THE EFFECTS OF MONETARY POLICY SHOCKS ON FLOW OF FUNDS: THE ITALIAN CASE

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Abstract

We study in a VAR model the effects of monetary policy shocks with new Italian flow of funds data for 1980-2002. First, our results are consistent with the literature, without being affected by commonly found puzzles. Second, new features of the transmission of monetary policy shocks to the Italian economy are provided. We do not find evidence in favour of financial frictions which would prevent firms from a prompt reduction of nominal expenditures. Households also quickly adjust their portfolios leading to a careful evaluation of the hypothesis underlying limited participation models. Finally, the public sector increases net borrowing after the shock, improving on puzzling opposite results in the literature.

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1. Introduction

After the seminal paper by Sims (1980) an extensive literature begun to assess the effects of exogenous monetary policy shocks on the business cycle with vectorial auto-regressive models (VAR). The impact of such shocks on the flows of borrowing and lending of economic agents, such as firms, households and the public sector, has been much less investigated. Nevertheless, we think that the analysis of the changes in the financing and investment activities of the different sectors of the economy, i.e. in their demand for financial assets and supply of financial liabilities, in response to unexpected variations in the policy interest rate, may be very important for studying the transmission mechanism of monetary policy and its effects on the business cycle.

To fully capture these responses, Christiano, Eichenbaum and Evans (1996) (CEE (1996) hereafter), analysed the effects of U.S. monetary policy with a VAR model applied to the flows-of-funds data from 1961 to 1991. This choice allowed them to perform an analysis of the variations of the financial assets and liabilities of each economic sector, and within those two aggregates, of the different classes of financial instruments. The economic literature did not pursue afterwards this research area, possibly because of the absence of historical time series of adequate length, frequency and level of detail.

The recent availability of reconstructed quarterly flow-of-funds time series for Italy from 1980, made possible in this work to analyse the effects of monetary policy on the choices of financing and investment of the economic sectors (non financial firms, households, general government, financial firms and the foreign sector) with a VAR model, exploiting the information content of the heterogeneity of the response to the monetary policy shocks in Italy.

This is actually, to our best knowledge, the first attempt to exploit the rich information content of a fully integrated and internally consistent accounting framework like the Italian financial accounts, in order to examine the effects of monetary policy with a VAR model. According to our results, the use of such data can provide further insights into the empirical evaluation of the effects of monetary policy in Italy.

2. Related literature

The use of VAR methodology to assess the effects of unexpected monetary policy shocks on the economic system has been very intense in the recent past.[2] In this section we recall the main results of such literature, focusing on the papers which are more closely related to our aim of analysing the financing and investment decisions of the Italian economic sectors with flow-of-funds data.

The issue of how to evaluate empirically the reaction of the borrowing and lending behaviour of different categories of economic agents to monetary policy shocks, was first addressed by CEE (1996), who used the US flow of funds. Among their results, net funds raised by firms in the financial markets (that is, net incurrence in new liabilities net of acquisition of financial assets) increase for about a year after a tightening of monetary policy, and begin to fall only later, when a recession takes place. The authors point to the existence of financial frictions which would prevent firms from adjusting immediately their level of inventories to the new (lower) level of demand, as standard monetary business cycle models would predict. This might happen because of a limited ability of altering quickly nominal expenditures, possibly due to contracts in place. A second result is that households do not adjust their financial position to monetary policy shocks for a number of quarters, in line with the predictions of limited participation models that claim a certain degree of rigidity of households in adjusting their financial assets and liabilities. Finally, there appears to be a (surprising) temporary reduction in net lending of the government.[3]

Since we are interested in extending this kind of study to the Italian case, we find necessary to compare our results with those of authors who employed the VAR methodology to investigate the mechanism of monetary policy shocks transmission to the Italian economy. Their main findings are recalled in the following.

According to Gaiotti (1999), the interest rate on main refinancing operations of the Bank of Italy is a suitable measure of monetary policy in Italy.[4] Adopting a structural VAR

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[2] For a review of the literature see, among others, Bagliano and Favero (1998), Bernanke and Mihov (1998), Christiano, Eichenbaum and Evans (1999) (hereafter CEE(1999)) and Kim (1999).

[3] CEE(1996) deem this letter result to be "puzzling" and point, as a possible explanation for that, to a temporary increase in personal tax receipts, which vanishes after about a year, as the recession takes hold.

[4] See Gaiotti (1999) also for a detailed description of the transmission of monetary policy in Italy from 1967 to 1997.

model, the author finds that following an unexpected increase in the policy interest rate output and prices fall. These results are consistent with the results of the international literature.

De Arcangelis and Di Giorgio (2001) provide a further term of comparison, proposing an identification method based on a detailed institutional analysis of the Italian monetary policy procedures (limited to the '90s). The analysis suggested the authors to choose the overnight interest rate as the most suitable monetary policy indicator. Moreover, they find the exchange rate to play an essential role in their model, given that Italy is identified as a small open economy.

Dedola and Lippi (2005) analyse the monetary transmission mechanism with disaggregated industry data from five industrialised countries, including Italy. They find significant differences across industries as to the effects of monetary policy. Sectoral output responses to monetary policy shocks turns out to be systematically related to the industry output durability, financing requirements, borrowing capacity and firm size. Their approach, following CEE (1999), uses a recursiveness assumption to identify the unexpected component of monetary policy and seems to fit the Italian data quite well.

Neri (2004) focuses on the relation between monetary policy and stock prices, suggesting a structural VAR approach to study the case of Italy. Similarly to other studies, they assume a Choleski identification scheme for the reduced form variance-covariance matrix of the VAR residuals corresponding to commodity price index, nominal exchange rate, consumer price index and industrial production index. Non-recursive restrictions, on the other hand, are imposed on the short-term interest rate, a monetary aggregate and the stock market index. The results of the paper are in line with other works which used different identification schemes.

As to the study of the reaction of Italian firms to monetary policy shocks, Gaiotti and Generale (2002) estimate the effects of monetary policy on the investment behaviour of a number of categories of Italian firms, using a panel data-set from the Company Accounts Data Service (*Centrale dei Bilanci*). Their main findings are that financial variables do actually matter, and that the difference in the response of investment by different types of firms to monetary policy is not negligible.

3. Data

Flow-of-funds data enable us to examine the links among the financial positions of the different sectors of the economy, allowing for the possibility of reconciling the fact that saving and real capital formation in any period are identical for the economy as a whole, while at the same time individual spending units (sectors) still have the option of investing (in real assets) more or less than they have saved. For each sector, in fact, the difference between fixed investment and gross saving results in a change in the net financial position, also called "net lending/net borrowing", towards the rest of the economy (both domestic and foreign sectors). For sector *i*, in fact,

$$I^i - S^i = FL^i - FA^i = \textit{net funds raised} \qquad (1)$$

where S is saving, i.e. the excess of disposable income over consumption, I is tangible investment (fixed capital formation and changes in inventories), FL and FA are the net incurrence of financial liabilities and the net acquisition of financial assets, respectively. Since any financial asset is necessarily a liability to someone else, for the economy as a whole eq. (1) reduces to the well known national accounts identity $S = I$.

We consider the following sectors: (i) households, (ii) non financial firms, (iii) financial firms, (iv) general government, (v) foreign sector.[6] For each sector, besides net funds raised, we look at the assets and the liabilities components, *FA* and *FL*. Moreover, in the case of households and non financial firms we provide further insight observing the

[6] In the present work we consider a purely "consumer" household sector, while in the Italian flow of funds it also comprises the "producer" households (small unincorporated firms and sole proprietorships with less than five employees). We prefer to include the latter among non financial firms, so to join all the producer units in the non financial sector, regardless of the firm size or of its legal form. The other sectors are consistent with the ESA95 (European System of National Accounts) classification, which is also applied in the Italian flow of funds. Financial firms include banks, money market funds, financial auxiliaries and insurance corporations and pension funds (thus the Bank of Italy is not included). The general government sector includes central government, local government and social security funds. The foreign sector include all the units non resident in Italy.

responses of more detailed variables. As for households, for example, we also consider distinguish among deposits (and cash), short-term securities, long-term securities, equity (both listed and unquoted) on the assets side; among liabilities, we analyse short-term and long-term loans separately. As for non financial firms, instead, we prefer to focus on liabilities, distinguished between short-term and long-term liabilities, and further splitting this latter into equities and other long-term debts (corporate bonds and long-term loans).

As regards financial assets and liabilities of the various sectors, we employ a recent reconstruction of the flows of funds data for Italy since from 1980 which was recently performed by the Statistics Sector at the Economic Research Department. In the former dataset, in fact, time series before and after 1995 were not directly comparable, mainly because of differences in the compilation methodology, in classification criteria and in the accounting principle introduced by the adoption of the ESA95 (European System of National Accounts).

Figure 4 presents the quarterly flow of funds data for Italy. Each graph shows net funds borrowed (series above zero) or lent (series below zero) by the sectors from 1980 to 2002. Not surprisingly for the Italian economy, households are net lenders over the whole period; the opposite is true for general government and, with very few exceptions, for non financial firms.

4. Measures of policy shocks

4.1 Identification

Following CEE (1999) we adopt a recursive VAR (Vector Auto Regression) approach.[7] Our model includes the industrial production index (IP), the consumer price index (P), the import price of raw materials in local currency (PIMP), the nominal exchange rate of the Italian lira vis-à-vis the German mark[8] (EXR), a policy interest rate, namely the repo

[7] Details on the model are provided in the Appendix.

[8] The exchange rate since January 1999 is of course a constant because of the adoption of the single currency.

rate[9] (R), and a monetary aggregate (M2). In the recursive VAR framework, only the variables' order matters in deriving the impulse response functions to the policy shocks. Variables in the y_t vector are ordered from the most exogenous to the most endogenous. We consider the following vector in our recursive VAR model:

$$y_t' = \left(IP, PIMP, P, EXR, R, M2\right) \tag{1}$$

All variables, except *EXR* and *R*, were seasonally adjusted.

The ordering in the y_t vector corresponds to our identifying assumption that policy shocks have only lagged (and no contemporaneous) effects on the first four variables in brackets in equation (1). Nevertheless, we assume that the monetary authorities know these variables at the time the interest rate level is set; in other words, IP, PIMP, P, and EXR are in the information set of the central bank within the quarter. The only variable which is assumed to respond to the interest rate within the same quarter is the money aggregate, M2.

In practice, given the identification achieved with the recursiveness assumption of CEE (1999), we characterise the monetary policy as reacting contemporaneously to the non-policy variables ordered before our monetary policy measure (the repo rate, R). On the other hand, these variables, i.e. industrial production, prices, import price of raw materials and the exchange rate, are assumed to react only with a lag to monetary policy. We consider the exchange rate in our specification, in line with the consideration that Italy can be regarded as a small open economy in the period observed.[10] We consider M2 to be the only policy variable, that is, a variable reacting contemporaneously to monetary policy shock, but to which monetary policy reacts only with a lag.[11]

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[9] From 1980 to 1981: average interest rate on fixed term advances; from 1982 to 1998: auction rate on repurchase agreements between the Bank of Italy and credit institutions; from 1999 onwards: interest rate on main refinancing operations of the ECB. This latter interest rate does not present a particular break at the beginning of stage three of EMU with respect to the Italian repo rate, even of course the convergence of interest rates begun since 1993, accelerated the pace to reach its maximum in 1998 (circumstance that we try to acknowledge with a dummy).

[10] The exchange rate, that is not the focus of this work, is regarded as a non-policy variable, in line with Neri (2004), because of the difficulties of monetary policy to influence the exchange rate, particularly in the first half of the eighties. We also checked for a treatment of the exchange rate as a policy variable, postponing it to the interest rate in the VAR order, without detecting significant changes in the results.

[11] We chose not to perform cointegration analysis at this stage, in line with the empirical approach to modelling the effects of unexpected monetary usually employed in the literature. Secondly, according to Sims et al. (1990) standard asymptotic tests are still valid if the VAR is estimated in levels, even if the variables are cointegrated.

Our choice of the non-policy variables is partially inspired by Kim and Roubini (2000) who study the effects of monetary policy innovations on the G7 countries with a SVAR model and seem to deal with the empirical puzzles that troubled the literature with a certain degree of success. We chose an interest rate as indicator of monetary policy in line with the approach of Bernanke and Blinder (1992) and with De Arcangelis and Di Giorgio (2001), who argue that interest rate indicators outperform the ones based on money aggregates in identifying Italian monetary policy shocks. In particular, we decided to use the interest rate on repurchase agreements between the Central bank and the credit institutions which, also according to Gaiotti (1999) and Gambacorta and Iannotti (2005), better describes the monetary policy operating procedures adopted by Bank of Italy.[12]

The decision on how many lags to include in our VAR model was driven by the selection criteria reported in Table 1 (LR and Final Prediction Error) and by the quarterly nature of our dataset. Those considerations led us to choose four quarters as a suitable lag order, in line with most quarterly VAR in the empirical literature.

The VAR residuals show no autocorrelation (LM test results are reported in Table 1) and no heteroschedasticity (White test results are in Table 2). Furthermore, the hypothesis of normality is not rejected at high significance levels for all the variables considered for the single equations of the VAR[13] (see the Jarque-Bera test results in Tables 3). Three point dummies were included in the model, so to obtain "white" enough residuals in the six estimated equations.[14]

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[12] We tried to use as alternative monetary policy indicators reserve aggregates in line to CEE (1996). Difficulties in interpretation of these data, particularly at the beginning of the '80s, put us in the same position of other authors who considered the monetary policy in those years to be not well described by a market-based approach, therefore we resorted only to interest rate indicators.

[13] For the multivariate case, as is often the case in this kind of applications, we can not reject the hypothesis that there is non normality, due to the presence of kurtosis, see Table 4.

[14] The three dummies also happen to be related to the three more relevant perturbations of the monetary policy in the period observed. The dummy in 1992Q3 accounts for the contraction of monetary policy during the exchange rate crisis of fall 1992; the second dummy, in 1995Q1, corresponds to the monetary restriction that contrasted inflationary pressures and the exchange rate depreciation; the dummy 1998Q3 considers the series of interest rate cuts put in place to achieve convergence to the interest rate levels of the new monetary area started in 1999.

4.2 *Assessing monetary policy shock measures*

Our measure of exogenous shocks to monetary policy is an orthogonalised shock to the policy interest rate, i.e. the repo rate, *R*. Figure 1, where the shaded areas correspond to the recessions of the Italian economy as identified by Altissimo et al. (2000)[15], shows that the residuals of the interest rate equation fit sufficiently well with the recessions' chronology. With the possible exception of the first period (when the policy rate is highly volatile), the monetary policy is relatively tight in the period before each recession and the stance becomes easier during the recession period.

In order to further check if we have identified monetary policy shocks we control for the response to a one standard deviation increase in the monetary policy interest rate of the macroeconomic variables directly affected by monetary policy; in Figure 2 we report the impulse response functions.[16]

The industrial production begins to decline, though with initial limited significance, in the quarter following the shock and continues for about two years; it then bounces back to the pre-shock level three years after the shock has occurred. This result is consistent with the Italian empirical literature and the international VAR literature. Prices (as measured by the consumer price index) decline persistently starting two quarters after the shock; differently from what is found in large part of the literature, no "price puzzle" is observed. The exchange rate appreciates (a lower value of EXR means an appreciation if the Italian currency), though with a very limited statistical significance, reaching the maximum appreciation three quarters after the shock.[17] The money aggregate M2 declines immediately, consistently with the presence of a liquidity effect and then bounces back, losing statistical significance after a year (quite interestingly, this is also the period in which the response of

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[15] Altissimo et al. (2000) identify as recessions the periods between March 1980 and March 1983, March 1992 and July 1993, November 1995 and November 1996.

[16] The responses of the variables to a monetary policy shock were computed with 1000 Monte Carlo simulations over 16 quarters; following Sims and Zha (1999) the confidence bands are one standard error wide, corresponding to a 68 per cent confidence interval, since "[…], for characterising likelihood shape, bands that correspond to 50% or 68% posterior probability are often more useful than 95% or 99% bands, and confidence intervals with such low coverage probabilities do not generally have posterior probabilities close to their coverage probabilities."

[17] This result attenuates the "exchange rate puzzle" documented in Chiades and Gambacorta (2004) and in De Arcangelis and Di Giorgio (2001), possibly due to the circumstance that the period analysed in this work includes also the years before 1984 and those after 1998.

the interest rate is significantly different from zero, i.e. the first four quarters following the shock).

In Table 6 the forecast error variance decomposition for the VAR variables is reported at different time horizons, i.e. from the impact up to 3 years after the shock has occurred. Interest rate policy shocks account for 22% of the 2-years-ahead forecast error variance of industrial production, 11% of the import price of raw materials and about 5% of the consumer price index, of the exchange rate and of M2. Monetary policy seems to be an important source of output fluctuations also looking at Table 7, where the same decomposition is shown for other macroeconomic variables considered in the analysis: shocks to the policy rate account for 30% of the 2-years-ahead forecast error of fixed investment and for about 16% for private consumption and wages.

In order to provide further evidence on the goodness of our identification of monetary policy shocks, following CEE (1996) we also examine the responses of other relevant macroeconomic aggregates not directly affected by monetary policy (they are not included in our VAR specification). As reported in Figure 3, private consumption declines persistently, reaching the maximum contraction after 5 quarters; collective consumption, on the other hand, has a positive, even if not significant, reaction. What is notable is that, as expected from theoretical and empirical a priori, the negative reaction to the monetary policy shock of the gross fixed investment, at its maximum at the seventh quarter, is more marked than that of private consumption. The unemployment rate also, as expected from the theory and similarly to the findings of CEE (1996), has a positive reaction to the monetary policy shock. Wages react negatively to the increase in the interest rate, possibly as a result of the fall in production and the rise in unemployment. The reactions of these macroeconomic variables seem to support our identification of the repo rate as the monetary policy indicator, and strengthen our confidence in having identified correctly the monetary policy shocks.

Overall the results are consistent with the theory predictions of the effects of unexpected monetary policy shocks and with the empirical literature on VAR models of the economy. Notably the results are not affected by significant “price puzzle”, “liquidity puzzle” or “exchange rate puzzle”, differently from the results often found in VARs models of the Italian economy.

4.3 Robustness

We explored different specifications of the VAR models inspired from the vast literature, but our main results stayed virtually unchanged as for the qualitative and quantitative responses of the model. In particular, we tried to consider different interest rates, such as a short-term (three month) interest rate, an overnight interest rate (partially reconstructed) and different averages of these rates and of the repo rate. In alternative to industrial production, we also considered GDP measures. We tried also, in place of the money aggregate M2, to use other aggregates such as M1 and M3 (reconstructed), with different measures, simple or moving averages, and different definitions of the same aggregate.[18] We explored also alternative measures of inflation (the GDP deflator) and of commodities prices (including oil or not) and, finally, a number of definitions of exchange rates, effective, vis-à-vis the German Mark, the US Dollar, real or nominal. We controlled also for the exogeneity of commodity prices, but we detected a worsening in the quality of the response of M2, without observing improvements in the response of the other variables, hence we preferred to not assume commodity prices as exogenous. Finally, we also controlled for an exclusion of the last four years of the sample to account for the possible change in the monetary policy regime, given by the start of the single currency area. Even if we did not detect significant changes in our results and we are not concerned with structural parameters, we acknowledge that the issue has to be further investigated with a thorough analysis of parameters stability.

5. Effects of monetary policy shocks on flows of funds by sector

Following CEE (1996), our aim is to assess the effects of monetary policy shocks (an unexpected increase of the policy interest rate of one standard deviation, equal to 92 basis points) on the borrowing and lending activities of the sectors of the economy. To this aim, confident to have identified a reliable measure of monetary policy shocks, we move now to analyse the flow-of-funds data to detect the dynamic response of non financial firms,

[18] During the period of observation, a part for the major methodological break in 1999, when new monetary aggregates definitions were adopted, also M2 witnessed changes in its definition as well as different definitions of M1 are conceivable. Moreover both the aggregates can be considered as evaluated at the end of each period, as averages, simple or moving, and seasonally adjusted or not.

households, general government, financial firms and the foreign sector. To do so, we add as the last variable in the VAR the net borrowing (total and by class of financial instrument) of the five sectors in turn, employing the so-called "marginal" method: this implies that monetary policy does not react in the short run to changes in the patterns of these variables, but that the behaviour of these classes of agents responds to monetary policy shocks within the quarter.

In the rest of this section we briefly describe our results as to the borrowing and lending behaviour of the sectors of the Italian economy.

Non financial firms. – A first analysis of the response of the non financial firms to the monetary policy shock can be developed looking at Figure 5.

We do not observe a strong reaction of the net flow of funds of the non financial firms, as a result of two counterbalancing reactions on the asset and on the liability side respectively. Accumulation of assets decrease significantly in the first two quarters and then the variation fades away. Total financial liabilities diminish after the monetary shock for two years. Shares and other equity decline significantly for only one quarter while the decrease in the bonds and long-term loans is protracted for one year and a half.

Following a contractionary monetary policy shock, CEE (1996) observed an increase in both firms' financial assets and liabilities (net borrowing also rises), pointing to some degree of inertia in the firms' level of nominal expenditures as a possible explanation.[19] Our results are different in many respects: except for a slight increase in the same quarter of the shock, the response of net funds raised is never significant. The reduction in firms' issuance of new debt is consistent with both "money view" (standard IS/LM models) and "credit view" (e.g. Bernanke and Blinder, 1988) transmission mechanisms of monetary policy, and also with monetary business cycle models (Fuerst, 1994). Thus, we do not find such strong evidence in support of costs inertia, with the possible exception of a slight, and non significant, increase in short-term liabilities in the first three quarters, which might be explained by some financial frictions of the kind mentioned by CEE(1996).

[19] CEE (1996) find, actually, that in the United States there exist frictions that prevent firms from adjusting immediately their level of inventories to the new lower level of demand, as, on the contrary, standard monetary business cycle models would predict. See also Bernanke and Blinder (1992) and Gertler and Gilchrist (1993).

The fall we observe in the acquisition of new financial assets by firms, on the other hand, is also in line with standard predictions on the effects of a contractionaty policy shock.

Households. - Net funds borrowed by households decline significantly over the first year following the shock. In other words, households' net financial position improves after the shock, as a result of a smaller debt issuance and a larger amounts of funds lent to other sectors (acquisition of new financial assets).

As we can see in Figure 6, the strong result on net funds raised is the result of two counterbalancing, but quite weak, effects on the assets and the liabilities side. The maximum effect on flows of new financial liabilities is reached in the second quarter, while financial assets increase significantly only in the first quarter and then the positive effect vanishes. The responses of the flows of assets and liabilities on households was much stronger in CEE(1996). Looking at those aggregates, our results would seem, indeed, more consistent with "limited participation" models (Christiano and Eichenbaum, 1995) than those of CEE(1996). Nevertheless, looking deeper at the impulse response functions of the household sector, an adjustment in their financial portfolio arises, more consistently with friction-free standard models. Within the financial assets class of instruments, in fact, deposits and shares show a marked decline in the first quarter. This evidence seems sensible for shares, given the worsened perspectives for economic activity. It could also be considered a reasonable result for deposits, that could fall due to an increase in the opportunity cost, if we believe that financial corporations do not adjust the passive interest rates as quickly as alternative liquid instruments available on the market, such as Treasury's short term securities.[21] On the other hand, acquisition of short-term securities increase in the first quarter, displaying then a marked drop during the second year gradually reabsorbed; bonds, after an initial upsurge, do not react much to the shock. As for the liabilities, we can observe that short-term loans increase in the first quarter, while long-term loans decrease significantly up to the third quarter. This evidence, if the interest rate curve is shifted up only for the short-term part, since the increase in the interest rate is perceived as temporary, may indicate, like in the case of non financial firms, possible difficulties of households, in the first quarter after the shock,

[21] This could reflect some sluggishness in the response of bank deposit rates as found by Gambacorta and Iannotti (2005), especially before the introduction of the Consolidated Law on Banking in 1993.

to transform short-term liabilities in long-term ones. While if the entire curve shifts upwards, without increasing the relative convenience of long-term loans, we would observe not financial frictions but rational optimisation of the liabilities structure of the firms.

Other sectors. - The picture of the effects of an unexpected tightening of monetary policy on the net financial flows of the other sectors, can be gauged at a glance looking at the responses of the total net funds raised by every sector in Figure 7.

General government experiences a deterioration of the net financial position, increasing the financial resources borrowed on the market by the other sectors; the effect is statistically significant from the second to the seventh quarters and might be due to a fall in tax receipts and to a probable increase in the burden of the service of the public debt. This result, coherent with existing economic literature, is an improvement with respect to CEE (1996), that obtained an opposite result, deemed to be puzzling.

The limited relevance of the absolute level of the net funds raised by financial firms, given the globally compensating effects of borrowing and lending flows and the high volatility shown (see Figure 4) do not allow us to derive clear implications for this sector.

The foreign sector's balance (see Figure 7) does not reveal a significant response, with the possible exception of a slight deterioration of the financial balance one year after the shock.

6. Conclusions

From the analysis of the response of the Italian economic system to an unexpected one standard deviation increase of the policy interest rate (corresponding to 92 basis point), we reach the following conclusions.

The results of the VAR analysis for the main macroeconomic aggregates are consistent with the predictions of the theory and with the empirical literature. In the first four quarters industrial productions decreases of 0.43 percentage points, price levels of 0.11, money of 0.34. Our results seem to be not affected by price and liquidity puzzles and, even if with very limited significance, by exchange rate puzzle.

Non financial firms in the first four quarters decrease both financial assets and liabilities. As a result, net funds raised by firms do not respond significantly to the shock. We do not find strong evidence in our results in favour of financial frictions which would prevent firms, as in CEE(1996), from adjusting their nominal expenditures. Households in the first quarter after the shock increase short-tem liabilities, diminish the acquisition of liquid assets and increase that of securities. The observed “quick” adjustment of households’ portfolio leads to a careful evaluation of the hypothesis of financial frictions in limited participation models that, on the contrary, postulate absence of variations of households’ financial choices in the period immediately subsequent to the official interest change.

The public sector increases net borrowing until almost two years after the shock, due to an increase in the burden of the service of the public debt and to a fall in tax receipts. This result, consistent with the literature, nevertheless seems an improvement with respect to the seminal Christiano, Eichenbaum and Evans (1996), that obtained a puzzling opposite result.

We acknowledge that our results may have to be considered with caution, since a more formal investigation about the robustness of the results to the possibility of the existence of different regimes of monetary policy throughout the period of observation, and in particular with respect to the adoption of the single currency area in 1999, may be required.

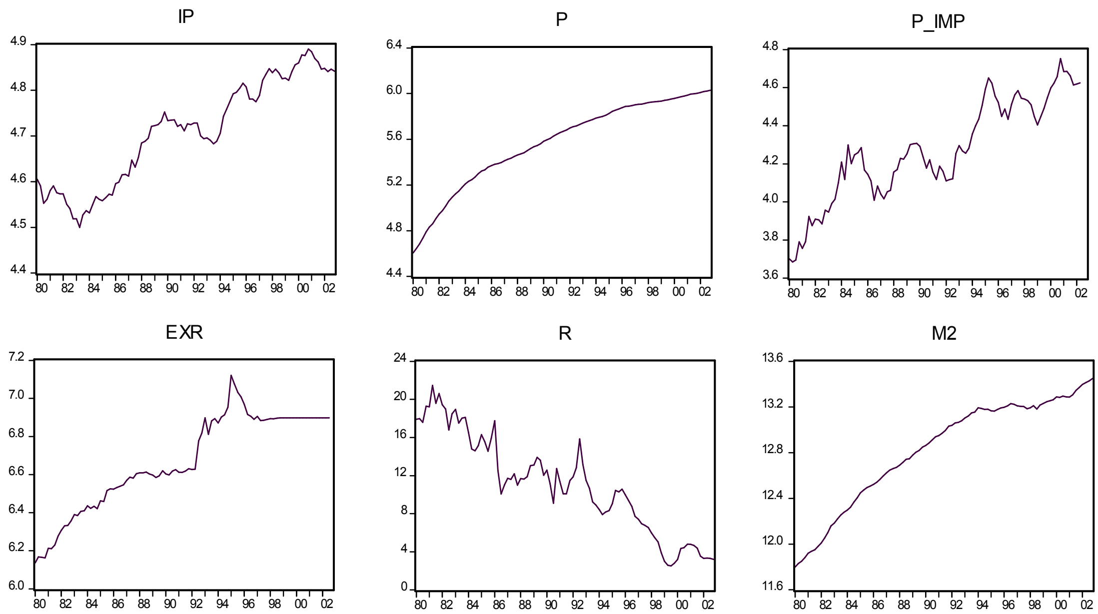
Appendix

Appendix 1: data description

VAR endogenous variables:

IP: log of seasonally adjusted industrial production index.
P: log of seasonally adjusted consumer price index.
P_IMP: log of seasonally adjusted import price of raw materials (in local currency).
EXR: log of nominal exchange rate (ITL per DM; from 1999 it is a constant).
R: short-term interest rate (from 1980 to 1981: average interest rate on fixed term advances; from 1982 to 1998: auction rate on repurchase agreements between the Bank of Italy and credit institutions; from 1999 onwards: interest rate on main refinancing operations of the ECB).
M2: log of seasonally adjusted monetary aggregate M2.

VAR endogenous variables' graphs



<u>Financial accounts series</u> (converted to billions of 1995 ITL using the gdp deflator, and seasonally adjusted):

- non-financial corporations: net funds raised (NFNET=NFTLI-NFTAS), total financial assets (NFTAS), total financial liabilities (NFTLI), short term liabilities (NFSLI), long-term liabilities (NFLLI=NFELI+NFDLI), shares and other equity (NFELI), other long-term debt (NFDLI), short-term liabilities (NFSLI=NFTLI-NFLLI);

- financial corporations: net funds raised (FCNET=FCTLI-FCTAS), total financial assets (FCTAS), total financial liabilities (FCTLI);

- households: net funds raised (HTNET=HTTLI-HTTAS), total financial assets (HTTAS), currency and deposits (HTDAS), short-term securities (HTSAS), long-term securities (HTBAS), shares and other equity (HTEAS), total financial liabilities (HTTLI), short-term loans (HTSLI), long-term loans (HTLLI);

- general government: net funds raised (GGNET=GGTLI-GGTAS), total financial assets (GGTAS), total financial liabilities (GGTLI);

- rest of the world: net funds raised (RWNET=RWTLI-RWTAS), total financial assets (RWTAS), total financial liabilities (RWTLI).

Appendix 2: methodological issues

We assume the economy to be described by a structural form equation like the following:

$$A(L)y_t = u_t \tag{1}$$

where *A(L)* is a matrix polynomial in the lag operator *L*, i.e. $A(L) = A_0 + A_1 L + A_2 L^2 + \ldots$, y_t is an n×1 vector containing the variables of interest, and u_t is an n×1 structural disturbances vector. Let $\Omega = \text{var}(u_t) = E[u_t u_t']$ be the n×n variance-covariance matrix of the *structural disturbances*; since u_t are assumed to be mutually uncorrelated, the matrix Ω is diagonal, the n diagonal elements being the variances of the n structural disturbances.

Writing (1) in reduced form gives the following representation:

$$y_t = B(L)y_t + e_t \tag{2}$$

which can be estimated using OLS equation by equation. *B(L)* is a matrix polynomial in the lag operator *L* and the e_t terms in equation (2) are the VAR (reduced-form) *residuals* resulting from the estimation of the n regressions. We call $\Sigma = \text{var}(e_t) = E[e_t e_t']$ the variance-covariance matrix of the residuals.

Stopping for simplicity to a lag polynomial of order 2, eq. (1) is $A_0 y_t = -A_1 y_{t-1} - A_2 y_{t-2} + u_t$, with reduced form $y_t = -(A_0^{-1} A_1) y_{t-1} - (A_0^{-1} A_2) y_{t-2} - A_0^{-1} u_t$, that is representation (2) with $B(L) = -(A_0^{-1} A_1 L + A_0^{-1} A_2 L^2)$; besides, it is straightforward to notice that the structural disturbances u_t and the reduced form residuals e_t are related by:

$$e_t = A_0^{-1} u_t \tag{3}$$

where the coefficients in the A_0 matrix are those of the contemporaneous relations among the variables in the y_t vector. From eq. (3) and remembering that $\text{var}(e_t) = \Sigma$ and $\text{var}(u_t) = \Omega$, we can easily derive $\text{var}(e_t) = E(e_t e')_t = E(A_0^{-1} u_t u' A_0^{-1'}) = A_0^{-1} E(u_t u_t') A_0^{-1'}$, and thus:

$$\Sigma = A_0^{-1} \Omega A_0^{-1'} \tag{4}$$

The issue is now to recover the parameters in the structural form equations (1) from the coefficients estimated in the reduced form equations (2). Sample estimates of Σ can be used in order to obtain maximum likelihood estimates of Ω and A_0. Given that Σ is a $n \times n$ symmetrical matrix, it contains $n \times (n+1)/2$ parameters, which can be estimated via OLS. On the right-hand side of eq. (4), instead, there are n^2 parameters to be estimated in A_0 and n in Ω, that is, a total of $n \times (n+1)$ free parameters. This means that we need at least $[n \times (n+1) – n \times (n+1)/2] = n \times (n+1)/2$ additional restrictions on the right-hand side of eq. (4) in order to achieve identification (n of those restrictions can simply be derived normalising to 1 the diagonal elements of A_0), so that $n \times (n-1)/2$ further restrictions are left.

We make use of a Choleski factorisation in order to orthogonalize the residual covariance matrix Σ. In practice, this corresponds to imposing just $n \times (n-1)/2$ restrictions on the matrix A_0, that is supposed to be lower triangular (all the upper diagonal elements are set to be 0); as a result, the VAR is just identified.

Appendix 3: figures and tables

Fig. 1 – Estimated interest rate policy shocks
(three-quarters centered moving average)

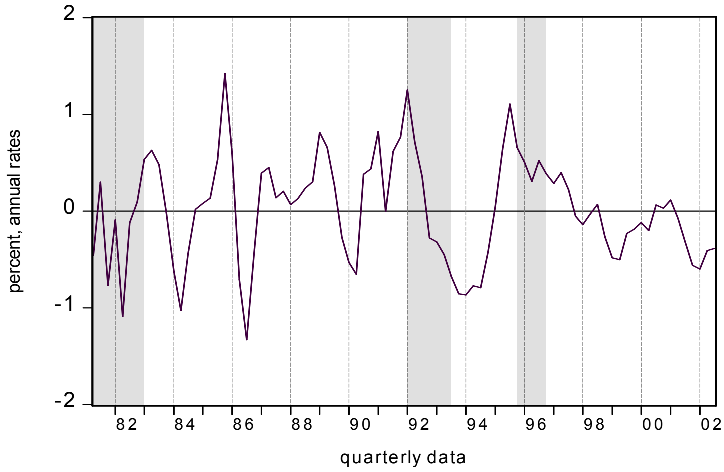
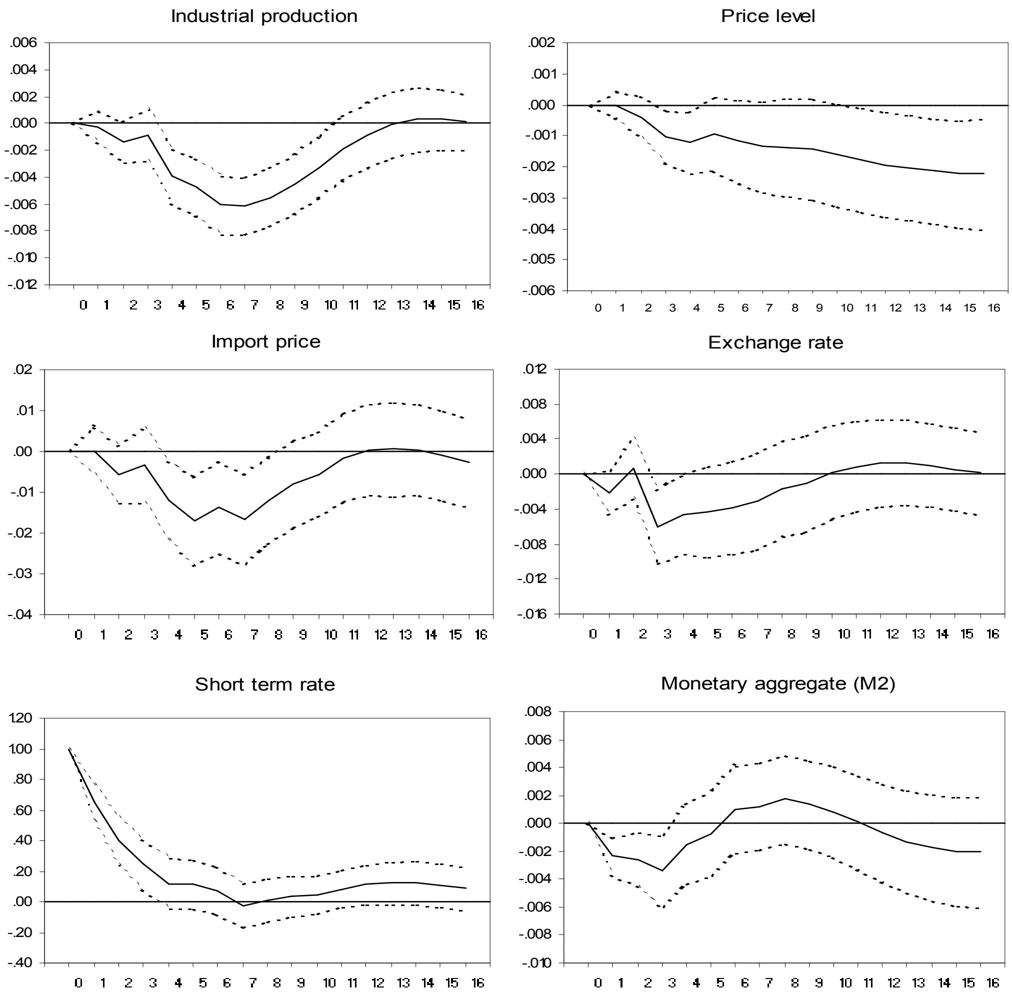
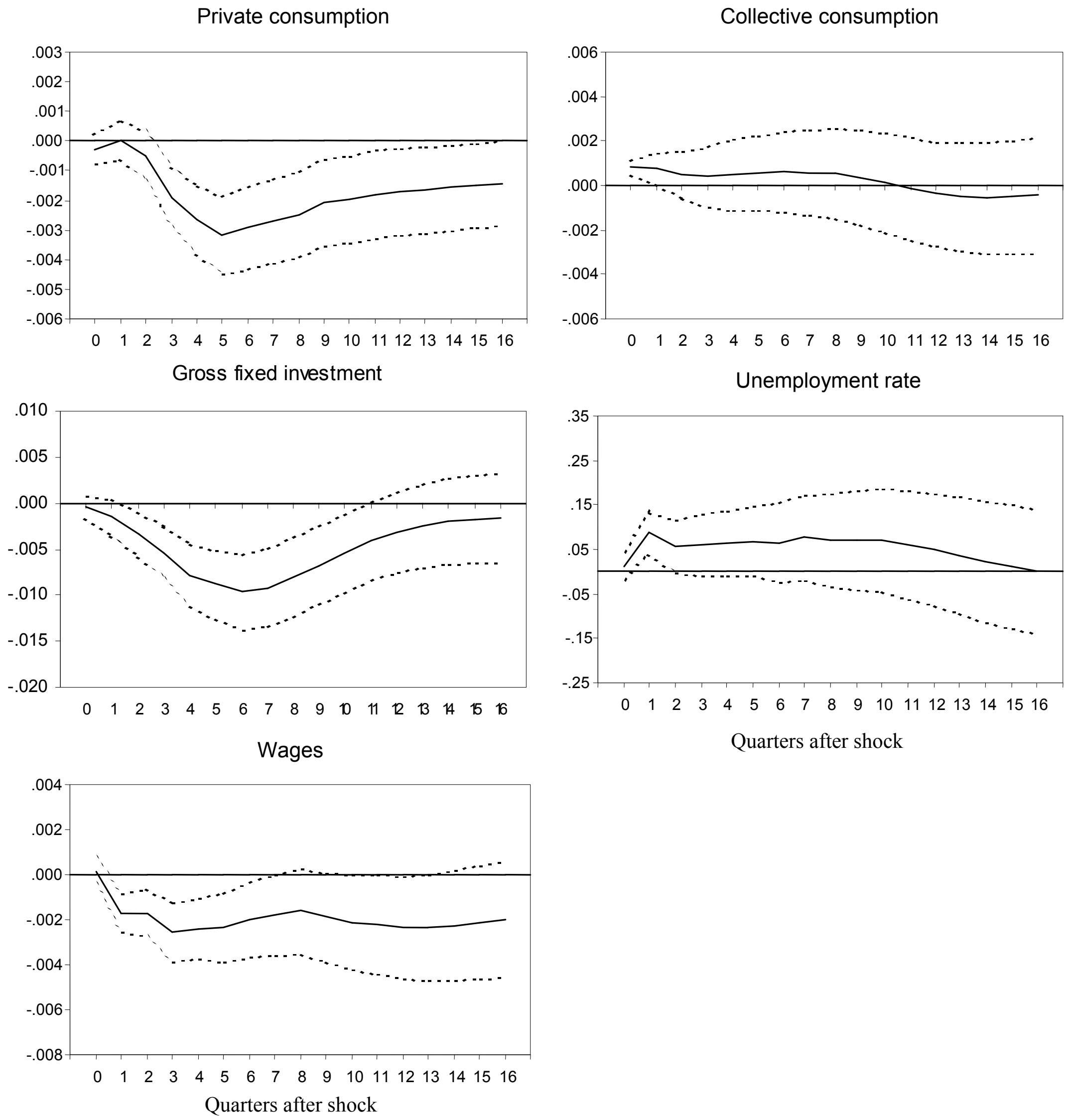


Fig. 2 – Responses to a contractionary monetary policy shock: VAR variables



Note: estimated impulse responses to a one standard deviation increase in the short term interest rate. The dashed lines are ± 1 standard error bands, computed by means of Monte Carlo integration, following Sims and Zha (1999).

Fig. 3 – Responses to a contractionary monetary policy shock: other macro variables



Note: the estimated impulse responses were estimated from 7-variable VARs in which we added one of the above variables, in turn, to the original 6-variable VAR, placing it in the last position. The dashed lines are ± 1 standard error bands, computed by means of Monte Carlo integration, following Sims and Zha (1999).

Fig. 4 – Flow of funds data: net funds raised by sectors
(converted to billions of 1995 ITL using the gdp deflator and seasonally adjusted)

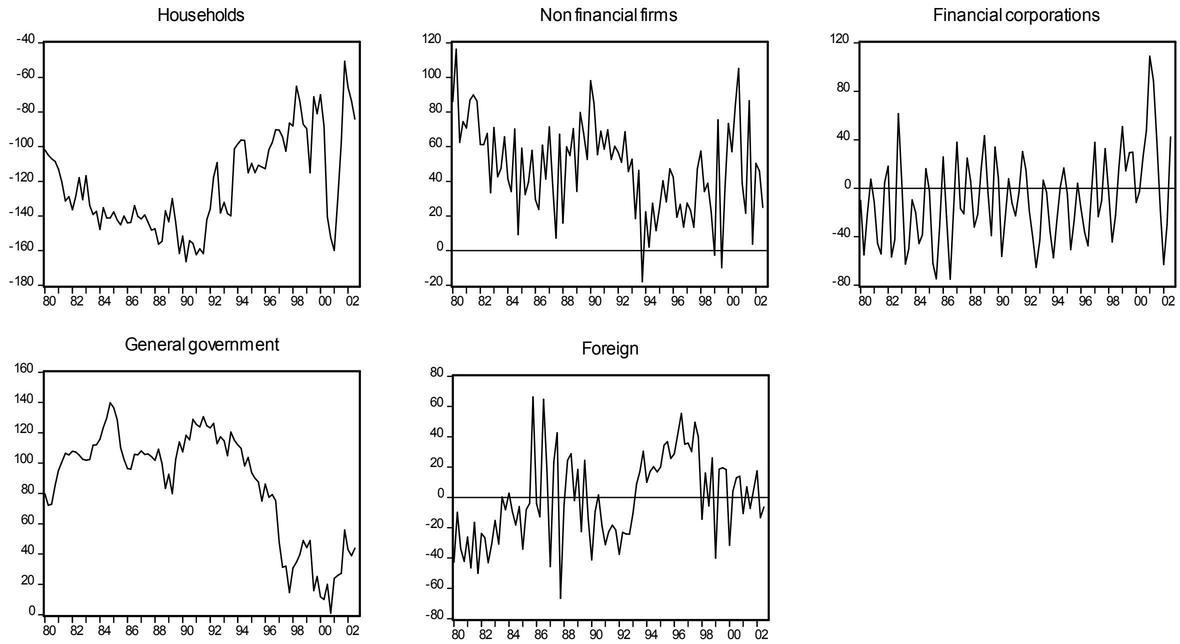


Fig. 5 – Responses to a contractionary monetary policy shock: non-financial firms

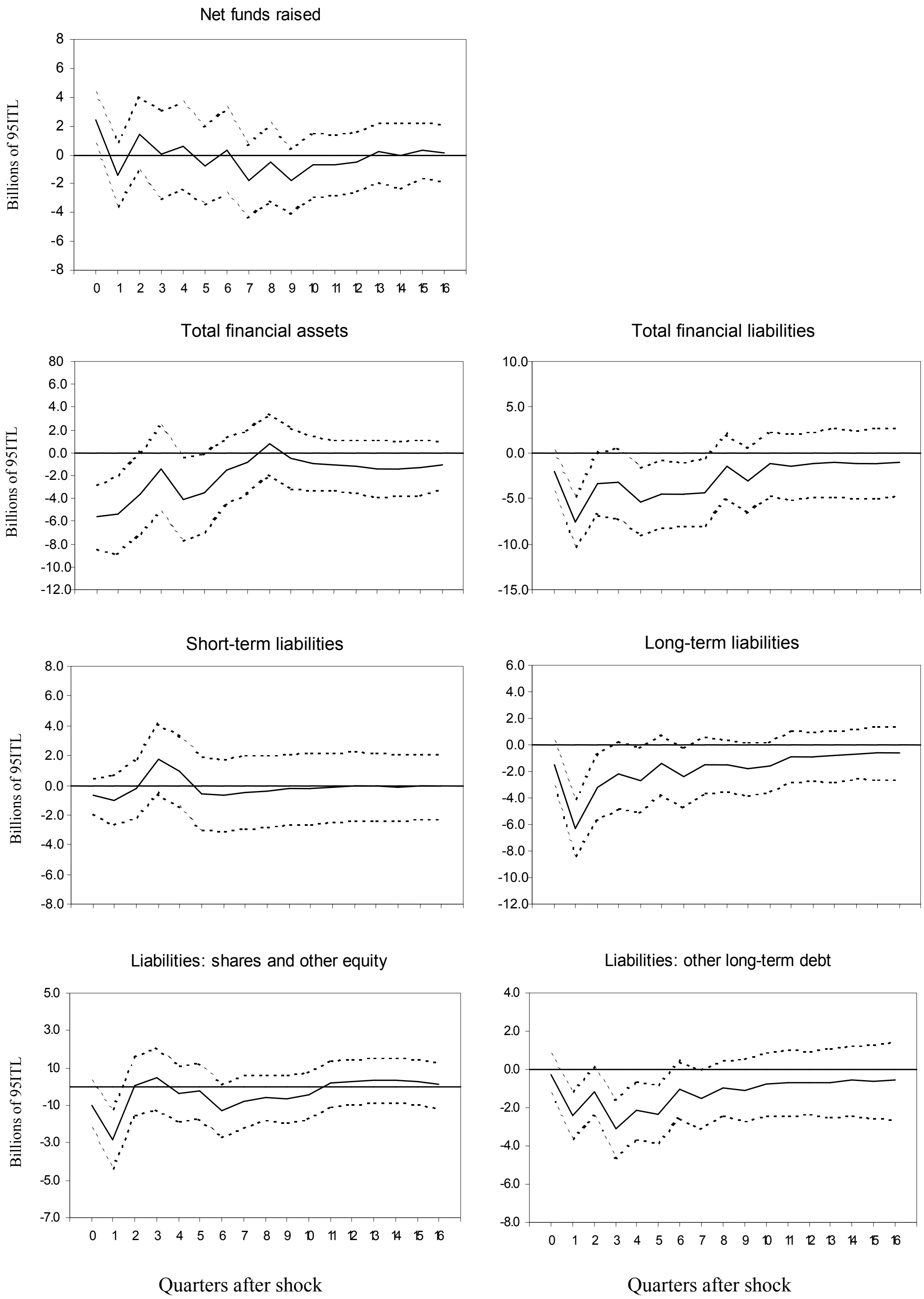


Fig. 6 – Responses to a contractionary monetary policy shock: households

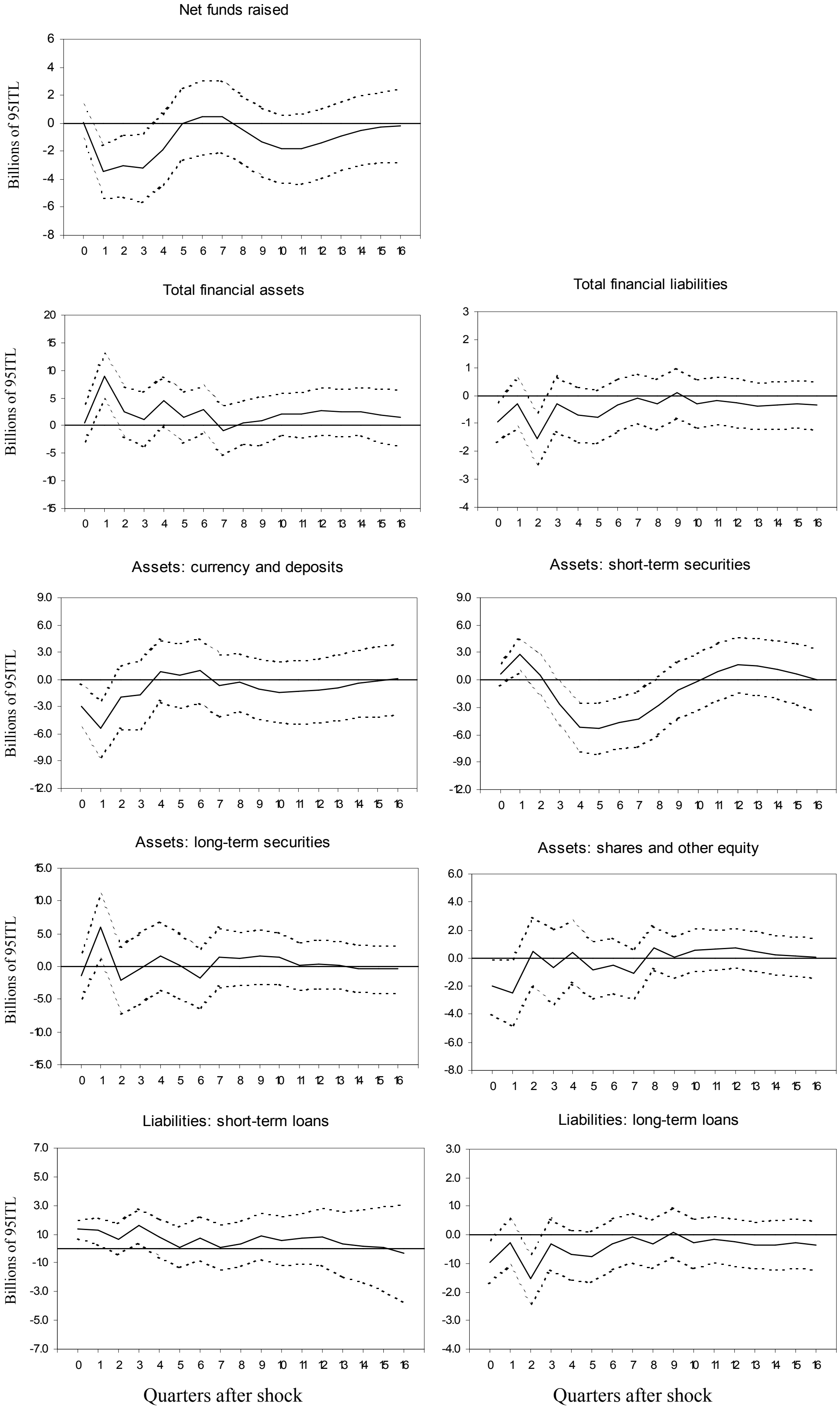
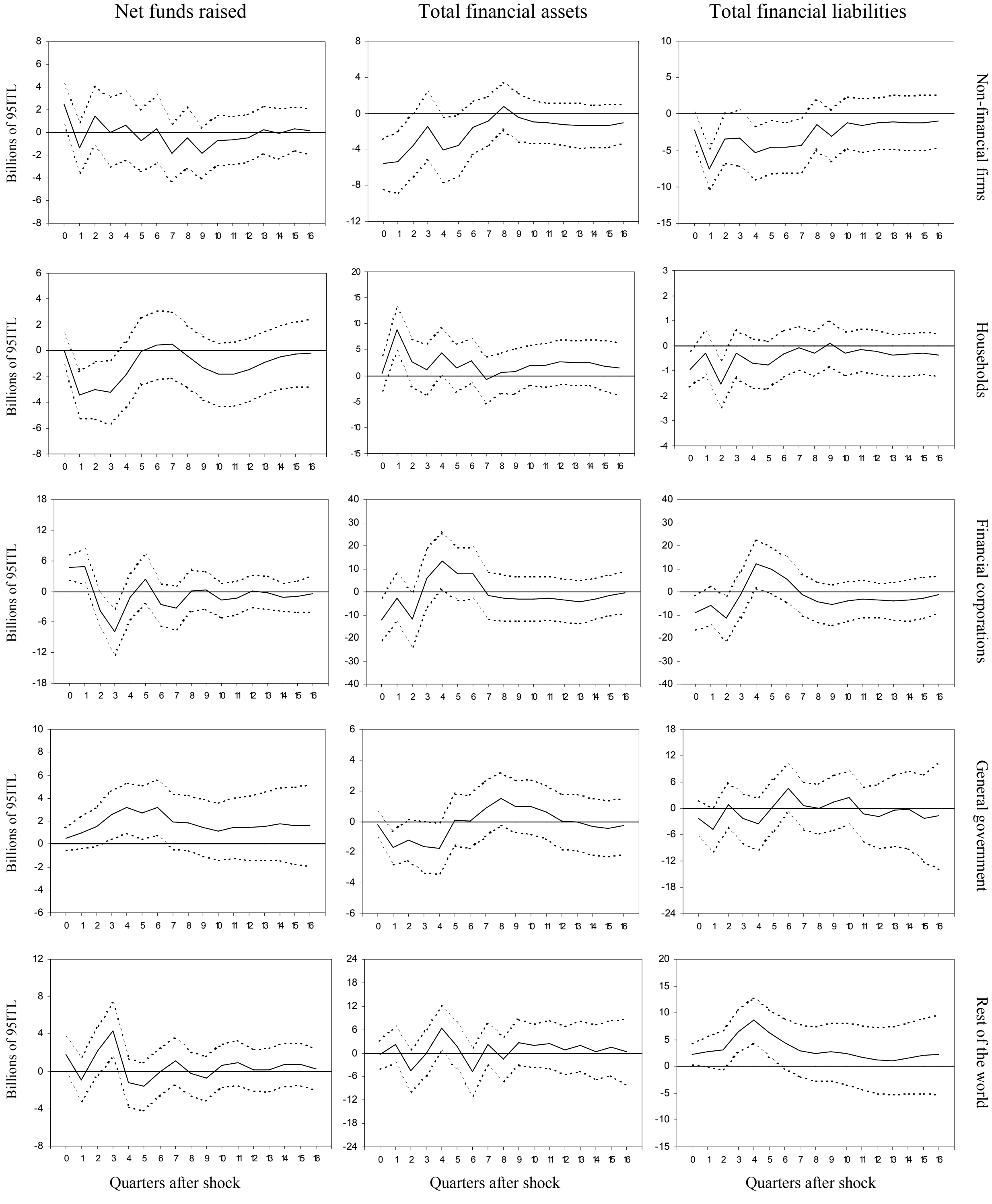


Fig. 7 – Responses of the flow-of-funds data to a contractionary monetary policy shock



Note: the estimated impulse responses were estimated from 7-variable VARs in which we added one of the above variables, in turn, to the original 6-variable VAR, placing it in the last position. Dashed lines are ± 1 Monte Carlo standard error bands.

Table 1 – VAR diagnostic tests: autocorrelation LM test
(H_0: no serial correlation at lag order h)

Lags	LM-Stat	Prob.
1	42.3	0.22
2	36.5	0.45
3	43.1	0.19
4	38.7	0.35
5	23.6	0.94
6	40.0	0.30
7	30.9	0.71
8	31.3	0.69

Probs from chi-square with 36 d.o.f.

Table 2 – VAR diagnostic tests: White heteroschedasticity test

Joint test:

Chi-sq	df	Prob.
1097.60	1071	0.28

Individual components:

Residuals from the equation for	R-squared	F(51,34)	Prob.	Chi-sq(51)	Prob.
IP	0.39	0.44	0.99	34.22	0.97
P	0.77	2.18	0.01	65.88	0.08
P_IMP	0.64	1.17	0.31	54.85	0.33
EXR	0.77	2.27	0.01	66.50	0.07
R	0.65	1.22	0.27	55.69	0.30
M2	0.55	0.82	0.74	47.57	0.61

Table 3 – VAR diagnostic tests: residual descriptive statistics and univariate normality test

Residuals from equation for:	IP	P	P_IMP	EXR	R	M2
Mean	2.32E-15	-1.25E-15	1.96E-13	3.91E-14	-3.64E-12	-8.03E-15
Median	-0.0007	6.39E-05	0.0013	0.0004	-0.0006	-0.0004
Max	0.0273	0.0083	0.1076	0.0446	2.7194	0.0230
Min	-0.0246	-0.0085	-0.0967	-0.0502	-2.2028	-0.0255
Std. Dev.	0.0090	0.0030	0.0418	0.0177	0.9212	0.0093
Sum	2.00E-13	-1.07E-13	1.69E-11	3.36E-12	-3.13E-10	-6.91E-13
Sum Sq. Dev.	0.0069	0.0007	0.1487	0.0266	72.133	0.0074
Observations	86	86	86	86	86	86
Skewness	0.237	-0.208	0.041	0.063	0.125	0.133
Kurtosis	3.496	3.186	2.821	3.835	3.587	3.469
Jarque-Bera	1.687	0.744	0.139	2.558	1.461	1.046
Probability	0.430	0.689	0.933	0.278	0.482	0.593

Table 4 – VAR diagnostic tests: residual normality test (Lutkepohl)
(H_0: residuals are multivariate normal)

Component	Skew.	Chi-sq	df	Prob.	Kurt.	Chi-sq	df	Prob.	Jarque-Bera	df	Prob.
1	0.13	0.25	1	0.62	1.59	7.12	1	0.01	7.37	2	0.02
2	-0.12	0.19	1	0.66	1.55	7.52	1	0.01	7.71	2	0.02
3	-0.02	0.01	1	0.95	1.24	11.03	1	0.01	11.03	2	0.01
4	0.04	0.03	1	0.87	1.91	4.30	1	0.04	4.32	2	0.12
5	0.06	0.05	1	0.82	1.56	7.39	1	0.01	7.44	2	0.02
6	0.09	0.13	1	0.72	1.64	6.65	1	0.01	6.77	2	0.03
Joint		0.649	6	0.99		44.01	6	0.00	44.66	12	0.00

Table 5 – VAR diagnostic tests: lag order selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	325.650	NA	3.33e-11	-7.09766	-6.40797	-6.82024
1	1090.81	1350.27	1.19e-18	-24.2543	-22.5301*	-23.5607*
2	1128.94	61.9144	1.15e-18	-24.3046	-21.5458	-23.1949
3	1168.47	58.5918	1.11e-18	-24.3875	-20.5942	-22.8618
4	1208.92	54.2555*	1.08e-18*	-24.4923	-19.6645	-22.5504
5	1246.37	44.9327	1.19e-18	-24.5263*	-18.6639	-22.1683

* indicates lag order selected by the specific criterion.
LR: sequential modified LR test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion

Table 6 – Forecast error variance decomposition: endogenous variables (standard errors in parentheses)

Time after the shock	IP	P	P_IMP	EXR	M2
impact	-	-	-	-	0.3 (1.6)
1 quarter	0.0 (1.2)	0.0 (0.7)	0.0 (1.2)	0.5 (1.3)	3.6 (4.2)
2 quarters	0.4 (1.6)	0.4 (1.7)	0.6 (1.9)	0.4 (1.4)	4.2 (4.8)
1 year	3.5 (4.3)	3.4 (4.4)	2.5 (3.9)	3.2 (3.7)	6.5 (7.0)
2 years	21.9 (10.1)	5.6 (6.7)	10.6 (7.8)	5.1 (4.2)	4.7 (6.5)
3 years	22.9 (10.2)	9.3 (8.9)	10.3 (7.6)	4.0 (5.2)	3.6 (6.1)

Percentage of the variance of the column variable's forecast error at the various horizon attributable to the monetary policy shock.

Table 7 – Forecast error variance decomposition: other aggregates (standard errors in parentheses)

Time after the shock	UR	GFINV	W	C
impact	0.2 (1.7)	0.0 (1.3)	0.0 (1.3)	0.2 (1.8)
1 quarter	9.2 (6.0)	0.1 (1.7)	4.4 (3.9)	0.1 (1.6)
2 quarters	9.8 (7.0)	1.3 (2.5)	5.7 (5.0)	0.3 (2.0)
1 year	13.0 (7.8)	8.9 (6.9)	7.6 (6.5)	8.1 (6.2)
2 years	15.7 (9.1)	28.6 (12.2)	5.9 (5.8)	15.5 (9.4)
3 years	17.0 (10.1)	31.5 (12.6)	7.0 (6.4)	15.8 (9.8)

Each variable was added as the last one to the original 6 variables VAR. UR: unemployment rate; GINV: gross fixed investment; W: real wages; C: private consumption.

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