Has the monetary transmission process in the euro area changed? Evidence based on VAR estimates

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Abstract

Empirical evidence on whether the euro area monetary transmission process has changed is, at best, mixed. We argue that this inconclusiveness is likely to be due to the fact that existing empirical studies concentrate on the effects of a *particular* development on a *specific* transmission channel. Another problem of this literature is that specific changes could have off-setting effects regarding the *overall* effectiveness of monetary policy, leaving open the question whether the ability of monetary policy to control inflation has been altered. In order to shed light on this issue, we investigate whether there has been a significant change in the overall transmission of monetary policy to inflation and output by estimating a standard VAR for the euro area and by searching for a possible break date. We find a significant break point around 1996 and some evidence for a second one around 1999. We compare impulse responses to a monetary policy shock for these episodes and find that the well-known "stylized facts" of monetary policy transmission remain valid. Therefore, we argue that the general guiding principles of the Eurosystem monetary policy remain adequate. Moreover, it seems that monetary transmission after 1998 is not very different from before 1996, but probably very different in the interim period. This implies that evidence for the euro area could be biased by an "atypical" interim period 1996-1999.

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1 Introduction

The hypothesis that key economic structures could have undergone significant changes in recent years is currently being discussed intensively among academics and policymakers. Examples are the ongoing debates on the stability of money demand, on the sometimes suspected breakdown of the money-inflation nexus in several countries or on the usefulness of the Phillips curve. All of these developments could have implications for monetary transmission. Of course, this is a key issue from a monetary policy perspective because changes in the transmission process could have serious consequences, such as for the assessment as to whether effects from previous policy actions are still "in the pipeline", for the set of indicators to be used in order to assess the stance of monetary policy and even for the overall orientation of monetary policy.

In the current literature, typically three main developments are listed as potential causes for such changes: the swift financial development, the increased globalisation, and – specifically in the case of the euro area – the creation of the European Monetary Union (EMU):

(a) The decision to create EMU as well as the integration processes before and after the event might have considerably changed the structure of the euro area economy and therefore the monetary transmission process. One obvious example for this is the exchange rate channel, which could have been weakened simply by the fact that nominal exchange rates vis-à-vis the euro are fixed within EMU, and vary only little in case of the ERM II countries. Another example is that EMU has fostered integration among different euro area economies, leading to more competitive markets and improved area-wide price transparency. And a third one is the introduction of a uniform monetary policy with a clear medium-term price stability objective which may inter alia have altered the way inflation expectations are formed.

(b) But also outside EMU, the recent decade has seen tremendous financial development which inter alia led to many new financial products,[1] to more competition, to intensified securitization and disintermediation, and to a consolidation process in the banking sector. These developments widened the range of activities of financial market participants and changed their behaviour – and thereby possibly also their reaction to monetary policy (Visco, 2007). For instance, changes in short-term interest rates could be more quickly transmitted to other segments of the financial system, especially to long-term interest rates, bank rates and asset prices, because financial markets are more liquid and complete now.

(c) Even more generally, globalisation – by strengthening cross-border linkages – may have changed the relationships between key domestic macroeconomic variables worldwide.[2] For instance, increased international trade is often assumed to have reduced the dependency of domestic inflation on domestic output, possibly lowering the effectiveness of monetary transmission channels which work through the domestic output gap.[3] Another example is that globalisation of financial markets has led to closer international linkages in the financial sphere which could have reduced the power of domestic monetary policy in influencing key domestic financial variables, such as long-term interest rates or asset prices.

Whether monetary transmission has been altered by these factors and – if so – to which extent and in which direction cannot be answered on a theoretical basis but has to be addressed empirically. In the following section, we therefore start with an extensive summary of the recent empirical literature on this issue. Unfortunately, it turns out that this leaves us with a broad range of different, partly contradicting results. In section 3 we argue that the inconclusiveness of the results may be due to the fact that these studies focus either on specific transmission channels and/or on single causing factors. The empirical identification of a change in a particular transmission channel caused by a specific factor is very demanding since it requires both, the empirical identification of the transmission channel of interest and the empirical isolation of the driving factor from other potential influences. Moreover, concentrating too much on specific channels and single causes does not allow conclusions about the development of the *overall* effectiveness of monetary policy. This aspect is even more important if one considers that globalisation, financial development and the creation of EMU are likely to interact, so that they could in

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1 See, e.g. Blundell-Wignall (2007).

2 See also the recent literature on the “great moderation”, e.g. Galí and Gambetti (2007) and Giannone, Lenza and Reichlin (2008).

3 See also Boivin and Giannoni (2008): “…global forces might have contributed to reducing some of the persistence in the responses, two or more years after the shocks”.

principle reinforce or weaken each other with regard to the overall effect on monetary transmission.

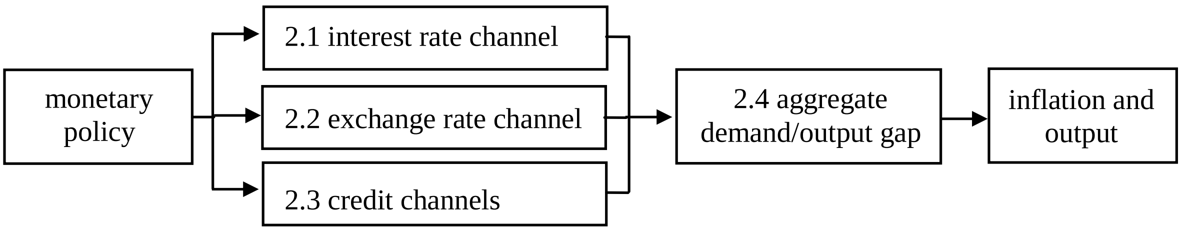
We therefore take a different route by (a) identifying potential break dates in monetary transmission in the euro area independent of specific causes, and (b) checking whether or not monetary transmission to output and inflation *as a whole* has changed. To do so, we estimate a standard VAR for the euro area and check whether there have been notable changes in the general way monetary policy shocks affect output and inflation. More specifically, instead of assuming a specific break date, we first apply a data-driven (agnostic) search for such a date. We find a significant break point around 1996 and evidence for a second one around 1999. Then, we compare the impulse responses (IRFs) to a monetary policy shock for the resulting sub-periods and find that monetary transmission looks significantly differently in the middle period 1996-1998, while we do not find significant differences in the IRFs to a monetary policy shock between the period before 1996 and the period after 1998. We interpret this as evidence in favour of an "atypical interim period" which biases the results of respective empirical work if not accounted for properly.

All in all, while we document breaks in monetary transmission (which, at first sight, would tend to make monetary policy more difficult and uncertain) our result of no significant difference between the transmission process before 1996 and after 1998 is generally reassuring. It implies that the monetary transmission process in the euro area is not really different from what we have observed, say, in the 1980s and early 1990s. We summarise the results and draw some conclusions in Section 4.

2 Existing empirical literature

Somewhat surprisingly, the recent empirical literature has not paid much attention to whether or not monetary transmission to output and inflation *in its entirety* has changed at all and, if so, in which direction. Rather, the existing literature focuses on the issue whether specific factors or developments (such as financial innovation) have changed a specific transmission channel (such as the bank lending channel).In order to differentiate among the various avenues through which the aforementioned forces might have transformed the monetary transmission process, it is therefore helpful to decompose it in a very stylized textbook-like manner. Figure 1 serves as a guide for the subsequent discussion and, by and large, captures the different aspects of what has been examined in the literature so far.[4]

Figure 1: Stylized representation of the transmission process



2.1 Interest rate channel

The creation of EMU, financial development and globalisation are likely to have had a crucial influence on the pass-through from policy rates to other interest rates, such as short- and long-term bank rates and capital market rates. More specifically, increased competition in banking together with an enhanced availability of alternative capital market-based instruments for financial investment has the potential to amplify and/or speed up the effects of monetary policy changes on bank interest rates (and, ceteris paribus, on output and inflation):

- Increased competition between different financial market segments, such as the strong growth of money market mutual funds (Mojon, 2000) and the increasing use of non-bank sources of corporate finance (de Bondt, 2005) may have led to a closer link between different interest rates, speeding up the interest rate pass through.
- Consolidation in the banking system may have sped up the transmission of monetary policy shocks to bank interest rates and other financial variables as well. If the reduction in the number and the increase in the average size of banks has improved arbitrage between different financial markets then monetary policy impulses will now be spread more rapidly from the money market to other market segments of the financial system.

[4] For a more detailed graphical description of the monetary transmission process, see e.g. Worms (2004).

- The deepening of financial markets has likely enhanced the role of expectations and thereby increased the speed at which changes in short-term interest rates are transmitted to other financial variables and to the real economy. Specifically, financial innovation, such as the increased prominence of non-bank financial intermediaries in supplying credit and the increased reliance of fund-raising via capital markets could have led to a closer link between short-term market rates to bank lending rates.

All in all, the existing empirical studies indeed point to a faster interest rate pass-through caused by deeper, more complete and more competitive financial markets. E.g., Leuvensteijn, Kok Sorensen, Bikker and van Rixtel (2008) show that stronger market competition in selected euro area countries led to a quicker transmission from changes in market rates to bank rates. The estimates of de Bondt (2005) suggest that the monetary policy control of the short-end of the yield curve at the euro area level has strengthened since 1999. de Bondt, Mojon and Valla (2005) observe a significant speeding-up of adjustment since the advent of the euro.[5] The estimates of Gropp, Kok Sørensen and Lichtenberger (2007) indicate that financial innovation has sped up the interest-rate pass through because of advances in risk management technologies. According to their results, the pass-through to rates on long term loans to non-financial corporations and to rates on mortgages is considerably higher if there is easy access to financial instruments which allow the hedging of interest rate risk. Further, in countries where securitization is relatively widespread (a large share of securitization transactions in the euro area involves mortgages) the pass-through of market rates to long-term rates is also substantially higher than in other countries.[6]

However, while the interest rate pass-through seems to be sped up by financial development it could have been weakened by globalisation. Over the past years, financial openness of many countries has increased very strongly, even more than their trade openness. From a monetary policy perspective, one of the crucial issues in this respect is that this increased financial integration could have eroded monetary policy's influence on national long-term interest rates. More recently, this discussion gained prominence when

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5 However, they do not observe a uniform increase in the pass-through.

6 Financial innovation does not appear to have effects more broadly on the speed of pass-through, i.e. it increases the speed of pass-through to those retail bank interest rates that are directly related to specific innovation.

the US monetary policy tightening of the years 2004-2006 was only insufficiently translated into a respective increase in US long-term interest rates ("conundrum").

Empirical studies confirm such a significant influence of global factors on long-term real interest rates. Yet, this is not necessarily a new phenomenon, but has already emerged prior to the last surge of globalisation (Barro and Sala-i-Martin, 1990). The high degree of synchronisation between movements in long-term nominal interest rates of key industrial countries, however, is a much more recent finding. For example, US and German capital markets have converged significantly since the beginning of the 1990s and are highly correlated at present (Deutsche Bundesbank, 2007). Clearly, a high correlation between national long-term interest rates does not necessarily imply that central banks no longer exert an influence on their domestic long-term rates. Rather, co-movements of long-term interest rates could also reflect the influence of global factors which affect countries in much the same way and therefore, ultimately, national monetary policies.

On the basis of a panel analysis for a group of countries – which allows modelling the "world's capital market rate" as a pure time factor equal for all countries – Upper and Worms (2003) estimate how strongly domestic long-term real interest rates depend on the respective domestic short-term interest rate. They find that the extent to which cross-country variations of the long-term rate can be explained by cross-country variations in the short-term rate has decreased over the recent years, which is compatible with a smaller influence of monetary policy on long-term interest rates (but which is also compatible with an increased homogeneity of monetary policy across countries). However, despite this result, they find that domestic monetary policy still exerts a significant influence on long-term real rates. This is in line with empirical studies for the euro area which find evidence that the Eurosystem's monetary policy exerts an influence on domestic long-term interest rates.[7] However, it may well be that this influence has diminished recently. For instance, the results in Boivin, Giannoni and Mojon (2008) suggest that the response of bond yields to monetary policy shocks in the euro area has decreased since the advent of EMU.[8]

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[7] See e.g. Ehrmann, Fratzscher and Rigobon, 2005

[8] Note, as asset prices are nowadays determined by conditions in financial markets worldwide, the link between domestic policy actions and movements in bond and equity prices may have become more uncertain and therefore, harder to predict (see also Kohn, 2008).

2.2 *Exchange rate channel*

Like the interest rate channel, the exchange rate channel is expected to be influenced by globalisation, financial development and EMU through a broad range of driving forces:

- The advent of the euro has led to a weaker exchange rate channel of monetary transmission for the euro area countries because – compared to the situation prior to 1999 – the euro area has become a comparatively closed economy since a large share of trade now remains within the EMU.
- Cross-border production and increased international trade linkages heightened the relative importance of the exchange rate in the economy. By expanding the share of tradable goods and services in the euro area, globalisation is likely to have increased the role of the exchange rate as a transmission channel of monetary policy (Deutsche Bundesbank, 2007). Per se, the larger the share of imports and exports in the economy, the greater the change in net exports for a *given* change in the exchange rate. Similarly, the larger the share of imports in the economy, the larger should be the effect on CPI inflation of a *given* change in import prices (Mishkin, 2008). In this sense, globalisation has probably made the euro area economy more responsive to foreign shocks.
- On the other side, the impact of exchange rate movements on import prices may have weakened as trade integration may be one factor behind the lower exchange-rate pass-through often found in empirical analysis (Kohn, 2008).
- Globalisation could not just have increased the relative importance of the exchange rate channel directly (anything else equal), but also indirectly, that is, by altering the relative importance of other transmission channels. For instance, increased trade integration may imply that changes in domestic demand are offset by induced changes in imports (Mishkin, 2008). Ihrig et al. (2007) report evidence in this regard by noting that correlations between GDP growth and growth of domestic demand have declined in the United States and in other industrial countries over the past decades.
- Turning to financial globalisation and the associated deepening of financial markets, standard open economy models predict that, as capital mobility increases, monetary policy-induced changes in interest rates trigger sharper exchange rate changes. However, there is evidence (see below) that traditional interest rate/exchange rate

mechanisms have been shut down, at least temporarily. As such, there may be now even more uncertainty regarding the role of the exchange rate in the monetary policy transmission process.

Boivin and Giannoni (2008) cannot find a systematic influence of international factors on key macroeconomic variables or a clear indication that international factors have become generally more important for the US. Regarding monetary transmission they also find only little evidence that global forces have had an effect – more specifically, they cannot find much evidence for a change over the last several years.[9]

As regards the exchange-rate pass-through, Ihrig, Marazzi and Rothenberg (2006) find a decline in import-price and consumer price pass-through for almost all G-7 countries. It is not clear, however, whether the fall in consumer-price pass-through can be explained by the decline in import-price pass-through. For individual countries like France and the United Kingdom, it seems highly plausible that reductions in import-price pass-through (the so-called first-stage pass trough) might explain most of the change in consumer-price pass-through (the so-called second stage pass-through). For other countries, however, e.g. Italy, the declines in import-price and consumer-price pass-through do not seem to be closely related.

There is little empirical evidence for the euro area on possible changes of the exchange rate channel in recent years. The few existing studies find mixed results. Moreover, as a general caveat, much of this evidence still relies on pre-1999 data. One major reason for this inconclusiveness is the difficulty of empirically pinning down the exchange rate channel at all. Angeloni, Kashyap, Mojon and Terlizzese (2003, p. 384), summarizing Eurosystem research until 2003, find that “the response of exchange rates to monetary policy is notoriously hard to predict”. A methodological reason for this could be that the usual identification of monetary policy shocks via timing assumptions is especially difficult in case of exchange rate and interest rate movements which are closely linked to each other at high frequencies; it is difficult to identify empirically whether the exchange rate reacts to monetary policy or vice versa.

9 Specifically, Boivin and Giannoni (2008) compare impulse responses by allowing a different relationship between the US and international factors before and after 2000. For both sub-samples they get almost identical impulses response functions for the first 6 to 7 quarters. After that, the responses based on the more recent international factors reveal a slightly more rapid return to the initial level. Most changes do not appear be statistical significant.

More recent experience with carry trades suggests that exchange rate movements do not always offset interest rate differentials as assumed by interest parity conditions (see, for instance, Galati, Heath and McGuire, 2007). This has cast doubt on whether traditional interest-exchange rate "mechanics" are still operative. Rather, the experience with carry trades seems to suggest that currencies with higher short-term interest rates have tended to appreciate against currencies with lower interest rates. Thus, exchange rates moving one-in-one with short-term interest rates could magnify the effects on the economy of an interest rate increase.[10] Hence, macroeconomic models that impose an uncovered interest parity condition may struggle with these recent exchange rate movements. However, as carry trades rest on the assumption that arbitrage can persist for a prolonged time, we should be careful in interpreting this evidence and do not take it for granted. It is doubtful whether this is really a permanent feature.

2.3 The credit channel

The credit channel looks at monetary-policy induced changes in the supply of funds. Two main sub-channels are discussed in the literature: the bank lending channel, which concentrates on the effects of monetary policy on the supply of bank loans (either via the liability side of the banks' balance sheets or via bank capital), and the balance sheet channel which looks at the effects of monetary policy on the overall supply of funds (via borrowers' net worth).

(a) The bank lending channel

The bank lending channel is generally believed to have lost importance due to the financial development of the recent years, mainly because it has increased banks' flexibility to react to restrictive monetary policy and because it has reduced the dependency of borrowers on banks. With a higher flexibility on the banks' side, e.g. caused by securitization or an improved risk management, banks became able to better isolate their loan costumers from monetary policy impulses. In consequence, European banks can nowadays react more flexibly to changes in market conditions than before. The empirical results of Altunbas, Gambacorta and Marques (2007) point in this direction and

[10] The empirical results of Boivin, Giannoni and Mojon (2008) suggest that since 1999 EA-wide real exchange rate tend to react more pronounced to monetary policy shocks.

suggest that asset securitization may have reduced the importance of the bank lending channel for monetary policy transmission as asset securitization augments banks' liquidity and shrinks banks' funding needs after a monetary tightening. Furthermore, it allows banks to transfer parts of their credit risk to other market participants such as institutional investors. Thus, those banks that use securitization more intensively are better sheltered against monetary policy. However, as the authors note, securitization per se does not allow shielding loan supply completely from monetary policy shocks.

To our knowledge, there is only little empirical evidence for the euro area that evaluates the effects of an increased use of derivative instruments on the banks' lending process (for a notable exception see Gropp et al., 2007). A priori, it is reasonable to assume that lending policies of banks that use derivative instruments have become less vulnerable to macroeconomic shocks – such as monetary policy - as some derivatives may generate high cash flows in bad states of the world and are therefore able to shield their balance sheets (see also Froot et al., 1993). In addition, derivative instruments should facilitate banks' ability to raise non-reservable sources of funds, for instance, by improving a bank's liquidity. Vrolijk (1997) uses data from the UK to investigate the effects of the development of derivatives markets on the transmission process but does not find any significant effect. Drawing on US data, Purnanandam (2007) shows that lending by derivative-user banks is not sensitive to a Federal funds rate shock. On the other hand, derivative non-user banks (even the very large ones) significantly cut their lending volume when the Fed tightens monetary policy. Hence, these results suggest that derivatives allow banks to shield themselves from monetary policy shocks.

However, credit protection through credit derivatives may be associated with an increase in bank credit supply, as has been found for other innovations like securitizations. Drawing on US micro data, Hirtle (2007) finds that greater use of credit derivatives is associated with greater supply of bank credit for large term loans. Commercial and industrial loans also appear to have increased. Thus, the improved possibility of transferring credit risk may not have resulted in reducing risk from a specific activity (such as lending) but have increased that activity. Thus, banks might have expanded their business while maintaining more or less an unchanged level of credit risk exposure. One implication could be that new financial instruments may, in general, trigger a switch to larger balance sheets but once such a transition is complete, monetary policy will still operate through a bank lending channel as balance sheet constraints stemming from reserve or capital requirements would become effective (again).

In addition, even with high levels of securitization, bank equity capital should still be affected by an increase in default rates, caused, for example, by a monetary tightening. As the originators of the assets (e.g. banks) often retain (parts of) the tranche bearing the highest risk, securitization does not completely shield banks from credit risk (Franke and Krahnen, 2005). In times of financial disruption, this exposure will reduce profits and therefore squeeze banks' equity capital. Further, huge amounts of loan-backed instruments have been acquired by entities known as conduits/structural investment vehicles which, while not appearing in banks' balance sheets, benefit from large contingent credit lines granted by banks that set them up. The turbulence since the second half of 2007 have just illustrated that, as structural investment vehicles claim on their credit lines, bank balance sheets can greatly enlarge in times of stress (ECB, November 2007). In the end, the amount of excess capital is reduced and not available to back new lending.

The recently introduced International Financial Reporting Standards (IFRS) in the EU may also work to support the bank capital channel. The aim of the IFRS is to increase the transparency and the comparability of financial statements and requires that assets and liabilities be booked at market prices or, when prices are not available, at an equivalent estimated "fair value". In consequence, bank equity capital will be more influenced by monetary policy, as valuation effects will impinge more on assets than on liabilities.[11]

However, there are arguments which would imply a strengthening of the bank lending channel caused by financial development as well, namely by a weakening of those factors that have led to a weak bank lending channel in the first place. For instance, in the case of Germany, the apparent weakness of the bank lending channel can be traced back to the institutional structure of the German banking system and the long-term relationships between banks and customers which tend to entail an implicit insurance of the credit customer against adverse shocks, such as a restrictive monetary policy (Ehrmann and Worms, 2004). If financial development increases competition between banks but also between banks and other financial market segments, then this so-called "housebank principle" could loose importance, thereby ceteris paribus strengthening the bank lending channel.

(b) The balance sheet channel

The second important part of the credit channel is the balance sheet channel. In a world of imperfect information borrower balance sheet effects arise because monetary policy can influence the net worth of borrowers.[12] Such changes influence consumption and investment decisions as lenders will extend credit more easily when borrowers have sound balance sheets. Financial liberalization and innovation have generally facilitated the access of standardized credit to borrowers. For instance, supply-side innovations in credit markets have eased the access to credit for lower-income borrowers and reduced financial constraints for first-time homebuyers. While household debt, of which mortgages are a major part, has increased considerably, the same is true for total household wealth, reflecting the boost in property prices in recent years and a raise in homeownership rates.

As a result, the weight of financial and non-financial assets and households' balance sheets has increased, thereby potentially fostering the importance of asset prices. As households in a number of OECD countries have leveraged balance sheets their sensitivity regarding interest rate volatilities has probably increased (Girouard, Kennedy and André, 2006). With expanded possibilities to borrow against net wealth (such as mortgage equity withdrawal) households' access to credit is increasingly tightly connected to their balance sheets.[13]

On the other side, consolidation in the banking industry resulted in fewer banks and in on average larger institutions which – if larger institutions can employ superior technologies to assess borrower risk – could have lowered the importance of collateral and thereby of the balance sheet channel. Consolidation, however, could as well have

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[11] For instance, a rise in short-term interest rates will reduce the value of the portfolio of fixed-rate existing loans (on average they should have been issued at lower rates), therefore reducing banking sector assets while higher short-term rates tend to increase funding costs; in consequence equity capital contract (ceteris paribus).

[12] Asset values are crucial as collateral when firms or consumers ask for a loan. Given an information asymmetry between borrower and lender collateral that is easily valued and easy controlled decreases considerably potential losses to the lender if the borrower defaults on the loan (Mishkin, 2007).

[13] Mortgage equity withdrawals may not be of importance that much as a direct causal influence on consumption, but rather a manifestation of the increased ability of households to borrow against housing wealth (Muellbauer, 2007).

enhanced this channel instead of weakening it. If consolidation implies that locally active institutions have become less important, then this could have led to a loss of institutional knowledge about local conditions and local borrowers, hence increasing the importance of collateral and thereby the balance sheet channel. In any case, the remarkable rises in property prices and household indebtedness in several industrial countries calls for a deep understanding for both the determinants of such rises and their implications for monetary policy.

Yet, to our knowledge there is no direct evidence for the euro area if and to which extent balance sheet effects might have changed in the recent decade or so.[14] Innovations in housing finance in advanced economies over the past two decades (IMF, 2008) have likely increased the importance of asset (property) prices for credit availability and therefore for spending. This in turn has not only enabled homeowners to overcome credit constraints more easily but affected the monetary transmission process as well. With the improved access to mortgage markets in recent years consumer spending may have become more sensitive to increases in house prices (see Box I). Indeed, Calza, Monacelli, Stracca (2007) document that the correlation between private consumption and house prices at business cycle frequencies is related to mortgage markets characteristics with that correlation being larger in countries featuring more developed mortgage markets. In addition, output tends to react more pronouncedly to monetary policy shocks in those countries where country-specific measures such as mortgage debt to GDP ratio, the loan-to-value ratio (LTV) and the existence of equity release products indicate an enhanced development/flexibility in mortgage markets. In the same vein, the estimates of IMF (2008) suggest that the responses of house prices and output to monetary policy shocks to be stronger in the United States, United Kingdom, the Netherlands and in France in a recent sub-sample (1983-2007) than a first one (1970-1982) (see also Goodhart and Hofmann, 2007, 2008 and Assenmacher-Wesche and Gerlach, 2008).

Box I: Relaxation of borrowing constraints and monetary transmission

In order to get a *qualitative* impression to which extent the monetary transmission process could have been altered due to a relaxation of borrowing constraints we illustrate the macroeconomic importance of a variation of borrowing constraints in a monetary business cycle model where nominal loans and collateral constraints are tied to housing values (see also Aoki, Proudman and Vlieghe, 2004; Iacoviello, 2005).

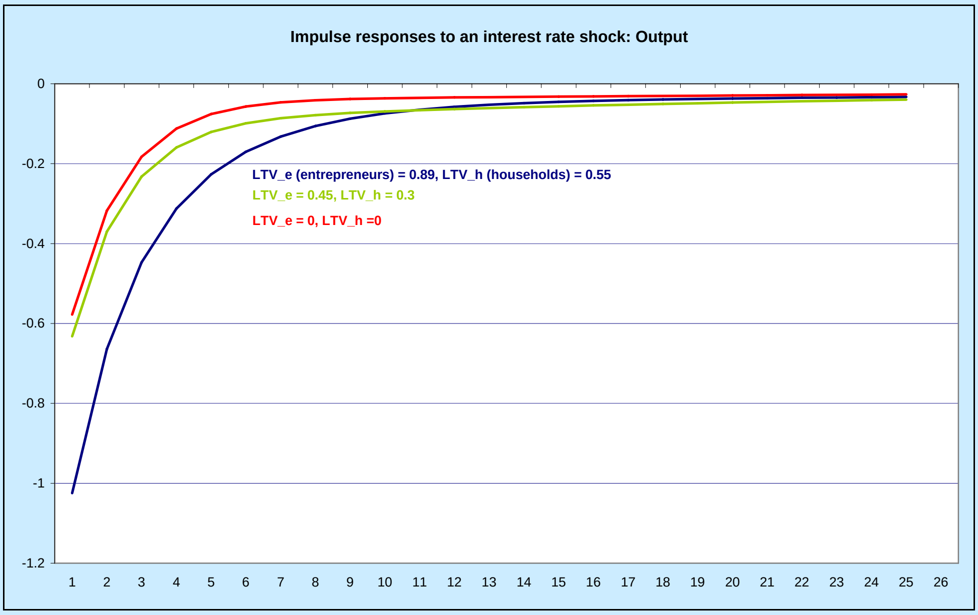
[14] Iacoviello and Minetti (2007) test for a credit channel in four European housing markets (Germany, Finland, Norway and UK). They use time series for regressions that end in 2000 or earlier and do not test for changes in the transmission mechanism.

Specifically, the model is a variant of the Bernanke, Gertler and Gilchrist (1999) New Keynesian model in which endogenous variations in the balance sheet of firms give rise to a financial accelerator. In the following, we use the setup of Iacoviello (2005) that embodies to additional features. First, a collateral constraint tied to real estate values for firms; second, nominal debt for a subset of households. The model economy is populated by entrepreneurs, retailers, unconstrained and constrained households. A central bank adjusts money supply and transfers to support an interest rate rule. We will not delve into the details of the models but refer to Iacoviello (2005) for a complete description of the model (including the parameterization). Here it suffices to note that financial frictions (liquidity constraints) both apply to firms and households. As in Bernanke, Gertler and Gilchrist (1999) retailers are the source of nominal rigidity.

The model's transmission works basically as follows. Suppose a positive demand shock: when demand increase, consumer and asset prices increase, too. The rise in asset prices increases the borrowing capacity of the debtors, allowing them to spend more. The rise in consumer prices reduces the real value of the outstanding debt obligations, positively affecting their net worth. Given that borrowers have a higher propensity to spend than lenders, the net effect on demand is positive and acts as an amplification process (Iacoviello, 2005).

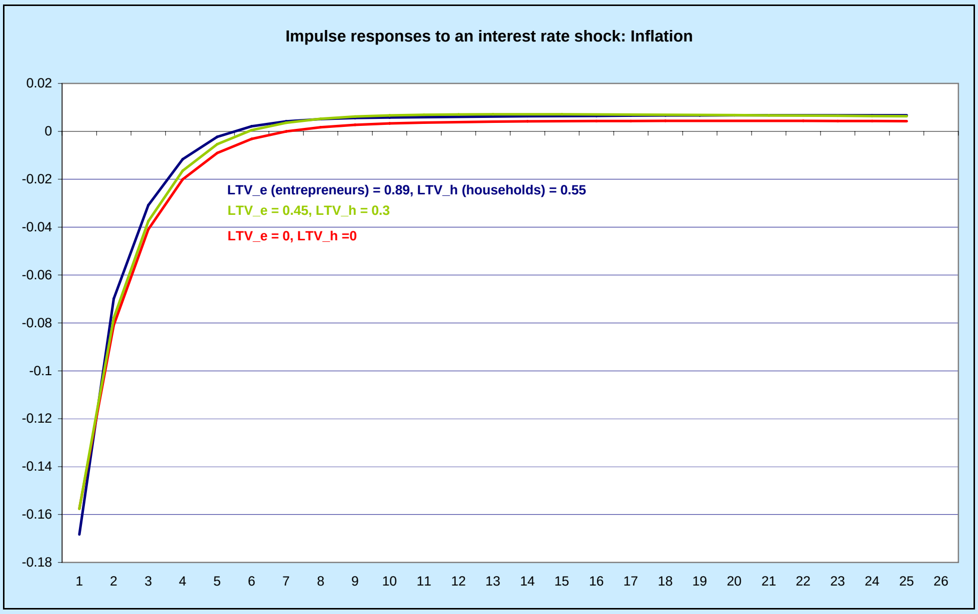
Figure I.1 displays a monetary tightening and the corresponding impulse response functions of output and inflation for alternative loan to value ratios (LTV).[15] With sticky prices, monetary actions affect the real rate and its increase works by discouraging current consumption and hence output. The effect is reinforced through the fall in housing prices, which leads to lower borrowing and lower entrepreneurial housing investment. If obligations are not indexed, deflation raises the cost of the debt service, further depressing consumption and investment of the borrowers. When debt deflation and collateral effects are shut off, only the interest rate channel is operative (The output drop is then mainly driven from intertemporal substitution in consumption). In sum, Figures I.1 and I.2 illustrate in a stylized manner how a relaxation of binding credit constraints in the form of higher loan-to-value ratio can rationalize pronounced responses of output and inflation. The greater the importance of collateral effects the stronger the (impact) response output and inflation. Thus, when credit markets allow more easily to convert asset values into borrowing, and therefore spending, consumption (and therefore output) can be more responsive to monetary policy shocks (see also Calza, Monacelli and Stracca, 2007).

Figure I.1.



[15] Here, LTV is a parameter that determines the extent to which housing can be used as collateral for borrowing. A higher LTV represents a more developed mortgage market.

Figure I.2.



Additional insights about the macroeconomic effects of an easier access to credit have been gained from empirical studies that explore the relationship between housing wealth and consumer expenditure, taking explicit account of credit market liberalization. These studies show that the increased ability of households to extract or borrow against their home equity has altered consumer spending and saving behaviour in several countries (Muellbauer, 2007; Aron, Muellbauer and Murphy, 2007). In the UK, credit market liberalization, beginning in 1980, significantly increased the consumption to income ratio and significantly altered the response of consumption to several variables, including housing wealth. Before 1980, there was no housing wealth effect on consumption, but thereafter the size of the effect increased as credit supply conditions eased. The same has been observed the US: the easing of credit market conditions has caused a significant rise in consumption to income ratio and a positive shift in the housing collateral effect. As in the UK, the marginal propensity to consume out of liquid assets minus debt has turned out to be higher than out of illiquid financial assets (see also Carroll, Otsuka and Slacalek, 2006). By contrast, in Japan there was no important easing of credit conditions between 1980 and 2000. Here, the estimates suggest that higher residential land prices (as a proxy for house prices) decrease consumer expenditure. As regards the EMU, credit liberalization has not gone as far in Germany, France and Italy as in the US and UK. For the euro area as whole, it is therefore likely that the evolution of institutional features affecting the efficiency of credit markets has been taken place at a much slower pace. Nevertheless, it is reasonable to assume that the aforementioned amplification has also taken place in the recent past in the euro area.[16]

The importance of financing constraints for the operation of a firm and its investment decisions has been studied extensively as well. Yet, a consensus about their empirical importance has not been achieved (ECB, June 2007). Given that lack of consensus regarding the significance of financial constraints and thereby firm balance sheet effects, it is even harder to pin down the impact of the evolving financial landscape on this relationship. A priori, however, it is reasonable to argue that changes in the financial environment have had a noteworthy impact in terms of cost and availability of funds. With the innovations in credit markets firms should have benefited from easier access to credit from banks.

On the other side, regulatory changes which took place in the euro area in the recent past may have had the potential of strengthening the balance sheet channel. For instance, as already mentioned, the introduction of IFRS, one of the main regulatory changes, is likely to have reinforced firm balance sheet effects. In countries such as France or Germany the move to IFRS has probably been a significant change as many categories of corporate assets have previously been booked at historical rather than market prices. Market prices or the "fair value" of an asset is sensitive to shifts in interest rates while their historical cost is not. As regards the case of rising disintermediation, it is not implausible to assume that the company balance sheet to be affected that much: a firm's net worth is likely to be as important for buyers of corporate bonds as for financial intermediaries. Although we are not aware of direct evidence for the euro area, some recent analyses support the presumption that balance sheet effects on businesses may still operative even in countries where a deepening in financial markets has gone quite far. For instance, Angelopulou and Gibson (2007), investigating the relationship between firm financial constraints and monetary policy in the UK, provide some evidence that firms as a

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[16] It is plausible to assume that significant differences in the efficiency of credit markets imply important asymmetries in monetary transmission between, say, UK and the euro area. HM Treasury agreed that

whole show greater investment sensitivity to cash flow during periods of tight money and the effect tends to be higher on those that are potentially financially constrained (see also Benito and Young, 2007). For the US, the results of Ashcraft and Campello (2007) support the existence of an independent, demand-driven credit channel. Their evidence suggests that monetary policy will have a stronger effect on economic activity during economic downturns, when balance sheets are weak, than during economic expansions.

2.4 Phillips curve

The literature reviewed so far concentrated on the transmission of monetary policy shocks to aggregate demand.[17] If we portray the transmission process according to Figure 1, it is obvious that up to now we only focused on (the first) part of the transmission process. However, the second part – namely the relationship between aggregate demand, output gap and inflation, i.e. the Phillips curve – might also have been affected by the creation of EMU, financial development or globalisation. A priori, it seems reasonable that at least some of these forces have had a non-negligible impact on the aggregate price dynamics in the euro area and, thus, on the monetary transmission process (see Box II for an illustration). More specifically, if we think in terms of a (forward-looking) Phillips curve, the following aspects or features of the Phillips curve might have been affected.

- *Inflation persistence,* i.e. the tendency of inflation to converge slowly towards its long-run value following a shock (Angeloni et al., 2004). Recent research of the Eurosystem Inflation Persistence Network (IPN) suggests that estimates of euro area inflation persistence turn out to be comparatively high unless a shift of the mean of inflation – for which ample evidence exists – is allowed for. Thus, a failure to account for significant changes in the mean seems to produce spuriously high degrees of inflation persistence. As there is evidence that these breaks in mean may be related to the change in the monetary policy regime caused by EMU (see, for instance, Altissimo, Ehrmann und Smets, 2006) the perception of inflation persistency as "hard-wired", i.e. as structural (in the sense of Lucas, 1976) has recently been challenged (Sbordone, 2007; Benati, 2008).

housing market differences were a key impediment to adoption of the Euro (Muellbauer, 2007). See also Hoeller and Rae (2007).

[17] The short section on the exchange rate pass-through to prices is a notable exception.

- *Price stickiness*, i.e. the responsiveness of inflation with respect to changes in marginal costs or the output gap (the slope of the Phillips curve). Per se, the more rigid prices are, the less responsive inflation becomes to changes of its determinants. Recently, there has been increasing interest in understanding how and to which extent globalisation might have influenced the domestic inflation process. Specifically, it has been suggested that the domestic price development has become more dependent on worldwide capacity utilisation and less so on the domestic output gap. Moreover, this suggestion has been accompanied by the recommendation that central banks that aim to maintain price stability should pay more attention to global rather than to domestic output gaps (Calza, 2008). Some observers even suggest that domestic monetary policy should concentrate more on the business cycle now, since domestic inflation developments became more or less independent of domestic monetary policy.

Recent evidence based on reduced-form analysis as well as based on structural evidence from estimated sticky-price DSGE models suggests that (after allowing for a shift in the mean of inflation) the degree of inflation persistence has declined following the introduction of the euro. This is especially apparent for the euro area considered as a whole while the evidence for some individual countries like Germany and Italy is mixed (see, for instance, Benati, 2008). Under the *current* monetary policy regime, inflation persistence in the euro area is gauged as being 'moderate' (Altissimo, Ehrmann and Smets, 2006).[18] There remains, however, notable uncertainty about the estimated degree of inflation persistence.[19]

The sensitivity of inflation to measures of economic activity also appears to have declined. Specifically, a flattening of the Phillips curve has not only been observed for the euro area but for other advanced countries as well (Bordo and Filardo, 2007; Deutsche Bundesbank, 2007; Ihrig, Kamin, Lindner and Marquez, 2007; Musso, Stracca and van Dijk, 2007).[20] However, most empirical estimates regarding the inflation-output-gap-nexus are based on reduced-form models. Hence, since they are not structural, a flattening

18 Anchoring of inflation expectations of economic agents in the EMU has likely been crucial in reducing the degree of inflation persistence.

19 See Rudd and Whelan (2007) for a critical review. Recently, Benati (2008) has challenged the notion that the intrinsic component of inflation persistence – captured in New Keynesian Phillips curves by a notable extent of backward-looking indexation – is structural in the sense of Lucas (1976). See also Sbordone (2007).

20 Note, Sbordone (2007) and Woodford (2007) argue that such changes are not likely to be large.

of the Phillips curve can, in principle, be due to different structural factors. For instance, it may owe to a genuine change in the relationship between output and inflation; likewise, it could be due to a shift in the monetary policy regime caused by the creation of EMU (regarding the latter see Roberts, 2006 or Boivin and Giannoni, 2006). Currently, there does not seem to be a consensus whether a change in the monetary policy regime that led to more stable inflation expectations and less inflation persistence or other factors, including globalisation, has been decisive in making inflation in the euro area less responsive to rising resource utilization.

Regarding the United States, Mishkin (2008) reports a flattening of the Phillips starting in the 1980s that is, well before the recent rush of globalisation but just after inflation expectations started to become anchored. Accordingly, he interprets a flattening of the Phillips curve as a direct result of an improved monetary policy. In the same vein, Ihrig, Marazzi and Rothenberg (2006) do not find evidence that a flattening of the Phillips curve in the United States and in other countries might have been due to increased trade integration. Moreover, they do not find foreign output gaps to be important determinants of US inflation (see also Pain, Koske and Sollie, 2006; Ball, 2006).

Box II: Inflation persistence in the Smets/Wouters (2003) model

The *implications* of different degrees of (intrinsic) inflation persistence and different degrees of price stickiness can be illustrated by investigating the impulse responses to a cost-push shock in the estimated euro area model of Smets and Wouters (2003).[21] This model features a number of frictions in order to capture the dynamics of important macroeconomic variables. The key equation that captures the degree of inflation persistence (i.e. the coefficient of lagged inflation) and price level stickiness (i.e. the slope of the Phillips curve) takes the form of a hybrid New Keynesian Phillips curve. As before, monetary policy is described be means of a Taylor-type rule. The parameterization is based on euro area data over the period 1980-1999.

Figures II.1, II.2 and II.3 illustrate to which extent different degrees of (intrinsic) inflation persistence determine the response of key macroeconomic variables to an (exogenous) cost-push shock. Specifically, a smaller degree of (intrinsic) inflation persistence implies less pronounced responses of inflation and output. Likewise, both in terms of amplitude and persistence, the policy rate shows a smaller response to cost-push shocks. The intuition for such a dampened reaction is straightforward. First, if inflation persistence is low agents anticipate a lower persistence of this inflation shock and therefore do not raise their expectations of future inflation very much. Thus, the immediate impact of an inflation shock is small and has an immediate dampening effect on inflation. Second, as the response of inflation is small, the negative response of the output gap will be small, too. Finally, as the response of inflation is less persistent, the response of the real rate will be less persistent, too. Thus, a low degree of inflation persistence is tantamount to an improved output-inflation variability trade-off and therefore monetary policy can respond in a more decent way.

[21] We will not stick to the details of the model but refer to the paper. For a similar exercise see Altissimo, Ehrmann and Smets (2006). Two factors motivate the focus on cost-push shocks. First, in the recent years the euro area has been hit by a bunch of cost-push shocks. Second, cost-push shocks tend to force output and inflation to drift in opposing directions.

Turning to the impact of different degrees of price stickiness it turns out that a smaller degree of price stickiness leads to a reduced output response, whereas the effect on the inflation response is relatively negligible. However, a smaller degree of price stickiness necessitates a more aggressive monetary policy reaction, in the sense of a stronger response of the nominal interest rate as with a lower degree of price stickiness a given change of nominal interest rates will have a smaller effect on the real interest rate and thus on output. (The parameter *gamma_p* represents the indexation parameter: a small *gamma_p* implies a small dependence on lagged inflation).

Figure II.1

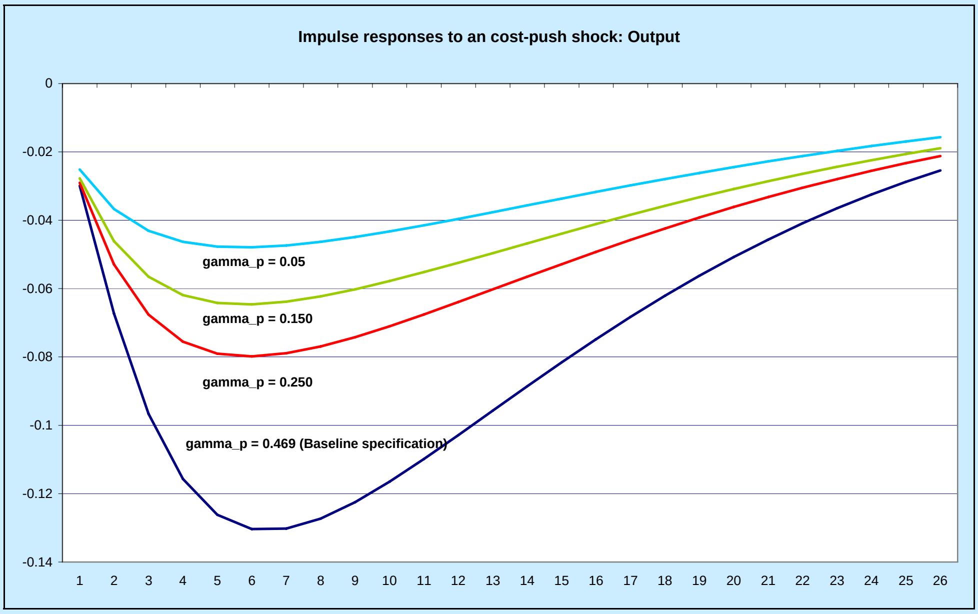


Figure II.2

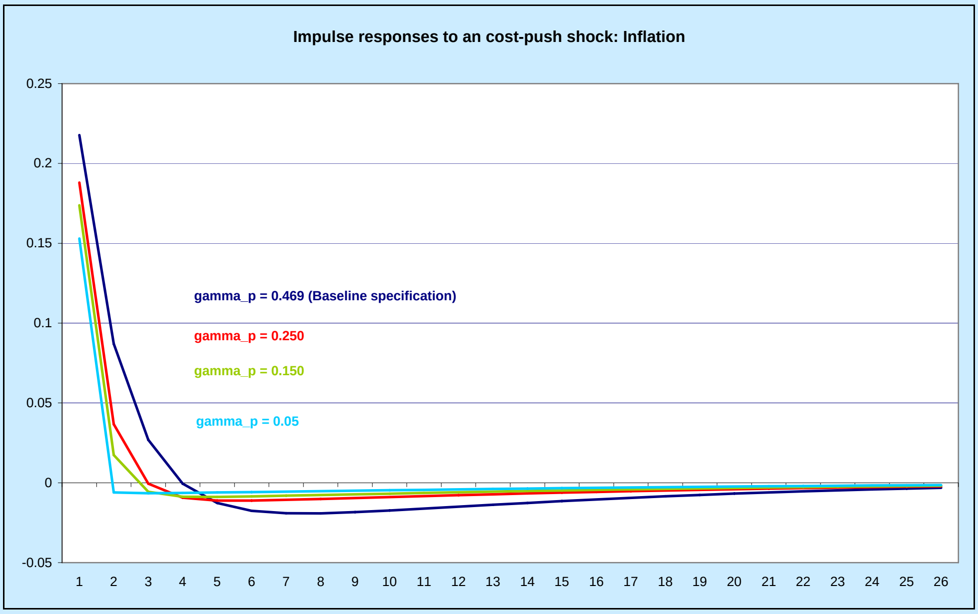
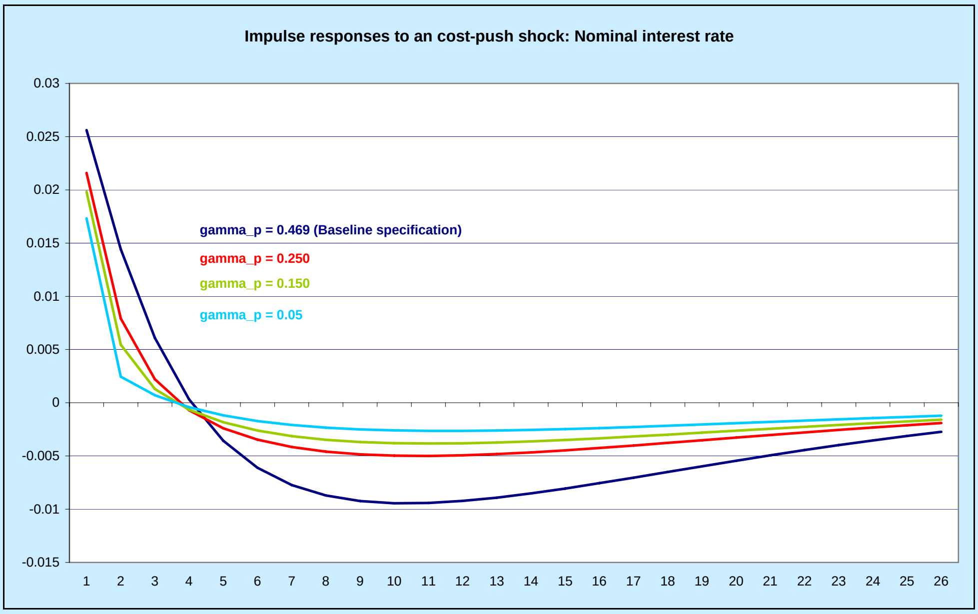


Figure II.3



By contrast, Borio and Filardo (2007) provide evidence that global output gap measures have become more important than the domestic output gap as a key determinant of domestic inflation in many countries. As regards the euro area, however, their evidence appears to be inconclusive.[22] Calza (2008) provides some additional evidence for the euro area regarding the information content of foreign output gaps on contemporaneous consumer price inflation. He finds only little evidence that global capacity constraints have either explanatory or predictive power for domestic consumer price inflation in the euro area. Given this relatively scarce evidence for the euro area we should be cautious regarding an overhasty reinterpretation of the evidence so far. Specifically, the implication that central banks should take into account developments in global output gaps does not seem to be justified for the euro area.

3 Has the monetary transmission process in the euro area changed?

All in all, the existing empirical literature on possible changes in monetary transmission caused by globalisation, financial development and the creation of EMU is at

[22] Their econometric specification has been challenged as being not robust; see Ihrig, Marazzi and Rothenberg (2006).

best mixed. While some analyses do not find evidence for changes, others do – however, often with contradicting implications for the direction of the change. A substantial part of this literature has focused very much on specific transmission channels (such as the interest rate channel), on selected stages of the transmission chain (such as the Phillips curve) and/or on single factors that might have caused the suspected changes (such as globalisation). Such a fairly narrow perspective has its merits but it comes with a number of problems, too. One of these problems, and a potential source for the inconclusiveness of the results, is that the empirical identification of a change in a particular transmission channel caused by a specific factor requires both (i) the empirical identification of the transmission channel of interest and (ii) the empirical isolation of the driving factor from other potential influences. In applied work, both proves to be daunting for several reasons: first, the transmission process is complex and consists of many co-existing and intertwined channels, which are even more difficult to separate at later stages of the transmission process (see e.g. Worms, 2004). Second, the potential causes of structural changes are difficult to identify, to measure, and to separate because they often occur at the same time and are not independent of each other.

Another limitation that comes with concentrating on specific channels and single causes is the impossibility of assessing whether the overall effectiveness of monetary policy has changed. The previous discussion has shown that, a priori, the net effect of such changes remains an open issue, both theoretically as well as empirically. It could well be that different driving forces operate simultaneously in opposite directions so that the ultimate net effect on the overall dynamics and the strength of monetary policy transmission turns out to be negligible while at the same time certain channels and stages of the monetary policy transmission process are significantly affected. In that case, concentrating on specific transmission channels would be misleading by giving a too limited impression of the ultimate effects of monetary policy on inflation and output.

We find it therefore worthwhile to take a different route by identifying potential break dates in monetary transmission in the euro area independent of possible causes, and to check whether or not the monetary transmission process to output and inflation *as a whole* has changed. In order to do so, it is necessary to take an aggregate look at the data without imposing too many *a priori* restrictions. Other examples of such an approach include contributions based on Vector autoregressive (VAR) models, such as Peersman and Smets (2003), Angeloni and Ehrmann (2003) or (optimization-based) structural models like Smets and Wouters (2003) or Christiano et al. (2007). In the past, the short time span since the start of EMU has severely constrained the possibility of checking for changes in monetary transmission. However, with the tenth anniversary of EMU ahead, we are increasingly able to rely on sufficient data for such an exercise.

3.1 VAR specification

Our baseline VAR specification can be written in matrix form as

$$y_t = k + A(L)\,y_{t-1} + Bx_t + u_t\,. \tag{1}$$

y_t is the vector of endogenous variables, k the vector of constants, x_t the vector of exogenous variables and u_t is the vector of serially uncorrelated disturbances that have a zero mean and a time invariant covariance matrix. A and B are coefficient matrices, L is the lag-operator. In our baseline specification, the vector of endogenous variables y_t consists of four euro area variables: real GDP (gdp_t), the GDP deflator ($pgdp_t$), an indicator for real housing wealth ($hhwreal_t$) and a domestic nominal short-term interest rate rs_t (for a similar specification see, for instance, Iacoviello, 2005):

$$y_t' = \begin{pmatrix} gdp_t & pgdp_t & hhwreal_t & rs_t \end{pmatrix}. \tag{2}$$

The vector of exogenous variables contains a non-oil commodity price index (pcm_t) and a US short-term interest rate ($usrs_t$):

$$x_t' = \begin{pmatrix} pcm_t & usrs_t \end{pmatrix}. \tag{3}$$

The exogenous variables are included mainly in order to avoid a potential ‘price puzzle’ (i.e., a price increase following an interest rate tightening) that is widespread in the empirical VAR literature. By treating these variables as exogenous, we allow for a contemporaneous impact of the exogenous on the endogenous variables, but not for a feedback (see also Peersman and Smets, 2003).

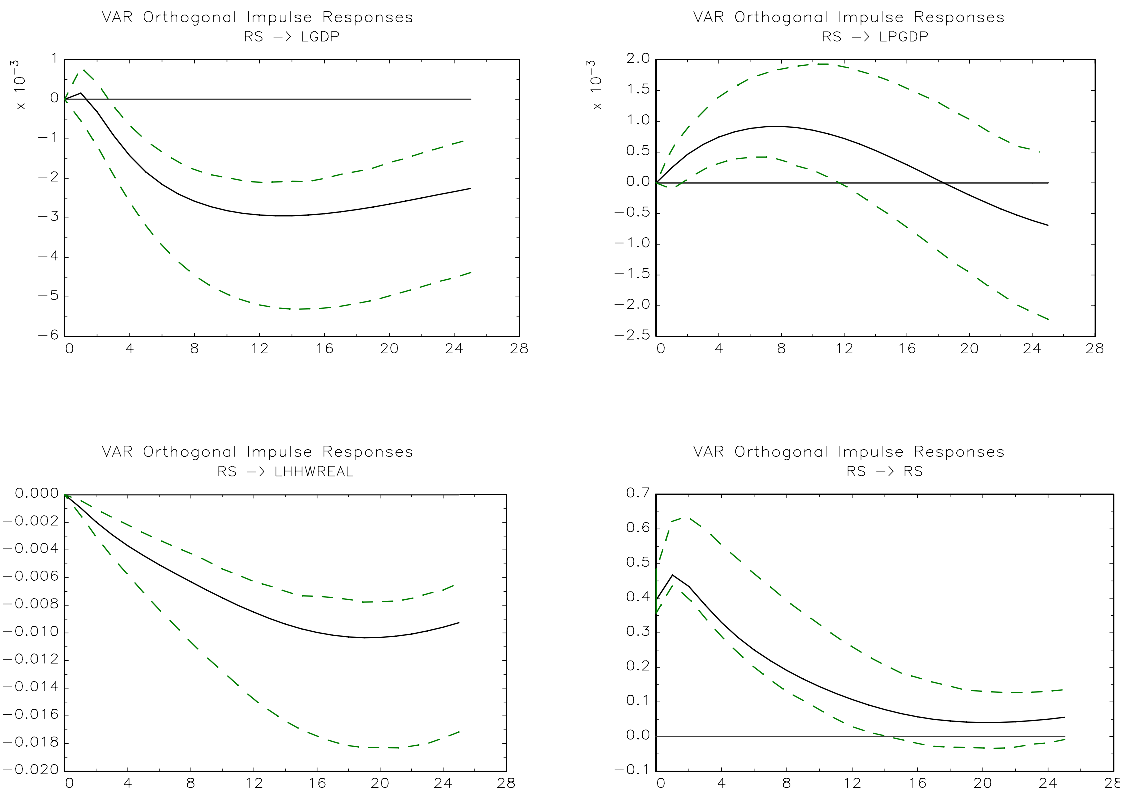
We use standard information criteria to determine the lag length of the VAR. Based on the Hannan-Quinn (HQ) and the Schwarz criterion (SC) the lag order turns out to be two.[23] We identify monetary policy shocks by a standard Choleski-decomposition with the variables ordered as in (2). This implies that monetary policy shocks do not have a contemporaneous impact on output, prices and housing wealth but allows for a contemporaneous reaction of monetary policy to all other variables of the system. However, varying the ordering does not affect the results significantly. Moreover, using the more agnostic sign restriction approach of Uhlig (2005) corroborates that the triangular Choleski identification scheme is reasonable.

The VAR model is estimated in levels, using quarterly data over the period 1980:1-2006:4 (for a short description of the time series properties of the variables, see Appendix). All variables except the interest rates are transformed to logarithms. We use a three-month interest rate as the monetary policy instrument. GDP and the GDP deflator are seasonally adjusted, households' housing wealth, which covers the value of all dwellings including the value of land on which the buildings are constructed, is only available on a semi-annual basis and has therefore been interpolated (ECB, 2006). Data for the euro area has been obtained from an updated version of the Area-Wide Model data base by Fagan et al. (2001) and official ECB statistics. The US short-term interest rate is taken from the Federal Reserve Bank of St. Louis data base (FRED).

Estimating the VAR over the whole sample period 1980:1 – 2006:4 and identifying monetary policy shocks as described yields the IRFs to monetary policy shocks displayed in Figure 2 (for the whole set of IRFs, see Appendix). The results, however, oppose economic theory and the "stylized facts" of monetary transmission. More specifically, a restrictive monetary policy shock reduces output in the long run and, therefore runs counter the notion of long-run neutrality of monetary policy. In addition, monetary policy seems not to be able to pin down inflation in the long run since it appears unable to cause a significant long-run reduction of the price level. On the contrary, a quite persistent "price puzzle" is observed, that is, the interest rate rise goes (temporarily) hand in hand with a significantly higher price level (despite the inclusion of "standard" exogenous variables which according to earlier work should reduce or eliminate the "price puzzle").

[23] We disregard the Akaike criterion as it asymptotically overestimates the order with some probability, whereas HQ estimates the order consistently and SC is even strongly consistent (see, for example, Lütkepohl, 2005).

Figure 2: IRFs to monetary policy shock for whole sample period (1980:1 – 2006:4)



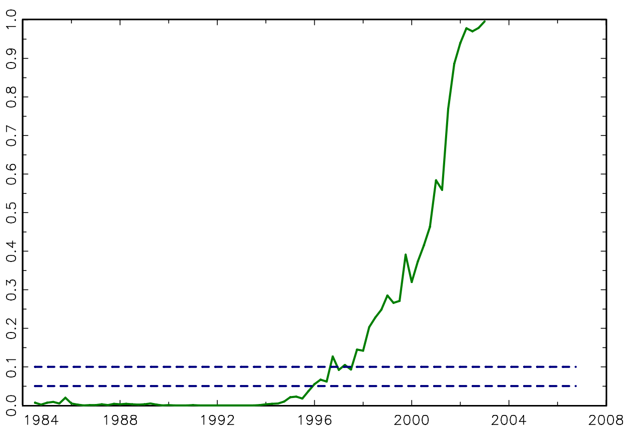
The dashed lines represent 95% Hall (1992) percentile (1000 bootstrap replications).

One possible reason for this unsatisfactory description of monetary transmission could be that the set of variables is insufficient or inadequate to describe macroeconomic dynamics in the euro area. The chosen set of endogenous and exogenous variables, however, is fairly standard in the literature, possibly with the exception of real housing wealth. Yet, including real housing wealth improves the overall fit of the model and proves to be an important explanatory variable for the euro area in other instances as well (see, e.g., the money demand analysis of Greiber and Setzer, 2007). Moreover, excluding it or including additional variables such as a long-term interest rate and/or money does not change or improve the overall picture (see also Section 3.4 below). Another reason for the unsatisfactory results could be that the chosen identifying procedure is inappropriate. However, varying the order, using structural or agnostic identification schemes does not improve the results either.

3.2 Searching for a possible single break date

Another explanation for these unsatisfactory results could be that the euro area economy underwent significant structural changes over the sample period 1980 to 2006 which are not adequately captured by the estimated VAR. To check this possibility, we investigate the stability of the benchmark VAR by performing several alternative break-point tests. We use test statistics applied to the individual equations of the benchmark VAR as well as to the complete vector model. For the vector model we apply two different types of Chow tests. However, as Chow tests may have distorted distributions relative to the asymptotic χ^2 and approximate F distributions in dynamic models we use a (system) bootstrap version of a sample-split and a break-point Chow test as proposed by Candelon and Lütkepohl (2001).[24] Basically, these tests compare the residual variance estimate from a constant parameter coefficient model with the residual variance estimate of a model that allows for a change in the parameters at a (single) given point in time. The tests are performed repeatedly for every quarter between 1984 and 2002 as potential break points. Figure 3 plots the bootstrapped *p*-values for the sample-split test applied to the baseline VAR.

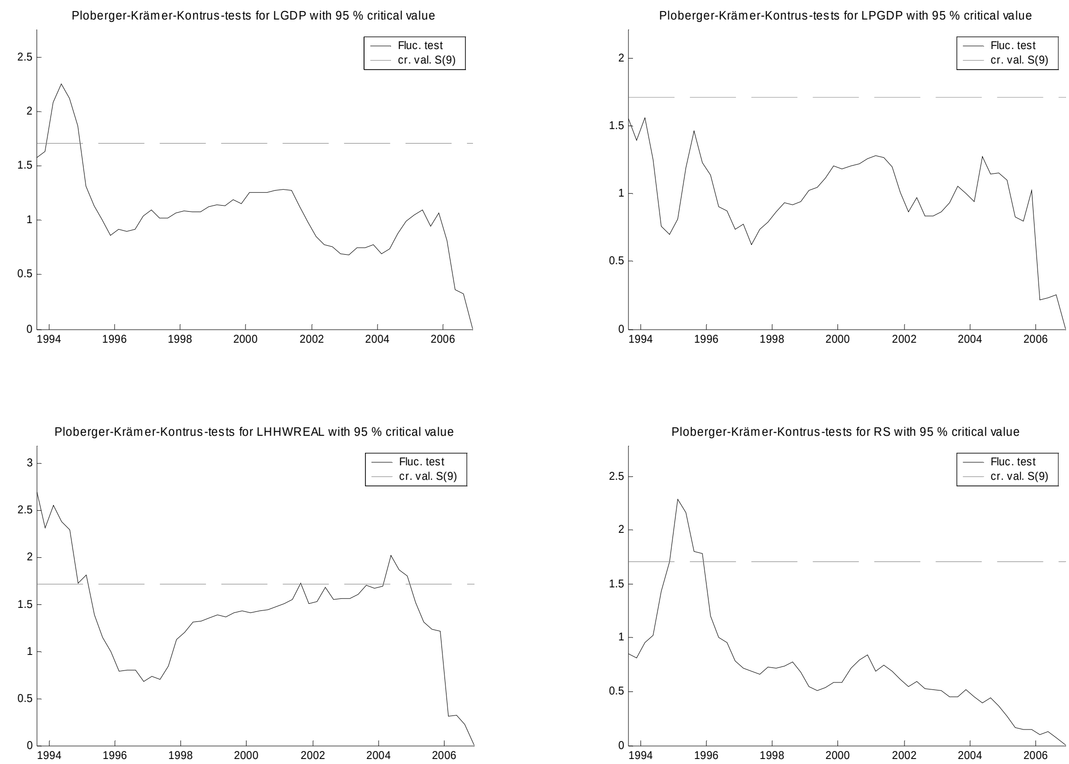
Figure 3: Sample-split Chow-test: bootstrapped *p*-values (1000 replications)



[24] As noted by Candelon and Lütkepohl (2001) it turns out that in samples of common size the χ^2 and F approximations of the actual distributions may be poor even if a single break point is tested. The actual rejection probabilities may be much larger than the desired type I error. For completeness we also apply a system 1-step Chow test as implemented in Doornik and Hendry (2007). This test indicates parameter instability for the mid 1990s, although somewhat earlier as indicated by the bootstrap versions.

Obviously, the *p*-values remain below 5% until 1996 and give rise to concerns regarding the stability of the model over the whole sample period. The null hypothesis of parameter constancy is generally rejected according to the break-point test which additionally checks the constancy of the white noise variance. Thus, it appears that not only the propagation of the VAR shocks has changed over the past decades but the variance of the innovations as well. We interpret this as strong evidence in favour of structural changes in the sample.[25]

Figure 4: Ploberger, Krämer and Kontrus fluctuation test (1989)



As a complementary check we use the Ploberger, Krämer and Kontrus (1989) fluctuation test on an equation-by-equation basis. The idea behind this test is to reject the null hypothesis of parameter constancy whenever these estimates fluctuate too much. Unlike the Chow tests this test does not require that possible break points are set ex ante.

[25] Note, to the extent that the true model of the economy is appropriately described by a linear model, potentially omitted variables do not generate spurious instability (Boivin and Giannoni, 2002). A possible omission might bias the parameter estimates of the systematic component, but would not imply structural changes across samples.

As in the case of the system Chow tests this test indicates parameter instability for the mid 1990s as well (Figure 4).[26]

Taking the results of these tests altogether does not allow us to pin down the break date to a specific quarter. Rather, they indicate significant structural changes of the data generating process that might have occurred at least until 1996. This interpretation is confirmed by a similar result in Breitung and Eickmeier (2008).

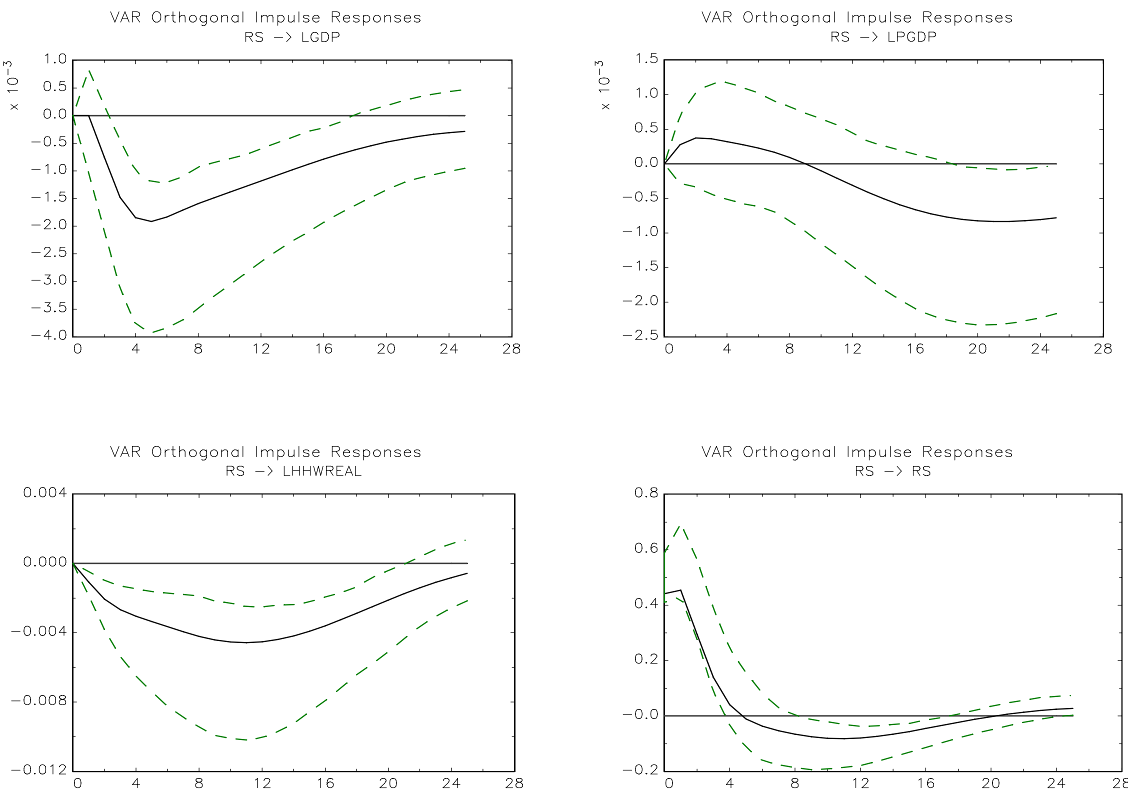
3.3 VAR estimations with one break in 1996

We now examine whether theses changes have indeed significantly affected the transmission of monetary policy shocks. In order not to restrict ourselves to specific transmission channels, we do so by comparing the IRFs of the endogenous variables of the benchmark VAR (esp. output and prices) estimated over the two sub-samples before and after this break point. Based on the test results we obtained so far, the first sub-sample corresponds to 1980:1-1996:1 and the second sub-sample corresponds to 1996:2-2006:4. When estimating the VARs only observations from the respective sub-sample are used, including the initial lags. However, as we will discuss later in some detail, our results do *not* critically impinge on this specific break date. Rather, they turn out to be robust as long as the break date is chosen to lie between 1990 and 1998.

Notwithstanding, describing monetary policy in the euro area over the whole sample period remains a subtle issue. Obviously, the operating framework of monetary policy before and after the beginning of the EMU has been different. Particular care has to be exercised when evaluating the monetary transmission process for the period before 1999. In particular, the difference between the two distinct monetary regimes cannot be precisely captured by a single VAR that is estimated with aggregated variables. With this caveat in mind, we nevertheless follow standard practice and use the short-term interest rate as the key monetary policy instrument (for a similar procedure see, for instance, Peersman and Smets, 2003 and Boivin, Giannoni and Mojon, 2008).

[26] We used Anders Warne's program Structural VAR 0.40.

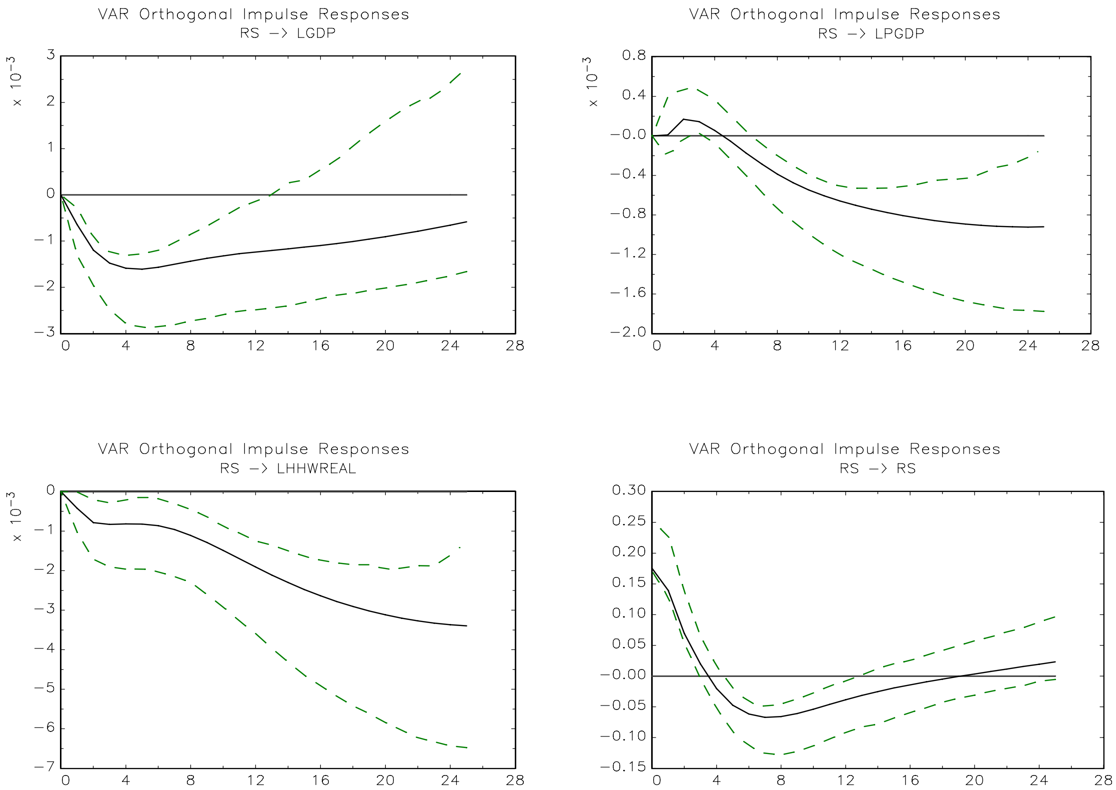
Figure 5: IRFs to monetary policy shock for sub-sample 1980:1 – 1996:1



The dashed lines represent 95% Hall (1992) percentile (1000 bootstrap replications).

Figure 5 displays the IRFs with respect to an unexpected increase in the short-term interest rate for the period 1980:1-1996:1 and Figure 6 the respective IRFs for 1996:2-2006:4 (for the complete set of IRFs, see Appendix). The following similarities and differences appear. Generally, in contrast to the IRFs for the whole sample period, the IRFs for both sub-periods now show a reasonable shape for the reaction of the endogenous variables to a restrictive monetary policy shock. More specifically, we observe long-run neutrality of monetary policy with respect to real GDP and a significant negative long-run reaction of the GDP deflator. The short-term interest rate converges to its initial level in the long run. In the short run, we observe a significant contraction of output and a significant decrease of the GDP deflator, which is in line with both the previous empirical literature and with theory.[27] Also in line with the empirical literature, the price reaction becomes significant only with a lag, that is, after GDP has already declined. A persistent “price puzzle” cannot be observed. Furthermore, real housing wealth decreases significantly in the short run in both sub-samples but returns (although slowly) to its initial level only in the first sub-sample.

Figure 6: IRFs to monetary policy shock for sub-sample 1996:2 – 2006:4



The dashed lines represent 95% Hall (1992) percentile (1000 bootstrap replications).

While the key stylized facts of monetary transmission are captured by both sets of IRFs, a quantitative comparison seems to indicate a change in monetary transmission as well (see Figure 7): after 1996 (red lines) real GDP seems to react faster and stronger and the GDP deflator appears to react stronger than it did before (blue lines). Moreover, the short-term interest rate reaction is more pronounced and the short-term reaction of real

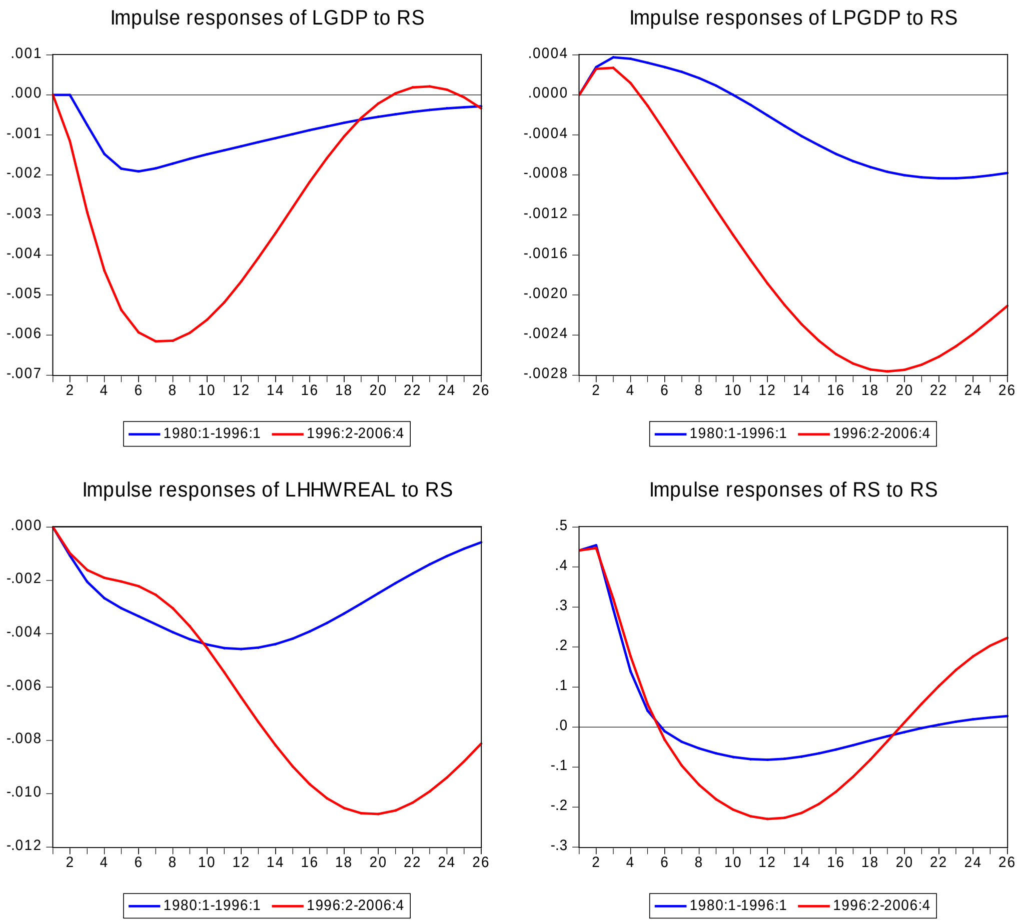
[27] The figure shows the effects of a one standard deviation monetary policy shock. If we assume a tightening of 100 bp, GDP falls about 0.5% after six quarters in the first sample and about 0.9% after six quarters in the second one. GDP deflator falls about 0.2% and 0.4% after four years, respectively. Using a sample that starts in 1988 and ends in 2007 Boivin et al. (2008) obtain point estimates in the magnitude of 1% after a one year for GDP and about 0.4% after roughly four years for the GDP deflator.

household wealth appears stronger after 1996. A persistent negative reaction of housing wealth can be detected in the second sub-sample, which is not present in the first. Finally, the standard deviation of the monetary shock in the second sub-sample is about half the size compared to the first sub-sample. All in all, the IRFs in the second sample period appear more pronounced and more persistent.

In order to test whether these differences are statistically significant or not, we re-estimate an extended version of the baseline VAR by including a vector of dummy variables. These dummy variables take the value zero for the period 1980:1-1996:1 and the value one for the period 1996:2-2006:4:

$$d_t = \begin{cases} 0 & \text{for } t \leq 1996:1 \\ 1 & \text{for } t > 1996:1 \end{cases} . \qquad (4)$$

Figure 7: IRFs to monetary policy shock for sample period 1980:1-1996:1 and for sample period 1996:2-2006:4



More specifically, we extend the VAR system with a dummy variable that interacts with all lags of the endogenous and the (contemporaneous) exogenous variables:

$$y_t = k + A(L)\, y_{t-1} + Bx_t + C(L)\, d_t y_{t-1} + Dd_t x_t + u_t \,. \qquad (5)$$

As equation (5) illustrates, the coefficients on the lagged endogenous variables are equal to $A(L)$ for the period 1980:1 to 1996:1 and $A(L)+C(L)$ for 1996:2 to 2006:4; for the exogenous accordingly the coefficients are B and $B+D$, respectively. Given that our baseline model has two lags we have to estimate ten additional parameters per equation.

In order to evaluate whether the transmission of monetary policy shocks has indeed changed significantly in the past decades we proceed as follows. First, we estimate all coefficients of the matrices *A, B, C* and *D*. In order to get a parsimonious model with sufficient degrees of freedom, we subsequently apply a "general-to-specific" procedure to the matrices *C* and *D*: we test for zero restrictions in the coefficient matrices *C* and *D* and set those coefficients equal to zero consecutively if they turn out to be insignificant.[28] We end up with around half of the coefficients displaying a significant break.[29] Figure 7 displays the impulse responses of the endogenous variables for the two sub-samples obtained from this exercise. For the sake of comparability, we impose the monetary shock to be of the same size in both sub-samples.

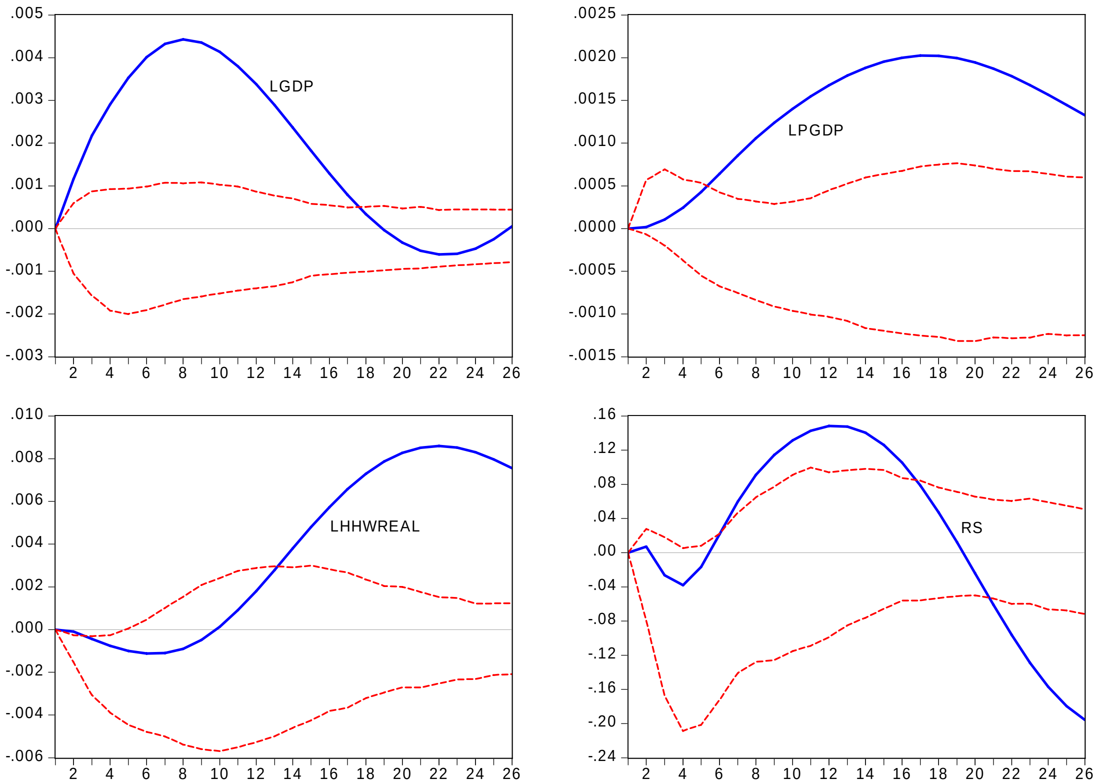
In order to check whether the differences between the IRFs are significantly different from zero we apply a bootstrap procedure: We first estimate equation (5), compute the IRFs for $d_t = 0$ and for $d_t = 1$ and take the difference between the respective IRFs. We then generate bootstrap residuals by randomly drawing them with replacement from the estimated residuals of the complete sample (with $d_t = 1$). Subsequently, the residuals are used to recursively compute bootstrap time series under the null hypothesis of parameter constancy ($d_t = 0$), starting from given pre-sample values. Then, based on the bootstrap

[28] Specifically, we used the System SER procedure implemented in JMulTi, see Lütkepohl and Krätzig (2004). In this procedure, in each step of a sequential elimination process the parameter with the smallest *t*-ratio is checked and potentially eliminated. The decision regarding the elimination has been based on a threshold value of two: only variables with a *t*-ratio larger than the threshold are maintained.

[29] The bootstrap procedure implicitly assumes that the standard deviations of the VAR residuals do not change over time. This assumption is supported by a time series plot of the residuals.

time series equation (5) is re-estimated and the respective IRFs are calculated.[30] For every such bootstrap-iteration the difference between the respective IRFs is calculated. Repeating this many times yields an empirical bootstrap distribution of the difference of the IRF which is used to derive confidence intervals for the differenced IRFs.

Figure 8: Differences between IRFs for sub-sample 1980:1-1996:1 and for sub-sample 1996:2-2006:4 (with 95% confidence interval)



The dashed lines represent 95% standard percentile (1000 bootstrap replications).

The result of this exercise is displayed in Figure 8. It turns out that the IRF-differences of interest are significantly different from zero: After 1996, real GDP reacts significantly faster and stronger, the GDP deflator reacts stronger, the short-term interest rate reaction is more pronounced and the short- to medium-term reaction of real housing wealth is significantly stronger than before.

At this point, it might be helpful to stress that by allowing the possibility of an altered transmission process in the second sub-sample we do *not* restrict the monetary

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[30] Note, under the null hypothesis of parameter constancy the respective impulse response functions should differ only randomly.

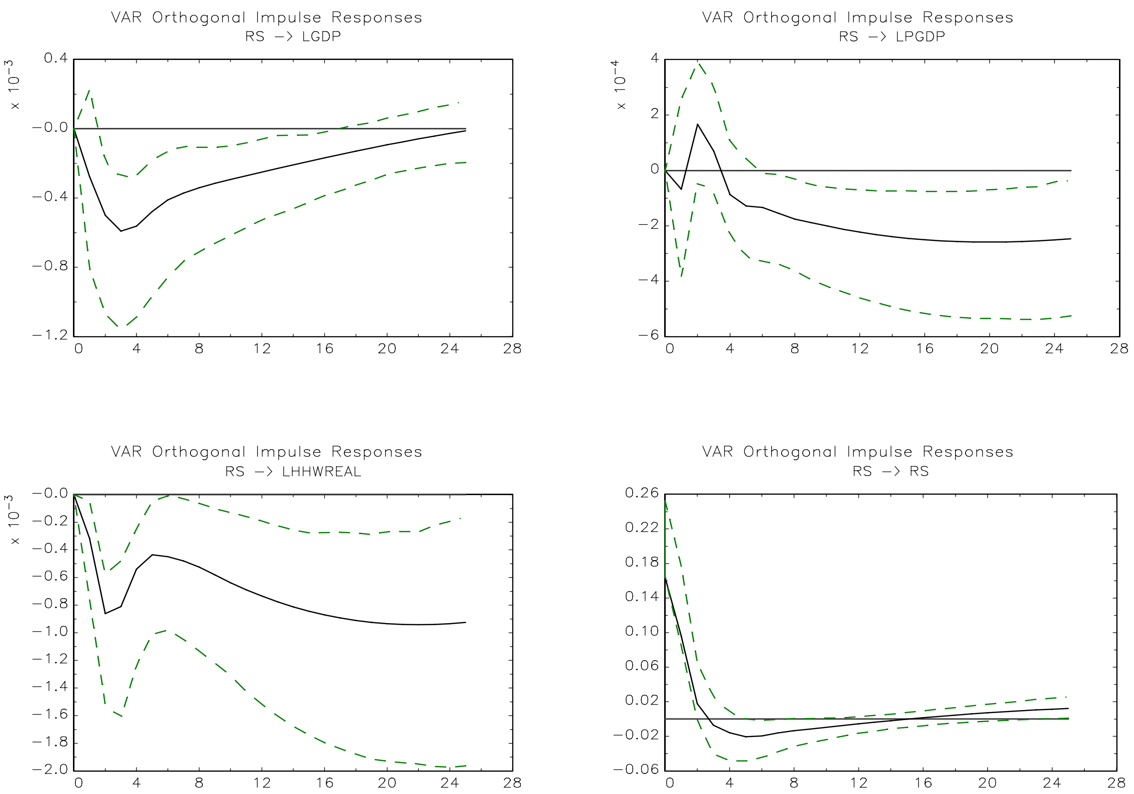
policy reaction function to be the same across the two sub-samples. In fact, we allow virtually all parameters of the (reduced form) reaction function as well as those of all other equations to change, i.e., we do not impose any restriction regarding monetary policy reaction or any other equation. Therefore, every change in the monetary transmission process that we find showed up *despite* the fact that we allowed for changes in the monetary policy reaction function or any other equation of the VAR.

3.4 Sensitivity analysis and robustness checks

In order to check whether the results obtained so far are robust we subsequently vary the econometric setup of our empirical exercise. Specifically, we examine the effects of using alternative break points and different econometric specifications of the VAR. Regarding the latter, we estimate a series of IRFs based on variations of our baseline VAR with additional lags, additional variables or different shock identification schemes. Moreover, we estimate some VAR models not nested in the (augmented) baseline VAR.

- Adding (the log of) M3 or a long-term interest rate does not change the key results. Specifically, we find evidence for significant break points in the sample. Not surprisingly, the exact date of this break point varies somewhat with the specification, but in most cases break points are detected until the mid 1990s or somewhat later.
- Further varying our baseline approach, specifically by using an alternative commodity prices index, substituting CPI (HICP) for GDP deflator, substituting house prices for housing wealth or estimating the variables in differences does not yield notable different insights.
- Using two VAR specifications of Peersman and Smets (2003) that are not nested in our (augmented) benchmark VAR we reproduce our key results. Specifically, when excluding housing wealth and including a real exchange rate instead, we get break points around the mid 1990s and the IRFs in the second sub-sample appear, once again, more pronounced.

Figure 9: IRFs to monetary policy shock for sample period 1999:1 – 2006:4



The dashed lines represent 95% Hall (1992) percentile (1000 bootstrap replications).

As already mentioned, shifting the break point of the two sub-samples between 1990 and 1998 yields qualitatively similar results. In particular, the evidence of stronger impulse responses of output and household wealth in the second sub-sample seems not to depend on choosing a specific split date. In the same vein, starting the sample in 1984 does not yield any noteworthy new insights.[31] This conclusion, however, does not hold if we allow the second sub-sample to start as late as 1999 (Figure 9). In this case, the IRFs turn out to be *smaller* in the second sub-sample than in the first one even if we control for the reduced size of the monetary policy shock. This "switch" is robust to augmenting the VAR by additional variables, i.e. assuming a single break point in 1999 turns our results upside down. Interestingly, this is in line with a recent paper by Boivin, Giannoni and

[31] There is some evidence that the mean of consumer price inflation has changed in the mid 1980s (see Altissimo, Ehrmann and Smets, 2006). Note, our results do not dependent on the aggregation method used for the euro area data. Specifically, if we construct euro area GDP and the euro area GDP deflator with flexible exchange rates does not have a notable effect.

Mojon (2008).[32] Using a factor-augmented VAR they find that the effects of monetary policy shocks on key macroeconomic variables have become *smaller* after 1999 compared to the pre-1999 period. The fact that we can replicate this result is reassuring since it indicates that the use of our small set of variables does not necessarily imply a major loss of important information. Instead, it shows the key role regarding the "choice" of a specific break point: With a break point in 1996, we find that monetary transmission has strengthened, with a break point only three years later, we find the opposite.

3.5 Another break?

Up to now, we (implicitly) assumed only one notable structural change and an associated break in monetary transmission which was endogenously determined to lie around 1996 (or earlier).[33] This is certainly a simplification since structural relationships probably do not change dramatically from one quarter to another but rather take a more or less extended "transition" period.[34] Moreover, we cannot rule out that another notable break or change occurred during the sample period.

However, given the short remaining time span, it is difficult to detect such an additional break point or an interim period with statistical methods (alone). As our Chow tests have already identified a break point in 1996 (and not later), it might be difficult to detect an additional (subsequent) break as the period up to 1999 covers only three additional years. In the following, we therefore take an indirect approach to assess whether there could have been another break point around 1999 or an interim period from 1996 to

[32] Boivin, Giannoni and Mojon (2008) use a factor-augmented VAR (FAVAR) similar to Bernanke, Boivin and Eliasz (2005) in order to jointly model the dynamics of a large set of euro area-wide as well as country-level variables. In the empirical part of the paper they do not restrict themselves to a specific channel or a certain stage of the transmission process but rather look – as we do – at monetary policy transmission as a whole. However, their study differs from ours in that it takes a break point in 1999 as given (obviously, because the authors investigate whether the creation of EMU has had an impact on monetary transmission). We, instead, allow for possible break points in every quarter between the mid 1980s and 2002, and "let the data speak" accordingly.

[33] Yet, such a break point is reasonable from an economic point of view. For instance, in the euro area the exchange rate became unavailable as a monetary policy tool already around 1995. If one takes it for granted that we have witnessed at least one such notable change it is not too surprising that our estimates for the whole sample do not appear fully satisfactory.

[34] The documented change in the relative strength of monetary policy is unlikely to have happened at a specific date. For instance, as regards EMU the fact that monetary regimes in Europe would change on January 1, 1999 was well known before. Hence, agents likely started to prepare quite some time before that event. Further, it is reasonable to assume that these preparations for adjustment were stretched over several years.

1999. More specifically, we re-estimate the extended VAR (equation (5)) with *two* different types of interaction terms (controlling for 1996-1998 and 1999-2006 separately) and calculate the IRFs for the first (1980-1996) and the third sub-period (1999-2006). If the IRFs for 1980-1996 and 1999-2006 are not significantly different from each other – given our previous result of significantly different IRFs for 1980-1996 and 1996-2006 – this could be an indication of another break point around 1999 or likewise of an "atypical" interim period between 1996 and 1999.

Figure 10: IRFs to monetary policy shock for sample period 1980:1-1996:1 and for sample period 1999:1-2006:4

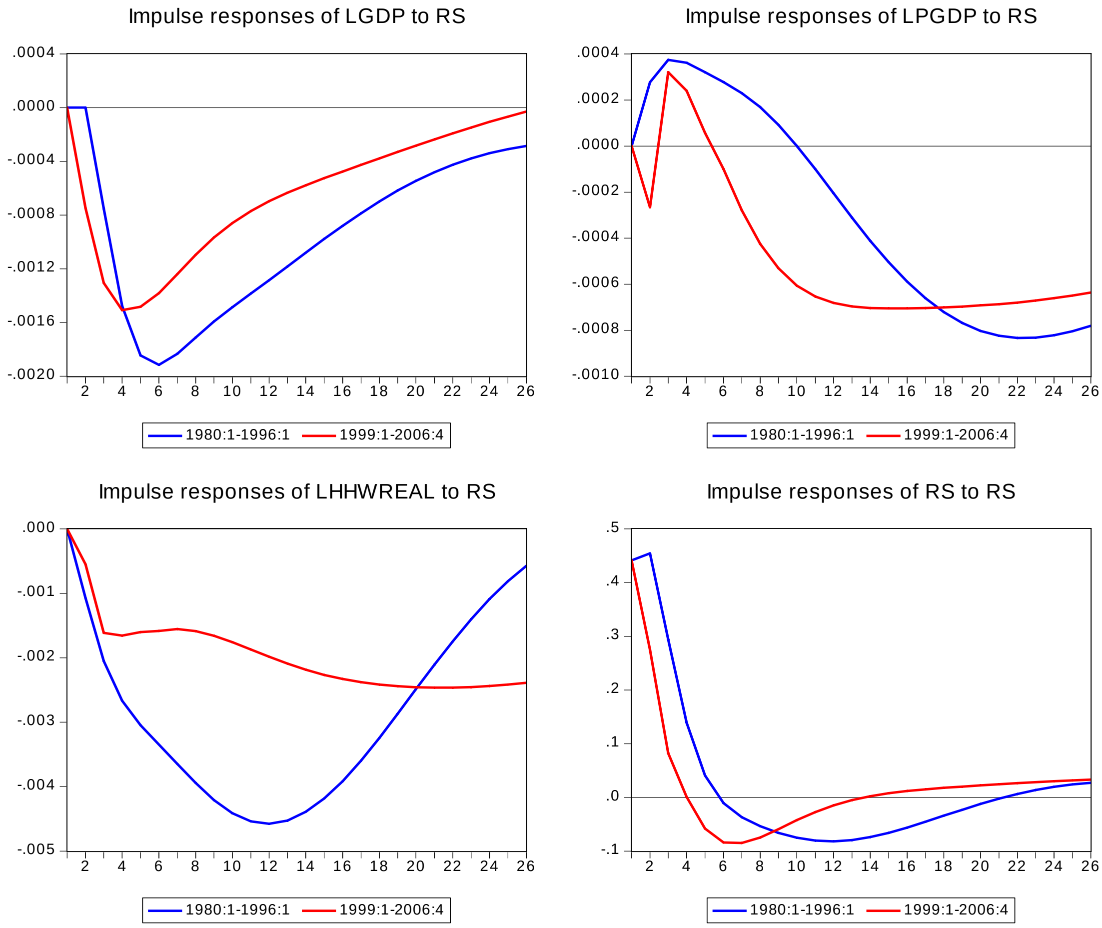
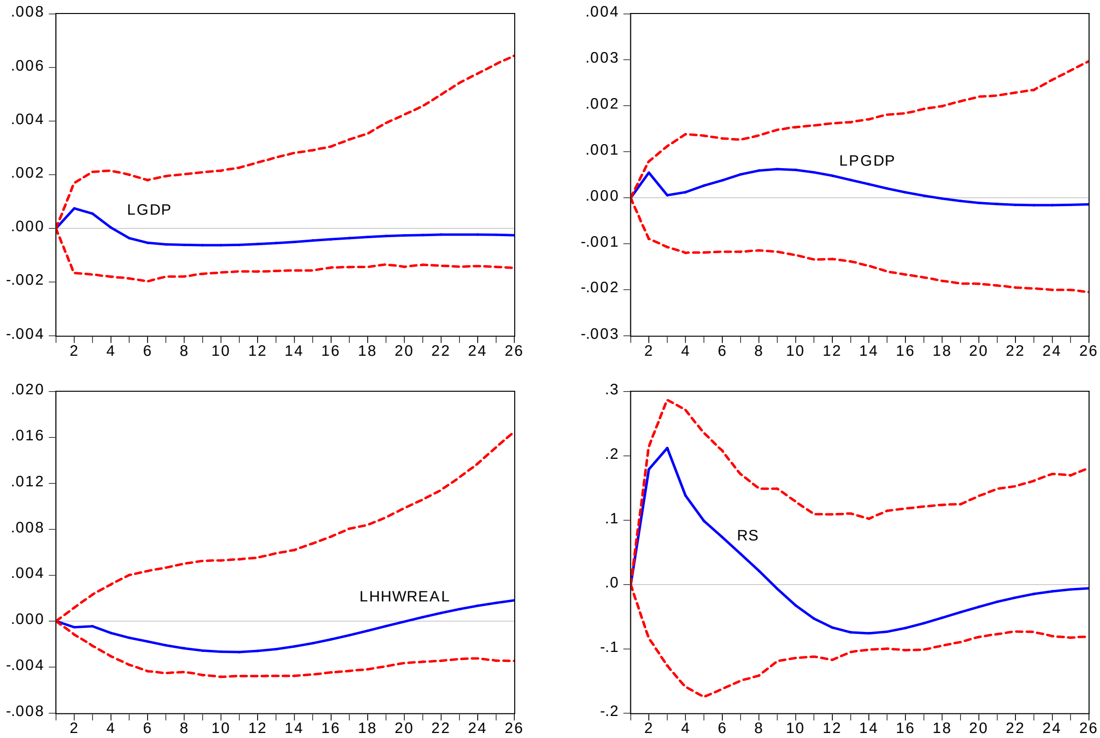


Figure 10 shows the IRFs resulting from this exercise and highlights that both the IRFs for the first period 1980:1-1996:1 and for the third period 1999:1-2006:4 appear quite similar (relative to the differences in Figure 7) – maybe with the exception of the response of housing wealth. Figure 11 displays the differences between these IRFs together with a 95% confidence band and illustrates that none of the differences appear statistically significant, i.e. they do not deviate significantly from zero. Thus, it appears that the IRFs for the first and the third sub-period portray a similar monetary policy transmission. Or, to put it differently, there is (weak) evidence in favour of an "atypical" interim period from 1996:1 – 1998:4 which lies between two more or less similar regimes. Of course, given the short time span from 1999-2006 we should interpret this result with great care.

Figure 11: Differences between IRFs of first sub-sample (1980:1-1996:1) and third sub-sample (1999:1 – 2006:4) with 95% confidence interval



The dashed lines represent 95% standard percentile (1000 bootstrap replications).

Taken at face value, this evidence is compatible with the view that – in the end – the monetary transmission process in the euro area has not changed tremendously: The IRFs for the first period 1980-1996 do not differ notably from those for the third period 1999-2006, while monetary policy was propagated very differently in the interim period. Due to data limitations, however, it is difficult to pin down how exactly the monetary transmission process looked like in that period, but it seems plausible that transmission was faster and stronger than in the other sub-samples. This conclusion basically relies on the observation that by assuming only one break point and merging the interim period with the first sub-period, the IRFs indicate that transmission became weaker; but if we merge the interim phase with the later sub-period, then the results point to a faster and stronger transmission.

In addition one has to keep in mind that all empirical work on the euro area data still suffers from the fact that it relies on rather short time series. At the end of the day, we therefore cannot rule out that the two periods 1980-1996 and 1999-2006 might better characterised by two different regimes displaying two genuine different transmission processes, so that the "*interim* period" is more a "*transition* period" that carries one regime over to the next one.

4 Summary of results and conclusions

We would like to summarise our main findings as follows:

(1) Euro area monetary transmission has undergone notable changes in the mid 1990s; specifically, there is evidence for a structural break occurring around 1996 and possibly a second one around 1999. Estimating a VAR for the whole sample period without controlling for (at least) one of these breaks significantly biases the estimates.

(2) These changes of the monetary transmission process have not altered the long-run responses of real output and inflation to monetary policy: long-run neutrality holds and monetary policy is able to control inflation in the long-run.

(3) Overall, monetary transmission for 1980-1996 is not significantly different from that for 1999-2006.[35] This might be interpreted as evidence in favour of an "atypical" interim period characterized by "fluctuations" or "perturbations" lasting from 1996 to 1999. However, given the data limitations regarding the second period, we cannot rule out that the period 1996 to 1999 characterizes a transition period "connecting" one regime with another one.

These results are robust against a broad range of variations.

[35] The same is true if we start our sample in 1984 and compare 1984-1996 with 1999-2006.

Our endogenously-determined break point in 1996 and the possible interim period 1996-1999 are in principle compatible with all three driving factors that we have discussed in the first half of this paper. As concerns the timing, EMU as well as globalisation and financial innovation could have been decisive for the changes we have documented. However, it is striking that the timing we find by conducting a data-driven analysis is very much in line with the hypothesis that the run-up to EMU has caused "perturbations" or "adjustments" in the data which disappear afterwards. With convergence already starting well before 1999, the joint dynamics of key macro variables in single euro area countries and therefore also in the euro area as a whole might have been different from earlier periods.[36] That – together with other factors like globalisation and financial innovation – could have been responsible for a "break point" well before 1999. The fact that we also find (weaker) evidence for another break date around 1999 points to the possibility that this period of EMU convergence ended with the launch of the euro. Whether the system then really returned to its "previous" structure or whether we are in a new state compared to the pre-convergence period remains an open question. However, our dataset does *not* suggest significant differences in the IRFs.

We find this latter result reassuring since it indicates that our (prior) knowledge about monetary transmission is still useful, despite the break point(s) we found. Especially, our estimates stress that – for all sub-periods – monetary policy ultimately affects prices, but not real activity. Therefore, one of the cornerstones of the Eurosystem's monetary policy strategy, that is, giving price stability clear priority as the goal of monetary policy, was and is still well justified: In the long-run, monetary policy can – and should – anchor inflation and inflation expectations at low levels, but it cannot – and should not – (try to) foster (unsustainable) output growth. This is clearly good news.

This positive assessment applies to the two pillars of the Eurosystem monetary policy strategy as well. Our finding that breaks or an interim period occurred just illustrates that monetary policy always faces considerable uncertainty about the true structure of the economy, about its state and about the impact monetary policy exerts on it (see, for instance, Walsh, 2003). At the end of the day we should take the

[36] In a certain sense, this specific interim period is similar to other periods that have been scrutinized from a monetary policy point of view. Specifically, the interim regime 1996-1998 witnessed similar patterns of disinflation as the time spans after the appointment of Paul Volcker in the United States and the period following the decision of Deutsche Bundesbank to switch to monetary targeting.

recommendations of the growing literature on “monetary policy under uncertainty” to heart: Monetary policy should not concentrate on too narrow a set of indicators and should not ignore important explanations or models for inflation when judging the monetary policy stance or when making monetary policy decisions (see e.g. Deutsche Bundesbank, 2004). Here, the monetary policy strategy of Eurosystem is well suited, since – within its two pillars – it regularly looks at a broad range of indicators for inflationary pressures and takes both, “real” and “monetary” models of inflation into account.

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APPENDIX

Figure A1: Time series included in the VAR analysis

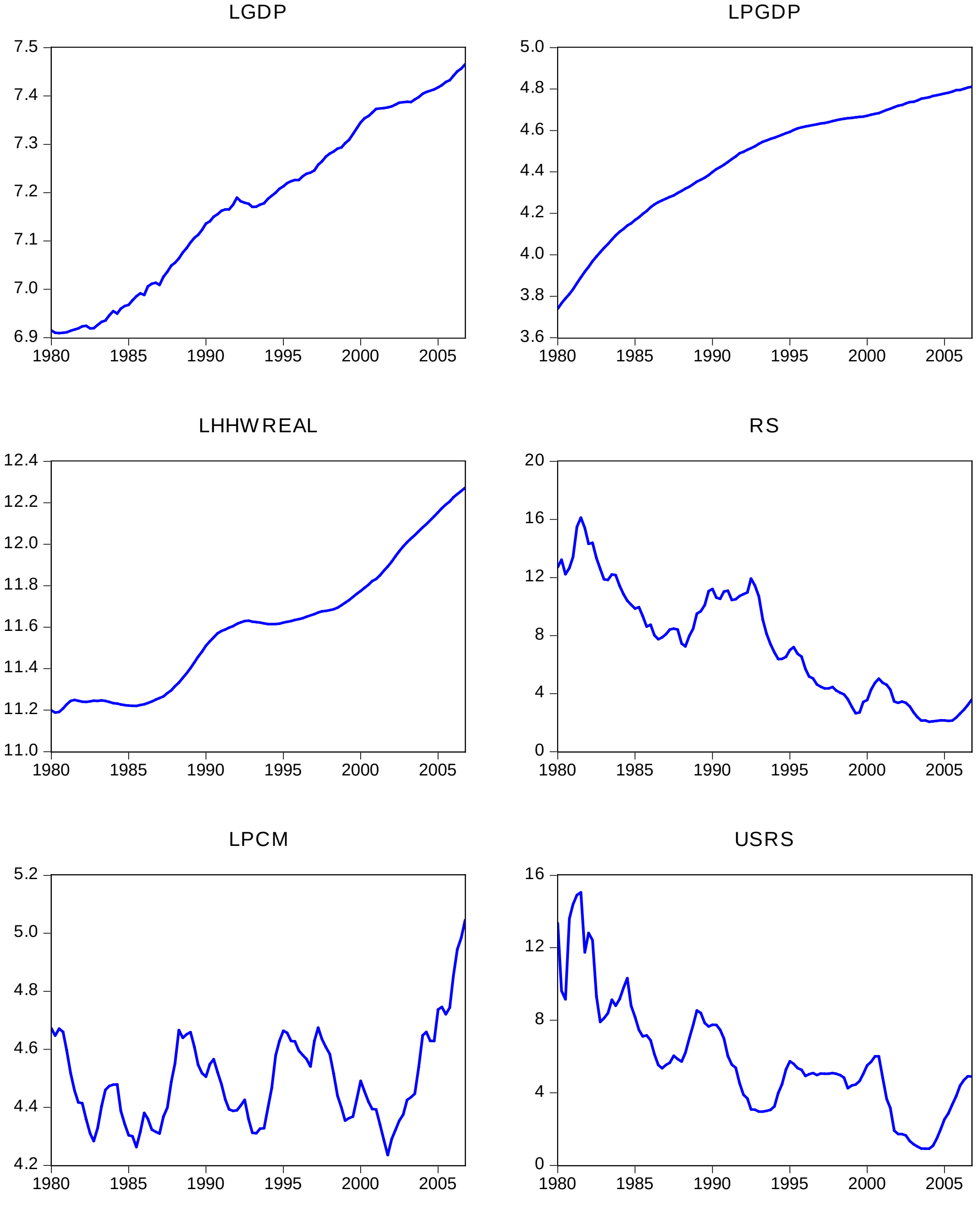

Table A1: Uni-Root-Tests

Augmented Dickey-Fuller test

Null Hypothesis: LGDP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.038485	0.5735
Test critical values:	1% level	-4.046072	
	5% level	-3.452358	
	10% level	-3.151673	

Null Hypothesis: LPGDP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.728000	0.0247
Test critical values:	1% level	-4.047795	
	5% level	-3.453179	
	10% level	-3.152153	

Null Hypothesis: LHHWREAL has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.977471	0.6065
Test critical values:	1% level	-4.047795	
	5% level	-3.453179	
	10% level	-3.152153	

Null Hypothesis: RS has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.698644	0.2394
Test critical values:	1% level	-4.046925	
	5% level	-3.452764	
	10% level	-3.151911	

*MacKinnon (1996) one-sided p-values.

Kwiatkowski-Phillips-Schmidt-Shin test statistic

Null Hypothesis: LGDP is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 8 (Newey-West using Bartlett kernel)

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.104225
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

Null Hypothesis: LPGDP is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 8 (Newey-West using Bartlett kernel)

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.316983
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

Null Hypothesis: LHHWREAL is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 9 (Newey-West using Bartlett kernel)

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.137399
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

Null Hypothesis: RS is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 8 (Newey-West using Bartlett kernel)

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.069537
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Lanne, Lütkepohl and Saikkonen (2002) test

```
UR Test with structural break for series: LGDP
sample range:                   [1980 Q4, 2006 Q4], T = 105
number of lags (1st diff):     2
value of test statistic:      -1.6135
used break date:               1986 Q2
shiftfunction:                 shift dummy
time trend included
critical values (Lanne et al. 2002):
---------------------------------------
 T          1%         5%         10%
---------------------------------------
1000       -3.55      -3.03      -2.76
---------------------------------------
```

```
UR Test with structural break for series: LPGDP
sample range:                   [1980 Q4, 2006 Q4], T = 105
number of lags (1st diff):     2
value of test statistic:      -0.1539
used break date:               1984 Q4
shiftfunction:                 shift dummy
time trend included
critical values (Lanne et al. 2002):
---------------------------------------
 T          1%         5%         10%
---------------------------------------
1000       -3.55      -3.03      -2.76
---------------------------------------
```

```
UR Test with structural break for series: LHHWREAL
sample range:                   [1980 Q4, 2006 Q4], T = 105
number of lags (1st diff):     2
value of test statistic:      -2.6097
used break date:               2001 Q1
shiftfunction:                 shift dummy
time trend included
critical values (Lanne et al. 2002):
---------------------------------------
 T          1%         5%         10%
---------------------------------------
1000       -3.55      -3.03      -2.76
---------------------------------------
```

```
UR Test with structural break for series: RS
sample range:                   [1980 Q4, 2006 Q4], T = 105
number of lags (1st diff):     2
value of test statistic:      -2.5742
used break date:               1981 Q2
shiftfunction:                 shift dummy
time trend included
critical values (Lanne et al. 2002):
---------------------------------------
 T          1%         5%         10%
---------------------------------------
1000       -3.55      -3.03      -2.76
---------------------------------------
```

Figure A2: IRFs for complete sample period (1980:1 – 2006:4) with 95% confidence interval

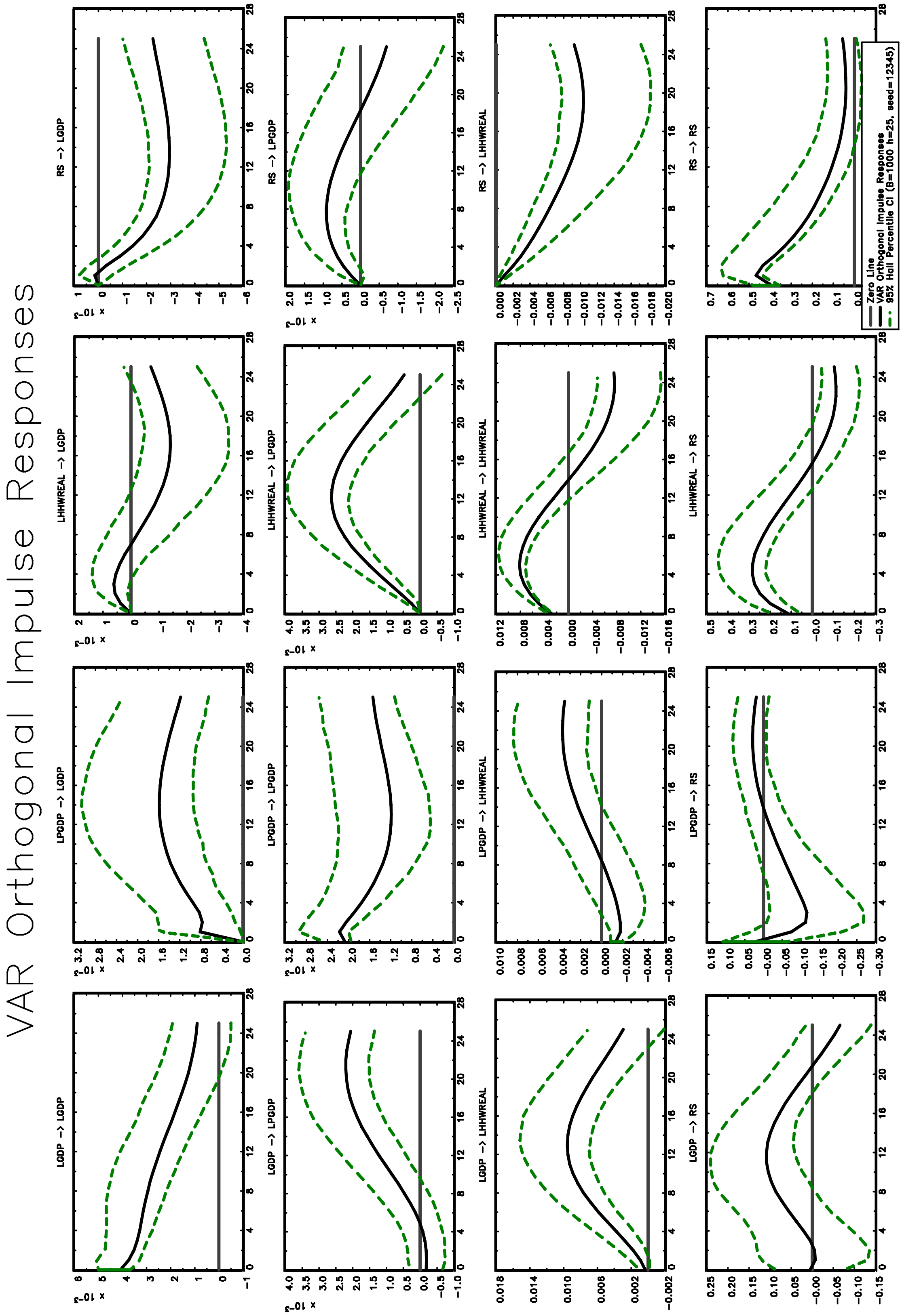

Figure A3: IRFs for sample period 1980:1 – 1996:1 with 95% confidence interval

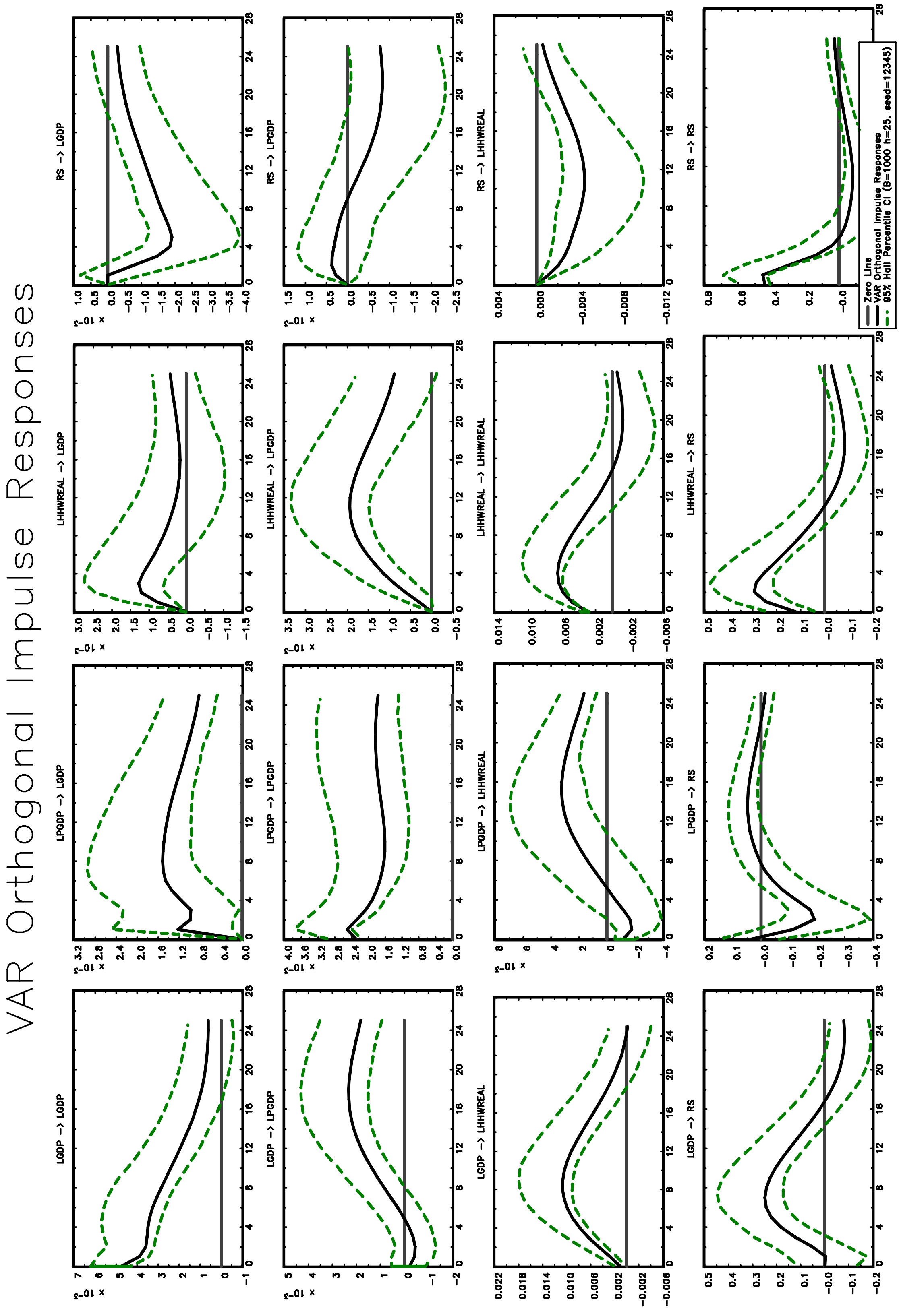

Figure A4: IRFs for sample period 1996:2 – 2006:4 with 95% confidence interval

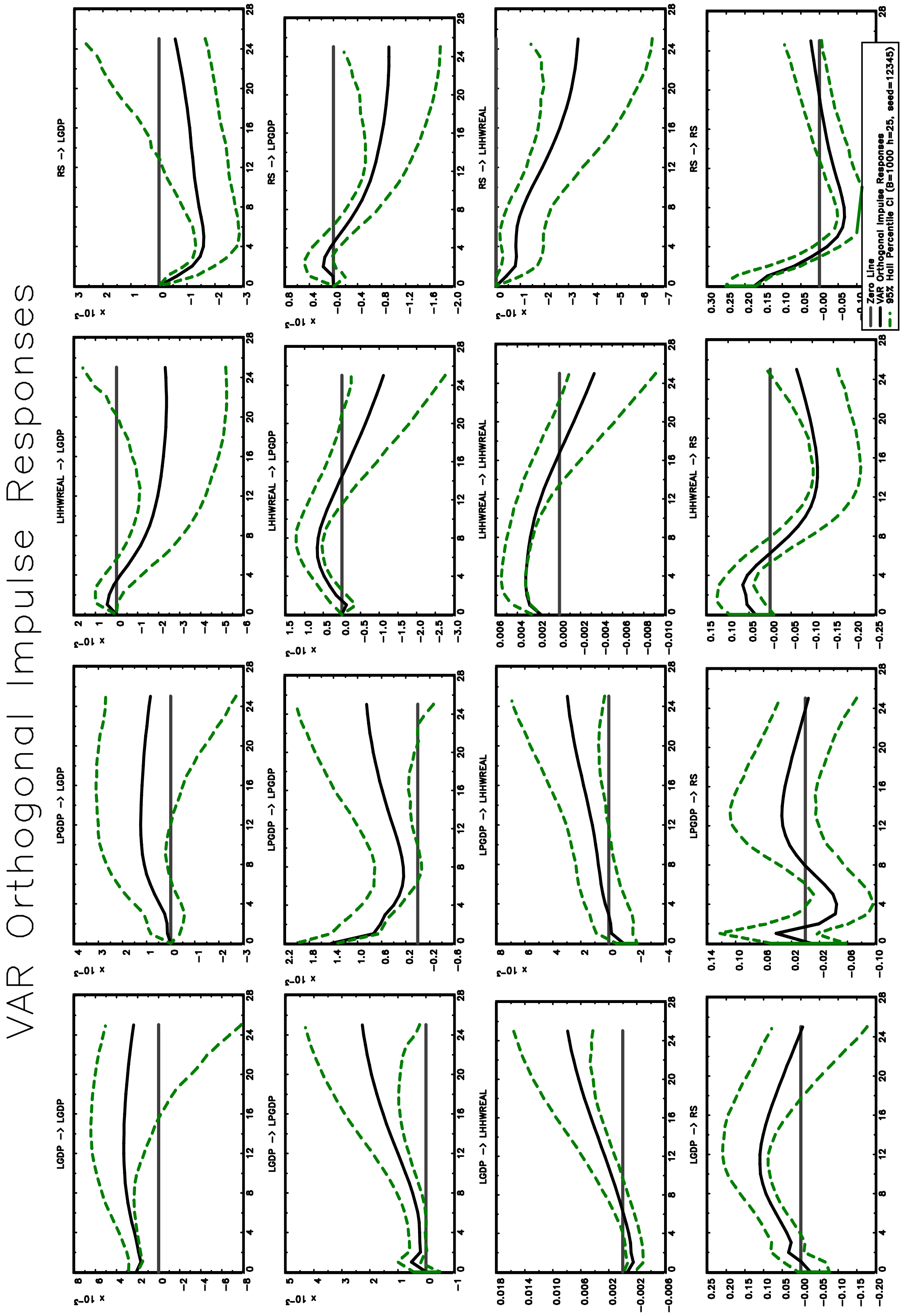

Figure A5: IRFs for sample period 1999:1 – 2006:4 with 95% confidence interval