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The Transmission of Monetary and Technology Shocks in the Euro Area*

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Abstract

We build structural VARs for the euro area to analyze the responses of a set of euro area macroeconomic variables to monetary policy and technology shocks. We then test their robustness to different specifications of hours worked, sample periods and the definition of the variables used. We conclude that while the responses to monetary policy shocks appear to be broadly robust, the responses to technology shocks crucially depend on whether hours worked are introduced in levels or in first differences.

JEL Classification: E32

Keywords: technology and monetary shocks, euro area, long-run restrictions

1 Introduction

The purpose of the study is to analyze the dynamic response of a set of euro area macroeconomic variables to monetary policy and technology shocks. We start by developing structural VAR models for the euro area that allow the identification of monetary and technology shocks. The shocks are identified by imposing model-consistent zero restrictions (both in the short-run and the long-run) in the line of recent studies (e.g. Altig, Christiano, Eichenbaum and Linde, 2004). Previous work on structural VARs in the context of the euro area includes Peersman and Smets (2001) who, however, do not attempt to estimate technology shocks, and Peersman and Straub (2004) who estimate both monetary and technology shocks using model-based sign restrictions.

Our VARs include measures of labor productivity, hours worked (per capita), inflation, consumption to output ratio, investment to output ratio, capacity utilization, productivity to

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real wage ratio, interest rate and money velocity. One requirement in the use of the methodology is that all of the variables included in the VAR be stationary. From the statistical analysis conducted we are able to distinguish between stationary variables and non-stationary ones with the exception of hours worked per capita for which the results of unit root tests are ambiguous. As a consequence, we choose to work with two specifications, one assuming that hours are stationary and the other assuming they are non-stationary. We show that the dynamic responses to a monetary policy shock are not very sensitive to this assumption. In addition, some of the responses of the variables to a technology shock are also robust to changes in the stationarity assumption for hours. However, as in the related literature, we find that the response of hours worked to a neutral technology shock depends on the stance taken to the stationarity of hours. If hours are assumed to be stationary, then a positive technology shock leads to an increase in hours worked. If they are non-stationary, then hours decline in response to positive technology shocks. The latter outcome is somewhat disturbing as it would suggest that positive technology shocks lead to a reduction in the amount of labor used in the economy. It also would question the Real Business Cycle (RBC) paradigm, which attributes a significant importance to technology shocks in generating business cycles.

2 Identification of shocks

In the identification of the technology and the monetary policy shocks, we follow the methodology of Altig et al (2004). The analysis is based on the following reduced-form VAR,

$$Y_t = \eta + B(L)Y_{t-1} + u_t, \quad E u_t u_t' = V \quad (1)$$

where $B(L)$ is a polynomial of order q in the lag operator, L , u_t is the vector of the one-step-ahead forecast errors to Y_t . The Y_t vector is defined as,

$$\underbrace{Y_t}_{9 \times 1} = \begin{pmatrix} \Delta \ln(GDP_t/\text{Hours}_t) \\ \ln(\text{Hours}_t) \\ \Delta \ln(GDP \text{ deflator}_t) \\ \ln(C_t/GDP_t) \\ \ln(I_t/GDP_t) \\ \text{Capacity Utilisation}_t \\ \Delta \ln(GDP_t/\text{Hours}_t) - \ln(W_t/P_t) \\ \text{Interest Rate}_t \\ \Delta \ln(GDP \text{ deflator}_t) + \ln(GDP_t) - \ln(M1_t) \end{pmatrix}$$

Starting with the monetary policy shocks, we identify monetary policy shocks as deviations from a policy rule that is assumed to be followed by policymakers (see Christiano, Eichenbaum and Evans, 1999):

$$R_t = f(\Omega_t) + \varepsilon_{Rt}$$

where R_t is the interest rate, f a linear monetary policy rule, which is a function of the information set Ω_t available to the policymakers. ε_{Rt} is the monetary policy shock.

The identification of the monetary policy shocks is achieved by assuming that ε_{Rt} is orthogonal to the information set Ω_t . In addition, we require that the only date t variables in the information set are productivity, measures of economic activity (hours, capacity utilization), wages and inflation. We assume that the central bank does not react contemporaneously to velocity shocks.

In identifying the technology shock, we follow much of related literature by imposing the restriction that only technology shocks can affect labor productivity in the long run. In implementing it, we pursue the methodology advocated by Shapiro and Watson (1988). The structural representation of the VAR models we use can be written as:

$$A_0 Y_t = A(L) Y_{t-1} + e_t, e_t = \begin{bmatrix} \underbrace{e_{zt}}_{(1 \times 1)} \\ \underbrace{e_{1t}}_{(6 \times 1)} \\ \underbrace{e_{Rt}}_{(1 \times 1)} \\ \underbrace{e_{2t}}_{(1 \times 1)} \end{bmatrix}$$

where the structural shocks, e_t , which are unobservable, are assumed to be mutually independent and related linearly to the one-step-ahead forecast errors, u_t :

$$u_t = C e_t, \quad E e_t e_t' = I.$$

The parameters of the structural form are therefore linked to those of the reduced form by:

$$C = A_0^{-1}, B(L) = A_0^{-1} A(L) \tag{2}$$

where the first and eighth columns of C are the objects we need to uniquely identify in order to compute the impulse responses pertaining to a technology and monetary shocks, respectively. It turns out that we need to estimate A_0 in order to estimate the technological and monetary shocks as well as their dynamic effects on Y_t . The identifying restrictions laid down above impose the following structure on the matrix A_0 :

$$A_0 = \begin{bmatrix} \underbrace{A_0^{1,1}}_{(1 \times 1)} & \underbrace{A_0^{1,2}}_{(1 \times 1)} & \underbrace{A_0^{1,3}}_{(1 \times 6)} & \underbrace{0}_{(1 \times 1)} & \underbrace{0}_{(1 \times 1)} \\ \underbrace{A_0^{2,1}}_{(6 \times 1)} & \underbrace{A_0^{2,2}}_{(6 \times 1)} & \underbrace{A_0^{2,3}}_{(6 \times 6)} & \underbrace{0}_{(6 \times 1)} & \underbrace{0}_{(6 \times 1)} \\ \underbrace{A_0^{3,1}}_{(1 \times 1)} & \underbrace{A_0^{3,2}}_{(1 \times 1)} & \underbrace{A_0^{3,3}}_{(1 \times 6)} & \underbrace{A_0^{3,4}}_{(1 \times 1)} & \underbrace{0}_{(1 \times 1)} \\ \underbrace{A_0^{4,1}}_{(1 \times 1)} & \underbrace{A_0^{4,2}}_{(1 \times 1)} & \underbrace{A_0^{4,3}}_{(1 \times 6)} & \underbrace{A_0^{4,4}}_{(1 \times 1)} & \underbrace{A_0^{4,5}}_{(1 \times 1)} \end{bmatrix}$$

As seen above, we assume that in the short-run real economic activity and prices do not react contemporaneously to monetary policy shocks or to shocks to money velocity, which explains the zero restrictions on the first seven rows of the two last columns of the A_0 matrix above.

The restriction that technology shocks (e_{zt}) are the only shocks having a non-zero effect on labour productivity in the long-run implies that the matrix $A_0 - A(1)$ has all zeros in the first row except in the (1,1) element.

3 Data

3.1 Description

The data used in the paper refer to the current twelve euro area member states for the period from the first quarter of 1970 to the third quarter of 2004. For periods prior to 1999, the data correspond to an aggregation of the available country series.

As far as possible we used official statistical sources, such as the Eurostat, the ECB, the European Commission and the OECD. However, euro area series at a quarterly frequency are often available only for a relatively short time-span and we had to backdate a number of series. To do this we relied mostly on the database by Fagan, Henry and Mestre (2001) (hereafter Area-Wide Model (AWM) database). This was the case of the Eurostat national account series in volume, which only start in 1991 and therefore had to be chained backwards. Therefore, some caution is needed when analyzing the data in the beginning of sample, not only due to methodological considerations but also because country data availability becomes scarcer as we move back in time.

Regarding national accounts deflators, the Eurostat series were chain linked with ECB data, which corrects for exchange rate variations among member countries in the period prior to 1999. Data on the compensation per employee are published by the ECB. The series starts in the first quarter of 1991, and was chain-linked with data from the AWM database. The euro area capacity utilization series is published by the European Commission and is available since 1985. For the earlier periods we constructed a *proxy* for the euro area aggregate based on available data for the member countries. The monetary aggregates series are published by the ECB. The

short-term interest rate series used is the three-month Euribor provided by *Bloomberg* and for periods before 1999 we used data from the AWM database.

One important novelty in this paper is the use of a quarterly series for hours worked in the euro area. As there is no official series of average hours worked in the euro area we had to construct a new series. To do this we used country data on average hours worked per person in employment published by the OECD. However, and as mentioned by the OECD, there are significant differences in the sources and coverage of national data, implying that comparisons of the level of average hours worked across countries are probably not suitable. Therefore, we aggregated the quarterly rates of change of country series based on the euro area structure of employment (across countries) to get an index of average hours worked in the euro area.¹ Finally, we obtain per capita hours by multiplying average hours per persons in employment by total employment and then dividing by working age population.

All variables are in logarithms, except for the short-term interest rate. Inflation is measured as annualized quarterly changes in the logarithm of the GDP deflator.

3.2 Low-Frequency Properties of the Variables

A proper identification of the monetary and technology shocks requires all variables in the VAR to be stationary. Looking at figure 1 it is apparent that while some variables seem clearly stationary, others less so. Among the variables that do not look stationary, some seem to be driven by deterministic trends.

In order to ascertain as accurately as possible the low-frequency properties of the data, we carry out a series of formal tests in pursuit of sources of nonstationarity in the data. The strategy we put in place to unveil the low-frequency properties of the series consists of three main steps. First, we apply a battery of unit root tests to distinguish the stationary from the nonstationary variables in the sample. Second, we test for the presence of linear or quadratic deterministic trends among the variables labeled as nonstationary. Lastly, whenever significant, the deterministic trends are removed and the unit root tests re-run². After the de-trending process, the variables that remain nonstationary according to the unit root tests are first-differenced and so employed in the VAR.

On a first passage, we subject each variable to three distinct unit root tests, namely the

¹The behavior of the constructed series seems reasonable, namely when compared with the one of the ECB's estimate of euro area average hours worked published in the October 2004 Monthly Bulletin. The ECB used annual data from the European Labor Force Survey, which is available only at annual frequency and for a relatively short time span.

²Since the presence of deterministic trends affects the power of the unit root tests, and the presence of unit roots tampers inference on the significance of deterministic trends by altering the sampling distribution of the relevant test-statistics, we also tried to apply the unit root tests after looking for the presence of deterministic trends. Although not reported here, inverting the testing sequence did not alter the outcome regarding the low-frequency properties of all our variables.

Variable	Test-Statistic		
	ADF	PP	KPSS
Productivity growth	-9,35***	-9,88***	1,25***
Hours	-2,98**	-3,60***	1,25***
Inflation	-0,99	-2,40	1,23***
Consumption/GDP	-2,78*	-2,78*	0,24
Investment/GDP	-2,50	-1,71	0,80***
Capacity Utilization	-3,98***	-3,40**	0,13
Productivity/Real Wage	-0,77	0,45	1,30***
Interest Rate	-1,66	-1,26	0,69**
Money Velocity	-1,11	-1,38	0,60**

*, **, ***, denote rejection at the 10%, 5%, 1% significance level, respectively.

Table 1: Unit Root Tests

Augmented Dickey-Fuller (ADF), the Phillips-Perron (PP), which have unit root as the null hypothesis, and the Kwiatkowski, Phillips, Schmidt and Shin (1992) (KPSS), which has stationarity as the null hypothesis. The results of these tests are summarized in table 1³.

The joint results of the three tests summarized in table 1 suggest that stationarity in levels is beyond doubt only in the case of capital utilization. On the other hand, inflation, investment to output ratio, productivity to real wage ratio, the interest rate and money velocity, all seem to be nonstationary. The less clear cut cases pertain to productivity growth, hours per capita, and consumption to output ratio.

In order to analyze the borderline cases, it should be borne in mind that the KPSS test has severe size-distortions for highly persistent, albeit stationary series⁴. In this context, we decide in favor of stationarity of productivity growth and consumption to output ratio, given the relatively high values of the test statistics of the ADF and PP for these two series, in spite of the evidence against stationarity of the KPSS test. As for the per capita hours series, the picture emerging from the tests is more blurred. In fact, while the ADF and PP test point to the stationarity of per capita hours, the plot and the KPSS test strongly suggest otherwise. For the remaining variables, namely, inflation, investment to output ratio, productivity to real wage ratio, interest rate, and money velocity, the outcome of the tests are overwhelmingly in favor of nonstationarity of the series. We then gather the nonstationary variables (and per capita hours) and search for the presence of significant deterministic components.

³The reported tests include a constant, but no time trend.

⁴This problem is well documented in Kwiatkowski et al. (1992) and Caner and Kilian (2001).

Variable	Zivot-Andrews Test	
	ADF-statistic	Break Date
Hours	-3,75	1983Q1
Inflation	-6,23***	1997Q1
Investment/GDP	-4,25*	1981Q4
Productivity/Real Wage	-4,72**	1974Q4
Interest Rate	-4,17*	1980Q1
Money Velocity	-2,07	1990Q3

Table 2: Tests of Unit Root v Broken Trend Stationarity

Since none, among the group of nonstationary variables, seems to have a linear trend along the whole sample, we resort to the procedure proposed by Zivot and Andrews (1992) that enables to test the null of a unit root against the alternative of stationarity about a broken linear trend. In particular, this procedure estimates the (single) break date that maximizes the evidence against the null of nonstationarity, computes an ADF-type test-statistic and provides the relevant critical values⁵. The outcomes of the application of the Zivot and Andrews test to the group of nonstationary variables are summarized in table 2.

Based on the results of table 2, we take the variables inflation, investment to output ratio, productivity to real wage ratio and the interest rate to be stationary around a broken linear trend. It follows that the broken trends have to be estimated and then removed before the relevant variables are included in the VAR. As regards hours and money velocity, it seems that a broken linear trend is not enough to induce stationarity to these variables. In the case of money velocity, graphical inspection of the series suggests that a quadratic trend might be a better characterization of the deterministic components at play. In fact, the inclusion of a quadratic trend is found to be highly significant and to make detrended money velocity stationary⁶.

To sum up, to estimate the VAR we use productivity growth, consumption to output ratio, capital utilization as in their original series. For the variables, inflation, investment to output ratio, productivity to real wage ratio and the interest rate, broken linear trends must be estimated and removed, whilst for money velocity a quadratic trend must be extracted. As for per capita hours, since there is conflicting evidence on its stationarity, we run a version of the VAR with hours in first-differences and another with hours as in its original series.

⁵As suggested by Zivot and Andrews (1992), the break date is searched between the 15th and the 85th percentile of the sample.

⁶The ADF test-statistic for money velocity after removing the estimated quadratic trend is -1.95 , thereby implying the rejection of the null of unit root at the 5% significance level.

4 Benchmark specifications

In this section, we report the responses of our set of macroeconomic variables to a monetary shock and a neutral technology shock. In the following description of the results, we concentrate on the first 20 quarters after the occurrence of each shock. Since we abstain from taking a stand on the stationarity of per capita hours, we estimate two specifications of the VAR. One with hours in first-differences (henceforth DSVAR) and another with hours in levels (henceforth LSVAR).

4.1 Impulse responses to a monetary policy shock

The responses of the variables to the monetary shock for the DSVAR and the LSVAR specifications are shown in figures 2 and 3 respectively. In all those figures the solid lines depict point estimates and the gray areas their respective 95% confidence bands⁷. The responses of all variables are measured in percentages, except the interest rate, which is measured in basis points. In both cases the one-standard deviation monetary policy shock is estimated to be around 40 basis points which is somewhat higher than the estimate of 30 basis points obtained by Peersman and Smets (2001).

Starting with the DSVAR, the first thing to notice is that only money growth and velocity react contemporaneously to the monetary policy shock, a feature that stems directly from our identifying assumptions. Not surprisingly, the expansionary monetary shock induces a liquidity effect that fades away in tandem with the nominal interest rate. The response of inflation is characterized by a fall on impact followed by a rebound that takes approximately two years to reach its peak⁸. Moreover, output, consumption, investment, hours per capita and capacity utilization all exhibit hump-shaped responses that in general (with the exception of consumption) take approximately one-and-half years to get to the peak. Notice that, as expected, investment responds in a quantitatively stronger fashion than consumption. Surprisingly, the very short run reaction of real wages is to decline and that is in spite of inflation falling in the same time frame. That effect is reversed soon thereafter so that real wages' response goes into positive territory. Finally, it must be said that, although the qualitative pattern of the responses to a monetary policy shock does not change much when the LSVAR specification is adopted (see figure 3), in quantitative terms it seems that this latter specification yields stronger responses than the DSVAR.

⁷These bands were computed by bootstrap simulation with 2.000 draws.

⁸An initial negative response of inflation to an expansionary policy shock has been dubbed as the 'price puzzle'. This effect has also been identified in several empirical studies for the US (see e.g. Altig et al., 2004).

4.2 Neutral technology shock

The responses of the variables to the neutral technology shock for the DSVAR and the LSVAR specifications are shown in figures 4 and 5 respectively. According to figure 4, the impact of a one-standard deviation positive technology shock using the DSVAR is to generate a steady increase in output that reaches roughly 0.8% after 20 quarters. There is also a positive permanent effect on real wages, consumption and investment, as expected. It is still worth noting that, contrary to what the RBC paradigm predicts, the impact on inflation is not statistically different from zero throughout. Per capita hours endure what seems to be a permanent fall, a result similar to the one reported by Galí (2004) for the euro area⁹. This outcome is somewhat disturbing given that, if true, it means that positive technology shocks generate a lasting drop in the amount of labor input used in the economy. Moreover, and as a corollary, it renders the RBC paradigm useless in accounting for the empirical stylized fact of the pro-cyclicality of hours worked, since this paradigm attributes a significant importance to technology shocks in generating the business cycles. Turning now to figure 5, we immediately conclude that the effects of a technology shock on hours differ substantially when the specification adopted is the LSVAR. In fact, hours worked rise in response to a positive technology shock instead of declining. The response of inflation is to fall on impact and to gradually recover towards zero through time, and capacity utilization shows a hump-shaped positive response. The trajectories of the remaining variables are not too different from those obtained with the DSVAR.

To conclude, in spite of the qualitative pattern of the responses to the monetary shock being robust to hours per capita entering the VAR in levels or first-differences, the choice between the DSVAR or the LSVAR specifications matters when technology shocks are considered. That is because the predictions of the effects of a neutral technology shock, particularly on per capita hours, inflation, and capacity utilization are completely different across the two alternative specifications. The question of whether the variable that measures the labor input should enter in levels or first-differences is beyond the scope of this paper¹⁰. It is still worth mentioning that Peersman and Straub (2004), using an identification procedure based on sign-restrictions, find that hours worked (or employment) rise in the wake of a technology shock regardless of hours entering in levels or first-differences.

5 Robustness tests

This section tests the robustness of the impulse responses obtained with the two VAR specifications with respect to different sample periods and also to different definitions of some variables. The sample period tests consist of estimating the impulse responses recursively for different samples. Two exercises were conducted. In a first exercise, the start of the sample is progressively

⁹This is so in spite of Galí (2004) using employment rather than hours as the measure of labor input.

¹⁰This issue is thoroughly discussed in Alves, de Brito, Gomes and Sousa (2006).

increased while maintaining the end of the sample unchanged. In a second exercise, the end of the sample is progressively decreased while the start of the sample is kept unaltered.

5.1 Recursive estimation with increasing start of sample

The DSVAR impulse responses for the monetary policy shock and the technology shock estimated with a sample recursively starting in the first quarter of 1970 up to the last quarter of 1979 and ending in the third quarter of 2004 are shown in figures 6 and 7, respectively. Starting with the monetary policy shock, as seen in figure 6, the qualitative responses of the variables seem broadly to follow the patterns of the benchmark model. As for the the technology shock, the results show that, at least in a qualitative sense, in several cases the impulse responses are robust to the different starting points. However, there seems to be some uncertainty regarding the magnitude of the responses of output, consumption and investment. In addition, the responses of money velocity and the interest rate appear to be somewhat erratic, which is consistent with the full-sample result that they are not significantly different from zero.

Figures 8 and 9 show the results for the LSVAR. As regards the responses to monetary policy shocks, the main issue is that for some sample periods the effect of the monetary policy shock on real output, hours, consumption and investment seems to fade away more quickly (about 6 quarters) than in the baseline model. As for the neutral technology shock, the main qualitative observation is that the response of hours is not robust to different starting periods. In fact, for some observations, hours worked seem to decline or remain unchanged in response to a positive technology shock, which contrasts with the case of the full sample LSVAR model according to which hours rise in response to a positive neutral technology shock.

5.2 Recursive estimation with decreasing end of sample

Figure 10 shows the impulse responses of the monetary policy shock for the DSVAR model estimated with a sample starting in the first quarter of 1970 and with a decreasing end of sample (backwards from the last quarter of 2004 to the fourth quarter of 1997). From figures 6 and 10, it can be concluded that the impulse responses of most variables are more robust to changes in the end of sample than to the beginning of the sample. As for the technology shock (see figure 11), there are some signs of instability in the responses of hours, with some responses pointing towards a decline, others to no change or even a slight increase. Similarly, the response of capacity utilization is no longer unambiguously negative.

The recursive impulse responses for the LSVAR model are shown in figures 12 and 13. As seen in the figures, and similarly to the results obtained with the DSVAR, the responses to monetary policy shocks appear to be quite robust to the changes in the sample period. The same applies to the responses to the technology shocks. By contrast with the results of the DSVAR, hours worked now unambiguously rise in response to a neutral technology shock, irrespective of the

ending period.

5.3 Variable Specification

5.3.1 Different measures of the labor input

As in much of the related literature, we find that the effect of a technology shock on per capita hours worked depends on whether hours are included in the VAR estimation in levels, or first-differences. Given the importance attributed in the literature to this dichotomy, we test the robustness of this and other results to the use of alternative measures of the labor input¹¹. More specifically, we redo our VAR analysis considering alternatively detrended log per capita hours¹² and the first-difference of log per capita employment¹³.

Although not shown, the robustness of the effects of the monetary policy shock to the use of hours either in levels or first-differences is extended to the inclusion of the two alternative measures of the labor input. In fact, the qualitative pattern of the responses of all variables is not significantly altered by the consideration of either detrended per capita hours or employment per capita in first-differences.

As for the effects of a positive technology shock, recall that the main dissimilarities between using per capita hours in levels and in first-differences is that, in the former case, hours and capacity utilization rise, and inflation declines; and in the latter case, hours drop, and the changes in capacity utilization and inflation are not significantly different from zero. It turns out that the qualitative pattern that comes out of using any of the two alternative measures of the labor input is broadly similar to the one found for the inclusion of hours in first-differences.

5.3.2 Different measures of the money aggregate

Replacing the measure of money M1 by the broader measure M3 does not impart any significant change to the pattern of the effects of the monetary shock on all variable, except money growth. In fact, the liquidity effect that follows a monetary impulse is greater and more protracted when we use the M1 rather than the M3 measure of money.

¹¹Notice that changing the definition of the labor input requires re-specifying productivity and nominal wage variables accordingly.

¹²Given the shape of the plot of per capita hours, we found suitable to estimate a broken trend. In this context, we picked the break date resulting from the application of the Zivot-Andrews unit root test to per capita hours.

¹³This latter measure is considered in first differences because it has been found to be nonstationary (even after allowing for a linear broken trend). Notice that this measure corresponds to the one used by Galí (2004) in a similar context for the euro area.

6 Variance Decompositions

We now return to the benchmark specifications of the DSVAR and LSVAR to assess the contribution of the monetary and technology shocks to the forecast errors variance of the variables included in our VARs. Table 3 summarizes the results for both the DSVAR and the LSVAR specifications.

Before describing the evidence obtained for both VAR specifications it is useful to explain some patterns of the results that stem directly from the identification strategy. First, the contribution of the monetary shock to the fluctuations of the variables above the interest rate in the VAR list in equation (1) on impact (i.e. period 1) is zero. That follows from our timing assumption that those variables react to monetary shocks only with a lag. Second, the contribution of the technology shock to the fluctuations in output increases as we move forward in the horizon, a feature that stems from our identifying assumption that these shocks are the sole source of the unit root in labor productivity.

From table 3 it is worth highlighting that technology shocks play a significant role in explaining the fluctuations of output, hours worked and real wages, although their magnitude differs somehow in the two VAR specifications. This result, which is predicted by the RBC paradigm, contradicts that of Galí (1999) for the U.S., but is consistent with the evidenced gathered by Altig et al. (2004) for the U.S. and Peersman and Straub (2004) for the euro area. In addition, the contribution of the technology shock to the fluctuations in inflation is also significant in the LSVAR, although not in the DSVAR.

As for the monetary shock, we find its contribution to be relative unimportant in explaining the fluctuations of all variables, except the interest rate, as expected. That is also the thrust of the results in Altig et al. (2004) and Peersman and Straub (2004).

7 Conclusions

This study has provided new information characterizing the responses of euro area macroeconomic aggregates to monetary policy shocks and neutral technology shocks. The responses to the monetary policy shocks seem to be in line with the patterns found in the literature. As for the technology shocks, the main issue regards the response of hours worked. We find that, as in other studies, the response of hours worked to technology shocks depends crucially on the assumption regarding the stationarity of hours. If hours are assumed to be non-stationary, then they fall in response to a positive technology shock. This result seems to contradict the standard RBC prediction that positive technology shocks induce rises in the use of the labor input and therefore are key to explaining business cycles. However, if one assumes that hours are stationary in levels, then technology shocks lead to a rise in hours worked. Relative to the robustness of the results, our main findings are: qualitatively, the responses of the variables to

	DSVAR				LSVAR			
	Variance Due to Technology Shock							
Quarters	1	5	10	20	1	5	10	20
Output	29.7	72.4	85.7	92.5	26.4	53.2	56.7	74.1
Hours	26.7	26	27.4	37.7	1.7	15.4	21.7	30.2
Inflation	0.2	2	4.3	9.5	68	51.3	46.8	43.8
Capacity Utilization	0.2	0.2	0.7	7.3	9.9	32.8	28.9	24.4
Consumption	21.8	68.9	86.3	92	12.5	32	42.9	66
Investment	18.2	34.8	48.6	64.8	4.5	16.9	24.9	41.5
Real Wage	37.9	60	67.1	75.7	23.3	19.5	22.5	42.9
Interest Rate	0.6	0.8	1	2.1	0.6	0.6	2.3	3.6
Velocity	3.5	1.3	2.4	10.3	0.3	0.6	0.6	0.5
Money Growth	0	5.5	5.4	6	0.1	1.3	1.3	1.4
	Variance Due to Monetary Policy Shock							
Quarters	1	5	10	20	1	5	10	20
Output	0	2.3	1.7	0.5	0	7.8	16.4	9.9
Hours	0	6.7	11.3	5.3	0	14.5	32	25.4
Inflation	0	8.5	8.1	10.4	0	9.2	8.9	10.5
Capacity Utilization	0	8.2	17.7	16.7	0	10	23.5	21.3
Consumption	0	2.2	0.9	0.3	0	8.5	13.8	8.3
Investment	0	8.8	14.5	10.1	0	11.7	24.2	21.2
Real Wage	0	1.7	3.1	1.1	0	2.3	2.3	0.9
Interest Rate	82	61.8	40.2	33.6	83.4	65.6	43.1	36.2
Velocity	2.1	11.6	8.2	4.7	2.5	13.1	9.7	5.5
Money Growth	2.9	4.4	6.7	6.6	3.6	6.8	8.1	8.2

Table 3: Contribution of Technology and Monetary Policy Shocks for Forecast Variance in Both VAR Specifications (in percentage)

monetary policy shocks appear robust to changes in the sample period and the specification of hours. As regards the responses to technology shocks, the responses of hours and capacity utilization to technology shocks appear to be more sensitive to the sample choice. In the case of the LSVAR, the responses are more sensitive to the start of the sample while the results of the DSVAR are more sensitive to changes in the sample's end. Moreover, technology shocks have been found to explain a significant part of the fluctuations of output, hours worked and wages, a result that conforms with the RBC paradigm. On the other hand, monetary shocks seem to have a substantial contribution to the variations in the interest rate, as expected.

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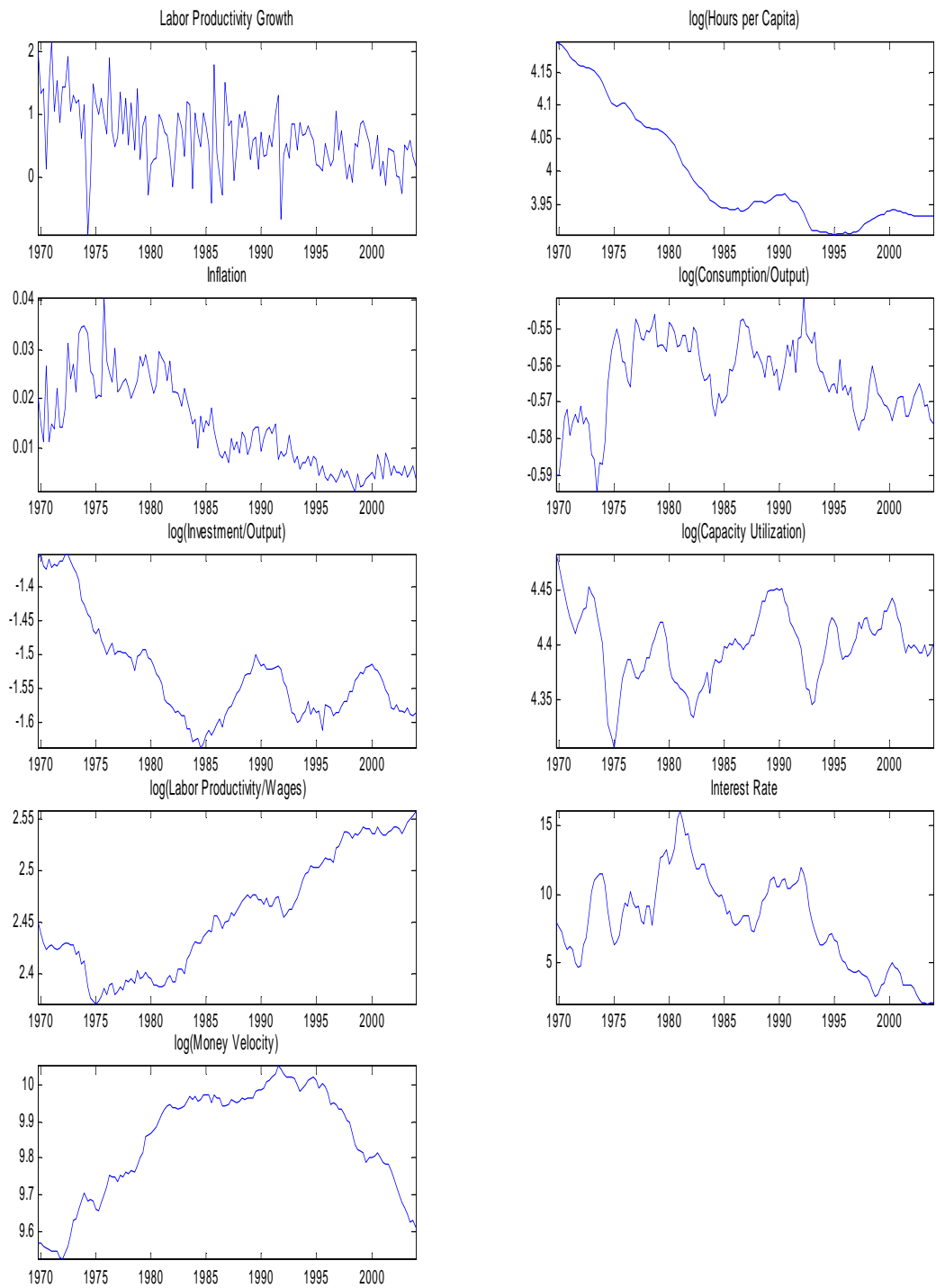


Figure 1: Raw data on the variables used in the VAR

Interest Rate Shock

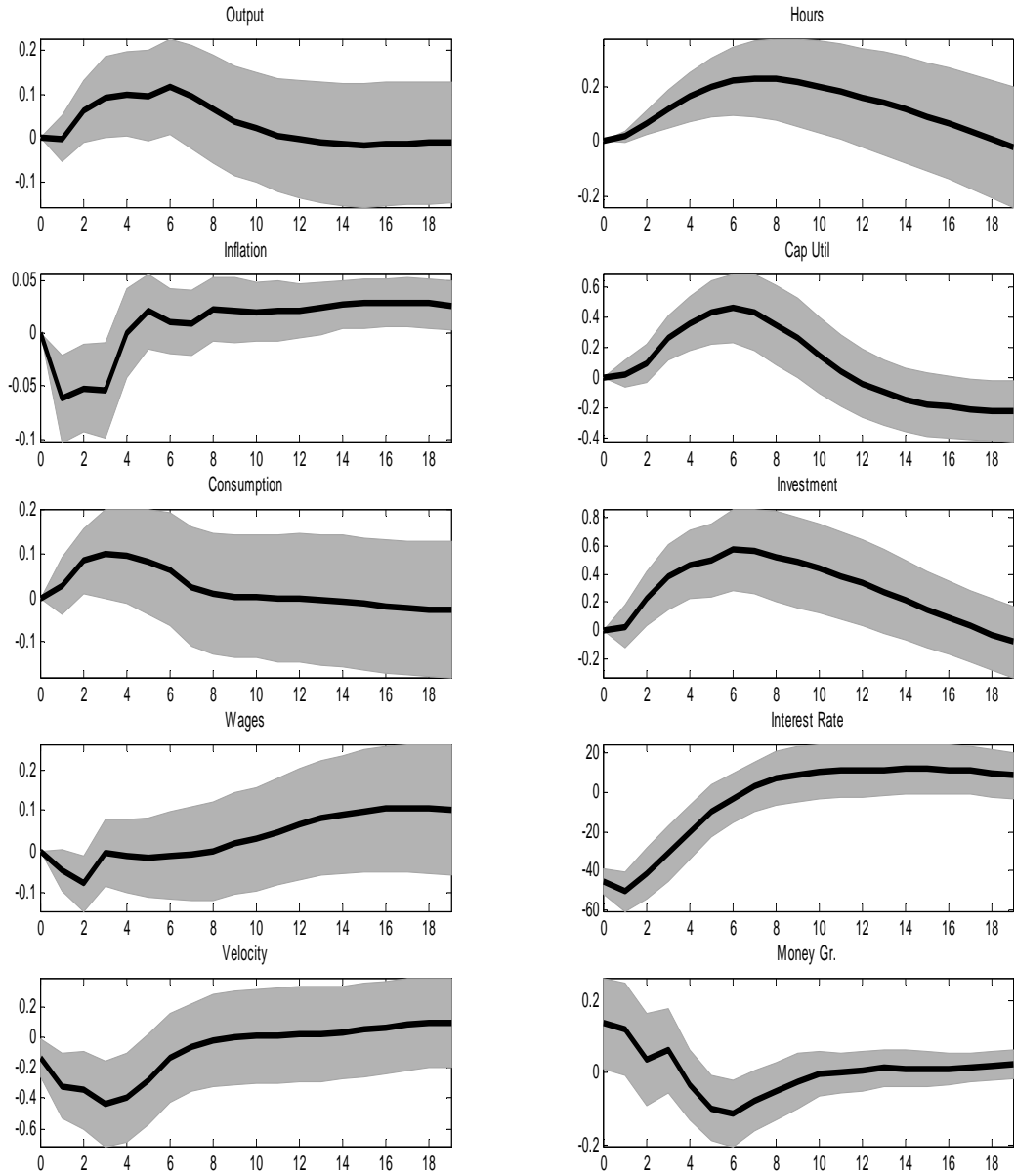


Figure 2: DSVAR - Impulse responses to a negative monetary policy shock.

Interest Rate Shock

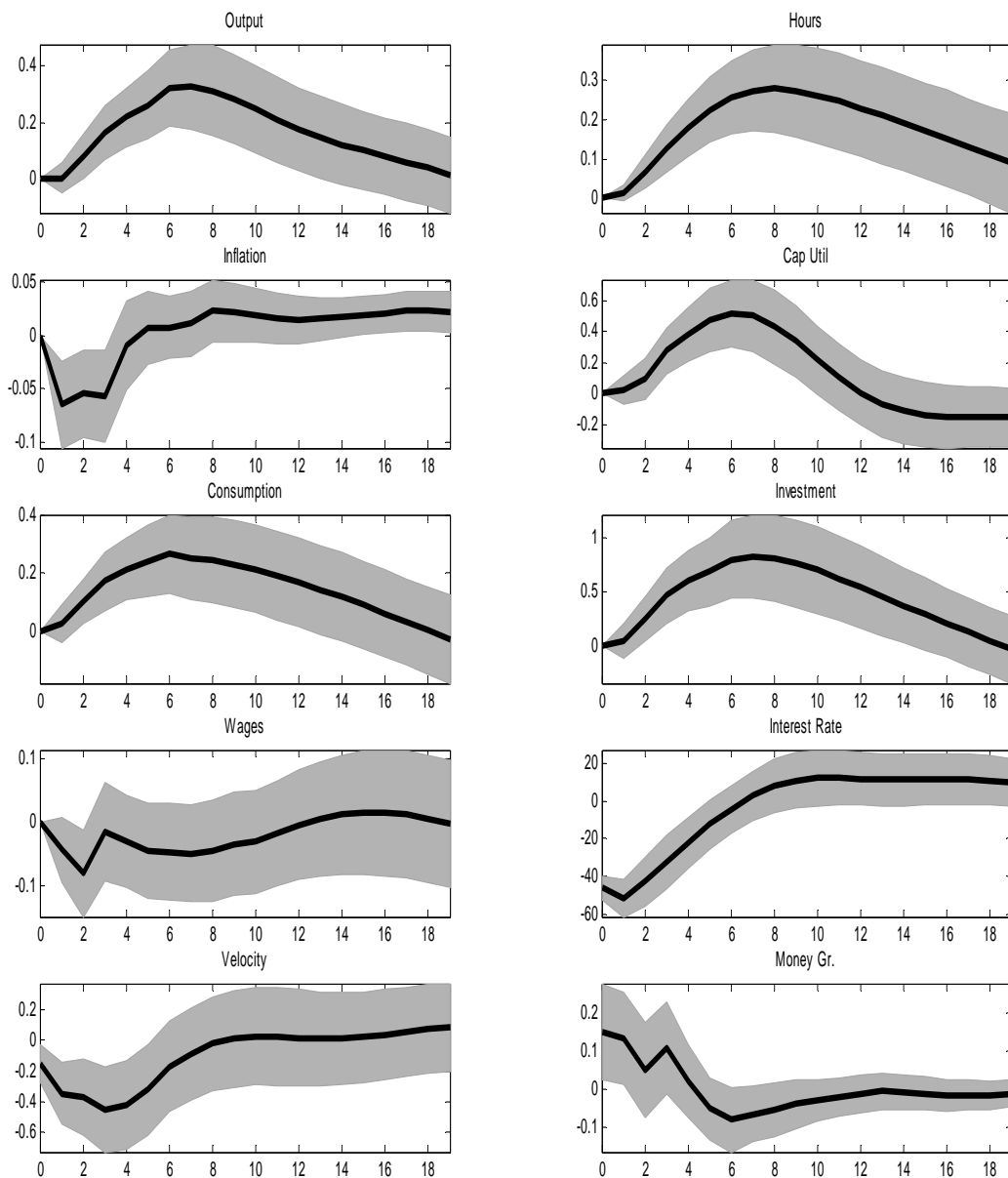


Figure 3: LSVAR - Impulse responses to a negative monetary policy shock.

Technology Shock

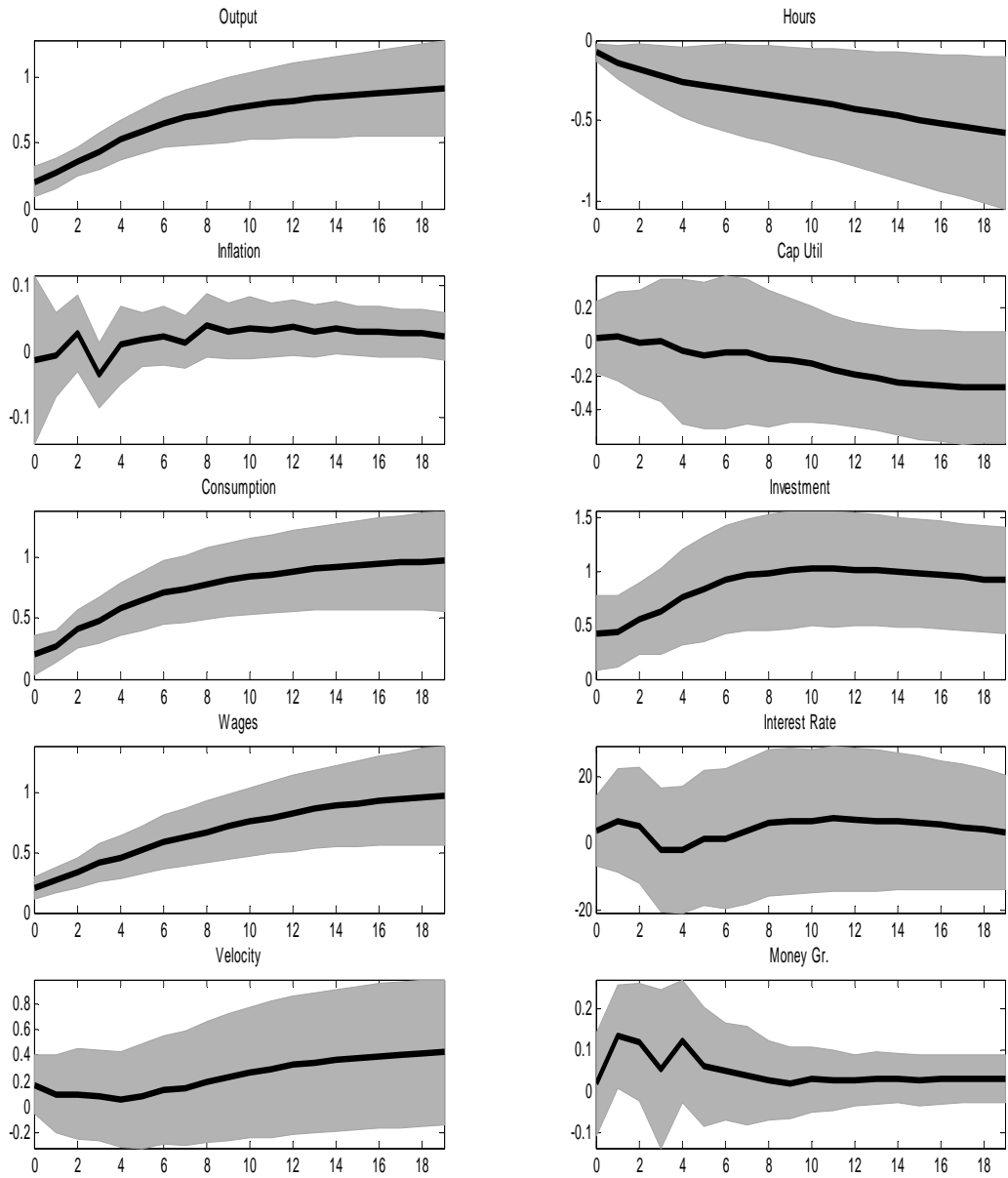


Figure 4: DSVAR - Impulse responses to a positive technology shock.

Technology Shock

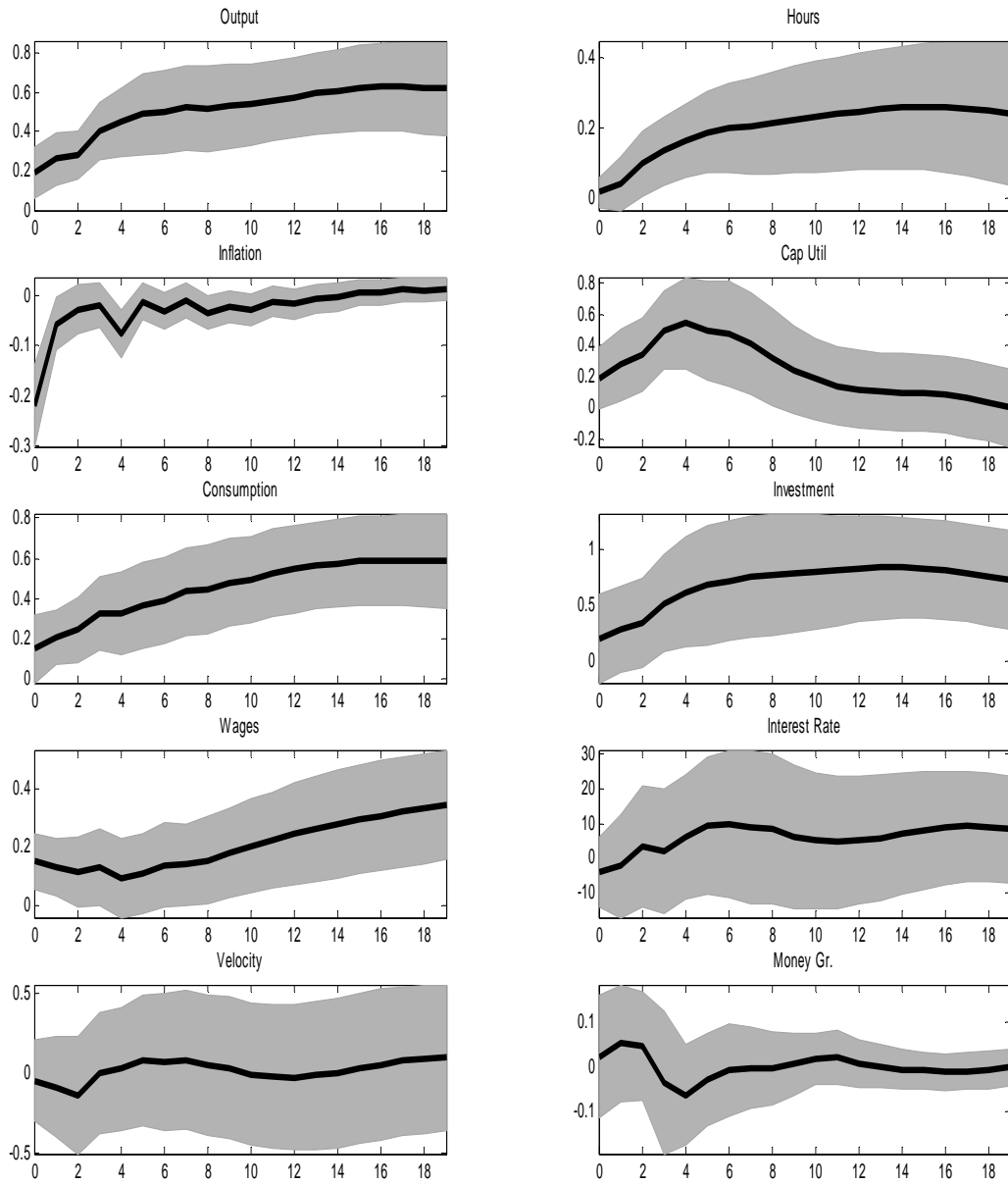


Figure 5: LSVAR - Impulse responses to a positive technology shock.

Interest Rate Shock

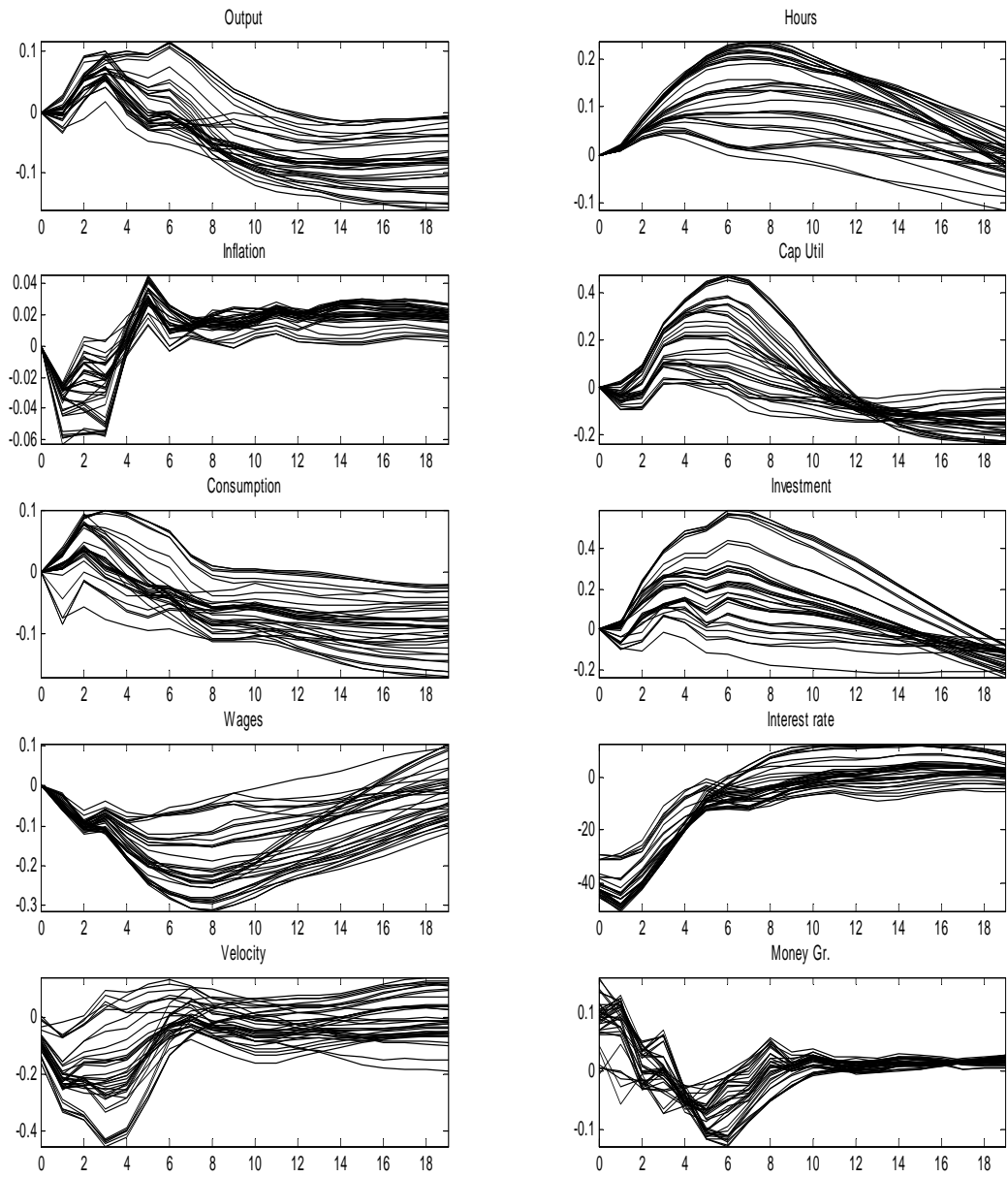


Figure 6: DSVAR - Impulse responses to a negative monetary policy shock with increasing start of the sample. Start: 1970Q2:1979Q4; end: 2004Q3.

Technology Shock

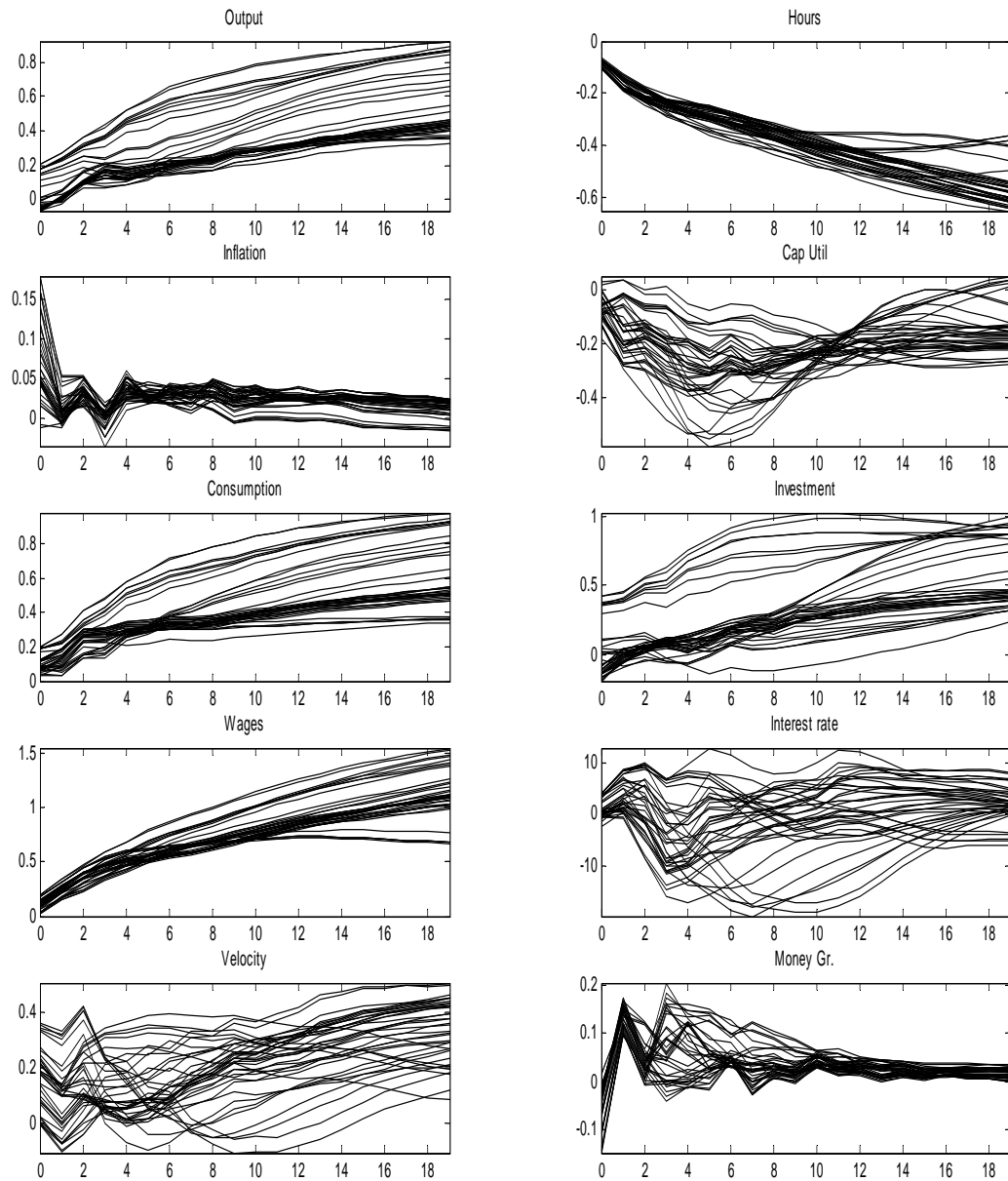


Figure 7: DSVAR - Impulse responses to a neutral technology shock with increasing start of the sample. Start: 1970Q2:1979Q4; end: 2004Q3.

Interest Rate Shock

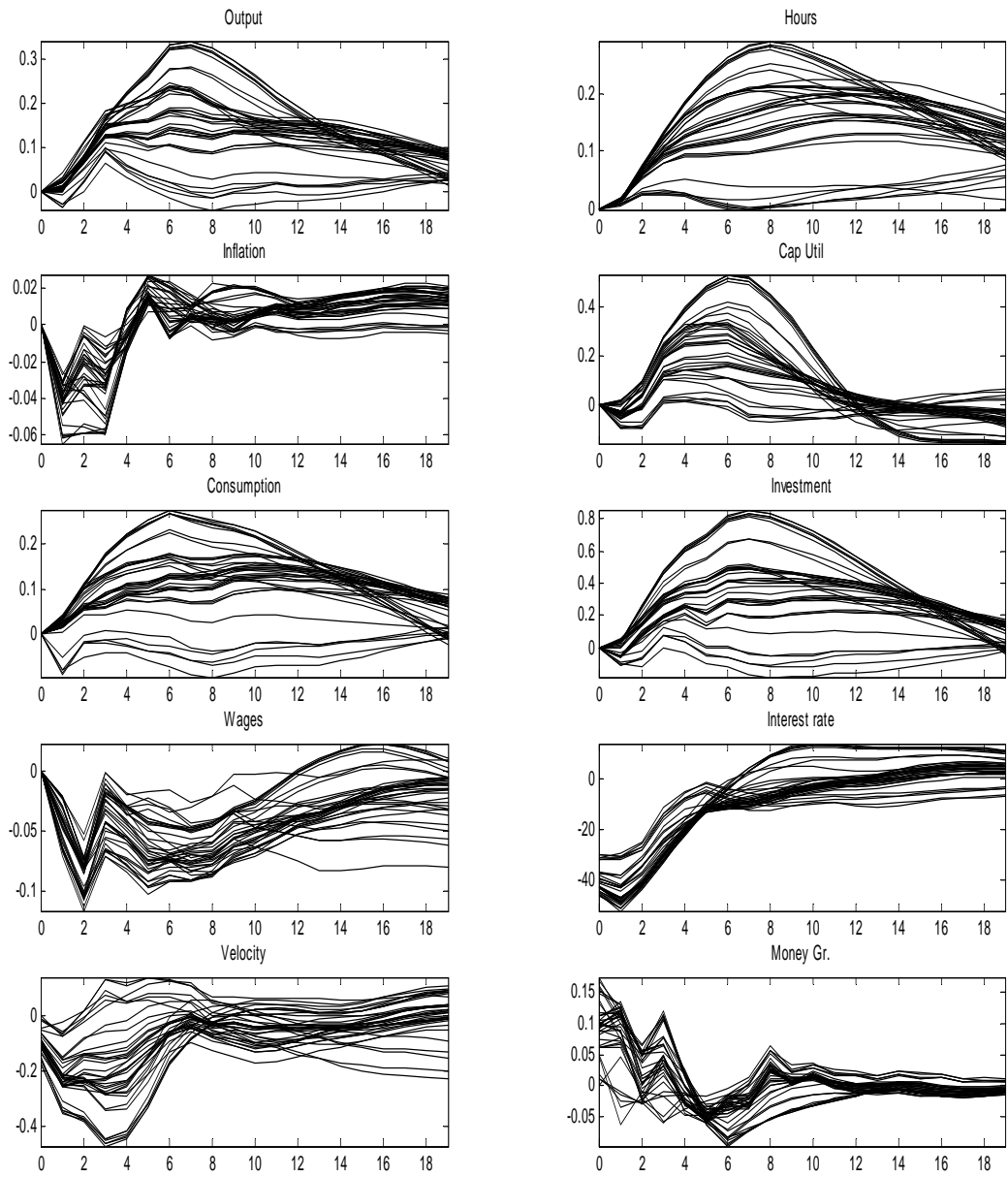


Figure 8: LSVAR - Impulse responses to a negative monetary policy shock with increasing start of the sample. Start: 1970Q2:1979Q4; end: 2004Q3.

Technology Shock

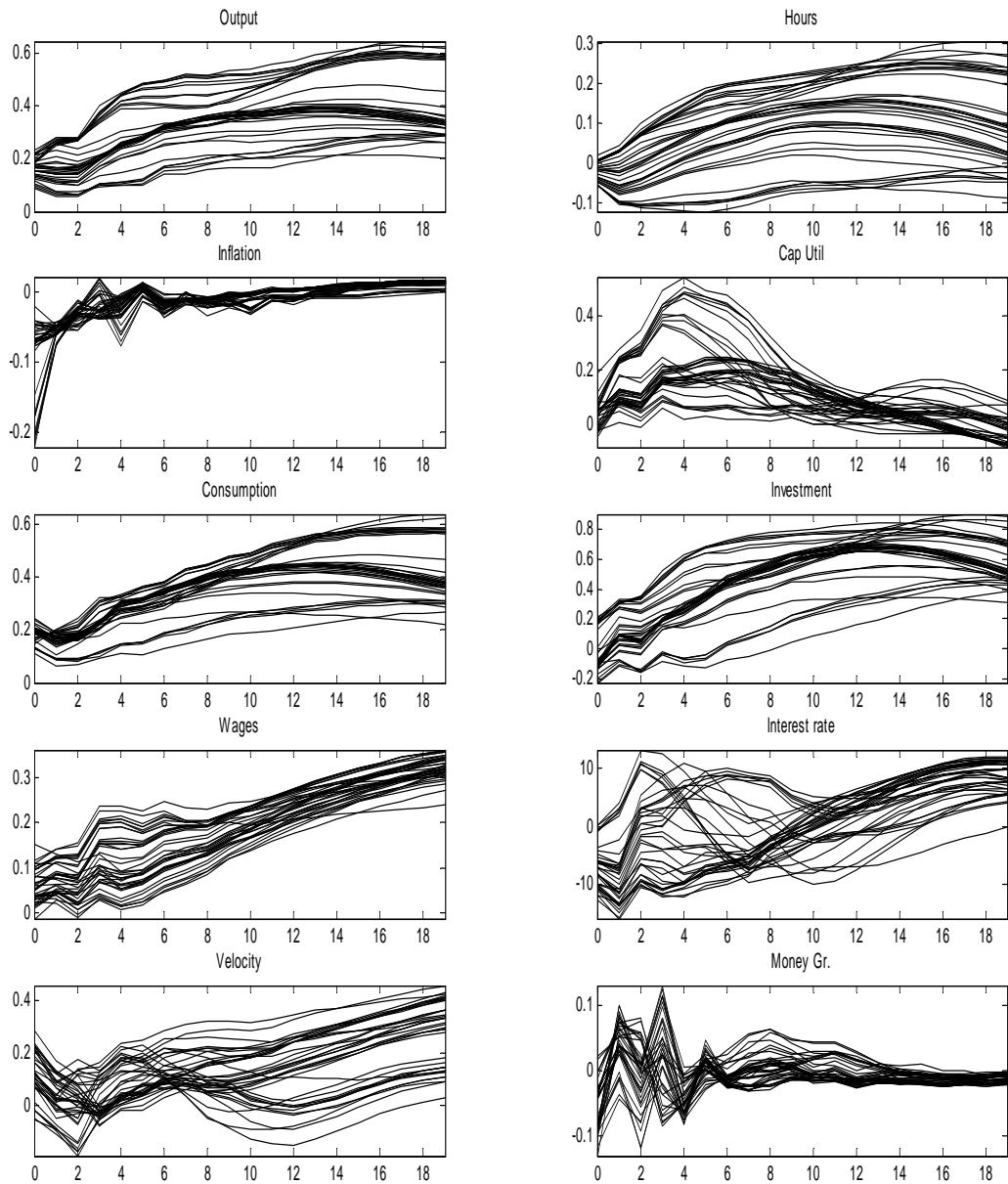


Figure 9: LSVAR - Impulse responses to a neutral technology shock with increasing start of the sample. Start: 1970Q2:1979Q4; end: 2004Q3.

Interest Rate Shock

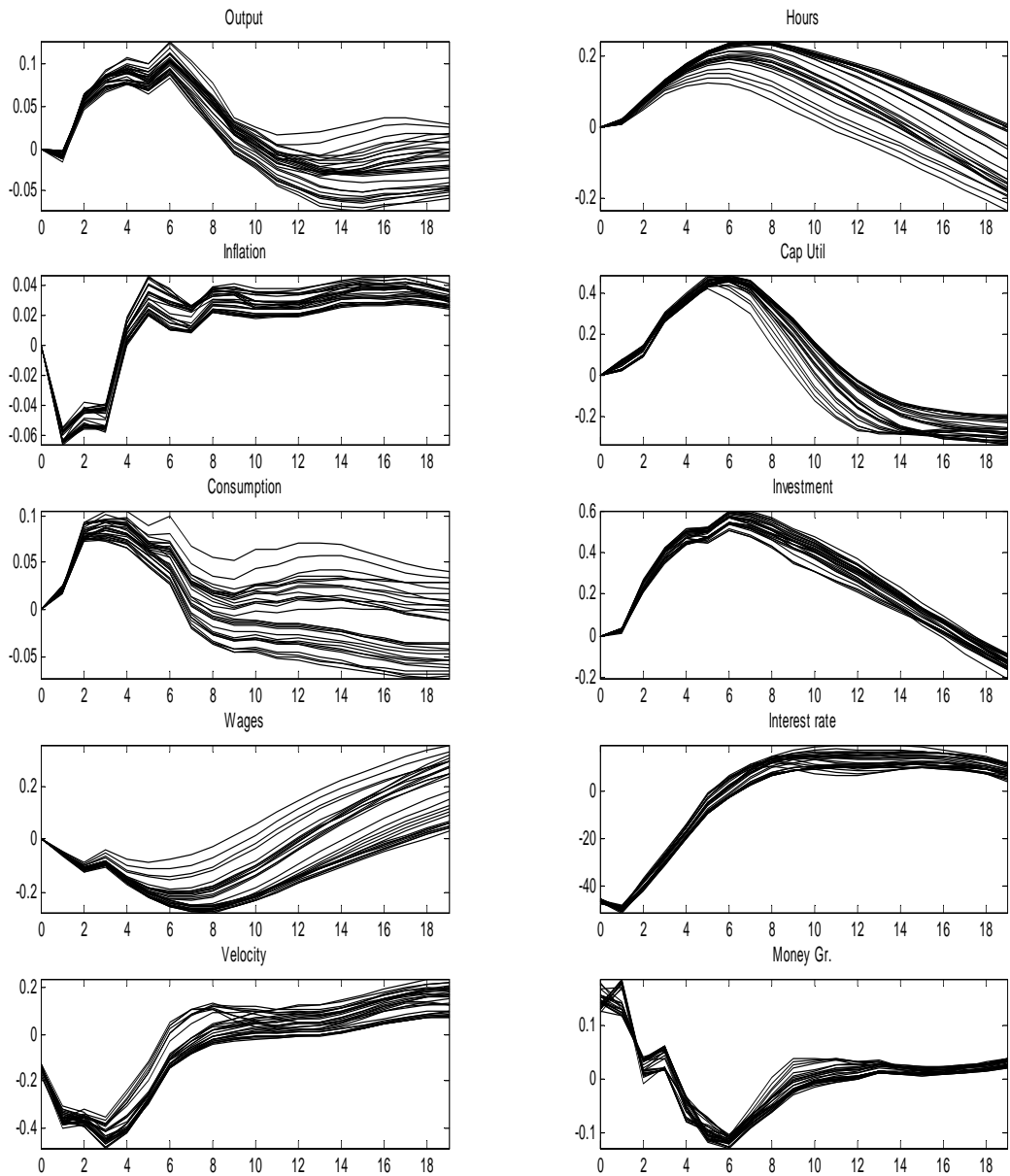


Figure 10: DSVAR - Impulse responses to a negative monetary policy shock with decreasing end of the sample. Start: 1970Q1; end: 1997Q1-2004Q3.

Technology Shock

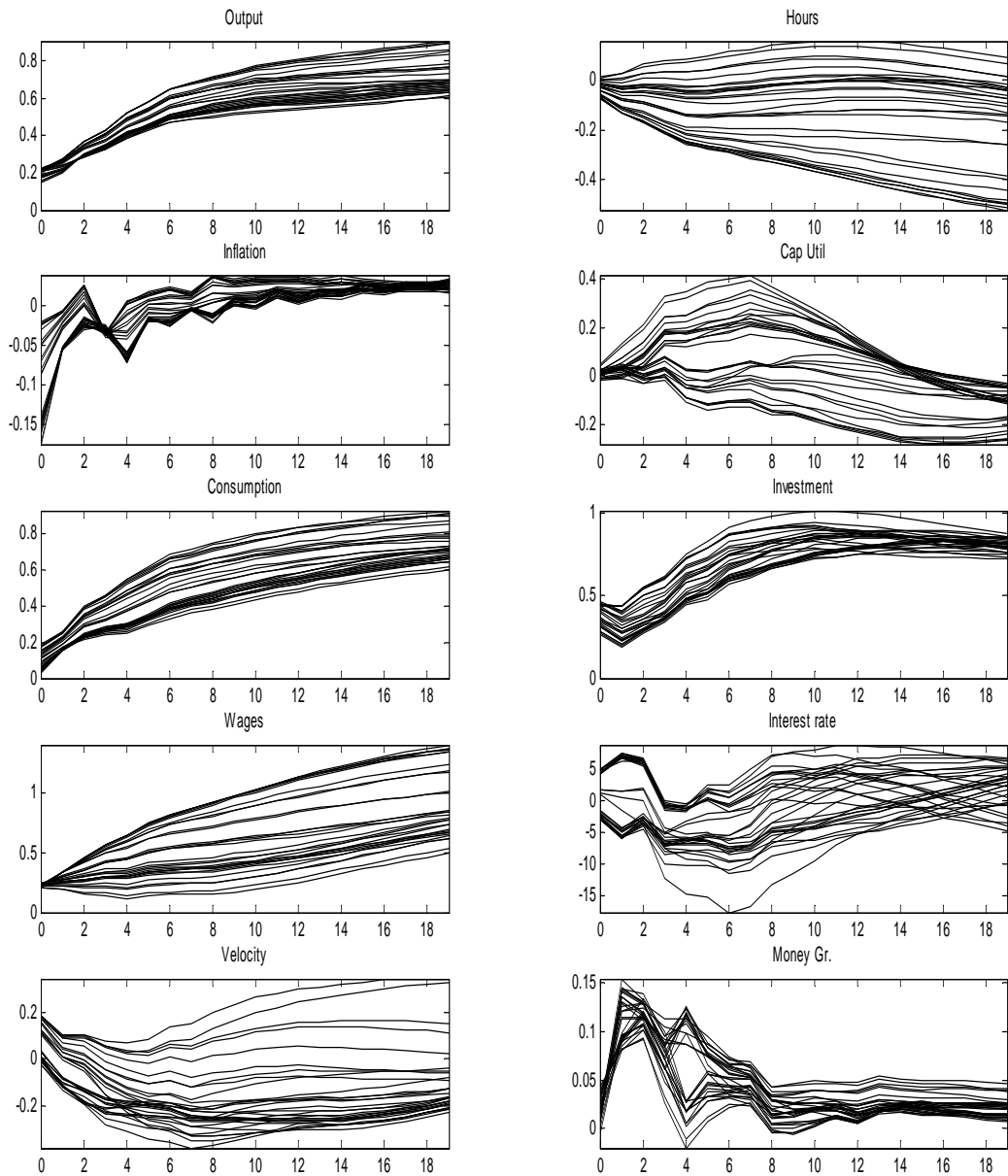


Figure 11: DSVAR - Impulse responses to a neutral technology shock with decreasing end of the sample. Start: 1970Q1; end: 1997Q1-2004Q3.

Interest Rate Shock

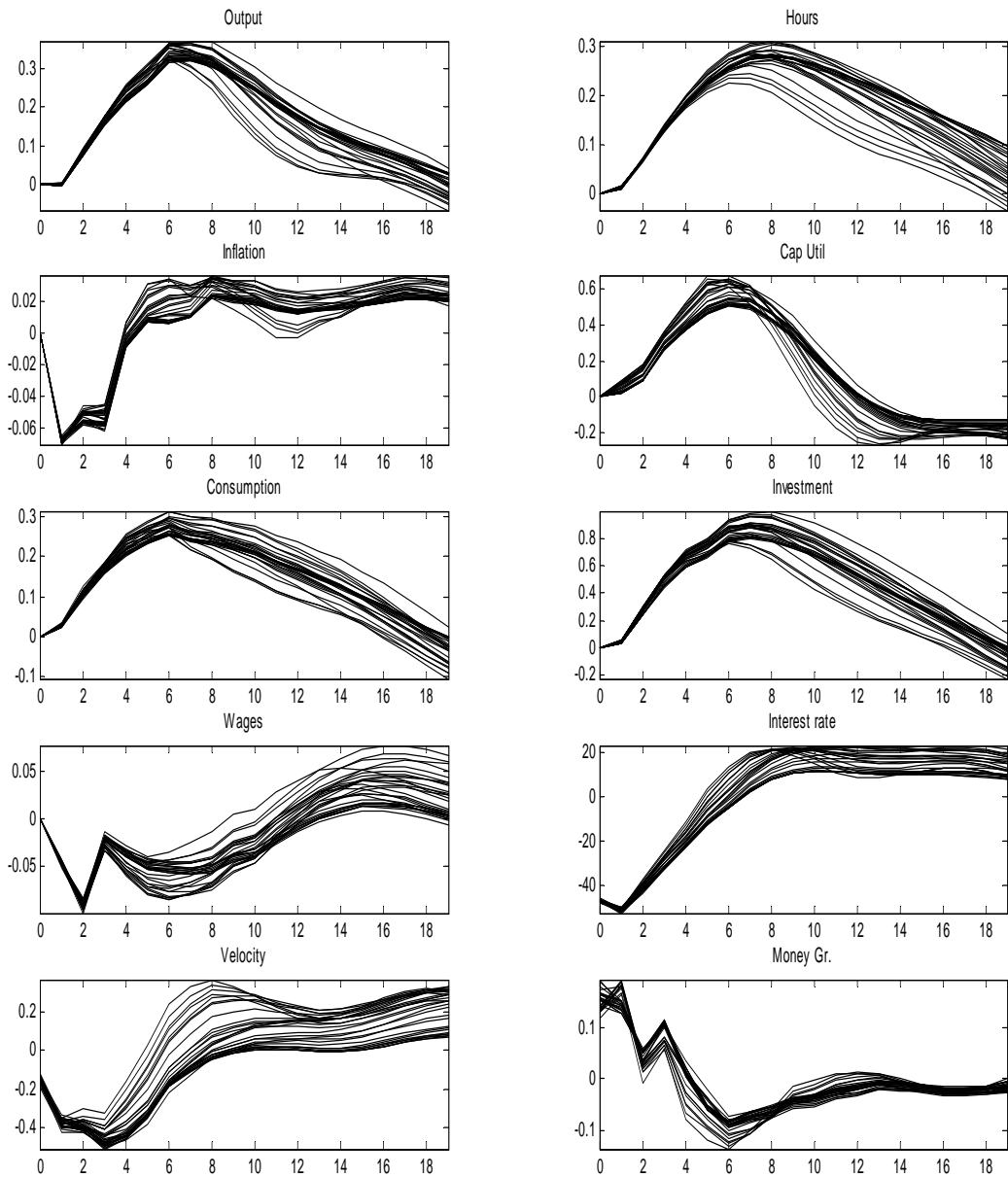


Figure 12: LSVAR - Impulse responses to a negative monetary policy shock with decreasing end of the sample. Start: 1970Q1; end: 1997Q1-2004Q3.

Technology Shock

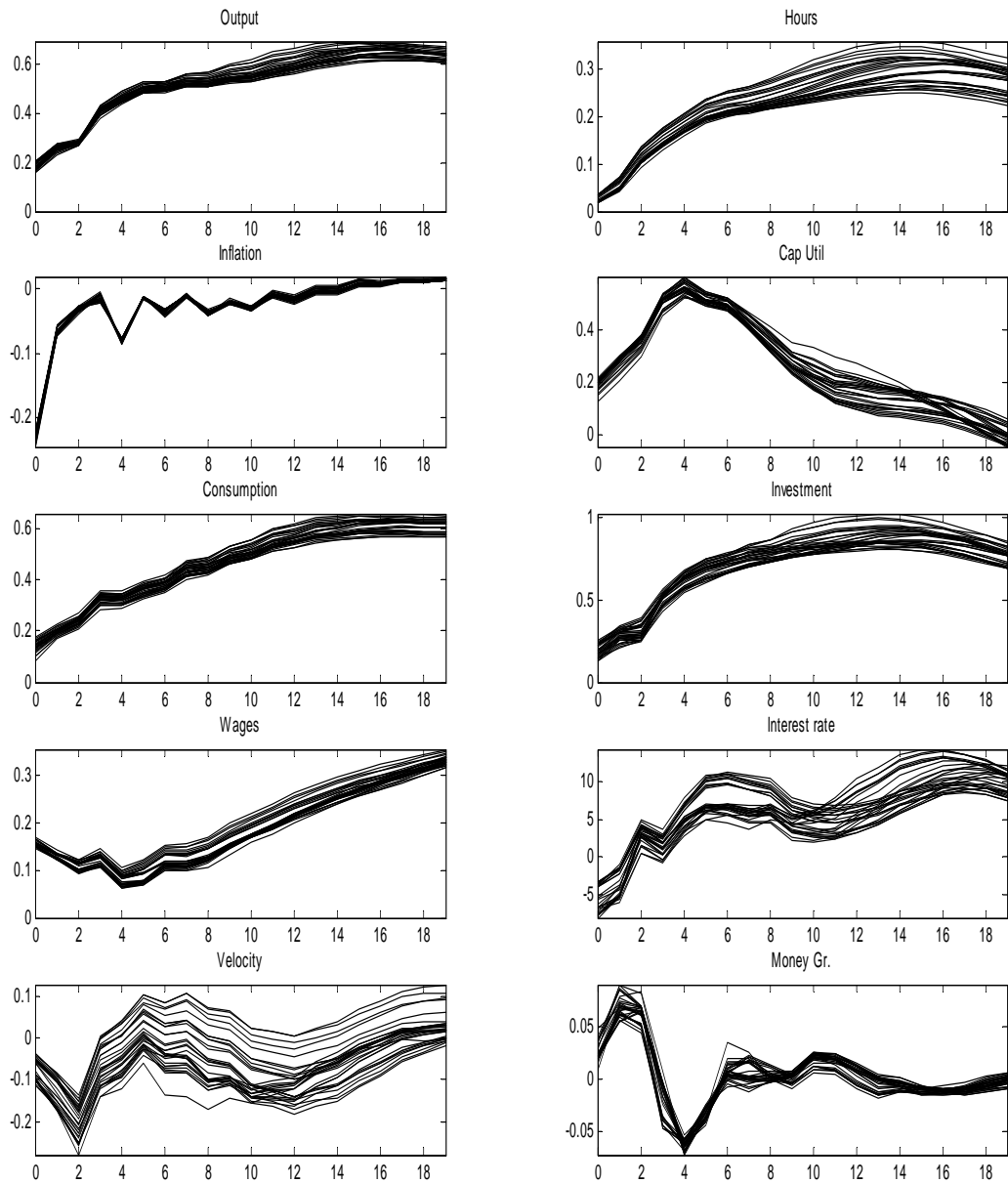


Figure 13: LSVAR - Impulse responses to a neutral technology shock with decreasing end of the sample. Start: 1970Q1; end: 1997Q1-2004Q3.