Oil Prices, Inflation and Interest Rates in a Structural Cointegrated VAR Model for the G-7 Countries

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Summary

Sharp increases in the price of oil are generally seen as a major contributor to business cycle asymmetries. Moreover, the very recent highs registered in the world oil market are causing concern about possible slowdowns in the economic performance of the most developed countries. While several authors have considered the direct channels of transmission of energy price increases, other authors have argued that the economic downturns arose from the monetary policy response to the inflation presumably caused by oil price increases. In this paper a structural cointegrated VAR model has been considered for the G-7 countries in order to study the direct effects of oil price shocks on output and prices and the reaction of monetary variables to external shocks. Empirical analysis shows that, for most of the countries considered, there seems to be an impact of unexpected oil price shocks on interest rates, suggesting a contractionary monetary policy response directed to fight inflation. In turn, increases in interest rates are transmitted to real economy by reducing output growth and the inflation rate.

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1 Introduction

Sharp increases in the price of oil are generally seen as a major contributor to business cycle asymmetries. Moreover, the very recent highs registered in the world oil market are causing concern about possible slowdowns in the economic performance of the most developed countries.

Thus, not surprisingly, a considerable body of economic research has studied the channels through which oil price shocks influence economic variables. From the theoretical point of view several economists have offered a number of explanations to account for the inverse relationship between oil price changes and aggregate economic activity.

The most intuitive explanation is the classic supply shock in which rising oil prices are indicative of the increased scarcity of energy. Because an important input to production is less available, output and labor productivity are reduced (in milder cases, their rate of growth is reduced). Moreover, if consumers expect a temporary rise in energy prices (or short-run effects more important than long-run effects) they could decide to save less or borrow more causing a fall in real balances and a further increase in the price level.

Another channel through which oil price shocks could influence economic activity is derived from the income transfer from oil importing countries to oil exporting nations. In fact rising oil prices can be thought as a tax levied from oil-exporting countries to oil-consumers. Although this reduction in the domestic demand should be offset, at least in part, by export demand from the foreign recipients of the income transfer, in net terms, there will be a negative impact on the consumer demand for goods produced in the oil importing nations[1].

A third explanation that economists offered for the aggregate economic effects of an oil price shock is the *real balance effect*. Under this theory, after an increase in oil prices, as people desire to rebalance their portfolios toward liquidity, there will be an increase in money demand. Hence, if monetary authorities fail to meet growing money demand with an increased money supply, so that the price level rise without a corresponding increase in the money supply, we have the case of a decrease of the real balances which, in turn, will boost interest rates.

Since the basic supply shock effects, the *real balance effect* and the income transfer can account for only a portion of the intense effect that oil price shocks have on aggregate economic activity, additional explanations have been presented.

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[1] According to this mechanism of transmission, the reduction in aggregate demand may put downward pressure on the price level. Economic theory suggests that real prices will continue falling until aggregate demand and GDP are restored to pre-shock level. However, if nominal prices are sticky downward, the process of adjustment will not take place and aggregate demand and GDP will not be restored.

Rising oil prices are usually amplified by the *adjustment costs* that could arise from the production technology embedded in the capital stock and short-term rigidities. After an increase in energy prices, industries would move from energy intensive sectors to energy efficient ones; since these realignments cannot be achieved quickly, there will be an increase in unemployment and an underutilization of resources (see, for example, Pindyck and Rotemberg, 1983). Other authors (for instance, Bernanke, 1983 and Van Soest *et al.*, 2000) have underlined the importance of *uncertainty*: in period characterized by oil price volatility because firms are not sure about the future movements of oil prices they will have an incentive to postpone investment decisions.

Several economists (Tatom - 1988 and 1993, Bernanke, Gentler and Watson - BGW - 1997) pointed out the monetary authority behavior as a possible explanation for the economic effects of oil price shocks. Since, as we have seen, an oil price shock has the effect to influence the real economy and inflation in different ways, central banks usually experience difficulties in stabilising inflation and production at the same time.

In particular if the central banks' aim is that of stabilizing output growth, they would react with a reduction in interest rates that could temporarily offset the losses in real GDP and increase inflationary pressures. On the other hand, monetary authorities that conduct a flexible inflation-targeting approach after an exogenous supply side shock could increase interest rate with negative effects on output[2].

Another specific difficulty that monetary policy faces when oil prices rise is in assessing to what extent the increase in oil prices also has effects on potential production. This may be the case if the increase in oil prices means, for instance, that parts of the real capital in the economy become obsolete and take time to replace. In this case, inflationary pressure will be higher than it would have otherwise been. Therefore relatively tighter monetary policy is needed to bring inflation back in line with the target. Where increases in oil prices affect the potential production of the economy, these effects will only be visible after a time lag.

This paper has the specific aims to measure the direct impact of oil prices on macroeconomic indicators and to verify if the central banks of the countries of the G-7 have reacted to exogenous oil price shocks.

This analysis has been done in the framework of a cointegrated structural vector autoregression. Models of this type have been extensively used in empirical analysis during the last two decades and, in particular, in order to analyze the effects of monetary shocks (Eichenbaum and Evans,

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[2] As noted by BGW, this negative effects will be greater if wages are nominally sticky downward: the initial reduction in GDP growth could be accompanied by a reduction in labor productivity and, hence, an increase in unemployment.

1995), the causes of unemployment (Dolado and Jimeno, 1997) and to explain exchange rates anomalies (Kim and Roubini, 2000). We have decided to adopt this methodology because it allows us to consider not only long-run (i.e. cointegrated) restrictions but also short-run (i.e. covariance) restrictions in form of economic relationships. Moreover, structural VECM has some important advantages in systems with stochastic trends and cointegration. In fact, other things being equal, estimates of impulse responses from structural VECM are more precise; for example, levels VAR can lead to exploding impulse response estimates even when the true impulse response is not exploding.

The paper is organized as follows. Section 2 reviews recent work on the response of monetary policy to oil price shocks. Section 3 describes the econometric framework and the macroeconomic model. Section 4 presents the estimated structural cointegrated VAR, the impulse response functions and three simulation exercises directed to estimate the effects of the 1990 oil price shock. Section 5 concludes.

2 Oil Prices and Monetary Policy. What the Empirical Literature Says

The empirical literature directed to verify the empirical relationship between business cycle and oil price fluctuations evolved after 1973, the year of the first oil price shock. The first two authors who estimated the impact of oil price increases on real income in the U.S. and other developed economies were Darby (1982) and Hamilton (1983). While Darby was not satisfied with the ability of the variables considered[3] to explain the recession which hit the U.S., Hamilton found statistically significant relationships between oil price changes and real GNP growth for the U.S. economy for both the period 1948-1972 and 1973-1980. The negative correlation between oil price movements and economic growth reflected a causal link from oil prices to aggregate economic activity.

Other studies confirmed Hamilton's results. While Gisser and Goodwin (1986) introduced the growth rate of nominal price of crude oil in St. Louis-type equations[4] of four indicators of macroeconomic performance (namely, real GDP, general price level, rate of unemployment and real investment), Burbidge and Harrison (1984) conducted vector autoregressions (VAR) and

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[3] The oil price shocks, a monetary policy variable directed to measure the effects of the policy directed to fight inflation and a measure of the price controls introduced over the period 1971-1975   [4] The St. Louis-type equations describe the impact of monetary and fiscal actions on nominal economic activity.

computed impulse responses to oil price changes with seven-variable VAR models. They found evidence of a causal relationship from oil price shocks to economic variables although the results for some countries were somewhat ambiguous.

The failure of the 1986 oil price collapse to produce an economic boom lead several authors to argue the existence of an asymmetric relationship between oil prices changes and economic activity: while oil price increases have clear negative effect, oil price declines have no clear positive effect and may indeed slow output growth. In particular, Mork (1989) after observing that Hamilton's study pertained to a period in which all the large oil price movements were upward, verified that, if the analysis is extended in order to include the oil price collapse of 1986, the oil price-macroeconomy relationship broke down. Hence he decided to test the symmetry hypothesis on U.S. data by allowing real increases and decreases in the price of oil to have different coefficients in a regression equation with real GNP growth as the dependent variable. The coefficients on oil price increases now turned out negative and highly significant; the coefficients on price declines tends to be positive, but small, and no statistically significant; moreover, coefficients on oil price increases and oil price decreases were significantly different from each other demonstrating that the effects of oil price increases and decreases were asymmetric.

In an extension of this analysis to other countries, Mork, Olsen and Mysen (1994) found that all countries except Norway experienced a negative relationships between oil price increases and GDP growth. However, for most of these countries, the coefficients of oil-price decreases tend to be of the opposite sign to the corresponding coefficients for price increases, indicating that oil-price decreases may have adverse effects on the business cycle. For many countries, these coefficients are not significantly different from zero.

Other authors asserted that the relationship between oil price shocks and U.S. macroeconomic fluctuations broke down because of a new regime of highly volatile oil price movements. For example, Lee, Ni and Ratti (LNR, 1995) argued that *'an oil price shock is likely to have greater impact in an environment where oil prices have been stable than in an environment where oil price movements have been frequent and erratic'*, because price changes in a volatile environment are likely to be soon reversed[5].

A different specification for oil price changes has been proposed by Hamilton (1996). In direct response to Hooker (1996) who found strong evidence that oil prices no longer Granger cause

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[5] In particular, by replacing the simple oil price-change variable with a variable representing the oil price changes normalized by their conditional variation of oil price changes constructed considering a *generalized autoregressive conditional heteroskedasticity model* (GARCH) they found a strong negative relationship between unanticipated oil-price changes and GNP growth.

many U.S. macroeconomic variables in data after 1973, Hamilton introduced the concept of *net oil price increase* (NOPI), series constructed only considering the positive difference between the oil price level and the maximum price of the previous four quarters. The introduction of this variable in a VAR model for the U.S. economy was able to restore a significant relationship between oil prices and real GNP.

With regard to the response of monetary authority to oil price changes, Bohi (1989) asserted that, if a classic supply shock explains the principal effects of an oil price shock, energy-intensive industries should be the most affected after an increase in energy prices. However, since he found no relationship between these industries and their level of energy-intensity and no statistically significants effects of oil price shocks on the business cycle of four countries, he concluded that the restrictive monetary policy carried out by the central banks of these countries accounts for much of the decline in aggregate economic activity in the years that followed oil price increases.

Similarly, results by Bernanke, Gentler and Watson (1997) clearly support this view demonstrating that if, following an oil price shock, the Federal Reserve had not increased interest rates, the economic downturns that hit the U.S. might be largely avoided. In particular they show that the U.S. economy responds differently to an oil price shock when the federal funds rate is constrained to be constant than in the case in which monetary policy is unconstrained. In the unconstrained case, a positive oil price shock leads to an increase in the federal funds rate and a decline in real GDP. With the federal funds rate held constant, BGW find that a positive oil price shock results in an increase of real GDP and of the inflation rate. According to the three authors these results show the importance of the part of the real effects of oil price shocks due to the monetary policy response.

Hamilton and Herrera (2001) challenged the conclusions of BGW on two grounds. First, they found that both the nature and magnitude of the actions suggested for the U.S. central bank are sufficiently inconsistent with the historical correlations as to call into question the feasibility of such a policy. Second, they demonstrated that if a longer lag length is considered even when the federal funds rate is kept constant an oil price shock still yields a sizable reduction in output, which implies that monetary policy has little effect in easing the real consequences of an oil price shock.

The analysis of Hamilton and Herrera is consistent with those of other authors who show that counter-inflationary monetary policy was only partly responsible for the real effects of oil price shocks that hit the U.S. during the last thirty years.

Brown and Yucel (1999), for example, constructed a vector autoregressive (VAR) model of the

U.S. economy similar to the BGW model and found that after an oil price shock the economy responds with a reduction in real GDP, an increase in interest rates and in the price level. Since the decline in real GDP and the rise in deflator are similar in magnitude, so that nominal GDP remains relatively constant - the finding that conforms to Robert Gordon's definition of monetary neutrality - the Federal Reserve seems to have been neutral to oil price increases. Since they observed that if the federal funds rate is held constant after an oil price increase real GDP, the price level and nominal GDP increase (effects consistent with *accommodative monetary policy*), they argued that U.S. monetary policy has probably had no role in worsening the effects of past oil price shocks.

Other authors who have stressed as causes of the economic downturns that hit the developed countries in the '70s and '80s possible indirect effects arising from the Federal Reserve's response to the inflation presumably caused by an oil price increases have been Barsky and Kilian (2001). Their analysis suggests that the Great Stagflation observed in the 1970s is unlikely to have been caused by oil price shocks; however, it was at first a monetary phenomenon: in substantial part it could have been avoided, if the Federal Reserve had not permitted major monetary expansions in the early 1970s.

Finally, several economists have argued that monetary policy could be responsible for the asymmetric response of aggregate economic activity following an oil price shocks. While Tatom (1988) provided some early evidence that monetary policy responded asymmetrically to oil price shocks by showing that the economy responded symmetrically to oil price shocks if the stance of monetary policy is taken into account, Ferderer (1996) showed that monetary policy cannot account for the asymmetry in the response of real activity to oil price shocks in his model.

More recently, Balke, Brown and Yucel (2002) found that, even if negative and positive oil price shocks have asymmetric effects on output and interest rates, the Federal Reserve's response to oil price shocks does not cause asymmetry in real economy activity. In fact while interest rates does appear to respond asymmetrically to oil prices movements, the asymmetric response of real GDP does not go away - and in fact is enhanced - when movements in either the Fed Funds rate or the Fed Funds rate and expectations of the Fed Funds are eliminated.

3   A Structural Cointegrated VAR Analysis

3.1   The econometric framework

Vector Autoregressive (VAR) models have become increasingly popular after Sims's (1980) critique of the simultaneous equation approach. However, the standard VAR is a reduced form model and economic interpretation of the results is often impossible, unless the reduced form VAR is linked to an economic model. If economic theory is used to provide the link between forecast errors and fundamental shocks, we call the resulting model a SVAR.

We assume that the economy is described by a structural form equation:

$$B_0 y_t = k + B_1 y_{t-1} + B_2 y_{t-2} + \ldots + B_p y_{t-p} + u_t \tag{1}$$

$$B_L y_t = u_t \tag{2}$$

where:

$$B_L = B_0 - B_1 L - B_2 L^2 - \ldots - B_p L^p \tag{3}$$

is a matrix polynomial in the lag operator L, y_t is an K x 1 data vector, and u_t is an K x 1 structural disturbances vector[6]. A sufficient number of lags of p are included so that u_t is vector white noise, i.e., u_t is serially uncorrelated and $var(u_t) = \Omega$, diagonal matrix where diagonal elements are the variances of structural disturbances.

If each side of (1) is pre-multiplied by B_0^{-1}, the result is a reduced form equation:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + \epsilon_t \tag{4}$$

$$y_t = A_L y_t + \epsilon_t \tag{5}$$

where:

$$A_L = A_1 L + A_2 L^2 - \ldots + A_p L^p \tag{6}$$

is a matrix polynomial in lag operator L.

In order to recover the parameters in the structural form equations, Blanchard and Watson (1986) and Bernanke (1986) suggest a generalized method (Structural VAR) which allow non-recursive structures and impose restrictions only on contemporaneous structural parameters.

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[6] It is important to note that B_0 represents the contemporaneous coefficient matrix in the structural form.

Then, if

$$B(L) = B_0 + B^0(L) \tag{7}$$

the parameters in the structural form equation and those in the reduced form equation are related by:

$$A(L) = -B_0^{-1} + B^0(L) \tag{8}$$

In addition, the structural disturbances and the reduced form residuals are related by:

$$u_t = B_0 \epsilon_t \tag{9}$$

Since $\Sigma = E(\epsilon_t, \epsilon_t)$, it implies that we can find a lower triangular matrix A such that:

$$\Sigma = A\Omega A \tag{10}$$

$$\Sigma = B_0^{-1} \Omega B_0^{-1} \tag{11}$$

To summarize, it is possible to recover the structural shocks and variances through the imposition of a sufficient number of restrictions on the B_0 matrix defined by equations that can capture the instantaneous correlations among the endogenous variables.

It is also possible to apply the SVAR technique to vector error correction models (VECM) with cointegrated variables. In particular, the question of indentifying of a SVAR which has $r < k$ cointegrating vectors is discussed in, inter-alia, Johansen and Juselius (1994) and Robertson and Wickens (1994). The SVECM analysis starts from the reduced form standard VAR(p) model:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + u_t \tag{12}$$

where y_t is a k x 1 vector of time series and $A_1, \ldots, A_p$ are k x k coefficient matrices. The reduced form disturbance u_t is a K x 1 unobservable zero mean white noise process with covariance matrix Σ_u. The equation (12) has a vector error correction representation denoted as VECM(p):

$$\Delta y_t = \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{p-1} \Delta y_{t-p+1} + u_t \tag{13}$$

which is obtained by subtracting y_{t-1} from both sides of (12) and rearranging terms. In cointegrated models Π has reduced rank $r = rank(\Pi) < K$ and can be decomposed as $\Pi = \alpha\beta'$, where α and β are K x r matrices containing the loading coefficients and the cointegration vectors, respectively. We are interested in the effects of the fundamental shocks ϵ_t on the system variables y_t. These shocks can be expressed in terms of the structural form VECM:

$$B\Delta y_t = \Psi y_{t-1} + \Lambda_1 \Delta y_{t-1} + \ldots + \Lambda_{p-1} \Delta y_{t-p+1} + \epsilon_t \tag{14}$$

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where the K x 1 vector ϵ_t contains structural disturbances and has the covariance matrix Σ_ϵ. Thus, to compute the responses to the economic shocks ϵ_t, we have to link the forecast errors u_t to the structural shocks ϵ_t. Premultiplying the system (14) by B^{-1} gives the reduced form (13) with $\Gamma_1 = B^{-1}\Lambda_1$, ..., $\Gamma_{p-1} = B^{-1}\Lambda_{p-1}$ and

$$u_t = B^{-1}\epsilon_t = A_0\epsilon_t \tag{15}$$

which relates the reduced form disturbance u_t to the underlying structural shocks.

To analyze the effects of the underlying structural shocks, we need to recover the K^2 elements of A_0. For this purpose we need identifying restrictions coming from economic theory. We can use equation (15) to write:

$$\epsilon_t = E\left[u_t u_t'\right] = A_0 E\left[\epsilon_t \epsilon_t'\right] A_0' = A_0 \Sigma_\epsilon A_0' \tag{16}$$

and use the standard assumption that the structural shocks are uncorrelated and have unit variances, i.e. $\Sigma_\epsilon = I_B$, to get:

$$\epsilon_u = A_0 A_0' \tag{17}$$

We have to note that, conditional on having chosen the cointegrating rank r, it is necessary to consider the identification of the contemporaneous coefficients A_0 and the long run coefficients β, and these are essentially separate issues in that there are no mathematical links between restrictions on A_0 and those on β. In particular, since a Π matrix of rank r is identified and satisfies $\Pi = \alpha\beta = A_0^{-1}A\beta$, it follows that restrictions are required to identify β even if A_0 were known. Conversely, restrictions on β have no mathematical implication for the restrictions on A_0. It remains possible though that the economic interpretation of a restricted set of cointegrating vectors βz_t may have implications for the nature of restrictions on A_0 that will be economically interesting, particularly when A is restricted via α. Mathematical, and possibly economic, linkages do exist between restrictions on the adjustment coefficients α and those required to identify β.

3.2 The macroeconomic model

In this section we briefly describe a simple macroeconomic model for the countries considered in the study. We consider both long-run and short-run restrictions based on economic theory; while the former are expressed as linear restrictions on the cointegrated vectors in order to capture a

money demand function and/or an excess demand relationship, the short-term restrictions are imposed on the residual covariance matrix on the basis of the economic theory.

Because of its implication on policy behavior much applied research in monetary economics has been devoted to the specification of the money demand function. Much of the empirical research on money demand has estimated a conventional money demand function of the following functional form:

$$\frac{M}{P} = \beta_0 + \beta_1 Y - \beta_2 i - \beta_3 \Delta P \tag{18}$$

where M is nominal money balances, P the price level, Y the output level, i a short-term nominal rate of interest and P the price level . The parameters β_1, β_2 measure respectively the long-run income and opportunity cost elasticities.

With the variables considered in the study we can also specify a long-run relationship expressing the excess output in which the difference from trend is a direct expression of inflation rate, exchange rates and interest rates:

$$y - t = \beta_4 + \beta_5 e - \beta_6 i - \beta_7 \Delta P \tag{19}$$

While increases in inflation and interest rates (implying, respectively, a real appreciation of exchange rates and a higher cost of capital) are supposed to have a negative impact on output, the theoretical literature (see, for example, the studies of Edward (1989), Kamin (1996), Calvo, Reinhart and Vegh (1994)) provides evidence of both positive and negative effects of exchange rates on national output[7].

With regard to the short-run dynamics we can describe the model by means of two blocks of equations. While the first two relationships relate to the money market equilibrium, the next two describe the domestic goods market equilibrium. Finally we introduce two short-run relationships in order to describe the exchange rates movements and the exogenous shock originating from oil price changes.

Concerning the demand for real money balances, we assume that, in the short run, the main driving forces are interest rates and inflation rate, excluding the three other variables:

$$\epsilon_m = b_{11} u_m + b_{12} u_r + b_{14} u_p \tag{20}$$

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[7] If, on the supply side, exchange rates should affect prices paid by the domestic buyers of imported goods and, indirectly, prices of domestically produced goods, an appreciation (devaluation) of the national currency could have the effect to reduce (increase) foreign demand for domestic goods (aggregate demand effects)

For the interest rates' short-run dynamics, we assume that, given the inexistence of information delays and the hypothesis that economic macroindicators are able to anticipate the business cycle, monetary authority can respond within the period to price level and output variations. In this context, interest rates are expected to increase when current output is higher than potential and when inflation rate over the past year increases over its long-term target[8]. We also assume that additional short-run determinants of the interest rate dynamics are oil prices and exchange rates.

This means that in the structural part of the model we will have the following relationship:

$$\epsilon_r = b_{22}u_r + b_{23}u_y + b_{24}u_p + b_{25}u_e + b_{26}u_o \tag{21}$$

In order to describe the domestic goods market equilibrium we consider two equations, representative of the short-run dynamics of inflation rate and output. Concerning the output level, we assume that changes in economic activities are related to the inflation rate, the movements of exchange rates and oil price changes. If, on the one hand, the inflation rate is important because of *'real business effects'*, on the other hand, we think that oil price affects not only prices but also the real sector contemporaneously because of its importance for many economic sectors (as we have already noted):

$$\epsilon_y = b_{33}u_y + b_{34}u_p + b_{35}u_e + b_{36}u_o \tag{22}$$

with regard to the inflation rate, it is assumed to depend on exchange rates movements and on oil price changes: a devaluation of the national currency and an increase in oil prices will have the effect to influence (in a positive manner) the inflation rate:

$$\epsilon_p = b_{44}u_p + b_{45}u_e + b_{46}u_o \tag{23}$$

With regards to the equation describing the exchange rate market we assume that oil prices have a direct effect on exchange rates. This is done according to the analysis of Golub (1983) which argued that the wealth transfer effects associated with oil price rises, causing a temporaneous disequilibrium in portfolios, may influence exchange rates because of differential portfolio preferences. Therefore our short-run relationship becomes:

$$\epsilon_e = b_{55}u_e + b_{56}u_o \tag{24}$$

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[8] This is a simplified version of the Taylor rule, rule that predicts whereby the central banks respond to the deviation of inflation from a determined target and to deviations of actual from potential output: $r_t = r_{t-1} + \beta_1(\Pi_t - \widetilde{\Pi_t}) + \beta_2(y_t - \widetilde{y_t})$. In this equation $\widetilde{y_t}$ and $\widetilde{\Pi_t}$ represent respectively the monetary authorities' inflation and output target.

At last, in order to consider the shock originating from oil price changes, the identifying restriction in this equation for the price of oil consider this variable as being contemporaneously exogenous to any variable in the domestic economy:

$$\epsilon_o = b_{66} u_o \tag{25}$$

This six equations allow us to describe the following identification matrix:

$$\epsilon_t = B_0 u_t \tag{26}$$

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\begin{bmatrix} \epsilon_m \\ \epsilon_r \\ \epsilon_y \\ \epsilon_p \\ \epsilon_e \\ \epsilon_o \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & 0 & b_{14} & 0 & 0 \\ 0 & b_{22} & b_{23} & b_{24} & b_{25} & b_{26} \\ 0 & 0 & b_{33} & b_{34} & b_{35} & b_{36} \\ 0 & 0 & 0 & b_{44} & b_{45} & b_{46} \\ 0 & 0 & 0 & 0 & b_{55} & b_{56} \\ 0 & 0 & 0 & 0 & 0 & b_{66} \end{bmatrix} \begin{bmatrix} u_r \\ u_m \\ u_p \\ u_y \\ u_e \\ u_o \end{bmatrix} \tag{27}
$$

where u_r, u_m, u_p, u_y, u_e, u_o are the residuals in the reduced form equations, which represent unexpected movements (given information in the system) of each variable and ϵ_r, ϵ_m, ϵ_p, ϵ_y, ϵ_e, ϵ_o are the structural disturbances, that is money supply shocks, money demand shocks, price shocks, GDP shocks, oil price shocks and exchange rate shocks, respectively.

Based on the preceding discussion the econometric analysis of the macroeconomic models considered involves the following steps: first, we determine the cointegration rank of the system of interest and impose over-identifying restrictions on the cointegrating vectors using the ML method proposed by Johansen (1988). The identified cointegration relations can be used to setup a full VECM, where no further restrictions are imposed. Residuals from the VECM are used to form an estimate for Σ_u. Second, long run and contemporaneous identifying restrictions derived form the model presented in this section are used to form estimates of A_0. Using the estimated contemporaneous impact matrix, the structural shocks can be recovered and their impact can be analyzed using an impulse response analysis.

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4   Empirical Results

4.1   The data and their statistical properties

In our model, the data vector is r, m, p, y, o, e where r is a short-term interest rates (treasury bill or lending rate), m is a monetary aggregate (generally M1), p is the consumer price index, y is the real gross domestic product, o is the world price of oil in terms of the U.S. dollar and e is the exchange rate expressed as the ratio of the SDR rate to the U.S. SDR rate for each country except the US. For the U.S. the exchange rate is the ratio of the U.S. SDR rate to the average of the other six countries' SDR rates (Sims, 1991)[9].

While the first four variables are well known in business cycle literature the world price of oil is included in order to account for current systematic responses of monetary policy to exogenous shocks. Finally, we have decided to include the exchange rate because we think that it plays a prominent role in more open economies so that central banks find it useful to target it. Moreover, monetary authorities in open economies may offset some of the contemporaneous exchange rate shocks they face because these shocks significantly affect the economy, again suggesting a role for the exchange rate in the measurement of the policy stance.

Vector autoregressive (VAR) systems were estimated for data from Canada, France, Germany, Italy, Japan, the United Kingdom and the United States. The macroeconomic data used were taken from the International Financial Statistics (*International Monetary Fund*) databases and national sources (ISTAT for Italy and INSEE for France) and are presented in Table 1. Data are quarterly for the period 1980(1) to 2003(4)[10, 11]. All variables entered as logarithm except interest rates.

When discussing the statistical properties of an econometric model it is important to test the presence of unit roots in order to avoid the problem of spurious regression. In fact, if a variable contains a unit root (i.e. it is *non-stationary*) and it does not combine with other non-stationary series to form a stationary cointegration relationship, then regressions involving the series can falsely imply the existence of a meaningful economic relationship.

There are several ways of testing for the presence of a unit root. However, we focus our attention on the Augmented Dickey Fuller test (ADF).

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[9] The SDR is an international reserve asset that serves as the unit of account of the International Monetary Fund and some other international organizations. Its value is based on a basket of key international currencies.

[10] We chose this sample because our purpose is to verify the role of exogenous shocks in a period of volatile oil prices. Our analysis is in line with the results obtained by Hooker (1999), who found that oil price effects on U.S. GDP changed qualitatively around 1980.   [11] For some countries the period covered is different because of data limitations, see Table 1.

The first aspect to be considered is the possibility that the true but unknown data generating process (d.g.p.) contains deterministic components (constant and trend). Even in this case, the inclusion of additional dermistic components in the regression model used for testing the presence of unit roots results in an increased probability that the null hypothesis of non-stationarity will be accepted when in fact the true d.g.p. is stationary. On the other hand, the presence of unnecessary nuisance parameters (constant and trend terms) has the effect to lower the power of the test against stationarity alternatives. Consequently we have decided to use the sequential testing procedure suggested by Perron (1988).

As far as the number of lags (p) to introduce in the ADF regression, it has been chosen by considering the procedure suggested by Hall (1994) (*from general to specific*)[12]. The results from using the Augmented Dickey Fuller tests on the set of macroeconomic variables considered in the study are reported in Table 2.

Real output, interest rates, exchange rates are $I(1)$ for all countries considered: important exceptions are represented, however, by exchange rates for the U.K. and the U.S. and interest rates for Canada which appear $I(0)$. ADF tests indicate that money and consumer price indices turn out to be $I(2)$ variables across all countries. Following Harris (1995), we decided to deal with this problem by deflating the logarithm of nominal money by the logarithm of the price index [13] and considering the inflation rate[14]. Finally, international oil prices appear to be $I(1)$.

4.2 Cointegration Analysis

Once we have specified the variables to be included in the different country models, the corresponding cointegrating VAR models are estimated and the rank of their cointegrating space determined. Consider a VAR(k) model in an K x 1 vector of $I(1)$ variables, y_t:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + u_t \tag{28}$$

where A_1, $\ldots, A_p$ are K x K matrices of unknown parameters and u_p is a K x 1 vector of disturbances that is $i.i.d.(0, \Sigma)$. The model specified in (28) can be reparameterized as a

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[12] Banerjee *et al.* (1993) noted that it is very important to select the appropriate lag-length; in fact, while too few lags may result in over-rejecting the null when it is true (i.e., adversely affecting the size of the test), too many may reduce the power (unnecessary nuisance parameters reduce the effective number of observations available).

[13] So that real money is defined which may be an $I(1)$ process. [14] While we have decided to tranform our model from an $I(2)$ to $I(1)$ system, other authors (see, for example, Paruolo (1996), Johansen (1992, 1995), Jorgesen *et al.* (1996)) propose a different approach based on the decomposition of the r cointegrationg relationships.

Vector Error Correction Model (VECM):

$$\Delta y_t = \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{p-1} \Delta y_{t-p+1} + u_t \tag{29}$$

which is obtained by subtracting y_{t-1} from both sides of (29) and rearranging terms. If cointegration among the variables y_t is present, model (29) includes both long-run and short-run stationary components. The maximum likelihood method proposed by Johansen and Juselius (1990) tests the presence of cointegration at the system's level by determining the rank of the long-run matrix, Π. If $rank(\Pi) = r$, with $0 < r < n$, the matrix Π can be decomposed as $\Pi = \alpha\beta'$, where α is a n x r matrix of adjustment or feedback coefficients, which measure how strongly the deviations from equilibrium tend to disappear.

Specifically, Johansen's just identified estimator of β is obtained by selecting the r largest eigenvectors of the system, subject to 'orthogonalization' restrictions. This approach has been criticized, as a 'pure mathematical convenience' (Pesaran and Shin, 2001), rather than an economically justified approach.

The first stage of our modelling sequence is to select the lag order of the underlying VAR in these variables, based on the Akaike Information Criterion (AIC). According to this criterion and assuming that the maximal lag order should not exceed 5 (given the number of observations and of variables considered) we choose for Canada, France and Germany a lag-length of $p = 4$. For Italy and the U.K. the AIC suggests a lag length of three while for Japan and the U.S. the number of lags introduced has been equal to two.

The estimated VAR was subjected to diagnostic checking (see Table 3): particular attention has been given to autocorrelation residual tests for single equation analysis and vector autoregressive residuals. While single equation LM-tests indicate that there is some autocorrelation left in the inflation rate equation for the U.S. and in the treasury bill rate for Germany, a vector LM-test on the system indicates no autocorrelated errors. Increasing the lag length of the VAR model does not fix the autocorrelation problem possibly indicating that a VARMA representation would be more appropriate. Although uncorrelated errors would be desirable, they are not a precondition for the validity of the cointegration tests (Lutkepohl and Saikkonen, 2000). We therefore concluded that the model provided an acceptable basis for the analysis of the equilibrium and dynamic relationships among the variables.

With regard to the number of cointegrating relationships (see Table 4), we find 1 long-run relationship for all the countries considered with the exception of Canada for which the evidence suggests that $r = 2$ is appropriate.

The development of system-based cointegration methods permits more satisfactory analysis of macroeconomic relationships where relevant time series are non-stationary, and where endogeneity among variables is expected: integration and cointegration analysis can avoid the problem of spurious regressions among non-stationary series, while a system approach allows for important interactions among the variables considered.

However, since matrices α and β are not uniquely identified without additional information, an identification problem arises. Pesaran and Shin (2001) show that r^2 restrictions are needed for exact identification. The restrictions must be evenly distributed across the cointegrating vectors, i.e., there must be r restrictions per vector.

The most common approach used to impose these identifying restrictions is Johansen's statistical approach. Recently, in order to solve the trade-off between the demands of theory and econometrics, developments in cointegration analysis have emphasized the use of economic theory in guiding the search for long-run exact/over identification restrictions.

With this approach, having selected the order of the underlying VAR model, the number of cointegrating relations has to be tested. The following step is to compute maximum likelihood (ML) estimates of the model's parameters subject to over-identifying restrictions on the long-run coefficients.

In our analysis we have used cointegration analysis to verify whether any of the described models is a reasonable description of the long-run relationships considered in the theoretical analysis (long-run money demand function and excess output formulation). In doing that we have started from the exactly identified system and used χ^2 statistics to test over-identifying restrictions.

Table 5 shows that while for Italy the interpretation of the cointegration vector as an error correction mechanism measuring the excess demand for money is straightforward, for other countries (France and the U.K.) a modified version of this long-run relationship is not rejected by the data. On the other hand, for Germany, Japan and the U.S. the long-run relationship refers to the notion of excess output. Finally, for Canada, for which we have found evidence of two long-run relationships, the restrictions we imposed are linked to the notion of both excess demand of money and excess output.

4.3   The structural model. Impulse response analysis

Having verified the existence of long-run relationships, we can proceed to examine the short-run linkages among the variables considered in the study. In particular, in order to assess the

relationship between oil price shocks and aggregate economic activity, we use impulse response function as they trace over time the effects on a variable of an exogenous shock to another variable.

Using the model presented in Section 3.2, our aim is to investigate the effect of oil price shocks on the economic activity and inflation, as well as the impact of the monetary response to the other variables.

Before considering the impulse response analysis, we can analyze the estimated coefficients of the structural part of the model (see Table 6). For all countries except for Japan and the U.K. the coefficient of the impact of oil prices on the inflation rate is statistically significant[15]. Furthermore, for Germany and the U.K., output is negatively correlated with oil prices.

On the side of monetary policy response, interest rates tend to rise after a shock to inflation rate in Japan and the U.K.. The response to an output shock is statistically significant for Italy and the U.K.: an increase in real GDP growth is followed by an increase of interest rates, evidence which indicates a tightening in monetary policy.

In table 6, likelihood ratio tests (1990) of the over-identifying restrictions we imposed are presented. For all the countries considered the test does not reject our identifying restrictions at any conventional significance level[16]. Finally, Table 7 present diagnostic tests on the SVECM.

In Figures 1 and 2 we display the estimated impulse responses for each country. In particular, Figure 1 shows the impulse responses to one-standard deviation oil price shocks of the other five variables of the model with the corrisponding standard confidence error bands.

Impulse response estimates from our structural cointegrated vector autoregression model indicate that, for Japan, an oil price increase is followed by a rise in inflation. In particular the peak response of inflation rate occurs few quarters after the shock. Likewise for some countries (Italy and the U.S.) output is significantly influenced by the external shock; however this effect tends to disappear progressively.

With regard to the response of monetary policy, the central banks of most of the countries considered reacted to the oil price shock by increasing interest rates and decreasing real money balances. If this is particularly true for Japan and Italy, for other countries, this evidence is

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[15] For Japan, the estimated coefficient, statistically significant, is negative.   [16] However, the starting point has been that of considering the standard money demand and excess-output given in equations (18) and (19). However, results (available from the authors upon request) do lead to a rejection of the null hypothesis. Moreover since, as noted by Omtzigt and Fachin (2002) and Garratt *et al.* (2001), the asymptotic procedures proposed by Johansen (1991) has been shown to suffer from severe size distortion, we decided to estimate the actual small sample distribution by the bootstrap. Even in this case the tests reject the null hypothesis.

not verified: an increase in oil prices seems to lead to a decrease in the short-term interest rates rejecting thus the hypothesis of a monetary policy directed to fight inflation.

Next, we consider the impact of a contractionary monetary policy response. The impulse response functions for the effects of an increase in interest rates are given in Figure 2[17].
While in Japan the inflation rate tends to decrease in immediate response to the contractionary monetary shock, in Italy, U.K. and the U.S., the tightening of monetary conditions seems not to succeed in reducing price growth.
Because one of the effects of a monetary shock is to cause an appreciation of the exchange rate, it is important to observe the impact effect of the monetary policy shock on exchange rates. Our results suggest that, for Canada, U.K. and Italy an increase in interest rate is consistent with significant but transitory real effects on the value of the their currencies, a conclusion that is consistent with previous research.
Finally, the impact effect of the monetary policy shock on the output growth is significant in Canada and the U.S.. However, in both cases, the contractionary effects of the policy begin to be felt on output and real money balances after three/four quarters.

4.4   The direct and indirect effects of 1990 oil price shock.

In order to measure the effects of oil price increases, we consider three exercises of policy simulation. In the first one we examine the impulse responses obtained considering the 1990 oil price shock[18] (which, for most of the countries considered, has been followed by a recession). This is a standard simulation exercise intended to estimate the effects on the economy of the oil price shock, obtained by including also the indirect effect arising from the endogenous response of other variables.
For nearly all the countries considered Figure 3 shows a negative impact of the oil price shock on output. Important exceptions are represented by U.K. and Canada - two net oil exporters - for which the total impact of the oil price shock is positive, and, surprisingly, Japan - for which

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[17] We have decided to present only the responses of inflation rate and output growth, the other graphs are available from the authors upon request.   [18] From the second to the fourth quarter of 1990, the (nominal) price of oil rose from $15.82 per barrel to $31.00 per barrel. In real terms it rose, according to the country, by a percentage ranging from 89.55 percent (U.S.) to 93.27 percent (Germany).

the oil shock does not seem to affect the output growth[19]. On the other hand, France and the U.S. are heavily affected by the shock; while for the former the estimated reduction in real GDP due directly or indirectly to the oil price shock is equal to -0.217% after four quarters, the total reduction in real GDP for the U.S. after four quarters can be estimated in -0.480%. Another country particularly hit by the shock is Italy for which the total reduction in real GDP is estimated in -0.170%[20]. The temporary rise of oil prices fuels also inflationary pressures: the estimates of the total effect after a year from the increase of oil prices on the consumer price index range from 0.211% for Germany to 0.881% for Canada[21].

As for as the monetary policy response to the shock is concerned, the interest rates rise sharply in Italy and the U.S.. However, for both countries the increase reaches its maximum after the first two quarters from the shock, but a progressive reduction of interest rates starts thereafter, which we can interpret as an expansionary response to the economic slowdown. Moreover, while in Japan the response of monetary authorities is unambiguously restrictive, in Canada, France and Germany the oil price increase is followed by a reduction of interest rates. Finally, for the U.K., results suggest no effects of the oil price increase on short-term interest rates.

The second exercise is directed to measure the effects arising directly from the oil price shock and to assess their role in the slowdown of the early 1990s. For each country Figure 4 shows the actual path of three key variables (output, the price level and interest rates) for the period 1989q4-1993q4, together with their behavior assuming two alternative scenarios.

In the first one, while oil prices are repeatedly shocked so that they equal their historical values, all other shocks in the system are assumed to be equal to zero. Consequently, all variables are allowed to respond endogenously to the reaction of the system (*'endogenous scenario'*). In a second scenario, the oil price variable is arbitrarily fixed at a value close to its initial value in the period (*'no oil price shock'*). The comparison between the results of the two scenarios and the historical path allows us to estimate the total impact of the change in oil prices on output and inflation rate.

This exercise suggests some interesting findings. If, on the one hand, the direct impact of higher

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[19] For Japan the plunge in the recession of the first half of the 1990s, known as the *'bursting of the bubble economy'*, was primarily due to the reduction in stock market prices and the drop in land prices from their speculative peak. Higher interest rates exacerbated this situation by reducing investments and further depressing share prices. [20] Our results are not substantially different from those obtained by Abeysinghe (2001) who estimated the total effects of a 50% oil price on GDP growth of 12 economies. The total impact of oil price was found to be much larger for the U.S. economy (-0.30% after 4 quarters) than for the rest of the OECD countries (-0.10%). [21] The reduction of prices in France constitutes a *'puzzle'* of the model.

oil prices on real GDP is positive for the U.K. and Canada, on the other hand, for Italy, France and the U.S. the exclusion of the 1990 oil price shock produces higher values of output than the endogenous case, suggesting a negative role of oil prices[22]. However, the fact that the output value is higher in the endogenous case implies that, for all the countries considered, the decline in output is not uniquely explained by the oil price increase but there are factors other than those implied in the model that influence the output growth rate.

As for the impact of the oil shock on prices, we can summarize our results by saying that, although there is a direct effect on the inflation rate on nearly all the countries considered, nonetheless it seems that counter-inflationary forces react in order to reduce the direct and indirect impact of oil increases on prices[23]. This is particularly true for the U.S. and Germany where not only is the price level higher in the endogenous hypothesis than in the *'no oil price shock'* scenario, but it also has a particularly lower growth rate.

Finally, with regard to interest rates, for Italy, Japan and the U.S. the inflationary pressures related to the increase in oil prices well explain the response of the monetary authorities. However, after this impulse response, while in Italy interest rates continue to increase, in Japan and the U.S. there is a progressive easing of monetary policy; responses that in both cases appear not to be directly linked to the external shock.

For Canada and France, our results show that, if there was not the price shock, the interest rates would be higher with respect to the endogenous scenario, suggesting an expansionary monetary policy response to the oil price increase. However, while in the former case, the shock explains, at least in part, the reduction of interest rates, in France other factors lead to the progressive tightening of monetary conditions. Finally, even in Germany the expansionary response of the central bank in the aftermath of the shock is partially influenced by the consequences on the economy.

Our third exercise is aimed at isolating the economic effects that results directly from the oil price shock and those arising indirectly from the associated monetary policy response. Even in this case the actual historical path of each of the three variables is compared with those obtained by analyzing two alternative scenarios.

The first case is the *'endogenous scenario'* considered in the previous exercise. It is intended to compute the total effects of the oil price shocks and is based on the following hypothesis:

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[22] All these results confirm the evidence resulting from the first exercise.   [23] Two notable exceptions are represented by Canada and Italy. For these countries the historical prices are higher than the level obtained by considering an endogenous scenario, a fact that reflects the importance of other factors.

the oil price variable is supposed to be exogenous, while other shocks are not able to influence the system. Consequently the interest rates respond directly to changes in the oil variable and endogenously to the induced changes in the other variables.

In the alternative scenario (described by the line *'no monetary policy'*) we assume that the interest rate is arbitrarily fixed at a value close to its initial value in the period, oil prices equal their historical values and all other variables are not shocked. This second scenario leaves only the direct effect eliminating the indirect (*'via monetary policy action'*) impact of the oil price shock.

From Figure 5 we can draw the following conclusions: by comparing the path of the variables in the endogenous scenario with their path in the hypothesis of constant interest rates (*'no monetary policy'* scenario) we can see that, for most countries, the period would exhibit a lower positive growth. For the U.S., the (delayed) reduction of interest rates (see panel *c*)) has positive effects on output growth: in fact in absence of the monetary response the ouput growth rate would be lower. Although this results would confirm the importance of the effects arising from the substantial reaction of monetary policy, our simulation exercise shows that, for all countries, the slowdown that hit the developed countries is due also to other specific exogenous shocks.

With regard to the response of prices, for Germany and Japan (and, in part, Italy) if we assume no policy response the path of prices is lower suggesting a role of monetary policy in increasing prices. In contrast, for all other countries, there is evidence that the scenario with monetary policy response to the oil price shock does not lead to higher inflationary pressures.

In general, the results of the three simulation exercises (a synthesis is presented in Table 8) suggest that, for some countries, a significant part of the effects of the oil price shock is due to the monetary policy reaction function rathen than being directly linked to the changes in oil prices. For other countries, however, the total impact is offset at least in part by an easing of monetary conditions. Another point to note is that the results are highly consistent with the view that the oil price shock occurred in a period where the most developed countries were already facing problems induced by other exogenous shocks (e.g. the spill-over of financial fragilities onto the real economy, as the bursting of the *'bubble economy'* in Japan.).

5 Conclusions

In this paper we have estimated a vector autoregressive model for the G-7 countries in order to verify if the oil price changes of the last twenty years have been transmitted to the monetary policy action. We have introduced not only long-run but also short-run relationships; while the former, expressed as linear restrictions on the cointegrated vectors, have had the aim to verify the presence of a money demand function and/or an excess demand relationship, the short-term restrictions have been imposed on the residual covariance matrix and considered six short-run relationships.

Our results suggest that, for most of the countries considered, an unexpected oil price shock is followed by an increase in inflation rate and by a decline in output growth. The response of some central banks has been directed to reduce - through lower interest rates - the impact of the shock on output growth rate. In contrast, monetary authorities of most countries reacted by raising interest rates, suggesting a contractionary monetary policy directed to fight inflation. Moreover, the results of simulation exercises directed to estimate the total impact of the 1990 oil price shock indicate that a significant part of the effects of the oil price shock resulted indirectly from the response of monetary policy.

Our future research efforts will follow two main directions. On the one hand, we are confident that the recent econometric techniques based on multivariate regime switching models are able to better represent the dynamics of business cycle movements. On the other hand, our analysis will be addressed to verify possible asymmetric or nonlinear relationships between oil price and the macroeconomy.

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Table 1: The data

Canada - 1980:1 2003:3	
Interest Rates	Treasury Bill Rate - percent per annum
Consumer Prices	Consumer Price Index - Index Number
Gross Domestic Product	Real Gross Domestic Product, seasonally adjusted, constant prices (1995) - national currency, billions
Money Aggregate	Money, seasonally adjusted - national currency, billions
Exchange Rates	National currency per SDR

France - 1980:1 2002:3	
Interest Rates	Treasury Bill Rate - percent per annum
Price Index	Consumer Price Index - Index Number
Gross Domestic Product	Real Gross Domestic Product, seasonally adjusted, constant prices (1995) - national currency, billions
Money Aggregate	M1*, seasonally adjusted - national currency, billions
Exchange Rates	National currency per SDR

Germany - 1980:1 2003:3	
Interest Rates	Treasury Bill Rate - percent per annum
Price Index	Consumer Price Index - Index Number
Gross Domestic Product	Real Gross Domestic Product, seasonally adjusted, constant prices (1995) - national currency, billions
Money Aggregate	M1*, seasonally adjusted - national currency, billions
Exchange Rates	National currency per SDR

Italy - 1980:1 2003:4	
Interest Rates	Treasury Bill Rate - percent per annum
Price Index	Consumer Price Index - Index Number
Gross Domestic Product	Real Gross Domestic Product, seasonally adjusted, constant prices (1995) - national currency, billions
Money Aggregate	M1*, seasonally adjusted - national currency, billions
Exchange Rates	National currency per SDR

Japan - 1980:1 2003:1	
Interest Rates	Lending Rate - percent per annum
Price Index	Consumer Price Index - Index Number
Gross Domestic Product	Real Gross Domestic Product, seasonally adjusted, constant prices (1995) - national currency, billions
Money Aggregate	Money, seasonally adjusted - national currency, billions
Exchange Rates	National currency per SDR

United Kingdom - 1980:1 2003:3	
Interest Rates	Treasury Bill Rate - percent per annum
Price Index	Consumer Price Index - Index Number
Gross Domestic Product	Real Gross Domestic Product, seasonally adjusted, constant prices (1995) - national currency, millions
Money Aggregate	M4, seasonally adjusted - national currency, millions
Exchange Rates	National currency per SDR

United States - 1980:1 2003:3	
Interest Rates	Federal Funds Rate - percent per annum
Price Index	Consumer Price Index - Index Number
Gross Domestic Product	Real Gross Domestic Product, seasonally adjusted, constant prices (1995) - national currency, billions
Money Aggregate	Money, seasonally adjusted - national currency, billions
Exchange Rates	U. S. dollars per SDR

Crude Oil Prices	International average price.

* For Italy, Germany and France data after 1999 are obtained by summing the currency in circulation and demand deposits.

Table 2. Results of ADF unit-root test.

Country	constant	trend	p	ADF TEST
EXCHANGE RATES: in Levels				
Canada	yes	no	4	-2.478
France	yes	no	3	-2.773*
Germany	yes	no	3	-1.748
Italy	no	no	5	0.133
Japan	yes	no	12	-1.921
United Kingdom	yes	no	11	-3.833***
United States	yes	no	3	-2.955**
EXCHANGE RATES: in First Log-Differences				
Canada	no	no	2	-3.702***
France	no	no	12	-2.870***
Germany	no	no	12	-2.603***
Italy	no	no	2	-4.243***
Japan	no	no	2	-4.751***
United Kingdom	no	no	12	-2.543**
United States	no	no	12	-2.982***
SHORT-TERM INTEREST RATE: in Levels				
Canada	yes	yes	3	-4.282***
France	yes	no	1	-1.154
Germany	yes	yes	10	-3.183*
Italy	yes	yes	1	-2.448
Japan	yes	yes	2	-1.793
United Kingdom	yes	yes	6	-2.990
United States	yes	yes	5	-3.054
SHORT-TERM INTEREST RATE: in First Log-Differences				
Canada	no	no	3	-5.201***
France	yes	no	12	-7.304***
Germany	no	no	12	-2.280**
Italy	no	no	0	-5.851***
Japan	yes	no	1	-4.450***
United Kingdom	no	no	12	-2.819***
United States	no	no	12	-1.802*
REAL GDP: in Levels				
Canada	yes	yes	1	-2.217
France	yes	yes	9	-3.366*
Germany	no	no	4	1.874
Italy	no	no	0	6.796
Japan	yes	no	3	-1.911
United Kingdom	yes	yes	3	-2.637
United States	yes	yes	9	-3.372*
REAL GDP: in First Log-Differences				
Canada	yes	no	10	-3.797***
France	yes	no	11	-2.903**
Germany	yes	no	3	-3.049**
Italy	yes	no	0	-9.088***
Japan	yes	yes	2	-3.696***
United Kingdom	yes	no	7	-2.855*
United States	yes	no	11	-3.879***

MONETARY AGGREGATE: in Levels				
Canada	yes	yes	7	-3.048
France	yes	yes	8	-1.876
Germany	yes	yes	8	-2.054
Italy	yes	yes	8	-3.146
Japan	yes	no	1	2.846
United Kingdom	yes	no	1	-4.116
United States	yes	yes	3	-2.100
MONETARY AGGREGATE: in First Log-Differences				
Canada	yes	no	1	-5.152***
France	yes	no	7	-3.654***
Germany	yes	no	7	-1.950
Italy	yes	no	5	-1.320
Japan	no	no	12	0.781
United Kingdom	yes	no	4	-1.753
United States	yes	no	2	-3.503**
CONSUMER PRICE INDEX: in Levels				
Canada	yes	yes	1	-4.190***
France	yes	yes	11	-3.915**
Germany	yes	yes	8	-2.102
Italy	yes	no	11	-2.559
Japan	yes	no	7	-1.949
United Kingdom	yes	yes	1	-1.708
United States	yes	no	10	-2.739*
CONSUMER PRICE INDEX: in First Log-Differences				
Canada	yes	yes	0	-5.228***
France	yes	yes	11	-2.196
Germany	yes	yes	3	-2.840
Italy	yes	no	8	-2.530
Japan	yes	yes	6	-3.046
United Kingdom	yes	yes	11	-2.643
United States	yes	yes	9	-4.480***
OIL PRICES				
Levels	yes	no	3	-2.730*
First Log-Differences	no	no	1	-8.210***

Notes: the estimated equations are the following: $\Delta y_t = \alpha + \beta \cdot t + \gamma \cdot y_{t-1} + \sum_{i=1}^{p} \Delta y_{t-i} + \varepsilon_t$ (all variables with the exclusion of interest

rates are considered in logaritms); $\Delta^2 y_t = \alpha + \beta \cdot t + \gamma \cdot \Delta y_{t-1} + \sum_{i=1}^{p} \Delta^2 y_{t-i} + \varepsilon_t$ (first differences of the variables). The data frequency

is quarterly; the sample period of the variables considered in the study is given in table 1. p is the order of augmentation chosen by considering the procedure suggested by Hall (*from general to specific*).
*** (**, *) refer to rejection of a unit root given a significance level of 1% (5%, 10%) on the basis of the critical values given in MacKinnon (1996).

Table 3. Unrestricted VAR (UVAR) estimation: goodness of fit and system evaluation.

	Lag-length		REAL GDP	OIL PRICES	T-BILL INTEREST RATE	INFLATION RATE	EXCHANGE RATE	MONETARY AGGREGATE (m-p)	VAR
Canada	4	R^2	99.94%	92.57%	97.58%	77.00%	95.29%	99.76%	
		RSS	0.002	0.544	0.589	0.001	0.036	0.035	
		σ	0.005	0.097	0.101	0.004	0.025	0.025	
		F-statistic	3313.41	23.30	75.43	6.26	37.85	777.58	
		Log Likelihood	361.93	102.17	98.63	381.33	224.02	225.45	
		AR 1 - 4 test (F-test)	0.48	0.93	0.69	0.58	0.57	0.92	
		LM statistics (4)							37.29
France	4	R^2	99.94%	93.54%	97.49%	93.88%	93.19%	96.30%	
		RSS	0.001	0.447	0.570	0.000	0.161	0.020	
		σ	0.004	0.092	0.104	0.003	0.055	0.019	
		F-statistic	2819.61	23.99	64.27	25.42	22.65	43.10	
		Log Likelihood	373.35	104.14	93.68	411.01	148.14	238.04	
		AR 1 - 4 test (F-test)	1.55	0.32	1.29	0.37	0.48	2.60	
		LM statistics (4)							47.09
Germany	4	R^2	99.85%	87.11%	98.41%	81.71%	95.86%	99.76%	
		RSS	0.005	0.943	0.248	0.001	0.153	0.037	
		σ	0.009	0.130	0.067	0.003	0.052	0.026	
		F-statistic	1094.66	11.47	104.81	7.58	39.27	696.27	
		Log Likelihood	316.83	77.41	137.53	410.84	159.21	222.91	
		AR 1 - 4 test (F-test)	1.01	2.30	1.09	1.08	0.33	0.07	
		LM statistics (4)							30.25
Italy	3	R^2	99.86%	88.60%	98.92%	92.47%	93.50%	99.22%	
		RSS	0.002	0.886	0.386	0.001	0.203	0.030	
		σ	0.006	0.115	0.076	0.003	0.055	0.021	
		F-statistic	1992.76	21.70	256.85	34.30	40.14	353.12	
		Log Likelihood	361.28	83.05	121.26	405.58	150.78	238.05	
		AR 1 - 4 test (F-test)	0.64	0.89	2.21*	2.59**	2.57**	4.61***	
		LM statistics (4)							43.44

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	Lag							
Japan	2	R^2	99.90%	88.92%	99.91%	81.87%	97.19%	99.71%
		RSS	0.003	0.794	0.021	0.001	0.222	0.036
		σ	0.007	0.117	0.019	0.003	0.062	0.025
		F-statistic	1940.56	16.05	2162.51	9.03	69.28	686.17
		Log Likelihood	333.60	82.31	242.85	393.24	138.28	218.07
		AR 1 - 4 test (F-test)	1.46	1.04	1.11	0.81	0.99	0.60
		LM statistics (4)						37.75
United Kingdom	3	R^2	99.94%	86.38%	96.89%	90.28%	85.55%	99.93%
		RSS	0.002	1.043	0.460	0.001	0.140	0.009
		σ	0.005	0.127	0.084	0.004	0.046	0.012
		F-statistic	4374.98	16.49	80.95	24.16	15.40	3554.99
		Log Likelihood	371.02	74.21	111.44	399.56	165.53	292.29
		AR 1 - 4 test (F-test)	0.50	2.98**	0.44	1.48	1.36	0.82
		LM statistics (4)						39.58
United States	2	R^2	99.93%	83.45%	97.53%	61.38%	92.36%	99.04%
		RSS	0.003	1.330	0.764	0.001	0.205	0.023
		σ	0.006	0.133	0.101	0.004	0.052	0.018
		F-statistic	6426.58	23.64	185.30	7.45	56.70	485.03
		Log Likelihood	344.96	64.33	89.81	393.17	150.43	251.02
		AR 1 - 4 test (F-test)	1.73	1.35	0.92	2.62**	1.98	0.97
		LM statistics (4)						27.67

Notes: *** (**, *) denotes rejection of the null hypothesis at the significance level of 1% (5%, 10%). The statistics presented for each regression are: the R-squared statistics (R^2), the standard error of the regression (σ), the sum of squared residuals (RSS), an F-test of the hypothesis that all of slope coefficients in the regression are zero, the value of the log likelihood function and a serial correlation LM. Finally a multivariate LM test statistics for residual serial correlation up to the specified order (4) is presented. Under the null hypothesis of no serial correlation of order k, the LM statistics is asymptotically distributed as a χ^2 with k^2 degrees of freedom (see Johansen, 1995).

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Table 4. UVAR Cointegration analysis of the 6-variables VAR.

H0	Canada	France	Germany	Italy	Japan	United Kingdom	United States	0.05 Critical Value
Trace Statistics								
r=0	168.23***	157.75***	152.49***	132.79***	151.96***	172.88***	121.59**	117.71
r≤1	115.57***	103.90***	89.27**	78.54	100.29***	106.20***	76.95	88.80
r≤2	71.58**	68.64	59.16	53.07	63.31*	72.23**	49.13	63.88
r≤3	42.45*	38.21	32.11	34.87	38.52	43.36	30.30	42.92
r≤4	23.05	21.39	16.16	18.76	21.13	18.71	14.31	25.87
r≤5	8.95	9.07	5.41	5.76	5.15	8.98	6.44	12.52
Maximum Eigenvalue Statistics								
r=0	52.66***	53.84***	63.22***	54.25***	51.67***	66.68***	44.64**	44.50
r<1	43.99***	35.26*	30.11	25.47	36.98*	33.98*	27.82	38.33
r≤2	29.14	30.43	27.05	18.20	24.79	28.87	18.83	32.12
r≤3	19.40	16.82	15.95	16.11	17.40	24.64	15.99	25.82
r≤4	14.10	12.32	10.75	13.00	15.97	9.73	7.87	19.39
r≤5	8.95	9.07	5.41	5.76	5.15	8.98	6.44	12.52

Notes: *** (**, *) denotes rejection of the hypothesis at the 1% (5%, 10%) level. The 0.05 critical values are based on the response surface coefficients from MacKinnon-Haug-Michelis (1999). The reported critical values assume for all countries but France no exogenous variables other than an intercept and a trend.

Table 5. Cointegration analysis of the restricted system

	Restricted cointegrating coefficients (standard error in parentheses)								
Country	y_t	o_t	r_t	Δp_t	e_t	m_t	c	trend	LR test
Canada:									
1st cointegrating vector	1	-	-0.021	-20.799	1.624	-	-5.954	-0.016	$\chi^2(2) =$
			(0.002)	(4.367)	-0.33			(0.001)	0.05 (0.97)
2nd cointegrating vector	-1	0.1814		-50.49	3.43	1	6.555	-0.023	
		(0.028)		(9.273)	(0.693)			(0.003)	
France	-1	-0.181	-0.16	-	-	1	5.560	-	$\chi^2(3) =$
		(0.0478)	(0.0212)						1.16 (0.76)
Germany	1	-	-0.075	36.10	0.18	-	-6.204	-0.008	$\chi^2(2) =$
			(0.009)	(5.116)	(0.038)			(0.0004)	2.43 (0.43)
Italy	-1	-	1.693	112.24	-	1	2.441	0.054	$\chi^2(3) =$
			(0.542)	(25.807)				(0.016)	2.19 (0.15)
Japan	1	0.262	-0.08	29.888	-	-	-13.05	-0.009	$\chi^2(2) =$
		(0.052)	(0.017)	(5.612)				(0.0013)	0.59 (0.74)
United Kingdom	-1	-	-	46.90	1.41	1	-3.298	0.001	$\chi^2(3) =$
				(5.961)	(0.207)			(0.001)	4.79 (0.19)
United States	1	0.16	-	-26.02	0.22	-	-8.511	-0.009	$\chi^2(2) =$
		(0.036)		(3.191)	(0.059)			(0.0004)	2.44 (0.30)

Table 6. Contemporaneous coefficients in the structural model.

	Canada	France	Germany	Italy	Japan	United Kingdom	United States
b_{11}	0.022***	0.021***	0.025***	0.017***	0.025***	0.0105***	0.0177***
	(0.0017)	(0.0016)	(0.0018)	(0.0013)	(0.0019)	(0.0008)	(0.0018)
b_{12}	-0.009***	-0.0021	-0.0033	0.0008	0.0031	0.0039***	-0.0024
	(0.0025)	(0.0023)	(0.0026)	(0.0018)	(0.0027)	(0.0011)	(0.0019)
b_{14}	-0.008***	0.0021	-0.0070***	-0.0035*	-0.0016	-0.0048***	-0.0016
	(0.0026)	(0.0023)	(0.0027)	(0.0019)	(0.0027)	(0.0013)	(0.0019)
b_{22}	0.694***	0.684***	0.370***	0.781***	0.103***	0.732***	0.636***
	(0.0521)	(0.0525)	(0.0278)	(0.0579)	(0.0077)	(0.0546)	(0.0472)
b_{23}	-0.107	-0.023	0.172***	0.1166	0.0013	0.160**	0.0987
	(0.0684)	(0.0739)	(0.0410)	(0.0822)	(0.0109)	(0.0733)	(0.0665)
b_{24}	0.194**	0.194**	0.084*	0.0645	0.008***	0.336***	-0.022
	(0.0759)	(0.0758)	(0.0438)	(0.0829)	(0.0110)	(0.0829)	(0.0675)
b_{25}	0.0986	-0.173**	0.0508	-0.035	-0.0070	-0.1789	-0.0407
	(0.0701)	(0.0782)	(0.0437)	(0.0831)	(0.0109)	(0.087)	(0.0671)
b_{26}	-0.0771	0.0810	0.0230	0.0933	0.0164	-0.038	0.0840
	(0.0782)	(0.0797)	(0.0446)	(0.0834)	(0.0111)	(0.0886)	(0.0680)
b_{33}	0.0054***	0.0037***	0.0085***	0.0064***	0.0084	0.0044***	0.0052***
	(0.0004)	(0.0003)	(0.0006)	(0.0005)	(0.0006)	(0.0003)	(0.0004)
b_{34}	-0.00148	-0.00005	-0.006	-0.0004	-0.002	0.00002	0.0003
	(0.0006)	(0.0004)	(0.0010)	(0.0007)	(0.0009)	(0.0005)	(0.0005)
b_{35}	-0.00006	-0.0007	0.0016	-0.0004	-0.0003	-0.00122	0.0005
	(0.0006)	(0.0004)	(0.0011)	(0.0007)	(0.0009)	(0.0005)	(0.0005)
b_{36}	0.0012**	0.0002	-0.0032***	-0.00007	0.0011	-0.0016***	0.0001
	(0.0006)	(0.0004)	(0.0011)	(0.0007)	(0.0009)	(0.0005)	(0.0005)
b_{44}	0.004***	0.003***	0.004***	0.003***	0.003***	0.005***	0.002***
	(0.0003)	(0.0002)	(0.0003)	(0.0003)	(0.0003)	(0.0004)	(0.0002)
b_{45}	0.0001	0.0003	-0.0001	-0.0001	-0.0002	-0.0009*	-0.0001
	(0.0004)	(0.0003)	(0.0004)	(0.0004)	(0.0004)	(0.0005)	(0.0002)
b_{46}	0.002***	0.001***	0.002***	0.001**	-0.001***	0.0004	0.002***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0005)	(0.00030)
b_{55}	0.025***	0.057***	0.055***	0.052***	0.063***	0.043***	0.054***
	(0.0018)	(0.0044)	(0.0041)	(0.0038)	(0.0047)	(0.0032)	(0.0040)
b_{56}	-0.00004	-0.0041	-0.0037	-0.001	0.0014	-0.007	0.0071
	(0.0026)	(0.0062)	(0.0059)	(0.0054)	(0.0067)	(0.0045)	(0.0057)
b_{66}	0.133***	0.138***	0.130***	0.142***	0.129***	0.135***	0.138***
	(0.0100)	(0.0106)	(0.0097)	(0.0105)	(0.0097)	(0.0101)	(0.0103)
Log-likelihood tests for over-identification.							
	$\chi^2(3)=$ 1.46 (0.48)	$\chi^2(3)=$ 1.77 (0.41)	$\chi^2(3)=$ 0.11 (0.95)	$\chi^2(3)=$ 3.32 (0.19)	$\chi^2(3)=$ 3.32 (0.19)	$\chi^2(3)=$ 1.04 (0.59)	$\chi^2(3)=$ 3.27 (0.19)

Notes: Coefficients represent our identification scheme, see equation (27). *** (**, *) denotes significance of the coefficient at the 1% (5%, 10%) level. Values in parentheses represent, respectively, standard errors of the contemporaneous coefficients and p-values for log-likelihood tests.

Table 7. SVECM estimation, goodness of fit and system evaluation.

	Lag-length		REAL GDP	OIL PRICES	T-BILL INTEREST RATE	INFLATION RATE	EXCHANGE RATE	MONETARY AGGREGATE (m-p)	SVECM
Canada	3	R^2	62.35%	34.44%	63.14%	64.31%	33.33%	34.64%	
		RSS	0.002	1.140	34.322	0.001	0.038	0.042	
		σ	0.006	0.133	0.732	0.004	0.024	0.026	
		F-statistic	4.42	1.40	4.57	4.81	1.33	1.41	
		Log Likelihood	348.16	67.63	-83.88	373.63	218.68	214.74	
		AR 1 - 4 test (F-test)	3.045**	1.37	1.84	2.29*	1.74	0.19	
		LM statistics (4)							42.17
France	4	R^2	63.33%	37.24%	35.41%	62.91%	40.97%	90.10%	
		RSS	0.001	1.054	29.904	0.001	0.178	0.025	
		σ	0.004	0.138	0.737	0.003	0.057	0.021	
		F-statistic	3.27	1.13	1.04	3.22	1.32	17.26	
		Log Likelihood	371.85	65.95	-76.21	380.32	141.56	224.81	
		AR 1 - 4 test (F-test)	0.02	0.03	2.90*	0.89	0.32	1.74	
		LM statistics (4)							38.62
Germany	4	R^2	48.13%	42.62%	54.47%	77.91%	43.11%	85.70%	
		RSS	0.007	0.998	10.427	0.001	0.181	0.039	
		σ	0.011	0.130	0.420	0.004	0.055	0.026	
		F-statistic	1.89	1.51	2.43	7.17	1.54	12.19	
		Log Likelihood	293.43	73.56	-30.87	380.35	149.45	217.43	
		AR 1 - 4 test (F-test)	1.42	0.55	0.37	0.24	1.22	0.51	
		LM statistics (4)							34.46

Italy	3	R²	26.33%	22.83%	26.77%	64.53%	42.95%	94.14%
		RSS	0.003	1.351	42.635	0.001	0.180	0.022
		σ	0.006	0.142	0.798	0.004	0.052	0.018
		F-statistic	1.04	0.86	1.06	5.30	2.19	46.79
		Log Likelihood	343.76	62.43	-94.63	397.60	154.14	250.74
		AR 1 - 4 test (F-test)	0.48	0.64	1.99	1.25	0.58	1.15
		LM statistics (4)						34.17
Japan	2	R²	17.33%	30.51%	74.88%	89.86%	22.95%	33.48%
		RSS	0.005	1.194	0.795	0.001	0.287	0.049
		σ	0.009	0.129	0.105	0.004	0.063	0.026
		F-statistic	0.94	1.98	13.41	39.86	1.34	2.26
		Log Likelihood	305.37	65.55	83.67	384.01	129.08	208.09
		AR 1 - 4 test (F-test)	1.30	2.32*	1.07	0.74	0.21	1.64
		LM statistics (4)						27.94
United Kingdom	3	R²	42.21%	30.21%	28.85%	88.51%	51.65%	42.33%
		RSS	0.002	1.221	48.058	0.002	0.124	0.010
		σ	0.005	0.135	0.847	0.005	0.043	0.012
		F-statistic	2.22	1.32	1.23	23.47	3.25	2.24
		Log Likelihood	365.07	65.81	-99.47	364.69	168.58	281.04
		AR 1 - 4 test (F-test)	0.94	1.67	0.86	0.60	1.00	0.86
		LM statistics (4)						28.30
United States	2	R²	54.33%	17.86%	44.08%	61.63%	27.63%	29.57%
		RSS	0.002	1.439	31.471	0.001	0.217	0.025
		σ	0.005	0.139	0.652	0.003	0.054	0.018
		F-statistic	5.50	1.01	3.65	7.43	1.77	1.94
		Log Likelihood	358.60	59.58	-80.81	402.10	145.68	243.74
		AR 1 - 4 test (F-test)	0.30	0.45	1.22	2.37*	1.42	1.43
		LM statistics (4)						23.95

See notes to table 3.

Figure 1. Impulse response to an oil price shock

Impulse Response to an Oil Price Shock - CANADA

Response of Inflation Rate

Response of Exchange Rates

Response of Real Gross Domestic Product

Response of Money

Response of Interest Rates

Impulse Response to an Oil Price Shock - France

Response of Inflation Rate

Response of Exchange Rate

Response of Real Gross Domestic Product

Response of Money

Response of Treasury Bill

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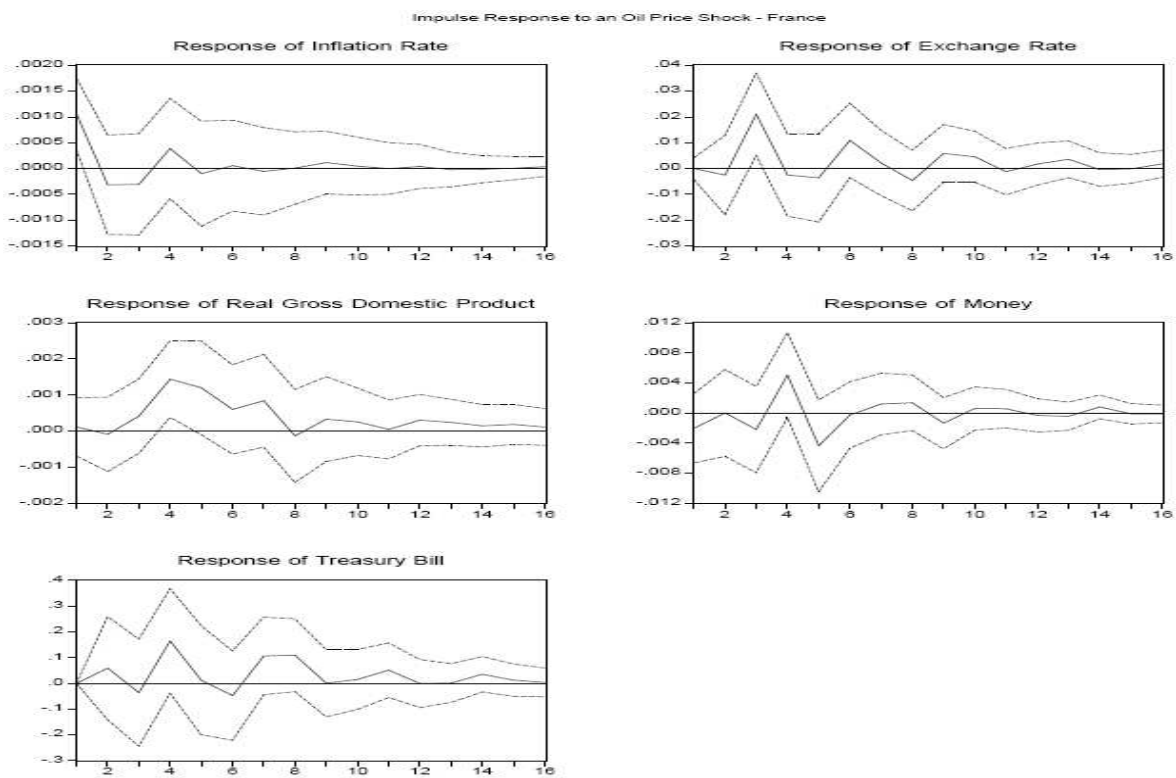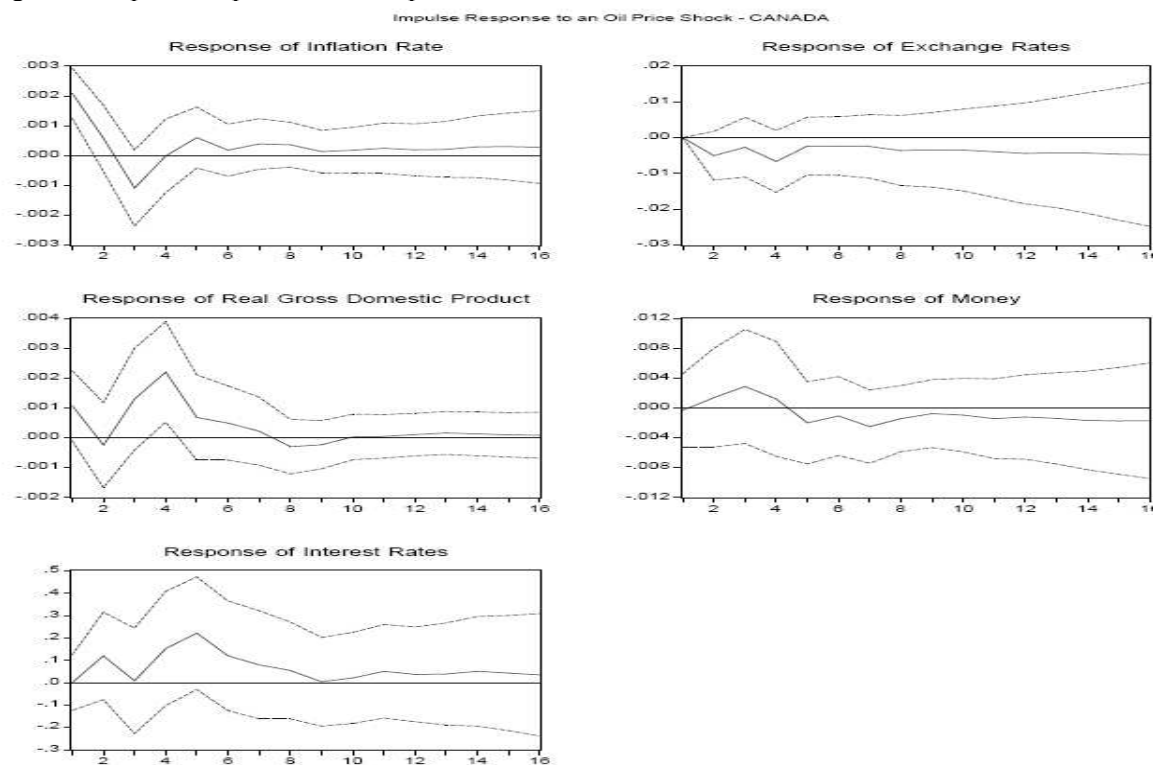
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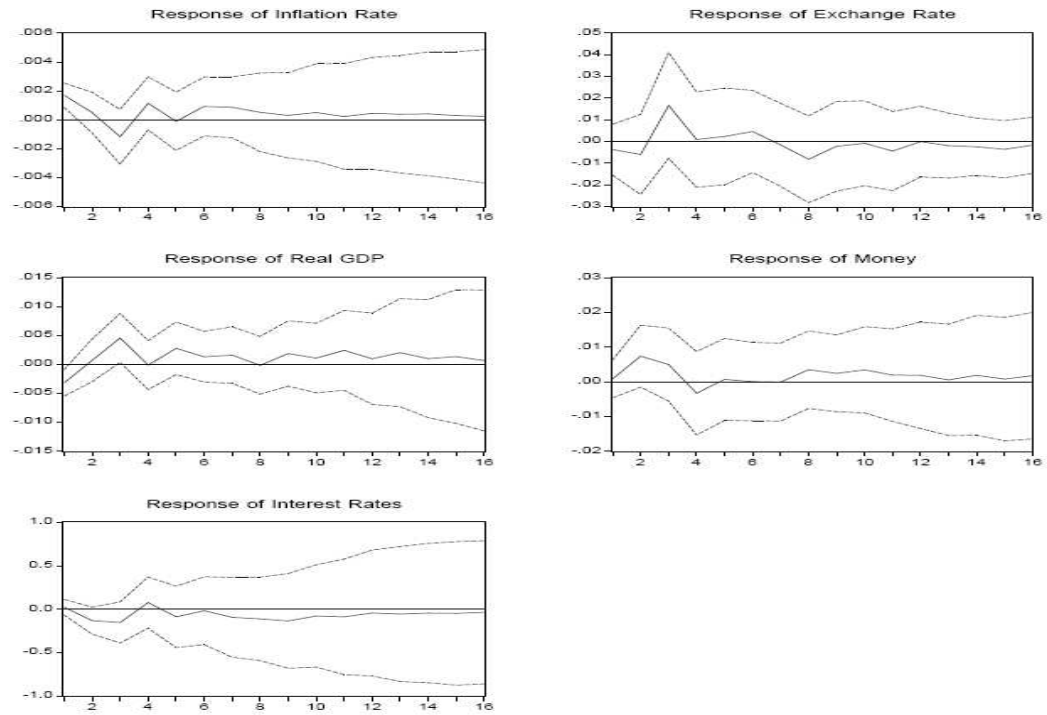
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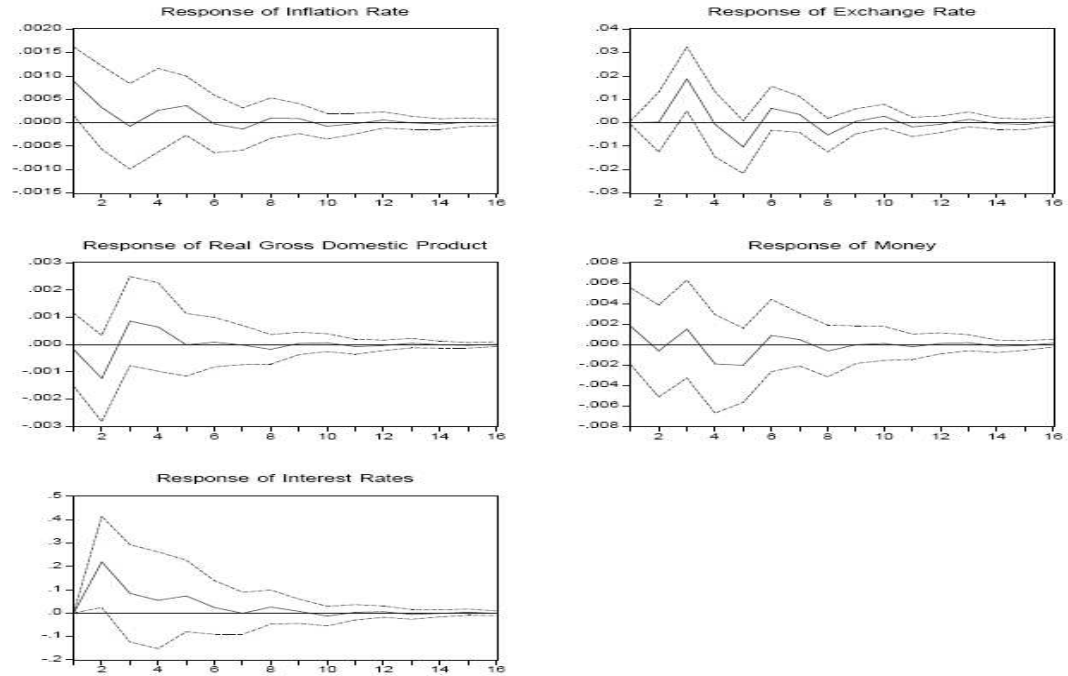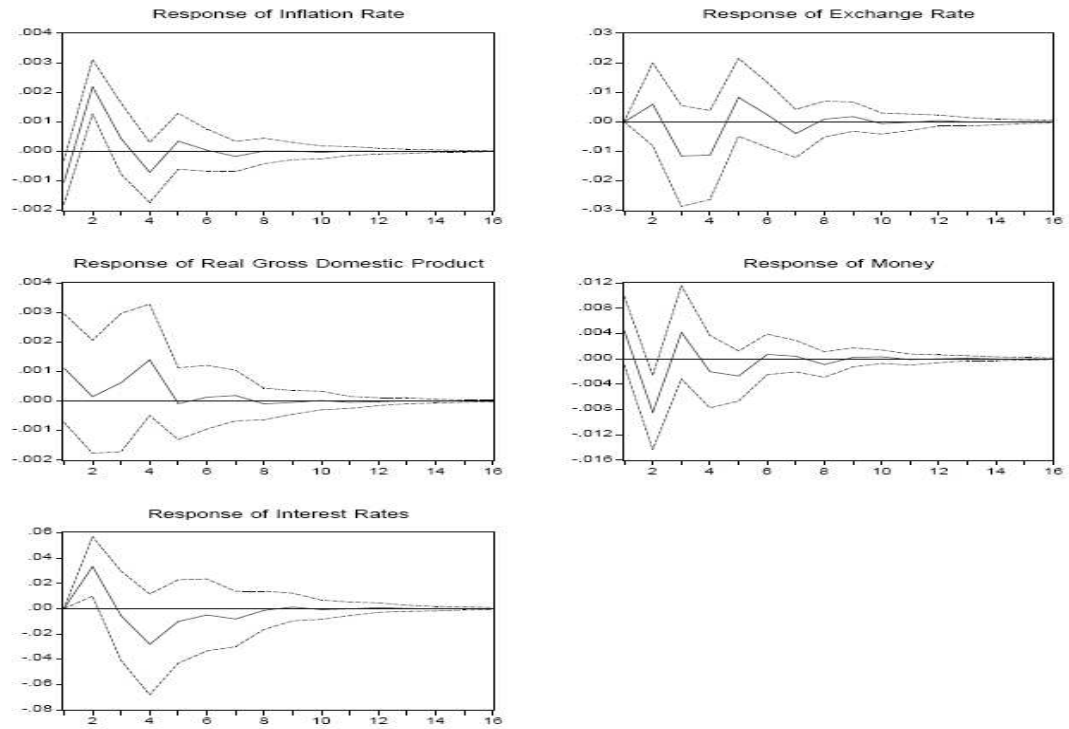
40

Response of Inflation Rate

Response of Exchange Rate

Response of Real Gross Domestic Product

Response of Money

Response of Interest Rates

Response of Inflation Rate

Response of Exchange Rate

Response of Real Gross Domestic Product

Response of Money

Response of Interest Rates

Response of Inflation Rate

Response of Exchange Rate

Response of Real Gross Domestic Product

Response of Money
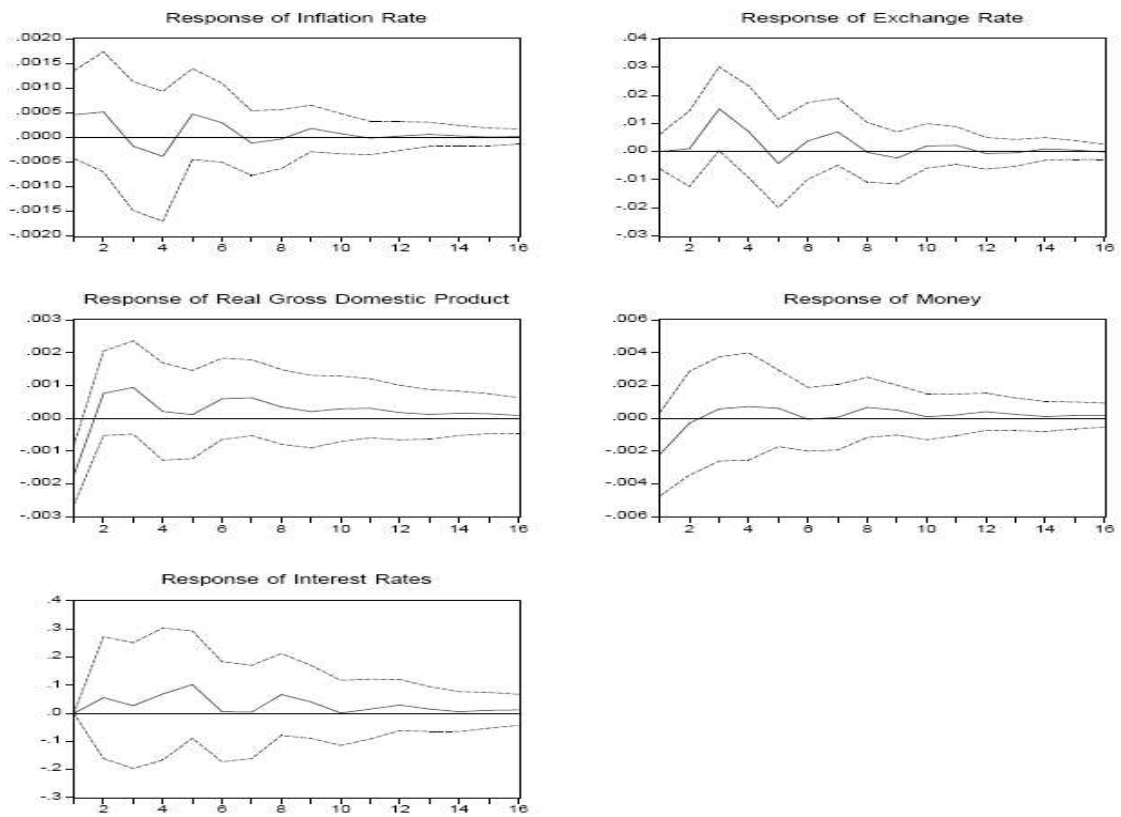
Response of Interest Rates
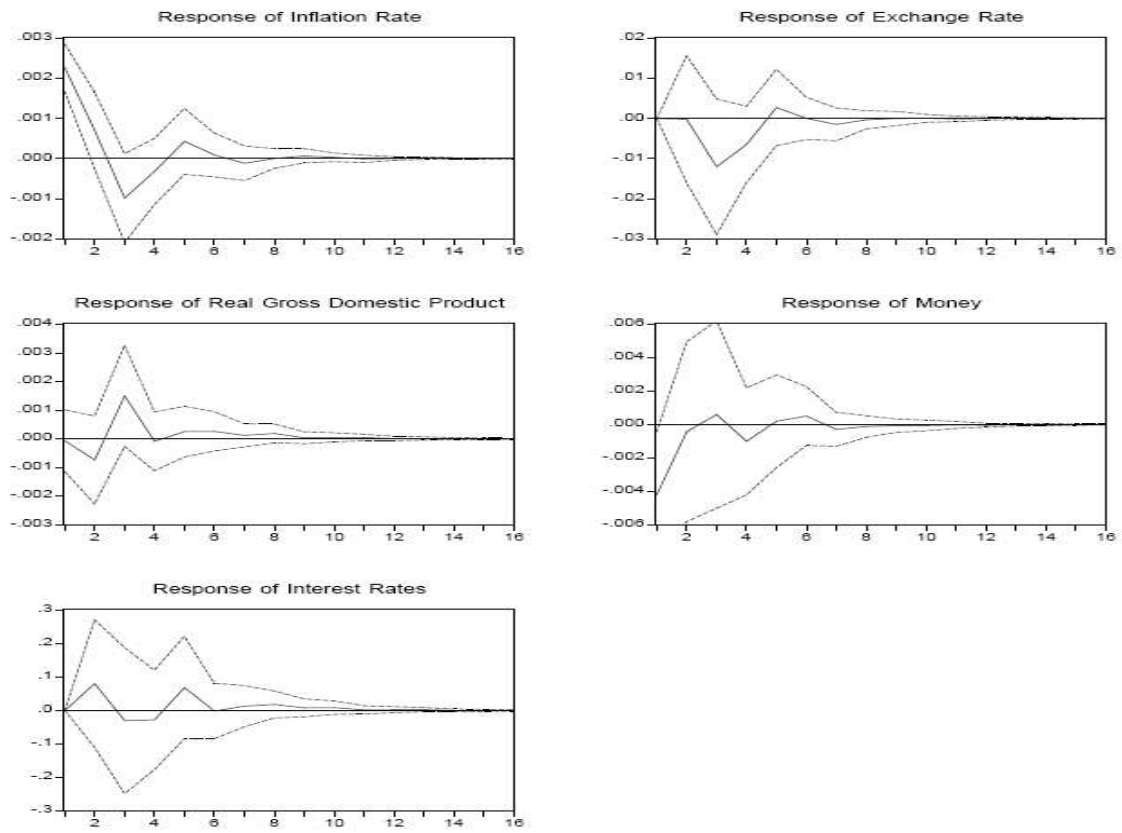
Figure 2. Impulse responses to a monetary policy shock.
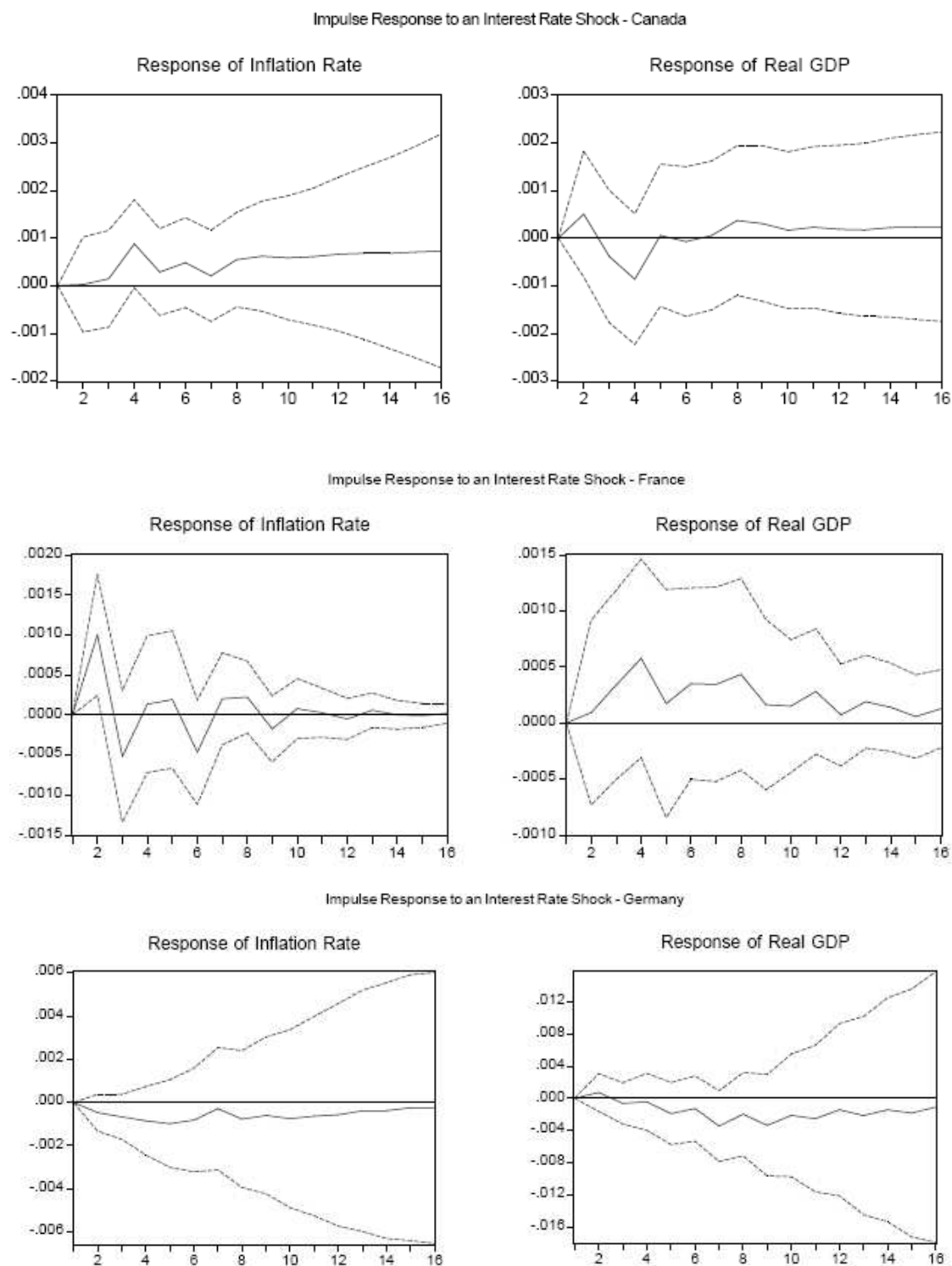
Impulse Response to an Interest Rate Shock - Canada
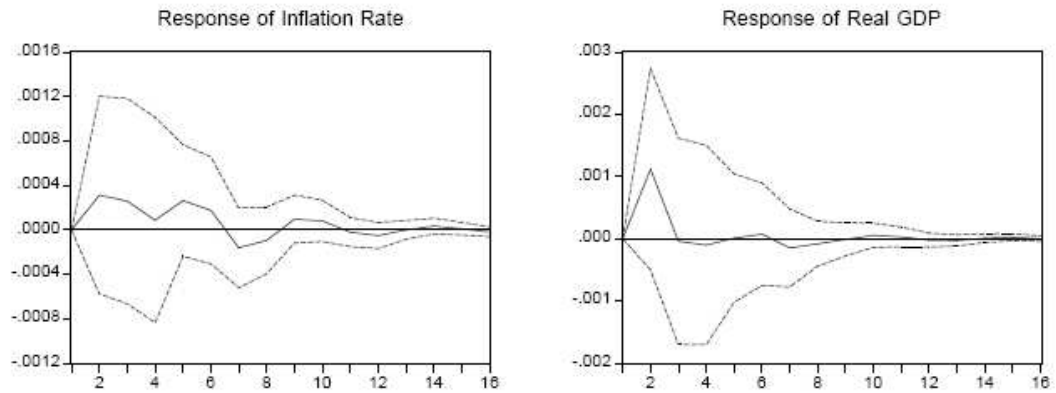
Response of Inflation Rate

Response of Real GDP

Impulse Response to an Interest Rate Shock - France

Response of Inflation Rate

Response of Real GDP

Impulse Response to an Interest Rate Shock - Germany

Response of Inflation Rate

Response of Real GDP

Impulse Response to an Interest Rate Shock - Italy

Response of Inflation Rate

Response of Real GDP

Impulse Response to an Interest Rate Shock - Japan

Response of Inflation Rate

Response of Real GDP
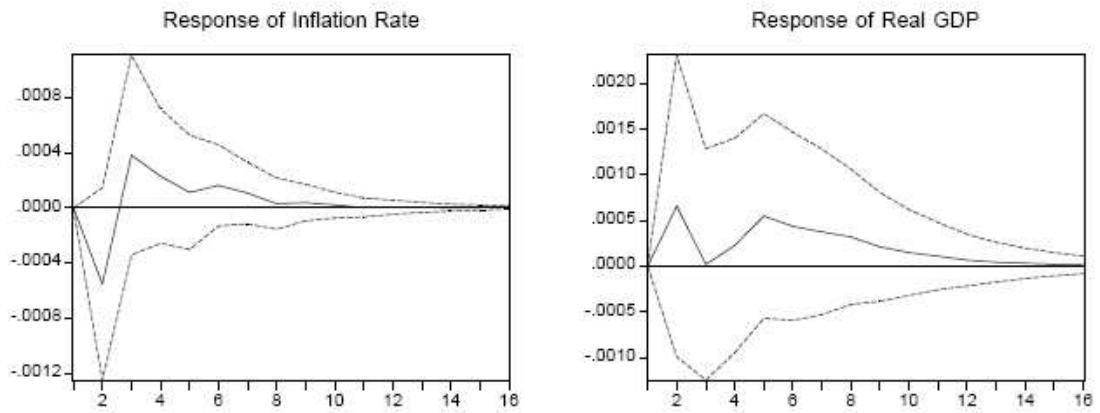
Impulse Response to an Interest Rate Shock - United Kingdom

Response of Inflation Rate

Response of Real GDP

44
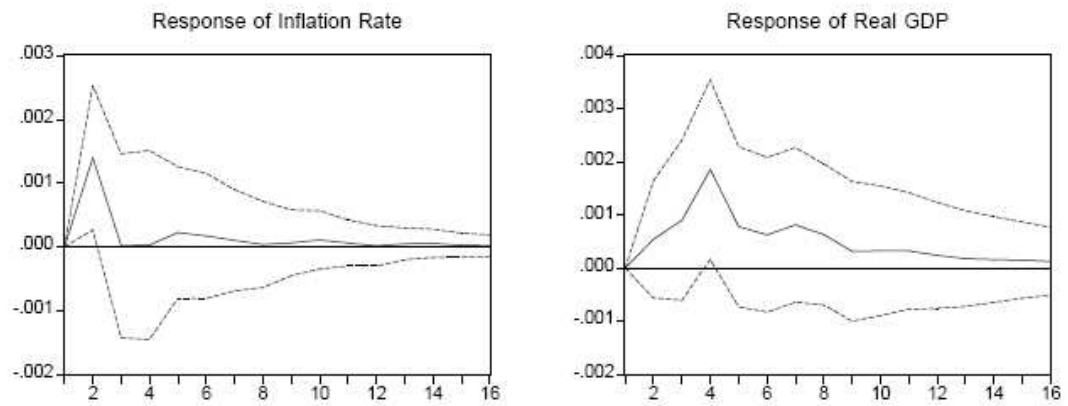
Impulse Response to an Interest Rate Shock - United States

Response of Inflation Rate

Response of Real GDP
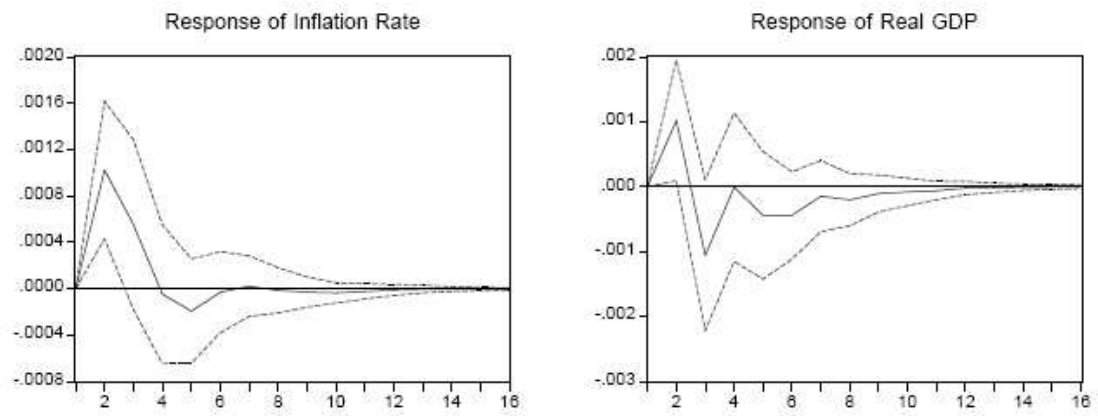
Figure 3. Response to the 1990 Oil Price Shock:
a) The effect on output.

Output CANADA

Output FRANCE

Output GERMANY

Output ITALY

Output JAPAN

Output UNITED KINGDOM

Output UNITED STATES

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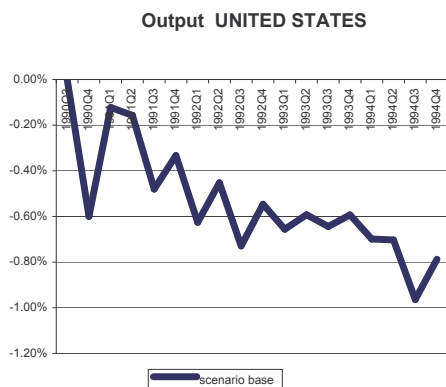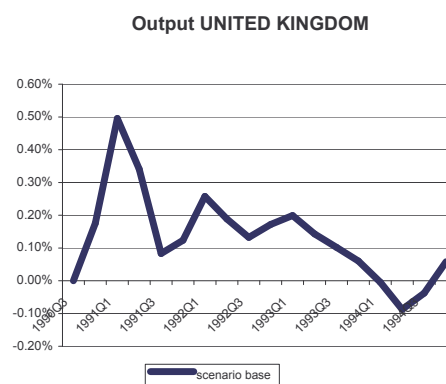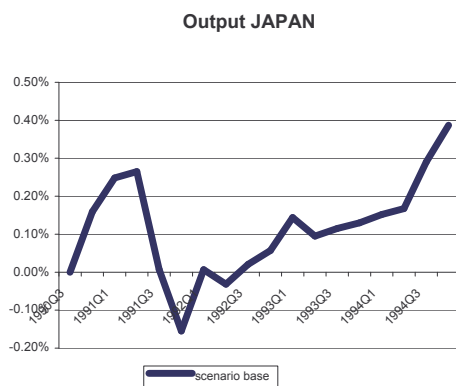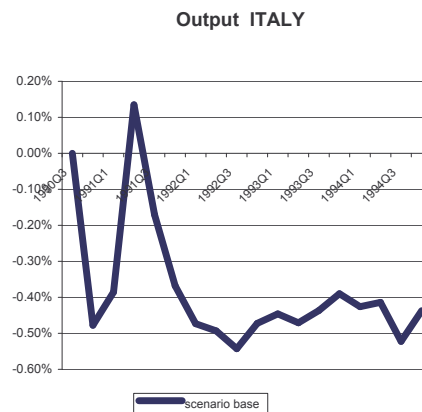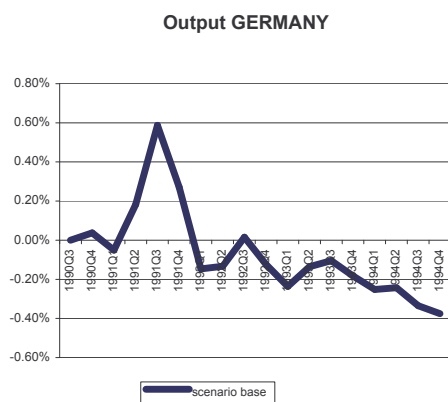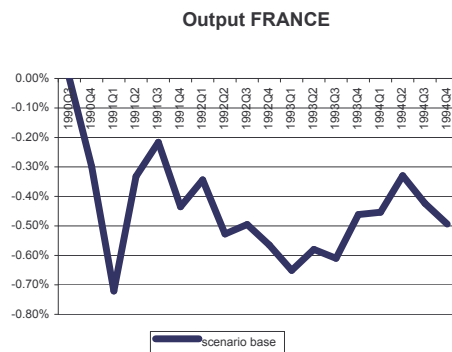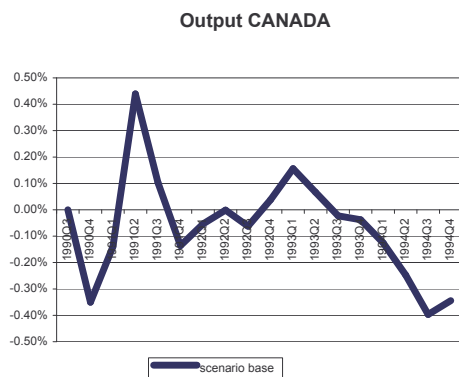
b) The effect on prices.

Prices CANADA
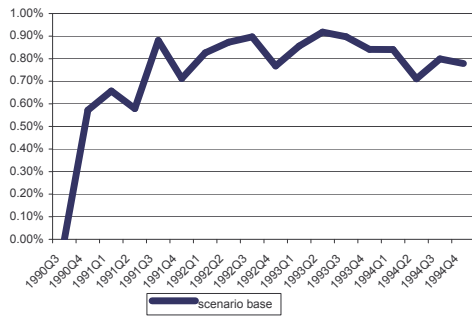
Prices FRANCE
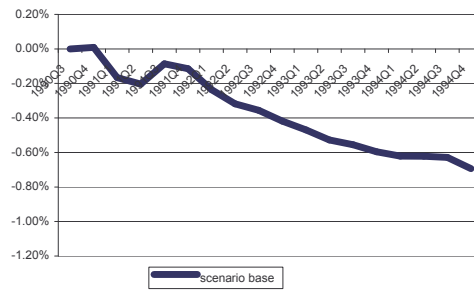
Prices GERMANY
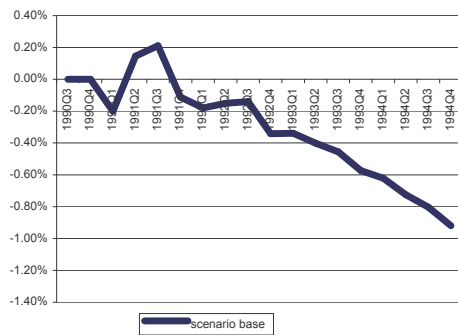
Prices ITALY
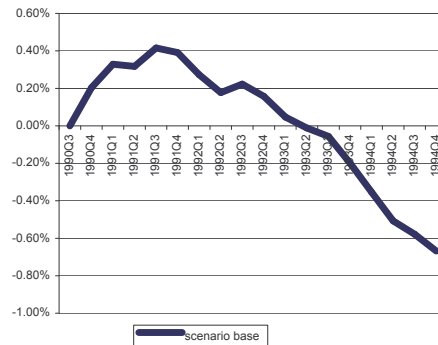
Prices JAPAN
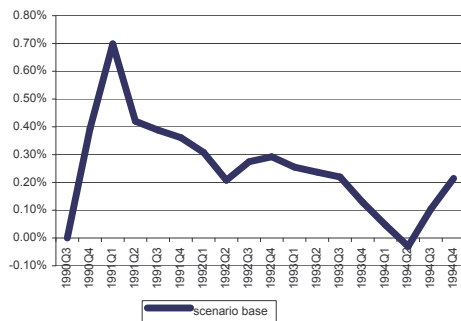
Prices UNITED KINGDOM
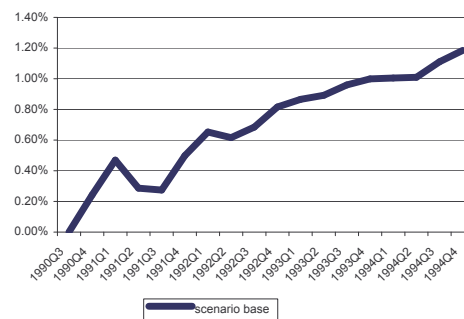
Prices UNITED STATES

47
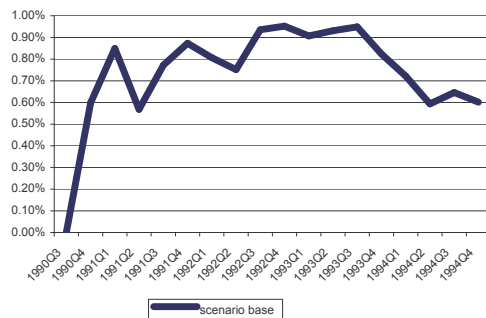
c) The effect on interest rates.

Interest Rates CANADA
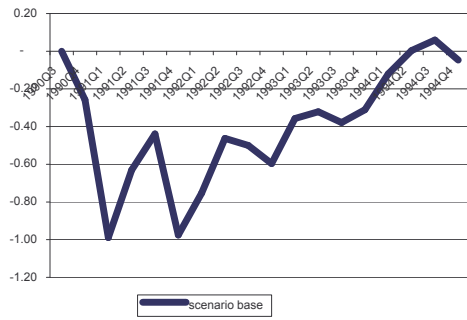
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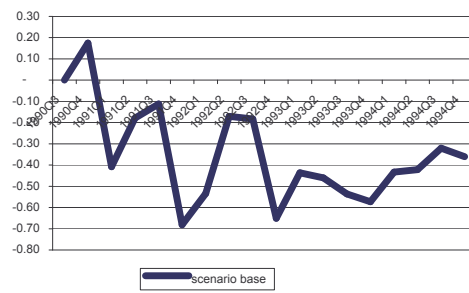
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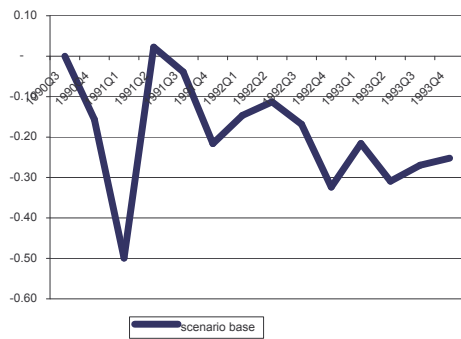
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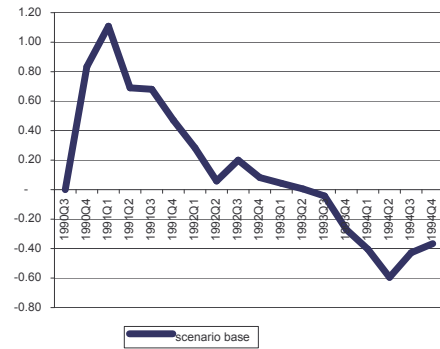
Interest Rates JAPAN
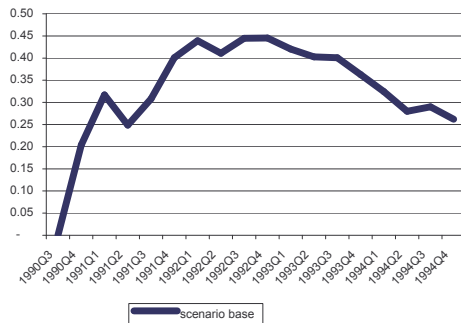
Interest Rates UNITED KINGDOM
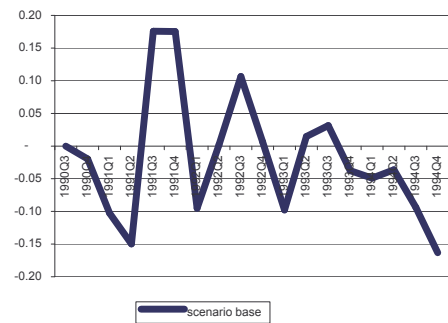
Interest Rates UNITED STATES

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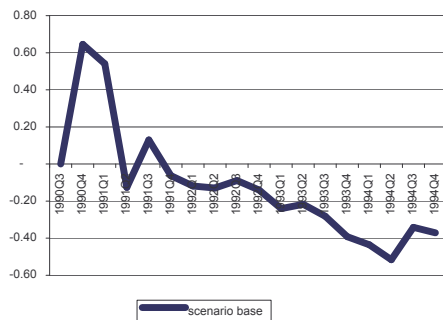
Figure 4: Simulation of the 1990 Oil Price Shock:
a) Effect of the oil shock on output.

Output (log-level) CANADA

Output (log-level) FRANCE

Output (log-level) GERMANY

Output (log-level) ITALY

Output (log-level) JAPAN

Output (log-level) UNITED KINGDOM

Output (log-level) UNITED STATES

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b) Effect of the oil shock on prices.

Prices (log-level) CANADA

Prices (log-level) FRANCE

Prices (log-level) GERMANY

Prices (log-level) ITALY

Prices (log-level) JAPAN

Prices (log-level) UNITED KINGDOM

Prices (log-level) UNITED STATES

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c) The effect on interest rates.

Interest rates (percent) CANADA

- historical path
- endogenous scenario
- no oil-price shock

Interest rates (percent) FRANCE

- historical path
- endogenous scenario
- no oil-price shock

Interest rates (percent) GERMANY

- historical path
- endogenous scenario
- no oil-price shock

Interest rates (percent) ITALY

- historical path
- endogenous scenario
- no oil-price shock

Interest rates (percent) JAPAN

- historical path
- endogenous scenario
- no oil-price shock

Interest rates (percent) UNITED KINGDOM

- historical path
- endogenous scenario
- no oil-price shock

Interest rates (percent) UNITED STATES

- historical path
- endogenous scenario
- no oil-price shock

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Figure 5: Simulation of the 1990 Oil Price Shock: the Monetary Response.
a) Output Level.

Output (log-level) CANADA

Output (log-level) FRANCE

Output (log-level) GERMANY

Output (log-level) ITALY

Output (log-level) JAPAN

Output (log-level) UNITED KINGDOM

Output (log-level) UNITED STATES

b) Price Level;

Prices (log-level) CANADA

Prices (log-level) FRANCE

Prices (log-level) GERMANY

Prices (log-level) ITALY

Prices (log-level) JAPAN

Prices (log-level) UNITED KINGDOM

Prices (log-level) UNITED STATES

c) Interest Rates.

Interest rates (percent) CANADA

Interest rates (percent) FRANCE

Interest rates (percent) GERMANY

Interest rates (percent) ITALY

Interest rates (percent) JAPAN

Interest rates (percent) UNITED KINGDOM

Interest rates (percent) UNITED STATES

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Table 8: Simulation of the 1990 Oil Price Shock.

a) Response of output (real GDP)*.

	Canada	France	Germany	Italy	Japan	United Kingdom	United States
Total Impact							
after 1 quarter	-0.35%	-0.30%	0.04%	-0.48%	0.16%	0.18%	-0.60%
4 quarters	0.10%	-0.22%	0.59%	-0.17%	0.01%	0.08%	-0.48%
average 12 quarters	-0.08%	-0.41%	0.13%	-0.41%	0.08%	0.12%	-0.61%
Impact assuming no monetary policy intervention							
after 1 quarter	-0.32%	-0.26%	0.04%	-0.48%	0.18%	0.18%	-0.63%
4 quarters	-0.36%	-0.26%	0.31%	-0.22%	-0.38%	0.11%	-0.34%
average 12 quarters	-0.21%	-0.37%	0.12%	-0.22%	-0.16%	0.20%	-0.54%

b) Response of prices*.

	Canada	France	Germany	Italy	Japan	United Kingdom	United States
Total Impact							
after 1 quarter	0.57%	0.01%	0.00%	0.20%	0.39%	0.24%	0.60%
4 quarters	0.88%	-0.09%	0.21%	0.42%	0.39%	0.50%	0.77%
average 12 quarters	0.81%	-0.25%	-0.10%	0.20%	0.32%	0.54%	0.81%
Impact assuming no monetary policy intervention							
after 1 quarter	0.54%	0.02%	0.00%	0.20%	0.43%	0.24%	0.56%
4 quarters	0.71%	0.00%	-0.01%	0.59%	0.42%	0.47%	0.63%
average 12 quarters	0.77%	-0.10%	0.01%	0.54%	0.29%	0.60%	0.53%

c) Response of interest rates**.

	Canada	France	Germany	Italy	Japan	United Kingdom	United States
Total Impact							
after 1 quarter	-0.26	0.17	-0.16	0.83	0.20	-0.02	0.65
4 quarters	-0.44	-0.11	-0.04	0.68	0.31	0.18	0.13
average 12 quarters	-0.39	-0.16	-0.16	0.42	0.34	0.07	0.10

* percentage points
** basis points

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(lxv) This paper was presented at the EuroConference on "Auctions and Market Design: Theory, Evidence and Applications" organised by Fondazione Eni Enrico Mattei and sponsored by the EU, Milan, September 25-27, 2003

(lxvi) This paper has been presented at the 4th BioEcon Workshop on "Economic Analysis of Policies for Biodiversity Conservation" organised on behalf of the BIOECON Network by Fondazione Eni Enrico Mattei, Venice International University (VIU) and University College London (UCL) , Venice, August 28-29, 2003

(lxvii) This paper has been presented at the international conference on "Tourism and Sustainable Economic Development – Macro and Micro Economic Issues" jointly organised by CRENoS (Università di Cagliari e Sassari, Italy) and Fondazione Eni Enrico Mattei, and supported by the World Bank, Sardinia, September 19-20, 2003

(lxviii) This paper was presented at the ENGIME Workshop on "Governance and Policies in Multicultural Cities", Rome, June 5-6, 2003

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(lxxiv) This paper was presented at the ENGIME Workshop on "Trust and social capital in multicultural cities" Athens, January 19-20, 2004

(lxxv) This paper was presented at the ENGIME Workshop on "Diversity as a source of growth" Rome November 18-19, 2004

(lxxvi) This paper was presented at the 3rd Workshop on Spatial-Dynamic Models of Economics and Ecosystems held in Trieste on 11-13 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics

(lxxvii) This paper was presented at the Workshop on Infectious Diseases: Ecological and Economic Approaches held in Trieste on 13-15 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics.