# Monetary Policy Shocks and Transmission in Italy: A VAR Analysis.[1]

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**Abstract**

This paper provides updated empirical evidence about the real and nominal effects of monetary policy in Italy, by using structural VAR analysis. We discuss different empirical approaches that have been used in order to identify monetary policy exogenous shocks. We argue that the data support the view that the Bank of Italy, at least in the recent past, has been targeting the rate on overnight interbank loans. Therefore, we interpret shocks to the overnight rate as purely exogenous monetary policy shocks and study how different macroeconomic variables react to such shocks.

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# 1 Introduction

Many studies have recently investigated how monetary policy affects the economy.[1] However, there is probably only one empirical finding that is robust enough, both over time and across countries, to be viewed as a monetary "fact". This finding is the existence of a close-to-one long run correlation between the rate of growth of different monetary aggregates and the inflation rate.[2] On one side, this can be considered as an argument supporting the old quantity theory of money. On the other side, it leaves ground for many important questions to be further investigated. From an empirical point of view, less consensus seems to have been obtained with respect to either the long run relationships between money growth (or inflation) and output growth,[3] or to the short run dynamics following monetary policy impulses. In the latter case, the transmission mechanism of monetary policy is clearly different across countries, being affected mainly by the structure of the financial system and the degree of openness of the economies. In turn, these factors might be depending on other institutional considerations, such as the legal and tax systems in place or the efficiency of court procedures.[4]

Most of the studies analyzing the short run response of the economy to monetary policy have been conducted by using the methodology of Structural Vector Autoregression (SVAR).[5] This approach has the advantage of imposing a minimal set of theoretical restrictions on the model to be tested, thereby allowing for a close-to-pure statistical investigation of the time series properties of the variables included in the analysis. In this literature, a monetary policy shock is identified with the residual of an equation regressing a monetary policy instrument on a set of variables that are considered relevant for the decisions of the central bank. Hence, monetary policy shocks are defined as statistical innovations and represent a purely *exogenous* component of policy. Impulse responses of different macroeconomic variables to these shocks are not subject to the rational-expectation critique[6] and can then be interpreted as the empirical dynamics beyond the comparative statics exercises developed in standard equilibrium analysis. A drawback of this analysis is that the impulse responses do not consider the "endogenous" component of monetary policy, such as any feedback rule linking policy to the state of the economy. Indeed, this endogenous component might well be even more important than the exogenous one. But, since it is hard to identify and single out the original source of the many shocks hitting the economy and to which policy responds, the consequences of these endogenous changes in monetary policy are more difficult to interpret as they combine the effect of the original shocks and that of the policy reaction.

[1] See Christiano, Eichenbaum and Evans (1998) and Clarida, Galì and Gertler (1999a) for recent surveys. Other useful general references are Goodfriend and King (1997) and the recent textbooks by Walsh (1998) and Blinder (1998).

[2] See Mc Candless and Weber (1995) and Lucas (1996).

[3] See Mc Candless and Weber (1995) and Barro (1995), for example.

[4] See Cecchetti (1999).

[5] See Bernanke and Blinder (1992), Christiano and Eichenbaum (1992), Sims (1992), Strongin (1995), Leeper, Sims and Zha (1996), Clarida and Gertler (1996), Bernanke and Mihov (1997,1998) and Bagliano and Favero (1998). Canova (1995) and Watson (1994) provide a general methodological discussion.

[6] See Keating (1990) for a discussion on SVAR and rational-expectations econometric models.

In this paper we present empirical evidence about how monetary policy shocks can be identified and are transmitted to other variables in the Italian economy, by applying VAR analysis.[7]

We believe that Italy provides an interesting case study for different reasons.

First, important institutional changes have affected, in the last decade, both the degree of economic and political independence[8] of the Bank of Italy, as well as the environment in which monetary policy is decided and implemented. In terms of central bank independence, between 1992 and 1994 a series of laws were passed giving the central bank Governor the exclusive responsibility to set and change the monetary policy instruments (the discount rate and the reserve coefficient, as well as full control on the growth rate of the monetary base). In particular, any source of direct and permanent financing of the Treasury deficit via high-power money was prohibited.[9] As regards the modus operandi of monetary policy, this had already been substantially modified by the introduction, at the end of the 80s, of a series of important institutional changes in the money market. A screen-based market for Treasury Bills was opened in 1988, the one for interbank deposits in 1990. The mandatory reserve regime was also gradually reformed (starting by 1990) so as to allow banks to average provisions in the maintenance period. Other important changes have been the abolition of the floor price on T-Bills auctions (1988) and a new discipline in terms of fixed-term advances.[10]

Second, in the 90s, Italy achieved a stable reduction in the inflation rate. This was accompanied by a lower-than-average rate of economic growth with respect to previous decades. Economic growth was also considerably lower, in this period, than in other European countries that were facing similar (although smaller in magnitude) problems in terms of fiscal adjustment required to meet the Maastricht budget criteria. It is important to assess the role that monetary policy played in generating these macroeconomic outcomes.

Third, Italy can be viewed as a good example of a "small" open economy. Most of the studies on the US and Germany are conducted in a closed economy framework. In the Italian case, we will be interested in evaluating the role of the exchange rate under different perspectives: as a monetary policy intermediate target, as a transmission channel of the monetary impulses and as an information variable monitored by the central bank. The different roles performed by this variable might have affected the operating procedures that the central bank used in order to conduct monetary policy.

We start by presenting some general and preliminary descriptive evidence on short run empirical relationships between money, interest rates and output in Italy.

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[7]See Nicoletti Altimari et al. (1995) for a study conducted on the basis of the Bank of Italy Quarterly Econometric Model. Previous applications of VAR analysis to Italy are Bagliano and Favero (1995), Buttiglione and Ferri (1994), De Arcangelis and Di Giorgio (1998, 1999), and Gaiotti, Gavosto and Grande (1997).

[8]Political independence is defined as the ability of the central bank to establish its policy targets without government interference. Economic independence is defined as the ability of the central bank to autonomously maneuver its instruments in order to reach the monetary policy goals. See Grilli, Masciandaro and Tabellini (1991).

[9]See Passacantando (1996). Price stability was explicitly stated as the primary target of monetary policy only in 1998.

[10]See Gaiotti (1992) and Sarcinelli (1995).

Although interesting, and maybe suggestive, this evidence deals with simple statistical associations. It cannot be used to derive any conclusion in terms of causality links among these variables. Hence, we move to what we consider a more sophisticated form of dynamic correlation analysis, and estimate simple and atheoretical VAR models that use monthly data on output, prices, a money aggregate and an interest rate. Here, we show how it is possible to use different, although arbitrary, identification mechanism in the attempt to isolate a measure of an exogenous monetary policy shocks. Simulation analysis conducted through these models, however, produces results which are quite at odd with the predictions of traditional as well as new theoretical views of what the effects of monetary policy should be. Many empirical "puzzles" seem to arise from this analysis.

Hence, we turn to give a structural content to the VAR methodology, by linking econometric analysis with the institutional knowledge of how the market for banks reserves (i.e., the market in which monetary policy is actually conducted) works, following a research strategy introduced by Strongin (1995) and Bernanke and Mihov (1998) and extended to Italy by De Arcangelis and Di Giorgio (1998). We estimate a larger dimension VAR model where identification hinges on a detailed description of the operating procedures used by the Bank of Italy. The advantage of this procedure is that it allows the researcher to directly test different model alternatives that are nested in the same specification, without imposing *a priori* one identification mechanism. The correct measure of a monetary policy shock is then selected by the data itself.

Finally, we use our measure of monetary policy shocks to simulate the response of a set of nominal and real macroeconomic variables to a monetary impulse. We study how different interest rates, as well as variables in the banking sector, react following a monetary contraction. But we do also study the dynamics of aggregate demand components, employment and wages.

The paper is organized as follows. In section 2, we provide some basic descriptive evidence using dynamic correlations and graphs. VAR analysis is introduced in section 3, where identification is achieved by imposing an arbitrary order of exogeneity to the variables included in the analysis. In section 4 we discuss how it is possible to combine vector autoregression techniques with institutional analysis, while in section 5 we present our model of the Italian economy. The transmission of monetary policy shocks to other macroeconomic variables is studied in section 6, and we briefly conclude in 7.

# 2 Descriptive Evidence

Short run empirical relationships between monetary and real variables are relevant as they provide information about the way in which private agents react to changes in the state of the economy ("shocks") and about how monetary policy is managed in order to respond to these shocks.

A first look at these relationships can be obtained by simply computing cross-correlations and plotting graphs of the relevant time series. We restrict to the post 1982 period, as monetary policy in Italy could hardly be considered as independently managed before the so called "divorce" from the Treasury (1981). In Figure

1, we plot the detrended log of real GDP with different monetary aggregates, each in its detrended form.[11] Over the time horizon considered, the statistical definition of the monetary aggregates was modified to include new monetary instruments originated by financial innovation, or in response to a change in the economic function performed by a single instrument. However, roughly speaking, M0 is the monetary base, cash held by the private sector plus banking reserves; M1 is cash plus checking deposits (and some minor items), while M2 includes M1 plus time and savings deposits and CDs. We observe that Figure 1 provides no evidence of a positive correlation between detrended monetary aggregates and output. The finding of such a correlation, plus the observation that periods of high monetary growth were usually preceding output peaks in the US economy was the basic foundation for Friedman and Schwartz (1963)'s conclusions that "money matters" and "money leads output". Although the same correlation is not any longer evident in post 1982 US data (see Walsh, 1998), Figure 1 seems to present a totally opposite picture. In Italy, a negative statistical correlation can be observed between detrended money and output.

This finding is confirmed by Figure 2, plotting the dynamic correlations of detrended monetary aggregates ($MI_{t+j}$) with current detrended output ($Y_t$), where $I = 0, 1, 2$ and $j = -8, \cdots - 1, 0, 1 \ldots 8$. Periods of high output with respect to trend are associated with previous periods of low levels of money (with respect to trend). Moreover, with the exception of the monetary base, money measures are negatively correlated with output up to 5 leads. If we restrict the analysis to the 90s, similar results are obtained.

Tobin (1970) and, more recently, King and Plosser (1984) have argued that evidence of a positive correlation between money and output cannot be interpreted as suggesting that high money levels induce or "cause" high levels of output. Analogously, our finding does not lead to conclude either that monetary policy or that money growth has a negative effect on output. The reason is that monetary aggregates cannot be viewed as correct indicators of monetary policy, as they combine elements of both money supply and money demand. If the reverse causation argument is accepted (King and Plosser, 1984), so that money "follows" output, then a negative correlation might as well be explained by the following story. High levels of output are often associated with rising prices. This can induce expectations of higher inflation rates and increase the nominal interest rate, which in turn will induce a portfolio reallocation away from money. Moreover, if monetary policy is targeting the inflation rate it will respond to these movements by reducing the monetary base and finally money supply. Of course, other stories are equally admissible. One might also wonder if any sensible relationship can be detected from real money balances and output. In Figure 3, we show the dynamic correlations of real balances (in terms of M1 and M2) vis a vis output. Here, the pattern exhibited by the data replicates the standard finding of the aggregate-demand/aggregate-supply textbook model. Real money balances are positively correlated with output at lags; high levels of output with respect to trend are preceeded by high levels of real money balances (and followed by low levels, as at leads the correlation is negative). But again the evidence is only suggestive. In any case a relevant endogeneity problem

[11] Data are quarterly observations. Trends are obtained by using a Hodrick-Prescott filter.

is present when using monetary aggregates as a monetary policy indicator. This problem might be particularly severe if the monetary authorities used a short term interest rate as a monetary policy instrument. And indeed, many authors have underlined that, in many countries, this is the case.[12]

Figure 4 (and 5) associate movements in short term interest rates with detrended real GDP. We have used the 3-month Treasury bill rate and the overnight rate (for the latter, the time series is reasonable only starting from 1988, due to the characteristics and the peculiar functioning of the old "market" for interbank loans in the country[13]).

These figures provide some support to the view that monetary policy might have contributed to the Italian business cycle. For example, the two serious slowdowns of the 90s have been preceeded by increased levels of the interest rates. However, the endogeneity problem, in a way, is present also here, in particular regarding the T-bill rate. As a matter of fact, the market rate is simultaneously determined by supply and demand conditions. High interest rates might be induced by high market demand for credit or low credit supply, as well as by restrictive monetary policy.

# 3 Preliminary VAR Analysis

Although monetary aggregates and the level of short term interest rates could be regarded as useful indicators of the monetary conditions in a single country, the discussion above made clear that changes in their time pattern cannot be unambiguously interpreted as monetary policy shocks. However, from an empirical point of view it is essential to be able to isolate these shocks. Should we only focus on monetary policy "actions", which include feedback responses of policy to many other possible shocks hitting the economy, we would never come up with a measure of the macroeconomic effects originated by a purely exogenous change in monetary policy. We would only describe the mixed effects originated by different heterogeneous shocks and by how policy makers react to these shocks. Even though this reaction might in practice account for most of the ordinary monetary policy interventions, from a scientific point of view we would still like to investigate the effects of a monetary policy shock isolated both by other kinds of shocks in the economy and by the endogenous changes that these other shocks might push. Moreover, as mentioned above, the responses to unforecastable (and structural) innovations are less subject to the Lucas' critique.

Structural VARs have been useful in pursuing this strategy. In a structural VAR, after the estimation of the unrestricted vector autoregression (i.e., with no contemporaneous interactions among the variables), the econometric identification of economically meaningful (i.e., structural) innovations occurs in a second stage where reasonable constraints must be introduced.[14] These constraints are typically designed as restrictions on the contemporaneous influence among fundamental (i.e.,

[12] See Blinder (1998), Clarida, Galì and Gertler (1999a, 1998). A careful analysis of monetary policy operating procedures in the major industrial countries was undertaken by Borio (1997).

[13] See Cotula (1989), Sarcinelli (1995) and Passacantando (1996).

[14] See Amisano and Giannini (1997, chap. 1). Technically, the estimation of a structural VAR with Choleski decomposition can be developed equation by equation with ordinary least squares, by using the properties of a Wold causal chain.

non-structural) and structural innovations, where the latter are assumed to be mutually and serially uncorrelated. Basically, the analyst has to make a number of identifying assumptions in order to be able to estimate the reaction function of the central bank, including assumptions on what variables are monitored and on what kind of interaction the exogenous policy shock has with variables in the reaction function of the monetary authority (the so called endogenous component of policy). The main identifying assumption is that policy shocks have to be orthogonal to variables in the reaction function of the central bank.[15] Hence, within the system of equations in the VAR, policy shocks can be estimated as the residuals in the linear regression of the central bank instrument on the variables in the central bank reaction function. According to this assumption, the monetary policy instrument changes following a contemporaneous innovation to the variables in the information set of the central bank; while these latter variables are constrained to have no contemporaneous reaction to a change in the policy instrument. Obviously, this assumption can be sensibly maintained when the observation period is one month. It is less acceptable when the VAR deals with yearly or even quarterly data.[16]

We start by estimating two simple 3-variable monthly VARs including, in order, consumer prices, an index of real activity (industrial production), and a monetary policy instrument. The latter is a monetary aggregate (M2, which was actually used as an intermediate target in the 80s and the early 90s) in the first VAR and a short term interest rate (3-month T-bill rate) in the second. Identification is achieved by imposing a triangular recursive structure among the variables, according to the assumption that prices and output do not contemporaneously respond to a change in the monetary instrument (and that prices do not even contemporaneously respond to a change in output). The data set goes from January 1982 to May 1998; estimation is performed by including twelve lags and uses the full information maximum likelihood (FIML) method. The impulse response functions to a monetary policy shock are plotted in Figure 6. The results are quite disappointing. In Panel (a) of Figure 6, for example, a positive innovation in money supply (because of our identifying assumption) has a positive impact effect on prices and a negative impact effect on output. After a few months, the response is never significantly different from zero on both variables.[17] In Panel (b) of Figure 6, a positive innovation in the short term rate (contractionary monetary policy shock) induces an increase in consumer prices which is significant for up to 2 years. Output declines one year after the shock with a negative peak at about 2 years. However, the information set in these models may be too limited. We then move to estimate a set of 4-variable VARs including both a short-term interest rate and a monetary aggregate.

Within the same sample, we nest the previous two exercises and estimate a VAR including consumer prices, output, M2 and the 3-month T-bill rate. The impulse response functions (IRF) are plotted in Figure 7.[18] In Panel (b) of Figure

[15] Christiano, Eichenbaum and Evans (1998) call this the Recursiveness Assumption.

[16] An alternative identifying assumption is to exclude contemporaneous reaction of the policy instrument to variables in the central bank information set while allowing the latter to contemporaneously respond to changes in the policy instrument. See Leeper, Sims and Zha (1996).

[17] In this paper "significant" is always referred to the 95% confidence interval. In all graphs of the impulse response functions dashed-line bands refer to the 95% confidence interval and are computed by the delta method (Hamilton, 1994, and Amisano and Giannini, 1997).

[18] We have also estimated the model with quarterly data and obtained similar results.

7, by interpreting a positive innovation to the interest rate as a contractionary monetary policy shock we see that money declines immediately and significantly for almost two years and output is also negatively affected and exhibits a hump-shaped response. The response of prices is instead puzzling, as they continue to show a persistent increase after the shock. This "price puzzle" has been discovered in other studies focusing both on Italy and other major industrial countries. The rationale which appears to be more accepted is that it must be considered a signal of mispecification of the model.[19] In Panel (a) of Figure 7, we plot the responses to a positive innovation in M2 in the same model. If the latter were to be interpreted as a monetary policy shock, the response of the interest rate would be puzzling, as it shows an impact positive reaction. This finding, labeled the "liquidity puzzle", has been at the centre of quite a lively debate in the US literature.[20] In our model, and given our identifying assumption, this response is not surprising if the innovation to the money aggregate is interpreted as a money-demand shock (rather than as a money-supply shock).

When replacing M2 with a narrower money aggregate (i.e. the monetary base or total bank reserves), instead of solving the likely endogeneity problems linked to the definition of M2, one obtains that the IRFs to a positive innovation in the short-term interest rate show evidence of both a "price" and a "liquidity" puzzle. Consumer prices and the monetary base (or bank reserves) increase after a contractionary shock. These results might be induced by the fact that although the 3-month T-Bill rate is a money market rate and closely follows monetary policy actions, it could be hardly identified with a policy instrument and its innovations with a monetary policy shock. Accordingly, we limit estimation to the subsample for the 90s and substitute in the original VAR model the interest rate on overnight interbanking loans to the 3-month T-Bill rate. Figure 8 reports the obtained IRFs. In Panel (b) of Figure 8, after a monetary contraction, M2 slightly declines, and output and prices fall, with the reduction in output stronger and statistically significant at impact and after 10 months (and up to 22). We repeated the exercise with the monetary base and total bank reserves in place of M2, obtaining qualitatively similar results, although sometimes less statistically significant. Panel (a) of Figure 8 confirms that a structural innovation to M2 induces a positive impact increase in the overnight rate. The effect on output and prices is instead considerably different from the one obtained in Panel (a) of Figure 7. The price level is not affected, while output increases (significantly) only after more than 2 years from the original shock.

Overall, the exercises performed in this section are based on simple statistical models that have no theoretical foundations or institutional background. The "measure" of monetary policy shock is left to the arbitrariness of the researcher, that can select it among different candidates, including a battery of monetary aggregates and short-term rates. And a "measure" is preferred to another if the results that

[19] Sometimes, adding an index of commodity prices help to either reducing the entity or eliminating the puzzle (See Sims, 1992). For the Italian economy, Gaiotti, Gavosto and Grande (1997) show that the puzzle disappears if price expectations and import prices are included in the VAR. We have estimated our simple VAR model with the IMF world index of export commodities (IFS 00176AXD) and found no evidence of success in eliminating the puzzle. However, the price puzzle is practically eliminated by estimating a larger VAR including a set of variables from the market of bank reserves, as we show in section 5 below.

[20] See Gordon and Leeper (1992) or the comment to Sims (1992) by Christiano (1992).

produces are more or less in accordance with previous believes about what the effects of monetary policy should be. Moreover, the impulse response functions are also sensible to the ordering of the variables in the VAR. In the next two sections, we will show how it is possible to overcome these limits by linking econometrics to knowledge of the institutional aspects of how monetary policy is actually managed and implemented in each single country, by describing the targets, instruments and procedures that define a so called "monetary regime". Within this framework it will be possible to test for different specifications of the same analytical model, each based on a different proposed "regime" and have the correct one singled out and supported by the data. This methodology has been developed by Strongin (1995) and Bernanke and Mihov (1998). It has been extended to an open-economy framework and applied to Italy by De Arcangelis and Di Giorgio (1998). Although it is not itself immune from criticism,[21] we believe it is the best current framework to identify monetary policy shocks and study the effects of such shocks on the economy.[22]

# 4 Econometrics meets Economics

In the preliminary analysis presented above, we have analyzed simple structural VARs where *one* policy variable is listed last. This is similar to what has been done for the US economy by Bernanke and Blinder (1992), who used the Fed Funds rate, or by Christiano and Eichenbaum (1992), who selected the nonborrowed reserves aggregate. The ordering structure is meant to reflect policy endogeneity; within the time unit (e.g., one month) policy variables are not allowed to affect nonpolicy variables (e.g., an index of the general price level, an index of output, etc.).

Bernanke and Mihov (1997, 1998) have recently generalized the approach of Bernanke and Blinder (1992) and Christiano and Eichenbaum (1992) by considering a *vector* of policy variables, instead of just one policy variable. In the first stage, the estimation of an unrestricted VAR generates two subvectors of innovations, one related to nonpolicy variables ($\mathbf{u}_{y,t}$) and one to policy variables ($\mathbf{u}_{p,t}$)[23]

$$\mathbf{R}(L)\begin{bmatrix}\mathbf{y}_t\\ \mathbf{p}_t\end{bmatrix}=\begin{bmatrix}\mathbf{u}_{y,t}\\ \mathbf{u}_{p,t}\end{bmatrix}$$

where $\mathbf{R}(L)$ is a matrix of polynomials in the lag operator $L$ and $\mathbf{R}(0)=\mathbf{I}$; $\mathbf{y}_t$ is the vector of nonpolicy variables and $\mathbf{p}_t$ is the vector of policy variables.

In the estimation of the orthogonalized, economically meaningful (structural) innovations in the second stage, a recursive causal block-order is assumed from the set of nonpolicy variables to the set of policy variables. Moreover, the recursive causal order is also established for the nonpolicy variables in $\mathbf{y}_t$. In terms of the relationship between the fundamental innovations, $\mathbf{u}_{y,t}$ and $\mathbf{u}_{p,t}$, and the structural innovations, $\mathbf{v}_{y,t}$ and $\mathbf{v}_{p,t}$, which are mutually and serially uncorrelated, this implies:

[21] See Rudebusch (1996) and Christiano, Eichenbaum and Evans (1998).

[22] Bagliano and Favero (1999) show that the main features of the monetary transmission mechanism in US and Germany are not relevantly affected by including in the VAR models exogenous measures of monetary policy shocks derived from financial market information.

[23] Bold lower-case (capital) letters indicate vectors (matrices).

$$\begin{bmatrix} \mathbf{A}_{1,1} & \mathbf{0} \\ \mathbf{A}_{2,1} & \mathbf{A}_{2,2} \end{bmatrix} \begin{bmatrix} \mathbf{u}_{y,t} \\ \mathbf{u}_{p,t} \end{bmatrix} = \begin{bmatrix} \mathbf{B}_{1,1} & \mathbf{0} \\ \mathbf{0} & \mathbf{B}_{2,2} \end{bmatrix} \begin{bmatrix} \mathbf{v}_{y,t} \\ \mathbf{v}_{p,t} \end{bmatrix}$$

where $\mathbf{A}_{1,1}$ is lower-triangular and $\mathbf{B}_{1,1}$ is diagonal so that there is a Wold recursive (causal) ordering among the nonpolicy variables in $\mathbf{y}_t$. Moreover, $\mathbf{A}_{2,1}$ is a full matrix so that there is a Wold block-recursive (causal) ordering between nonpolicy and policy variables.

Building on previous work by Strongin (1995), the vector of policy variables contains aggregates and interest rates characterizing the market for bank reserves. As a matter of fact, monetary policy is effectively conducted through the market for bank reserves. The idea is then that, in order to correctly identify a monetary policy shock, it could be useful to model the different operating procedures of the central bank according to appropriate constraints in the relationship between $\mathbf{u}_{p,t}$ and $\mathbf{v}_{p,t}$. Hence, the core of the analysis focuses on the shape that the matrices $\mathbf{A}_{2,2}$ and $\mathbf{B}_{2,2}$ must take for the different operating procedures to work properly. This requires linear and nonlinear constraints on the elements of those two matrices. A test for overidentifying restrictions can finally be applied to check whether the constraints implied by the different regimes are rejected by the data. Impulse response functions of policy and nonpolicy variables to monetary shocks are used to further check whether the identified monetary-policy innovations can be plausibly qualified so.[24]

# 5 A model of the Italian Economy

In this section we summarize and re-estimate in a larger sample the model in De Arcangelis and Di Giorgio (1998). This model applies the empirical framework described in section 4 to study recent Italian monetary policy.[25] The focus of our analysis will be on the market for bank reserves, where monetary policy is actually implemented. We define different monetary regimes according to the necessary constraints implied on the central bank operating procedures in this market.

[24] In this empirical approach to monetary policy, nonstationarity of the data is not generally emphasized and cointegration analysis not undertaken. A first justification is that the data may be *quasi-nonstationary*; in fact, the presence of unit roots in the time series cannot be tested with high power (see, for instance, Campbell and Perron, 1991). Moreover, even though unit roots may characterize the data, Sims, Stock and Watson (1990) show that most traditional, standard asymptotic tests are still valid if the VAR is estimated in levels.

The neglecting of cointegration constraints is motivated by the following considerations. First, the analysis is generally focused on short-run constraints and the short-run dynamic response of the system. When cointegration constraints are excluded, this only implies that the *long-run* responses of some variables are not constrained and might follow a divergent path. However, the short-run analysis is still valid. Second, Sims, Stock and Watson (1990) proved that standard asymptotic inference is not affected even when the variables included in the VAR in levels are cointegrated. Finally, although FIML estimates are no longer efficient if cointegration constraints are not included, they still remain consistent. Hence, the lower efficiency in the estimates can be justified by the objective difficulty in the economic interpretation of some of the cointegration constraints showed by the data.

[25] See Bernanke and Mihov (1997) and Clarida and Gertler (1997) for similar studies on monetary policy in Germany.

We include in the VAR model two nonpolicy variables, consumer prices and an index of industrial production. These variables affect the estimation as they enter in the reaction function of the central bank. We also take into account the exchange rate vis-a-vis Germany, explicitly modelling Italy as a small open-economy.

Following Kim and Roubini (1995) and Clarida and Gertler (1997), we chose to consider the real rather than the nominal exchange rate. Indeed, according to sticky-price models the two rates have an identical pattern in the short run, so that the real exchange rate inherits the jumping (asset-price) nature of the nominal one. However, the real exchange rate plays a more important role in the transmission mechanism of monetary policy and, therefore, is more informative to study the dynamics of the nonpolicy variables.

In the VAR model, the exchange rate is listed last, after the block of policy variables. Indeed, although the exchange rate is clearly a nonpolicy variable, we cannot exclude the contemporaneous reaction of the exchange rate to innovations in the policy variables, in particular to innovations in the short-term rate.[26]

Hence, the relationship among fundamental and structural innovations can be summarized as follows:

$$\begin{bmatrix} \mathbf{A}_{1,1} & \mathbf{0} & \mathbf{0} \\ \mathbf{A}_{2,1} & \mathbf{A}_{2,2} & \mathbf{0} \\ \mathbf{a}_{3,1} & \mathbf{a}_{3,2} & 1 \end{bmatrix} \begin{bmatrix} \mathbf{u}_{y,t} \\ \mathbf{u}_{p,t} \\ u_{r,t} \end{bmatrix} = \begin{bmatrix} \mathbf{B}_{1,1} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{B}_{2,2} & \mathbf{b}_{2,3} \\ \mathbf{0} & \mathbf{0} & b_{3,3} \end{bmatrix} \begin{bmatrix} \mathbf{v}_{y,t} \\ \mathbf{v}_{p,t} \\ \nu_{r,t} \end{bmatrix}$$

where $u_{r,t}$ and $\nu_{r,t}$ are respectively the fundamental and structural innovation related to the real exchange rate; $\mathbf{a}_{3,1}$ and $\mathbf{a}_{3,2}$ are full (row) vectors and the (column) vector $\mathbf{b}_{2,3}$ represents the possible correlations between the structural innovations in the market for bank reserves (including a possible monetary policy-induced variable) and the structural innovations in the exchange rate.

The kernel for our identification strategy is the lower-right corner of the system, which models the market for bank reserves and explicitly considers the role of the exchange rate:

$$1) \qquad \begin{bmatrix} \mathbf{A}_{2,2} & \mathbf{0} \\ \mathbf{a}_{3,2} & 1 \end{bmatrix} \begin{bmatrix} \mathbf{u}_{p,t} \\ u_{r,t} \end{bmatrix} = \begin{bmatrix} \mathbf{B}_{2,2} & \mathbf{b}_{2,3} \\ \mathbf{0} & b_{3,3} \end{bmatrix} \begin{bmatrix} \mathbf{v}_{p,t} \\ \nu_{r,t} \end{bmatrix}$$

## 5.1 The Italian Market for Bank Reserves

A description of how the Italian market for bank reserves works and of the operating procedures of the Bank of Italy is given in Buttiglione, Del Giovane and Gaiotti (1997).[27] Here we simply explain our model equations. In terms of innovations, we specify the demand for total reserves as:[28]

[26] See Bagliano et al. (1999) for a complete discussion of the difficulties that emerge in correctly identifying monetary policy shocks in a setting where the exchange rate is also present. These difficulties are normally due to the simultaneous relation between interest and exchange rates innovations, and can be responsible of new empirical puzzles, as the one of an impact depreciation of the nominal exchange rate following a contractionary monetary policy shock in the domestic country.

[27] See also De Arcangelis and Di Giorgio (1998).

[28] We omit the time subscript $t$ to ease notation.

$$2) \qquad u_{TR} = -\alpha u_{OV} + \sigma^d \nu^d$$

where $u_{TR}$ is the innovation in total reserves, $u_{OV}$ is the innovation in the overnight interest rate and $\nu^d$ is the unit-variance, orthogonal innovation in the demand for total reserves (i.e., an indicator of the shifting in the demand for total reserves); $\sigma^d$ is a measure of the standard deviation of the structural shock assigned to this equation. We use the rate on overnight loans since this has recently become the most important interest rate in the market for bank reserves.

We then divide the total amount of bank reserves in the sum of two aggregates that we define, in line with the US literature, as *borrowed* and *nonborrowed* reserves. We define fixed-term advances as borrowed reserves.[29] The nonborrowed reserves aggregate thus includes the item *Anticipazioni Ordinarie*[30] and all open-market operations. Our sorting can be motivated by the fact that *Anticipazioni Ordinarie*: a) were of limited amount, established by the central bank; b) should have rationally been used first as the least-costly source of finance;[31] and c) could in principle be canceled by the Bank of Italy with short notice.[32]

In terms of innovations, the demand for fixed-term advances can be expressed as a positive function of the spread between the overnight rate and the rate on fixed-term advances:

$$3) \qquad u_{FTA} = -\beta(u_{i_{FTA}} - u_{OV}) + \sigma^b \nu^b$$

where $u_{FTA}$ is the innovation in the fixed-term advances and $u_{i_{FTA}}$ is the innovation in the interest rate on fixed-term advances; $\nu^b$ is a unit-variance, orthogonal shock related to the borrowed-reserves component (i.e., a measure of the shift in the demand for fixed-term advances) and $\sigma^b$ is the standard deviation of the structural shock related to this equation. Since the rate on fixed-term advances has always been changed discretely and according to monetary-policy decisions during the period under investigation, we set $u_{i_{FTA}} = 0$ and consider only innovations in the overnight interest rate as a determinant of the demand for fixed-term advances.[33]

We then model the central-bank direct intervention in the market for bank reserves by specifying how it supplies nonborrowed reserves, namely:

$$4) \qquad u_{NBR} = \phi^d \nu^d + \phi^b \nu^b + \phi^r \nu^r + \sigma^s \nu^s$$

[29] Fixed-term advances (*Anticipazioni a Scadenza Fissa*) is an explicit standing facility that could be automatically drawn by banks and on which a penalty rate is applied. This "ceiling" rate in the money market was established by the central bank analogously to the discount rate. The two official interest rates defined a corridor that normally contained the every-day fluctuations of all other money-market rates.

[30] A credit line that banks could activate with the Bank of Italy, providing a limited amount of low-cost finance. The discount rate (*tasso ufficiale di sconto*), usually a floor for money market rates, was the cost paid by banks on the amount of credit effectively drawn from this line.

[31] In reality, though, this credit line is never completely used since many cash managers keep a portion of the line as a buffer stock. However, the unused credit is quantitatively negligible.

[32] Similar choice was made in Bernanke and Mihov (1997b) for Germany.

[33] The same strategy, with respect to the discount rate, has been applied by Bernanke and Mihov (1998) in their study of US monetary policy. Alternatively, Bernanke and Mihov (1997) considered an additional equation for the rate on fixed-term advances when studying German monetary policy.

where $\nu^r$ is the unit-variance, orthogonal innovation in the real exchange rate (to be defined in the last equation), whereas $\nu^s$ is the own (unit-variance and orthogonal) innovation in monetary policy, a measure of the *exogenous* component of the monetary policy stance; $\sigma^s$ is the standard deviation of this measure.

The latter equation represents the *operating* reaction function of the monetary authorities in the market for bank reserves. An innovation in the supply of nonborrowed reserves is designed to offset structural innovations in the demand for total reserves ($\nu^d$), in the demand for borrowed reserves ($\nu^b$) and in the exchange rate ($\nu^r$); $u_{NBR}$ could be also induced by an *exogenous* innovation in monetary policy.

The three innovations on the quantitative variables are not independent since $u_{TR} \equiv u_{FTA} + u_{NBR}$. Hence, $u_{NBR}$ can be replaced in the last equation by the difference between the innovation in total reserves and the innovation in the demand for fixed-term advances. As a result, by substituting equations 2 and 3 in 4, the latter can be rewritten as follows:[34]

$$4') \qquad -(\alpha+\beta)u_{OV} = (\phi^d - \sigma^d)\nu^d + (\phi^b + \sigma^b)\nu^b + \phi^r\nu^r + \sigma^s\nu^s$$

Finally, the equation for the exchange rate[35] establishes that its innovation can be affected by the innovations in all the other variables included in the VAR. We can thus write

$$u_r + \gamma'_{TR}u_{TR} + \gamma_{NBR}u_{NBR} + \gamma_{OV}u_{OV} = \sigma^r\nu^r$$

or equivalently, since $u_{TR} \equiv u_{FTA} + u_{NBR}$,

$$5) \qquad u_r + \gamma_{TR}u_{TR} + \gamma_{FTA}u_{FTA} + \gamma_{OV}u_{OV} = \sigma^r\nu^r$$

where obviously $\gamma_{TR} = \gamma'_{TR} + \gamma_{NBR}$ and $\gamma_{FTA} = -\gamma_{NBR}$.

Equations 2),3),4') and 5) provide the specified version of 1) for our model. In extensive form:

$$6) \quad \begin{bmatrix} 1 & 0 & \alpha & 0 \\ 0 & 1 & -\beta & 0 \\ 0 & 0 & -(\alpha+\beta) & 0 \\ \gamma_{TR} & \gamma_{FTA} & \gamma_{OV} & 1 \end{bmatrix} \begin{bmatrix} u_{TR} \\ u_{FTA} \\ u_{OV} \\ u_r \end{bmatrix} =$$
$$\begin{bmatrix} \sigma^d & 0 & 0 & 0 \\ 0 & \sigma^b & 0 & 0 \\ (\phi^d - \sigma^d) & (\phi^b + \sigma^b) & \sigma^s & \phi^r \\ 0 & 0 & 0 & \sigma^r \end{bmatrix} \begin{bmatrix} \nu^d \\ \nu^b \\ \nu^s \\ \nu^r \end{bmatrix}$$

The order condition for the identification of the complete VAR model is violated since 21 variances and covariances are available from the first stage of the estimation and these are not sufficient to obtain the 23 parameters included in the structural

[34] The following is the correct formulation, given that our notation is slightly different from the one in Bernanke and Mihov (1998). In De Arcangelis and Di Giorgio (1998) the corresponding equation contained a mistake which however did not affect the results of the estimation.

[35] In our definition, an increase (decrease) in the exchange rate represents a real depreciation (appreciation) of the Lira with respect to the DM.

form, whose lower-right corner is 6). Identification can be achieved by imposing appropriate constraints that reflect different operating procedures of monetary policy. We describe two possible monetary regimes based on these operating procedures, one based on the control of the overnight rate and the other on the control of the nonborrowed reserves aggregate[36]. Technically, these regimes correspond to two distinct overidentified structures that can be tested in order to select which one, if any, is accepted by the data. In our framework, overidentification requires fixing 3 parameters.

*(1)* ***OV Regime***. In this policy regime the monetary authorities offset all exogenous shifts in the market for bank reserves (i.e., all the structural innovations $\nu^d$ and $\nu^b$) so as to control the overnight rate. In terms of parameter constraints this means that $\phi^d = \sigma^d$and $\phi^b = -\sigma^b$. Moreover, the authorities are also assumed not to allow the supply of nonborrowed reserves to respond to innovations in the exchange rate: i.e., $\phi^r = 0$. Therefore, eq. 4') becomes:

$$-(\alpha + \beta)u_{OV} = \sigma^s \nu^s$$

and the relative estimated indicator of monetary policy shocks (i.e., $\sigma^s \nu^s$) is proportional to the estimated innovation in the overnight interest rate.

*(2)* ***NBR Regime***. In this quantitative regime the monetary authorities are assumed to offset exogenous shifts in the market for bank reserves in order to control the total amount of nonborrowed reserves. In this case, the central bank's operating procedures imply $\phi^d = 0$, $\phi^b = 0$ and $\phi^r = 0$ as the appropriate parameter constraints. The estimated indicator of monetary policy shocks then coincides with the innovation in the nonborrowed components of reserves:

$$u_{NBR} \equiv u_{TR} - u_{FTA} = \sigma^s \nu^s$$

## 5.2 Data, Estimation and Results

We estimate the model between June 1989 and May 1998. The sample does not include the 80s as in this period monetary policy in Italy could not be described as following a market-based approach. We also excluded the last months of 1998 because the (credible) announcement of the "in-countries" might have affected the conduct of monetary policy in the second half of 1998.

All data are monthly. The variables included in the VAR are (from top to bottom): the consumer price index and the industrial production index as nonpolicy variables; total bank reserves, fixed-term advances and the overnight interest rate as policy variables; finally, the real exchange rate between Italy and Germany as the last variable. The price index, the industrial production index and the real

[36] See De Arcangelis and Di Giorgio (1998) for other regimes as well as for an analysis of just-identified structures.

exchange rate have been log-transformed. Total reserves and fixed-term advances have been normalized by dividing them by the 18-month (past) moving average of total reserves in order to use the level relationship among total reserves, fixed-term advances and nonborrowed reserves.[37] Since the Italian banking system experienced some relevant changes in the reserve requirement ratios in the sample period, we used the adjusted series for total bank reserves offered by the Bank of Italy.[38] The overnight rate is in levels. Further details on the data are given in the Appendix.

The number of lags employed is six and the estimation is based on the FIML method. As shown in Table 1, the results in De Arcangelis and Di Giorgio (1998) are confirmed. In particular, the regime based on controlling the overnight rate is accepted, while the overidentifying test rejects the hypothesis that the Bank of Italy in the 90s was targeting the nonborrowed reserves aggregate.

Table 1: Estimation Results

| | $\alpha$ | $\beta$ | Overid.Test (prob.) |
|---|---|---|---|
| OV | -0.149<br>(0.11) | **0.486**<br>(0.11) | 0.23 |
| NBR | **0.824**<br>(0.167) | **1.437**<br>(0.165) | 2.11e-12 |

Note: Standard errors in parenthesis; bold face indicates 95% significance.

This conclusion seems valid not only in the full sample, but also in the 1993–96 subsample characterized by the free floating of the Lira (see De Arcangelis and Di Giorgio, 1998). Hence, although the role of the exchange rate varied from being an intermediate target to only working as a transmission channel[39], there is no evidence that this induced a change in the monetary policy operating procedures.

The impulse response functions generated by monetary policy shocks in the two regimes that we have compared are shown in Figures 9 and 10.[40] These pictures provide further support to the OV regime.

[37] Bernanke and Mihov (1997a) claim that this kind of strategy is more appropriate than the short-run normalization proposed by Strongin (1995).

[38] The only available data on total reserves (adjusted for the numerous changes in the required reserves ratio) and fixed-term advances refer to the maintenance period of required reserves that does not coincide with the calendar month (the maintenance period goes from the 15th of one month to the 14th of the next one). All the other data are instead referred to the common calendar month. This mismatch may cause some problems in the relationship between the reserve aggregates and the other data within the month. The problem may appear particularly serious for the relationship between reserves aggregates and the overnight rate, on which it hinges our identification procedure. However, when we compared our time series for the interest rate with another series that matches the reserve aggregate period, we found very high correlation in both levels and in first differences between the series. Hence, the bias introduced by the mismatch does not seem to be operatively very relevant, although methodologically important.

[39] See Arcelli and Di Giorgio (1995).

[40] All impulse response functions have been constructed by designing a restrictive monetary shock leading to a 100 basis-point increase in the overnight rate for all the monetary regimes. Responses in output, prices and the exchange rate are percent deviations from the corresponding variables' values before the shock. Dashed-line bands refer to the 95% confidence interval and are computed by the delta method (Hamilton, 1994, and Amisano and Giannini, 1997).

In Figure 9, after a monetary contraction, output falls at impact. The slowdown in economic activity lasts for about two years, but it is statistically significant only in the period between the $8^{th}$and the $18^{th}$ month after the shock. Although we have not included a commodity price index, we find no evidence of a price puzzle.[41] The response in terms of the price level is never significantly different from zero. Although total reserves slightly increase right after the monetary contraction, this effect is totally explained by the response in the demand for fixed-term advances (FTA), that increase considerably at impact and in the first 3 months after the shock. As a consequence, nonborrowed reserves do indeed fall, exactly as predicted by the standard liquidity effect, and the model does not exhibit a liquidity puzzle either. Finally, the response of the exchange rate is never statistically significant at our confidence level. Overall, these IRFs seem coherent with textbook predictions of the effects of a monetary policy shock. We interpret them as a signal of correct, although still parsimonious, specification of the statistical model.

We also computed the Forecast Error Variance Decompositions (FEVD) of both the price level and output (Figure 11). This exercise provides information about the quantitative importance of each of the identified structural shocks in explaining the variability of our nonpolicy variables. Exogenous monetary policy shocks account (significantly at the 95% level) for about 15 to 20% of the output volatility one year after the shock, while their contribution to price volatility is almost null. Exactly the opposite is true for exogenous shocks to the real exchange rate: these have been particularly effective on price dynamics. Hence, *exogenous* monetary policy shocks were important in determining output dynamics, while the sharp reduction in inflation of the 90s might be explained by either the *endogenous* component of monetary policy[42] or by the dynamics of the exchange rate (first as an intermediate target, and then as a transmission channel of monetary impulses).

The IRF shown in Figure 10 are relative to a monetary policy shock in the NBR regime. They are clearly less appealing, when not intuitively totally wrong. Following the same monetary contraction, the reduction in output is practically never statistically significant and prices show a persistent increase. The response of the exchange rate indicates a real depreciation following (for about one year) the monetary contraction.

In Figure 12, we plot the estimated monetary policy shocks in the OV model. By construction, they have a noisy pattern that makes them hard to be interpreted as a possible source of change in any other relevant macro variable. However, we still would like to check whether it is possible to link these exogenous monetary policy shocks to changes in the level of the overnight interest rate, as obviously the latter is also affected by overall liquidity and demand conditions in the market for bank reserves.

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[41] In the smaller sample estimated in De Arcangelis and Di Giorgio (1998), the puzzle was still present, although only temporary (the first 4 periods) and much less intensively than in the previous VAR analysis.

[42] In order to check for this, we have estimated a simple forward looking monetary policy rule a la Clarida, Galì and Gertler (1999a,b) for Italy in the 90s and obtained that the coefficient on deviations of inflation from target was significantly higher than 1 (1.3), while the one on output stabilization was not statistically different from zero. We interpret this finding as suggesting that the endogenous component of Italian monetary policy in the 90s, as embedded in such a simple monetary policy rule, was focusing on inflation and not on output stabilization.

In other words, it could be interesting to discover whether in some periods interest rates did fall even in presence of an exogenous restrictive component of policy; or whether they increased but not for the will of the monetary authorities. In order to achieve this target, we computed the 3-month centered moving average of our policy shocks and plotted it against the 3-month change in the level of the overnight rate (Figure 13). The picture can provide some useful information about some episodes in the sample under consideration. Two episodes seem to be highlighted. The first is related to the first months of 1993, after the EMS crisis that led Italy to abandon the exchange rate peg with the D-mark: money market interest rates were considerably falling even in presence of a neutral or slightly restrictive exogenous component of policy. The second regards the second half of 1997 and the first months of 1998, when the reduction in the overnight was slow and gradual. The picture indicates that exogenous restrictive components in the monetary policy stance were actually countering the interest-rate fall.

## 5.3 Robustness

A preliminary check of robustness for the model presented above consists in re-estimating it with quarterly data.[43] This is important for two reasons. First, we want to check whether our identification mechanism based on no contemporaneous reaction of the nonpolicy variables to monetary policy shocks is still acceptable at such a lower frequency (it would not be so, for example, with yearly data). Second, as we are interested in documenting the effects of a monetary policy shock on a set of real variables whose data are quarterly, the simplest available strategy is to use the quarterly version of the model to produce the necessary monetary policy shocks.

It turns out that the monetary regime based on the control of the overnight rate is still accepted when the model is estimated with quarterly data. We plot the corresponding IRF in Figure 14. It is evident that the qualitative results are very similar to the ones obtained in the monthly version of the model. The only exception is the response of the exchange rate, which is now significantly positive after a monetary contraction.[44]

Another exercise was performed in De Arcangelis and Di Giorgio (1999), where a closed-economy version of the model, including a wider monetary aggregate (M1), is estimated. The finding that the operating procedures of the central bank were aiming at controlling the overnight rate is confirmed. Moreover, by adding M1 to the VAR, the effects of a money demand shock can also be studied. The latter induces an impact positive response in the overnight rate, indicating that the money demand shock is only partially accommodated by the central bank.

We now turn to study how monetary policy shocks are transmitted to the economy.

[43] We used quarterly GDP at constant 1995 prices as a measure of output, and the GDP deflator. All the other variables have been obtained as quarterly averages of the original monthly data.

[44] This "exchange rate puzzle" is due to the simultaneous relation of interest and exchange rate innovations. This problem obviously becomes more relevant with quarterly data. It is also probably due to the sample bias in the data originated by the large swings of the Lira in Summer 1992 and Winter 1995.

# 6 Monetary Transmission

We will focus on the effect of a monetary policy shock on real and nominal variables, and we will try to check whether any conclusion can be drawn from aggregate data about the monetary transmission channels that are at work in the Italian economy. In particular, we will try to establish whether any evidence can be obtained suggesting the effectiveness of a credit channel of monetary transmission[45]. This channel would work side by side with the traditional Keynesian mechanism based on changes in the real interest and exchange rates.

## 6.1 Real Variables

We start by investigating how a monetary policy shock affects the components of aggregate demand, in particular consumption and investment, and aggregate employment. Since national accounting data on these variables are released quarterly, we used the quarterly version of our OV model to estimate a monetary policy shock and to analyze its effects on the real economy. There are two possible methodologies that can be followed, given the limited availability of data.

The first consists in estimating a series of VARs identical to the one described in section 5, but for the substitution of output with another real variable (consumption, investment, imports, exports, employment, earnings). In this case, we maintain our identification hypothesis, with the drawback that we are excluding output from the reaction function of the central bank and substituting it with another variable. This could seem quite strong. However, given the major concern about inflation reduction in the 90s, we are quite convinced that output stabilization was not too heavily weighted in the reaction function of the Bank of Italy. Our estimates of a simple monetary rule a la Clarida, Gali, Gertler (1999a,b) support this belief.[46] The endogenous component of monetary policy was aiming at reducing inflation. Our analysis in section 5 shows that exogenous monetary policy shocks did instead negatively affect output. Overall, these results indicate that although monetary policy was successful in reducing inflation, it also played a role in the observed slow dynamics in the real economy.

The alternative methodology is to order the policy block first in the VAR and assume that prices and output can contemporaneously react to monetary policy shocks, but that the policy variables are not contemporaneously affected by innovations in the nonpolicy variables. Hence, one can estimate a series of VARs with different real variables listed last. The two exercises would provide similar results if the variance-covariance matrix of the innovations were close to block-diagonal.[47] In this case, the selected identification strategy would not affect estimation results, meaning that it would be true that neither policy nor nonpolicy variables react contemporaneously to innovations in the other group of variables. Given the previously expressed caveats about the soundness of our identification strategy in a quarterly

[45] See Bernanke (1993), Kashyap and Stein (1994) and Hubbard (1995) for a discussion of the credit channel. Di Giorgio (1995) surveys the first empirical studies focusing on Italy.

[46] See footnote 42.

[47] The only value added of this second modeling strategy would be to obtain the response of the nonpolicy variables within the first quarter.

model, we have followed both the alternatives, and found that some differences emerge only with respect to the response of employment (and of real earnings (retribuzioni lorde reali)) to a monetary policy shock. The response of employment was however limited and mostly concentrated in the industrial sector.

In Figure 15, we plot the (significant) response of GDP, aggregate consumption, investment, exports and imports to a monetary contraction leading to an increase of 100 basis points in the overnight rate. As expected, investments show a quick and pronounced fall with a negative peak at about 6 quarters. Consumption and output do also fall, but more gradually and less intensively. We also observe a strong negative reaction of real imports. This is explained by the fall in output and by the fact that, in the quarterly version of our model, a monetary contraction has a significant (but puzzling) effect on the real exchange rate, as it induces a real depreciation. The response of exports is also negative (even though somehow more difficult to interpret, as this component of aggregate demand is heavily dependent on foreign variables which are not considered in the VAR, as foreign income and foreign interest rates).[48]

Notice that, at first, the responses of consumption and investment seem to be coherent with the standard money view of the transmission mechanism. The initial propagation of the monetary shock is attributed to a change in the real interest rate that affects investment. The fall in investment reduces output and income; it is then transmitted to consumption and so on, via the standard multiplier analysis. However, we should notice that the strong impact response of investment may be somehow puzzling since this component should react to changes in the long-term real interest rates rather than to changes in nominal short-term ones. Moreover, empirical investigations have usually reported poor performance of the interest rate as an explanatory variable on aggregate investments (see Hubbard, 1997, for a survey). As argued by Bernanke and Gertler (1995) in their study on the US economy, this reasoning could suggest that other transmission mechanisms might be originated by the monetary policy shock.

In order to further check this possibility, we move to study the response of investment and consumption components. Although these are statistically significant only for the first two quarters after the policy shock, Figure 17 shows that the impact response in the consumption sector is much quicker and stronger for durables with respect to both nondurables and services. In Figure 18, we plot the significant responses of investment components. After a monetary policy shock, investments in transportation means decline more rapidly and intensively. Machinery equipment and housing investments decline more gradually. The less responsive component is that of gross fixed investment, whose reaction is however also the longer lasting (8 quarters).

This evidence on the composition effects of a policy shock is actually perfectly consistent with the traditional money view, as the faster reacting investment components are those more dependent on a short-term interest rate. Of course, this does not imply that a credit channel of monetary policy transmission is not at work in

[48]We also derived the IRF to an exogenous shock to the real exchange rate, in order to check the response of trade components to a real depreciation, obtaining that real exports do significantly increase for about one year, and real imports fall (Figure 16).

the Italian economy, as suggested by some other previous studies.[49] It only supports the view that from aggregate data it is quite difficult to obtain empirical evidence that can be used to disentangle the different transmission channels. As a matter of fact, the money channel works through bank liabilities while the credit channel through bank assets. However, assets and liabilities are linked by accounting identities, and this originates a difficult identification problem. Some more useful insight may be provided by empirical studies using disaggregated data on firms and banks. Although much work remain to be done in this field, the first papers that have examined whether heterogenous banks and firms respond differently to the same monetary policy shock seem to support the view that a broadly defined credit channel of monetary policy transmission, including a financial balance-sheet channel, is at work in the Italian economy.[50]

We also studied the response of employment and real earnings to a monetary policy shock, obtaining a small (and not very long lasting) fall in both variables (Figure 19).

In summary, after a monetary policy shock, output falls as the result of a reduction in both real investments and (by a smaller amount) consumption. The demand components which respond faster and more intensively to the shock are those of consumption durables and investment in transportation means. Real imports fall. Employment is only slightly affected, as well as real earnings. Finally, prices are maintained mostly constant, so that inflation is also reduced.[51]

## 6.2 Nominal Variables

We now move to investigate the impact of a monetary policy shock on the whole interest rate structure, and on variables in the banking sector. We apply the same methodology used to study the response of real variables, but we use the monthly version of our model. As we cannot exclude the contemporaneous reaction of interest rates to a monetary policy shock, we have ordered last in the VAR the variables we investigate (one at a time, due to limited availability of the data).[52] First, we have estimated the dynamic response of four different returns on Government Debt (Figure 20). After a 1% increase in the overnight rate on interbank loans, we would normally observe a flatter yield-curve, as the response of the rate on shorter term debt (like 3-month and 6-month BOTs) is considerably higher (and longer lasting) than that on either 12-month BOT or 5 years BTP. This is probably due to the so called expected inflation effect induced by a monetary contraction. As the agents

[49] See Buttiglione and Ferri (1994) and Bagliano and Favero (1995).

[50] See Angeloni et al. (1995) for a study based on the balance sheets of Italian banks, and Rondi et al. (1993) for a study on a panel of Italian firms. The same conclusion is also suggested by some descriptive figures on the financial and industrial structure of the country. See Di Giorgio (1995).

[51] Overall, one could be quite skeptical about the seemingly absence of any transmission lag from the monetary policy shock to the real economy. However, previous evidence on monetary policy transmission lags was mostly related to monetary policy interventions, including the endogenous component of policy, rather than to monetary policy shocks. For a cross-country comparison of output and inflation responses to an interest rate shock in a simple 4 variable VAR model, see Cecchetti (1999).

[52] Given the limited number of observations, we substituted the real exchange rate for all the interest rates and the quantity of loans. An attempted FIML estimation of a 7-variables VAR (including the exchange rate) showed serious problems of convergence.

perceive this policy to be effective on prices, inflation expectations are reduced. This pushes long-term interest rates down. However, our simulations suggest that this effect on the return on higher-maturity debt is not strong enough to offset the standard liquidity effect induced by the monetary contraction. As a result, long-term interest rates do still increase, even though considerably less with respect to short term-ones.[53]

Then, we focused on banking sector variables and studied how the lending-borrowing spread and the quantity of loans to residents are affected by an exogenous monetary policy shock. In Figure 21 we observe that lending rates react quicker and more intensively with respect to deposit rates. Hence, a contractionary monetary policy shock seems to widen the lending-borrowing spread: the effect is significant for about one year and is particularly relevant between the second and the sixth month. The average interest rate on loans does also increase more than the risk-free returns on long-term debt. A similar finding had already been obtained by Bagliano and Favero (1995) and Buttiglione and Ferri (1994) in previous VAR studies on Italy[54]. They interpreted it as possible evidence for a credit channel in monetary policy transmission, in analogy to the widening of the spread between the rate on commercial paper and the T-Bill rate observed in the US economy (see Kashyap, Stein and Wilcox, 1993, and Kashyap and Stein, 1994). Or at least for the existence of one of the prerequisites for this channel to work (the imperfect substitutability between different financial assets and heterogeneity in the cost of business funding). In addition, Buttiglione and Ferri (1994) used data on credit lines granted by banks and credit effectively used by firms in a smaller sample (1988-may 1993) to obtain evidence of a credit supply contraction following a monetary policy shock. This evidence would also suggest a plausible active bank credit channel of policy transmission. We could not check whether their finding is confirmed in our model because of a data break in the time series "credit granted" after 1995. We just studied the response of the quantity of bank loans in lire used by residents and obtained no economically significant reaction of this variable to the policy shock.[55]

[53]This could as well be due to the fact that in the sample we studied the Bank of Italy was still working on building its anti-inflation reputation. Buttiglione, Del Giovane and Gaiotti (1997) have conducted a similar exercise using a single equation approach in the 1990-95 period. They studied the effects of changes in two distinct policy rates (the discount rate and the rate on repos), trying to disentangle the liquidity from the expected inflation effect of a monetary policy intervention. They find that the repo rate does mainly affect the shorter term segment of the yield curve, while the effect of a change in the discount rate was more effective on inflation expectations.

[54]See Nisticò (1999) for a preliminary study of different regional responses of banking sector variables to a monetary policy shock.

[55]In a recent study, Favero et al. (1999) analyzed the response of loans to a contractionary monetary policy reducing bank reserves using balance-sheet data from banks in Italy, France, Germany and Spain. They find no evidence of a bank lending channel in monetary policy transmission in these countries. As in our study loans are generally not affected by a monetary contraction. In Germany, Italy and Spain, they also observe that smaller banks do actually expand loans after a contractionary monetary policy. This finding could be rationalized as the attempt to benefit from the higher intermediation margin that is available after the interest rate policy shock.

# 7 Conclusions

This paper deals with the identification and transmission of monetary policy shocks to the Italian economy. It shows that correct identification can be obtained by linking econometric analysis with a detailed description of the institutional and operative procedures used by the central bank to intervene in the money market. In particular this analysis allows the researcher to avoid the need of arbitrarily choosing a measure of monetary policy shocks. Different monetary policy regimes can be nested in the same model and directly tested, so that the correct representation of the exogenous monetary policy shocks is selected by the data itself. Our results can be summarized as follows.

In the 90s, monetary policy in Italy has been based on an interest rate targeting regime, with the central bank controlling the rate on overnight loans. We find no evidence that the monetary policy regime has been affected by the different roles performed by the exchange rate in the sample, although this conclusion needs to be further checked. Shocks to the overnight rate, or the residual of a regression of this rate on a set of variables in the information set of the central bank, can then be interpreted as purely *exogenous* monetary policy shocks, as opposed to the endogenous component of policy which might result from a feedback rule linking the monetary policy instrument to different state variables.

Our impulse response analysis is fully coherent with the expected effect of a monetary policy shock on output and inflation. In particular output declines after a contractionary shock, while the price level is kept mainly constant. Our estimated monetary policy shocks explain about 20% of output volatility but very little of price variability. This finding does not suggest however that monetary policy was not effective on inflation in the period we study. On the contrary, it might well be that the "endogenous" component of policy was very successful in achieving the primary target of monetary policy. In this direction, our estimates of a monetary policy forward looking rule a la Clarida, Galì and Gertler (1999a,b) suggest that in the recent past, in Italy, monetary policy was mainly directed to counteract inflation. Output stabilization was not explicitly given a particular weight. These two pieces of evidence lead us to conclude that monetary policy "actions" (including endogenous and exogenous components of monetary policy) were indeed effective in reducing inflation in the 90s. Exogenous monetary policy shocks must also be considered partially responsible for the low output growth observed.

We also show how it is possible to use the model to simulate the response of different nominal and real variables to a monetary policy shock, thereby collecting some aggregate evidence on monetary policy transmission. Although our findings are generally consistent with predictions of both the money and the credit view of monetary policy, we were not able to distinctly identify the different channels of transmission of monetary policy. It has already been stressed that aggregate macroeconometric analysis performs poorly in this job (Hubbard, 1995). Identifying whether bank credit falls after a monetary contraction because of a shrink in the supply of loans (as suggested by the credit view) or because of a reduction in the demand for credit induced by the increase in the interest rate (as underlined in the money view) is not an easy task. And similar difficulties arise when concentrating on price (interest rates) behavior rather than on credit quantities. When disaggregated data on banks and firms are used, conclusions are less disputable. Asymmetric and distributive effects of monetary policy could not only be reflecting the higher cost of funds, as stressed in the money view. The weight of monetary restrictions falls disproportionally on the shoulders of small firms, whose borrower's ability declines, and of small banks, whose liability management is harder. This seems particularly relevant in Italy: the high percentage of small firms compared to big corporations in this country suggests that the role of a "broad" lending channel is relevant. Up to now, no success has however been obtained in measuring which part of the output effect of an exogenous monetary policy shock is due to the credit rather than to the interest rate (or the exchange rate) channel.

Further empirical studies on the transmission mechanism of monetary policy would necessarily rely on disaggregated and sectoral data. However, they will have to explicitly tackle the problem of correctly identifying truly exogenous policy shocks. We hope this paper will be useful in this direction.

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Figure 1: Detrended GDP and Money Aggregates

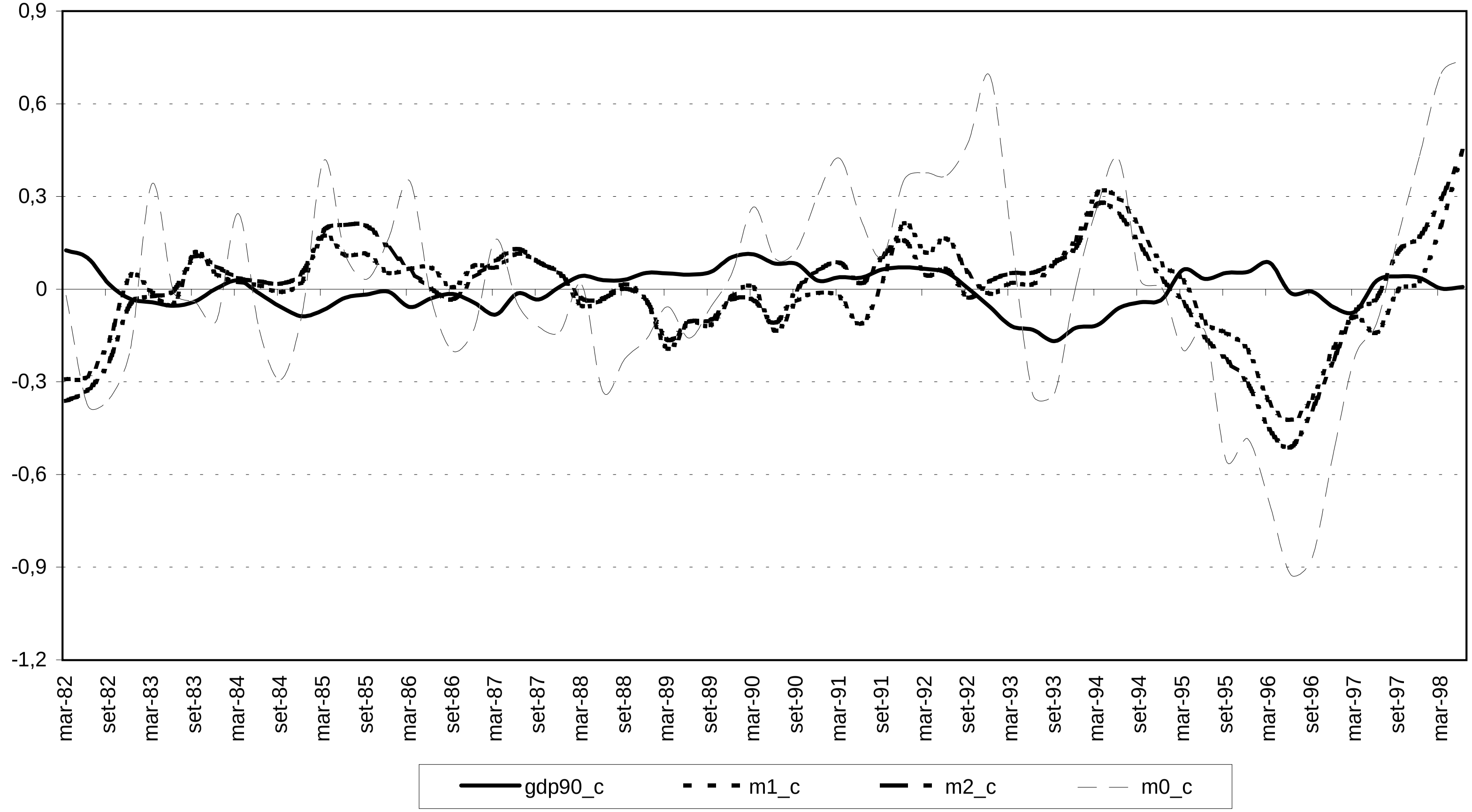

Figure 2: Dynamic Correlation of detrended real GDP with detrended (nominal) M0, M1 and M2 (1982:I-1998:II)

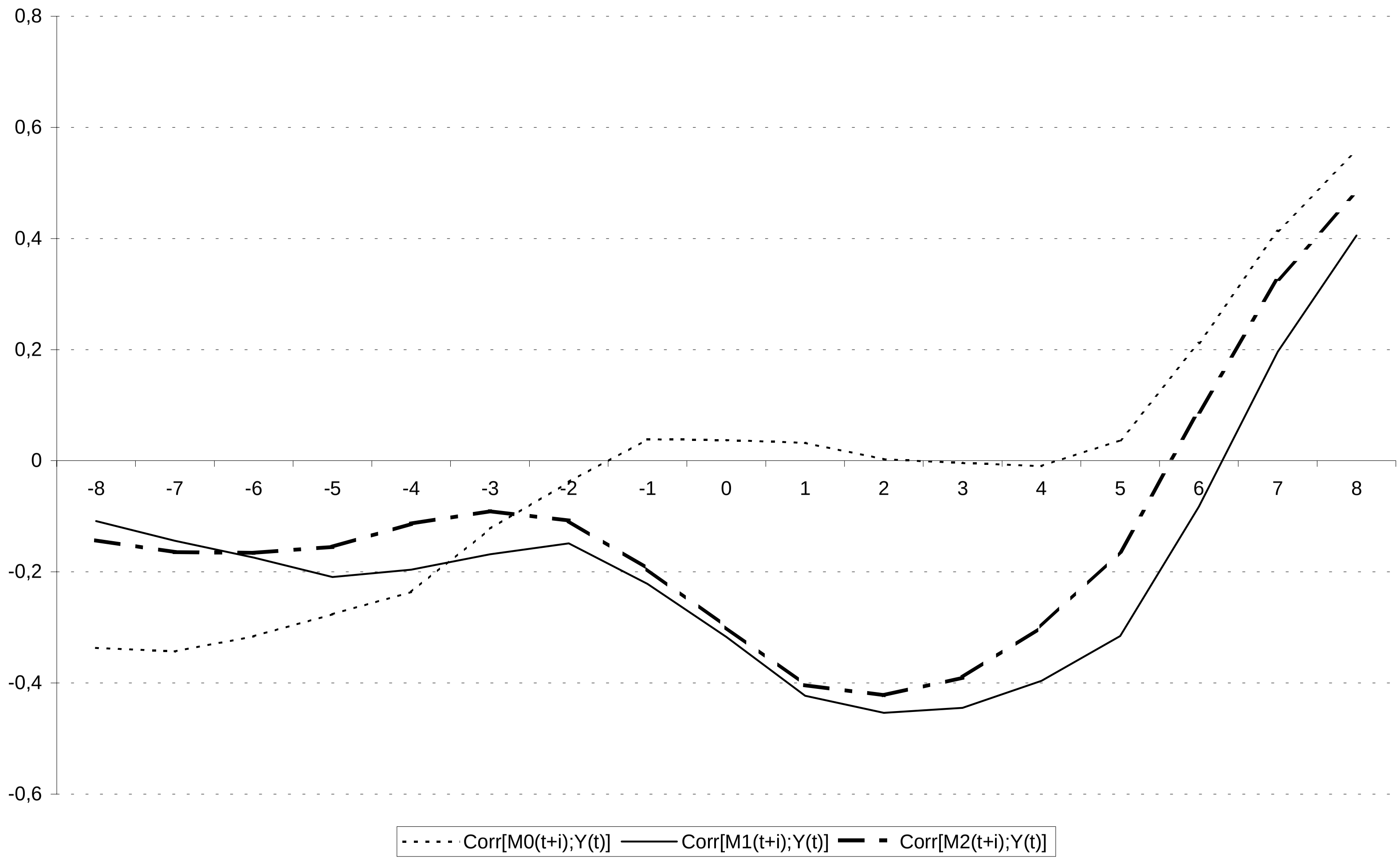

Figure 3: Dynamic Correlation of detrended real GDP with detrended (real) M1 and M2 (1982:I-1998:II)

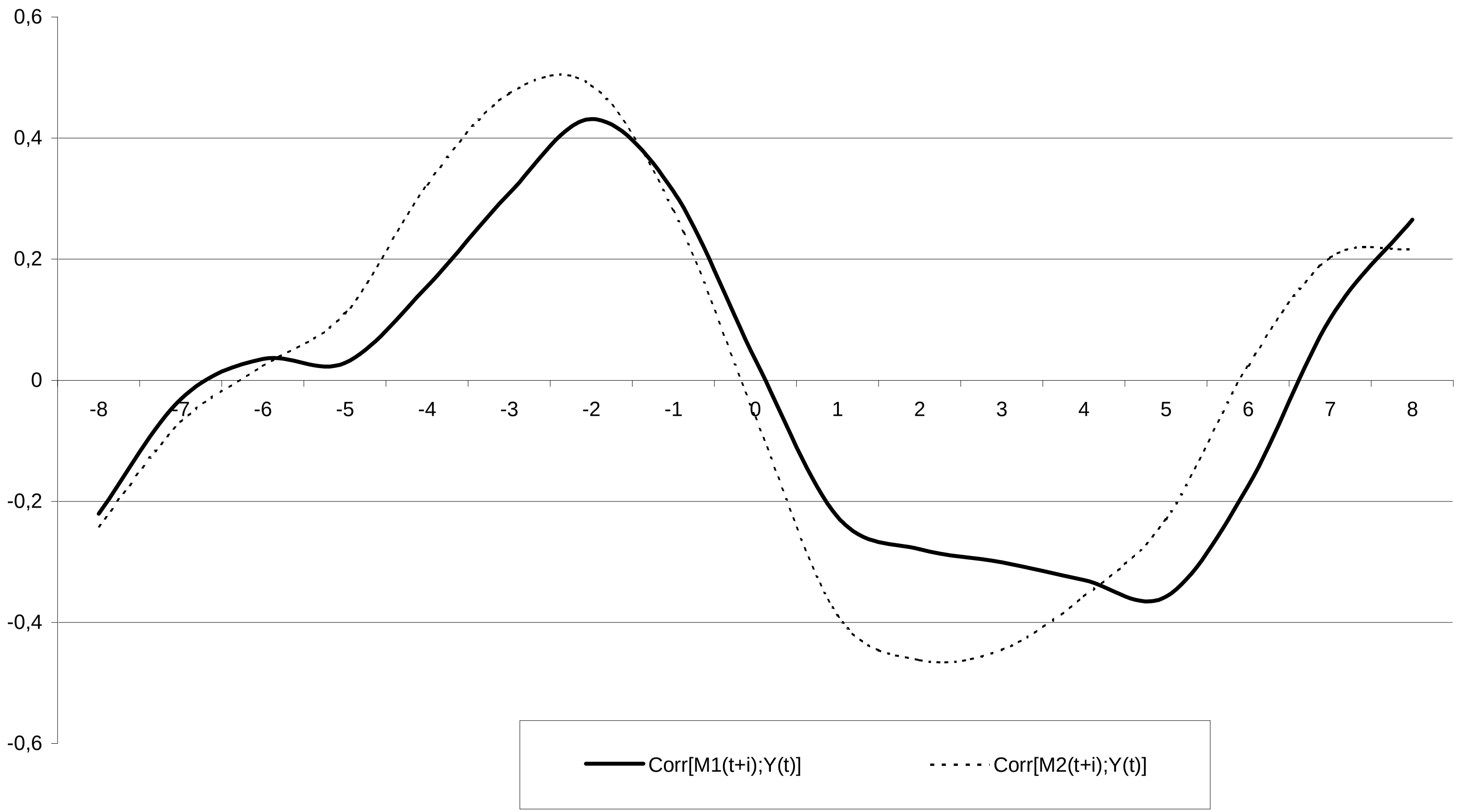

Figure 4: Detrended GDP and the Nominal 3-month Treasury Bill Rate

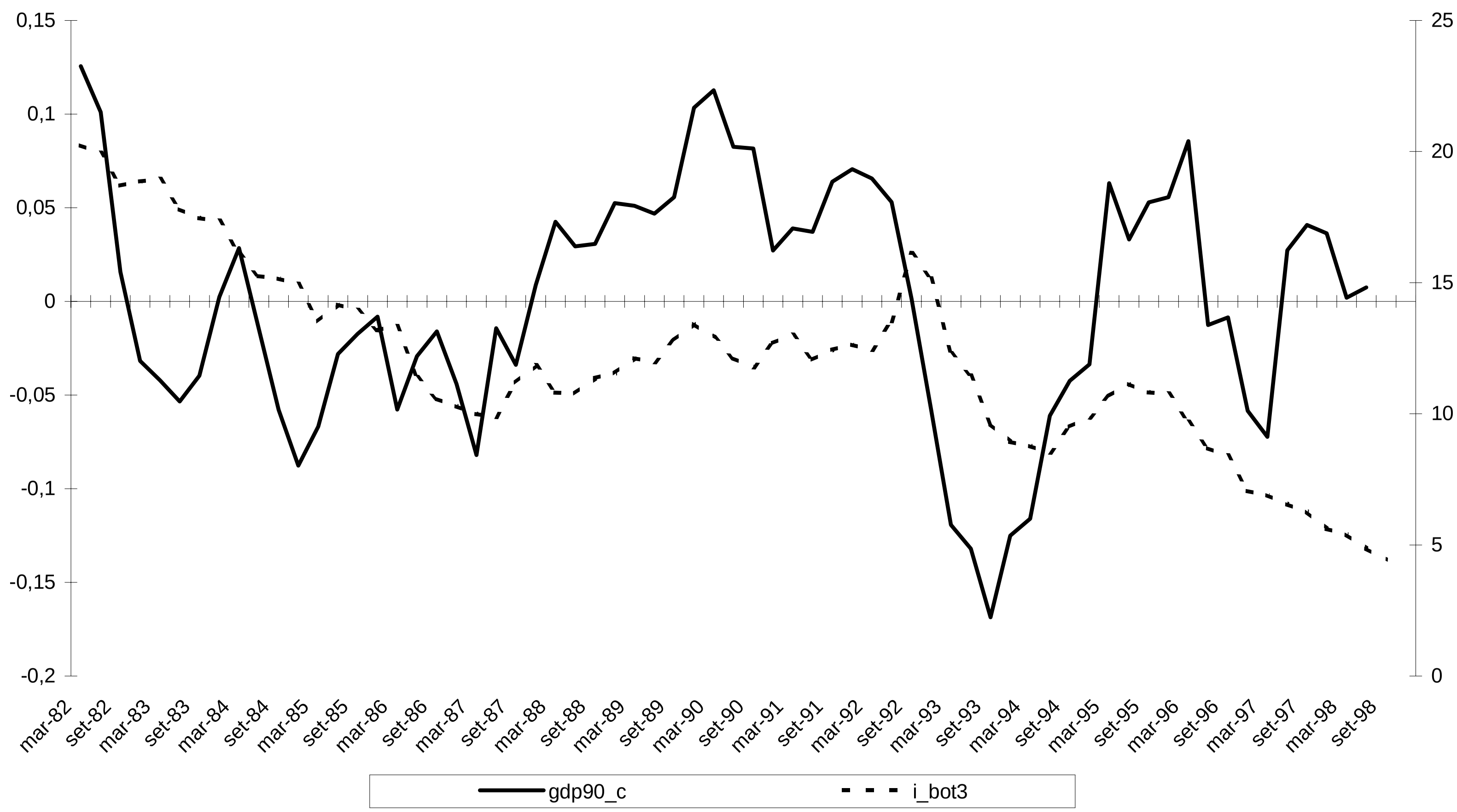

Figure 5: Detrended GDP and the overnight rate)

Figure 6: Impulse Response Functions in the 3-variable VAR

(a) M2 as policy variable

(b) 3-month T-Bill Rate as policy variable

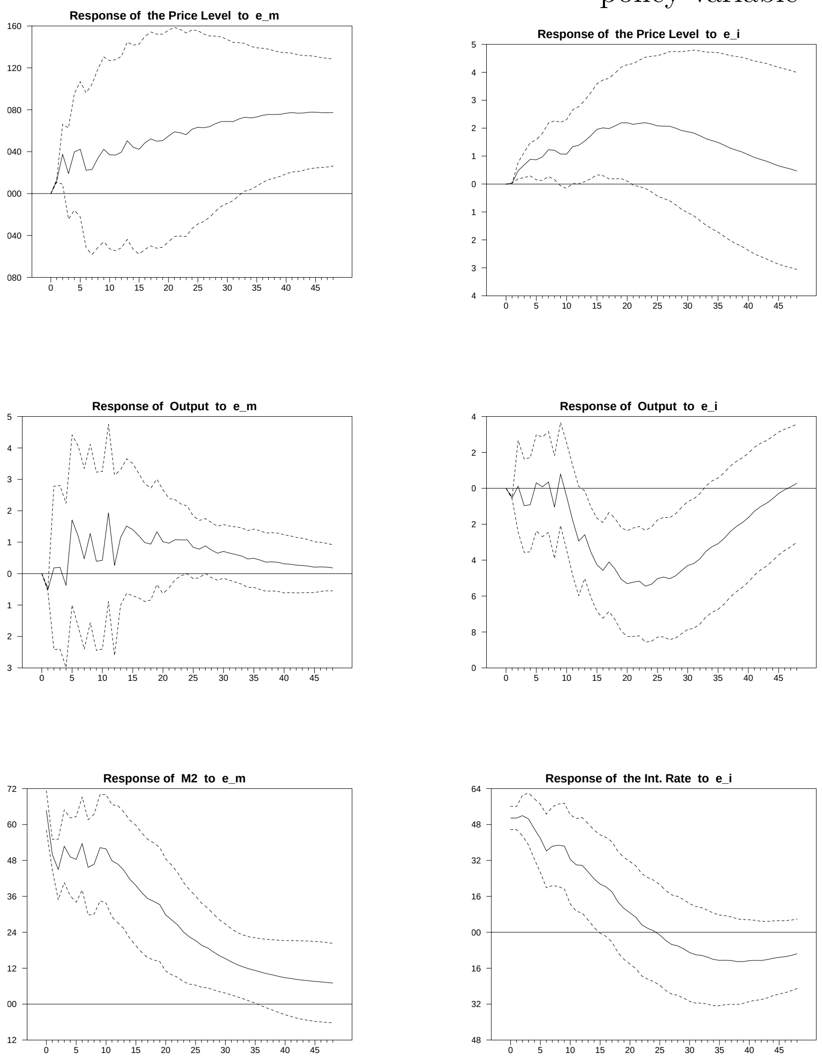

Figure 7: Impulse Response Functions in the 4-variable VAR (1982:1-1998:5)

(a) M2 as policy variable

(b) 3-month T-Bill Rate as policy variable

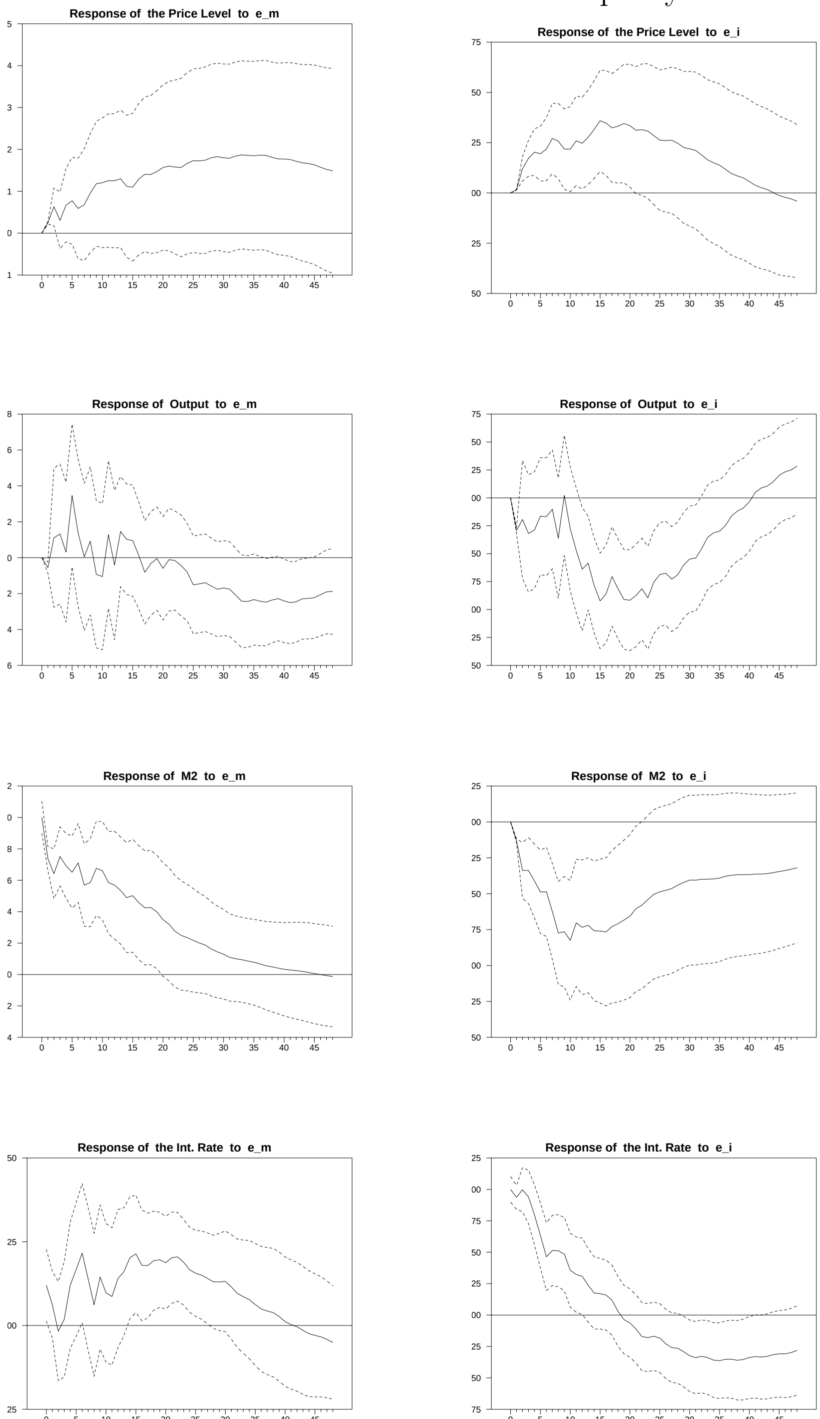

Figure 8: Impulse Response Functions in the 4-variable VAR (1990:1-1998:5)

(a) M2 as policy variable

(b) Overnight Rate as policy variable

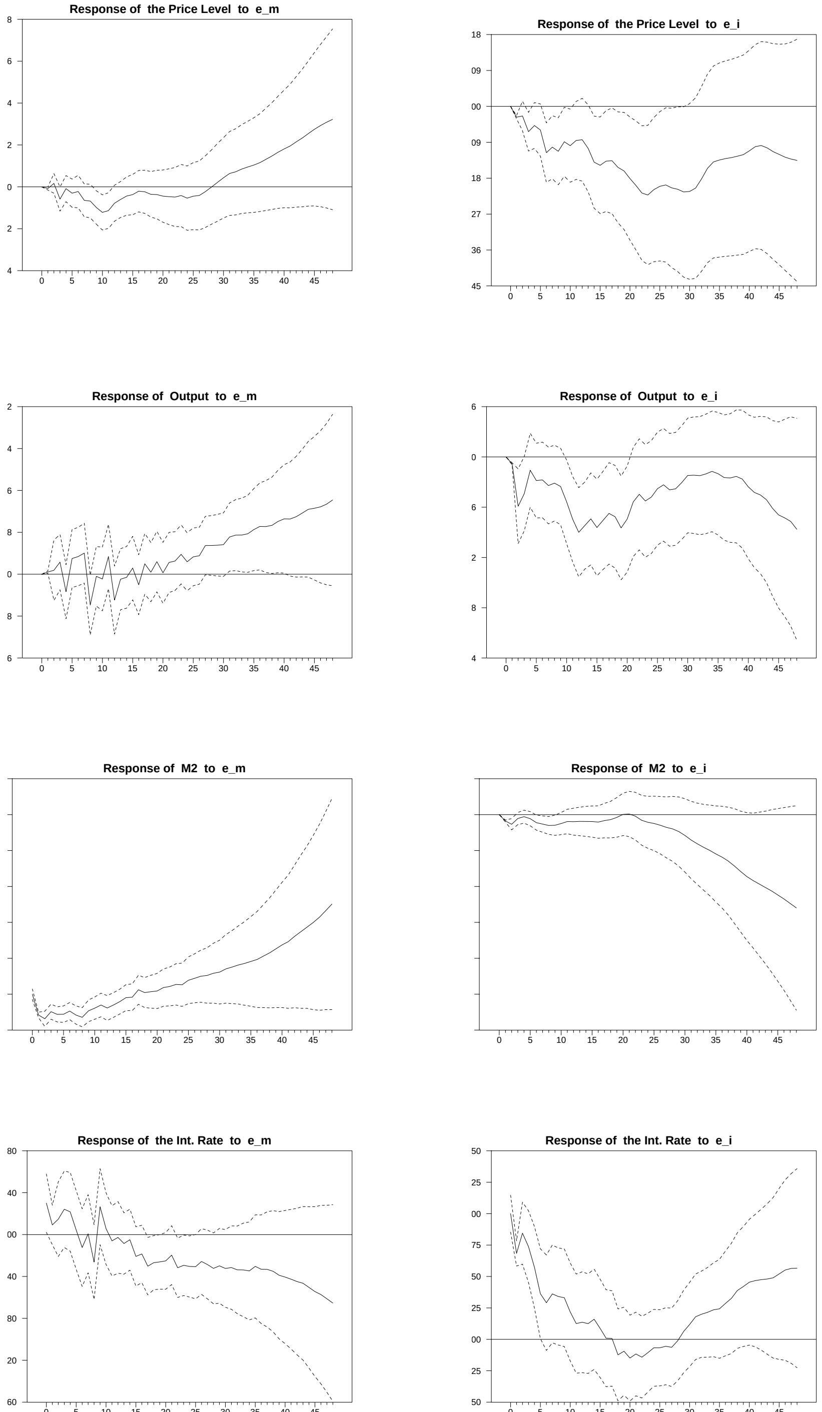

Figure 9: OV Regime(Monthly Model): Responses to a Monetary Contraction (1% Increase in the OV Rate)

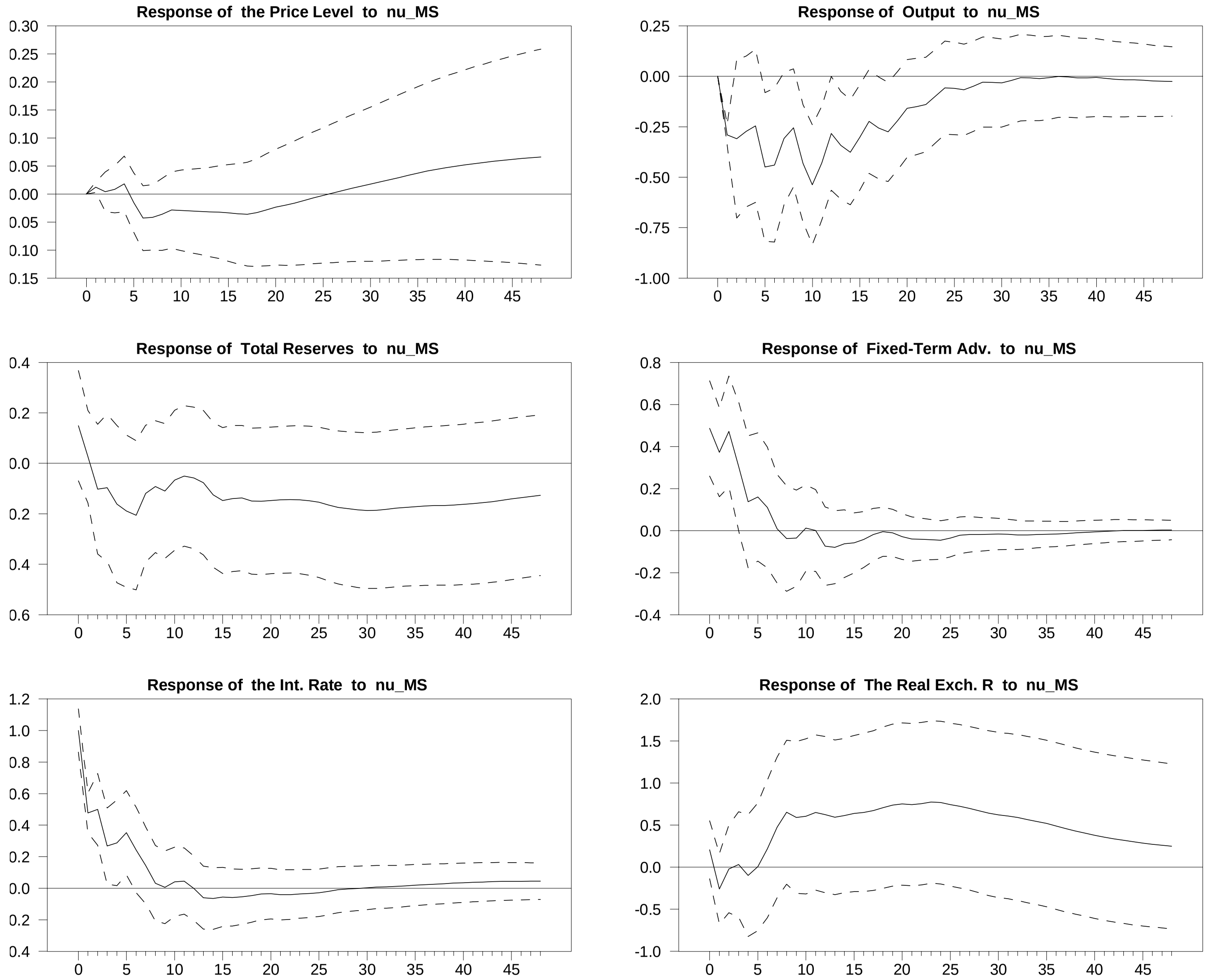

Figure 10: NBR Regime: Responses to a Monetary Contraction (1% Increase in the OV Rate)

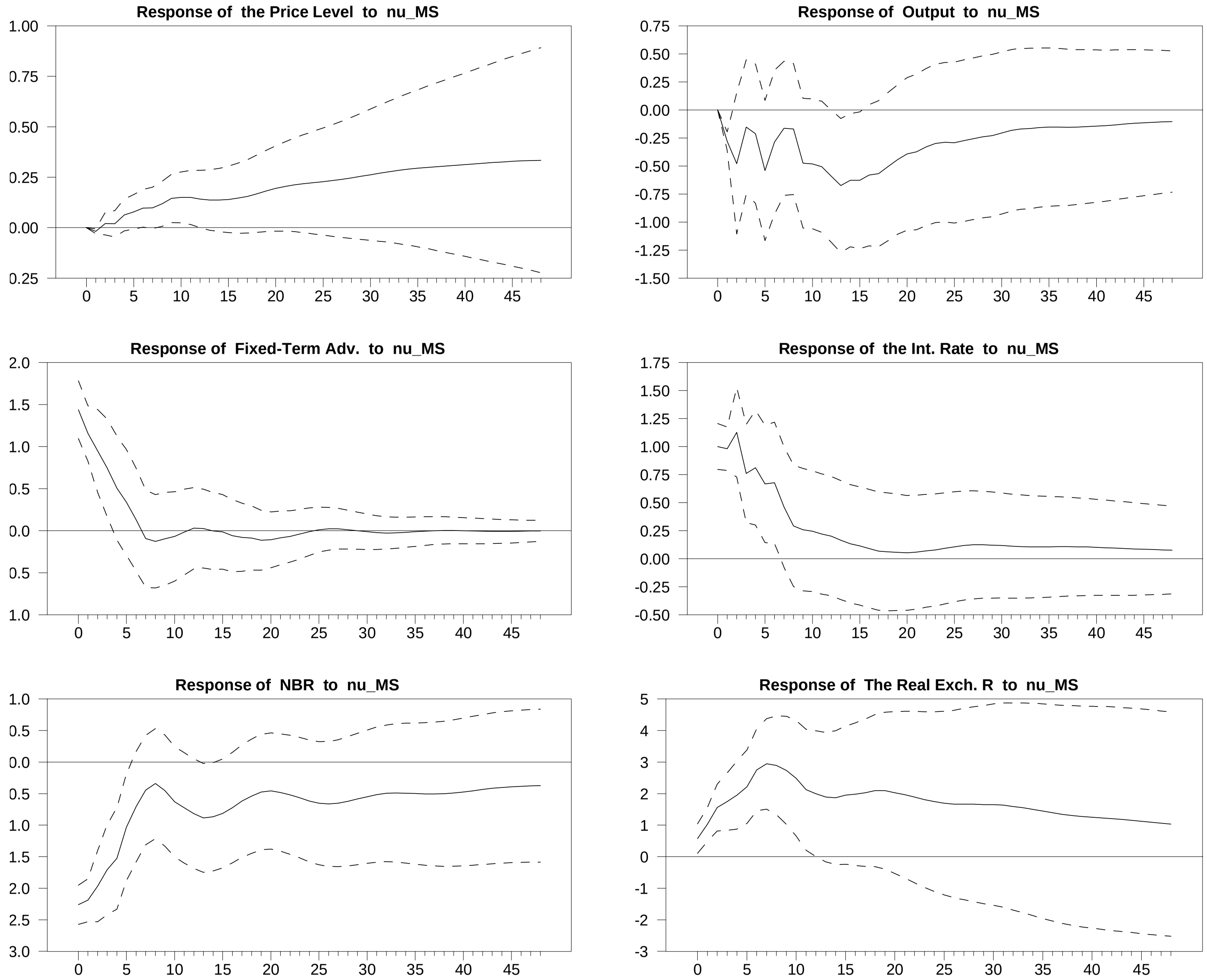

Figure 11: Forecast Error Variance Decomposition Of the Price Level and Output

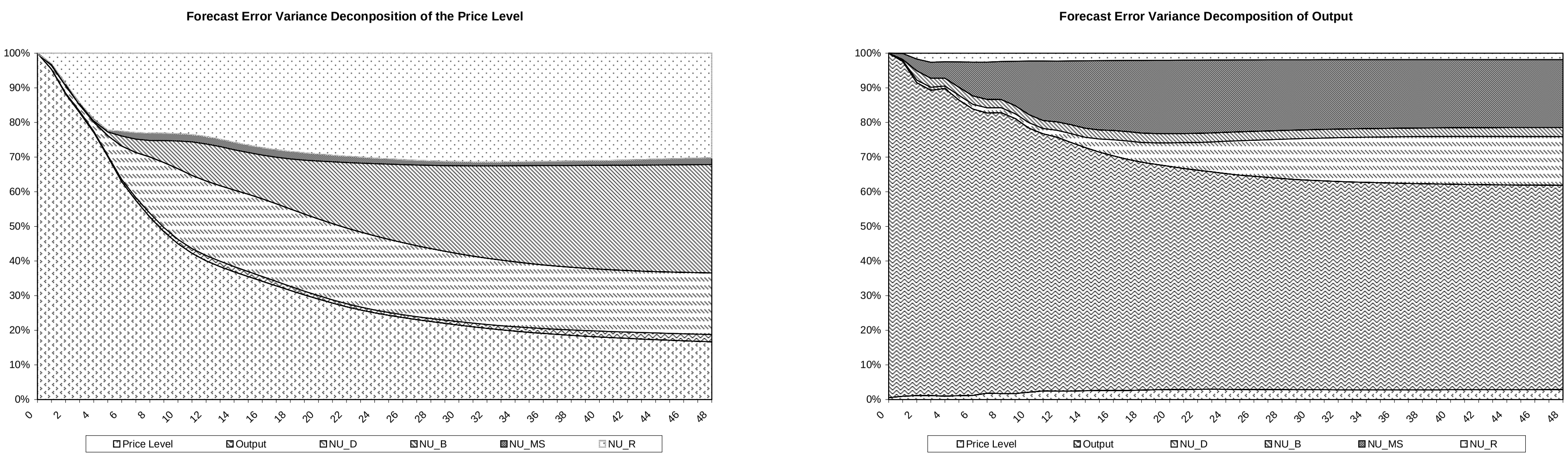

Figure 12: OV Regime: Monetary Policy Shocks

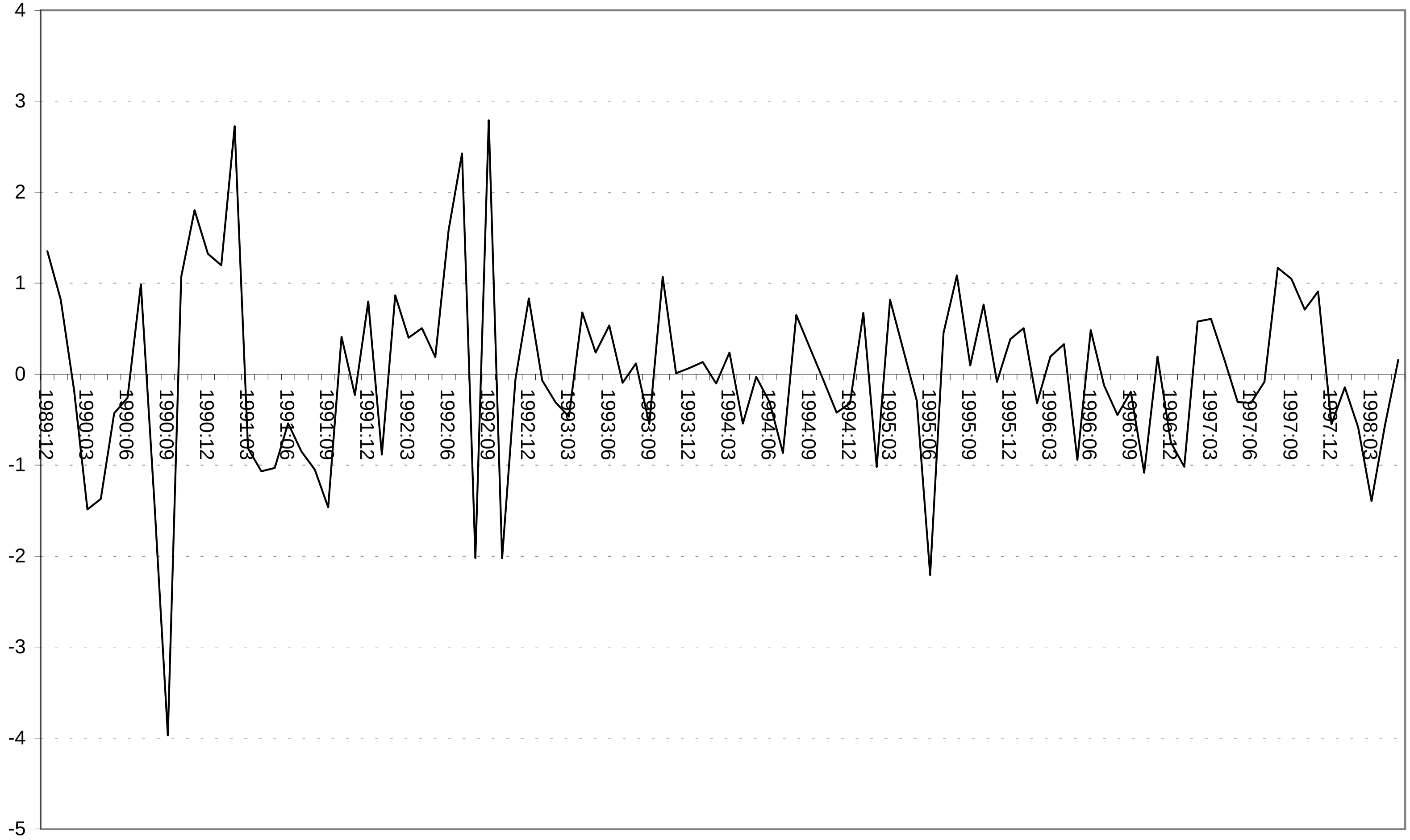

Figure 13: MA(3) of Monetary Policy Shocks and MA(3) of Monthly Changes in the OV Rate

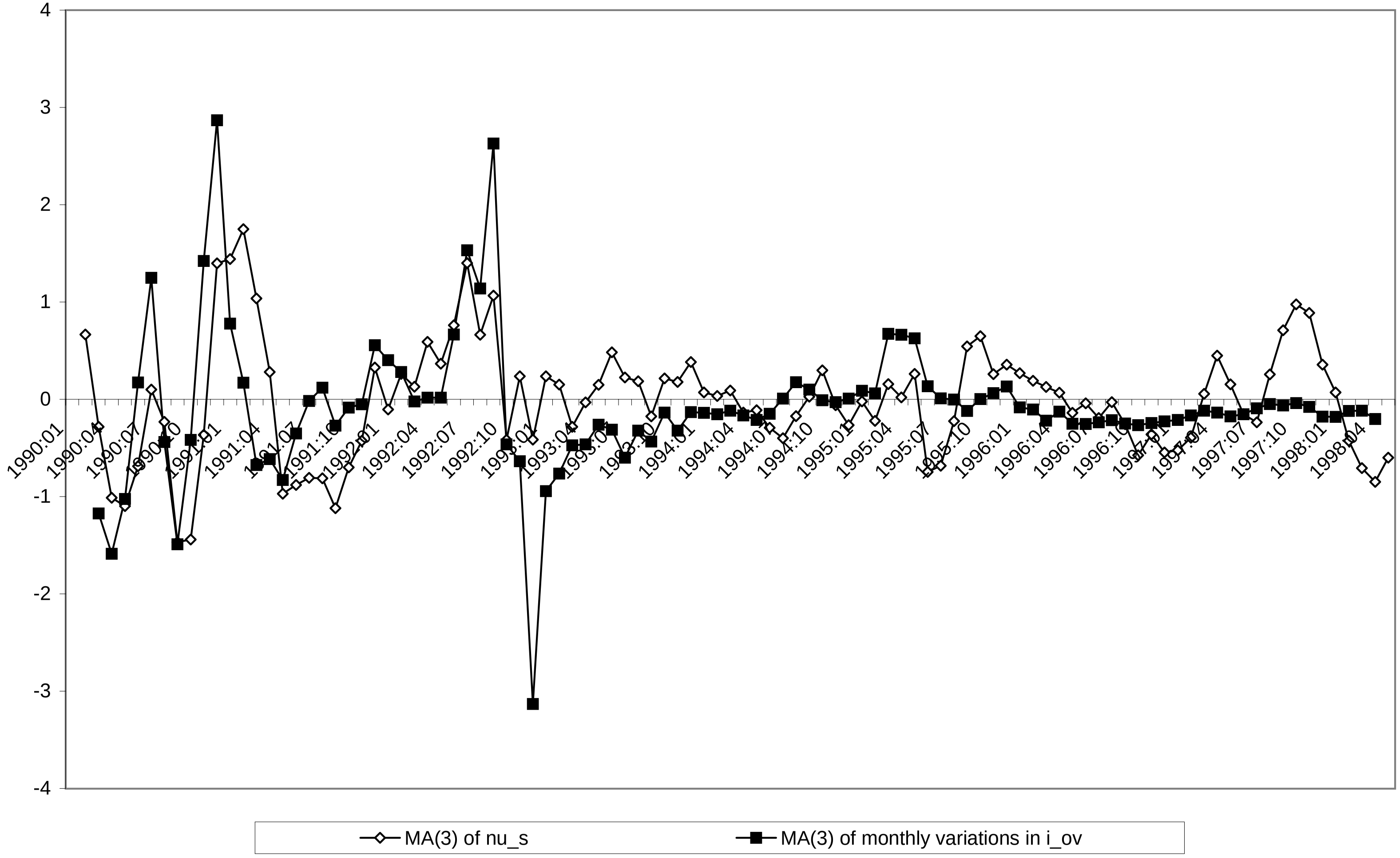

Figure 14: OV Regime (Quarterly model): Responses to a Monetary Contraction (1% Increase in the OV Rate)

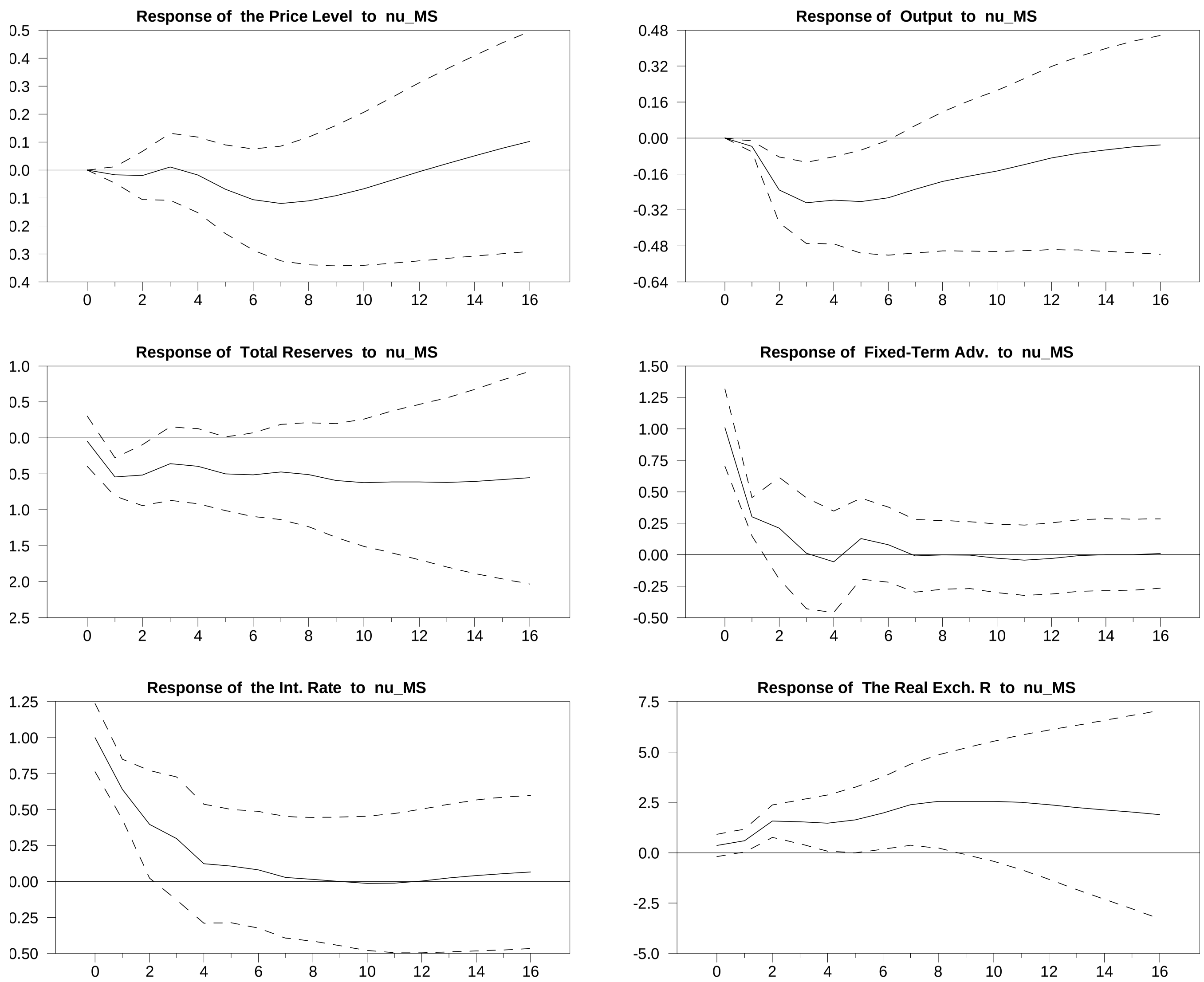

Figure 15: Responses of Consumption, Investment, Exports and Imports to a Monetary Contraction (1% Increase in the OV Rate)

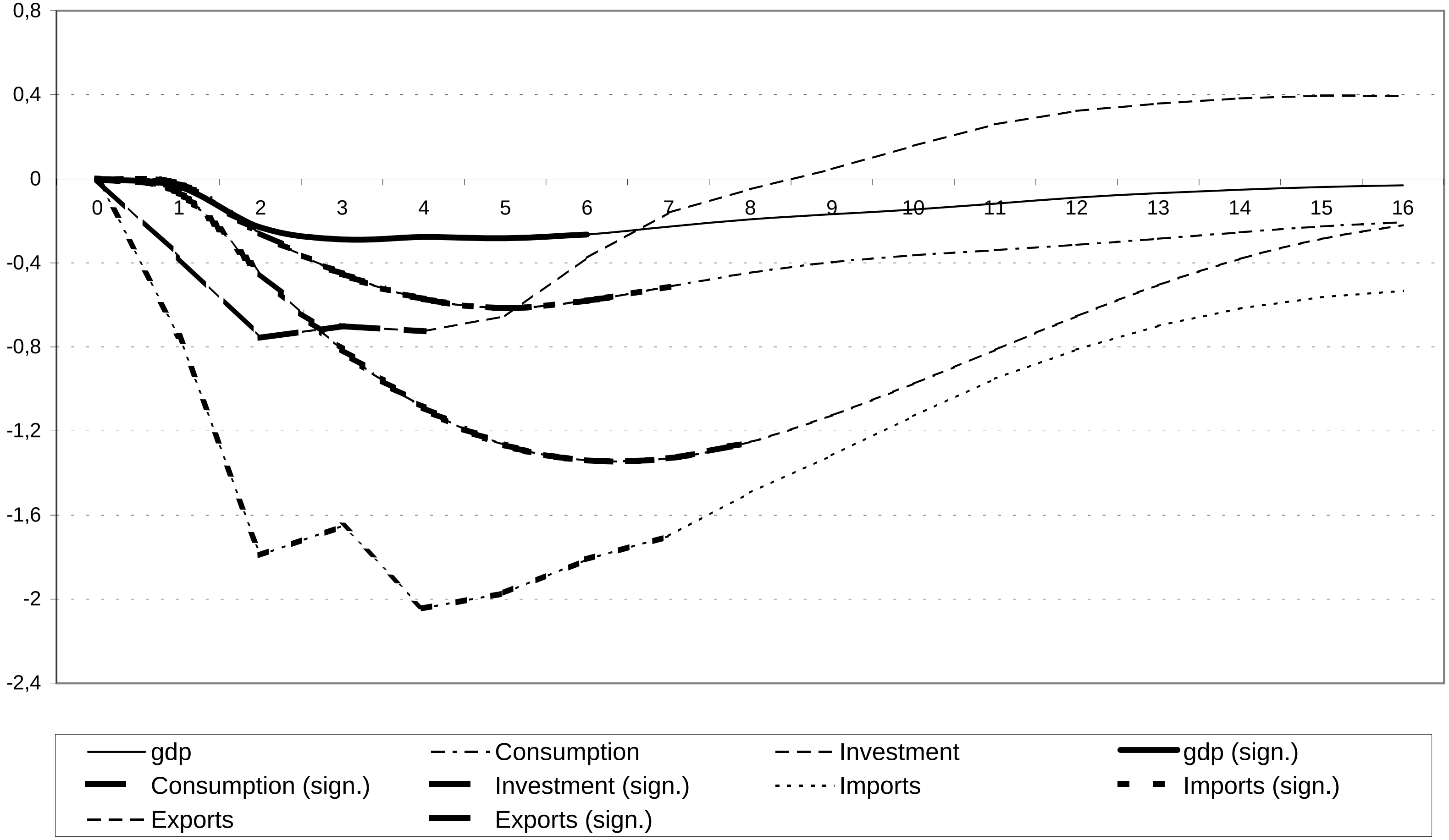

Figure 16: Responses of Exports and Imports to a 1% Real Depreciation

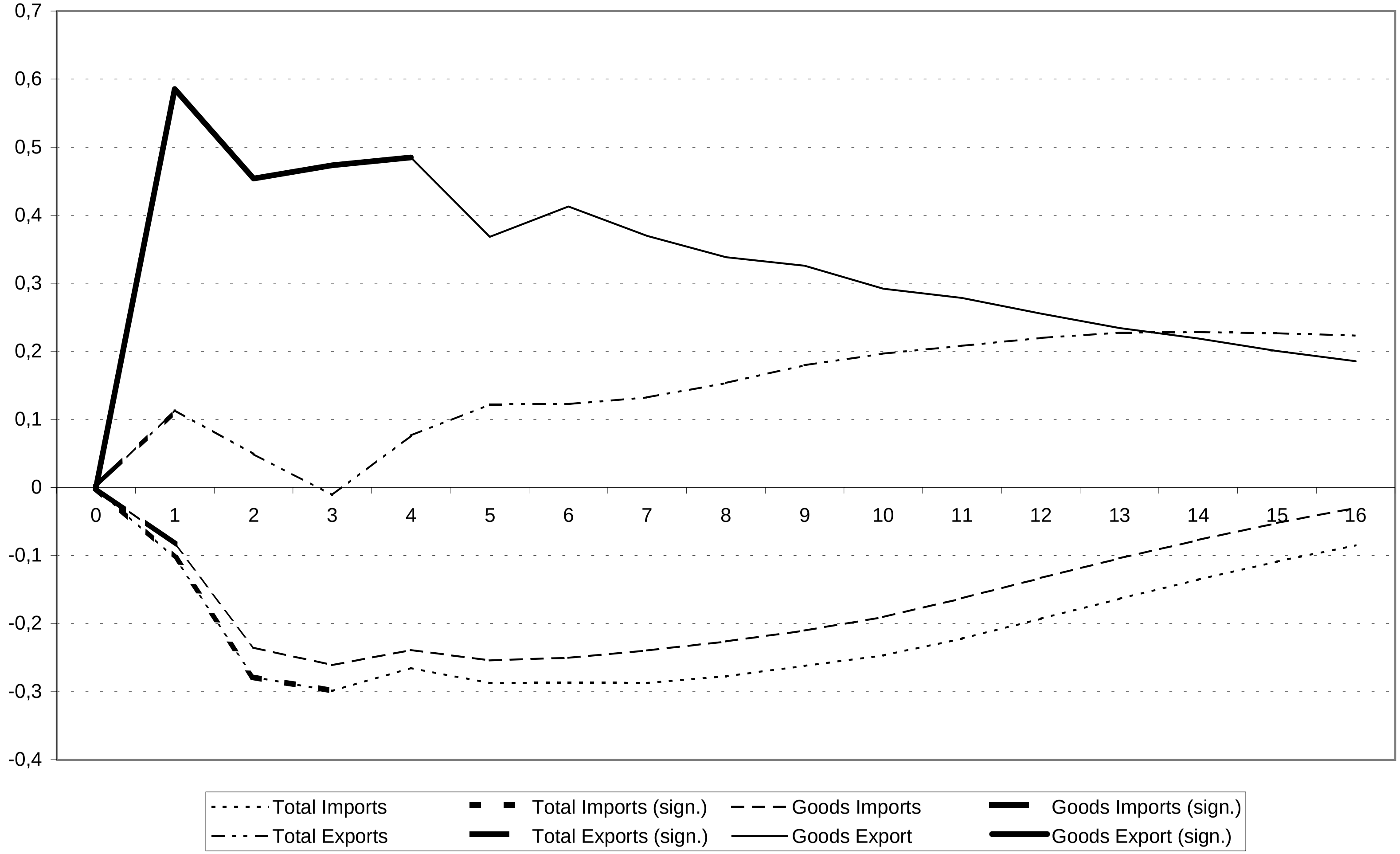

Figure 17: Responses of Consumption Components to a Monetary Contraction (1% Increase in the OV Rate)

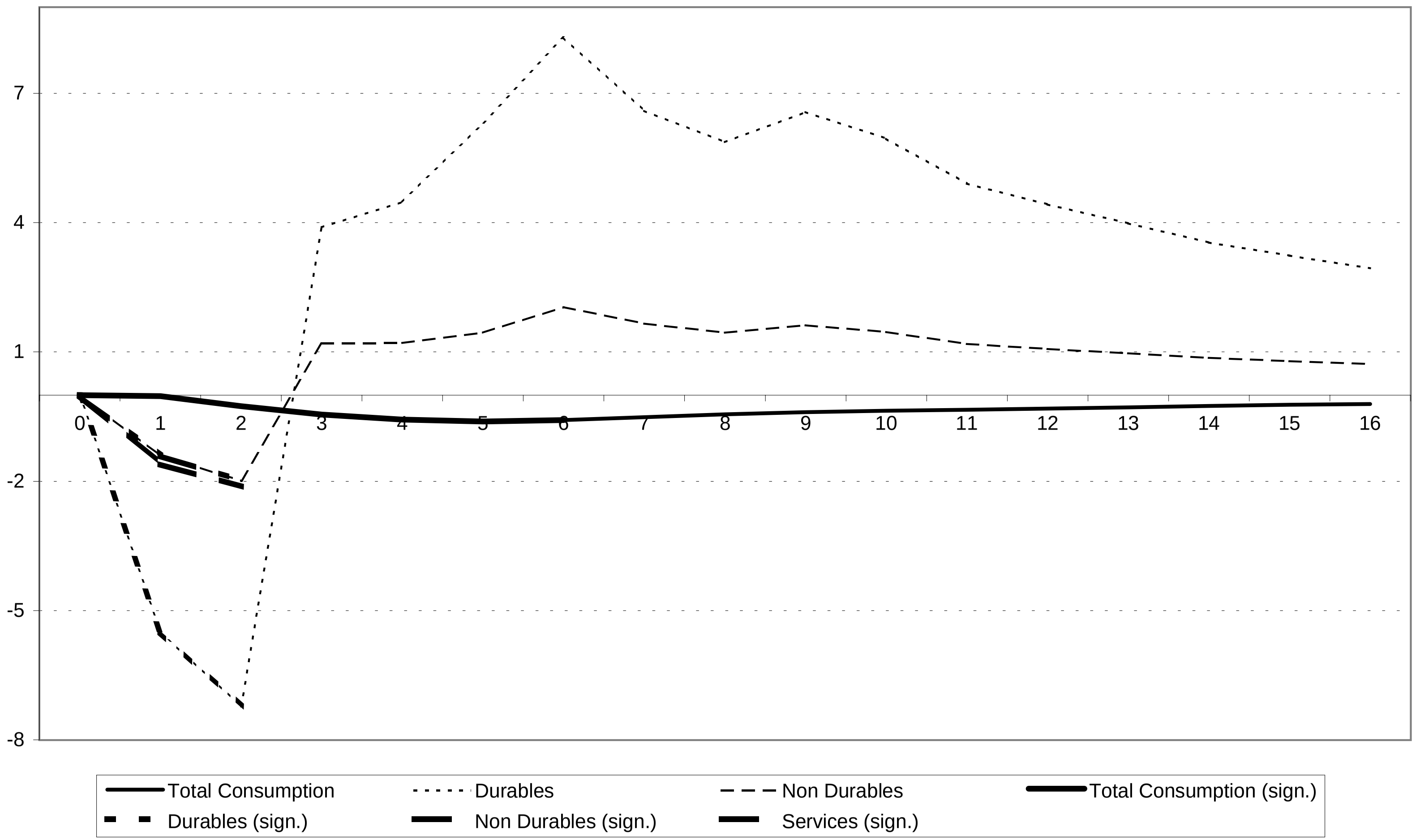

Figure 18: Responses of Investment Components to a Monetary Contraction (1% Increase in the OV Rate)

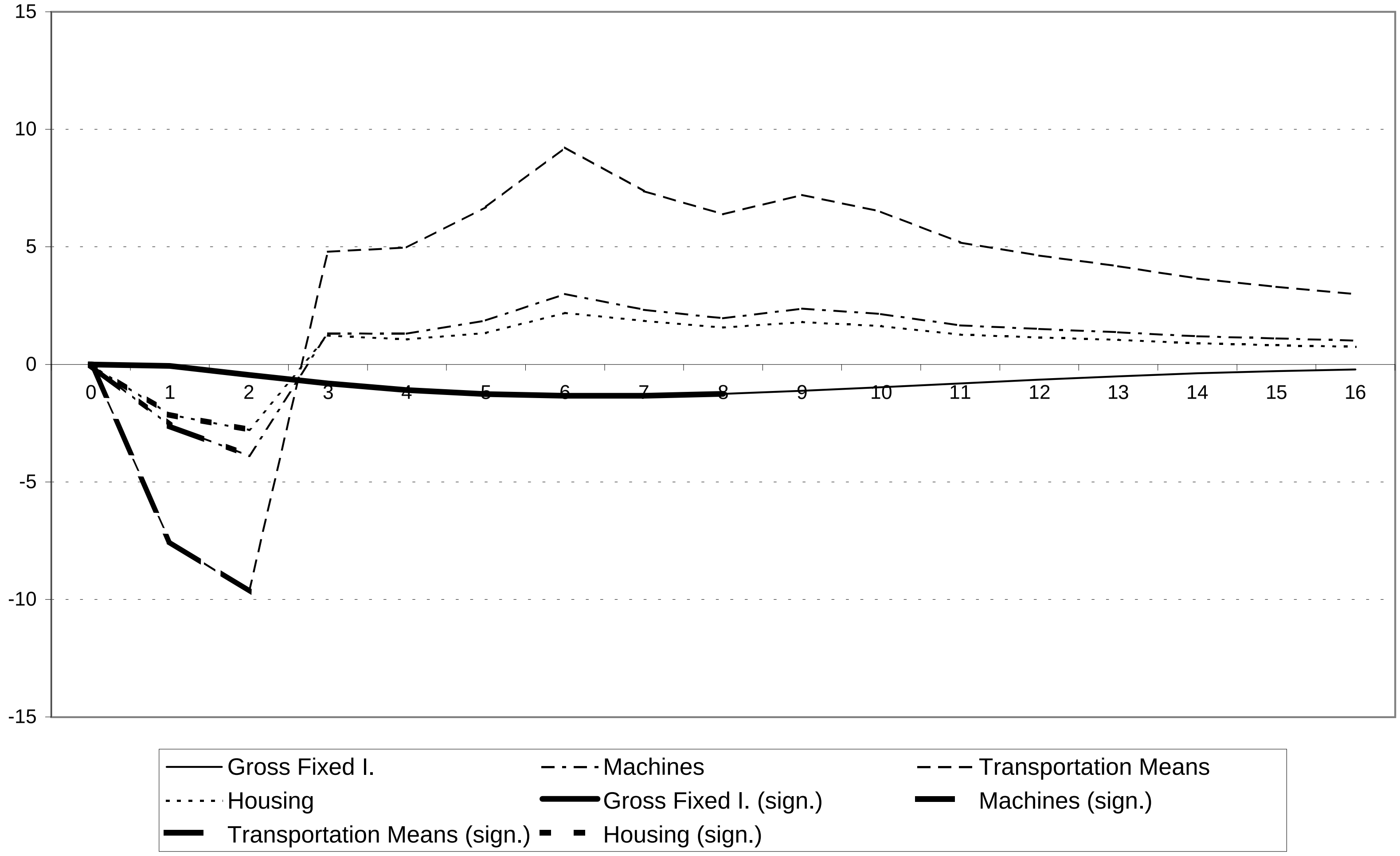

Figure 19: Responses of Employment and Wages to a Monetary Contraction (1% Increase in the OV Rate)

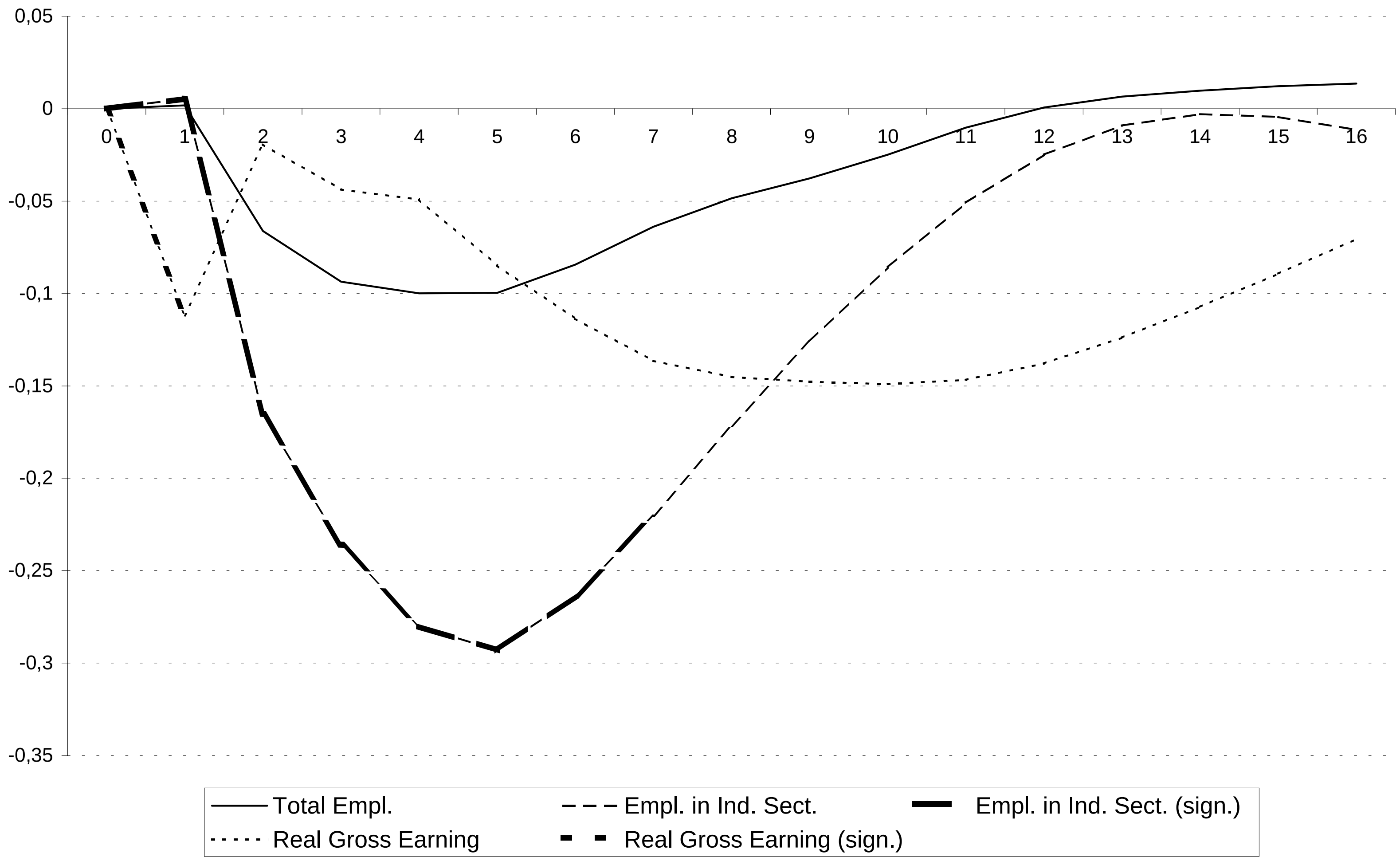

Figure 20: Responses of Government Bond Yields to a 1% Increase in the OV Rate

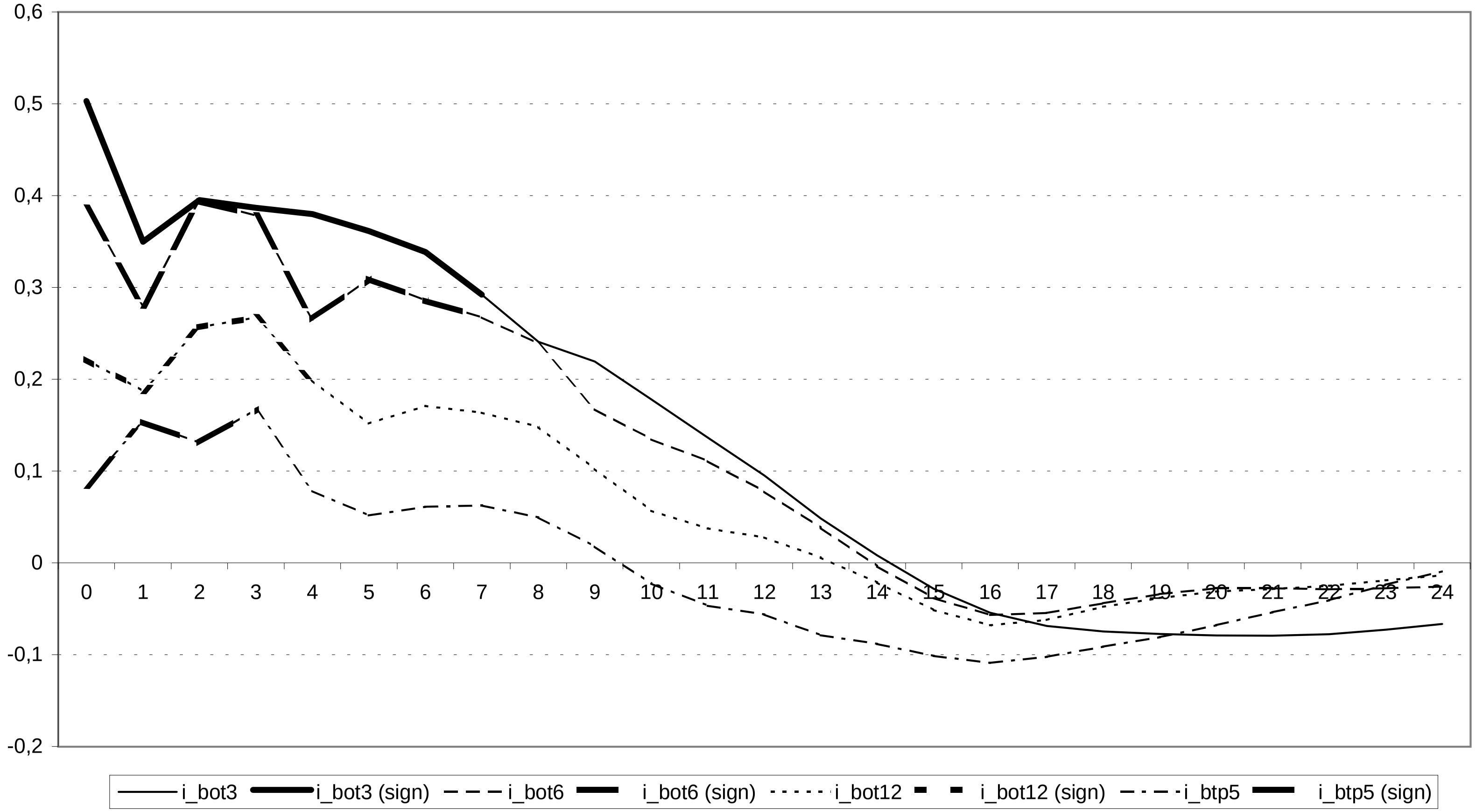

Figure 21: Responses of Banking Rates and Loans