Wealth, Money Demand and Policy Rule: Evidence from the Euro Area

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Abstract

This paper investigates empirically the relation between monetary policy and asset markets using quarterly data for the Euro Area. I find that a monetary policy contraction leads to a substantial fall in both financial and housing wealth, and their major components. However, while financial wealth effects from monetary policy shocks tend to be of short duration, housing wealth effects are very persistent. I also show that after a positive interest rate shock: (*i*) both GDP and consumption fall, while the unemployment rate rises; (*ii*) the price of raw materials substantially fall, but the aggregate price level only gradually falls; and (*iii*) there is a flight towards assets that are less liquid but also earn higher rates of return.

Additionally, the results suggest that the monetary authority should increase the interest rate only briefly in order to achieve a lower inflation. Moreover, expected inflation seems to be the major source of fluctuations in nominal rates over long periods.

The findings also show that the money demand function for the Euro Area is characterized by small output elasticity and relatively large interest elasticity. By its turn, the estimated policy rule reveals that the monetary authority pays a lot of attention to developments in the monetary aggregates while adopting a vigilant posture regarding financial markets.

Finally, using country-level data, the empirical evidence suggests that both stock and housing prices fall in response to the shock, although the reaction of stock prices is much faster. This reflects the existence of important spillover effects.

Keywords: *housing wealth, financial wealth, monetary policy*
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1 Introduction

Understanding the role of monetary policy requires a deep knowledge of the models that describe monetary transmission. The money demand and the monetary policy rule are key ingredients of this mechanism. In one hand, money demand brings together the real and the nominal sides of the economy, and allows us to extract information about medium to long-term price stability. On the other hand, the monetary policy rule describes the systematic relationship among economic developments and the central bank's response to them, and provides the basis for forecasting future changes in its instruments.

Despite the relevance of these two major elements, the economic literature has only recently modelled them in an unified framework, namely, by using parsimoniously restricted multivariate time-series models. Moreover, it has typically neglected the impact that monetary policy decisions may have on different categories of wealth, and, consequently, on other macroeconomic aggregates through the so called "wealth effects".

It is well known that asset markets react to economic news and policy changes, and consumers react to changes in asset markets. The consumption-wealth channel of monetary policy reflects this mechanism: changes in monetary policy affect asset values, and these, in turn, affect consumer spending.

The recent developments in asset markets have renewed the interest of academics, central bankers and governments on the role that fiscal and/or monetary policy decisions can play in order to prevent and minimize the (negative) consequences of financial turmoils. Financial markets undoubtedly contain relevant information about agents' expectations for the course of policy, economic activity, and inflation. Similarly, housing markets represent a large share of GDP and a major asset in households' portfolios from which they derive direct utility and collateral services. As a result, understanding how the two sides of monetary policy (namely, money demand and policy rule) and the two components of wealth (that is, financial and housing wealth) interact is of crucial importance, and is simultaneously the major goal of this paper.

The present work looks at the relationship between monetary policy and asset markets. Using data for the Euro Area at quarterly frequency and for the period 1980:1-2007:4, I ask how financial wealth measures (gross and net financial wealth, currency and deposits, debt securities, shares and mutual fund shares, insurance reserves, and mortgage loans) and housing wealth measures (gross and net housing wealth) are affected by monetary policy shocks. To the extent that I find a link between monetary shocks and wealth, I look at the magnitude and the persistence of the effects. Then, I compare the "quantity" effects with the "price" effects that emerge from the unexpected variation in monetary policy, that is, I look at the impact of monetary policy on housing prices and stock prices.

I pay close attention to the identification of the monetary policy shock and focus on the empirical evidence linking monetary policy and wealth variables. Specifically, I identify the monetary policy shock using a recursive partial identification based on the work of Christiano et al. (1996, 2005), and estimate a Bayesian Structural Vector Autoregression (B-SVAR), therefore, accounting for the posterior uncertainty of the impulse-response functions. I also use a fully simultaneous system approach in a Bayesian framework based on the works of Leeper and Zha (2003), and Sims and Zha (1999, 2006a, 2006b), therefore, allowing for simultaneity of the response of money to shocks in the interest rate.

The results show that after a monetary policy contraction, both financial and housing wealth substantially fall. However, while the adjustment in financial wealth is relatively fast, housing wealth changes very slowly. In addition, the effects tend to be substantial both for stock prices and housing prices, but the first are of shorter duration.

Other dimensions of monetary policy are also analyzed. To be more concrete, I consider the effects of monetary policy on a set of macroeconomic aggregates (GDP and private consumption), aggregate prices (GDP deflator, price of raw materials), and monetary aggregates (broad money, M_3 minus M_1, and narrow money, M_1). Additionally, I show that after a positive interest rate shock: (*i*) both GDP and consumption fall, while the unemployment rate rises; (*ii*) the price of raw materials substantially falls, but the aggregate price level only gradually falls; and (*iii*) the growth rate of broad money increases while the growth rate of narrow money falls, reflecting the flight towards assets that are less liquid but also earn higher rates of return.

In general, the initial liquidity effect lasts for about 6 quarters, after which the interest rate falls to a persistently lower (than initial) level. This, therefore, gives rise to the idea that the monetary authority should increase the interest rate only briefly in order to achieve a lower inflation. Moreover, in the long-run, the fall in the interest rate is quantitatively similar to the fall in the inflation rate, suggesting that expected inflation is the ultimate source of fluctuations in nominal rates over long periods.

The empirical findings also support the existence of a money demand function for the Euro Area characterized by a small output elasticity and a relatively large interest elasticity. By its turn, the policy rule reveals that the monetary authority pays a lot of attention to developments in the monetary aggregates while adopting a vigilant posture regarding the dynamics of financial markets.

Finally, I estimate the effects of monetary policy shocks on regional asset prices, that is, on housing and stock prices at the country level. This provides an informative summary of the spillover effects generated by monetary policy decisions and assesses the similarities/differences in the patterns of regional asset markets' reaction. The results are in line with the findings for the Euro Area and suggest that the effects of monetary policy contractions on stock prices are particularly important for France, Germany, Italy, Netherlands, and Spain - that is, the most important countries in terms of stock market capitalization - where the trough is normally associated with a fall of 3% to 5% in the stock price. In addition, an increase of the interest rate leads to a negative and very persistent impact on the housing prices. This pattern is particularly visible for Belgium, France, Ireland, Italy, and Netherlands, where the trough is characterized by a fall of around 2%.

The rest of the paper is organized as follows. Section 2 provides a brief review of the related literature. Section 3 explains the modeling strategy used in the identification of the monetary policy shocks. Section 4 describes the data and discusses the results. Section 5 focuses on the wealth effects from monetary policy. Section 6 looks at the impact of monetary policy on stock prices and housing prices at the country level. Section 7 conducts a VAR counterfactual exercise aimed at describing the effects of shutting down the shocks in the interest rate. Section 8 concludes with the main findings and policy implications.

2 A Brief Review of the Literature

According to popular wisdom, the dramatic run ups in housing prices have been caused by market-wide low interest rates, the increased availability of credit, or even money illusion.[1] Additional factors such as the fundamental restructuring of the housing finance system from a regulated system dominated by savings, loans and mutual savings banks to a relatively unregulated system dominated by mortgage bankers and brokers, the process of mortgage securitization, and a greater competitiveness in the primary mortgage market have also led to a reduction in volatility of residential investment. In fact, the housing finance system is now integrated with the broader capital markets in the sense that "mortgage rates move in response to changes in other capital market rates, and mortgage funds are readily available at going market rates" (Hendershott and Shiling, 1989).

As a result of these transformations, the transmission of monetary policy to residential investment has changed and a tightening of monetary policy is now less likely to result in nonprice rationing of mortgage credit. McCarthy and Peach (2002) show that the eventual magnitude of the response of residential investment to a given change in monetary policy is similar to what it has been in the past. Fratantoni and Schuh (2003) also study the effects of monetary policy on regions in the U.S. and find that the response of housing investment to monetary policy varies by region. Iacoviello and Minetti (2003) document the role that the housing market plays in creating a credit channel for monetary policy. Aoki et al. (2004) argue that there is a collateral transmission mechanism to consumption but do not condition on monetary policy. Iacoviello (2005) emphasizes the monetary policy-house price to consumption channel and finds that monetary policy shocks have a significant effect on house prices. Iacoviello and Neri (2007) analyze the contribution of the housing market to business fluctuations and show that: (*i*) a large fraction of the upward trend in real housing prices over the last 40 years can be accounted for by slow technological progress in the housing sector; (*ii*) residential investment and housing prices are very sensitive to monetary policy and housing demand shocks; and (*iii*) the wealth effects from housing on consumption are positive and significant. Del Negro and Otrok (2007) try to disentangle the relative importance of the common component in OFHEO house price movements from local (state- or region-specific) shocks and find that while historically movements in house prices were mainly driven by the local component, the increase in house prices in the period 2001-2005 is mainly a national phenomenon. Chirinko et al. (2008) study the interrelationship between stock prices, house prices, and real activity, focusing on the role that asset prices play in the formulation of monetary policy, and show that housing shocks have a much greater impact that equity shocks.

While the literature mentioned above discusses the role of monetary policy on housing markets, some authors have also looked at its impact on financial markets or, more specifically, on stock prices. Goto and Valkanov (2000) use a VAR-based method to analyze the covariance between inflation and stock returns. Rigobon and Sack (2002, 2003) report a significant response of the stock market to interest rate surprises using an heteroskedasticity-based estimator to correct for possible simultaneity bias, an approach subsequently extended by

[1] Brunnermeier and Julliard (2008) show that a reduction in inflation can fuel housing prices if people suffer from money illusion. Investors who decide whether to rent or buy a house by simply comparing monthly rent and mortgage payments do not take into account the fact that inflation lowers future real mortgage costs. The authors decompose the price-rent ratio into a rational component and an implied mispricing and find that inflation and nominal interest rates explain a large share of the time-series variation of the mispricing.

Craine and Martin (2003). Bernanke and Kuttner (2005) find that, on average, a hypothetical unanticipated 25-basis-point cut in the Federal funds rate target is associated with about a 1% increase in broad stock indexes. Adapting a methodology due to Campbell and Ammer (1993) and identifying the monetary policy shock from data on futures, the authors show that the effects of unanticipated actions on expected excess returns account for the largest part of the response of stock prices. Boyd et al. (2005) also consider the linkage between policy and stock prices, but their analysis focus on market's response to employment news, rather than to monetary policy directly.

Whichever is the asset market under consideration for the purpose of analyzing the effects of monetary policy decisions, the empirical evidence tells us that the linkages between financial markets and housing markets have substantially increased in recent years and, not surprisingly, developments in housing markets are now widely considered in models of stock returns' predictability.[2]

In addition, modelling monetary transmission is also central to understanding the linkages between monetary policy and asset markets. Money demand is commonly seen as an important link in that transmission mechanism, as it relates real and nominal aspects of the economy and plays a central role in resource allocation, and it is a crucial element of the framework used to extract signals about the risks to medium and long term price stability.

Another important ingredient for the analysis of the systematic relationship among economic developments and the central bank's response to them is the monetary authority's reaction function. The policy rule has received a large interest both from academics and central banks for several reasons. First, it captures the major considerations underlying a central bank's interest rate setting. Second, it provides a basis for forecasting changes in the central bank's policy instruments, as it illustrates how interest rates were set in the past. Third, it allows us to evaluate the monetary authority's policy and the effects of other economic shocks in the context of macroeconomic modelling. Fourth, it is an crucial element in the estimation of models with rational expectations.

A large body of the empirical literature is, therefore, available in estimating money demand functions for the US (Goldfeld, 1973; Jain and Moon, 1994; Butkiewicz and McConnell, 1995; Ireland, 2008) and the UK (Thomas, 1997a, 1997b; Brigden and Mizen, 1999; Chrystal and Mizen, 2000, 2001). Since the beginning of the nineties, many studies have also been devoted to the econometric analysis of the Euro area money demand. These have focused on aggregate M_3 and attempted to estimate the parameters of the long-run money demand using either single equation approaches (Fagan and Henry, 1998; Fase and Winder, 1999; Coenen and Vega, 2001) or a cointegrated VAR approach (Brand and Cassola, 2000; Calza et al., 2001; Coenen and Vega, 2001; Funke, 2001; Cassola and Morana, 2002; Golinelli and Pastorello, 2002; Kontolemis, 2002; Bruggemann et al., 2003; Avouyi-Dovi et al., 2003; Carstensen, 2006; Dreger and Wolters, 2006; Von Landesberger, 2007). In contrast to these classical maximum likelihood techniques, Warne (2006) estimates a cointegrated VAR using Bayesian methods,

[2] Yogo (2006) and Piazzesi et al. (2007) emphasize the role of nonseparability of preferences in explaining the countercyclical variation in the equity premium. Lustig and Van Nieuwerburgh (2005) show that the ratio of housing wealth to human wealth (the housing collateral ratio) shifts the conditional distribution of asset prices and consumption growth and, therefore, predicts returns on stocks. Sousa (2007) argues that the composition of wealth is important not only because of its impact on consumption but also for its implications on the predictability of asset returns. Gomes et al. (2007) show that the demand for durable goods is more cyclical than that for nondurable goods and services and that, in consequence, the cash flow and stock returns of durable-good producers are exposed to higher systematic risk.

and shows that the interest rate semi-elasticities are often imprecisely estimated as the error bands tend to be wide.

Since the original work by Taylor (1993) that postulates that central bank bases the setting of short-term interest rate on the current situation regarding inflation and the business cycle, several studies have also developed different versions of the reaction function. Some include a lagged interest rate term and justify the decision on optimal monetary policy inertia or interest rate smoothing behavior (Woodford, 1999), data uncertainty (Orphanides, 1998), or simply a misspecification that fails to take into account the existence of correlation among different shocks (Rudebusch, 2002). Other works incorporated features of forward-looking behavior in the policy rule and emphasized the importance of inflation targeting (Clarida et al., 1998) or real-time data in the information set of the monetary authority (Orphanides, 2001).

While the previous papers mainly refer to the US, others have also tried to estimate the monetary policy rule for the Euro Area and the major European countries with the use of different methodologies. Gerlach and Schnabel (2000) find that the original Taylor rule is able to explain the fall in the average interest rate over the last decade. Peersman and Smets (1999) confirm the robustness of the forward-looking policy rule in Clarida et al. (1998), while Faust et al. (2001) conclude that the European Central Bank (ECB) puts a higher weight on the output gap that the Bundesbank. Dornbusch et al. (1998) and Clausen and Hayo (2002) estimate the reaction function by means of Full Information Maximum Likelihood (FIML), while Angeloni and Dedola (1999) estimate a set of bivariate systems of equations, each including Germany and another country (France, Italy, Spain or Netherlands). Muscatelli et al. (2002, 2003) use a Recursive Least Squares method and include the long-term yield spread vis-à-vis Germany and the German interest rate in the policy rule. Ruth (2004) applies panel techniques and estimates interest rate reaction functions within an error-correction model. Dolado et al. (2000), Wesche (2003), and Arghyrou (2005) focus on non-linear reaction functions by using dummy variables to capture the asymmetric response to inflation and to output gap or by estimating Markov-switching models. Gerdesmeier and Roffia (2003) emphasize the importance of accounting for monetary developments. Eleftheriou et al. (2006) use a GMM approach and show that the rule followed by each EMU country is distinct, but the parameter estimates reflect the principles proclaimed by the monetary policy authority.

Despite the relevance of the money demand function and the monetary policy rule as key pillars in the understanding of market developments and the conduction of monetary policy, they have only recently been modelled in parsimoniously restricted multivariate time-series models. Sims and Zha (1999, 2006a, 2006b) introduce an information variable[3] - the commodity prices - in an identified VAR model that allows for simultaneity, and solve two puzzling characteristics: (*i*) the liquidity puzzle", that is, a monetary contraction apparently failing to produce any rise in interest rates; and (*ii*) the "price puzzle", that is, a monetary contraction apparently unable to generate a decline in prices. In the same spirit, Leeper and Zha (2003) consider a setting in which the economy is divided into three sectors: (*i*) the financial sector summarized by commodity prices that react contemporaneously to all new information; (*ii*) the monetary sector that comprises the "money demand" (linking money reserves, short term interest rate, GDP, and GDP deflator) and the "money supply" (where

[3] This practice has been followed in other studies (Christiano et al., 1999; Hanson, 2004) and the information-variable idea has been extended to variables such as the exchange rate in open-economy studies (Kim and Rubini, 2000) and the interest rate of long-term bonds in term-structure works (Evans and Marshall, 1998, 2004).

monetary policy is assumed to react only to commodity prices - which are observed in real time -, money reserves and the interest rate; and (*iii*) the production sector.

Most importantly, little attention has been given to the wealth effects from monetary policy and the role that monetary authority may play by influencing real spending through household wealth.

This paper, therefore, builds on the literature on restricted multivariate time-series models and its usefulness for the identification of monetary policy shocks as in Christiano et al. (2005), Leeper and Zha (2003), and Sims and Zha (1999, 2006a, 2006b). I quantify the magnitude of the wealth effects from monetary policy shocks, while improving and extending the existing literature in several directions. First, I do not look at the effects of monetary policy on the net funds raised by a specific sector of the economy - as in Christiano et al. (1996) - or on aggregate asset wealth - as in Ludvigson et al. (2002) - but focus on the response of different components of wealth instead.[4] Second, I aim at disentangling between the quantity effects (that emerge from the impact of monetary policy on the net stock of financial wealth and the net stock of housing wealth) and the price effects (that is, the effects of monetary policy on stock prices and housing prices) and, as a result, the analysis is broader than Julliard et al. (2007).[5] Third, while the previous studies have focused on evidence for the US and/or the UK, I use data for the Euro Area. This has some drawbacks such as the fact that the historical data originates from the time prior to EMU when the member economies experienced different monetary policy regimes and the possibility of aggregation bias (Beyer et al. 2001). There are, in fact, two alternative approaches: (*i*) to construct separate models of the member economies and link them to form a multi-country model of the euro area; and (*ii*) to start by aggregating the relevant macroeconomic time series across member economies and then estimate a model for the euro area as a whole. I follow the last approach, because the objectives and instruments of Eurosystem monetary policy are defined in terms of euro area aggregates.[6] Finally, as a robustness check of the previous point, I look at both Euro Area effects and country level evidence, therefore, assessing the importance of the spillover effects.

3 Modelling Strategy

The modelling strategy adopted consists in the estimation of the following Structural VAR (SVAR)

$$\underbrace{\Gamma(L)}_{n\times n}\underbrace{X_t}_{n\times 1} = \Gamma_0 X_t + \Gamma_1 X_{t-1} + ... = c + \varepsilon_t \text{ where } \varepsilon_t | X_s, s < t \sim N(\underline{0}, \Lambda) \qquad (1)$$

[4] Christiano et al. (1996) show that after a contractionary monetary policy shock, net funds raised by the business sector increases for roughly a year, after which it falls, and find that households do not adjust their financial assets and liabilities for several quarters after the shock. On the other hand, Ludvigson et al. (2002) suggest that the wealth channel plays a minor role in the transmission of monetary policy to consumption, a finding that the authors attribute to the transitory nature of interest rate innovations on asset values.

[5] Julliard et al. (2007) develop a setup that simultaneously integrates the effects of monetary policy on housing prices and stock prices and show that: (*i*) monetary policy contractions have a large and significantly negative impact on real housing prices, but the reaction is extremely slow; and (*ii*) monetary policy shocks do not seem to cause a significant impact on stock markets, and the effect quickly erodes.

[6] This approach is also pursued by Brand and Cassola (2000), Fagan et al. (2001), Gerdesmeier and Roffia (2003), and Coenen and Wieland (2005).

where $\Gamma(L)$ is a matrix valued polynomial in positive powers of the lag operator L, n is the number of variables in the system, and ε_t (the fundamental economic shocks) that span the space of innovations to X_t. That is, in the "reduced form"

$$\Gamma_0^{-1}\Gamma(L)\,X_t = B(L)\,X_t = a + v_t \sim N\left(\underline{0}, \Sigma\right) \tag{2}$$

where $\Sigma := \Gamma_0^{-1}\Lambda\left(\Gamma_0^{-1}\right)'$, the vector $v_t = \Gamma_0^{-1}\varepsilon_t$ contains the innovations of X_t, and Γ_0 pins down the contemporaneous relations among the variables in the system. In what follows I use the normalization $\Lambda = I$.

3.1 Recursive Partial Identification

In this setting, the key issue in identifying monetary policy shocks is the choice of identification restrictions in the Γ_0 matrix. I report results based on Christiano et al. (2005), that is, a recursive partial identification procedure. I assume that the variables in X_t can be separated into 3 groups: (i) a subset of n_1 variables, X_{1t}, whose contemporaneous values appear in the policy function and do not respond contemporaneously to the policy shocks; (ii) a subset of n_2 variables, X_{2t}, that respond contemporaneously to the monetary policy shocks and whose values appear in the policy function only with a lag; and (iii) the policy variable itself in the form of a short term interest rate, i_t.[7] I include in the system the same variables as in Christiano et al. (2005) but also add a housing wealth measure among the X_{1t} variables, that is, I allow the monetary policy authority to react contemporaneously to changes in the housing wealth. I also add a financial wealth measure in X_{2t}. The recursive assumptions can be summarized by $X_t = [X_{1t}',\ i_t,\ X_{2t}']'$ and

$$\Gamma_0 = \begin{bmatrix} \underbrace{\gamma_{11}}_{n_1\times n_1} & \underbrace{0}_{n_1\times 1} & \underbrace{0}_{n_1\times n_2} \\ \underbrace{\gamma_{21}}_{1\times n_1} & \underbrace{\gamma_{22}}_{1\times 1} & \underbrace{0}_{1\times n_2} \\ \underbrace{\gamma_{31}}_{n_2\times n_1} & \underbrace{\gamma_{32}}_{n_2\times 1} & \underbrace{\gamma_{33}}_{n_2\times n_2} \end{bmatrix}. \tag{3}$$

The two upper blocks of zeros correspond, respectively, to the assumptions that the variables in X_1 do not respond to the monetary policy shock either directly or indirectly. This approach delivers a correct identification of the monetary policy shock but not of the other shocks in the system.

To make Γ_0 invertible, I add arbitrary zero restrictions in the non-policy blocks to obtain a total of $(n-1)\,n/2$ linearly independent restrictions - therefore delivering an exactly identified system. The identification of the monetary policy shocks, as well as the shape of the impulse-response function following a monetary policy shock are, by construction, independent from the choice of these additional restrictions.

Finally, I assess the posterior uncertainty about the impulse-response functions by using a Monte Carlo Markov-Chain (MCMC) algorithm. Appendix A provides a detailed description of the computation of the error bands.

[7] I also experimented using narrow money, M_1, as the monetary policy instrument.

3.2 Fully Simultaneous Systems

I start by considering two structural VAR models in which I relax the assumptions that: (*i*) some of the variables are predetermined with respect to monetary policy and that (*ii*) the monetary policy reacts only to variables that are predetermined with respect to the monetary policy shock. I build on the models of Sims and Zha (2006a, 2006b) and of Leeper and Zha (2003) to which I add the wealth measures.

3.2.1 Sims and Zha (2006a)

Sims and Zha (2006a) abandon two potentially unsatisfactory assumptions of the Christiano et al. (2005) type of identification scheme seen before: (*i*) they do not assume that the central bank reacts only to variables that are predetermined relative to policy shocks; and most importantly (*ii*) they assume that there are no predetermined variables with respect to ε^{mp} (this implies that one can not do OLS – nor IV – to identify the policy shocks). This is particularly appealing, especially with quarterly frequency data (their approach is also motivated by a structural model of the economy).

In order to reach identification, I postulate the following money demand function

$$M_t = b_1 Y_t + b_2 i_t + b_3 P_t + \text{lagged}\,(X_t) + \sigma_M \varepsilon_t^M$$

where M_t is the log monetary aggregate, P_t is the log aggregate price index, Y_t is the log GDP, ε_t^M is the money demand shock, X_t is a vector of variables in the information set of the central bank, and σ_M is its standard deviation (the coefficients on these variables are restricted to unity). I also assume that the monetary policy function can be expressed as

$$i_t = \phi_M M_t + \phi_{FW} FW_t + \text{lagged}\,(X_t) + \sigma \varepsilon_t^{mp}$$

where FW_t is the log of net financial wealth. Note that in this case the policy function does not contain contemporaneous values of the aggregate price level and output. In recognition of the fact that net financial wealth, FW_t, is determined in markets characterized by a continuous auction structure, I allow this variable to react contemporaneously to all the variables in the system. The other variables included in the system – the aggregate log GDP deflator, P_t, the unemployment rate, U_t, log real GDP, Y_t, and the log housing wealth, HW_t – are not predetermined relative to the monetary policy shocks but it is assumed that the policy shock can influence them contemporaneously through its effect on the price of raw materials. The remaining part of the Γ_0 concerning these variables is normalized to have an upper triangular structure, and this normalization is irrelevant for the identification of monetary policy shocks.

Note that Sims and Zha (2006a) consider a Markov switching structure but do not assume short-run price homogeneity, an approach that is also followed by Leeper and Zha (2003). On the contrary, Sims and Zha (1999, 2006b) develop models in which short-run price homogeneity is imposed.[8]

In this specification, I consider $X_t = [FW_t, M_t, i_t, Y_t, P_t, U_t, HW_t]'$. As in Sims and Zha (2006a), I do not assume that P and Y are predetermined relative to ε_t^{mp} (what Christiano et

[8] The assumption of short-run homogeneity in prices is not consensual. Goldfeld and Sichel (1990) suggest that the rejection of the unity of the price level coefficient can be interpreted as an indicator for misspecification. On the contrary, Evans and Wang (2008) show that the price elasticity of money demand should be less than unity under commodity standards, whenever monetary gold and nonmonetary gold are included in a standard money-in-utility model.

al. (2005) do to reach identification) but limit the channels by which monetary policy shocks can affect P and Y instead. In particular, I partition the data such that $X_t = [X'_{1t}, X'_{2t}]'$ where

$$X_{1t} = \begin{bmatrix} FW_t \\ M_t \\ i_t \end{bmatrix}; \; X_{2t} = \begin{bmatrix} Y_t \\ P_t \\ U_t \\ HW_t \end{bmatrix}.$$

The identifying restriction on the matrix of contemporaneous effects, Γ_0, is

$$\begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} & \gamma_{16} & \gamma_{17} \\ 0 & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} & 0 & 0 \\ 0 & \gamma_{32} & \gamma_{33} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \gamma_{44} & 0 & 0 & 0 \\ 0 & 0 & 0 & \gamma_{54} & \gamma_{55} & 0 & 0 \\ 0 & 0 & 0 & \gamma_{64} & \gamma_{65} & \gamma_{66} & 0 \\ 0 & 0 & 0 & \gamma_{74} & \gamma_{75} & \gamma_{76} & \gamma_{77} \end{bmatrix} \begin{bmatrix} FW_t \\ M_t \\ i_t \\ Y_t \\ P_t \\ U_t \\ HW_t \end{bmatrix} \quad (4)$$

where the second and third rows correspond, respectively, to the money demand and policy rule equation (and the second and third elements of ε_t correspond to ε_t^M and ε_t^{mp}). The zeros in the sub-column starting at $(4, 2)$ correspond to the assumption that monetary policy shocks have only an indirect contemporaneous effect on the X_{2t} variables.

This one again is a partially identified S-VAR (the last 4 equations are linearly dependent) where correct impulse-response functions to monetary policy shocks can be constructed independently from where the zero restrictions are inserted. It is, therefore, straightforward to add the housing wealth among the X_2 variables since these are unlikely to respond directly to monetary policy shocks at time t. In the other hand, I include net financial wealth (instead of the commodity price index as in Sims and Zha (2006a)) in the set of X_1 variables.

3.2.2 Leeper and Zha (2003)

In the same spirit, but somehow less restrictive, is the identification scheme of Leeper and Zha (2003). In this setting, the economy is divided into three sectors: a financial, a monetary and a production sector. The financial sector – summarized by commodity prices index, Pcm – reacts contemporaneously to all new information. The monetary sector, that allows for simultaneous effects, comprises: (*i*) "money demand" that links money reserves, M, with the short term interest rate, i, GDP, Y, and the GDP deflator, P; and (*ii*) "money supply", where monetary policy is assumed to react only to commodity prices (since they are observed in real time), money reserves and the interest rate (since the other data are not observed in real time by the central bank).

I depart from Leeper and Zha (2003) in that I assume that: (*i*) net financial wealth, FW, reacts contemporaneously to all new information; and (*ii*) the monetary policy reacts only to net financial wealth, money reserves and interest rate. In practice, I replace the commodity prices index (included in the Leeper and Zha (2003) specification) by net financial wealth, as financial prices can be observed in real time.

The production sector consists of log real GDP, Y, unemployment rate, U, the GDP deflator, P. I also add the housing wealth, HW. This sector does react contemporaneously to the financial sector but not directly to the monetary sector. The orthogonalization within this sector is irrelevant to identify monetary policy shocks correctly. The identification can be summarized in the following table where "+" indicates non-zero elements and I added a triangular orthogonalization for the production sector that is irrelevant for the identification of monetary policy shocks.

	Sector:						
Variable:	Financial	M Demand	M Policy	Prod Y	Prod P	Prod U	Housing
Financial wealth	+	+	+				
Money	+	+	+				
Interest rate	+	+	+				
GDP	+	+	+	+	+	+	+
Deflator	+	+			+	+	+
Unemployment	+					+	+
Housing wealth	+						+

Both fully simultaneous identification schemes considered deliver overidentification. This implies that the estimates of Γ_0 are obtained via numerical maximization of the integrated likelihood and that confidence bands for the impulse-response functions should be constructed by drawing jointly from the posterior distribution of $B(L)$ and Γ_0 (see Sims and Zha, 1999). This task is complicated by the fact that the integrated likelihood is not in the form of any standard probability density function, implying that one can not draw Γ_0 from it directly to make inference. This problem is solved by: (*i*) taking draws for Γ_0 using an importance sampling approach that combines the posterior distribution with the asymptotic distribution of Γ_0; and (*ii*) drawing $B(L)$ from its posterior distribution conditional on Γ_0. Confidence bands are then constructed from the weighted percentiles of the impulse-response functions drawn in this fashion. This Monte Carlo approach is explained in detail in the Appendix B.

3.3 An "Almost" Fully Simultaneous System

In addition to the fully simultaneous systems used in the identification of the monetary policy shock and as a final robustness check, I consider an "almost" fully simultaneously system.

As before, I consider $X_t = [FW, M, i, Y, P, U, HW]'$ and the data are partitioned such that $X_t = [X'_{1t}, X'_{2t}]'$ where:

$$X_{1t} = \begin{bmatrix} FW_t \\ M_t \\ i_t \end{bmatrix}; \; X_{2t} = \begin{bmatrix} Y_t \\ P_t \\ U_t \\ HW_t \end{bmatrix}.$$

The identifying restriction on the matrix of contemporaneous effects, Γ_0, is now given by

$$\begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} & \gamma_{16} & \gamma_{17} \\ 0 & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} & 0 & 0 \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & 0 & 0 & 0 & 0 \\ \gamma_{41} & 0 & 0 & \gamma_{44} & 0 & 0 & 0 \\ \gamma_{51} & 0 & 0 & \gamma_{54} & \gamma_{55} & 0 & 0 \\ \gamma_{61} & 0 & 0 & \gamma_{64} & \gamma_{65} & \gamma_{66} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \gamma_{77} \end{bmatrix} \begin{bmatrix} FW_t \\ M_t \\ i_t \\ Y_t \\ P_t \\ U_t \\ HW_t \end{bmatrix} \tag{5}$$

where the second and third rows correspond to the correspond, respectively, to the money demand and policy rule equation (and the second and third elements of ε_t correspond to ε_t^M

and ε_t^{mp}). The zeros in the sub-column starting at $(4, 2)$ correspond to the assumption that monetary policy shocks have only an indirect contemporaneous effect on the X_{2t} variables. In this framework, monetary policy decisions can have an indirect effect on housing wealth. However, housing wealth shocks do not impact on the other variables of the system.

4 Results and Discussion

4.1 Data

This section provides a summary description of the data employed in the empirical analysis. A detailed description can be found in Section C of the Appendix. All variables are in natural logarithms and measured at constant prices unless stated otherwise.

The Euro Area economic variables are computed by aggregating national data using the irrevocable fixed exchange rates. I follow Brand and Cassola (2000), Fagan et al. (2001), Gerdesmeier and Roffia (2003), and Coenen and Wieland (2005) among others.

For the recursive partial identification of the monetary policy shock (based upon the work of Christiano et al., 2005), the variables in X_{1t} – the ones predetermined with respect to monetary policy innovations – are the net stock of housing wealth, NHW_t, the producer price index of raw materials, PPI_t^{RM}, the real gross domestic product, Y_t, the real consumption, C_t, and the GDP deflator, P_t. The variables in X_{2t} – the ones allowed to react contemporaneously to monetary policy shocks – are the growth rate of broad money, $M_{3t} - M_{1t}$, and the net stock of financial wealth, NFW_t. That is, the recursive assumptions defined in (3) can be explicitly represented by $X_t = [X_{1t}',\ i_t,\ X_{2t}']'$, where $X_{1t} = [NHW_t, PPI_t^{RM}, GDP_t, C_t, P_t]$ and $X_{2t} = [M_{3t} - M_{1t}, NFW_t]$. I use the interest rate denoted by i_t as the monetary policy instrument. The data are available for the period 1980:1-2007:4.

For the other identification procedures, I follow the data choice of Sims and Zha (2006a) and Leeper and Zha (2003) with two major differences: (i) I add housing wealth; and (ii) I replace the commodity price index by a measure of financial wealth. That is, in practice, I include net financial wealth, nominal M_3, the interest rate - the monetary policy instrument -, GDP, the GDP deflator, the unemployment rate, and net housing wealth. I also provide results using M_1 instead of M_3.

4.2 Recursive Partial Identification

I start by analyzing the impact of changes in the interest rate. I identify the monetary policy shock by imposing the recursive assumptions defined in (3) and estimate the Bayesian Structural VAR (B-SVAR) represented by (1).

Figure 1 plots the impulse-response functions to a positive shock in the interest rate. The solid line corresponds to the point estimate, the red line represents the median response, and the dashed lines are the 68% posterior confidence intervals estimated by using a Monte-Carlo Markov-Chain algorithm based on 10000 draws.

The results are, broadly speaking, in line with the findings of Christiano et al. (2005) and suggest that after a contractionary monetary policy, both GDP and consumption fall and the trough is reached at after around 12 quarters. The price of raw materials also decreases substantially and the reaction is quick. In addition, the price level exhibits a high persistence and starts falling only after around 16 quarters. The response of the growth rate of M_3 minus M_1, that is, a broad measure of money that includes short-term time and saving deposits and marketable instruments is interesting: as a result of a positive interest rate shock, the growth rate of this monetary aggregate increases, reflecting the flight towards assets that are less liquid but also earn higher rates of return; then, as the shock to the interest rate erodes, the growth rate starts falling and even becomes negative at around after 6 quarters.

Looking at the behavior of wealth, the empirical findings show that both net financial wealth and net housing wealth fall after the shock. However, while the adjustment in financial wealth is relatively fast, housing wealth changes very slowly: net financial wealth falls, reaches a trough (of around -0.8%) at after 8 quarters, and then starts recovering; on the other hand, net housing wealth slowly falls over time and the effects are very persistent as this component of wealth remains at a lower level (about -0.8%) even after 20 quarters. The evidence suggests, therefore, that shocks to the interest rate have important wealth effects. Additionally, while housing wealth effects are very persistent, financial wealth effects tend to be of relatively short duration.

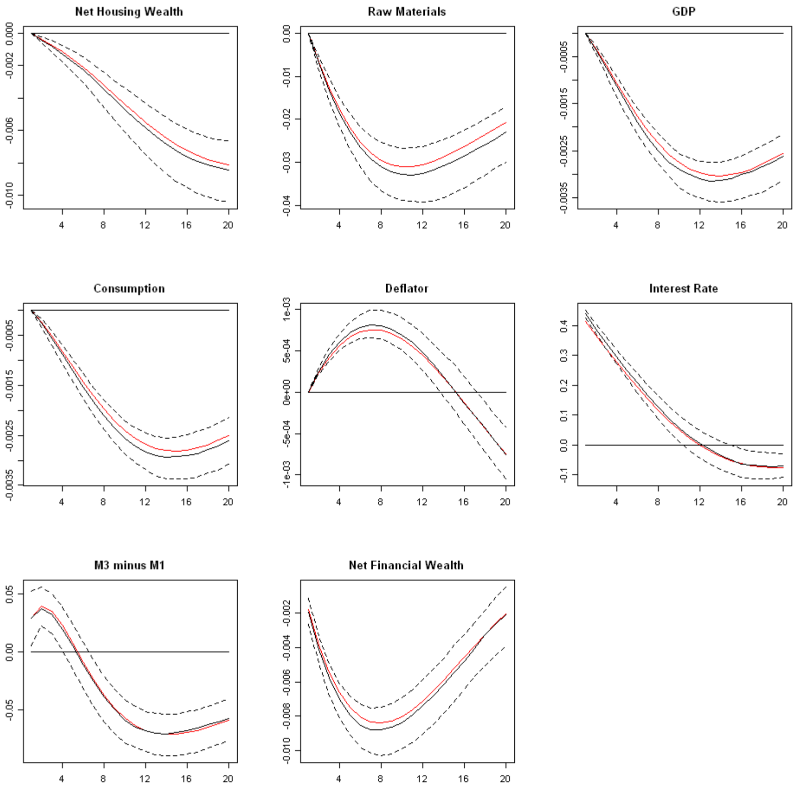

Figure 1: Impulse-response functions to a monetary policy contraction using Christiano et al. (2005) identification: inclusion of the growth rate of broad money, M_3 minus M_1.

The strategy for estimating the parameters of the model focuses on the portion of fluctuations in the data that is caused by a monetary policy shock. It is, therefore, natural to ask how large that component is. With this question in mind, Table 1 reports variance decompositions, and displays the percentage of variance of the k-step-ahead forecast error in the elements of X_t due to an interest rate shock, for $k = 1$, 4, 8 and 20. Notice that while policy shocks account for only a small fraction of inflation they are important determinants of the price of raw materials. On the other hand, monetary policy shocks are responsible for a substantial fraction of the variation GDP and consumption (about 30% of the variation 20 quarters ahead). A similar conclusion can be drawn with respect to wealth variables: monetary policy shocks explain about 11.5% of the variation in net housing wealth and 17.8% of the variation in net financial wealth 20 quarters ahead.

I repeat the same empirical exercise but replace the growth rate of broad money, M_3 minus M_1, by the growth rate of narrow money, M_1, in the set of variables of X_{2t}. The goal is to compare the reaction of liquid assets *versus* less liquid assets to the positive shock in the interest rate. Figure 2 plots the impulse-response functions of all the variables in the VAR. The solid line corresponds to the point estimate, the red line represents the median response, and the dashed lines are the 68% posterior confidence intervals estimated by using a Monte-Carlo Markov-Chain algorithm based on 10000 draws.

While quantitatively similar to the previous findings, the results suggest an important qualitative difference: the growth rate of M_1 falls immediately after the shock and only then starts recovering. This comes as the result of the agents' preference for assets that earn a higher rate of return which reverts as the monetary policy shock erodes.

Table 1: Percentage variance due to a monetary policy contraction.

	1 Quarter Ahead	4 Quarters Ahead	8 Quarters Ahead	20 Quarters Ahead
Net housing wealth	0.0 [0.0; 0.0]	0.5 [0.2; 0.8]	2.0 [1.0; 3.5]	11.5 [6.8; 17.1]
PPI for raw materials	0.0 [0.0; 0.0]	2.7 [1.8; 4.0]	9.9 [6.8; 13.7]	20.6 [14.8; 26.9]
GDP	0.0 [0.0; 0.0]	3.1 [2.0; 4.3]	15.3 [11.4; 19.3]	33.1 [27.3; 38.9]
Consumption	0.0 [0.0; 0.0]	1.9 [1.1; 2.9]	11.6 [8.4; 15.3]	31.2 [25.4; 37.2]
Deflator	0.0 [0.0; 0.0]	3.6 [2.5; 4.8]	8.4 [5.7; 11.3]	5.7 [4.1; 7.8]
Interest rate	83.4 [80.5; 86.6]	59.7 [55.1; 64.5]	37.3 [31.8; 42.2]	21.5 [17.5; 26.0]
M_3 minus M_1 growth	0.4 [0.2; 1.0]	1.0 [0.5; 1.7]	1.8 [1.2; 2.6]	6.5 [4.7; 9.1]
Net financial wealth	1.3 [0.6; 2.4]	8.6 [6.5; 11.4]	16.9 [13.1; 21.6]	17.8 [13.4; 22.9]

Note: Median and 68% confidence intervals computed using a Monte Carlo Markov-chain (MCMC) algorithm.

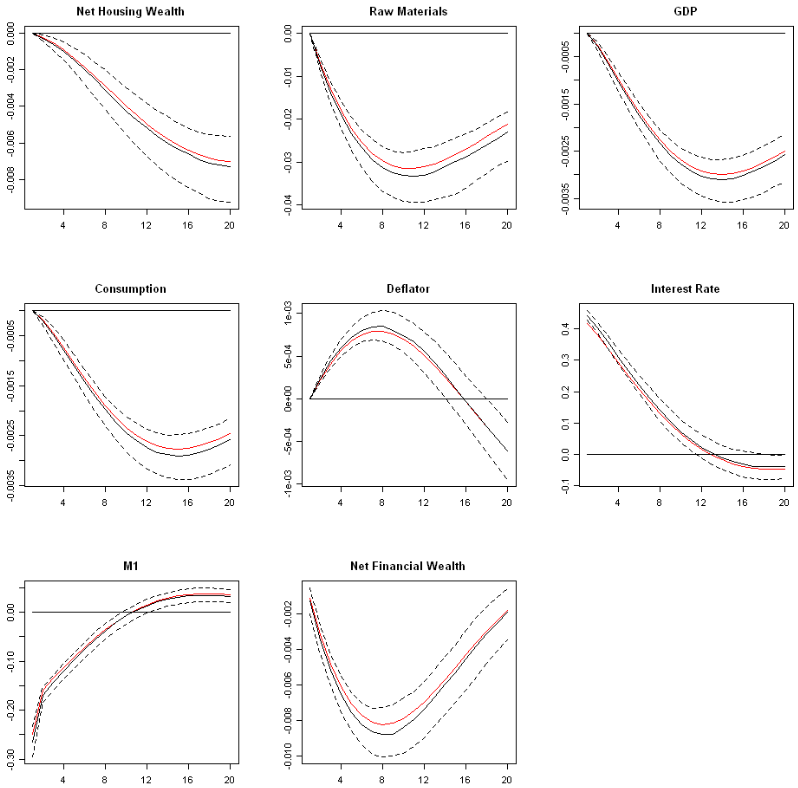

Figure 2: Impulse-response functions to a monetary policy contraction using Christiano et al. (2005) identification: inclusion of the growth rate of narrow money, M_1.

4.3 Fully Simultaneous Systems

I start by considering two fully simultaneous systems based on the identification procedure of Sims and Zha (2006a) and Leeper and Zha (2003).

4.3.1 Sims and Zha (2006a)

In this Sub-Section, I consider the effects of a monetary policy contraction using the Sims and Zha (2006a) identification scheme when broad money, M_3, is included in the model.

Figure 3 plots the impulse-response functions to a positive shock in the interest rate. The solid line corresponds to the point estimate, the red line represents the median response, and the dashed lines are the 68 percent posterior confidence intervals estimated by using a Monte-Carlo importance sampling algorithm based on 10000 draws.

The results show that after the shock, there is a significant decline in both M_3 and the price level. Output responds negatively with a lag of about 4 quarters, but the fall is not statistically significant. In contrast, unemployment significantly rises. In what concerns the response of the components of wealth considered in the model, the empirical evidence suggests that net financial wealth quickly shrinks after the shock and the trough - of around -1% - is achieved at after 8 quarters. On the other hand, net housing wealth also falls after the shock but the reaction is slower.

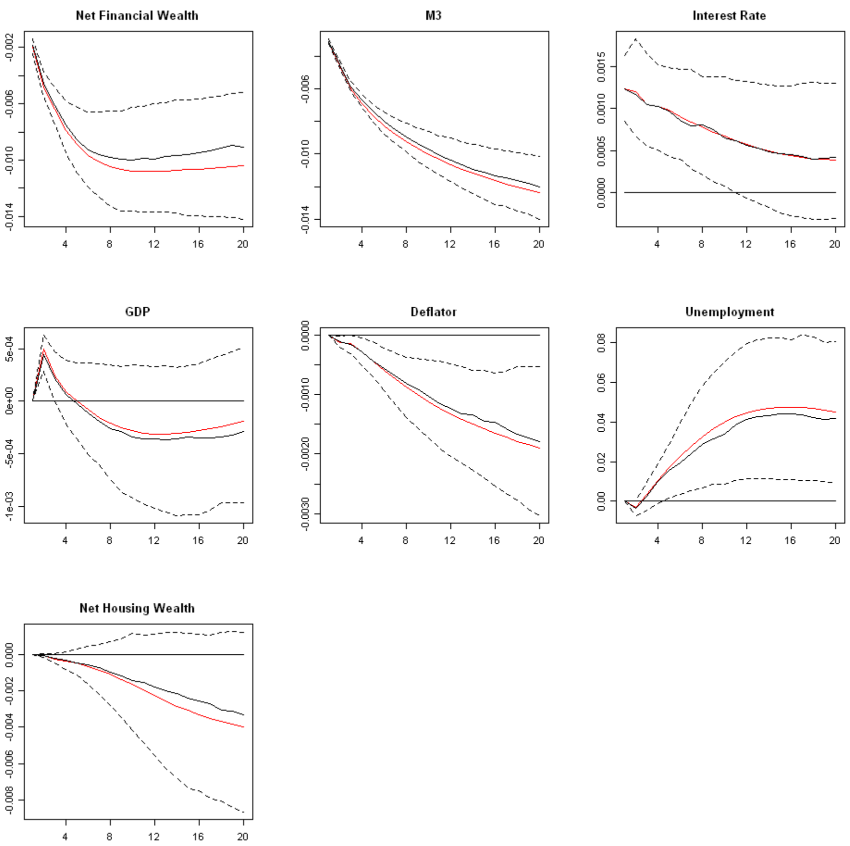

Figure 3: Impulse-response functions to a monetary policy contraction using Sims and Zha (1999, 2006a) identification.

I also report the estimated contemporaneous coefficients along with 68 percent equal-tailed probability intervals (which appear in brackets) for the two behavioral equations of interest. Those equations are money demand

$$\underset{[79.28;\ 152.57]}{118.72} M_{3t} + \underset{[276.99;\ 304.66]}{292.28} i_t \underset{[-72.96;\ -50.95]}{-61.18} Y_t \underset{[-57.16;\ 102.41]}{+79.73} P_t = \varepsilon_t^M,$$

and monetary policy

$$\underset{[-296.01,\ -262.24]}{-282.01} M_{3t} + \underset{[50.63;\ 122.99]}{87.50} i_t = \varepsilon_t^{mp}.$$

Money demand has reasonable economic interpretations: the interest elasticity of demand is negative; the output elasticity is positive; and, the price elasticity is imprecisely estimated. By its turn, monetary policy responds strongly to the money stock: disturbances that raise the broad money stock induce the monetary authority to increase the interest rate.

Table 2 reports variance decompositions, and displays the percentage of variance of the k-step-ahead forecast error in the elements of X_t due to an interest rate shock, for $k = 1$, 4, 8 and 20. Notice that while interest rate shocks account for only a small fraction of inflation, M_3 strongly reacts to them. Additionally, monetary policy shocks are responsible for a small fraction of the variation GDP and unemployment. A similar conclusion can be drawn with respect to wealth variables: shocks explain about 2.3% of the variation in net housing wealth and 8.3% of the variation in net financial wealth 20 quarters ahead.

Table 2: Percentage variance due to a monetary policy contraction.

Variable:	1 Quarter Ahead	4 Quarters Ahead	8 Quarters Ahead	20 Quarters Ahead
Financial wealth	1.7 [0.9;2.9]	5.7 [3.5;8.5]	7.0 [4.1;11.3]	8.3 [4.1;14.2]
M3	91.0 [81.5;96.6]	84.7 [75.6;89.8]	75.0 [66.5; 80.9]	54.3 [46.3; 61.0]
Interest rate	12.1 [5.0; 23.4]	6.1 [2.8; 12.9]	4.8 [2.4; 8.8]	4.2 [2.4; 7.0]
GDP	0.0 [0.0; 0.0]	0.7 [0.4; 1.2]	1.0 [0.6; 2.0]	2.2 [1.1; 4.3]
Deflator	0.0 [0.0; 0.0]	0.6 [0.2; 1.1]	1.4 [0.6; 2.8]	3.0 [1.4; 6.2]
Unemployment	0.0 [0.0; 0.0]	0.3 [0.2; 0.7]	1.0 [0.4; 2.1]	3.0 [1.2; 6.1]
Housing wealth	0.0 [0.0; 0.0]	0.3 [0.1; 0.6]	0.7 [0.3; 1.4]	2.3 [0.9; 4.7]

Note: Median and 68 percent confidence intervals computed using a Monte Carlo Importance Sampling algorithm.

4.3.2 Leeper and Zha (2003)

I next report the results based Leeper and Zha (2003), and consider the effects of a monetary policy contraction when broad money, M_3, is included in the model. Figure 4 plots the impulse-response functions to a positive shock in the interest rate. The solid line corresponds to the point estimate, the red line represents the median response, and the dashed lines are the 68 percent posterior confidence intervals estimated by using a Monte-Carlo importance sampling algorithm based on 10000 draws.

The empirical findings roughly replicate the ones from the Sims and Zha (2006a) identification. After a positive interest rate shock: (*i*) broad money and the price level significantly fall; (*ii*) GDP falls with a lag of 2 quarters while the unemployment rate significantly rises by about 0.9 percentage points. Regarding wealth components, the results suggest that while financial wealth quickly falls after the shock - the trough of -1.8% is achieved after 6 quarters -, housing wealth adjusts at a slower pace and remains at a persistently lower level even 20 quarters ahead.

The response of the interest rate to an exogenous policy contraction also shows that the initial liquidity effect lasts for about 6 quarters. However, after this period, the interest rate reverts and remains persistently at a lower level even 20 quarters ahead. This is the shape of the path of the short-term nominal interest rate following a monetary expansion that Friedman (1968) and Cagan (1972) describe as a short-lived liquidity effect followed by income and expected inflation effects. After five years the fall in inflation and the interest rate are roughly of the same size, as one might anticipate if expected inflation is the dominant source of fluctuations in nominal rates over long periods. Figure 3 shows, therefore, that to lower inflation persistently the monetary authority should raise the interest rate only briefly. Because lower inflation is ultimately associated with lower interest rate, the monetary authority must reduce the rate within about a year and an half, and then keep it lower.

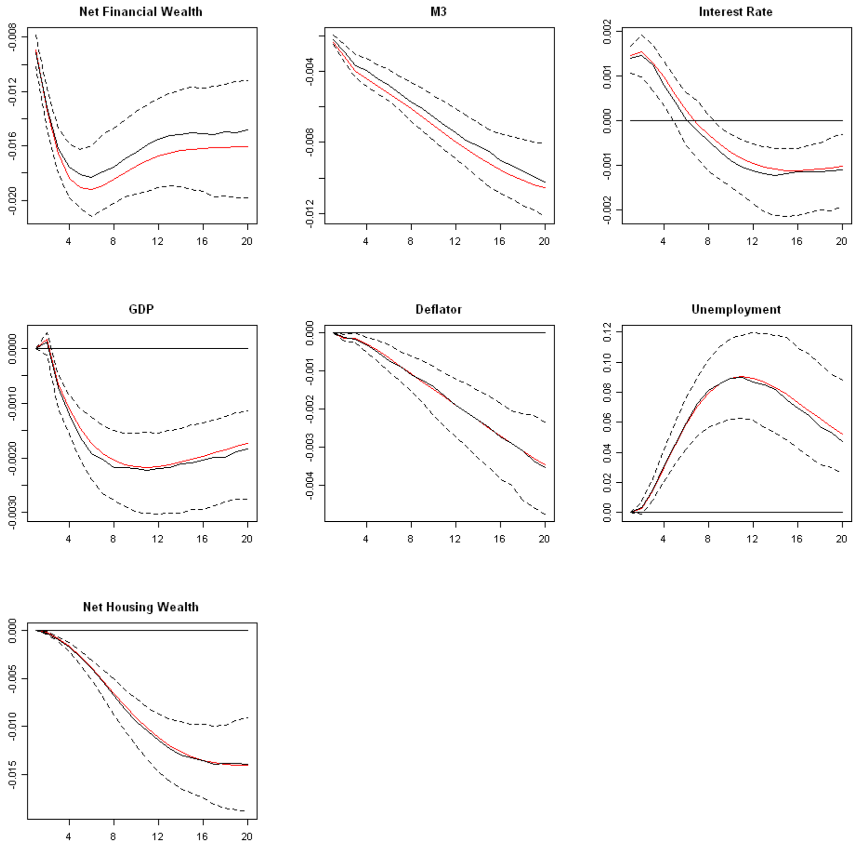

Figure 4: Impulse-response functions to a monetary policy contraction using Leeper and Zha (2003) identification.

Table 3 reports the median estimates of contemporaneous coefficient matrix. As can be seen from the "M Policy" column, the policy rule shows a much larger contemporaneous coefficient on M_3 than the interest rate, suggesting that the monetary authority pays a lot of attention to the developments in broad money. Moreover, the coefficient associated to financial wealth in the policy rule is positive, therefore, implying that monetary policy responds to financial wealth: disturbances that raise financial wealth induce the monetary authority to increase the interest rate.

Table 3: Contemporaneous coefficient matrix.

	Sector:						
Variable:	Financial	M Demand	M Policy	Prod Y	Prod P	Prod U	Housing
Financial wealth	62.78	0.00	-43.79	0.00	0.00	0.00	0.00
M3	-172.92	168.69	-190.16	0.00	0.00	0.00	0.00
Interest rate	96.85	273.30	99.83	0.00	0.00	0.00	0.00
GDP	-0.50	-57.78	0.00	258.27	8.64	151.96	-47.42
Deflator	172.33	81.52	0.00	0.00	464.64	-149.56	517.37
Unemployment	1.35	0.00	0.00	0.00	0.00	14.11	-0.49
Housing wealth	179.16	0.00	0.00	0.00	0.00	0.00	547.97

Note: Median estimates computed using a Monte Carlo Importance Sampling algorithm.

Table 4 displays the percentage of variance of the k-step-ahead forecast error due to an interest rate shock, for $k = 1$, 4, 8 and 20. Interest rate shocks account for a relatively small fraction of both GDP, inflation, and unemployment (respectively, 8.4%, 5.4% and 5,9% at 20 quarters ahead). The percentage of variance of the forecast error in M_3 that is due to an interest rate shock substantially falls relative to the previous specification (27.1% after 20 quarters, which compares with a mere 8.3% in Sims and Zha, 2006a). This reflects the fact that financial wealth is allowed to enter the monetary policy rule and, not surprisingly, the forecast error in financial wealth is now larger (30.3% at 20 quarters ahead). For housing wealth, the shocks explain about 8.8% of the variation after 20 quarters.

Table 4: Percentage variance due to a monetary policy contraction.

Variable:	1 Quarter Ahead	4 Quarters Ahead	8 Quarters Ahead	20 Quarters Ahead
Financial wealth	41.1 [29.3; 54.2]	45.0 [34.8; 57.8]	40.0 [31.1; 50.1]	30.3 [21.0; 40.8]
M3	46.2 [32.0; 60.6]	32.3 [20.0; 48.1]	26.4 [15.6; 41.3]	27.1 [17.9; 37.5]
Interest rate	13.5 [6.9; 22.3]	5.7 [2.5; 11.1]	4.5 [2.9; 6.7]	4.9 [3.2; 7.4]
GDP	0.0 [0.0; 0.0]	1.8 [0.9; 3.2]	5.5 [2.6; 8.7]	8.4 [4.1; 13.9]
Deflator	0.0 [0.0; 0.0]	0.5 [0.2; 1.1]	1.7 [0.7; 3.2]	5.4 [2.6; 9.1]
Unemployment	0.0 [0.0; 0.0]	0.8 [0.4; 1.6]	3.3 [1.7; 5.7]	5.9 [3.0; 9.6]
Housing wealth	0.0 [0.0; 0.0]	1.1 [0.5; 1.8]	3.5 [1.9; 5.6]	8.8 [4.6; 13.5]

Note: Median and 68 percent confidence intervals computed using a Monte Carlo Importance Sampling algorithm.

4.4 An "Almost" Fully Simultaneous System

Finally, and as a robustness check of the previous findings, I consider an "almost" fully simultaneous system where: (*i*) monetary policy decisions can have an indirect effect on housing wealth; and (*ii*) housing wealth shocks do not impact on the other variables of the system. I start by looking at the effects of a monetary policy contraction when broad money, M_3, is included in the model.

Figure 5 plots the impulse-response functions to a positive shock in the interest rate. The solid line corresponds to the point estimate, the red line represents the median response, and the dashed lines are the 68 percent posterior confidence intervals estimated by using a Monte-Carlo importance sampling algorithm based on 10000 draws.

The empirical results are qualitatively similar to the ones that emerge from the estimation of the fully simultaneous system based on the Sims and Zha (2006a) identification. After a positive interest rate shock: (*i*) broad money and the price level significantly fall; (*ii*) GDP falls with a lag of around 6 quarters (although not significantly), while the unemployment rate significantly rises after 4 to 8 quarters. Regarding wealth components, the results suggest that while financial wealth quickly falls after the shock - the trough of -0.5% is achieved after 8 quarters -, housing wealth and persistently falls over the following 20 quarters.

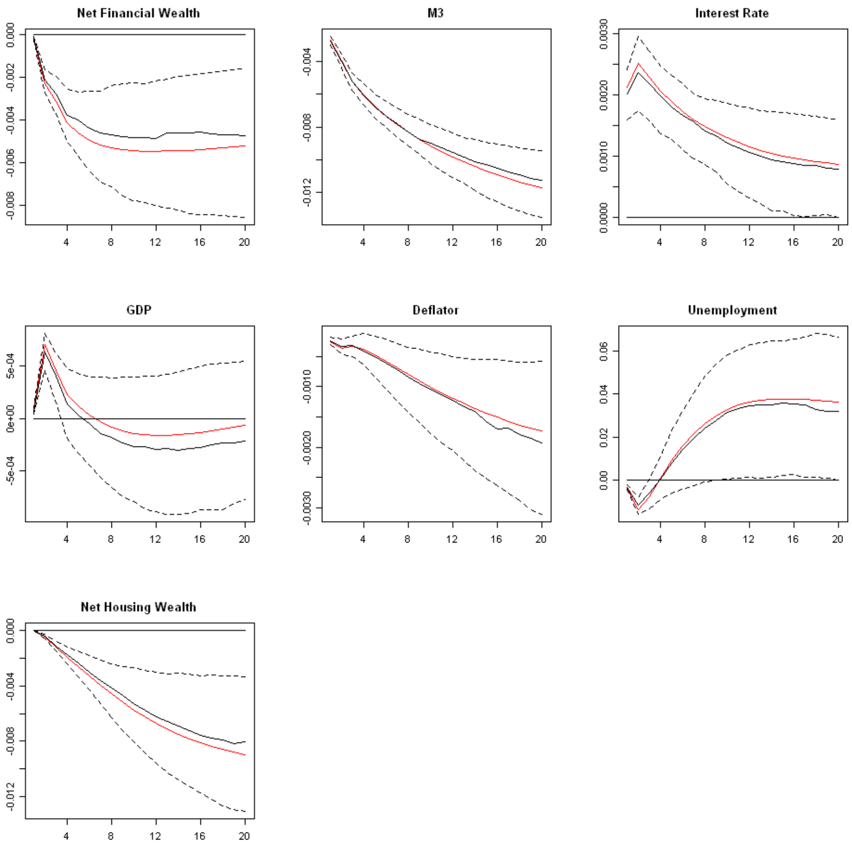

Figure 5: Impulse-response functions to a monetary policy contraction using an "almost" simultaneous system of equations.

Table 5 reports the median estimates of contemporaneous coefficient matrix. The "M Policy" column shows that the policy rule includes a larger contemporaneous coefficient on M_3 than the interest rate, suggesting that the monetary authority allocates a lot of attention to the developments in broad money. There is, however, weak evidence that the monetary policy responds to shocks in financial markets. By its turn, the "M Demand" column suggests that the interest elasticity and the output elasticity of money demand are, respectively, negative and positive.

Table 5: Contemporaneous coefficient matrix.

	Sector:						
Variable:	Financial	M Demand	M Policy	Prod Y	Prod P	Prod U	Housing
Financial wealth	-23.74	0.00	5.13	57.32	43.20	6.02	0.00
M3	50.29	184.75	-244.90	0.00	0.00	0.00	0.00
Interest rate	-31.19	260.28	159.48	0.00	0.00	0.00	0.00
GDP	58.07	-58.41	0.00	166.00	-192.99	153.94	0.00
Deflator	-707.62	81.18	0.00	0.00	-108.95	-160.23	0.00
Unemployment	-0.36	0.00	0.00	0.00	0.00	14.16	0.00
Housing wealth	-448.14	0.00	0.00	0.00	0.00	0.00	-362.66

Note: Median estimates computed using a Monte Carlo Importance Sampling algorithm.

Table 6 reports variance decompositions, and displays the percentage of variance of the k-step-ahead forecast error due to an interest rate shock, for $k = 1$, 4, 8 and 20. In accordance to the previous findings, monetary policy shocks account for a small fraction of GDP, inflation, and unemployment (respectively, 1.9%, 2.4% and 2.3% at 20 quarters ahead). In addition, they explain 3.3% and 4.0% of the variance of the forecast error in, respectively, financial wealth and housing wealth at 20 quarters ahead.

Table 6: Percentage variance due to a monetary policy contraction.

Variable:	1 Quarter Ahead	4 Quarters Ahead	8 Quarters Ahead	20 Quarters Ahead
Financial wealth	0.0 [0.0; 0.0]	1.6 [0.9; 2.7]	2.3 [1.1; 4.2]	3.3 [1.5; 6.7]
M3	67.3 [49.7; 82.5]	64.7 [47.6; 79.7]	57.8 [41.7; 71.5]	42.8 [31.7; 53.5]
Interest rate	38.7 [22.0; 56.6]	22.5 [11.1; 35.7]	14.2 [7.2; 22.4]	7.7 [4.6; 12.2]
GDP	0.0 [0.0; 0.1]	1.0 [0.6; 1.6]	1.1 [0.7; 1.9]	1.9 [0.9; 3.9]
Deflator	1.0 [0.5; 1.7]	1.0 [0.5; 1.8]	1.4 [0.6; 2.8]	2.4 [1.0; 5.2]
Unemployment	0.1 [0.0; 0.2]	0.5 [0.3; 0.8]	0.9 [0.4; 1.7]	2.3 [1.1; 4.6]
Housing wealth	0.0 [0.0; 0.0]	1.5 [0.7; 2.6]	2.2 [1.0; 4.0]	4.0 [1.7; 7.6]

Note: Median and 68 percent confidence intervals computed using a Monte Carlo Importance Sampling algorithm.

5 Wealth Effects from Monetary Policy

5.1 Financial Wealth

I now focus on the wealth effects of monetary policy. I start by analyzing the impact of interest rate shocks on different components of financial wealth and then drive the attention to the effects on different components of housing wealth. changes in the interest rate. The monetary policy shock is identified by imposing the recursive assumptions defined in (3) and I estimate the Bayesian Structural VAR (B-SVAR) represented by (1). To be more specific, the recursive assumptions can be summarized by $X_t = [X_{1t}', \ i_t, \ X_{2t}']'$, where $X_{1t} = [HW_t, PPI_t^{RM}, GDP_t, C_t, P_t]$ and $X_{2t} = [M_{3t} - M_{1t}, FW_t^i]$, where the HW_t and FW_t are, respectively, measures of housing and financial wealth, the superscript i represents a given component of financial wealth. Then, one component of financial wealth is chosen at time and the system is estimated, that is, the B-SVAR is reestimated each time a different component of financial wealth is included in the system.

I consider eleven different measures of financial wealth: (*i*) gross financial wealth; (*ii*) net financial wealth "2", that is, gross financial wealth minus financial liabilities (excluding mortgage loans); (*iii*) financial liabilities; (*iv*) "net" financial liabilities, that is, financial liabilities excluding mortgage loans; (*v*) net financial wealth "1", that is, gross financial wealth minus financial liabilities; (*vi*) currency and deposits; (*vii*) debt securities; (*viii*) shares and mutual fund shares; (*ix*) insurance reserves; (*x*) net others; and (*xi*) mortgage loans. I also consider stock prices in order to shed some light on the differences between the effects of monetary policy on quantity/stock and on prices.

Figure 6 plots the impulse-response functions of the different components of financial wealth to a shock in the interest rate. The solid line corresponds to the point estimate, the red line represents the median response, and the dashed lines are the 68% posterior confidence intervals estimated by using a Monte-Carlo Markov-Chain algorithm based on 10000 draws.

The results show that after the contractionary monetary policy most of the components of financial wealth sharply fall and only start recovering at after 8 to 12 quarters as the shock erodes. Additionally, while price effects are substantial (relative to stock/quantity effects), they also tend to be of shorter duration. In fact, the empirical evidence suggests that stock prices fall immediately after the shock - the trough (of about -2.0%) is reached at after 8 quarters - and then recover also quickly towards the initial level. A very similar pattern can be found for share and mutual fund shares. On the other hand, gross financial wealth and net financial wealth fall after the shock but they recover at a slower pace: the trough (of about -0.8%) is reached at after 8 quarters but these measures are still below their original levels even after 20 quarters. Interestingly, the impact on liabilities seems to be very persistent: both financial liabilities, mortgage loans and net financial liabilities (that is, financial liabilities excluding mortgage loans) fall after the shock - reaching a trough of around -0.3% to -0.4% - but remain at a lower level after 20 quarters. Finally, while debt securities increase after the shock (with a peak of about 1.2% reached at after 12 quarters), currency and deposits gradually fall as agents rebalance their portfolios towards assets that are less liquid but earn a higher return.

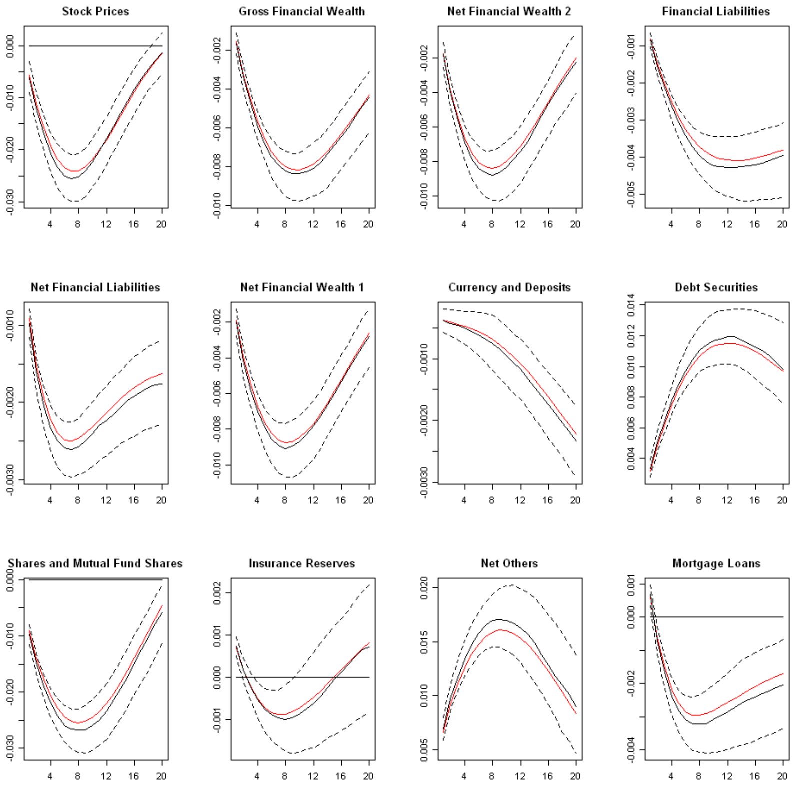

Figure 6: Impulse-response functions to a monetary policy contraction: comparison of the reaction of different components of financial wealth.

5.2 Housing Wealth

I now look at the effects of monetary policy on housing wealth. As before, the monetary policy shock is identified by imposing the recursive assumptions defined in (3), and summarized by $X_t = [X'_{1t},\ i_t,\ X'_{2t}]'$, where $X_{1t} = [HW_t^j, PPI_t^{RM}, GDP_t, C_t, P_t]$ and $X_{2t} = [M_{3t} - M_{1t}, NFW_t]$, where the superscript j represents a given component of housing wealth. That is, in practice, the B-SVAR is reestimated each time a different component of housing wealth is included in the system.

Figure 7 plots the impulse-response functions of the housing prices, gross housing wealth and net housing wealth (therefore, excluding mortgage loans) to a shock in the interest rate. The solid line corresponds to the point estimate, the red line represents the median response, and the dashed lines are the 68% posterior confidence intervals estimated by using a Monte-Carlo Markov-Chain algorithm based on 10000 draws.

The results show that after the contractionary monetary policy both housing prices and housing wealth fall. Nevertheless, while housing prices reach a trough (of about -0.4%) at after 12 to 16 quarters and then start recovering at a very slow pace, housing wealth keeps on falling even after 20 quarters. The empirical evidence, therefore, suggests two major differences between financial wealth and housing wealth effects generated by monetary policy:

(i) while the impact of monetary policy shocks on stock prices tend to be of short duration, the effects on housing prices are much more persistent; and (ii) financial wealth is fast in recovering towards its initial level, but housing wealth remains at a persistently lower level even 20 quarters after the shock.

While the price effects of monetary policy are in line with Julliard et al. (2007), the current work also looks at the quantity/stock effects by drawing on the impact of monetary policy on different wealth components. The empirical findings clearly show the importance of taking into account the different characteristics of wealth in assessing the effects on monetary policy: housing assets are much more illiquid that financial assets. As a result, housing wealth effects are much more persistent that financial wealth effects.

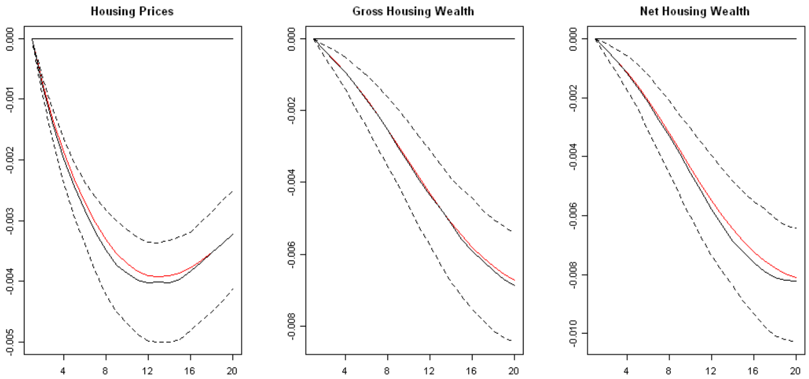

Figure 7: Impulse-response functions to a monetary policy contraction: comparison of the reaction of different components of housing wealth.

6 Country Level Evidence

As a final robustness check of the previous findings, I look at the country level effects of a monetary policy contraction. Specifically, I analyze the impact of a rise in the interest rate on country-level stock and housing prices. In practice, I estimate the B-SVAR defined in (1), that is, using Euro Area aggregates. However, the Euro Area measure for financial wealth (included in X_{2t}) is replaced by the stock price of a specific country, and the Euro Area measure for housing wealth (included in X_{1t}) is replaced by a country-level housing price. I repeat this procedure for each country and look at the impulse-response functions of stock and housing prices at the country level. This allows one to understand the magnitude of the spillover effects generated by a common shock in the monetary policy and disseminated among the different countries.

6.1 Stock Prices

Figure 8 plots the impulse-response functions of stock prices to a positive shock in the interest rate. The solid line corresponds to the point estimate, the red line represents the median response, and the dashed lines are the 68% posterior confidence intervals estimated by using a Monte-Carlo Markov-Chain algorithm based on 10000 draws.

The results are in line with the findings for the Euro Area: a monetary policy contraction has a negative impact on the stock price which reaches a trough at around after 4 to 8 quarters; then, stock markets quickly return to their original levels, that is, the impact tends to be of short duration. The effect of monetary policy is particularly important for France, Germany, Italy, Netherlands, and Spain - that is, the most important countries in terms of stock market capitalization - where the trough is normally associated with a fall of 3% to 5% in the stock price.

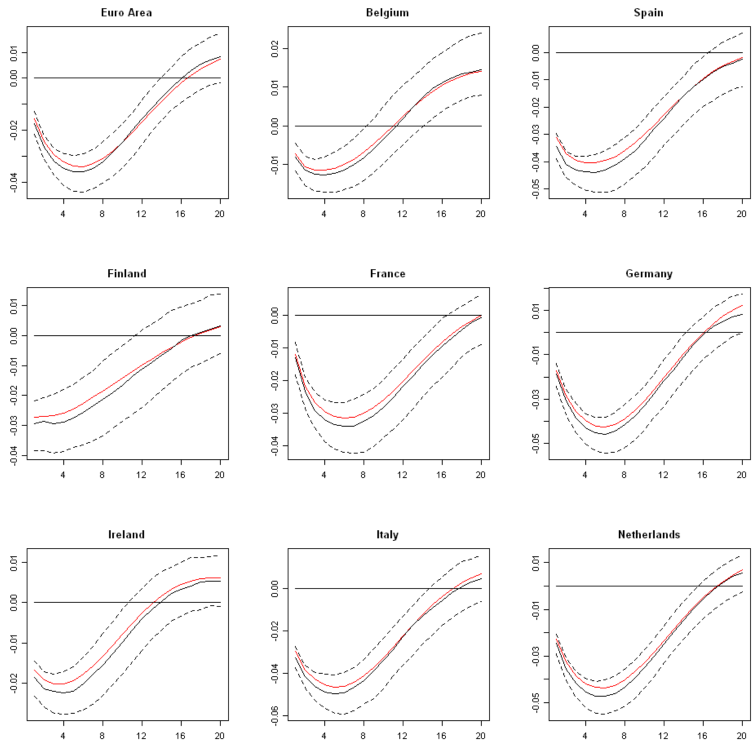

Figure 8: Impulse-response functions to a monetary policy contraction: comparison of the reaction of stock prices at the country level.

6.2 Housing Prices

Figure 9 plots the impulse-response functions of stock prices to a positive shock in the interest rate. The solid line corresponds to the point estimate, the red line represents the median response, and the dashed lines are the 68% posterior confidence intervals estimated by using a Monte-Carlo Markov-Chain algorithm based on 10000 draws.

As before, the results corroborate the findings for the Euro Area: an increase of the interest rate leads to a negative and very persistent impact on the housing price. Housing prices remain at a lower level even 20 quarters after the shock, and this pattern is particularly important for Belgium, France, Ireland, Italy, and Netherlands, where the trough is characterized by a fall of around 2%.

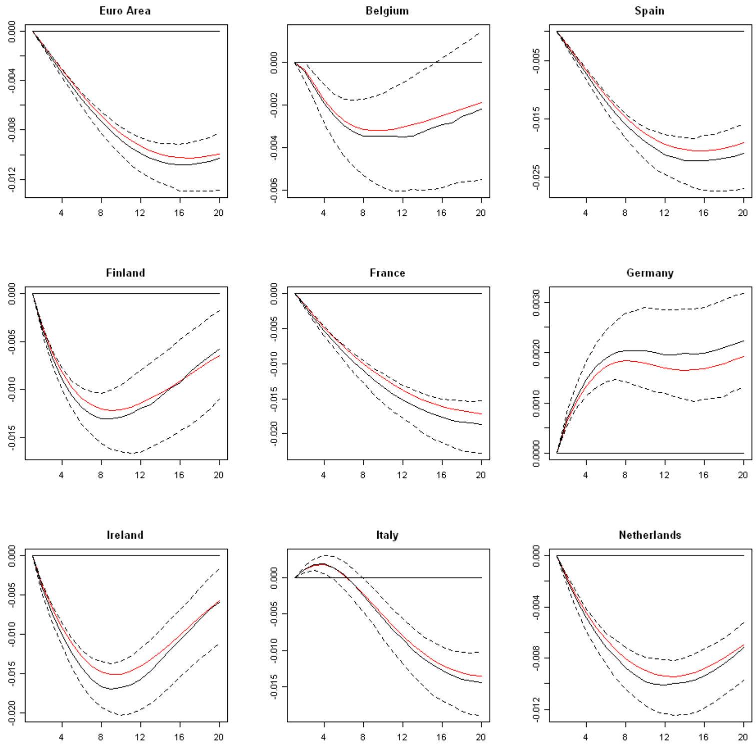

Figure 9: Impulse-response functions to a monetary policy contraction: comparison of the reaction of housing prices at the country level.

7 A VAR Counter-Factual Exercise

I now build a VAR counter-factual exercise aimed at describing the effects of shutting down the shocks in interest rate. In practice, after estimating the B-SVAR summarized by (2), I construct the counter-factual (CFT) series as follows:

$$\underbrace{\Gamma(L)}_{n\times n}\underbrace{X_t^{CFT}}_{n\times 1}=\Gamma_0 X_t^{CFT}+\Gamma_1 X_{t-1}^{CFT}+....=c+\varepsilon_t^{CFT} \tag{6}$$

$$v_t=\Gamma_0^{-1}\varepsilon_t^{CFT} \tag{7}$$

Since I am interested in analyzing the role played by monetary policy shocks, in particular, on understanding the impact on wealth stocks versus asset prices, this is equivalent to consider two vectors of structural shocks that come from the estimation of the corresponding B-SVARs:

$$\varepsilon_t^{CFT}=[\varepsilon_t^{NHW},\varepsilon_t^{PPI^{RM}},\varepsilon_t^{GDP},\varepsilon_t^{C},\varepsilon_t^{P},\varepsilon_t^{i},\varepsilon_t^{M_3-M_1},\varepsilon_t^{NFW}]'$$

$$\varepsilon_t^{CFT}=[\varepsilon_t^{HP},\varepsilon_t^{PPI^{RM}},\varepsilon_t^{GDP},\varepsilon_t^{C},\varepsilon_t^{P},\varepsilon_t^{i},\varepsilon_t^{M_3-M_1},\varepsilon_t^{SP}]'$$

$$\varepsilon_t^i = 0 \qquad \forall t.$$

Figure 10 plots the actual and the counter-factual series for the interest rate, net financial wealth and net housing wealth, stock prices and housing prices. The results suggest a considerable difference between the actual and the counter-factual series for the interest rate and, therefore, the importance of unexpected variation in monetary policy. Moreover, it can be seen that while there are significant effects on both stock prices and housing prices, the importance of monetary policy actions tends to be stronger for the measures of financial and housing wealth: for financial wealth, the actual and counter-factual series substantially depart from each other in the period 1985-2000; for housing wealth, the deviations are larger in the period 1990-2005. This evidence shows that monetary policy has important asset price and wealth effects.

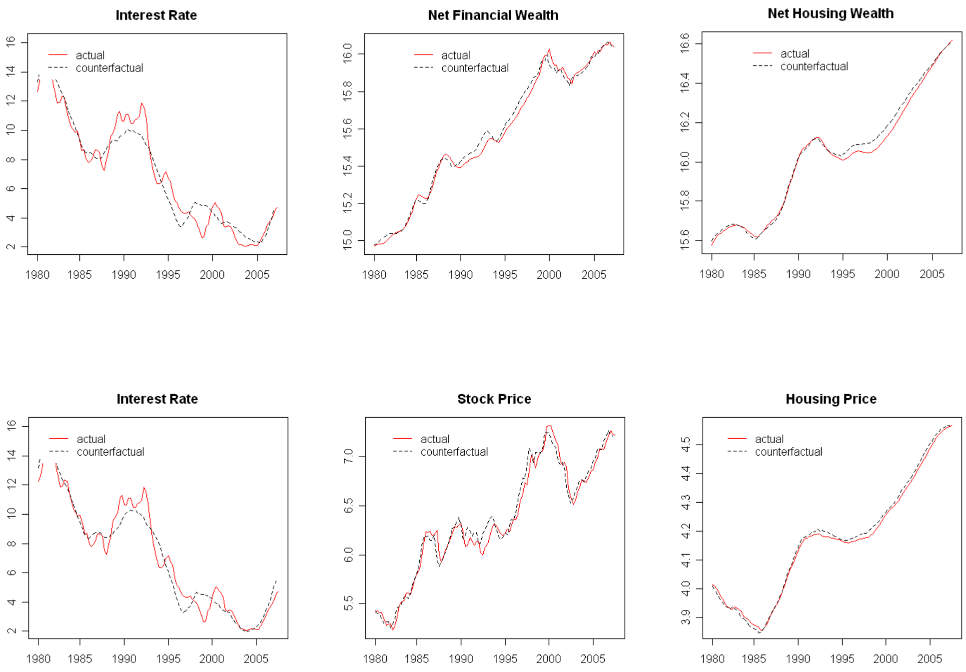

Figure 10: Actual and counter-factual series for the interest rate, net financial wealth, net housing wealth, stock prices and housing prices.

8 Conclusion

In this paper, I investigate the relationship between wealth and monetary policy in the Euro Area. I show that, after a monetary policy contraction, both financial and housing wealth substantially fall. Nevertheless, while the adjustment in financial wealth is relatively fast, housing wealth changes are very slowly. Moreover, the effects tend to be substantial both for stock prices and housing prices, but the first are of shorter duration

Additionally, I show that after a positive interest rate shock: (i) both GDP and consumption fall, while the unemployment rate rises; (ii) the price of raw materials substantially falls, but the aggregate price level only gradually falls; and (iii) there is a flight towards assets that are less liquid but also earn higher rates of return.

The response of the interest rate to an exogenous policy contraction reveals that the initial liquidity effect, in general, lasts for about 6 quarters. However, after this period, the interest rate persistently reaches a lower level where it remains even 20 quarters ahead. This suggests that to lower inflation persistently the monetary authority should raise the interest rate only briefly. Moreover, it shows that expected inflation is the dominant source of fluctuations in nominal rates over long periods.

The results from the estimation of the money demand function and the monetary policy rule for the Euro Area also lead to interesting conclusions. First, the interest elasticity of both broad and narrow money demands is relatively large while the output elasticity tends to be small in magnitude. Second, the monetary authority seems to pay a lot of attention to developments in broad money - and, to smaller extent, in narrow money - that is, the interest rate seems to play a secondary role in the monetary policy rule. This is in accordance with the findings of Julliard et al. (2007), who argue that the same focus on monetary aggregates can be found for the Bank of England while, on the contrary, the Fed emphasizes the role of the interest rate. Third, the monetary authority exhibits a vigilant behavior regarding the dynamics of financial markets despite not allocating a large weight to it in the policy rule.

Finally, I estimate the effects of monetary policy shocks on regional asset prices. The results are in line with the findings for the Euro Area and suggest that the effects of monetary policy contractions on stock prices are particularly important for countries with the largest stock market capitalization. On the other hand, an increase of the interest rate leads to a negative and very persistent impact on regional housing prices, which remain at a lower level even 20 quarters after the shock.

These findings can be useful when constructing models to better understand the aggregate implications of financial and housing market dynamics. Generating a highly persistent response of house prices and a quick answer of stock prices to monetary policy may prove to be a challenge in quantitative models of housing and stock market fluctuations.

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Appendix

A The Posterior Distribution of the Impulse-Response Function

The impulse-response function to a one standard-deviation shock is:

$$B(L)^{-1}\Gamma_0^{-1}. \tag{A.1}$$

To assess uncertainty regarding the impulse-response functions, I follow Sims and Zha (1999) and construct confidence bands by drawing from the Normal-Inverse-Wishart posterior distribution of $B(L)$ and Σ

$$\begin{aligned} \beta|_{\Sigma} &\sim N\left(\hat{\beta}, \Sigma \otimes \left(X'X\right)^{-1}\right) \\ \Sigma^{-1} &\sim \text{Wishart}\left(\left(T\hat{\Sigma}\right)^{-1}, T-m\right) \end{aligned} \tag{A.2}$$

where β is the vector of regression coefficients in the VAR system, Σ is the covariance matrix of the residuals, the variables with a hat denote the corresponding maximum-likelihood estimates, X is the matrix of regressors, T is the sample size and m is the number of estimated parameters per equation (see Zellner, 1971; Schervish, 1995; and Bauwens et al., 1999).[9] Note that the use of this Bayesian approach allows us to draw inference that is robust to the presence of non-stationary behavior in the variables, since the posterior will have an asymptotically Gaussian shape even in the presence of unit roots (Kim, 1994).

B A Mixed Monte Carlo Importance Sampling Algorithm for Drawing from the Posterior Distribution of the Impulse-Response Function

To be able to identify the structural monetary shocks, one needs at least $(n-1)\,n/2$ linearly independent restrictions. With enough restrictions in the Γ_0 matrix and no restrictions in the matrix of coefficients on the lagged variables, the estimation of the model is numerically simple since the log-likelihood will be

$$\begin{aligned} l(B, a, \Gamma_0) &= -\frac{T}{2} + \log|\Gamma_0| - \frac{1}{2} trace\left[S(B,a)\,\Gamma_0'\Gamma_0\right] \\ \text{where } S(B,a) &= \sum_{t=1}^{T} \left(B(L)\,X_t - a\right)\left(B(L)\,X_t - a\right)' \end{aligned} \tag{B.1}$$

and the maximum-likelihood estimator of B and a can be found simply doing OLS equation-by-equation regardless of the value of Γ_0. Integrating $l(B, a, \Gamma_0)$ (or the posterior with conjugate priors) with respect to (B, a) the marginal log probability density function of Γ_0 is

[9] This result is exact under normality and the Jeffreys' prior $f(\beta, \Sigma) \propto |\Sigma|^{-(p+1)/2}$ (where p is the number of right hand side variables), but can also be obtained, under mild regularity conditions, as an asymptotic approximation around the posterior MLE. The Jeffreys' prior formulates the idea of "lack of prejudice" on the space of distribution for the data, and is also flat over the space of the βs and remains flat under reparameterization.

proportional to

$$-\frac{T-k}{2}\log(2\pi)+(T-k)\log|\Gamma_0|-\frac{1}{2}trace\left[S\left(\hat{B}_{OLS},\hat{a}_{OLS}\right)\Gamma_0'\Gamma_0\right]. \tag{B.2}$$

In the S-VAR setting considered, the impulse-response functions are given by

$$B(L)^{-1}\Gamma_0^{-1}. \tag{B.3}$$

This implies that to assess posterior uncertainty regarding the impulse-response function one needs joint draws for both $B(L)$ and Γ_0.[10]

Since equation (B.2) is not in the form of any standard probability density function one can not draw directly from Γ_0 to make inference. Nevertheless, if one takes a second order expansion of equation (B.2) around its peak one gets the usual Gaussian approximation to the asymptotic distribution of the elements in Γ_0. Since this is not the true form of the posterior probability density function, one can not use it directly to produce a Monte Carlo sample. A possible approach is importance sampling, in which one draws from the Gaussian approximation, but weigh the draws by the ratio of (B.2) to the probability density function from which one draws. The weighted sample cumulative density function then approximates the cumulative density function corresponding to (B.2).

Note also that the distribution of $B(L)$, given Γ_0, is the usual normal distribution

$$vec(B(L))|\Gamma_0 \sim N\left(vec\left(\hat{B}_{OLS}\right),\Gamma_0^{-1}\left(\Gamma_0^{-1}\right)'\otimes\left(X'X\right)^{-1}\right). \tag{B.4}$$

So one can take joint draws using the following simple algorithm: (*i*) draw Γ_0 using (B.2); and (*ii*) draw $vec(B(L))$ using equation (B.4). Confidence bands for the impulse-response function are then constructed from the weighted percentiles of the Monte Carlo sample where the weights are computed by importance sampling.

Denote with $\hat{H}$ the numerical Hessian from the *minimization* routine at the point estimate and $\hat{\Gamma}_0$ the maximum-likelihood estimator. The algorithm used to draw the confidence bands from the posterior distribution is the following:

1. Check that all the coefficients on the main diagonal of $\hat{\Gamma}_0$ are positive. If they are not, flip the sign of the rows that have a negative coefficient on the main diagonal [that is, our point estimates are normalized to have positive elements on the main diagonal).

2. Set $i=0$.

3. Drawn $vech\left(\tilde{\Gamma}_0\right)$ from a normal $N\left(vech\left(\hat{\Gamma}_0\right),\hat{V}\right)$, where $\hat{V}=\hat{H}^{-1}$ and $vech(.)$ vectorizes the unconstrained elements of a matrix. That is, this step draws from the asymptotic distribution of Γ_0. There are 3 possible options to handle draws in which some of the diagonal elements of $\tilde{\Gamma}_0$ are not positive:

[10] If we take the classical approach instead and maximize $l(B,a,\Gamma_0)$ for $(B(L),a)$ holding Γ_0 fixed, we have the same expression with T rather than $T-k$ multiplying the first terms. I follow the common approach of using $|\Gamma_0|^k$ as an improper prior, so that the concentrated likelihood and the marginal posterior coincide. The last expression can be maximized with respect to Γ_0 to obtain the maximum-likelihood estimator, and a consistent estimate of the asymptotic variance of these parameters can be constructed from the Hessian evaluated at the estimated parameter values.

(a) if some of the diagonal entries of $\tilde{\Gamma}_0$ are not positive, reject the draw and go back to 2. to take another draw (this is what is also done in the Sims and Zha (2006a) and I follow this approach).

(b) reject the draw if and only if one of the negative entries on the main diagonal is more than "alpha" standard deviations away from the maximum-likelihood estimator.

(c) accept the draw and continue.

4. Compute and store the importance sampling weight

$$m_i = \exp\left[\begin{array}{c} T\log\left|\det\left(\tilde{\Gamma}_0\right)\right| - \frac{1}{2}trace\left(S\left(\hat{B}_{OLS}, \hat{a}_{OLS}\right)\tilde{\Gamma}_0'\tilde{\Gamma}_0\right) \\ -\log\left|\hat{V}\right|^{-\frac{1}{2}} + .5\left(vech\left(\tilde{\Gamma}_0\right) - vech\left(\hat{\Gamma}_0\right)\right)'\hat{V}^{-1}\left(vech\left(\tilde{\Gamma}_0\right) - vech\left(\hat{\Gamma}_0\right)\right) \\ -SCFT \end{array}\right] \tag{B.5}$$

where $SCFT$ is a scale factor that prevents overflow/underflow [a good choice for it is normally the value of the likelihood at its peak).[11]

5. Draw $vec\left(\tilde{B}(L)\right)$ from a normal $N\left(vec\left(\hat{B}_{OLS}\right), \tilde{\Gamma}_0^{-1}\left(\tilde{\Gamma}_0^{-1}\right)' \otimes (X'X)^{-1}\right)$ to get a draw for $\tilde{B}(L)$.

6. Compute the impulse-response function and store it in a multidimensional array.

7. If $i < \#draws$, set $i = i + 1$ and go back to 3.

The stored draws of the impulse-response function, jointly with the importance sampling weights, are used to construct confidence bands from their percentiles. Moreover, the draws of $\tilde{\Gamma}_0$ are stored to construct posterior confidence interval for these parameters from the posterior (weighted) quantiles.

Normalized weights that sum up to 1 are simply constructed as:

$$w_i = \frac{m_i}{\sum_i^{\#draws} m_i}. \tag{B.6}$$

When the number of draws is sufficiently large for the procedure outlined above to deliver accurate inference, the plot of the normalized weights should ideally show that none of them is too far from zero – that is, one single draw should not receive 90% of the weight.[12]

[11] Confidence bands constructed using unweighted quantiles are asymptotically justified (due to the asymptotic Gaussianity), and are good to give a quick look at the shape of the impulse-response function using a small number of draws. The unweighted approach should be used with caution since: (i) it is likely to produce unrealistically tight bands in the presence of multiple local maxima; and (ii) will not capture asymmetries of the confidence bands (that are important in detecting whether an impulse-response function is significantly different from zero).

[12] When the importance sampling performs too poorly (due to the variability in the weights), we can replace that part of the algorithm with the random walk Metropolis Markov-Chain Monte Carlo of Waggoner and Zha (1997), using also their approach to handle switch in the sign of the rows of Γ_0 (that is, use a normalization for each draw that minimizes the distance of Γ_0 from the maximum likelihood estimate).

C Detailed Data Description

Euro Area aggregates are calculated as weighted average of euro-11 before 1999 and, thereafter, as break-corrected series covering the real-time composition of the Euro Area.

GDP

Seasonally adjusted nominal GDP ('stocks') at market prices. From 1999 Q1 onwards, this series covers nominal GDP of the real-time composition of the euro area, correcting for the breaks caused by the several enlargements, i.e. currently the observations from 2007:4 backwards are extrapolations based on growth rates calculated from the levels series compiled for the euro area 15 in 2008. For period before 1999, the nominal GDP series for the euro area is constructed by aggregating national GDP data for euro 11 using the irrevocable fixed exchange rates of 31 December 1998 for the period 1980:1-1998:4. Again, growth rates from this series are used to backward extend the euro area GDP series.

The Euro Area seasonally adjusted real GDP series (at 2000 constant prices) has been constructed before 1999 by aggregating national real GDP data using the irrevocable fixed exchange rates. As for the Euro Area nominal GDP, an artificial Euro Area real GDP series has also been constructed using the procedure illustrated above. Data are quarterly, seasonally adjusted, expressed in million of Euro, and comprise the period 1980:1-2007:4.

Consumption

Total final private consumption. Data are quarterly, seasonally adjusted, expressed in million of Euro, and comprise the period 1980:1-2007:4. The construction principle is similar to that described for GDP.

Deflator

All variables are expressed in real terms by using the GDP deflator. The GDP deflator is calculated as a simple ratio between nominal and real GDP. The year base is 2000 (2000 = 100). Data are quarterly, seasonally adjusted, and comprise the period 1980:1-2007:4.

Short-Term Interest Rate

For short-term interest rates from January 1999 onwards, the Euro Area three-month Euribor is used. Before 1999, the artificial Euro Area nominal interest rates used are estimated as weighted averages of national interest rates calculated with fixed weights based on 1999 GDP at PPP exchange rates. National short-term rates are three-month market rates. Data are quarterly averages, and comprise the period 1980:1-2007:4.

Long-Term Interest Rate

From 1999 onwards, long-term interest rates correspond to the ten-year government bond yields. Before 1999, data are estimated using the closest available maturity calculated with fixed weights based on 1999 GDP at PPP exchange rates. Data are quarterly, and comprise the period 1980:1-2007:4.

M_3

All the data used are denominated in euro. The seasonally adjusted M_3 series for the Euro Area has been constructed using the index of adjusted stocks for the corresponding real time composition of the currency area. This index corrects for breaks due to enlargement, but as well for reclassifications, exchange rate revaluations and other revaluations. In order to translate the index into outstanding amounts, the M_3 seasonally adjusted index of adjusted stocks for the Euro Area has been re-based to be equal to the value of the seasonally adjusted stock for the Euro Area M_3 in January 2008. Before 1999, stocks and flows of the estimated "euro area M3" are derived by by aggregating national stocks and flows at irrevocable fixed exchange rates. Data are seasonally adjusted quarterly averages covering the period 1980:2 to 2007:4.

M_1

"Adjusted stock" (millions of euro). The seasonally adjusted index of adjusted stocks for M_1 is derived as described above for M_3. Data are quarterly averages, seasonally adjusted, and comprise the period 1980:2-2007:4.

PPI of Raw Materials

World market prices of raw materials. Total index. USD basis, converted into euro. Weighted according to commodity imports of OECD countries, 1989-1991, excluding EU-internal trade. Share in total index: 100%. Data are quarterly, seasonally adjusted, and comprise the period 1980:1-2007:4.

Financial Wealth

Net financial wealth is the difference between financial assets (currency and deposits, debt securities, shares and mutual fund shares, insurance reserves, net others) and financial liabilities (excluding mortgage loans) held by households and non-profit institutions serving households. Original series are provided at quarterly frequency from the Euro area quarterly sectoral accounts for the period 1999:1-2007:4 and at annual frequency from the monetary union financial accounts for the period 1995-1998 and from national sources for the period 1980-1994. Quarterly data before 1999 are back-casted and interpolated using quadratic smoothing and corrected for breaks. Data are quarterly, seasonally adjusted, expressed in million of Euro, and comprise the period 1980:1-2007:4.

Housing Wealth

Net housing wealth is the difference between gross housing wealth and mortgage loans held by households and non-profit institutions serving households. Original series are provided at annual frequency and quarterly data are back-casted and interpolated using quadratic smoothing. Housing wealth data are at current replacement costs net of capital depreciation based on ECB estimates. Data are quarterly, seasonally adjusted, expressed in million of Euro, and comprise the period 1980:1-2007:4.

Loans

Total loans to the private sector, including household loans, loans to non-financial corporations and loans to financial institutions other than MFIs. The principles of data construction match those described for M3 above. Data are quarterly averages, seasonally adjusted, expressed in million of Euro, and comprise the period 1980:2-2007:4.

Stock Price

The source is the International Financial Statistics (IFS) of the International Monetary Fund (IMF).

- For Belgium: series "12462...ZF Share price index (Share prices: INDUSTRIAL)";

- For Denmark: series "12862A..ZF Share prices: Industrial";
- For Finland: series "17262...ZF Share price index (Share prices: Industrial)";
- For France: series "13262...ZF Share price index (Share prices)";
- For Germany: series "13462...ZF Share price index (Share prices)";
- For Ireland: series "17862...ZF Share price index (Share prices)";
- For Italy: series "13662...ZF Share price index (Share prices)";
- For Netherlands: series "13862...ZF Share price index (Share prices:General)";
- For Norway: series "14262...ZF Share price index (Share prices: Industrial (2000=100))";
- For Spain: series "18462...ZF Share price index (Share prices)"; and
- For Sweden: series "14462...ZF Share price index (Share prices)".

Housing Price
The data on country-level housing prices comes from different sources.

- For Belgium: Price index of existing and new dwellings; Quarterly data 1980:1-2006:4 (Source BIS); Annual data 1970-1979 (Source: BIS) interpolated based on the Chow-Lin procedure using a construction cost index (Source: BIS) as reference series.
- For Denmark: Price index of new and existing houses, Good & poor condition; Quarterly data 1971:1-2006:4 (Source: ECB).
- For Finland: Price index of new and existing dwellings; Quarterly data 1978:1-2006:4 (Source: BIS); Annual data 1970-1977 (Source: BIS) interpolated based on the Chow-Lin procedure using the rent CPI (Source: OECD MEI) as reference series.
- For France: Price index for existing dwellings; Quarterly data 1996:1-2006:4 (Source: ECB); Price index for existing homes; Annual data 1970-1995 (Source: BIS) interpolated based on the Chow-Lin procedure using for 1980:2-1995:4 a price index for existing flats in Paris (Source: ECB) and for 1970:1- 1980:1 a cost index for new residential construction (source: BIS) and the rent CPI (Source: OECD MEI) as reference series.
- For Germany: Prices of good quality existing dwellings in 125 cities (in 4 capital cities prior to 1975); Annual data 1970-2006 (Source: BIS) interpolated based on the Chow-Lin procedure using a building cost index (Source: BIS) and the rent CPI (Source: OECD MEI) as reference series..
- For Ireland: Second hand house prices (from 1978) and new house prices (prior to 1978); Quarterly data 1975:1-2006:4 (Source: Irish Department of the Environment); New house prices; Annual data 1970-1974 (Source: ECB) interpolated based on the Chow-Lin procedure using the rent CPI (Source: OECD MEI) as reference series.

- For Italy: Price index new and existing dwellings; Semi-annual data (Source: ECB) interpolated based on the Chow-Lin procedure using a construction cost index (Source: BIS) and the rent CPI (Source: OECD MEI) as reference series.
- For Netherlands: Price index for one-family houses and existing flats; Quarterly data 1970:1-2006:4 (Source: BIS).
- For Norway: Registered purchase price of all dwellings; Quarterly data 1970:1-2006:4 (Source: BIS)
- For Spain: Price index of new and existing dwellings; Quarterly data 1987:1-2006:4 (Source: BIS); Madrid house prices; Annual data 1971-1986 (Source: BIS) interpolated based on the Chow-Lin procedure using a construction cost index (Source: OECD MEI) and the rent CPI (Source: OECD MEI) as reference series.
- For Sweden: Price Index of owner occupied new and existing dwellings; Quarterly data 1970:1-2006:4 (Source: BIS).