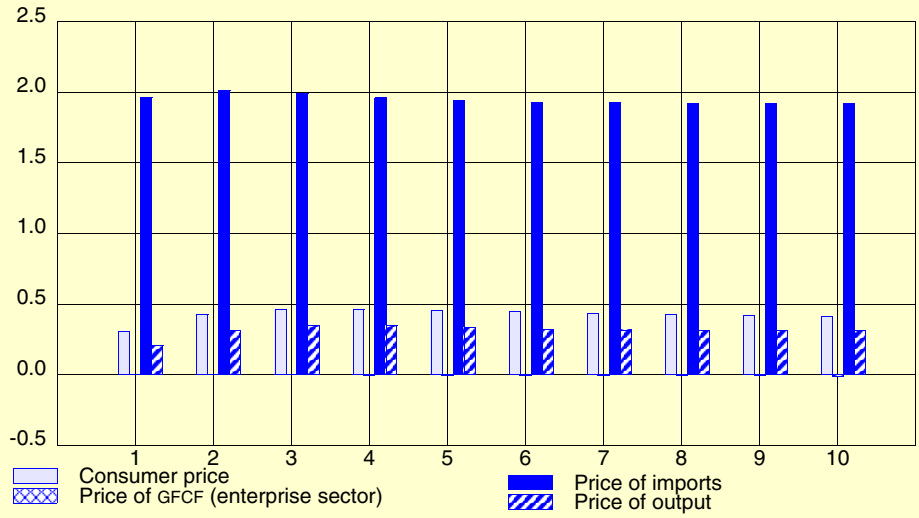
Public consumption is almost unaffected in the first year. Its subsequent fall below baseline reflects the fact that public consumption adjusts with a one year lag to changes in potential output.

Investment in residential buildings falls by 0.48 per cent in the first year, primarily due to the decline in household income and wealth, and the rise in interest rates. However, the fall is somewhat tempered by the smaller rise in the price of investment (up by 0.26 per cent) than in the price of private consumption (up by 0.30 per cent). In subsequent years, investment in residential buildings falls fur-

ther, reaching 0.65 per cent below baseline after two years, compared to 0.28 per cent in the new steady state.

Enterprise sector gross fixed capital formation increases slightly during the first three years, falls slightly below the baseline over the following couple of years, and converges gradually to the baseline thereafter. The initial modest rise in enterprise investment is caused by the fall in the relative price of capital, and arises in spite of the fall in private sector output and the initial increase in interest rates. The fall in the relative price of capital is due to the fact that the return on capital falls.

FIGURE 4 - Selected prices in the euro area
(deviations from baseline in per cent)



Public sector gross fixed capital formation tracks - by assumption - the evolution of the euro area's real GDP.

Euro area exports increase by 0.08 per cent in the first year, reflecting a 0.08 per cent increase in foreign effective demand and a 0.05 per cent appreciation of the euro area's real effective exchange rate. Foreign effective demand increases due to the 0.28 per cent increase in total demand of the oil-exporting Rest of the World (RW) bloc, which offsets to a large extent the fall in economic activity in the oil-importing country blocs. Indeed, the oil price hike induces a temporary income transfer, which brings a temporary boost to spending in the RW bloc. However, in subsequent years, as economic activity in the major country blocs declines further and oil imports continue to adjust to the higher oil price, the RW bloc's revenues from oil exports declines also, so that the euro area's foreign effective demand declines from 0.08 per cent above baseline in the first year to 0.14 per cent below baseline in the second year.

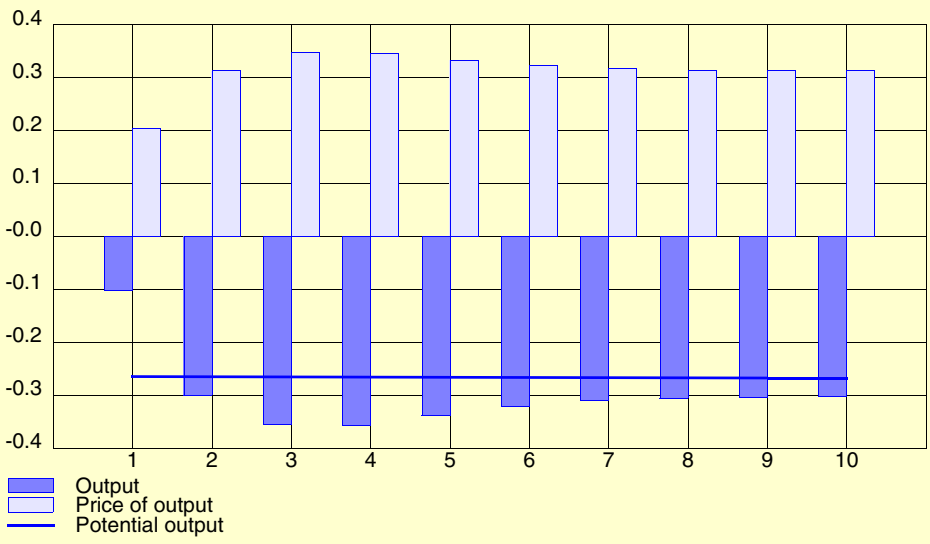
Imports fall by a relatively modest 0.43 per cent in the first year, despite the immediate 1.94 per cent increase in the price of intermediate imports. However, in the second year, imports fall by 2 per cent as output continues to fall, and as imports react fully to the initial rise in import prices. Imports then continue to

decline, and they reach 2.21 per cent below baseline in the third year, before converging towards 1.93 per cent below baseline in the new steady state.

All in all, the euro area's private supply for final demand falls by 0.10 per cent in the first year, bottoms out at 0.36 per cent below baseline after four years, and then converges gradually to its new steady state level, which is 0.27 per cent below baseline. At the same time, real euro area GDP falls by just 0.04 per cent in the first year, as total imports fall sharply. The decline in GDP bottoms out after four years at 0.06 per cent below baseline, and subsequently converges back towards its baseline level.

The price of private sector output increases by 0.20 per cent in the first year, thus carrying out the greater part of its adjustment towards its 0.25 per cent steady state increase. This immediate and sharp rise in the output price reflects the assumption that all economic agents are fully aware of the long-run price implications of the oil price shock, and incorporate this information immediately into their price setting scheme[1]. On balance, the GDP deflator, which reflects the increase in output prices as well as import prices (with a negative sign), increases and reaches 0.13 per cent above baseline in the fourth year, before converging gradually to its baseline level.

FIGURE 5 - Private sector output and output price in the euro area
(deviations from baseline in per cent)



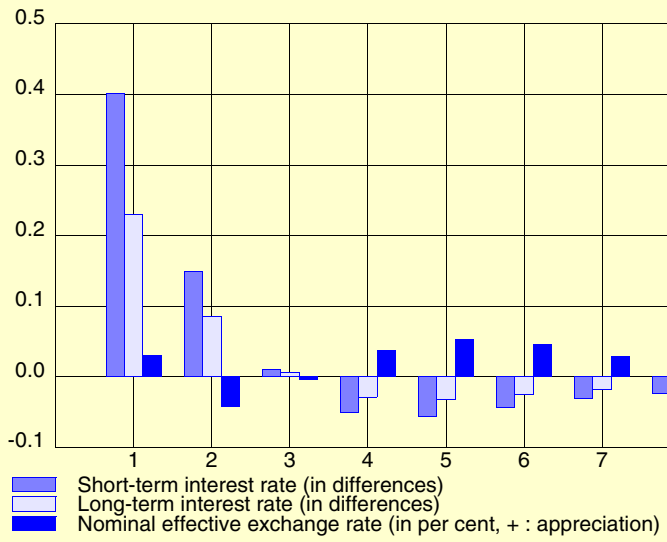
The nominal short-term interest rates increase by 0.40 percentage point rise in the first year, as the monetary authorities attempt to temper inflationary pressures and bring effective aggregate demand more into line with the new, and lower, potential output level. Nominal short-term interest rates fall back as of the second year, and subsequently fall below their baseline level as of the fourth year, as inflationary pressures disappear and effective demand falls below the new potential output level.

1. An alternative approach would be to assume that the economic agents learn only gradually about the long-run price increases.

The effective nominal exchange rate of the euro area appreciates by 0.03 per cent in the first year, and stays close to its baseline level in subsequent years, reflecting the relative stability of the equilibrium exchange rate, the inflation differential, and the interest rate differential.

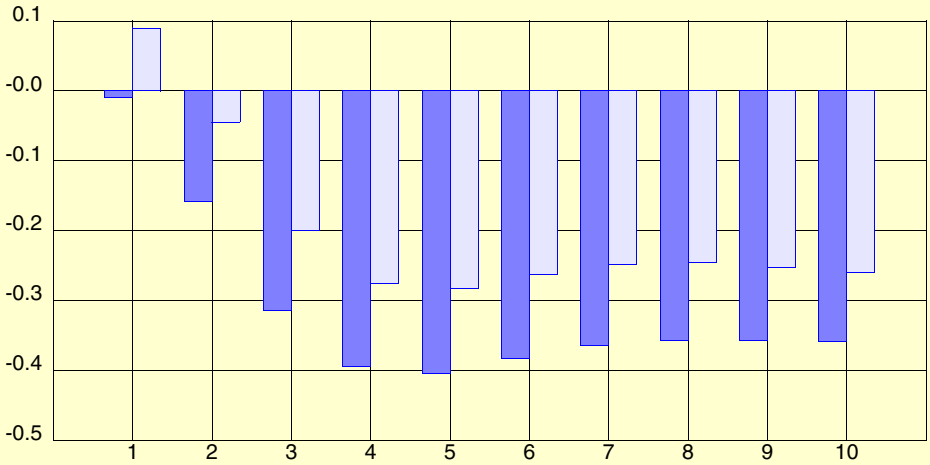
The real producer wage rate increases by 0.09 per cent in the first year, but then declines to 0.28 per cent below baseline in the fourth year, compared with 0.27 per cent in the long run. In the euro area, the real producer wage rate rises, mainly in response to changes in the price of private consumption (relative to the producer price). Indeed, in the first year, private consumption prices increase by 0.30 per cent, while producer prices increase by only 0.20 per cent. This implies that households - who use consumer prices to deflate their nominal wage - attempt to negotiate a nominal wage rate increase that is larger than what producers - who use the producer price to deflate their nominal wage costs - will accept to pay. Initially, the household sector has enough bargaining power to negotiate a nominal wage rise which matches to a large extent the rise in the consumer price. However, this increase in the real producer wage rate raises unemployment, thereby reducing the pressure on wages in subsequent years.

FIGURE 6 - Interest rates and the exchange rate in the euro area
(deviations from baseline)



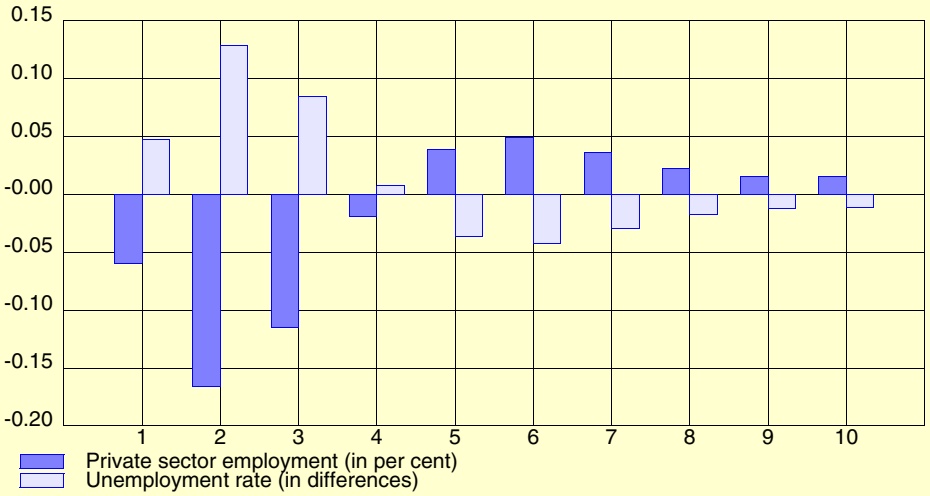
Although the nominal private sector wage rate increases by 0.29 per cent in the first year, this increase is insufficient to keep up with the increase in the price of private consumption. Hence, the real take home wage rate falls in the first year, followed by further decreases of up to 0.41 per cent below baseline in the fifth year. In the long run, the real take home wage falls 0.33 per cent below baseline.

FIGURE 7 - Private sector wage rate in the euro area
(deviations from baseline in per cent)



Private sector labour demand lies below baseline during the first four years of the shock. At the same time, the unemployment rate peaks to 0.13 percentage points above baseline in the second year. Labour demand declines initially, as the real producer wage rate falls only gradually to its new equilibrium, while aggregate demand falls below potential output as of the second year.

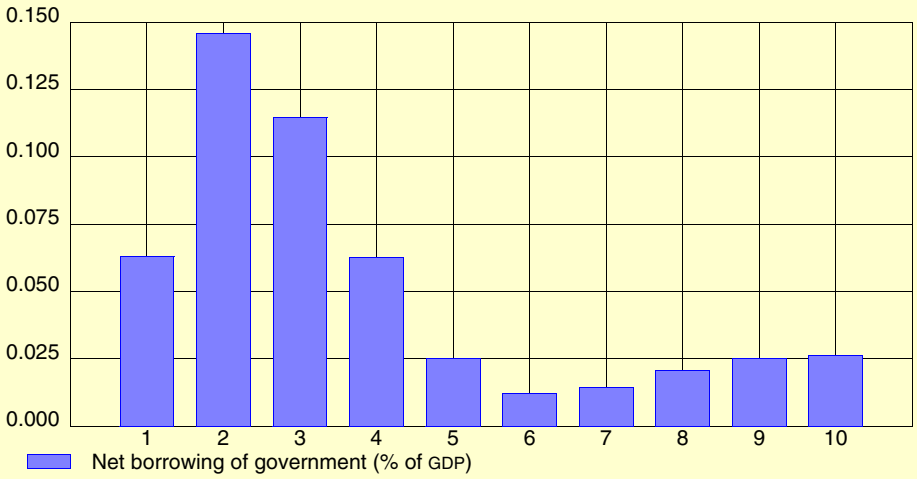
FIGURE 8 - Private sector employment and unemployment rates in the euro area
(deviations from baseline)



The euro area's fiscal stance deteriorates immediately after the oil price shock. The fiscal deficit-to-GDP ratio increases by 0.06 percentage points, as the fiscal automatic stabilisers are free to operate. The debt-to-GDP ratio increases immediately by 0.11 percentage point, primarily due to the 0.08 per cent reduction in nominal GDP. The debt-to-GDP ratio then increases further, to 0.49

percentage point above baseline after ten years. In the long run, a 0.01 percentage point rise in the direct tax rate ensures that the debt-to-GDP ratio returns to its baseline level.

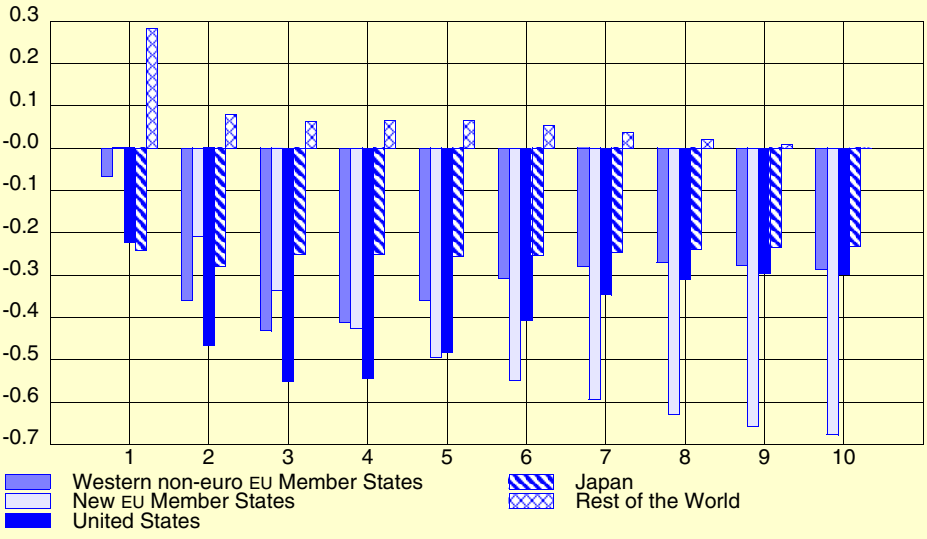
FIGURE 9 - Net borrowing of government in the euro area
(deviations from baseline in differences)



2. The other country blocs

Results similar to those obtained for the euro area are found for the other main oil-importing country blocs (see tables 2 to 5). In the Western non-euro EU Member States, private supply for final demand falls by 0.07 per cent in the first year and reaches a low of 0.43 per cent in the third year. In the United States, aggregate private supply falls by 0.22 per cent in the first year and reaches a low of 0.55 per cent in the fourth year. In Japan, private supply falls by 0.24 per cent in the first year and reaches a low of 0.28 per cent in the second year.

FIGURE 10 - Output in the other areas of the world
(deviations from baseline in per cent)



The prices of private consumption increase immediately by 0.13 per cent in the the Western non-euro EU Member States, by 0.26 per cent in the United States, and by 0.24 per cent in Japan.

The interest rates show important deviations from the baseline only in the first two years of the shock, as the inflationary pressures become more moderate after two years and the fall in aggregate demand brings it more in line with the new potential output level. The exchange rates do not change much, as changes in the equilibrium exchange rates, the interest rate differentials, and inflation differences are small.

In the Western non-euro EU Member States, the United States, and Japan, the real producer wage falls below the baseline as of the first year, while it initially increased in the euro area. This is because the change in the relative price of private consumption in the other oil-importing country blocs is smaller than in the euro area, and also because the changes in the tax wedge - which includes changes in the consumer price relative to the producer price - have a smaller impact on nominal wage changes, reflecting a stronger bargaining power of the enterprise sector in the other country blocs.

In the first year, total demand in the RW bloc increases by 0.28 per cent, as higher export earnings linked to oil exports bring a temporary boost to domestic demand. See Table 6. Indeed, exports of the oil-exporting RW bloc fall by only 0.19 per cent in the first year, while the bloc's (euro denominated) export price increases by 2.73 per cent. However, exports then fall to 0.83 per cent below baseline in the second year, and 2.33 per cent below baseline in the tenth year of the shock. In line with this evolution in export revenues, total output of the RW bloc falls to 0.08 per cent above baseline in the second year and then continues to return gradually towards its baseline level in subsequent years. At the same time, the rest of the world's imports increase by 0.47 per cent above baseline in the first year, rising further to 0.71 per cent above baseline in the second year, followed by a gradual decline to 0.75 per cent below baseline in the new steady state[1].

1. Interpreting this result for imports, it should be remembered that in the NIME model, the rest of the world's (RW) imports adjust to ensure that aggregate world imports balance aggregate world exports. Hence, as exports in constant prices of all the major world areas are initially less affected than their imports in constant prices, there tends to be an increase in the net exports in constant prices for these areas, which must be matched by a decline in the net exports in constant prices of the RW. The RW's real exports are determined by changes in foreign effective output and relative prices. The developments in these variables result in a decline in exports by the RW. Hence, in order to create the necessary decrease in the RW's real net exports, import volumes must increase in the first years. The specific numerical results for the RW's imports reflect the weight of the RW's trade in total world trade, the oil price shock's relative effects on imports and exports in the major world areas, the dynamics of the major areas' export and import equations and the dynamics of the RW's export equation.

C. Detailed area tables

TABLE 1 - The macroeconomic effects for the euro area of a permanent 25 per cent oil price shock[a]

	01	02	03	04	05	06	07	08	09	10	ss
I. Aggregate demand-supply											
1. Private consumption	-0.24	-0.42	-0.45	-0.44	-0.42	-0.39	-0.38	-0.37	-0.36	-0.36	-0.32
2. Public consumption	0.01	-0.12	-0.10	-0.09	-0.09	-0.10	-0.13	-0.15	-0.17	-0.19	-0.27
3. Gross fixed capital formation	-0.05	-0.09	-0.12	-0.14	-0.14	-0.14	-0.13	-0.13	-0.13	-0.13	-0.06
A. Residential	-0.48	-0.65	-0.65	-0.64	-0.62	-0.61	-0.61	-0.61	-0.61	-0.61	-0.28
B. Enterprises	0.07	0.05	0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01	-0.00
C. Public	-0.05	-0.04	-0.07	-0.07	-0.06	-0.05	-0.05	-0.05	-0.06	-0.06	-0.04
4. Exports	0.08	-0.13	-0.25	-0.29	-0.29	-0.28	-0.28	-0.28	-0.28	-0.29	-0.26
5. Imports	-0.43	-2.01	-2.21	-2.16	-2.09	-2.04	-2.01	-1.99	-1.97	-1.95	-1.91
6. Gross Domestic Product	-0.04	-0.03	-0.06	-0.06	-0.05	-0.05	-0.04	-0.05	-0.05	-0.05	-0.04
7. Total private supply for final demand	-0.10	-0.30	-0.36	-0.36	-0.34	-0.32	-0.31	-0.31	-0.30	-0.30	-0.27
8. Output gap (private sector)*	0.16	-0.03	-0.09	-0.09	-0.07	-0.05	-0.04	-0.04	-0.04	-0.03	0.00
II. Price indices											
1. Private consumption	0.30	0.43	0.46	0.46	0.45	0.44	0.43	0.43	0.42	0.41	0.30
2. Public consumption	0.28	0.39	0.37	0.30	0.24	0.22	0.22	0.23	0.25	0.25	0.25
3. Gross fixed capital formation	0.10	0.14	0.15	0.13	0.11	0.09	0.08	0.08	0.08	0.08	0.07
A. Residential	0.26	0.40	0.44	0.41	0.36	0.30	0.26	0.23	0.22	0.22	0.25
B. Enterprises	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.02
C. Government	0.28	0.42	0.42	0.35	0.28	0.22	0.21	0.21	0.23	0.24	0.25
4. Exports	0.19	0.19	0.19	0.19	0.20	0.20	0.20	0.20	0.20	0.20	0.24
5. Imports	1.94	1.99	1.97	1.94	1.92	1.91	1.91	1.91	1.90	1.90	1.89
6. Gross domestic product	-0.04	0.09	0.13	0.13	0.11	0.10	0.09	0.09	0.09	0.09	0.02
7. Total supply by private sector	0.20	0.31	0.35	0.35	0.33	0.32	0.32	0.31	0.31	0.31	0.25
III. Financial sector											
1. Nominal short-run interest rate *	0.40	0.15	0.01	-0.05	-0.06	-0.04	-0.03	-0.02	-0.02	-0.02	-0.00
2. Nominal long-run interest rate *	0.23	0.09	0.01	-0.03	-0.03	-0.03	-0.02	-0.01	-0.01	-0.01	-0.00
3. Spot exchange rate (local/eur)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Effective nominal exchange rate (+:depr.)	-0.03	0.04	0.00	-0.04	-0.05	-0.05	-0.03	-0.01	-0.00	0.00	-0.02
5. Effective real exchange rate (+:depr.)	-0.05	0.09	0.08	0.04	0.02	0.02	0.03	0.04	0.05	0.05	-0.00
6. Money	-1.63	-0.72	-0.15	0.14	0.20	0.19	0.16	0.14	0.14	0.14	-0.02
IV. Labour market											
1. Total employment	-0.05	-0.14	-0.10	-0.02	0.03	0.04	0.03	0.02	0.01	0.01	-0.01
A. private sector	-0.06	-0.17	-0.11	-0.02	0.04	0.05	0.04	0.02	0.02	0.02	-0.01
B. public sector	-0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	-0.00
2. Labour supply	0.00	0.00	-0.01	-0.01	-0.01	-0.00	-0.00	0.00	0.00	0.00	0.00
3. Unemployment rate *	0.05	0.13	0.08	0.01	-0.04	-0.04	-0.03	-0.02	-0.01	-0.01	0.01
4. Nominal wage private sector	0.29	0.27	0.15	0.07	0.05	0.06	0.07	0.07	0.06	0.05	-0.02
5. Nominal wage total economy	0.30	0.30	0.20	0.13	0.10	0.10	0.10	0.09	0.08	0.07	-0.02
6. Real take home private wage	-0.01	-0.16	-0.32	-0.40	-0.41	-0.38	-0.37	-0.36	-0.36	-0.36	-0.33
7. Real producer private wage	0.09	-0.04	-0.20	-0.28	-0.28	-0.26	-0.25	-0.25	-0.25	-0.26	-0.27
V. Household sector											
1. Total real means	-0.43	-0.41	-0.38	-0.36	-0.36	-0.36	-0.36	-0.35	-0.35	-0.34	-0.32
A. Disposable real income	-0.07	-0.23	-0.29	-0.32	-0.32	-0.32	-0.31	-0.31	-0.32	-0.32	-0.32
B. Inherited assets (deflated by cons. price)	-0.53	-0.46	-0.38	-0.33	-0.32	-0.32	-0.32	-0.32	-0.31	-0.30	-0.29
C. Expected future real income	-0.36	-0.38	-0.38	-0.39	-0.39	-0.39	-0.38	-0.38	-0.37	-0.37	-0.33
2. Net saving by households (% of disp. inc.)*	0.17	0.19	0.17	0.13	0.10	0.08	0.07	0.06	0.05	0.04	0.00
VI. Fiscal sector											
1. Nominal total revenue	0.17	0.12	0.09	0.07	0.07	0.07	0.07	0.06	0.06	0.05	0.01
2. Real total revenue	0.21	0.03	-0.04	-0.06	-0.04	-0.03	-0.03	-0.03	-0.04	-0.04	-0.01
3. Nominal total expenditures	0.32	0.44	0.34	0.21	0.13	0.10	0.10	0.11	0.12	0.11	0.01
4. Real total expenditures	0.36	0.34	0.20	0.08	0.01	0.00	0.01	0.02	0.02	0.02	-0.01
5. Direct labour tax rate *	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.01
6. Net lending by government (% of GDP)*	-0.06	-0.15	-0.11	-0.06	-0.03	-0.01	-0.01	-0.02	-0.03	-0.03	-0.00
7. Debt (% of GDP)*	0.11	0.17	0.28	0.35	0.38	0.39	0.41	0.43	0.46	0.49	-0.00
VII. International environment											
1. Effective foreign output	0.08	-0.14	-0.20	-0.22	-0.22	-0.21	-0.22	-0.23	-0.24	-0.25	-0.26
2. Effective foreign price	0.17	0.24	0.27	0.28	0.27	0.26	0.26	0.25	0.25	0.25	0.26
3. Effective foreign short term interest rate *	0.36	0.17	0.03	-0.06	-0.08	-0.06	-0.04	-0.02	-0.00	0.00	-0.00
4. Current account (% of GDP)*	-0.18	0.01	0.03	0.02	0.01	0.01	0.00	-0.00	-0.00	-0.00	0.00
5. Price of oil (in US $)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00

[a] without *: deviations from technical baseline in per cent; with *: deviations from technical baseline in percentage points; ss: steady state

TABLE 2 - The macroeconomic effects for the non-euro Western EU Member States of a permanent 25 per cent oil price shock[a]

	01	02	03	04	05	06	07	08	09	10	ss
I. Aggregate demand-supply											
1. Private consumption	-0.18	-0.49	-0.58	-0.55	-0.47	-0.39	-0.33	-0.31	-0.32	-0.33	-0.39
2. Public consumption	-0.03	-0.20	-0.22	-0.26	-0.29	-0.33	-0.34	-0.35	-0.34	-0.33	-0.30
3. Gross fixed capital formation	-0.03	-0.14	-0.16	-0.15	-0.13	-0.10	-0.09	-0.08	-0.07	-0.07	-0.05
A. Residential	-0.90	-0.72	-0.44	-0.27	-0.26	-0.32	-0.38	-0.41	-0.42	-0.42	-0.26
B. Enterprises	0.01	-0.04	-0.04	-0.04	-0.03	-0.02	-0.02	-0.01	-0.01	-0.00	-0.00
C. Public	-0.09	-0.60	-0.76	-0.73	-0.63	-0.51	-0.43	-0.39	-0.39	-0.40	-0.30
4. Exports	0.12	-0.16	-0.25	-0.25	-0.23	-0.22	-0.23	-0.24	-0.25	-0.25	-0.21
5. Imports	-0.14	-0.48	-0.51	-0.45	-0.40	-0.37	-0.37	-0.37	-0.38	-0.38	-0.30
6. Gross Domestic Product	-0.04	-0.28	-0.37	-0.37	-0.33	-0.29	-0.26	-0.25	-0.25	-0.26	-0.30
7. Total private supply for final demand	-0.07	-0.36	-0.43	-0.41	-0.36	-0.31	-0.28	-0.27	-0.28	-0.29	-0.30
8. Output gap (private sector)*	0.23	-0.06	-0.13	-0.11	-0.06	-0.01	0.02	0.03	0.02	0.01	0.00
II. Price indices											
1. Private consumption	0.13	0.31	0.39	0.39	0.34	0.29	0.26	0.25	0.26	0.27	0.43
2. Public consumption	0.20	0.35	0.40	0.39	0.36	0.34	0.33	0.33	0.34	0.34	0.34
3. Gross fixed capital formation	0.02	0.03	0.05	0.06	0.07	0.07	0.08	0.08	0.08	0.09	0.09
A. Residential	0.09	0.17	0.24	0.30	0.33	0.36	0.37	0.37	0.37	0.37	0.34
B. Enterprises	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.04
C. Government	0.09	0.17	0.24	0.29	0.33	0.36	0.37	0.38	0.38	0.38	0.34
4. Exports	0.21	0.22	0.22	0.23	0.23	0.24	0.24	0.24	0.24	0.24	0.24
5. Imports	0.28	0.32	0.33	0.34	0.34	0.33	0.33	0.33	0.34	0.34	0.34
6. Gross domestic product	0.08	0.22	0.30	0.30	0.27	0.24	0.22	0.21	0.22	0.23	0.34
7. Total supply by private sector	0.12	0.24	0.30	0.31	0.28	0.26	0.24	0.24	0.24	0.25	0.34
III. Financial sector											
1. Nominal short-run interest rate *	0.31	0.16	0.03	-0.05	-0.07	-0.04	-0.01	0.01	0.02	0.02	0.00
2. Nominal long-run interest rate *	0.08	0.04	0.01	-0.01	-0.02	-0.01	-0.00	0.00	0.01	0.01	0.00
3. Spot exchange rate (local/eur)	0.32	0.03	0.03	0.06	0.07	0.04	0.01	-0.02	-0.02	-0.01	0.06
4. Effective nominal exchange rate (+:depr.)	0.35	0.06	0.04	0.05	0.04	0.01	-0.01	-0.03	-0.02	-0.01	0.05
5. Effective real exchange rate (+:depr.)	0.29	0.07	0.07	0.07	0.05	0.01	-0.02	-0.04	-0.04	-0.02	-0.00
6. Money	-1.62	-1.59	-1.01	-0.36	0.06	0.18	0.12	-0.01	-0.12	-0.17	0.03
IV. Labour market											
1. Total employment	0.00	-0.04	-0.05	-0.04	-0.01	0.02	0.03	0.02	0.01	0.01	-0.00
A. private sector	0.00	-0.05	-0.06	-0.04	-0.01	0.02	0.03	0.02	0.01	0.01	-0.00
B. public sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Labour supply	0.00	0.00	-0.02	-0.02	-0.01	0.00	0.01	0.01	0.01	0.00	-0.00
3. Unemployment rate *	-0.00	0.04	0.03	0.02	-0.01	-0.01	-0.02	-0.01	-0.00	-0.00	0.00
4. Nominal wage private sector	0.02	-0.01	-0.03	-0.04	-0.07	-0.07	-0.05	-0.04	-0.03	-0.03	0.04
5. Nominal wage total economy	0.04	0.04	0.03	-0.01	-0.04	-0.06	-0.06	-0.04	-0.03	-0.03	0.04
6. Real take home private wage	-0.11	-0.32	-0.42	-0.43	-0.41	-0.36	-0.31	-0.29	-0.29	-0.30	-0.39
7. Real producer private wage	-0.11	-0.26	-0.33	-0.35	-0.35	-0.32	-0.29	-0.28	-0.27	-0.28	-0.30
V. Household sector											
1. Total real means	-0.36	-0.46	-0.48	-0.45	-0.40	-0.36	-0.33	-0.32	-0.33	-0.34	-0.39
A. Disposable real income	-0.06	-0.26	-0.33	-0.36	-0.38	-0.36	-0.33	-0.31	-0.30	-0.31	-0.39
B. Inherited assets (deflated by cons. price)	-0.45	-0.61	-0.63	-0.56	-0.46	-0.39	-0.35	-0.34	-0.35	-0.36	-0.40
C. Expected future real income	-0.31	-0.36	-0.39	-0.39	-0.37	-0.34	-0.32	-0.32	-0.32	-0.32	-0.39
2. Net saving by households (% of disp. inc.)*	0.12	0.23	0.24	0.19	0.10	0.03	0.00	0.00	0.02	0.03	0.00
VI. Fiscal sector											
1. Nominal total revenue	0.06	0.01	0.01	-0.00	-0.04	-0.06	-0.06	-0.05	-0.04	-0.03	0.03
2. Real total revenue	-0.02	-0.21	-0.28	-0.31	-0.31	-0.29	-0.28	-0.26	-0.26	-0.26	-0.31
3. Nominal total expenditures	0.12	0.13	0.16	0.10	-0.01	-0.07	-0.09	-0.07	-0.05	-0.03	0.04
4. Real total expenditures	0.04	-0.09	-0.14	-0.20	-0.28	-0.31	-0.30	-0.28	-0.27	-0.26	-0.30
5. Direct labour tax rate *	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
6. Net lending by government (% of GDP)*	-0.04	-0.09	-0.11	-0.08	-0.02	0.01	0.03	0.02	0.01	0.00	0.00
7. Debt (% of GDP)*	0.02	0.18	0.29	0.37	0.39	0.37	0.33	0.31	0.30	0.30	-0.00
VII. International environment											
1. Effective foreign output	0.04	-0.16	-0.21	-0.21	-0.21	-0.20	-0.20	-0.20	-0.21	-0.21	-0.21
2. Effective foreign price	0.15	0.22	0.25	0.25	0.24	0.24	0.23	0.23	0.23	0.23	0.19
3. Effective foreign short term interest rate *	0.38	0.16	0.02	-0.05	-0.07	-0.06	-0.04	-0.02	-0.01	-0.01	-0.00
4. Current account (% of GDP)*	0.05	0.08	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.00
5. Price of oil (in US $)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00

[a] without *: deviations from technical baseline in per cent; with *: deviations from technical baseline in percentage points; ss: steady state

TABLE 3 - The macroeconomic effects for the United States of a permanent 25 per cent oil price shock[a]

	01	02	03	04	05	06	07	08	09	10	ss
I. Aggregate demand-supply											
1. Private consumption	-0.28	-0.53	-0.60	-0.59	-0.52	-0.44	-0.37	-0.33	-0.32	-0.32	-0.40
2. Public consumption	-0.02	-0.12	-0.08	-0.06	-0.08	-0.12	-0.17	-0.22	-0.25	-0.26	-0.33
3. Gross fixed capital formation	-0.25	-0.46	-0.61	-0.65	-0.59	-0.48	-0.37	-0.29	-0.24	-0.22	-0.13
A. Residential	-1.03	-1.77	-1.98	-2.00	-1.84	-1.58	-1.32	-1.11	-0.97	-0.90	-0.39
B. Enterprises	0.06	0.02	-0.14	-0.20	-0.16	-0.09	-0.02	0.02	0.04	0.03	0.00
C. Public	-0.09	-0.16	-0.25	-0.26	-0.23	-0.17	-0.13	-0.10	-0.09	-0.09	-0.13
4. Exports	0.18	-0.00	-0.13	-0.15	-0.13	-0.13	-0.14	-0.15	-0.16	-0.17	-0.13
5. Imports	-1.03	-2.43	-2.38	-2.15	-1.96	-1.84	-1.79	-1.79	-1.80	-1.81	-1.88
6. Gross Domestic Product	-0.09	-0.16	-0.25	-0.27	-0.23	-0.18	-0.13	-0.10	-0.09	-0.09	-0.13
7. Total private supply for final demand	-0.22	-0.47	-0.55	-0.55	-0.48	-0.41	-0.35	-0.31	-0.30	-0.30	-0.33
8. Output gap (private sector)*	0.11	-0.13	-0.22	-0.21	-0.15	-0.07	-0.01	0.02	0.04	0.04	-0.00
II. Price indices											
1. Private consumption	0.26	0.46	0.57	0.60	0.58	0.54	0.50	0.47	0.45	0.44	0.38
2. Public consumption	0.28	0.43	0.43	0.37	0.31	0.28	0.28	0.30	0.31	0.32	0.31
3. Gross fixed capital formation	0.13	0.23	0.29	0.33	0.34	0.34	0.34	0.33	0.31	0.29	0.14
A. Residential	0.24	0.42	0.54	0.62	0.65	0.67	0.66	0.64	0.62	0.58	0.31
B. Enterprises	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.02
C. Government	0.24	0.43	0.55	0.63	0.67	0.68	0.68	0.66	0.63	0.59	0.31
4. Exports	0.08	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.11
5. Imports	2.24	2.21	2.05	1.92	1.86	1.84	1.85	1.85	1.86	1.86	1.86
6. Gross domestic product	-0.02	0.13	0.25	0.29	0.29	0.26	0.23	0.20	0.19	0.18	0.11
7. Total supply by private sector	0.20	0.36	0.46	0.49	0.48	0.45	0.42	0.40	0.38	0.38	0.31
III. Financial sector											
1. Nominal short-run interest rate *	0.37	0.18	0.04	-0.06	-0.09	-0.08	-0.05	-0.02	-0.00	0.01	-0.00
2. Nominal long-run interest rate *	0.10	0.05	0.01	-0.02	-0.03	-0.02	-0.01	-0.01	-0.00	0.00	-0.00
3. Spot exchange rate (local/eur)	0.14	-0.06	-0.03	0.01	0.03	0.03	0.02	-0.00	-0.02	-0.02	-0.00
4. Effective nominal exchange rate (+:depr.)	0.19	-0.03	-0.03	-0.01	-0.00	-0.00	-0.00	-0.01	-0.02	-0.02	-0.01
5. Effective real exchange rate (+:depr.)	0.20	0.01	0.02	0.03	0.03	0.03	0.02	0.01	0.01	0.00	-0.00
6. Money	-0.87	-0.28	0.14	0.39	0.43	0.36	0.26	0.17	0.11	0.07	-0.02
IV. Labour market											
1. Total employment	-0.03	-0.10	-0.12	-0.08	-0.02	0.02	0.04	0.04	0.03	0.02	-0.01
A. private sector	-0.03	-0.12	-0.14	-0.10	-0.03	0.02	0.04	0.04	0.04	0.02	-0.01
B. public sector	0.00	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.00
2. Labour supply	0.00	-0.01	-0.02	-0.03	-0.02	-0.01	0.00	0.01	0.01	0.01	0.00
3. Unemployment rate *	0.03	0.09	0.09	0.05	-0.00	-0.03	-0.03	-0.03	-0.02	-0.01	0.01
4. Nominal wage private sector	0.03	0.09	0.11	0.08	0.06	0.05	0.05	0.06	0.07	0.07	-0.02
5. Nominal wage total economy	0.07	0.14	0.17	0.14	0.10	0.08	0.07	0.07	0.07	0.07	-0.02
6. Real take home private wage	-0.23	-0.37	-0.46	-0.51	-0.52	-0.49	-0.45	-0.41	-0.38	-0.37	-0.41
7. Real producer private wage	-0.17	-0.28	-0.35	-0.41	-0.42	-0.41	-0.37	-0.34	-0.32	-0.30	-0.33
V. Household sector											
1. Total real means	-0.38	-0.46	-0.48	-0.46	-0.42	-0.38	-0.36	-0.34	-0.34	-0.34	-0.39
A. Disposable real income	-0.20	-0.36	-0.43	-0.46	-0.46	-0.43	-0.40	-0.38	-0.37	-0.37	-0.40
B. Inherited assets (deflated by cons. price)	-0.36	-0.53	-0.55	-0.49	-0.39	-0.30	-0.24	-0.21	-0.21	-0.23	-0.34
C. Expected future real income	-0.39	-0.43	-0.44	-0.44	-0.44	-0.42	-0.41	-0.40	-0.40	-0.40	-0.42
2. Net saving by households (% of disp. inc.)*	0.09	0.17	0.18	0.13	0.06	0.01	-0.03	-0.05	-0.05	-0.05	0.00
VI. Fiscal sector											
1. Nominal total revenue	0.04	0.03	0.05	0.06	0.06	0.07	0.08	0.08	0.07	0.07	0.02
2. Real total revenue	0.07	-0.10	-0.20	-0.24	-0.23	-0.19	-0.15	-0.13	-0.11	-0.11	-0.09
3. Nominal total expenditures	0.27	0.45	0.45	0.34	0.22	0.13	0.09	0.08	0.09	0.11	0.02
4. Real total expenditures	0.30	0.32	0.20	0.05	-0.07	-0.13	-0.14	-0.12	-0.10	-0.07	-0.10
5. Direct labour tax rate *	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.02
6. Net lending by government (% of GDP)*	-0.06	-0.12	-0.12	-0.09	-0.05	-0.03	-0.01	-0.01	-0.02	-0.02	0.00
7. Debt (% of GDP)*	0.13	0.20	0.30	0.38	0.41	0.42	0.42	0.43	0.45	0.48	0.00
VII. International environment											
1. Effective foreign output	0.12	-0.07	-0.10	-0.10	-0.10	-0.10	-0.11	-0.12	-0.13	-0.13	-0.13
2. Effective foreign price	0.09	0.13	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.12
3. Effective foreign short term interest rate *	0.37	0.16	0.02	-0.06	-0.08	-0.06	-0.04	-0.02	-0.01	0.00	-0.00
4. Current account (% of GDP)*	-0.10	0.02	0.02	0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.00
5. Price of oil (in US $)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00

[a] without *: deviations from technical baseline in per cent; with *: deviations from technical baseline in percentage points; ss: steady state

TABLE 4 - The macroeconomic effects for Japan of a permanent 25 per cent oil price shock[a]

	01	02	03	04	05	06	07	08	09	10	ss
I. Aggregate demand-supply											
1. Private consumption	-0.29	-0.29	-0.27	-0.28	-0.28	-0.28	-0.28	-0.27	-0.27	-0.27	-0.28
2. Public consumption	0.01	-0.12	-0.11	-0.10	-0.11	-0.13	-0.15	-0.16	-0.17	-0.17	-0.23
3. Gross fixed capital formation	-0.22	-0.19	-0.12	-0.10	-0.11	-0.11	-0.11	-0.10	-0.09	-0.08	-0.03
A. Residential	-1.17	-1.08	-0.86	-0.87	-0.90	-0.90	-0.87	-0.83	-0.80	-0.77	-0.25
B. Enterprises	-0.02	-0.03	-0.01	0.00	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	-0.00
C. Public	-0.51	-0.32	-0.14	-0.09	-0.08	-0.07	-0.05	-0.03	-0.01	0.00	-0.01
4. Exports	0.01	-0.22	-0.24	-0.26	-0.27	-0.25	-0.22	-0.20	-0.18	-0.18	-0.23
5. Imports	-0.13	-1.29	-1.74	-1.95	-2.05	-2.10	-2.15	-2.20	-2.25	-2.28	-2.47
6. Gross Domestic Product	-0.23	-0.15	-0.08	-0.05	-0.05	-0.04	-0.04	-0.03	-0.02	-0.02	-0.01
7. Total private supply for final demand	-0.24	-0.28	-0.25	-0.25	-0.26	-0.25	-0.25	-0.24	-0.24	-0.23	-0.23
8. Output gap (private sector)*	-0.01	-0.04	-0.02	-0.02	-0.02	-0.02	-0.01	-0.00	-0.00	0.00	-0.00
II. Price indices											
1. Private consumption	0.24	0.31	0.31	0.30	0.28	0.26	0.25	0.24	0.23	0.23	0.21
2. Public consumption	0.22	0.26	0.20	0.15	0.14	0.15	0.16	0.16	0.16	0.16	0.16
3. Gross fixed capital formation	0.05	0.07	0.06	0.04	0.02	0.02	0.02	0.02	0.02	0.02	-0.00
A. Residential	0.17	0.23	0.22	0.18	0.16	0.15	0.15	0.15	0.16	0.16	0.16
B. Enterprises	-0.00	-0.01	-0.02	-0.02	-0.03	-0.03	-0.03	-0.04	-0.04	-0.04	-0.07
C. Government	0.22	0.30	0.25	0.18	0.13	0.12	0.14	0.15	0.16	0.17	0.16
4. Exports	0.06	0.08	0.10	0.11	0.12	0.13	0.13	0.14	0.14	0.15	0.16
5. Imports	3.05	3.32	3.21	2.96	2.76	2.64	2.58	2.54	2.52	2.49	2.40
6. Gross domestic product	-0.08	-0.05	-0.05	-0.05	-0.04	-0.04	-0.04	-0.05	-0.05	-0.05	-0.06
7. Total supply by private sector	0.19	0.25	0.24	0.22	0.21	0.20	0.19	0.19	0.18	0.18	0.16
III. Financial sector											
1. Nominal short-run interest rate *	0.29	0.07	-0.02	-0.03	-0.03	-0.03	-0.02	-0.01	-0.01	-0.00	-0.00
2. Nominal long-run interest rate *	0.08	0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00
3. Spot exchange rate (local/eur)	0.06	0.18	0.06	-0.10	-0.15	-0.14	-0.11	-0.08	-0.07	-0.06	-0.05
4. Effective nominal exchange rate (+:depr.)	0.03	0.23	0.07	-0.12	-0.19	-0.18	-0.13	-0.09	-0.06	-0.05	-0.06
5. Effective real exchange rate (+:depr.)	0.12	0.39	0.27	0.07	-0.02	-0.02	0.00	0.03	0.05	0.05	-0.00
6. Money	-1.43	-0.44	-0.04	0.06	0.07	0.06	0.03	0.00	-0.02	-0.03	-0.07
IV. Labour market											
1. Total employment	-0.00	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	0.00	0.00	0.00	-0.00
A. private sector	-0.00	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	0.00	0.00	0.00	-0.00
B. public sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00
2. Labour supply	0.00	-0.00	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	0.00	0.00	-0.00
3. Unemployment rate *	0.00	0.01	0.01	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00
4. Nominal wage private sector	0.03	0.08	0.08	0.05	0.02	-0.01	-0.02	-0.03	-0.04	-0.04	-0.07
5. Nominal wage total economy	0.05	0.11	0.10	0.07	0.04	0.01	-0.01	-0.02	-0.02	-0.03	-0.07
6. Real take home private wage	-0.21	-0.23	-0.23	-0.25	-0.26	-0.27	-0.27	-0.27	-0.27	-0.27	-0.29
7. Real producer private wage	-0.16	-0.17	-0.16	-0.17	-0.19	-0.21	-0.21	-0.22	-0.22	-0.22	-0.23
V. Household sector											
1. Total real means	-0.36	-0.33	-0.30	-0.29	-0.28	-0.27	-0.26	-0.26	-0.26	-0.26	-0.28
A. Disposable real income	-0.17	-0.21	-0.21	-0.22	-0.24	-0.24	-0.25	-0.25	-0.25	-0.25	-0.28
B. Inherited assets (deflated by cons. price)	-0.48	-0.36	-0.29	-0.26	-0.25	-0.23	-0.22	-0.22	-0.21	-0.21	-0.27
C. Expected future real income	-0.28	-0.30	-0.31	-0.31	-0.30	-0.30	-0.29	-0.29	-0.29	-0.29	-0.29
2. Net saving by households (% of disp. inc.)*	0.12	0.08	0.06	0.05	0.04	0.04	0.03	0.03	0.02	0.02	-0.00
VI. Fiscal sector											
1. Nominal total revenue	0.03	0.04	0.04	0.03	0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.03
2. Real total revenue	0.11	0.09	0.09	0.07	0.05	0.04	0.03	0.03	0.02	0.02	0.02
3. Nominal total expenditures	0.22	0.17	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01	-0.06
4. Real total expenditures	0.30	0.22	0.16	0.11	0.09	0.07	0.07	0.06	0.06	0.05	0.00
5. Direct labour tax rate *	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.01
6. Net lending by government (% of GDP)*	-0.05	-0.04	-0.02	-0.02	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	0.00
7. Debt (% of GDP)*	0.24	0.21	0.19	0.19	0.20	0.22	0.23	0.24	0.25	0.27	0.00
VII. International environment											
1. Effective foreign output	-0.01	-0.24	-0.30	-0.30	-0.27	-0.24	-0.22	-0.21	-0.21	-0.22	-0.23
2. Effective foreign price	0.15	0.24	0.29	0.30	0.29	0.28	0.27	0.26	0.25	0.25	0.22
3. Effective foreign short term interest rate *	0.37	0.17	0.03	-0.06	-0.08	-0.07	-0.04	-0.02	-0.01	0.00	-0.00
4. Current account (% of GDP)*	-0.28	-0.15	-0.09	-0.06	-0.06	-0.07	-0.07	-0.07	-0.06	-0.05	0.00
5. Price of oil (in US $)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00

[a] without *: deviations from technical baseline in per cent; with *: deviations from technical baseline in percentage points; ss: steady state

TABLE 5 - The macroeconomic effects for the New EU Member States of a permanent 25 per cent oil price shock[a]

	01	02	03	04	05	06	07	08	09	10	ss
I. Expenditures in constant prices											
1. Private consumption	-0.13	-0.34	-0.54	-0.70	-0.82	-0.92	-0.99	-1.05	-1.09	-1.12	-1.20
2. Public consumption	-0.08	-0.21	-0.33	-0.44	-0.51	-0.57	-0.62	-0.65	-0.68	-0.70	-0.71
3. Total gross fixed capital formation	-0.08	-0.21	-0.34	-0.44	-0.52	-0.58	-0.62	-0.65	-0.68	-0.70	-0.71
4. Total exports	0.20	-0.04	-0.07	-0.07	-0.07	-0.07	-0.08	-0.09	-0.10	-0.10	-0.09
5. Total imports	-0.22	-0.59	-0.91	-1.16	-1.36	-1.52	-1.64	-1.74	-1.81	-1.87	-2.05
6. GDP	0.12	-0.00	-0.03	-0.03	-0.03	-0.03	-0.03	-0.04	-0.04	-0.04	-0.00
II. Prices											
1. Private consumption	0.94	1.14	1.18	1.19	1.19	1.19	1.18	1.18	1.18	1.17	1.18
2. Public consumption	0.51	0.64	0.68	0.69	0.69	0.69	0.69	0.69	0.70	0.70	0.70
3. Total gross fixed capital formation	0.49	0.68	0.70	0.69	0.69	0.69	0.69	0.70	0.70	0.70	0.70
4. Exports	0.14	0.10	0.11	0.10	0.10	0.10	0.09	0.09	0.10	0.10	0.08
5. Imports	1.87	1.98	2.02	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
6. GDP	-0.33	-0.20	-0.14	-0.11	-0.09	-0.08	-0.06	-0.05	-0.04	-0.04	-0.01
III. Financial variables											
1. Short-term nominal interest rate*	0.40	0.15	0.01	-0.05	-0.06	-0.04	-0.03	-0.02	-0.02	-0.02	-0.00
2. Nominal exchange rate (local/eur)	0.03	-0.05	-0.01	0.03	0.05	0.05	0.04	0.02	0.01	0.01	0.02
3. Nominal effective exchange rate (+:depr.)	0.10	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
4. Real exchange rate (+:depr.)	0.02	-0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	-0.00
IV. International environment											
1. Effective foreign output	0.17	-0.04	-0.06	-0.06	-0.06	-0.06	-0.06	-0.07	-0.08	-0.09	-0.08
2. Effective foreign price level	0.06	0.09	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.08
3. Effective foreign short-term interest rate *	0.38	0.17	0.03	-0.06	-0.08	-0.07	-0.05	-0.02	-0.01	0.00	-0.00
4. Price of oil (in US $)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00

[a] without *: deviations from technical baseline in per cent; with *: deviations from technical baseline in percentage points; ss: steady state

TABLE 6 - The macroeconomic effects for the Rest of the World of a permanent 25 per cent oil price shock[a]

	01	02	03	04	05	06	07	08	09	10	ss
I. Quantities											
1. Total private supply	0.28	0.08	0.06	0.07	0.06	0.05	0.04	0.02	0.01	-0.00	-0.00
2. Total exports	-0.19	-0.84	-1.21	-1.46	-1.64	-1.79	-1.94	-2.08	-2.21	-2.33	-3.04
3. Total imports	0.47	0.71	0.45	0.23	0.07	-0.04	-0.14	-0.22	-0.30	-0.37	-0.75
II. Prices											
1. Price level	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Price of exports (in euro)	2.73	2.80	2.87	2.94	3.00	3.04	3.07	3.10	3.11	3.12	3.06
3. Price of imports (in euro)	-1.70	-0.23	0.17	0.41	0.56	0.65	0.71	0.74	0.77	0.79	0.73
4. Price of oil (in US $)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
III. Financial variables											
1. Bilateral exchange rate (local/euro) (+:depr.)	-0.13	-0.08	-0.02	0.04	0.06	0.06	0.05	0.03	0.01	0.00	0.02
2. Nominal effective exchange rate (+:depr.)	-0.21	-0.07	-0.02	0.03	0.05	0.05	0.04	0.03	0.02	0.01	0.01
3. Real effective exchange rate (+:depr.)	-2.47	-2.34	-2.36	-2.42	-2.49	-2.55	-2.58	-2.60	-2.62	-2.62	-2.62

[a] without *: deviations from technical baseline in per cent; with *: deviations from technical baseline in percentage points; ss: steady state

IV Appendix: Modifications to the NIME model

In the first section of this appendix, we introduce oil as a separate good, and we discuss how it affects the definition of the aggregates. In the second section, we derive analytically how a change in the price of oil due to an increase in the price mark-up, causes a change in potential output through a change in total factor productivity. There, we also investigate the case that the oil price increase is caused by an increase in the productivity of oil. In the third section, we discuss how the export equations of the oil-importing blocs change, while in the fourth section we examine the stock market effects of an oil price shock. In the fifth section, we rewrite the equation determining the output of the rest of the world (RW) bloc, so that it better captures the temporary income effects of a change in the price of oil. In the last section, we conclude with a few remarks regarding the data.

A. Oil and the price of imports of the major country blocs

1. Import prices: the "old" approach

The enterprise sector combines labour, NP, capital, CIPO, and (intermediate) imports, MTO, to produce an output according to a constant returns to scale Cobb-Douglas production function. In the previous version of the NIME model imports are an aggregate, and its price, PMT, is set (in the long run) according to:

$$(1) \qquad \frac{PMT}{PASP(1-NITR)} = asp\_l3YMT$$

with PMT the price of total imports, denominated in local currency, PASP the price of domestic output, denominated in local currency, NITR the indirect tax rate, and YMT the productivity of (intermediate) imports (under perfect competition), and where the parameter asp_l3 is a parameter of the production function[1]. See, for instance, equation (III.12) of Meyermans and Van Brusselen (2001).

1. The results in this and the following sections refer to long-run equilibrium conditions. In the short-term, actual behaviour of some variables may deviate from these results due to various adjustment costs.

2. Import prices: the "new" approach

In this Working Paper, we assume explicitly that oil is part of aggregate imports, that its price, denominated in US dollars, is predetermined, and that oil is exported from the rest of the world bloc (RW) to the other country blocs. Furthermore, we also assume that the price of total imports, PMT, is set according to:

$$(2) \qquad PMT = POIL^{woil} \; PMTOTHER^{(1\text{-}woil)}$$

where POIL is the price of oil denominated in local currency, PMTOTHER the price of non-oil imports, denominated in local currency, and where woil is the share of oil in total imports ($0 \leq woil \leq 1$).

The following price setting schemes are used for oil, POIL, and non-oil imports, PMTOTHER.

3. The price of the non-oil imports: price makers

The price of non-oil imports, denominated in domestic currency, PMTOTHER, is determined as:

$$(3) \qquad \frac{PMTOTHER}{PASP(1 - NITR)} = asp\_l3 \;\; YMTOTHER$$

where YMTOTHER is the productivity of non-oil imports. Equation (3) shows that the real producer price of intermediate non-oil imports is equal to its marginal productivity.

Inserting equation (3) into equation (2), we get that, in equilibrium, the price of imports is determined by:

$$(4) \qquad PMT = POIL^{woil} \; [PASP \; (1\text{-}NITR) \;\; asp\_l3 \;\; YMTOTHER]^{(1\text{-}woil)}$$

4. The price of oil: price takers

The price of oil (denominated in US dollars), POILUSD, is predetermined, so that each country bloc is assumed to be a price taker for oil. The price of oil in local currency, POIL, is related to the price of oil in US dollars, POILUSD, and the exchange rate by:

$$(5) \qquad POIL = POILUSD \; / \; EX\_US\_XX$$

where EX_US_XX is the bilateral exchange rate, number of US dollars per unit of the domestic currency.

Oil is used in the production process and has its own productivity, YMTOIL. However, at the same time, oil exporters have a market power that allows them to charge a mark-up, TR_MP, over oil's productivity, i.e.:

$$(6) \qquad \frac{POIL}{PASP \; (1\text{-}NITR)} = asp\_l3 \;\; YMTOIL \;\; TR\_MP \; .$$

5. The price of total imports

The price of total imports is found after inserting equation (6) into equation (4), yielding:

$$(7) \qquad \frac{PMT}{PASP\ (1\text{-}NITR)} = asp\_l3\ \ YMT\ \ TR\_MP^{woil}$$

with YMT defined as:

$$(8) \qquad YMT = YMTOIL^{woil}\ \ YMTOTHER^{(1\text{-}woil)}.$$

B. The supply side effects of an oil price shock in the major country blocs: some analytical results

In the NIME model, an increase in the price of oil can be caused by an increase in the productivity of oil, YMTOIL, or by an increase in the mark-up over the oil price, TR_MP. The two cases have different impacts on potential output. First, we discuss the implications for the case where the mark-up increases. Next, we investigate the implications for the case where the productivity of oil (i.e., energy efficiency) increases[1]. We conclude the section with a brief discussion of the short-run dynamics of import prices.

1. The output effect of a change in the mark-up

Here, we consider a permanent oil price shock caused by a permanent change in the mark-up, TR_MP.

Remember that the constant returns to scale Cobb-Douglas production function of the NIME model reads as:

(9) ASPO = asp_l0 NP**asp_l1 CIPO**asp_l2 MTO**asp_l3

where ASPO is private supply for final demand, NP labour, CIPO the capital stock, MTO (aggregate) intermediate imports, and where asp_l0, asp_l1, asp_l2 and asp_l3 are parameters satisfying the condition asp_l1 + asp_l2 + asp_l3 = 1.

The first order conditions for an optimum are:

(10.a) WRP NP = asp_l1 ASPO PASP (1-NITR)

(10.b) USERIP CIPO = asp_l2 ASPO PASP (1-NITR)

(10.c) PMT MTO = asp_l3 ASPO PASP (1-NITR)

where WRP is the nominal wage rate, PASP the market price of output, NITR the indirect tax rate, USERIP the user cost of capital, and PMT the price of intermediate imports.

1. The analytical results derived in this section are steady state results.

Combining (10.a) and (10.b), we get:

(11.a) CIPO = (asp_l2/asp_l1) (WRP/USERIP) NP

and combining (10.a) and (10.c), we get:

(11.b) MTO = (asp_l3/asp_l1) (WRP/PMT) NP.

Inserting (11.a) and (11.b) into (9), yields[1]:

(12) ASPO = asp_l0 NP [(asp_l2/asp_l1) (WRP/USRIP)]**asp_l2 [(asp_l3/asp_l1) (WRP/PMT)]**asp_l3.

Furthermore, in equilibrium, real factor prices are set according to their trend marginal productivity, adjusted for a mark-up. Let[2]:

(13.a) $\frac{\text{WRP}}{\text{PASP (1-NITR)}}$ = asp_l1 YNP

(13.b) $\frac{\text{USERIP}}{\text{PASP (1-NITR)}}$ = asp_l2 YCP

(13.c) $\frac{\text{PMT}}{\text{PASP (1-NITR)}}$ = asp_l3 YMT TR_MP$^{\text{woil}}$

where equation (13.c) repeats equation (7).

From (13.a) and (13.b), it follows that:

(14.a) WRP/USERIP (asp_l2/asp_l1) = (YNP/YCP)

and from (13.a) and (13.c), it follows that:

(14.b) WRP/PMT (asp_l3/asp_l1) = (YNP/YMT) TR_MP$^{\text{-woil}}$.

Inserting (14.a) and (14.b) into (12), yields:

(15.a) ASPO = NP
asp_l0 (YNP/YCP)**asp_l2 (YNP/YMT)**asp_l3
TR_MP$^{\text{-woil asp_l3}}$

which can be rewritten as[3]:

(15.b) ASPO = NP YNP TR_MP$^{\text{-woil asp_l3}}$

1. Making use of asp_l1 + asp_l2 + asp_l3 = 1.
2. For analytical convenience, we consider here only the case that there is a mark-up in the market for intermediate imports.
3. Dividing both sides of equation (9) by ASPO yields:
   1 = asp_l0 (NP/ASPO)**asp_l1 (CIPO/ASPO)**asp_l2 (MTO/ASPO)**asp_l3
   which solves for:
   asp_l0 = YNP**asp_l1 YCP**asp_l2 YMT**asp_l3
   with YNP=ASPO/NP, YCP=ASPO/CIPO, and YMT=ASPO/MTO.
   Inserting the latter result for asp_l0 into equation (15.a), and using asp_l1 + asp_l2 + asp_l3 = 1, yields equation (15.b).

Equation (15.b) describes equilibrium output in terms of the predetermined natural level of employment[1], trend productivity of labour, and the market power to set in the import market prices above their marginal productivity. The existence of a mark-up induces a loss of efficiency in the production process equal to $TR\_MP^{-woil\ asp\_l3}$, as for the same amount of labour and capital fewer imports are available.

Differentiating equation (15.b) learns that an increase in the mark-up causes an output loss equal to[2]:

(16) d ln(ASPO) = - woil asp_l3 d ln(TR_MP).

At the same time, it should be noted that the demand for imports falls by[3]:

(17) d ln(MTO) = - woil d ln(TR_MP).

1. The natural level of employment is determined by the natural rate of unemployment, population, and the participation rate. In the NIME model, the latter two are exogenous, while the first is determined by the equilibrium values of taxes, the real interest rate, and market power in the goods market. See Meyermans (2003).
2. Two remarks. First, in the case that the country bloc is a net importer, but that it also produces some of its own oil, e.g. the United States, equation (16) is to be rewritten as:
   (16.b) d ln(ASPO) = - (woil asp_l3 /oil_imp) d ln(TR_MP),
   with oil_imp the share of oil imports in total oil consumption. (Note that in the main text the special case of oil_imp = 1 is discussed.)
   This result is derived as follows. Consider the production function:
   ASPO = asp_l0 NP**asp_l1 CIPO**asp_l2 MTOTHER**asp1_l3 OIL**asp1_l4
   with MTOTHER non-oil imports, and OIL total oil consumption. Total oil consumption consists of imported oil, OI, and domestic production of oil, OD, i.e.,
   OIL = OI**oil_imp OD**(1-oil_imp).
   Inserting the latter into the former, we get:
   ASPO = asp_l0 NP**asp_l1 CIPO**asp_l2 MTOTHER**asp1_l3 OI**(asp1_l4*oil_imp)
   OD**(asp1_l4*(1-oil_imp))
   Moreover, remember that total imports, MTO, are defined as:
   MTO = OI**woil MTOTHER**(1-woil).
   If we define:
   asp1_l3 = asp_l3 (1-woil)
   asp1_l4 = asp_l3 woil/oil_imp,
   we get that:
   ASPO = asp_l0 NP**asp_l1 CIPO**asp_l2 MTO**asp_l3
   OD**(asp_l3*(1-oil_imp)*woil/oil_imp)
   i.e., the original production function augmented with a component for domestic oil. Note that this domestic oil component, OD, drops out if oil_imp = 1.
   Going through the same manipulation as in the main text, we now find that equation (15.b) can be rewritten as:
   $ASPO = NP\ YNP\ TR\_MP^{-woil\ asp\_l3\ (1+(1-oil\_imp)/oil\_imp)}$
   $= NP\ YNP\ TR\_MP^{-woil\ asp\_l3\ (1/oil\_imp)}$
   which leads to equation (16.b).
   Second, in the case that the production of oil of a country bloc meets (or is larger than) its consumption, e.g., the NE bloc, we define the size of the shock to be the average of the size of the EU and US bloc. (See below, for a discussion of the modelling of the oil price shock in the RW bloc.)
3. Remember that the demand for intermediate imports reads as:
   MTO = asp_l3 ASPO (1-NITR) PASP/PMT
   $= ASPO\ /(YMTOIL^{woil}\ YMTOTHER^{(1-woil)}TR\_MP^{woil})$
   where use has been made of equations (7) and (8).

2. The output effect of a change in energy efficiency

If the energy efficiency (i.e. the productivity of oil) improves at the same time that oil prices increase, there will be no change in potential output. Indeed, from equation (15.b) we learn that trend output is not affected by trend productivity of oil.

However, in equilibrium, an increase in trend productivity of oil, YMTOIL, will induce a decrease in the amount of imports equal to:

(18) $d \ln(MTO) = - woil \, d \ln(YMTOIL)$.

Moreover, it also affects the import-labour ratio (in the steady state). Indeed, in equilibrium the imports-labour ratio changes by[1]:

(19) $d \ln(MTO/NP) = - woil \, d \ln(YMTOIL)$.

3. The effect of an oil price shock on real GDP

In the first variant of this paper, it is shown that an oil price shock affects real GDP of the euro area only marginally in the long run. Indeed, real GDP is reduced by 0.04 per cent vis-à-vis the baseline, in response to a permanent 25 per cent increase in the price of oil. However, the price shock reduces private sector output of the euro area by 0.27 per cent, while it reduces total imports by 1.91 per cent. Intuitively, it may not always be clear why the fall in private sector output (measured in constant prices) is almost completely matched by a similar fall in imports (measured in constant prices), so that real GDP is only marginally affected. In this section, we show analytically how the effects of an oil price shock on private output, imports and GDP are related to each other.

We start from the following accounting identities and equilibrium conditions:

(20) $GDPO = CPO + FCGO + GIO + DINVO + XTO - MTO$

(21) $ADO = CPO + FCGO + GIO + DINVO + XTO$

(22) $ADO = ASPO + ASGO$

whereby GDPO is real GDP, CPO is private consumption in constant prices, FCGO is public consumption in constant prices, GIO is total gross fixed capital formation, DINVO is the change in inventories in constant prices, XTO is exports in constant prices, MTO is imports in constant prices, ADO is total demand for final supply, ASGO is public supply for final demand, and ASPO is private supply for final demand.

From equations (21)-(22), it follows that:

(23) $ASPO = CPO + FCGO + GIO + DINVO + XTO - ASGO$

Using equation (23), we can rewrite equation (20) as:

1. Combine equations (10.a), (10.c), (13.a) and (13.c) and differentiate to derive equation (19).

(24) GDPO = ASPO + ASGO - MTO

Differentiating both sides of equation (24) yields:

(25) d GDPO = d ASPO + d ASGO - d MTO

Dividing both sides of (25) by GDPO, as well as multiplying and dividing each term of the right hand side with the same factor, yields:

(d GDPO)/GDPO =
ASPO/ GDPO (d ASPO)/ASPO
+ ASGO/ GDPO (d ASGO)/ASGO
- MTO /GDPO (d MTO)/MTO

which reads also as[1]:

(26) d ln(GDPO) = wp d ln(ASPO) + wg d ln(ASGO) - wm d ln (MTO)

where the parameters are defined as:

(27.a) wp = ASPO/GDPO

(27.b) wg = ASGO/GDPO

(27.c) wm = MTO/GDPO

On using equation (24), (27.a) and (27.b), we note that equation (27.c) can also be written as:

wm = MTO/GDPO = (ASPO+ASGO-GDPO)/GDPO = (wp+wg-1)

so that:

(28) wp + wg - wm = 1

The long-run impact of an oil price shock on private sector output and imports is calculated in equations (16) and (17) while, for the sake of mathematical convenience, we set here the effect of an oil price shock on public output equal to zero, i.e.:

(29) d ln(ASGO) = 0 d ln(TR_MP)

Inserting equations (16), (17) and (29) into equation (26) yields for an increase in the mark-up TR_MP:

(30) d ln(GDPO) = -wp woil asp_l3 d ln(TR_MP) + wm woil d ln(TR_MP)

which can be rewritten as:

(31) d ln(GDPO) = [wm - wp asp_l3] woil d ln(TR_MP)

Here, it should be remembered that, given the Cobb-Douglas nature of the production function in the NIME model, we have the following equilibrium relation:

1. Where use has been made of the fact that d ln(X) = (d X) / X.

(32) PMT MTO = asp_l3 ASPO PASP (1-NITR).

From equation (32), it follows that:

(33) asp_l3 = [MTO /ASPO] [PMT/(PASP (1-NITR))]

which is also equal to:

asp_l3 = (MTO/GDPO) / (ASPO/GDPO) [PMT/(PASP (1-NITR))]

or, on using equation (27.a) and (27.c):

(34) wp asp_l3 = wm [PMT/(PASP (1-NITR))]

Inserting equation (34) into equation (31), yields:

(35) d ln(GDPO) = [1-PMT/(PASP (1-NITR))] wm woil d ln(TR_MP)

where it should be remembered that the term [1-PMT/(PASP (1-NITR))].wm.woil is evaluated for the baseline values of the term's variables.

It should also be noted that, using equation (27.c):

wm woil = (MTO woil) / GDPO = 1/[GDPO/(MTO woil)]

i.e. the inverse of the oil intensity of real GDP (in the baseline), while:

[PMT/(PASP (1-NITR))] wm woil = (PMT MTO woil) / [GDPO (PASP (1-NITR))]

i.e., the inverse of the oil intensity of GDP evaluated for producer prices (in the baseline).

Equation (35) shows that, the larger the discrepancy between the inverse of the oil intensity of *real* GDP (in the baseline) and the inverse of the oil intensity of GDP *evaluated at producer prices* (in the baseline), the stronger the impact of an increase in the mark-up on real GDP.

Finally, as a check on the simulation results presented in the section on the permanent oil price shock, we note that for that exercise we have:

1- PMT/(PASP (1-NITR)) = - 0.199553

wm = 0.13714

woil = 0.0657

d ln(TR_MP) = 0.25

so that, on inserting these numbers in equation (35), we get:

d ln(GDPO) = -0.199553 * 0.13714 * 0.0657 * 0.25 = -0.000449

which corresponds to the 0.04 per cent fall in real GDP in the long run. See Table 1, last column.

4. Short-run price adjustment

The price of oil not only affects the price of imports in the long run, but also in the short run. Therefore, we must rewrite the short-run adjustment scheme for import prices. But first, we repeat here how in the NIME model prices are set in the short run.

a. Short-run price setting in NIME: a reminder

As explained in Meyermans and Van Brusselen (2001), in the NIME model, goods are sold at a price which adjusts itself only gradually to its equilibrium level because of menu costs, and "rule of thumb" behaviour. First, because of menu costs, the seller adjusts the price of only a fraction of the composite good to a new price, PMTL, which we call the "reset price". Let (1-pmt_sl) be the fraction of prices that is revised. Second, the "reset price", PMTL, is calculated partly "rationally", and partly by "rule of thumb". Setting the price to its "rational" value, PMTR, requires a lot of accounting work on behalf of the producer. The producer could expect that the cost of such an exercise would outweigh the expected benefit, and he could therefore decide to do this exercise for only (1-pmt_sw) per cent of the composite good for which he wants to change the price. For the other fraction of the good, the producer follows a simple rule of thumb, setting the new price equal to the old price adjusted for the cost push inflation that can be observed at negligible cost. For example, we assume that contemporaneous financial variables and price of oil are observable at negligible cost, while the contemporaneous unit factor costs are not observable at negligible cost. Formally speaking, Meyermans and Van Brusselen (2001) derive that prices are set according to[1]:

$$\begin{aligned}(36)\quad & \ln(PMT_t) - \ln(PMT_{t-1}) = (pmt\_sl-1)\,[\ln(PMT_{t-1}) - \ln(PMTR_{t-1})] \\ & + (1-pmt\_sl)\,[\ln(PMTR_t) - \ln(PMTR_{t-1})] \\ & - (1-pmt\_sl)\,pmt\_sw\,[\ln(PMTR_t) - \ln(PMT_{t-1})] \\ & + (1-pmt\_sl)\,pmt\_sw\,d\ln(UMP_t)\end{aligned}$$

whereby the "rule of thumb" reset price evolves along:

$$(37)\quad d\ln(UMP_t) = \{[d\ln(PMT_{t-1}) - d\ln(EFEX_{t-1})] + d\ln(EFEX_t)\}$$

and the rational reset price, $PMTR_t$, is defined in equation (7). Equation (37) states that the change in the rule of thumb price is equal to the price change, denominated in the foreign currency, of the previous period, adjusted for the contemporaneous change in the exchange rate. The latter is assumed to be observable at negligible cost.

b. Oil prices and import prices

Here, we rewrite the price setting scheme for the case where we make a distinction between oil-imports and non-oil imports. In the short run, the price of aggregate imports is determined by:

$$(38)\quad PMT = PMTOTHER^{(1-woil)}\quad POIL^{woil}.$$

1. See equation (III.16.d) of Meyermans and van Brusselen (2001).

The price of oil is determined in the world markets, and its price is immediately known to all economic agents, without cost, and it is immediately converted into local currency by:

(39) POIL = POILUSD / EX_US_XX.

As explained in the previous sub-section, in the short-term, the price of the non-oil imports are set according to:

(40) $\ln(PMTOTHER_t) - \ln(PMTOTHER_{t-1}) =$
$(pmt\_sl\text{-}1)\,[\ln(PMTOTHER_{t-1}) - \ln(PMTOTHERR_{t-1})]$
$+ (1\text{-}pmt\_sl)\,[\ln(PMTOTHERR_t) - \ln(PMTOTHERR_{t-1})]$
$- (1\text{-}pmt\_sl)\,pmt\_sw\,[\ln(PMTOTHERR_t) - \ln(PMTOTHER_{t-1})]$
$+ (1\text{-}pmt\_sl)\,pmt\_sw\,d\ln(UMTOTHER_t)$

where the rational reset price is defined in equation (3), and the change in the "rule of thumb" price is defined as:

(41) $d\ln(UMTOTHER_t) = [d\ln(PMTOTHER_{t-1}) - d\ln(EFEX_{t-1})] + d\ln(EFEX_t)]$

C. Exports of the major country blocs

a. Exports prices, PXTR

In the previous version of the model, the equilibrium export price of the oil-importing country blocs is determined by:

(42) ln(PXTR) = pxt_l0 + pxt_l1 ln[EFEX EFPASP (1-EFNITR) EFYMT]

whereby we define the effective foreign productivity, EFYMT, as:

(43) $EFYMP = \prod_{YY=\,EURO,NE,US,JP,EC,RW} YY\_YMT^{xx\_w\_xtyy}$

See equation (III.23.b) of Meyermans and Van Brusselen (2001).

In the previous section, we made a distinction between the price of oil and the price of the other imports. We also made the assumption that only the RW bloc exports oil. In other words, the main country blocs only export non-oil products. This implies that we must now rewrite the export price equation of the oil-importing country blocs as:

(44) ln(PXTR) = pxt_l0 + pxt_l1 ln(EFEX EFPASP (1-EFNITR) EFYMPOTHER)

with foreign effective productivity now defined as:

(45) $EFYMPOTHER = \prod_{YY=\,EURO,NE,US,JP,EC,RW} YY\_YMTOTHER^{xx\_w\_xtyy}$

b. Export volume

Note that the equations for exports, XTO, do not change.

D. Stock market effects for the major country blocs

Households hold part of their wealth in the form of equities which have a unit price, STOCK, which is determined by:

(46) $$STOCK = PROF\frac{1}{1 + LIP - (1 + G\_PCH)(1 + G\_YCP)}$$

whereby PROF is profits, LIP the discount rate, G_PCH trend inflation, and G_YCP trend productivity growth. See equation (A.16) of Appendix A of Meyermans (2003).

An increase in the price of oil as a result of an increase in the mark-up, reduces output. Here, it is assumed that the shock also affects the profitability of the enterprise sector, and that profits fall by the same amount as output, i.e.:

(47) d ln(PROF) = d ln(ASPO) = - asp_l3 woil d ln(TR_MP)

Hence the price of equities adjusts by:

(48) d ln(STOCK) = - asp_l3 woil d ln(TR_MP)

E. The rest of the world bloc

Here, we introduce some modifications to the RW bloc. First, we specify a new equation for the export prices of the RW bloc by making explicitly a distinction between the exports of oil and the exports of "other goods and services". Next, we specify an equation for aggregate demand of the RW bloc, thereby taking into account the effects of a temporary income transfer due to a change in the price of oil.

1. Export prices

The price of exports of the RW bloc is the aggregate of the price of oil, POILUSD, and the price of the other export goods, PXTOTHER, i.e.[1]:

(49) PXT = (POILUSD/EX_US_EU) **woil PXTOTHER**(1-woil)

whereby woil is the share of oil in the total exports of the RW bloc, $0 \leq woil \leq 1$.

The price of oil, denominated in US dollar, POILUSD, is determined outside the model.

The price of the other export goods, PXTOTHER, is determined in equilibrium as:

(50) PXTOTHER = pxt_l0
+ pxt_l1 ln(EFEX EFPASP (1-EFNITR) EFYMTOTHER)

1. Remember that in the NIME model, the export price of the RW bloc is denominated in euro. Hence, we use the bilateral exchange rate of the US dollar vis-à-vis the euro, EX_US_EU.

where EFEX is the effective exchange rate, EFPASP is the effective foreign price level, EFNITR is the effective foreign indirect tax rate, and EFYMTOTHER is the effective foreign productivity of non-oil exports.

In the short run, the price of the other export goods is set according to:

(51) $\ln(PXTOTHER_t) - \ln(PXTOTHER_{t-1}) =$
$(pxt\_sl\text{-}1)\ [\ln(PXTOTHER_{t-1}) - \ln(PXTOTHERR_{t-1})]$
$+ (1\text{-}pxt\_sl)\ [\ln(PXTOTHERR_t) - \ln(PXTOTHERR_{t-1})]$
$- (1\text{-}pxt\_sl)\ pxt\_sw\ [\ln(PXTOTHERR_t) - \ln(PXOTHERT_{t-1})]$
$+ (1\text{-}pxt\_sl)\ pxt\_sw\ d\ln(UXTOTHER_t)]$

whereby:

(52) $d\ln(UXTOTHER) = [d\ln(PXTOTHER_{t-1}) - d\ln(EFEX_{t-1})] + d\ln(EFEX_t)]$.

2. Output

In equilibrium, total output of the RW bloc, ASO, is determined exogenously as:

(53) ASO = HP_ASO

where HP_ASO is potential total output, which is calculated by applying a Hodrick-Prescott filter to the historical output series.

In the short-term, output is determined by total demand, ADO, i.e.:

(54) ASO = ADO.

Total demand is determined by domestic demand, ADDO, plus net-exports, i.e.:

(55) ADO = ADDO + XTO - MTO.

Here, we assume that aggregate domestic demand is function of permanent income, HP_ASO, wind-fall income from oil, YOIL, the nominal interest rate, LIC[1], and the inflation rate, INFL, i.e.:

$$\text{(56)}\quad ADDO = f(HP\_ASO^{+}, YOIL^{+}, LIC^{-}, INFL)$$

whereby YOIL is measured by:

(57) $YOIL = (XTUOIL / PASP)$
$\{[POILUSD/(WORLD\_PASP\ EX\_WORLD\_US)]/WORLD\_REALPOIL\text{-}1\}$

1. LIC is an average of the short-term interest rate, SI, and the long-term interest rate, LI.

where XTUOIL is the exports of oil[1], POILUSD is the spot price of oil denominated in USD, WORLD_PASP is the world price level (i.e., the average price level of the major country blocs), EX_WORLD_US is the bilateral exchange rate vis-à-vis the US dollar (i.e., the average exchange rate of the major country blocs), WORLD_REALPOIL is trend real price of oil, obtained applying a Hodrick-Prescott filter on the series POILUSD/(WORLD_PASP EX_WORLD_US).

Equation (57) states that the total windfall profit from the sale of oil accruing to the RW bloc is determined by the extent that the contemporaneous real price of oil, [POILUSD/(WORLD_PASP EX_WORLD_US)], deviates from its trend level, (WORLD_REALPOIL), and by the volume, (XTUOIL /PASP).

Net exports are function of domestic output, ASO, foreign effective output, EFASPO, and relative prices, i.e.:

$$\underset{(58)}{XTO - MTO} = g(\underset{-}{ASO}, \underset{+}{EFASPO}, \underset{-}{PASP/(EFEX\ EFPASP)}).$$

Combining equations (54), (55), (56) and (58), we get that:

$$\underset{(59)}{ASO} = h(\underset{+}{HP\_ASPO}, \underset{+}{YOIL}, \underset{-}{LIC}, \underset{+}{INFL}, \underset{+}{EFASPO}, \underset{-}{PASP/(EFEX\ EFPASP)})$$

Taking a log linearised version of this relation, and selecting an appropriate parametrisation, we get:

$$\begin{aligned}(60)\quad & d\ln(ASPO) = asp\_s1\ d\ln(1+LIC) \\ & + asp\_s2\ d\ln(PASP/(EFEX\ EFPASP)) + asp\_s3\ d\ln(INFL) \\ & + asp\_s4\ d\ln(HP\_ASPO) + asp\_s5\ d\ln(EFASPO) \\ & + asp\_s6\ d\ln(YOIL) + asp\_sl\ \ln(ASPO/HP\_ASPO)_{-1}\end{aligned}$$

with the parameters asp_s1, asp_s2 ≤ 0, asp_s4, asp_s5, asp_s6 ≥ 0, and $-1 \leq$ asp_sl ≤ 0.

Equation (60) states that in the short run, output of the rest of the world changes in line with changes in the domestic interest rate, the relative prices, the domestic inflation rate, domestic trend output, foreign effective output, windfall income from oil and an error correction term. Point estimates (with standard errors between brackets) are as follows:

$$\begin{aligned}d\ln(ASPO) = & - 0.371\ (0.173)\ d\ln(1+LIC) \\ & - 0.027\ (0.020)\ d\ln(PASP\ EX\_RW\_EU/EFPASP) \\ & - 0.062\ (0.033)\ d\ln(INFL) \\ & + 0.871\ (0.069)\ d\ln(HP\_ASPO) + 0.171\ (0.099)\ d\ln(EFASPO)_{-1} \\ & 0.011\ (0.006)\ d\ln(YOIL) - 0.320\ (0.166)\ \ln(ASPO/HP\_ASPO)_{-1}\end{aligned}$$

1. Exports of oil by the RW bloc is equal to the imports of oil by the other country blocs. The imports of oil by the other country blocs is xx_woil XX_MTU with xx_woil the share of oil in total imports of country bloc xx, XX_MTU is total imports of country bloc XX. Hence, total exports of oil are determined by: RW_XTUOIL= eu_woil EU_MTU + ne_woil NE_MTU /EX_NE_EU + us_woil US_MTU/EX_US_EU + jp_woil JP_MTU /EX_JP_EU+ ec_woil EC_MTU /EX_EC_EU.

and with the adjusted coefficient of determination equal to 0.399 and the Durbin-Watson statistic equal to 1.538.

Finally, in this exercise, it is assumed that an oil price shock does not affect potential output of the RW bloc. However, it should be remembered that, to the extent that the domestic oil market is not insulated from the world oil market, the oil-exporting countries may also suffer a loss in total factor productivity when the price mark-up increases. However, it is not unusual that the oil-exporting countries insulate their domestic market from world markets, e.g. Russia, so that no loss in total factor productivity is suffered by the domestic enterprise sector. Note also that a decline in world demand for oil will not lead to a fall in potential output, as the production factors that are freed when demand for oil falls will be reallocated to the production of other goods and services, be it in the long run.

F. Data

Four remarks regarding the data.

First, POILUSD is the dollar price per barrel of Brent crude, as published under line 112, Commodity Prices, petroleum, spot, UK Brent, in the International Financial Statistics of the International Monetary Fund.

Second, the shares of oil in total imports of a country bloc, i.e., woil, are the observed shares as available in the Trade Statistics of the OECD, except for the New EU Member States bloc for which a technical assumption was made.

Third, the productivity of the non-oil imports, YMTOTHER, is calculated as follows. Defining aggregate trend productivity of imports as:

$$(61) \quad YMT = YMTOTHER^{(1-woil)} \quad YMTOIL^{woil}$$

YMT is trend productivity of total imports calculated by applying a Hodrick-Prescott filter to the historical series of the productivity of imports, i.e., ASPO/MTO. YMTOIL is calculated by applying a Hodrick-Prescott filter to the historical series of the real world oil price, i.e., POILUSD / [WORLD_PASP EX_US_WORLD (1-WORLD_NITR)], whereby:

$$WORLD\_PASP = \prod_{XX=US,\,EU,\,NE,\,JP} XX\_PASP^{wxx},$$

$$WORLD\_NITR = \prod_{XX=US,\,EU,\,NE,\,JP} XX\_NITR^{wxx},$$

$$\text{and } EX\_US\_WORLD = \prod_{XX=US,\,EU,\,NE,\,JP} EX\_XX\_US^{wxx}$$

with wxx the share of bloc xx(=eu, us, ne, jp) exports plus imports in total sum of exports plus imports.

Having calculated YMT, and YMTOIL, we calculate YMTOTHER as:

$$YMPOTHER = YMP^{(1/(1-woil))} \quad YMPOIL^{[woil/(1-woil)]}$$

Fourth, the share of imported oil in total oil consumption is calculated using the information in:

http://www.bp.com/liveassets/bp_internet/globalbp/STAGING/global_assets/downloads/B/BP_statistical_review_of_world_energy_2003_workbook.xls

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