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THE MONETARY TRANSMISSION MECHANISM IN THE EURO AREA: MORE EVIDENCE FROM VAR ANALYSIS

BY GERT PEERSMAN AND FRANK SMETS

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The Eurosystem Monetary Transmission Network

This issue of the ECB Working Paper Series contains research presented at a conference on "Monetary Policy Transmission in the Euro Area" held at the European Central Bank on 18 and 19 December 2001. This research was conducted within the Monetary Transmission Network, a group of economists affiliated with the ECB and the National Central Banks of the Eurosystem chaired by Ignazio Angeloni. Anil Kashyap (University of Chicago) acted as external consultant and Benoît Mojon as secretary to the Network.

The papers presented at the conference examine the euro area monetary transmission process using different data and methodologies: structural and VAR macro-models for the euro area and the national economies, panel micro data analyses of the investment behaviour of non-financial firms and panel micro data analyses of the behaviour of commercial banks.

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Abstract

This paper applies the identified VAR methodology to synthetic euro area data from 1980 till 1998 to study the macro-economic effects of an unexpected change in monetary policy in the euro area. The focus is on the area-wide monetary transmission. It is shown that the overall macro-economic effects of a monetary policy shock in the euro area are very similar to those estimated for the United States and are surprisingly stable over time. In addition, the paper contains a number of robustness checks with alternative identification schemes and examines how various real and financial variables (such as the GDP or money components) respond to an area-wide monetary policy impulse.

JEL classification: E52

Key words: Monetary Transmission Mechanism; Vector Autoregressions

Non-technical summary

There is a large literature that has used identified Vector Autoregressions (VARs) to study the macroeconomic effects of an unexpected change in policy-controlled interest rates in the United States and in the euro area countries. Recently, Leeper, Sims and Zha (1998) and Christiano, Eichenbaum and Evans (2000) have reviewed what one has learned from this extensive literature regarding the monetary transmission mechanism in the United States. A large part of the literature on the euro area has focused on trying to identify cross-country differences. In these studies, VARs are estimated for the individual countries of the euro area, and the impulse responses of the main macroeconomic variables to a monetary policy shock are compared. The focus of this paper is on what we can learn regarding the area-wide monetary transmission from analysing a VAR estimated on synthetic euro area data from 1980 till 1998.

Using several standard identification schemes, we uncover plausible impulse responses of the main macro-economic variables to an unexpected monetary policy tightening in the euro area. A temporary rise in the nominal and real short-term interest rate tends to be followed by a real appreciation of the exchange rate and a temporary fall in output. Prices are more sluggish and only start to fall significantly below zero several quarters after GDP. These results are very similar to those obtained for the US economy using similar methodologies. More surprisingly, they also appear to be stable over different sample periods.

We also investigate the reaction of other macro variables and the GDP components to a monetary policy shock. The response of output is mainly due to a decrease in investment which responds with a magnitude three times as large as GDP, and to a lesser extent in private consumption. Employment falls in line with GDP, but less strongly which results in a pro-cyclical response of labour productivity. We find an immediate liquidity effect on M1, but a more gradual decrease of M3 and other credit aggregates. The long-term interest rate shows a muted response to the temporary rise in the short-term interest rate consistent with the expectations theory of the term structure. Share prices fall significantly on impact, while house prices respond more sluggishly.

Overall, these findings are encouraging and show in our view that the results from applying standard techniques to synthetic euro area data can be used as a benchmark for the further theoretical and empirical analysis of the transmission mechanism in the euro area. Of course, the caveats that come with this analysis are even more important in this case. In particular, we know that there was no common monetary policy in the euro area over the estimation period, so that identifying monetary policy innovations on the basis of an aggregate monetary policy reaction function may be problematic. It is therefore important to monitor how these results change as data from the new single monetary policy regime come in. In addition, the aggregate analysis results need to be complemented with a more disaggregated investigation that takes the features of the national monetary policy regimes into account. Recent work in that respect can be found in Sala (2001), Rebucci and Ciccarelli (2001) and Mojon and Peersman (2001).

1. Introduction

There is a large literature that has used identified Vector Autoregressions (VARs) to study the macroeconomic effects of an unexpected change in policy-controlled interest rates in the euro area countries.[1] The use of VARs for the analysis of monetary policy started with the seminal work of Sims (1980). Recently, Leeper, Sims and Zha (1998) and Christiano, Eichenbaum and Evans (2000) have reviewed what one has learned from this extensive literature regarding the monetary transmission mechanism in the United States. A large part of the literature on the euro area has focused on trying to identify cross-country differences. In these studies, VARs are estimated for the individual countries of the euro area, and the impulse responses of the main macroeconomic variables to a monetary policy shock are compared.

The focus of this paper is on what we can learn regarding the area-wide monetary transmission from analysing a VAR estimated on synthetic euro area data from 1980 till 1998. In the next section, we show that using a standard identification scheme as in Christiano, Eichenbaum and Evans (2000) and Eichenbaum and Evans (1995) delivers plausible estimates of the effects of monetary policy in the euro area. An unexpected, temporary rise in the short-term interest rate tends to be followed by a real appreciation of the exchange rate and a temporary fall in output after two quarters. The effect on output reaches a peak after 3 to 5 quarters, after which it slowly returns to baseline. Prices are more sluggish and only start to fall significantly below zero several quarters after GDP. The effect on prices is also more persistent.

In Section 3 we perform a number of robustness checks. We show that the impulse responses to a monetary policy shock are relatively stable over time. The results also appear robust to alternative identification schemes, similar to the ones used in Gali (1992) and Sims and Zha (1997). In Section 4, we use the VAR to examine how the various money, credit and GDP components respond to an area-wide monetary policy impulse, as well as some asset prices and labour market variables. Finally, in Section 5 we discuss the conclusions.

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1 For a recent survey, see, for example, Guiso et al (2000).

2. A VAR-model for the euro area

2.1. The benchmark specification

In this section we describe two benchmark VAR-models that we use to analyse the effects of a monetary policy shock in the euro area. The benchmark VARs have the following representation:

$$[1] \qquad Y_t = A(L)Y_{t-1} + B(L)X_t + \mu_t$$

where Y_t is the vector of endogenous euro area variables and X_t is a vector of exogenous foreign variables. Throughout this paper, the vector of exogenous variables contains a world commodity price index (cp_t), US real GDP (y_t^{US}), and the US short-term nominal interest rate (s_t^{US}):[2]

$$[2] \qquad X_t^{'} = \left[cp_t \quad y_t^{US} \quad s_t^{US} \right]$$

These variables are included to control for changes in world demand and inflation. The inclusion of these variables helps to solve the so-called price puzzle (i.e. the empirical finding in the VAR literature that prices rise following an interest rate tightening).[3] By treating these variables as exogenous, we implicitly assume that there is no feedback from the euro area variables to the foreign variables.[4] We also allow for a contemporaneous impact of the exogenous variables on the endogenous euro area variables.

In the first model, the vector of endogenous euro area variables, Y_t, consists of real GDP (y_t), consumer prices (p_t), the domestic nominal short-term interest rate (s_t) and the real effective exchange rate (x_t):[5]

$$[3] \qquad Y_t^{'} = \left[y_t \quad p_t \quad s_t \quad x_t \right]$$

In the second model, we also include a broad monetary aggregate (M3) (m_t) in the block of endogenous variables. Historically money developments have played an important role in the monetary policy strategies of some of the countries now participating in the monetary union. The inclusion of a money aggregate could therefore be helpful in

---

2 Each of the VAR models also contains a constant and a linear trend.

3 For example Sims (1992).

4 The results are very similar when such a feedback is allowed.

5 Most of the data used in this paper come from the AWM database. See Fagan et al (2001).

identifying monetary policy innovations. In this case, the vector of endogenous variables can thus be written as:

[3'] $Y_t' = [y_t \quad p_t \quad m_t \quad s_t \quad x_t]$

In both cases, the euro area monetary policy shock is identified through a standard Choleski-decomposition with the variables ordered as in [3] and [3'].[6] The underlying assumption is that policy shocks have no contemporaneous impact on output, prices and money, but may affect the exchange rate immediately. However, the policy interest rate does not respond to contemporaneous changes in the effective exchange rate. The latter assumption is appropriate for a large, relatively closed, economy such as the euro area as a whole.[7] In section 3, we provide a robustness analysis for alternative identification strategies.

Unless otherwise mentioned, each of the VAR-models is estimated in levels using quarterly data over the period 1980-1998.[8] In this paper we do not perform an explicit analysis of the long run behaviour of the economy. By doing the analysis in levels we allow for implicit cointegrating relationships in the data. A more explicit analysis of the long-run behaviour of the various variables is limited by the relatively short sample available.[9] The data are expressed in logs and seasonally adjusted, except the interest rates which are in levels. We use the three-month interest rate as the monetary policy rate as this is the only short-term interest rate that is available for all countries over the whole sample period. Standard likelihood ratio tests are used to determine the lag-order of the VARs, which turns out to be of order three. Finally, in order to test the stability of the VAR, we ran sequential Chow break tests starting in 1990:1. There is no evidence of instability at the 5% confidence level.

2.2. Basic estimation results

The results of the two benchmark VAR-models for the euro area are shown in the first two columns of Graph 1. This graph gives the effect of a domestic, one-standard deviation, monetary policy shock on domestic real GDP, domestic consumer prices, the exchange

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6 As in Sims (1980) and Christiano et al (1998).

7 Eichenbaum and Evans (1995) make the same assumption for the US. One can argue that the euro area as a whole is more like the US in terms of openness than like any of its individual members.

8 We took 1980 as a starting date because some of the data series used are only available from that year.

9 See Sims et al (1990). Coenen and Vega (1999) estimate a VECM model for the euro area.

rate and the domestic short-term interest rate, together with a 90 percent confidence band.[10]

The third column reports the results of a similar exercise for US data. The main difference with the VAR specification for the euro area is that in this case we do not include exogenous variables. Moreover, consistent with many other papers on the US (e.g. Christiano, Eichenbaum and Evans (2000)), we include commodity prices as an endogenous variable, $Y_{US,t}^{'} = [cp_t \quad y_t \quad p_t \quad s_t \quad x_t]$. The sample period is identical (1980-1998) and the identification of the US monetary policy shock is again obtained using a standard Choleski-decomposition.

The impulse response patterns reported in the graph are broadly in line with the existing empirical evidence for the United States and many other countries (Christiano et al, 2000; Gerlach and Smets, 1995). An unexpected, temporary rise in the short-term interest rate tends to be followed by a real appreciation of the exchange rate and a temporary fall in output after two quarters. The effect on output reaches a peak after 3 to 5 quarters and returns to baseline afterwards. Prices respond much more sluggishly, but the effects of the policy shock are more persistent.

A comparison of the first and second column of Graph 1 shows that overall the results obtained in the euro area models with and without money are very similar. The inclusion of M3 (model 2) does lead to somewhat tighter estimates. The effect of the policy shock on prices is now significant after eight quarters. Also, the initial positive impact on output disappears. In what follows we will therefore use the model with money as our benchmark for the euro area. An analysis of how M3 and its components are affected is given in Section 4.3 below.

Comparing the effects in the euro area and the United States, it is striking how similar the impulse response functions are. A typical monetary policy shock is somewhat greater in the US than in the euro area (45 basis points compared to 30 basis points), which is reflected in a somewhat stronger impact on output and prices. The impact on prices is, however, much faster in the US. One explanation for this finding could be that prices are more flexible in the US. The slower response of prices in the euro area may, however, also be due to aggregation bias, which given the heterogeneity of inflation rates in the individual countries of the euro area could be most severe for prices. The impact on the

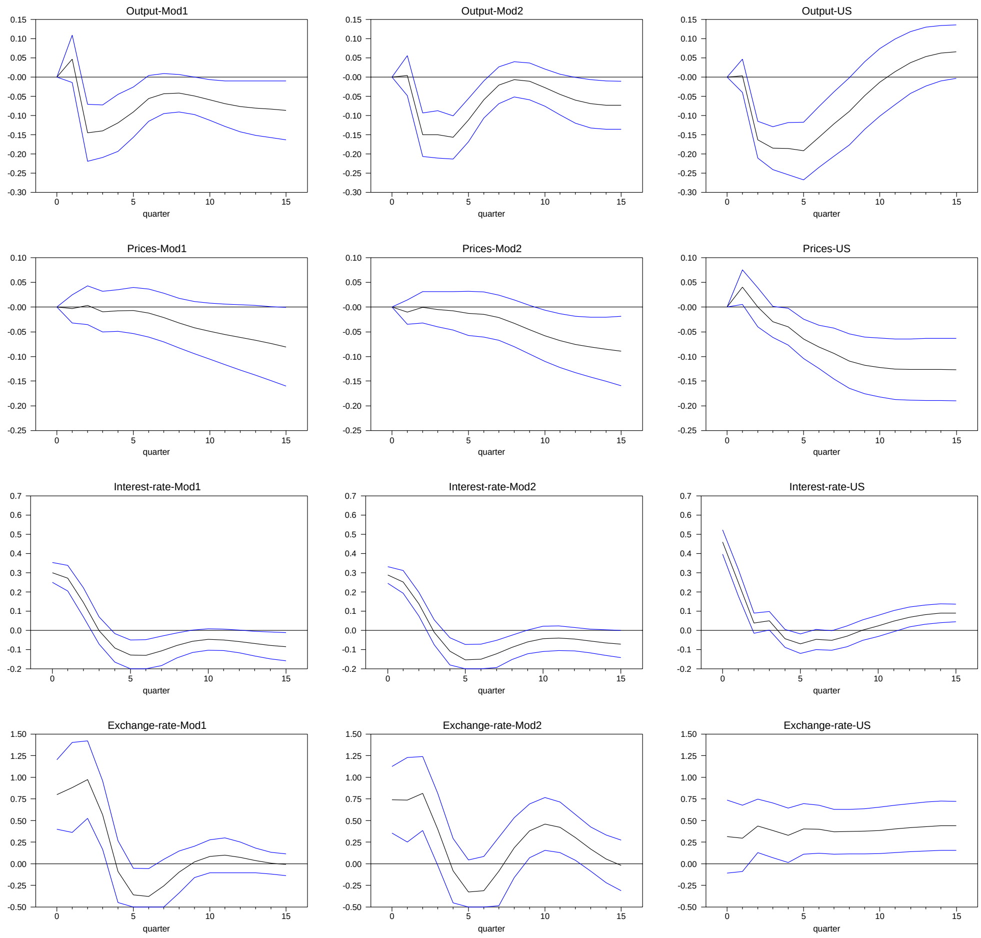
[10] The confidence band is obtained through a standard bootstrapping procedure with 100 draws. Very similar, though somewhat wider, confidence bands are obtained when Monte Carlo methods are used. See Sims and Zha (1999).

real effective exchange rate is much smaller, but more persistent in the US, which is somewhat consistent with the findings of Eichenbaum and Evans (1995).

Graph 1

The effects of a monetary policy shock in the euro area and the United States

(Estimation period: 1980-1998)



Note: 90 % confidence bands.

The size of the policy shock obtained for the euro area is much larger than the one obtained by Monticelli and Tristani (1999), who use a longer estimation period and an identification strategy that combines both short and long-run restrictions. These authors find that a one standard deviation monetary shock corresponds to a 10 basis points move in the interest rate. The maximum impact of this shock on GDP is, however, much larger at 0.4 percent.

Graph 2 shows the historical contribution of the monetary policy shocks to the short-term interest rate in the euro area and the US, whereas Table 1 provides the contribution of the monetary policy shocks to the variance of the forecast error of output, prices, the interest rate and the exchange rate at various horizons. From Graph 2, it is clear that periods of easy monetary policy in the euro area can be situated at the end of 1984 and in 1991. In contrast, monetary policy was on average relatively tight at the beginning of 1990 (possibly associated with the reunification of Germany) and again during the ERM crisis at the end of 1992 and the beginning of 1993. The timing of these episodes are quite different from those in the United States. In fact, the correlation coefficient between monetary policy innovations in the euro area and the US turns out to be negative in this sample period (-0.2).

Graph 2

Contribution of monetary policy shocks to the short-term interest rate

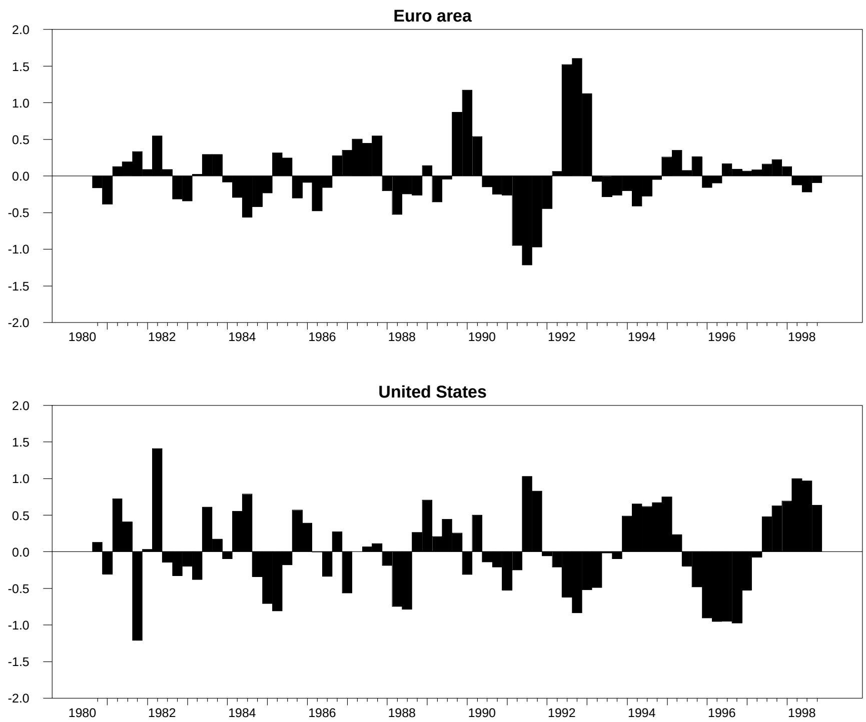


Table 1 shows that, as in most of the VAR literature, the contribution of policy shocks to output and price developments is rather limited. This is to be expected as the monetary policy shocks capture deviations of the short-term interest rate from average monetary policy behaviour over the estimation period. In a stable monetary policy regime such deviations should be limited. The fact that the contribution of monetary policy shocks to output and exchange rate developments is larger in the euro area than in the United States, is partly due to the fact that the overall variance to be explained is smaller because of the inclusion of exogenous variables in the euro area VAR.

Table 1
Contribution of monetary policy shocks to the forecast error variance

	Horizon 1 year	 2 year	 3 year	 5 year	 10 year
			Euro area		
Output	13	28	34	39	38
Prices	3	7	11	18	23
Interest rate	65	41	29	14	4
Exchange rate	17	21	23	27	33
			United States		
Output	4	2	5	10	20
Prices	7	16	18	15	14
Interest rate	50	25	23	21	21
Exchange rate	6	3	2	3	3

Note: in percent.

3. A robustness analysis

In this Section, we analyse the robustness of the results described in Section 2. First, we analyse the stability of the impulse responses over different sample periods (Section 3.1). Section 3.2 then provides a robustness analysis for alternative identification schemes. Two alternative strategies are investigated: the Sims and Zha (1998) methodology and an identification strategy using long-run restrictions as in Gali (1992).

3.1. Stability of the impulse responses over time

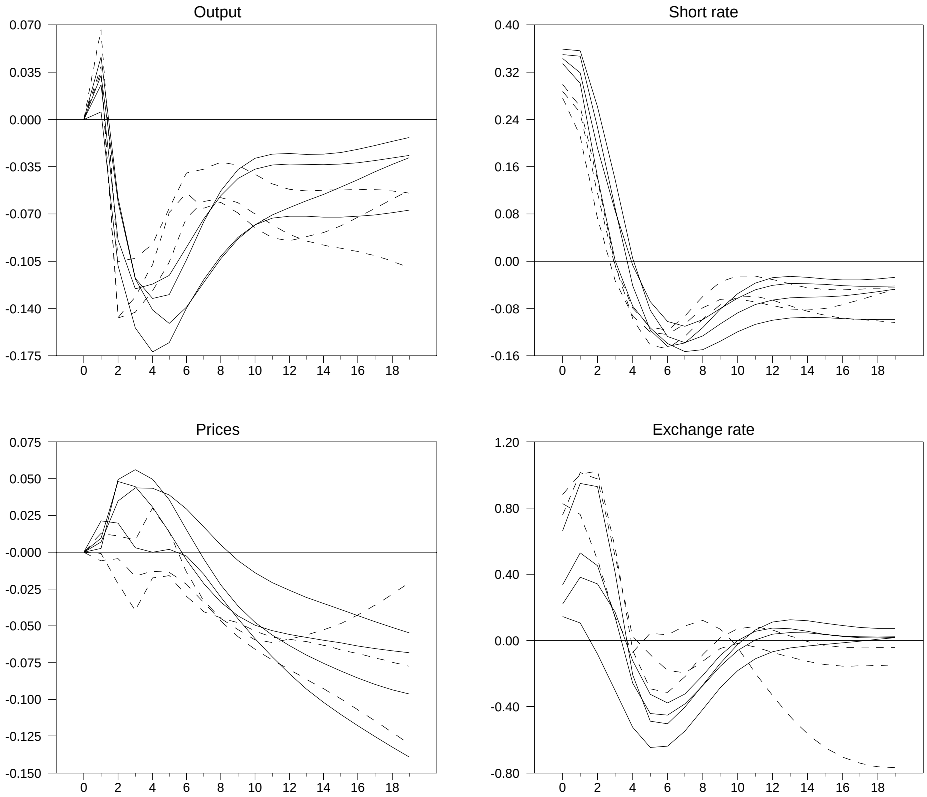
Using the recursive Chow tests referred to in Section 2, the null hypothesis that the benchmark VARs are stable over the estimation period can not be rejected. In order to test this further, we report in this Section impulse responses for both longer and shorter sample periods. Evidence of the stability of the impulse responses over time would suggest that the problems due to aggregation over different monetary policy regimes may be overrated. The recursive impulse responses also allow us to see whether there is any evidence that the transmission mechanism of monetary policy in the euro area has changed over time. Graph 3 reports recursive impulse responses to a monetary policy shock based on model 1 for the euro area.[11] The full lines refer to sample periods that start in the 1970s (1973, 1975, 1977 and 1979) and end in 1998, whereas the broken lines refer to shorter sample periods that start in the 1980s (1981, 1983, 1985).

Overall, the results confirm the stability of the VAR results. The qualitative effects of a monetary policy shock are quite similar over the different sample periods. There are some quantitative differences, which are unlikely to be significant. The average size of the interest rate shock has fallen somewhat in the latter period, while the associated exchange rate response is clearly larger. The stronger exchange rate effect is translated in a smaller price puzzle in the latter period. Compared to the full sample results, the effect of a monetary policy shock on output has been quicker in the 1980s and 1990s. The peak effect takes places in the second and third quarter, compared to the fourth and fifth quarter for the full sample.

[11] We do this analysis with the benchmark model without money because an area-wide money series is not available before the 1980s.

Graph 3

Recursive impulse responses to a monetary policy shock in the euro area



Note: the solid lines refer to the sample periods that start in 1973, 1975, 1977 and 1979; the dashed lines refer to the sample periods that start in 1981, 1983 and 1985. In all cases, the end of the sample period is 1998:4.

3.2. Alternative identification schemes

It is well-known that impulse response functions in VAR analysis can be sensitive to alternative identification schemes. In this Section we apply two alternative identification schemes to check the robustness of our previous results. The first is due to Sims and Zha (1998) and Kim and Roubini (2000) and allows for a contemporaneous interaction between the short-term interest rate, the exchange rate and the money aggregate. The second is based on Gali (1992) and uses a mixture of long and short-run restrictions to identify monetary policy shocks.

3.2.1. Allowing for a contemporaneous interaction between the short-term interest rate, the exchange rate and the money aggregate

In this Section we use a more general identification method suggested by Bernanke (1986) and Sims (1986) and applied by, for example, Sims and Zha (1998) and Kim and Roubini (2000). If μ_t are the residuals from the reduced form estimation of equation [1], then these residuals can be related to the structural shocks by the following general structural model:

[5] $$A\mu_t = B\,\varepsilon_t$$

In our basic, recursive identification strategy, A is assumed to be the identity matrix and B is assumed to be a lower triangular matrix. The policy shock then refers to the shock to the interest rate equation. Following Sims and Zha (1998) and Kim and Roubini (1997), an alternative, non-recursive identification scheme allows for a contemporaneous interaction between the short-term interest rate, money and the exchange rate. In the model with money, these authors propose the following restrictions on the A and B matrix:

[6] $$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & a_{34} & 0 \\ 0 & 0 & a_{43} & 1 & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix} \begin{bmatrix} \mu_t^y \\ \mu_t^p \\ \mu_t^m \\ \mu_t^s \\ \mu_t^x \end{bmatrix} = \begin{bmatrix} \varepsilon_t^y \\ \varepsilon_t^p \\ \varepsilon_t^m \\ \varepsilon_t^s \\ \varepsilon_t^x \end{bmatrix}$$

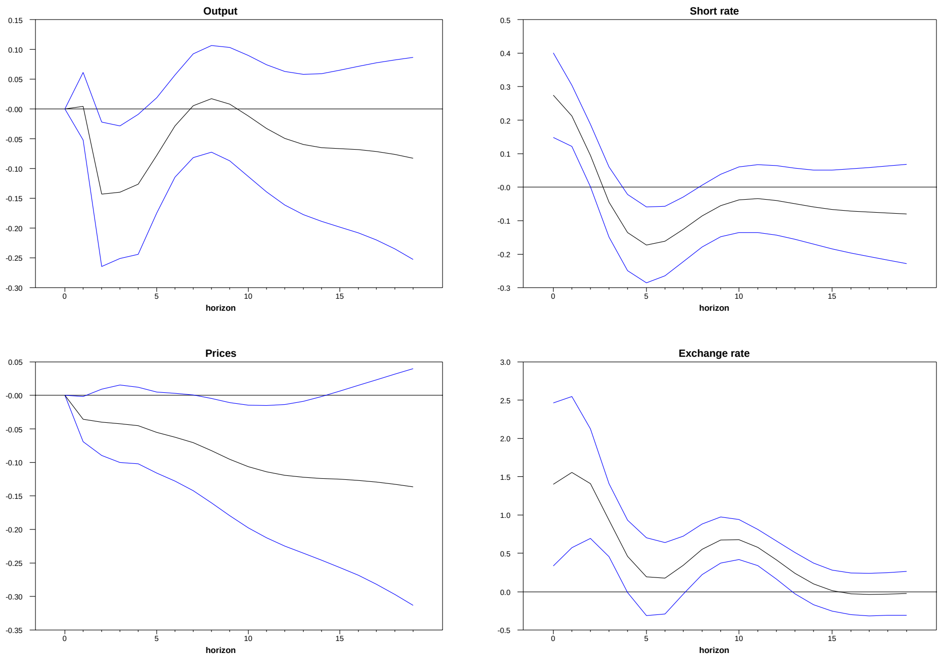
The first two equations represent the sluggish reaction of the real sector (output and prices) to shocks in the monetary sector (money, interest rate and exchange rate). There is no contemporaneous impact of the monetary policy, money demand, and exchange rate shock on output and prices. The third equation can be interpreted as a short-run money demand equation. Money demand is allowed to respond contemporaneously to innovations in output, prices and the interest rate. The fourth row represents the monetary policy reaction function. The monetary authority sets the interest rate after observing the current money stock and the exchange rate, but does not respond contemporaneously to disturbances in output and the price level. The argument is that information about the latter variables is only available with a lag. Finally, the exchange rate, being an asset price, reacts immediately to all the other innovations.

Graph 4 shows that the impulse responses obtained with this identification scheme are very similar to those of the basic model. The typical size of the interest rate shock is somewhat smaller, while the exchange rate appreciation is much stronger. Because of this appreciation the effect on prices is more immediate.

Graph 4

The effects of a monetary policy shock in the euro area

(Estimation period: 1980-1998; Sims-Zha identification)



Note: 90 % confidence bands.

3.2.2. A mixture of short and long-run restrictions

Another possible identification strategy is to combine short and long-run restrictions as in Gali (1992) and Gerlach and Smets (1995). In this case, we assume that the vector of the endogenous variables is given by:

[7] $$Y_t^{'} = \left[\Delta y_t \quad \Delta p_t \quad s_t \quad \Delta x_t\right]$$

and the vector of the structural disturbances:

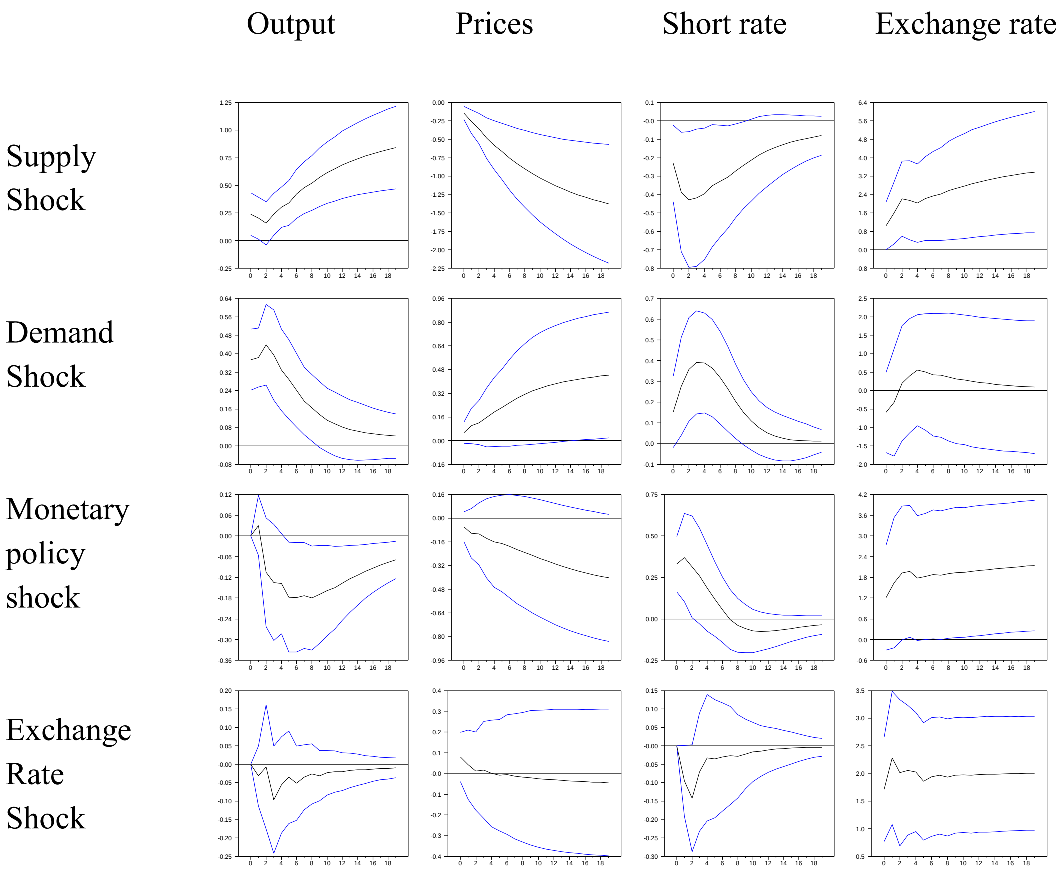
[8] $$\varepsilon_t^Y = \left[\varepsilon_t^s \quad \varepsilon_t^d \quad \varepsilon_t^p \quad \varepsilon_t^x\right]$$

with ε_t^s denoting a supply shock, ε_t^d a demand shock, ε_t^p a monetary policy shock, and ε_t^x an exchange rate shock. A typical restriction consistent with many macro-economic models is that only supply shocks have permanent effects on output, while demand, monetary policy and exchange rate shocks have zero impact on output in the long run (Blanchard and Quah, 1989). In order to discriminate between the aggregate demand shocks and the two other shocks, we use, as before, the restrictions that the latter two have no contemporaneous impact on output. Finally, in order to distinguish between the monetary policy shock and the exchange rate shock we assume, as in the basic model, that the interest rate is not contemporaneously affected by disturbances in the exchange rate.

Graph 5

Estimated impulse response functions for the euro area

(Estimation period: 1980-1998; short and long-run restrictions)



Note: 90 % confidence bands.

The results are reported in Graph 5. In the first row, we find the responses of output, prices, the interest rate and the exchange rate to a supply shock. As the textbook model predicts, a supply shock has a positive influence on output and a negative effect on prices.

Both variables reach a peak about three years after the shock and stabilize at that level subsequently. In line with lower inflation, the nominal interest rate also decreases following the supply shock. The response to a positive aggregate demand shock is given in the second row. Its effect on output dampens out after 4 to 5 years. This shock also leads to a rise in inflation and the nominal interest rate. The impact of a monetary policy shock (third row of Graph 5) is qualitatively comparable with the previous results. The impact on output is, however, somewhat more prolonged with a peak effect between five and eight quarters. The effect on prices is quantitatively much stronger and more immediate. This appears to be mostly due to the stronger and more persistent appreciation of the exchange rate. These results are broadly consistent with the findings of previous studies using this identification strategy as in Gali (1992) and Gerlach and Smets (1995).

3.2.3. Comparing the monetary policy shocks across models

Table 2 reports the correlations of the monetary policy shocks of the alternative identification strategies. Overall, the correlation of these shocks is quite high. The correlation is the weakest between the shocks derived from contemporaneous restrictions and those derived from the mixed short-long run restrictions.

Table 2

Correlations of policy shocks obtained under alternative identification strategies

	1	**2**	**3**	**4**
1. Benchmark model 1	1.00	0.95	0.91	0.71
2. Benchmark model 2 (+ money)		1.00	0.85	0.67
3. Sims-Zha			1.00	0.73
4. Short and long-run restrictions				1.00

4. The effect of monetary policy on other macro variables

4.1. The extended model

In this section, we discuss the influence of a monetary policy shock on other macroeconomic variables that are not included in the basic model. We do this by extending the basic model as follows:

[9] $$\begin{bmatrix} Y_t \\ Z_t \end{bmatrix} = \begin{bmatrix} A(L) & 0 \\ C(L) & D(L) \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ Z_{t-1} \end{bmatrix} + \begin{bmatrix} B(L) \\ E(L) \end{bmatrix} X_t + \begin{bmatrix} \mu_t^Y \\ c\mu_t^Y + \mu_t^Z \end{bmatrix}$$

As before, X_t and Y_t are respectively the vector of exogenous and endogenous variables. Z_t is the macro-economic variable of interest (for example investment). To keep the policy shock invariant to the inclusion of the different Z_t's, we assume that the macro-economic variable of interest does not affect the block of endogenous variables, Y_t.[12]

4.2. Components of GDP

Graph 6 shows the effects of an area-wide monetary policy shock on *the various components of GDP* (total real GDP, total investment, private consumption and net trade). The impulse response pattern of total investment is similar to the response of real GDP. However, the magnitude of the effect on investment is three times as large as the magnitude of the effect on GDP. After a typical monetary tightening of 30 basis points, investment falls by around 50 basis points. In contrast, the response of private consumption is weaker and slower. Consumption starts decreasing after two quarters and reaches its minimum impact after five quarters. Finally, following an initial negative impact, the net trade position improves significantly in line with the fall in domestic demand and associated imports.

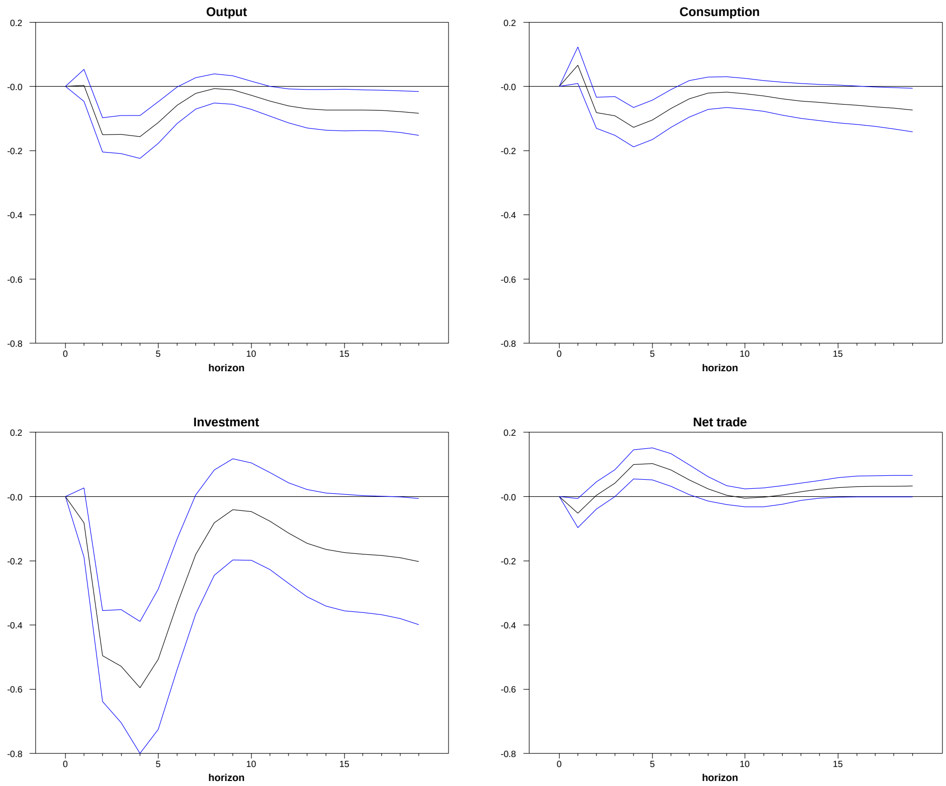
The influence on *total manufacturing and investment and consumption goods* in manufacturing is shown in Graph 7. As expected, the response of total manufacturing is larger than the response of real GDP (a peak of about 50 basis points after a monetary tightening of 30 basis points). Again, we find a significantly stronger impact on investment goods than on consumption goods.

[12] We have also estimated alternative VARs where the additional macroeconomic variable is included in the endogenous block of the model. In that case, this variable is ordered as the last one in the recursive structure ($F(L) \neq 0$). The results are very similar.

Graph 6

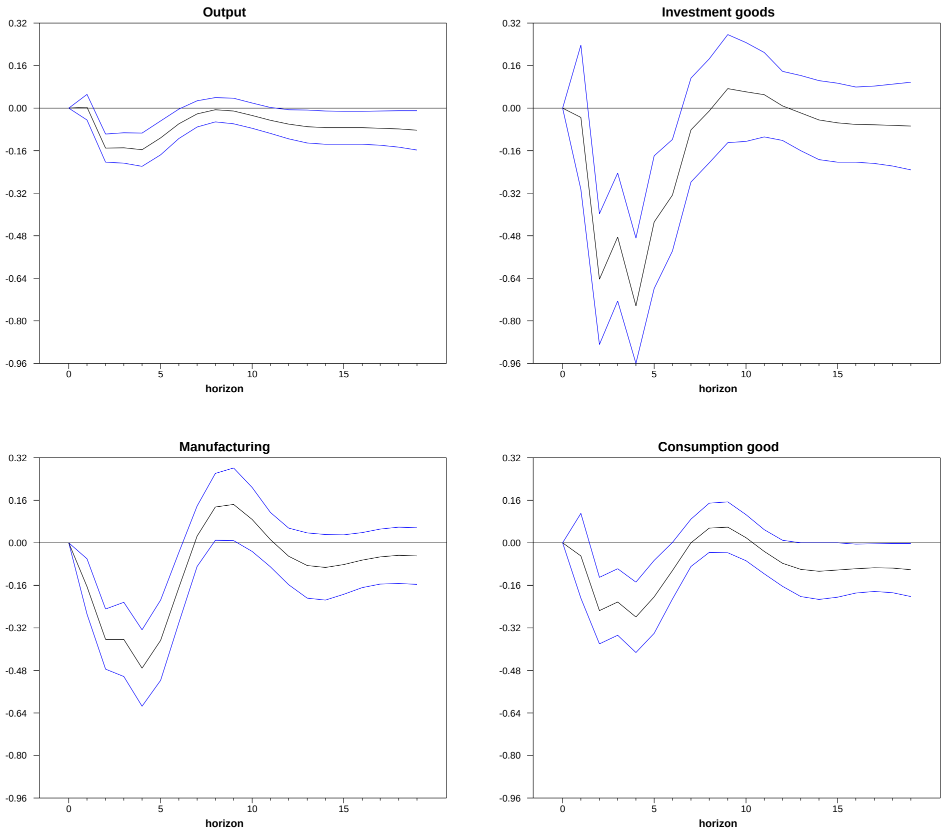
The effects of a monetary policy shock on components of GDP

(Estimation period: 1980:1-1998:4)



Note: 90 % confidence bands.

Graph 7
The effects of a monetary policy shock on manufacturing
(Estimation period: 1980-1998)



4.3. Monetary variables and asset prices

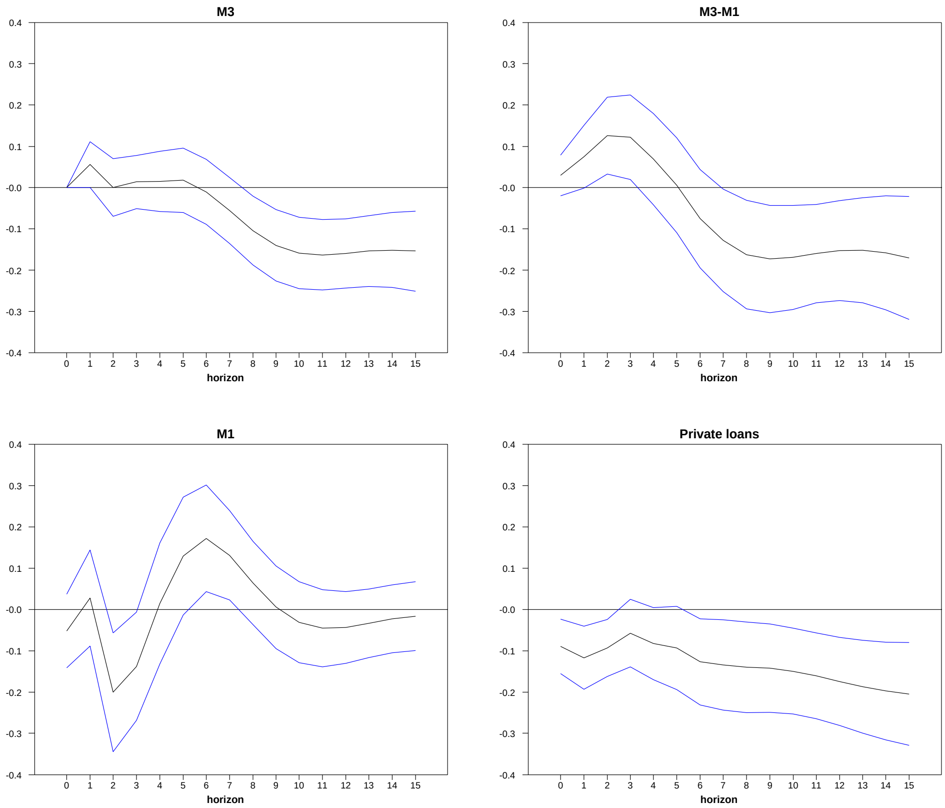
The impulse response functions of *M3, its components and loans to the private sector* to a contractionary monetary policy shock are presented in Graph 8. We find a negative, but not very significant, liquidity effect on M1, which appears to be robust to alternative identification schemes. The slow response of M3 is clearly due to the initial increase in the other components of M3. An interest rate tightening gives rise to substitution effects from money components that bear no or regulated interest to time deposits and money market funds that are included in the broader money aggregates. This finding is consistent with the literature on euro area money demand.[13] There is an immediate and negative effect on credit to the private sector.

13 For example, Fase and Winder (1992) find a negative relationship between M1 and the short-term interest rate, while the relation between M3 and the short-term interest rate is positive.

Graph 8

The effects of a policy shock on monetary variables

(Estimation period: 1980-1998)

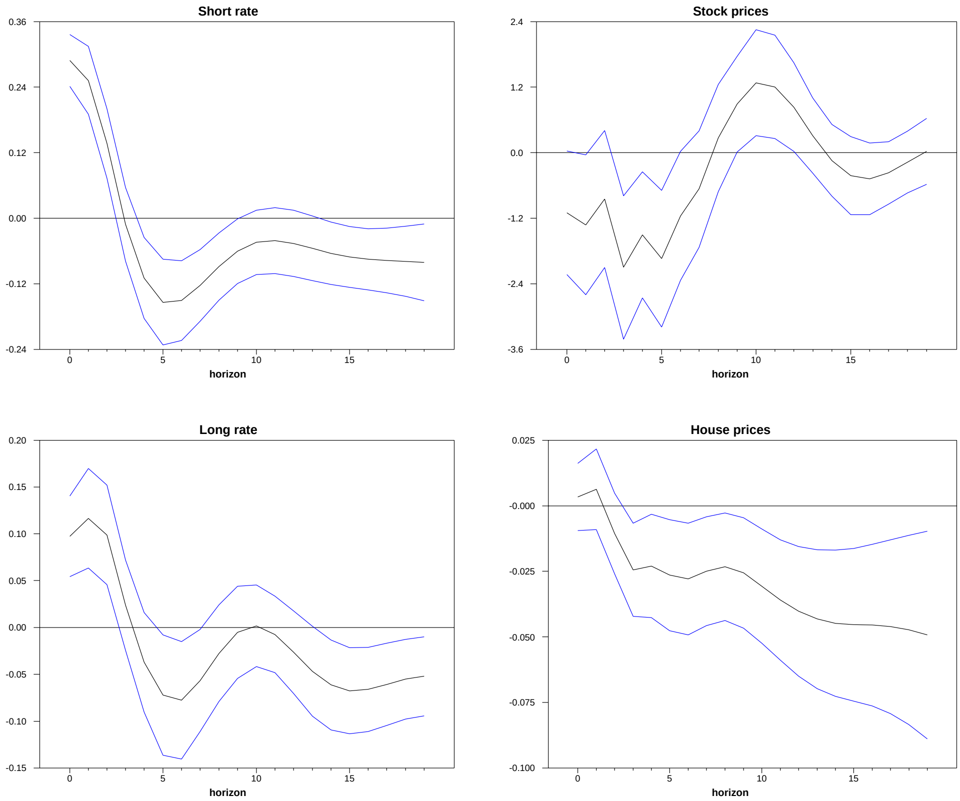


Graph 9 plots the response of various asset prices to a temporary monetary policy tightening. The increase of the short rate by 30 basis points is accompanied by a similar, but smaller increase in the long-term rate by about 10 basis points, as one would expect on the basis of the expectations hypothesis of the term structure of interest rates. As expected, stock markets fall immediately and quite strongly after a monetary policy tightening. In contrast, house prices fall much more gradually.

Graph 9

The effects of a policy shock on asset prices

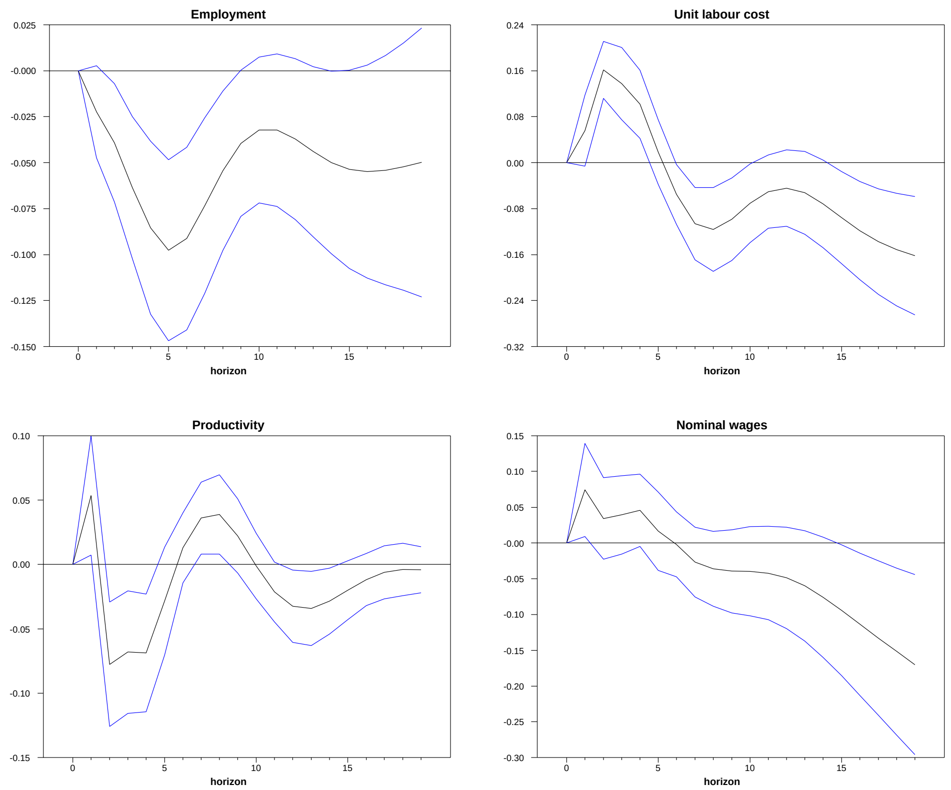
(Estimation period: 1980-1998)



4.4. Labour market variables

Finally, Graph 10 reports the impulse responses to a monetary policy shock of selected labour market variables: employment, labour productivity, unit labour cost and nominal wages. The pattern of employment is very similar to that of output. However, the quantitative effect on employment is less, resulting in a pro-cyclical movement of labour productivity. This pro-cyclical behaviour of labour productivity, together with the slight price puzzle that one can observe in the response of nominal wages, implies that unit labour costs rise quite significantly before falling back below base line.

Graph 10
The effects of a policy shock on other variables
(Estimation period: 1980-1998)



4.5. Individual country effects

The results discussed in the preceding sections of this paper are based on synthetic, euro area wide time series variables. Before concluding the analysis, it may be useful to check how output and prices in the individual countries of the euro area are affected by the common monetary policy shock defined in Section 2. For that purposes we include output and prices of each country in the extended model of Section 4.1. and calculate their response to the identified euro area monetary policy shock.

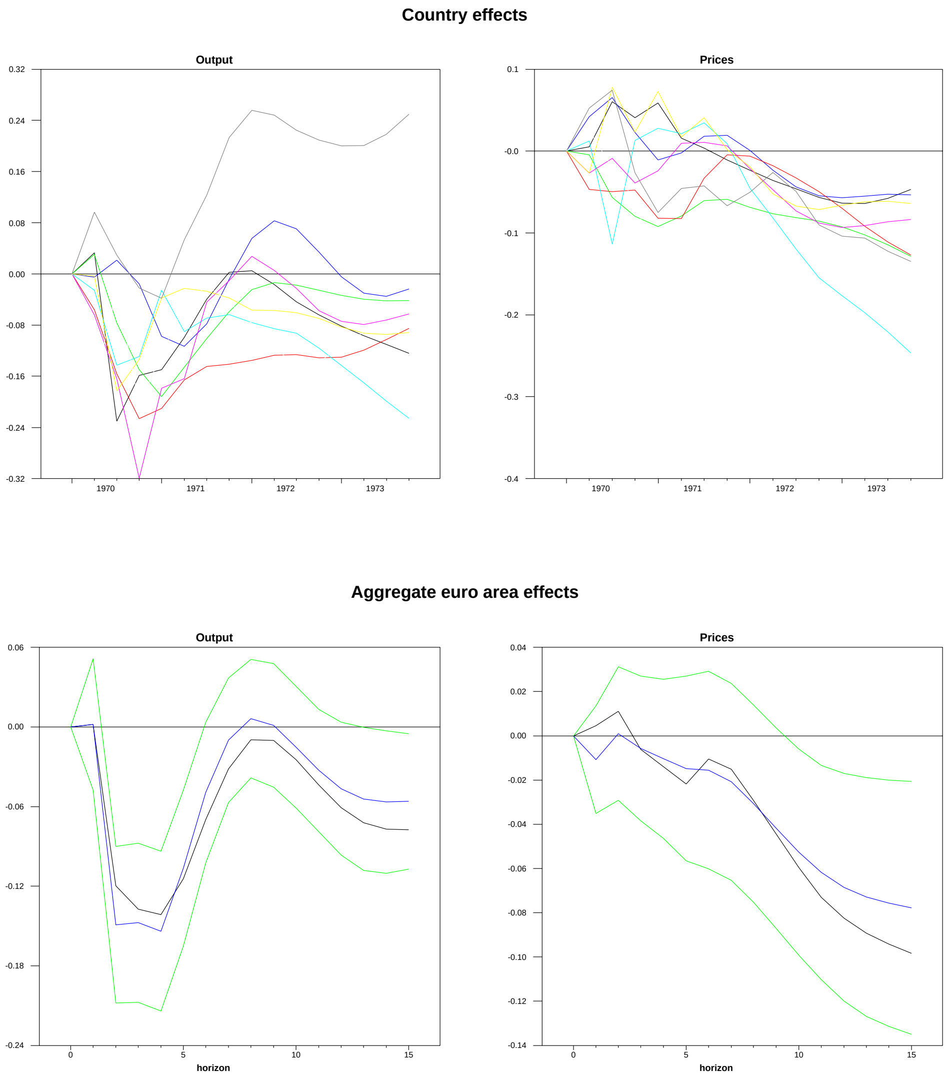
The results are summarised in Graph 11. The upper row plots the individual country effects, while the lower row compares the aggregate effects based on the area-wide benchmark model with the aggregation of the individual country effects using similar weights. From the upper part of Graph 11 it is clear that there is a quite large variability in how output and prices in the individual countries respond to the euro area policy shock. Nevertheless, with a few exceptions, the overall pattern of the responses are similar:

output falls quite quickly, while prices take more time to respond. When aggregating those responses across countries, one basically retrieves the area wide responses discussed in Section 2.

Graph 11

The effects of the area-wide policy shock on individual countries

(Estimation period: 1980-1998)



5. Concluding remarks

In this paper, we have estimated an identified VAR on synthetic euro area data from 1980 till 1998 to study the macro-economic effects of a monetary policy shock in the euro area. Using several standard identification schemes, we uncover plausible impulse responses of the main macro-economic variables to an unexpected monetary policy tightening in the euro area. A temporary rise in the nominal and real short-term interest rate tends to be followed by a real appreciation of the exchange rate and a temporary fall in output. Prices are more sluggish and only start to fall significantly below zero several quarters after GDP. These results are very similar to those obtained for the US economy using similar methodologies. These results appear to be stable over different sample periods.

We also investigated the reaction of other macro variables and the GDP components to a monetary policy shock. The response of output is mainly due to a decrease in investment which responds with a magnitude three times as large as GDP, and to a lesser extent in private consumption. Employment falls in line with GDP, but less strongly which results in a pro-cyclical response of labour productivity. We find an immediate liquidity effect on M1, but a more gradual decrease of M3 and other credit aggregates. The long-term interest rate shows a muted response to the temporary rise in the short-term interest rate consistent with the expectations theory of the term structure. Share prices fall significantly on impact, while house prices respond more sluggishly.

Overall, these findings are encouraging and show in our view that the results from applying standard techniques to synthetic euro area data can be used as a benchmark for the further theoretical and empirical analysis of the transmission mechanism in the euro area. Of course, the caveats that come with this analysis are even more important in this case. In particular, we know that there was no common monetary policy in the euro area over the estimation period, so that identifying monetary policy innovations on the basis of an aggregate monetary policy reaction function may be problematic. It is therefore important to monitor how these results change as data from the new single monetary policy regime come in. In addition, the aggregate analysis results need to be complemented with a more disaggregated investigation that takes the features of the national monetary policy regimes into account. Recent work in that respect can be found in Sala (2001), Rebucci and Ciccarelli (2001) and Mojon and Peersman (2001).

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