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Monetary policy, capital inflows and the housing boom

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Abstract

A range of hypotheses have been put forward to explain the boom in house prices that occurred in the United States from the mid-1990s to 2007. This paper considers the relative importance of two of these hypotheses. First, global imbalances increased liquidity in the US financial system, driving down long-term real interest rates. Second, the Federal Reserve kept interest rates low in the first half of the 2000s. Both factors reduced the cost of borrowing and may have encouraged the boom in house prices. This paper develops an empirical framework to separate the relative contributions of these two factors to the US housing market. The results suggest that capital inflows to the United States played a bigger role in generating the increase in house prices than monetary policy loosening. Using VAR methods, we find that compared to monetary policy, the effect of a capital inflows shock on US house prices and residential investment is about twice as large and substantially more persistent. Results from variance decompositions suggest that, at a forecast horizon of 20 quarters, capital flows shocks explain 15% of the variation in real house prices, while monetary policy shocks explain only 5%. In a simple counterfactual exercise, we find that if the ratio of the current account deficit to GDP had remained constant since the end of 1998, real house prices by the end of 2007 would have been 13% lower. Similar exercises with constant policy rates and the path of policy rates implied by the Taylor rule deliver smaller effects.

Key words: House prices, capital inflows, monetary policy.

JEL classification: E5, F3.

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Summary

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The results suggest that capital flows shocks played a much larger role in increasing house prices than monetary policy shocks. We find that compared to monetary policy, the effect of a capital inflows shock on US house prices and residential investment is about twice as large and substantially more persistent. This finding is confirmed by the results of variance decompositions which show that, at a forecast horizon of 20 quarters, capital flows shocks explain 15% of the variation in real house prices, while monetary policy shocks explain only 5%.

A simple counterfactual exercise suggests that if the Federal Reserve had kept policy rates constant since the end of 1998, house prices might have been 8% lower by the end of 2007. Similarly, if policy rates had been set according to the Taylor rule, house prices might have been 5.5% lower. House prices would have been considerably lower (13%) if the ratio of the current account deficit to GDP had remained constant since the end of 1998.

The evidence suggests that global imbalances played an important role in generating the housing boom that characterised the run-up to the current crisis. This result would lend support to calls for the development of policies to prevent the build-up of large current account imbalances in the future, making the international monetary system more resilient to crises like the one we recently experienced.

1 Introduction

The global economy is in a deep recession inflicted by a severe financial crisis. One of the major sources of the financial and economic problems of the past three years was the collapse of a housing boom that had been developing in the United States since the mid-1990s. This paper considers the relative importance of two potential causes of the boom:

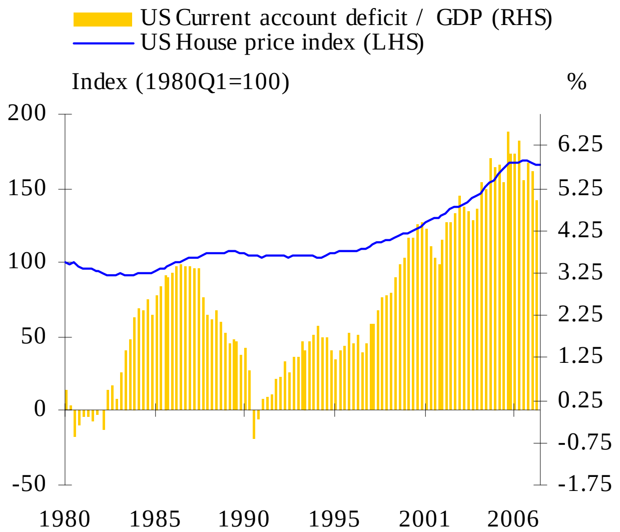
1. Global imbalances. One view is that the housing boom was caused by the increase in capital inflows to the United States that has been occurring since the mid-1990s. During that period, the US current account deficit widened while other countries, especially oil exporters and Asian economies, have been building surpluses. The flow of capital from EMEs to the United States generated an increase in liquidity in the US financial system and drove down long-term real interest rates. Low interest rates reduced the cost of borrowing and encouraged a credit boom and an increase in house prices. Low risk-free rates led portfolio investors to allocate a larger part of their wealth to higher yielding (and riskier) assets, including US sub-prime residential mortgage-backed securities and leveraged corporate loans. This hypothesis is advanced in King (2009) who suggests that 'the origins of the crisis lie in the imbalances in the world economy which build up over a decade or more'.

2. Loose monetary policy in the United States. This explanation also stresses the role of low interest rates in generating the housing boom. However, it attributes the decrease in interest rates to a monetary policy loosening rather than an increase in foreign capital inflows. According to this explanation, a fear of deflation led the Federal Reserve to keep short-term interest rates too low for too long. The reduction in the cost of borrowing encouraged a credit boom and an increase in house prices. This is the view in Taylor (2009), who shows that, since the early 2000s, the Federal funds rate has been significantly lower than the level implied by the Taylor rule.

Both explanations could have some merit. How much weight should we put on each one?

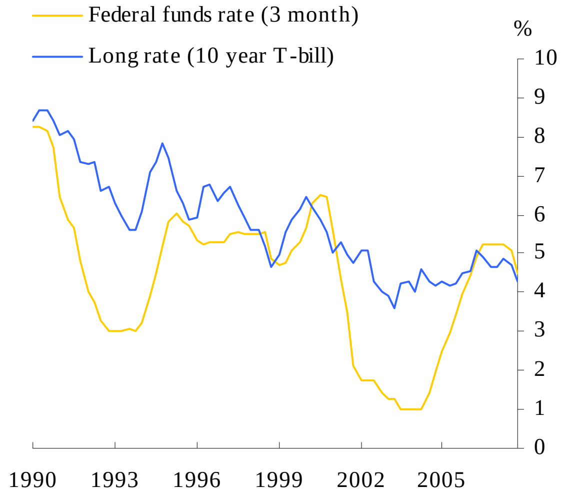
Chart 1 shows the evolution of the US current account balance and house prices. It is clear that the build-up in house prices since the mid-1990s happened at the same time as the widening in the US current account deficit. However, this does not imply causality and does not rule out the possibility of both variables being driven by some third factor.[1]

Chart 1: Current account balance and house prices



Sources: OECD Economic Outlook, Federal Housing Finance Agency (FHFA).

Chart 2: US short-term and long-term nominal interest rates



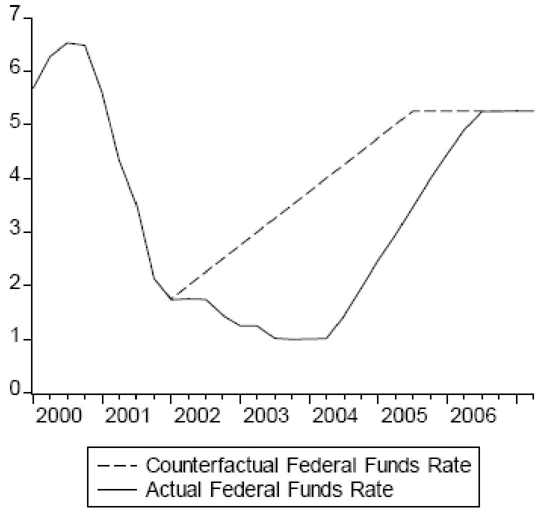
Source: IMF IFS and Federal Reserve Economic Data (FRED).

A piece of suggestive evidence in support of the hypothesis that global imbalances played a central role in the housing boom is the evolution of short and long-term nominal interest rates in the United States (Chart 2). As has been well documented, despite the rise in the short-term interest rate from 2004 until the current crisis, long-term bond yields have remained low — the so-called 'long rate conundrum' (Greenspan (2005)). This can be seen as evidence in favour of the global imbalances story: even though the Fed was increasing policy rates, long rates remained low over a period in which the US current account deficit kept rising. However, there are other factors which may explain the low level of long rates, for example high corporate savings or an increase in monetary policy credibility. And the increase in short rates from 2004 to 2007 does not immediately discard the loose monetary policy story. This story is not simply about changes in short rates, but rather about deviations from the appropriate level of rates as suggested, for example, by the Taylor rule. Chart 3 shows that, even though the Fed has been

[1] At first glance Chart 1 seems to suggest that the relationship between capital inflows and real house prices has become stronger over time. This could be either because this relationship is time-varying or because persistent capital inflows shocks are necessary to create persistent real house price appreciation. Current methods for estimating time-varying VARs cannot handle more than five variables, which makes an analysis of changing transmission mechanisms for both shocks impossible. But capital inflows could have a lagged effect on real house price appreciation. In this case, only persistent capital inflows would lead to persistent real house price appreciation. This could explain why real house price appreciation is much more persistent in the 1990s than in the 1980s.

increasing rates in the period from 2004 to 2007, rates were still kept at a level lower than what would be implied by the Taylor rule.

Chart 3: Actual and counterfactual (Taylor rule) Federal funds rate



Source: Taylor (2009).

A simple look at the data does not allow us to assess which of the two explanations is correct. Because the crisis is still ongoing, there are not yet many studies trying to disentangle its causes and quantify the relative contribution of different factors. In a recent speech, Bernanke (2010) discusses the link between monetary policy and house prices in the run-up to the crisis. Using cross-country evidence, he shows that 'countries in which current accounts worsened and capital inflows rose had greater house price appreciation' in the period 2001 Q4 to 2006 Q3. He concludes that capital inflows seem to be a promising avenue for explaining cross-country differences in house price growth.

There is a relatively large literature on the effect of monetary policy on house prices. Iacoviello (2005) estimates a vector autoregression (VAR) on interest rates, inflation, detrended output and house prices using US data from 1974 to 2003. He identifies monetary policy shocks through a Choleski decomposition and finds that monetary policy shocks have a significant effect on house prices. Del Negro and Otrok (2007) estimate a VAR on the Federal funds rate, the mortgage rate, total reserves of depository institutions, GDP, the GDP deflator, and the common factor of state-level house prices in the United States. The Federal funds rate and the mortgage rate are first differenced while the other variables are in growth rates. They adopt a different identification strategy from Iacoviello and use sign restrictions on the impulse responses to identify monetary policy shocks. The house factor shows a significant and persistent drop following a contractionary monetary policy shock. However, in a counterfactual exercise, Del Negro and Otrok simulate the evolution of the house factor in the absence of monetary policy shocks and find a small difference between the actual and the simulated series. This suggests that the impact of monetary policy shocks on house prices is small in comparison with the magnitude of recent fluctuations. Jarociński and Smets (2008) estimate a nine-variable VAR for the United States and identify monetary policy shocks using a combination of zero restrictions and sign restrictions. They find that a monetary policy shock which reduces the Federal funds rate by 25 basis points generates an immediate reduction in real house prices. The reduction reaches its peak of about 0.5% two and a half years after the shock.

There are also some studies looking at the effect of capital flows on US interest rates. Warnock and Warnock (2009) estimate that, if there had been no foreign official flows into US government bonds over the course of a year, long rates would be almost 100 basis points higher. Focusing on the spread between long-maturity corporate bond and Treasury bond yields, Krishnamurthy and Vissing-Jorgensen (2007) find that, if governmental holders (foreign central banks, US Federal Reserve banks, state and local governments) were to sell their holdings of US Treasuries and exit the market, the yield on US Treasuries would rise by the same amount as the yield on corporate bonds. Caballero and Krishnamurthy (2009) develop a model to show how capital flows to the United States triggered a sharp rise in asset prices and a decrease in risk premia and interest rates. All these studies point to a link between low US long interest rates and the demand for US assets by foreign savers.

The study that is closest to ours is Bracke and Fidora (2008) which explains the evolution of the US current account balance and asset prices by three types of shocks: monetary policy shocks, preference shocks (capturing changes in the savings rate), and investment shocks. The authors estimate two separate structural VARs, for the United States and emerging Asia. For the United States they look at a monetary policy expansion, a reduction in the savings rate and an increase in investment. For emerging Asia they define these shocks with the opposite signs (monetary policy contraction, increase in the savings rate and reduction in investment). The shocks are identified by imposing sign restrictions on the impulse responses. It is assumed that a reduction in the savings rate in the United States would lead to an increase in short-term interest rates, permitting the use of this variable to differentiate between preference shocks and monetary shocks (which would lead to a reduction in short-term interest rates). The findings suggest that monetary shocks explain the largest part of the variation in the US current account balance and asset prices.

We should note that Bracke and Fidora (2008) do not differentiate between the global imbalances and monetary policy hypotheses. When identifying the effect of a reduction in savings in the United States, they do not take into account the fact that there is also an increase in capital flows from the rest of the world. Therefore, it is not clear that interest rates should rise when the United States is saving less. In addition, if the preferences shock is permanent it should affect long-term rather than short-term interest rates.

Our paper develops an empirical framework to identify the relative contributions of global imbalances and monetary policy to the housing boom. We estimate a VAR model for the United States and identifying the effect of two types of shocks: a monetary policy expansion and an increase in capital inflows. Identification is achieved by imposing sign restrictions on the impulse responses, as in Uhlig (2005). To capture the housing boom that occurred in the run-up to the current crisis, the model includes residential investment and an index of real house prices.

Consistent with the evidence in Bernanke (2010), our results suggest that capital flows shocks have a significant and positive effect on residential investment and real house prices, while the effect of monetary policy shocks is smaller and less significant. One way of comparing the effects of the two types of shocks is by computing the fraction of the variation in house prices explained by each type of shock. We find that, at a forecast horizon of 20 quarters, capital flows shocks explain 15% of the variation in real house prices, while monetary policy shocks explain only 5%.

In addition to looking at impulse responses and variance decompositions, we perform a number of counterfactual exercises. We simulate the path of real house prices if the Federal Reserve had kept policy rates constant since the end of 1998 and find that house prices would have been 8% lower by the end of 2007. Similarly, if policy rates had been set according to the counterfactual path given by the Taylor rule in Chart 3, house prices would have been 5.5% lower. House prices at the end of 2007 would have been considerably lower (13%) if the ratio of the current account balance to GDP had remained constant since the end of 1998. These results are robust to the inclusion of non-US variables in the model.

The paper is structured as follows: Section 2 describes the model and the data, Section 3 discusses identification, Section 4 presents the results of the baseline model and Section 5 discusses the counterfactuals. The robustness of the results to the inclusion of foreign variables is studied in Section 6 and Section 7 concludes.

2 Model

We estimate the following VAR model for the United States:

$$Y_t = c + \sum_{k=1}^{L} A_i Y_{t-k} + u_t \quad t = 1, ...T \quad u_t \sim N(0, \Sigma) \tag{1}$$

where c is a constant term, L is the lag length, Y_t is a vector of endogenous variables, A_i is a matrix of coefficients and u_t is the error term. The vector Y_t contains ten endogenous variables:

$$Y_t = [i_t^s \; i_t^l \; GDP_t \; P_t \; R_t \; CP_t \; CA_t \; E_t \; RInv_t \; H_t]$$

where i_t^s and i_t^l are short-term and long-term nominal interest rates,[2] GDP_t is real GDP (in logs), P_t is the GDP price deflator (in logs), R_t is the level of total reserves of depository institutions (in logs), CP_t is a commodity price index (in logs), CA_t is the ratio of the current account balance to GDP, E_t is the dollar nominal trade-weighted exchange rate (in logs), $RInv_t$ is residential investment, and H_t is an index of real house prices (in logs) deflated by the GDP deflator. Table A lists the variables and data sources. The model is estimated with four lags on quarterly data from 1975 Q1 to 2007 Q4.

The first eight variables in the VAR were chosen to help identify monetary policy shocks and capital flows shocks. The next section discusses how we can rely on theory to derive predictions for how these variables should respond to the two types of shocks. The last two variables were chosen to capture the housing boom in the run-up to the current crisis.

[2] We use nominal and not real interest rates to follow standard practice in monetary policy VARs. See, for example, Sims (1992) and Christiano, Eichenbaum and Evans (1999).

Private residential investment is obtained from the Federal Reserve Economic Data (FRED). House prices are measured by the national house price index (HPI) constructed by the Federal Housing Finance Agency (FHFA, previously called OFHEO), deflated by the GDP deflator. This is a repeated-sales index, measuring average price changes in repeated sales or refinancings on the same properties. The use of repeated transactions helps to control for differences in the quality of the properties included in the sample. For this reason the HPI is described as a 'constant quality' HPI. It includes single-family properties whose mortgages have been purchased or securitised by Fannie Mae or Freddie Mac since January 1975. The evolution of this index is plotted in Chart 1, which shows that house prices have substantially increased since the late 1990s.

Table A: Variables and data sources

Variables	Description	Source
i_t^s	Federal funds rate (three month)	IMF IFS
i_t^l	Treasury bill rate (ten year)	IMF IFS
GDP_t	Real GDP	FRED, code GDPC96
P_t	GDP deflator	FRED, code GDPDEF
R_t	Total reserves	FRED, code TOTRESNS
CP_t	Commodity price index	Datastream
CA_t	Ratio of current account balance to nominal GDP	OECD *Economic Outlook*
E_t	Dollar nominal effective exchange rate	IMF IFS
$RInv_t$	Residential investment	FRED, code PRFI
H_t	Real house price index	FHFA index deflated by GDP deflator

The model has a large number of coefficients to be estimated. To increase the precision of our estimates, we impose priors on the coefficients. In particular, we use the prior suggested in Litterman (1986), often referred to as the Minnesota prior. Banbura, Gianonne and Reichlin (2007) provide a very intuitive explanation for this type of prior and show that its application to large Bayesian VARs results in good forecasting performance.

The basic principle behind the Minnesota prior is that the variables in the VAR are 'centred' around a random walk with a drift so that the prior mean can be associated with the following representation for Y_t :

$$Y_t = c + Y_{t-1} + u_t$$

This corresponds to shrinking the diagonal elements of A_1 in model **(1)** towards one and shrinking the off-diagonal coefficients as well as the coefficients in A_2, ..., A_L towards zero.[3] This prior is appropriate for variables that show a high degree of persistence, but is not appropriate for variables believed to be characterised by substantial mean reversion. Therefore, for short and long-term interest rates and the exchange rate we impose the prior of white noise by setting the prior mean equal to zero.

3 Identification

3.1 Sign restrictions: methodology

We are interested in identifying two types of shocks: an expansionary monetary policy shock and an increase in capital flows to the United States. The common identification problem in VAR models is that some restrictions need to be imposed on the covariance matrix in order to identify the structural shocks. Model **(1)** is the reduced form version of the structural model, where innovations are given by the vector v, with $E(vv') = I$. What is needed is to find a matrix B such that $u_t = Bv_t$, where the jth column of B represents the immediate impact on all variables of the jth structural shock, one standard error in size. The only restriction on B comes from the variance-covariance matrices of the reduced and structural form shocks:

$$\Sigma = E(u_t u_t') = E(Bv_t v_t' B') = BB' \quad \textbf{(2)}$$

This leaves many degrees of freedom in specifying B and hence further restrictions are necessary to achieve identification. The usual methodology is to impose a certain ordering on the sequencing of shocks — Choleski decomposition. This corresponds to imposing zero restrictions on the contemporaneous interactions between variables, for example assuming that output does

[3]To set the shrinkage parameter, we follow the approach in Banbura, Gianonne and Reichlin (2007) and choose it such that the in-sample fit of the model is the same found with a ‘smaller’ VAR. We estimate two smaller VARs: one with the short-term and the long-term interest rates and another with the short-term interest rate and the ratio of the US current account balance to GDP. Both give a shrinkage parameter of about 0.08.

not respond contemporaneously to changes in interest rates. However, theory does not always provide guidance on what the ordering should be.

Many studies have appealed to the reasonableness of the impulse responses as an 'informal' identification criterion and choose an ordering which delivers results consistent with conventional wisdom. However, it is preferable to be explicit about the identifying restrictions. This can be achieved with the method developed by Canova and de Nicoló (2002), Faust and Rogers (2003), Peersman (2005) and Uhlig (2005) of imposing sign restrictions on the impulse responses. The idea is to rely on economic theory to derive 'reasonable' signs for the impulse responses. We derive two sets of sign restrictions: one consistent with how theory predicts the variables in the VAR would respond to an expansionary monetary policy shock, and another consistent with how they would respond to an increase in capital flows. We choose different matrices B which satisfy condition **(2)** and, for each choice of B, generate the implied impulse response functions. Finally, we check whether the sign restrictions are satisfied and keep the impulse responses which satisfy the sign restrictions.[4]

To strike a balance between relying on theory to select impulse responses that look 'reasonable' and allowing the data to speak for itself, we impose a parsimonious set of sign restrictions. In particular, we do not impose any restrictions on the responses of residential investment and house prices, which are the variables we chose to capture the run-up to the current crisis. Instead, we leave them unrestricted and rely on the other variables for identification.

3.2 Theoretical and empirical validity of the sign restrictions

3.2.1 Monetary policy shocks

There is a large literature on the effects of monetary policy shocks. Bernanke and Mihov (1998) show that it is important to include both the Federal funds rate and reserves of depository institutions in the model to account for changes in the monetary policy regime. They show that the Federal Reserve changed from targeting bank reserves between late 1979 and 1982 (the 'Volcker experiment') to targeting the Federal funds rate in the Greenspan period. We therefore

[4]We have repeated the algorithm until we keep 100 impulse responses for each of the shocks. The results with an acceptance threshold of 1,000 are very similar.

estimate the model with total reserves, which measure credit extended by the Federal Reserve to depository institutions through the regular discount window and other liquidity facilities. The index of commodity prices is included as a non-policy variable in order to capture additional information available to the Federal Reserve about the future course of inflation. Exclusion of this variable tends to lead to the so-called 'price puzzle', ie the finding that monetary tightening leads to a rising rather than a falling price level (Sims (1992)).

The sign restrictions used to identify monetary policy shocks are shown in the first column of Table B. The restrictions on the responses of real GDP and the price level are relatively uncontroversial: we assume that output and the price level do not fall following an expansionary monetary shock. This is consistent with the findings in Canova and de Nicoló (2002) who show that, under a variety of different models, output and prices rise following an expansionary monetary policy shock.

Table B: Identifying sign restrictions

Variables	Monetary policy shocks	Capital flows shocks
i_t^s	≤ 0	
i_t^l		≤ 0
GDP_t	≥ 0	
P_t	≥ 0	
R_t	≥ 0	
CP_t		
CA_t		≤ 0
E_t	≤ 0	≥ 0
$RInv_t$		
H_t		

The restriction that the exchange rate does not appreciate following a monetary expansion is also uncontroversial. It is consistent with a simple Mundell-Fleming model with free capital mobility and with open economy macroeconomic models with intertemporal optimisation and sticky prices, in the tradition of Obstfeld and Rogoff (1995) (henceforth OR).[5] In the simple Mundell-Fleming model, a reduction in US interest rates would lead to capital outflows and an

[5]See Lane (2001a) for a survey of the new open economy macroeconomics literature.

improvement in the current account balance. Demand for dollars would fall, generating a depreciation. In OR a monetary expansion also leads to an exchange rate depreciation. This model has been extended along several dimensions and the prediction that a monetary expansion leads to a depreciation of the exchange rate has remained unaffected. For example, Betts and Devereux (2001) extend the model to include pricing to market, ie, prices set in the currency of the buyer. They conclude that a monetary expansion leads to a depreciation of the *nominal* exchange rate both with and without pricing to market. With pricing to market the *real* exchange rate also depreciates. This effect on the real exchange rate is not possible without pricing to market because in that case the law of one price would hold and the real exchange rate would remain constant. Tille (2001) extends OR to consider different degrees of substitutability between home and foreign goods. OR study the special case where the elasticity of substitution between home and foreign goods is larger than one. Tille (2001) shows that the conclusion that a monetary expansion leads to a depreciation carries through to the case where this elasticity is equal or greater than one. Lane (2001b) adapts the OR model to a small open economy with traded and non-traded goods and also finds that a monetary expansion leads to a depreciation.

Unlike for the exchange rate, the effect of a monetary expansion on the current account is heavily dependent on the parameters of the model. In a simple Mundell-Fleming model, the depreciation generated by a monetary expansion would lead to an improvement in the current account if the Marshall-Lerner condition is satisfied. Devereux (2000) shows that a similar condition must hold in an intertemporal optimisation model similar to OR: if the *elasticity of substitution between home and foreign goods* is greater than one, a depreciation shifts world spending towards home goods and improves the current account; the opposite happens if the elasticity of substitution between home and foreign goods is smaller than one. This model is then extended to consider the effect of pricing to market. When all prices are set in the currency of the buyer, a depreciation does not alter the prices paid by consumers. Therefore, the effect on the current account does not depend on the elasticity of substitution between home and foreign goods. However, a depreciation increases relative home income by increasing the export revenue of home firms and decreasing the export revenue of foreign firms. The increase in relative home income reduces the real interest rate at home and leads to an increase in present consumption and a fall in future consumption. The effect on the current account depends on the *elasticity of intertemporal substitution*: when the elasticity of intertemporal substitution is equal to one, the increase in present consumption equals the increase in relative home income and the current account remains unchanged; when the elasticity of intertemporal substitution is smaller (greater) than one, the increase in present consumption is smaller (greater) than the increase in real income and the current account improves (deteriorates). In the intermediate case of partial pricing to market, the effect on the current account depends on the relative strength of the elasticity of substitution between home and foreign goods and the intertemporal elasticity of substitution. A similar conclusion is derived in Lane (2001b) for a small open economy.

There is a significant amount of empirical work testing the effects of monetary shocks on the exchange rate and the current account. Eichenbaum and Evans (1995) find that a contractionary monetary policy shock in the United States leads to a persistent and significant appreciation of the dollar. Zettelmeyer (2004) finds the same result for Australia, Canada and New Zealand. Betts and Devereux (2001) estimate VARs on US and G7 variables and identify monetary shocks using a Choleski decomposition. They find that expansionary monetary shocks generate an exchange rate depreciation. Lane (2001b) focuses on the effect on the current account using long-run restrictions. He finds that the current account initially deteriorates following a monetary expansion, but quickly starts to improve and moves into surplus after about a year. Prasad (1999) estimates a structural VAR for G7 countries and also identifies monetary policy shocks using long-run restrictions. He finds that a monetary expansion leads to an exchange rate depreciation and an improvement in the current account. Lee and Chinn (2006) confirm this finding in a VAR for 67 countries. Bems *et al* (2007) estimate a VAR for the United States and identify monetary shocks using a Choleski decomposition. They confirm that a monetary expansion leads to a depreciation of the exchange rate, but find that it also causes a deterioration in the current account. Barnett and Straub (2008) arrive at a similar conclusion using a VAR with sign restrictions.

Since the effect of a monetary policy shock on the current account is theoretically and empirically uncertain, we do not impose any sign restrictions on the response of the current account and rely on other variables for identification. To let the data speak for itself, we allow for the possibility that these variables may not respond to the shock. All that is required is that they do not move in a direction contrary to that predicted by theory. Therefore, we impose that, following an expansionary monetary policy shock, the short-term interest rate does not increase, GDP and the price level do not fall, bank reserves do not fall, and the dollar does not appreciate.[6]

[6]Instead of focusing on the current account we could look at capital flows. We chose to focus on the current account since data on capital

Apart from deciding on the sign restrictions, we also need to decide over how many quarters we want to impose them. Following Uhlig (2005), we impose the sign restrictions for four quarters after the shock for all variables except output and prices, which have been shown to react with a lag (for example, in Christiano, Eichenbaum and Evans (1999)). For these two variables we impose the sign restrictions for four quarters, two quarters after the shock.[7]

3.2.2 Capital flows shocks

We understand a capital inflows shock to be an unexpected increase in foreigners' demand for US assets. The widening in the US current account deficit documented in Chart 1 was accompanied by an increase in surpluses in oil exporting and East Asian countries, especially China. A number of factors have been discussed as potential drivers of these imbalances. For example, Asian households may be saving more for precautionary reasons given the low levels of social security provision by the state. Imbalances may also be driven by the adoption of a managed exchange rate policy by China, with an aim to keep its exchange rate low and gain competitiveness in export markets. Asian economies may also be accumulating dollar reserves as self-insurance against crises. Another possibility is that foreign investors invest in the United States because of its developed financial market, which offers a greater variety of assets and more liquidity. Although these factors are quite distinct, we argue that the consequences for the US economy and in particular the housing sector should be similar. In all cases lower domestic interest rates should lead to an expansion in domestic credit and a boom in housing activity.

The large current account deficit of the United States during this decade led to a debate on the sustainability of global imbalances. The focus of these studies was on the magnitude of the dollar depreciation that would be required to reduce the size of imbalances. Some studies (for example, Blanchard, Giavazzi and Sá (2005) and Obstfeld and Rogoff (2005)) found that global imbalances would not persist because the United States would need to stabilise its external debt level, which would require a large depreciation of the dollar. Other studies found that global imbalances could persist for a long period of time because of differences in financial market development that make US assets attractive to foreign investors (for example, Caballero *et al*

flows tends to be more volatile due to measurement problems.

[7]We have also estimated the model imposing the sign restrictions only on the first quarter after the shock and the results did not change substantially.

(2008) and Forbes (2010)) or because of a persistent return differential between US and foreign assets - the so-called ‘exorbitant privilege’ (Gourinchas and Rey (2007)).

While these studies focused on the sustainability of global imbalances, not much has been written about the potential consequences of the increase in capital inflows for the US economy. Caballero *et al* (2008) develop a theoretical framework for analysing the implications of an increase in capital flows. The model contains two regions: the United States and the rest of the world. These two regions are initially symmetric and have the same degree of financial development, ie the same capacity to generate financial assets from real investments. The model can be used to analyse the implications of two phenomena: a reduction in the degree of financial development in the rest of the world following, for example, a collapse in its asset markets; and a gradual integration and emergence of fast-growing economies in the rest of the world. Both phenomena have the same implications, generating a current account deficit in the United States and a decline in long-term interest rates. The dollar appreciates in the short run and depreciates gradually until it stabilises in the long run.

Similar qualitative predictions are obtained in Sá and Viani (2010), who use a general equilibrium model to simulate the implications of a reduction in the preference of foreign investors for US assets, ie a reduction in capital inflows. The model shows that, if foreign investors invest a smaller share of their wealth in dollar assets, the dollar would depreciate in the short run and the current account would improve. The price of US assets would fall and the return would increase.

We rely on these studies to derive the sign restrictions in the second column of Table B. We assume that an increase in capital inflows does not lead to an increase in the long-term interest rate, a reduction in the current account deficit or a depreciation of the dollar in the short run. These restrictions are imposed for four quarters after the shock.

To be able to isolate the effects of capital flows shocks, we need to ensure that the sign restrictions are able to identify these shocks uniquely, ie, that the same set of restrictions could not be picking up the effect of other shocks. The effects of a positive productivity shock on the exchange rate and the current account are similar to those of an increase in capital inflows. An increase in productivity in the United States would make investment there more attractive and lead to capital inflows and a dollar appreciation. Glick and Rogoff (1995) develop a model in which country-specific positive productivity shocks cause a deterioration on the current account. Bems *et al* (2007) confirm this result empirically using a VAR on US data. Hence, the responses of the current account and the exchange rate do not allow us to distinguish between productivity and capital flows shocks. The key variable that differentiates the two types of shocks is the long-term interest rate. While an increase in capital inflows reduces the long-term interest rate, an increase in productivity leads to an increase in the marginal product of capital, pushing up long-term interest rates.[8]

4 Results

Chart 4 shows the impulse responses over ten years obtained from model **(1)** following an expansionary monetary policy shock and an increase in net capital inflows. The solid vertical lines indicate the horizon for which sign restrictions were imposed. We plot the median and the 16% and 84% quantiles of the posterior distribution of impulse responses. If the distribution was normal, these quantiles would correspond to a one standard deviation band.

[8]A positive productivity shock may also affect monetary policy through its impact on inflation. An increase in productivity has two counteracting effects on inflation. First, it reduces the cost of production for firms, at least in the adjustment period while wages and interest rates do not adjust to reflect the increase in productivity. Profit margins increase and firms are able to reduce prices. At the same time, an increase in productivity may lead to an increase in aggregate demand, which would generate upward pressure on inflation. This increase in aggregate demand may come from different sources: higher profits increase stock market gains and consumer wealth, consumers may perceive that the increase in productivity will lead to higher wages, and firms may increase investment in response to the higher level of productivity. Because of these two counteracting forces, the net effect of a positive productivity shock on inflation is unclear. If it turns out that the shock is deflationary, the monetary authority may respond by reducing policy rates, which would bring down long-term interest rates, mitigating the increase due to higher marginal product of capital. If the net effect on the long-term interest rate is negative our sign restrictions would not be able to distinguish between productivity and capital flows shocks. However, this seems an unlikely scenario. It relies on the assumption that productivity increases are deflationary and the response of the monetary authority leads to a reduction in long rates that more than offsets the increase due to productivity gains.

Chart 4 (a): Impulse responses to monetary policy shocks

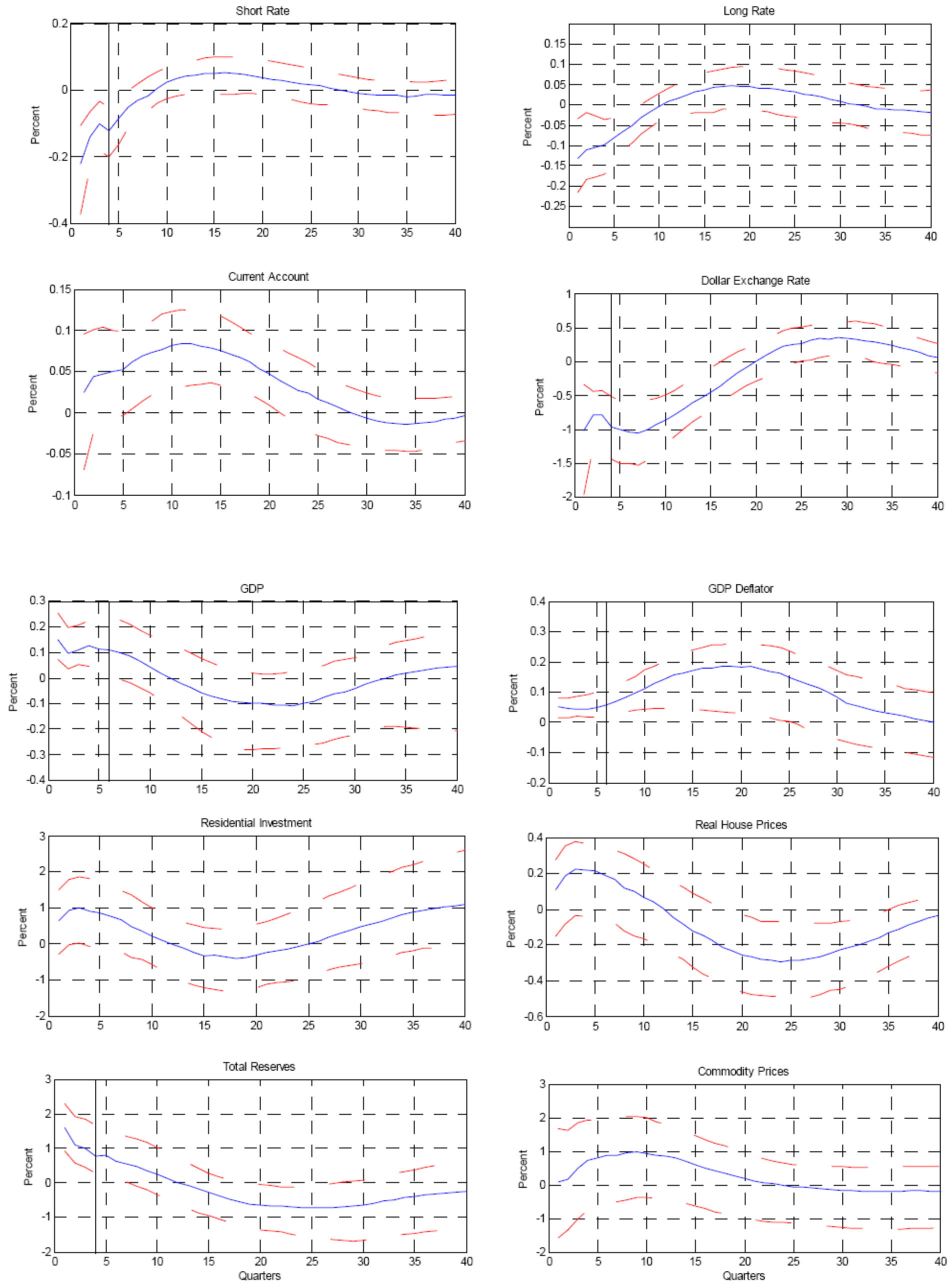
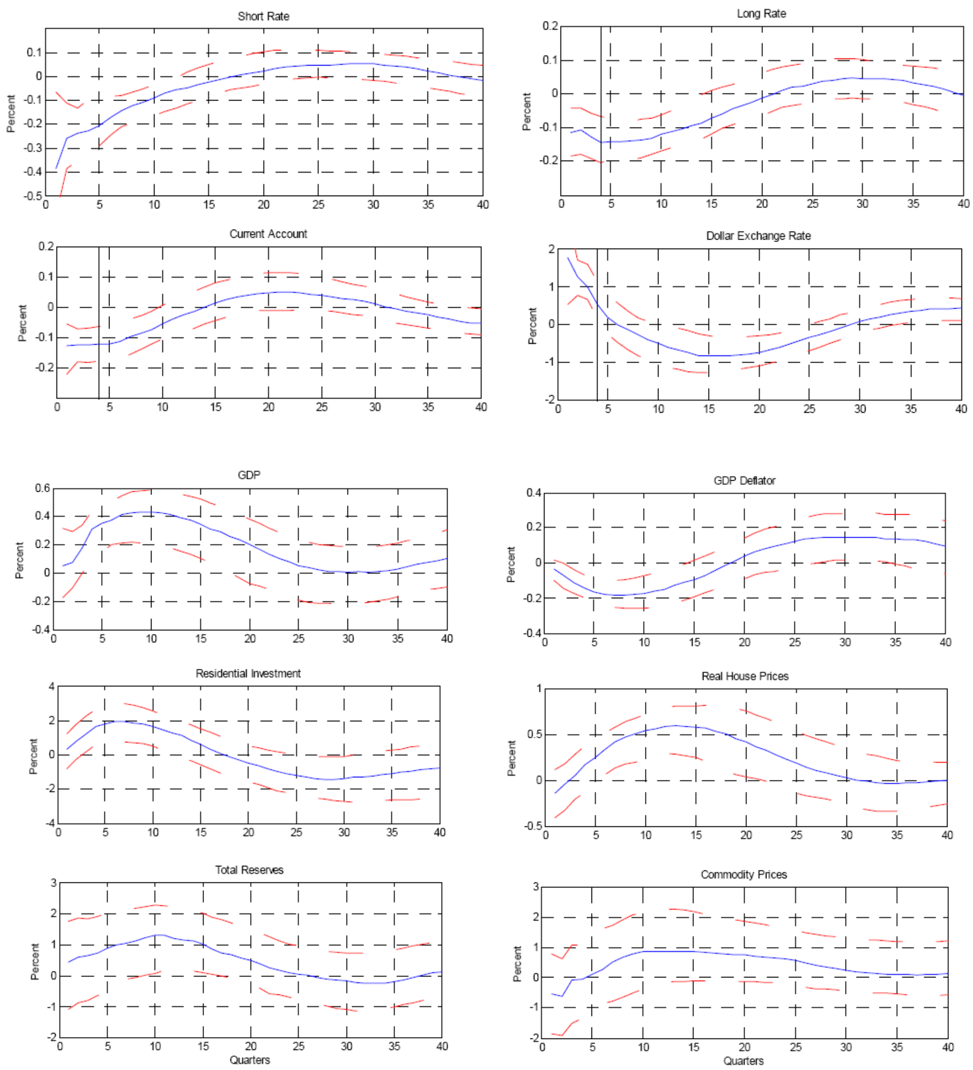


Chart 4 (b): Impulse responses to capital flows shocks



We focus on the responses of the variables for which we have not imposed any restrictions, since the other variables behave according to our predictions by construction. The results can be described as follows:

1. Both monetary policy and capital flows shocks have a negative effect on long-term interest rates. The effect is more persistent for capital flows shocks: while for monetary policy shocks the effect on long rates becomes insignificant after about eight quarters, capital flows shocks have a significant effect until about fifteen quarters after the shock.[9]

[9]The persistent effect of capital flows shocks on long rates is not an automatic outcome of our sign restrictions which are only imposed for four quarters after the shock.

2. Capital flows shocks have a positive effect on GDP, which rises by about 0.4% within seven quarters. The GDP deflator falls, probably as a result of substitution away from domestic goods towards cheaper foreign-produced goods.[10]
3. The effect of monetary policy shocks on residential investment and real house prices is positive but not significant, with zero lying within the posterior coverage intervals.[11] In contrast, capital flows shocks have a statistically significant and positive effect on both variables. The increase in residential investment reaches a peak of about 2% six quarters after the shock. The increase in real house prices reaches a peak of about 0.6% between 13 and 16 quarters after the shock.

A possible explanation for the difference in the effects of the two types of shocks on house prices is the structure of the US mortgage finance market, which is dominated by fixed-rate mortgages. In 2000, 74% of mortgages in the United States were fixed rate, with a typical term of 30 years (OECD (2000)). Tsatsaronis and Zhu (2004) find that house prices are more sensitive to long-term interest rates in countries where fixed-rate mortgages dominate. Because capital flows shocks have a more persistent effect on long-term rates, it is not surprising that they play a larger role in driving up house prices than monetary policy shocks.

An increase in real house prices of 0.6% may seem small, given that house prices doubled in the period from 1990 to 2007. However, we should note that, because the coefficients in the model are time invariant, the impulse responses show the effect of the shocks on average over the whole sample period. It could be that capital flows shocks have become more important from the mid-1990s as a result of financial globalisation. Also, we are simulating the responses to a one-time shock. With repeated shocks over time, the cumulative response would be larger. The most important result from these impulse responses, in our view, is that capital flows shocks have a positive effect on residential investment and house prices, while monetary policy shocks do not seem to have a significant effect.

[10]Notice that, since any change in net foreign assets is equal, by definition, to the trade balance (plus interest earned on the existing stock of net foreign assets and valuation effects due to exchange rate movements), the increase in net capital inflows is matched by a reduction in net exports.

[11]This result appears inconsistent with previous studies which found a significant effect of monetary policy in house prices (for example, Iacoviello (2005) and Jarociński and Smets (2008)). However, it should be noted that most of these studies rely on zero restrictions for identification of monetary policy shocks, whereas our identification relies only on sign restrictions. Using a framework more comparable to ours, Del Negro and Otrok (2007) find a significant but small effect of monetary policy shocks on residential investment and house prices using a VAR in first differences. Their model estimated in levels delivers even smaller effects.

One way of comparing the relative contributions of the two types of shocks is through variance decompositions. We ask what fraction of the variance of the k-step ahead forecast revision $E_t(Y_{t+k}) - E_{t-1}(Y_{t+k})$ in, for example, real house prices, is accounted for by monetary policy and capital flows shocks.

Chart 5 plots the variance decompositions at different forecast horizons. Capital flows shocks explain a much larger fraction of the variation in real house prices than monetary policy shocks at all forecast horizons. For example, at a forecast horizon of 20 quarters capital flows shocks explain 15% of the variation in real house prices, while monetary policy shocks explain only 5%. We interpret 15% as a sizable fraction, given that house prices should be affected by many other shocks such as income and mortgage market innovations. Capital flows shocks also explain a larger fraction of the variation in residential investment at all forecast horizons.[12]

[12]The effects of both shocks are quite persistent. Uhlig (2005) also finds that monetary shocks explain a significant fraction of the variation in the variables in the model even five years after the shock.

Chart 5 (a): Variance decompositions for monetary policy shocks

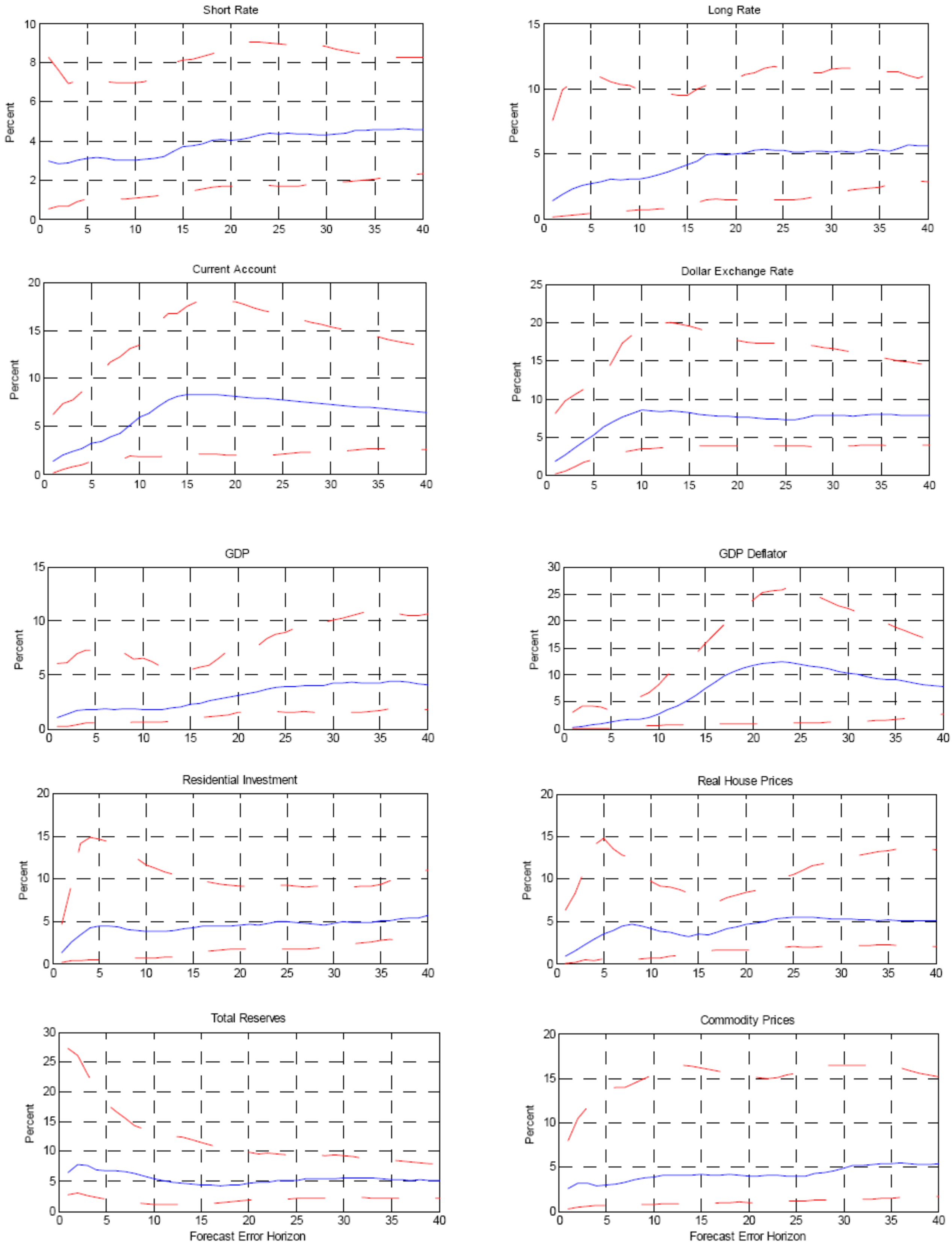
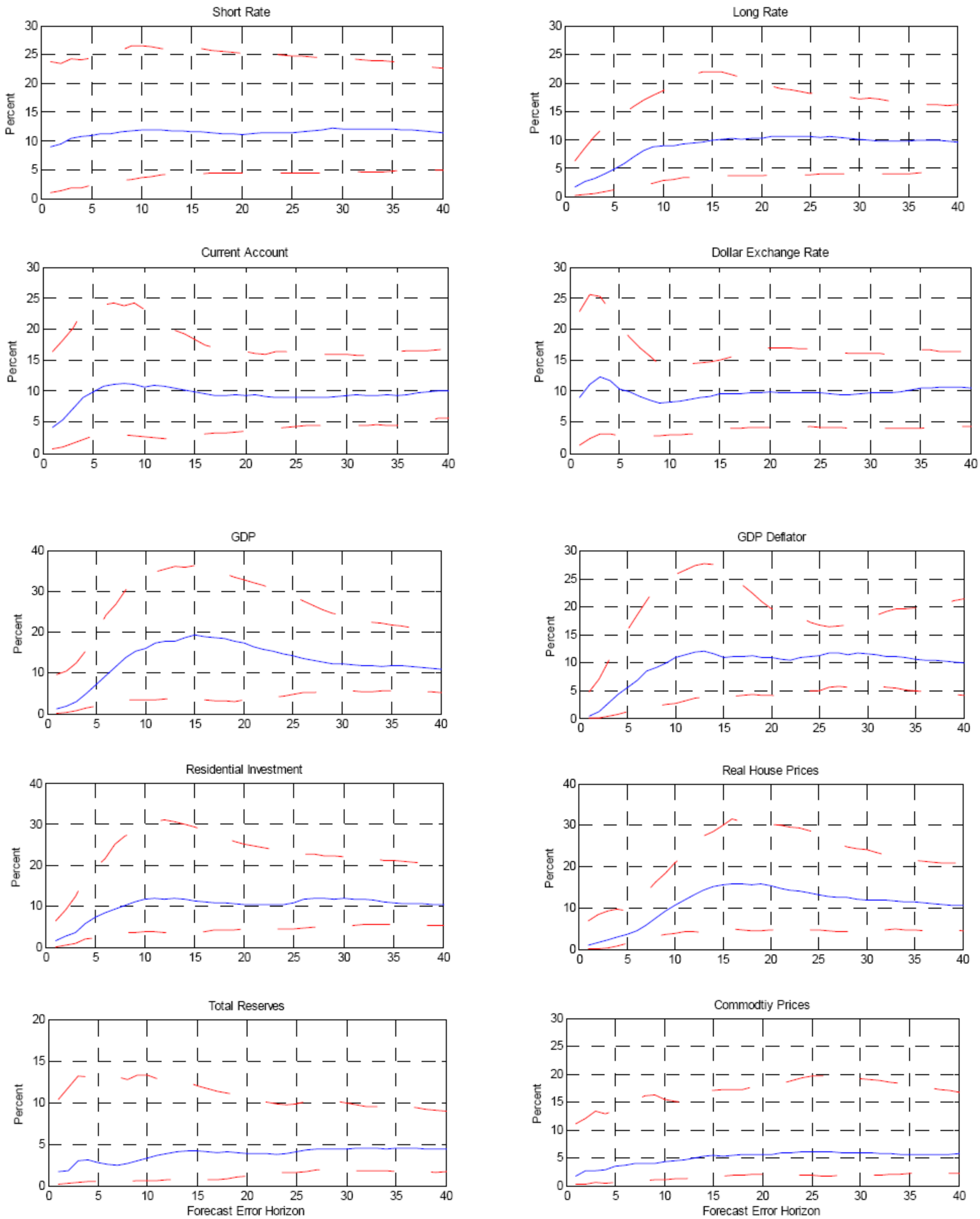


Chart 5 (b): Variance decompositions for capital flows shocks



5 Counterfactuals

In this section we perform some counterfactual exercises. In particular, we ask what would have happened to real house prices if short-term interest rates or the ratio of the current account balance to GDP had remained at the level that prevailed in 1998 Q4. We then ask what would have happened if the Federal Reserve had followed the Taylor rule. This allows us to test the assertion in Taylor (2009) that the Federal Reserve's deviation from the Taylor rule in the period from 2002 to 2007 led to the housing boom.

To perform these counterfactuals, we first estimate the model with the actual data for all variables. We then use the estimated coefficients to generate the path for all other variables when, for example, the short-term interest rate stays constant from 1998 Q4 onwards. Naturally, a Lucas critique issue arises in this type of counterfactual analysis. If short-term interest rates were to remain constant from 1998 Q4 onwards or were to follow the Taylor rule, rational and forward-looking agents would take this into account and modify their behaviour accordingly. Hence, the coefficients in the model would be different from the ones estimated using the actual rather than the counterfactual data. While this is an important issue, we believe that the counterfactual exercises are nonetheless informative and provide some sense for the importance of monetary policy and capital flows in explaining the evolution of house prices.

Chart 6 (a) shows the actual and the counterfactual evolution of real GDP and real house prices if the short-term interest rate had remained constant since 1998 Q4 (at a level of around 5%). The bottom charts plot the difference between the actual and counterfactual series. If the Federal Reserve had kept policy rates constant at around 5%, real house prices in 2007 Q4 would have been about 8% lower. The higher path for interest rates would have had a strongly negative effect on GDP, reducing it by 5% at the end of 2006. Chart 6 (b) does the same exercise keeping the ratio of the current account balance to GDP constant since 1998 Q4 (at approximately −2.7%). This is slightly lower than the historical average over our sample period, which equals −2.2%. If the current account ratio had remained at −2.7%, real house prices would have been about 13% lower. These results are consistent with the findings from the impulse responses and variance decomposition and confirm that capital flows shocks played a much stronger role in generating the housing boom than monetary policy shocks.

Finally, we ask what would have happened if the Federal Reserve had not deviated from the Taylor rule. To do this, we use our model to generate the path of real GDP and real house prices if short-term interest rates had followed the counterfactual Taylor rule series reported in Taylor (2009) and reproduced in Chart 3. The results are shown in Chart 6 (c). If the Federal Reserve had not deviated from the Taylor rule in the period from 2002 to 2007, policy rates would have been significantly higher. The largest deviation is at the end of 2004, when the counterfactual path would have implied an interest rate about 315 basis points higher than the one set by the Federal Reserve. If interest rates had been kept at this higher path, house prices would have been only slightly lower: at the end of 2007 they would have been about 5.5% lower. This is a smaller difference than the one obtained with a constant ratio of the current account balance to GDP. The deviation from the Taylor rule does not seem to have contributed significantly to the boom in house prices.

Chart 6 (a): Constant interest rate counterfactual

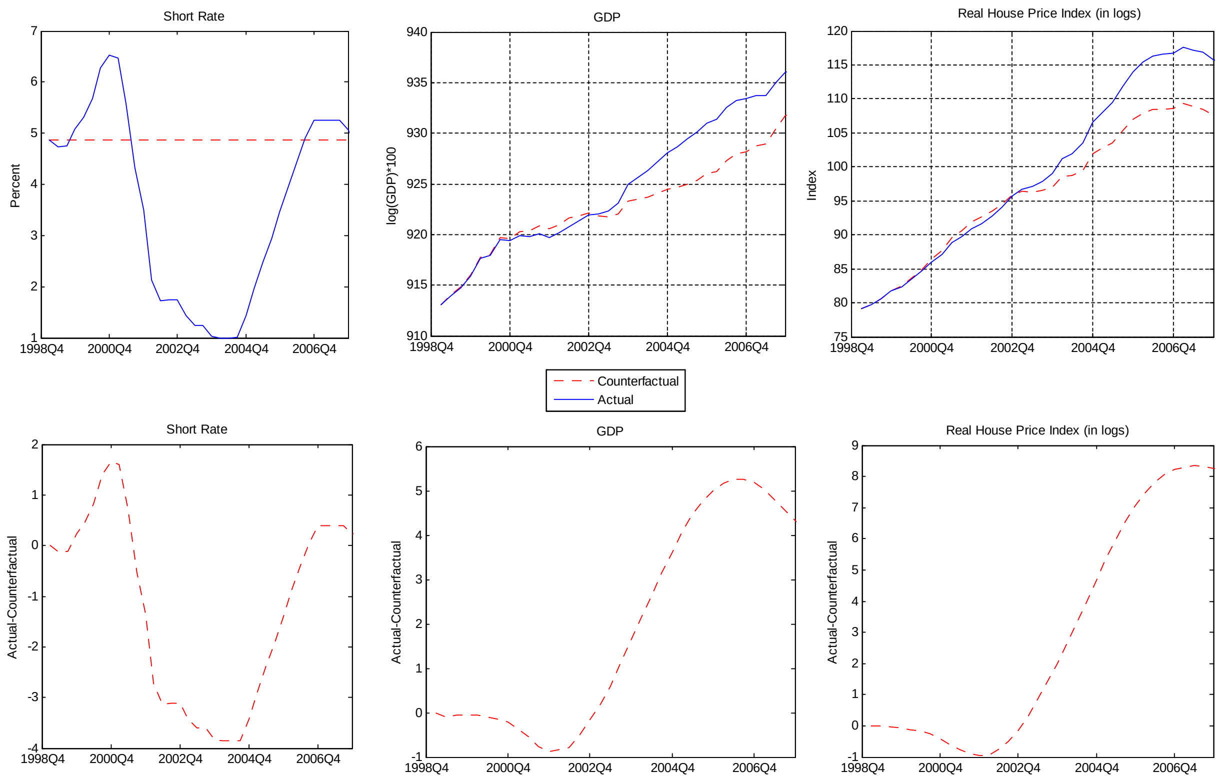


Chart 6 (b): Constant Current Account/GDP counterfactual

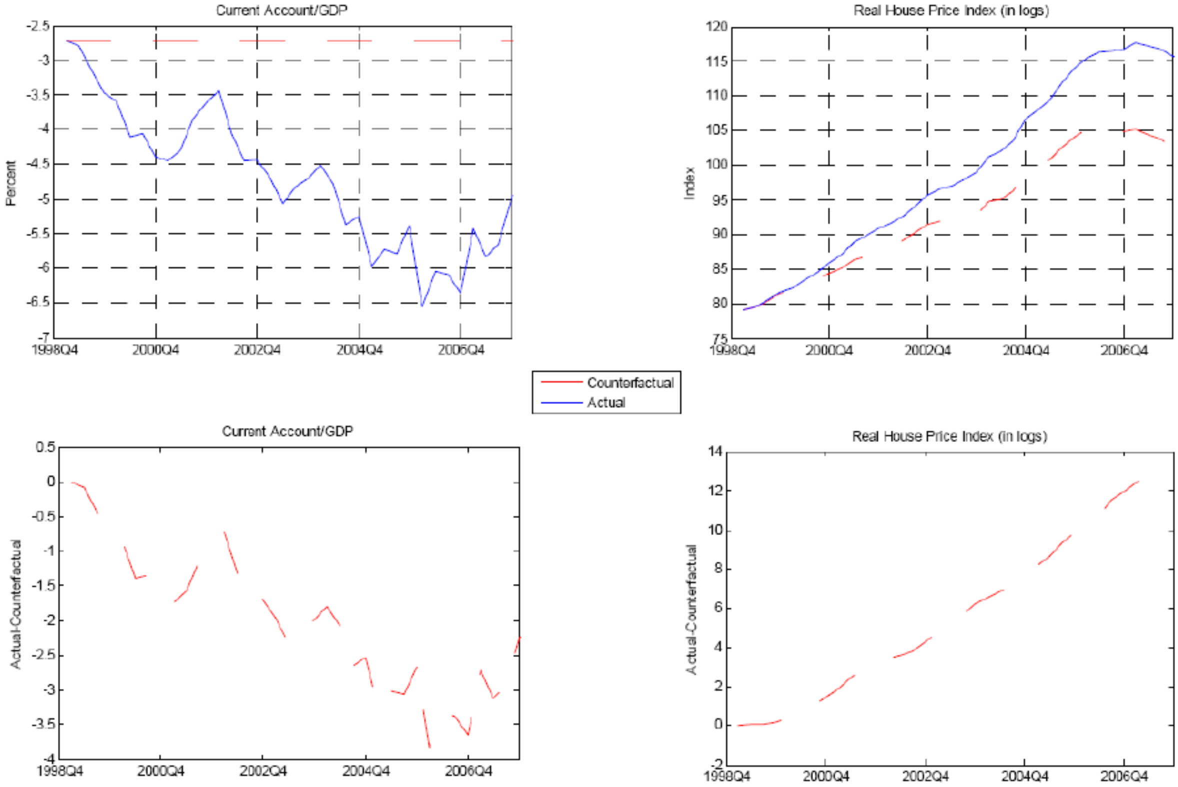
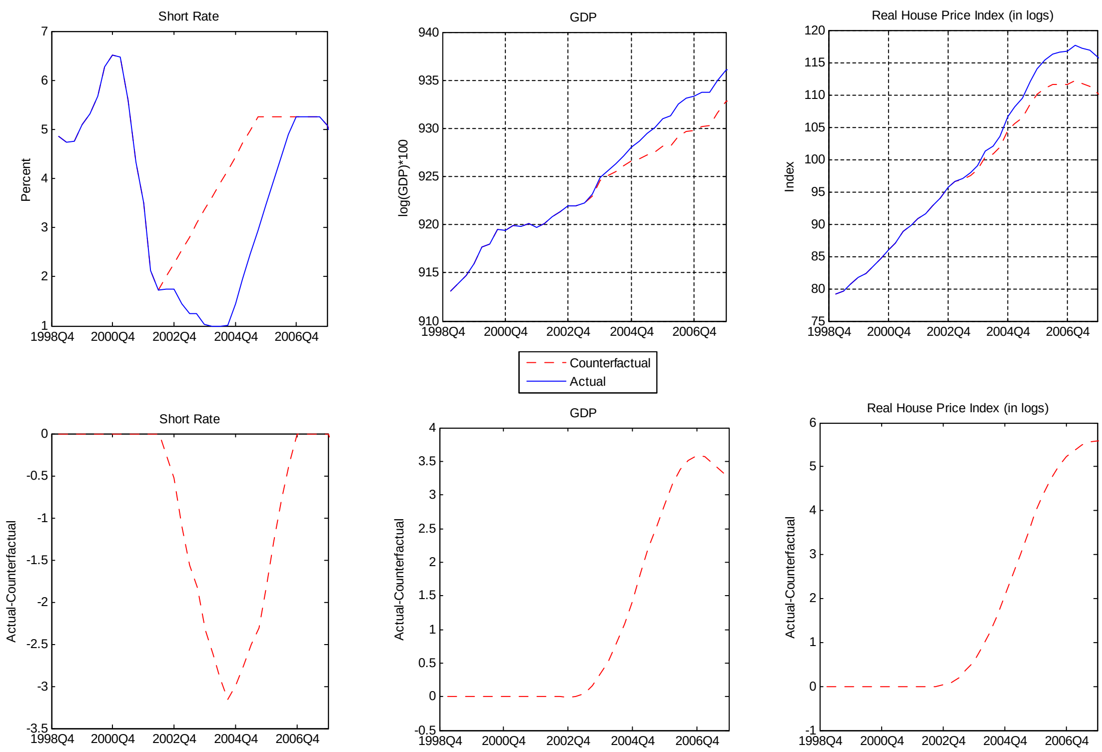


Chart 6 (c): Taylor rule counterfactual



6 Robustness: foreign variables in the VAR

In this section we extend the VAR model to include foreign variables. This is standard practice in open economy VARs — see, for example, Betts and Devereux (2001) and Lane (2001b) — and is important to ensure that the shocks are identified correctly. For example, without controlling for foreign variables, it is hard to tell whether the monetary policy shock that we are identifying is indeed a US shock or a global liquidity shock. To account for this, we extend the vector of variables in the VAR to:

$$Y_t = [i_t^s \ i_t^{s*} \ i_t^l \ i_t^{l*} \ GDP_t \ GDP_t^* \ P_t \ P_t^* \ R_t \ CP_t \ CA_t \ E_t \ RInv_t \ H_t]$$

The variables are defined in the same way as before. Starred variables refer to the rest of the world, proxied by a GDP-weighted average of the non-US G7 countries.[13] Data is obtained from the IMF International Financial Statistics database.

[13] We have also estimated a VAR where, instead of the non-US G7 aggregate, we include individual country data for Germany, the United Kingdom and Japan (in addition to the United States). The results remained broadly the same and are available upon request.

Chart 7 (a): Model with foreign variables – impulse responses to monetary policy shocks

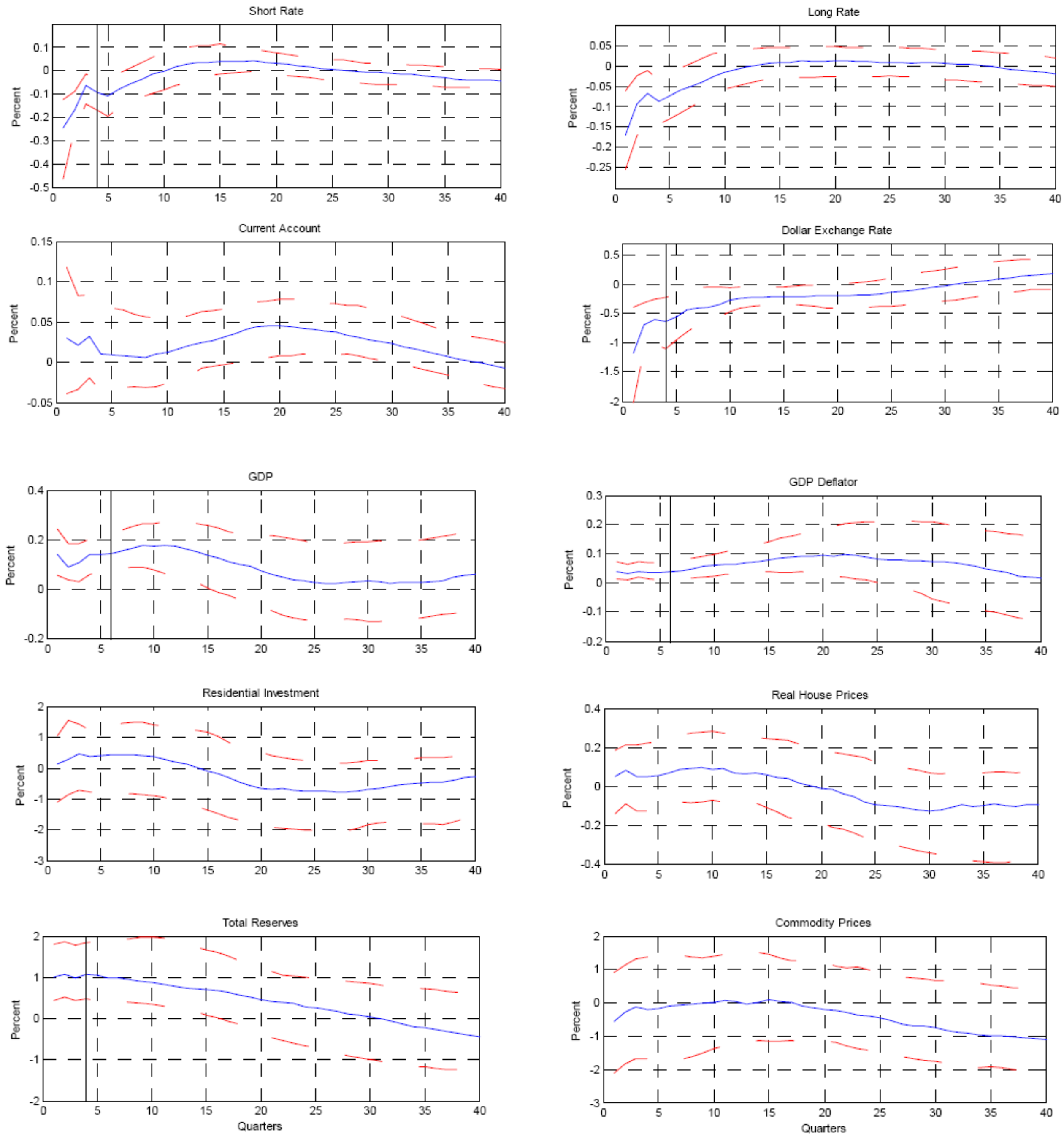


Chart 7 (b): Model with foreign variables – impulse responses to capital flows shocks

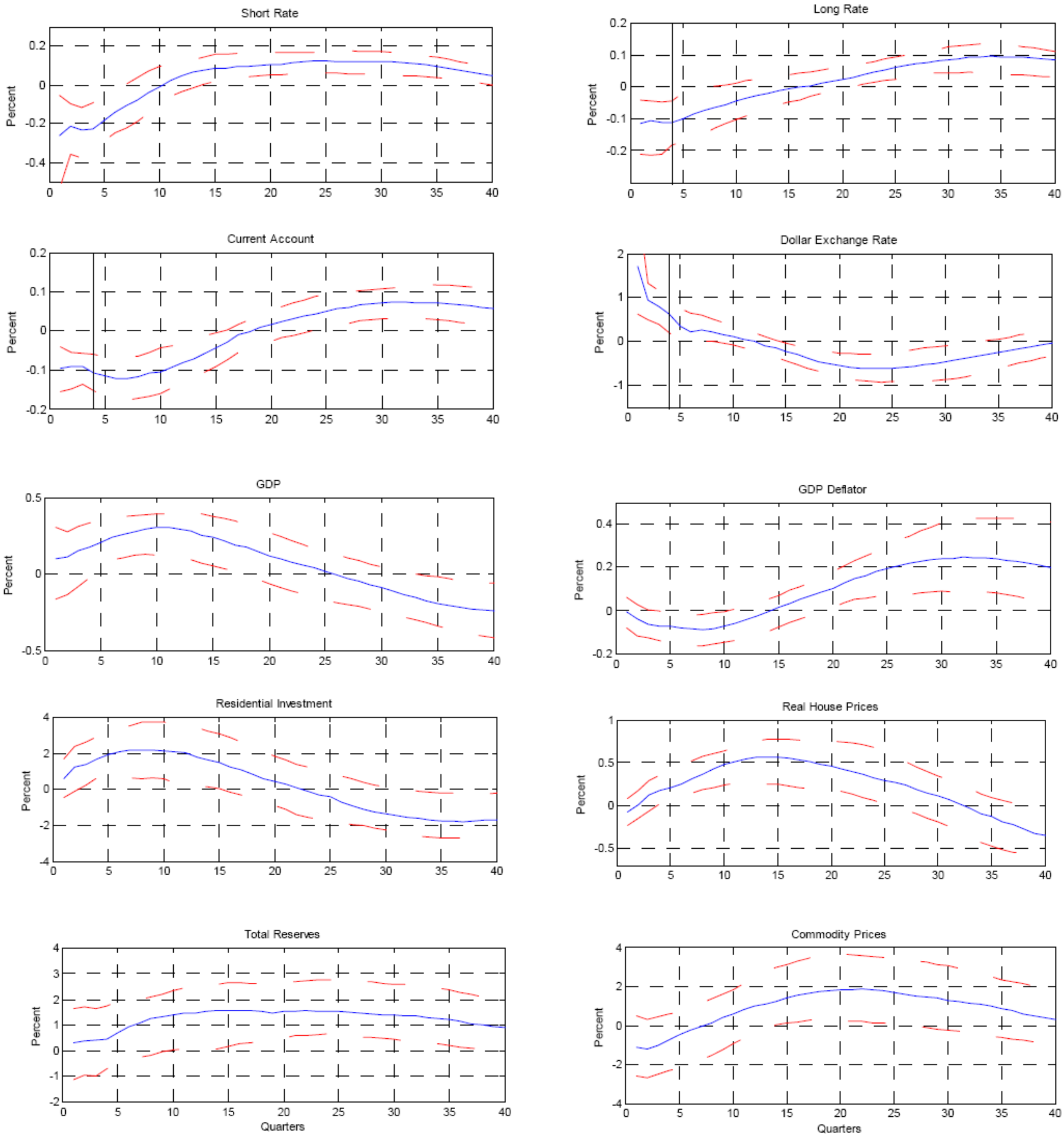


Chart 8 (a): Model with foreign variables – variance decompositions for monetary policy shocks

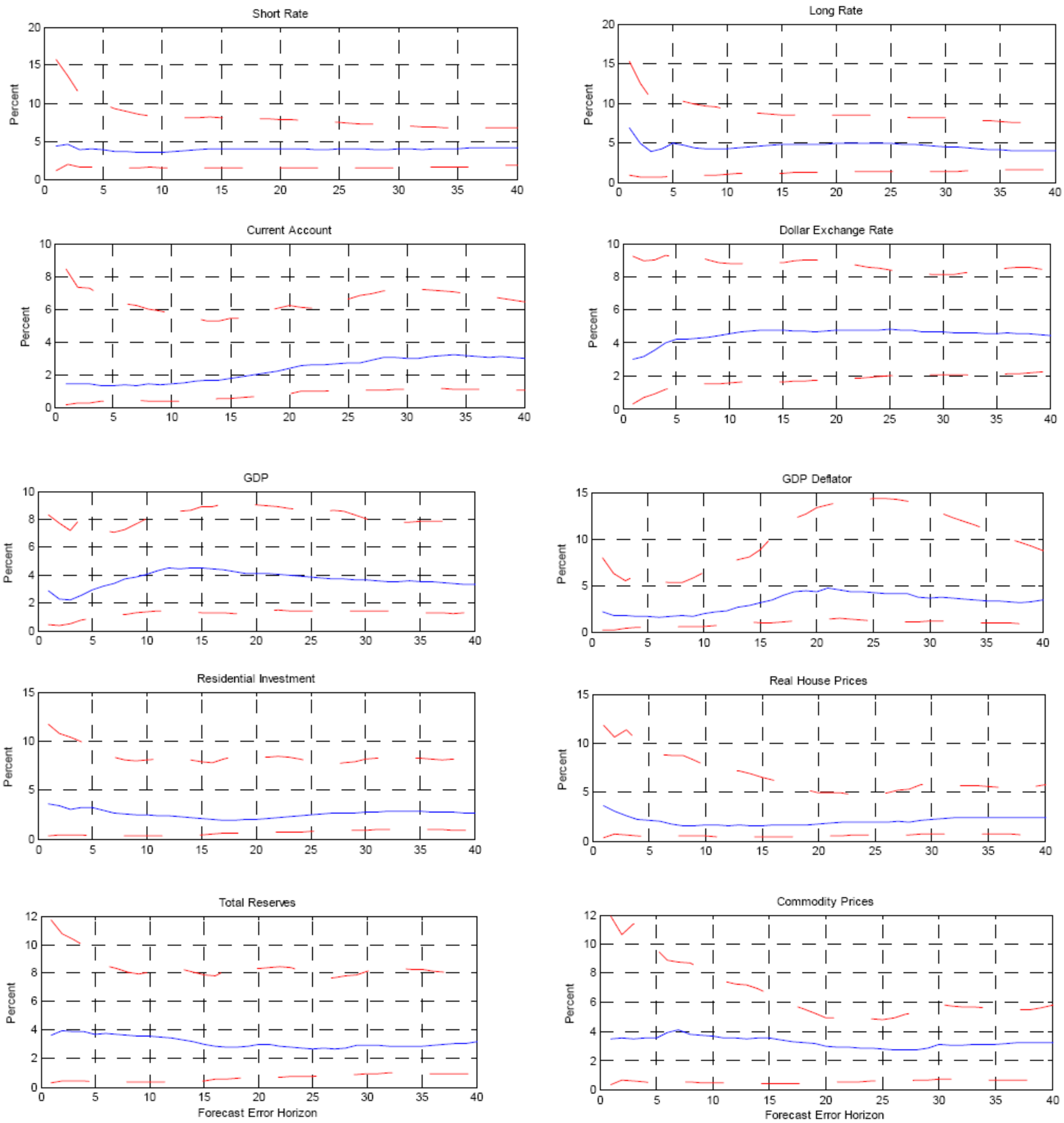
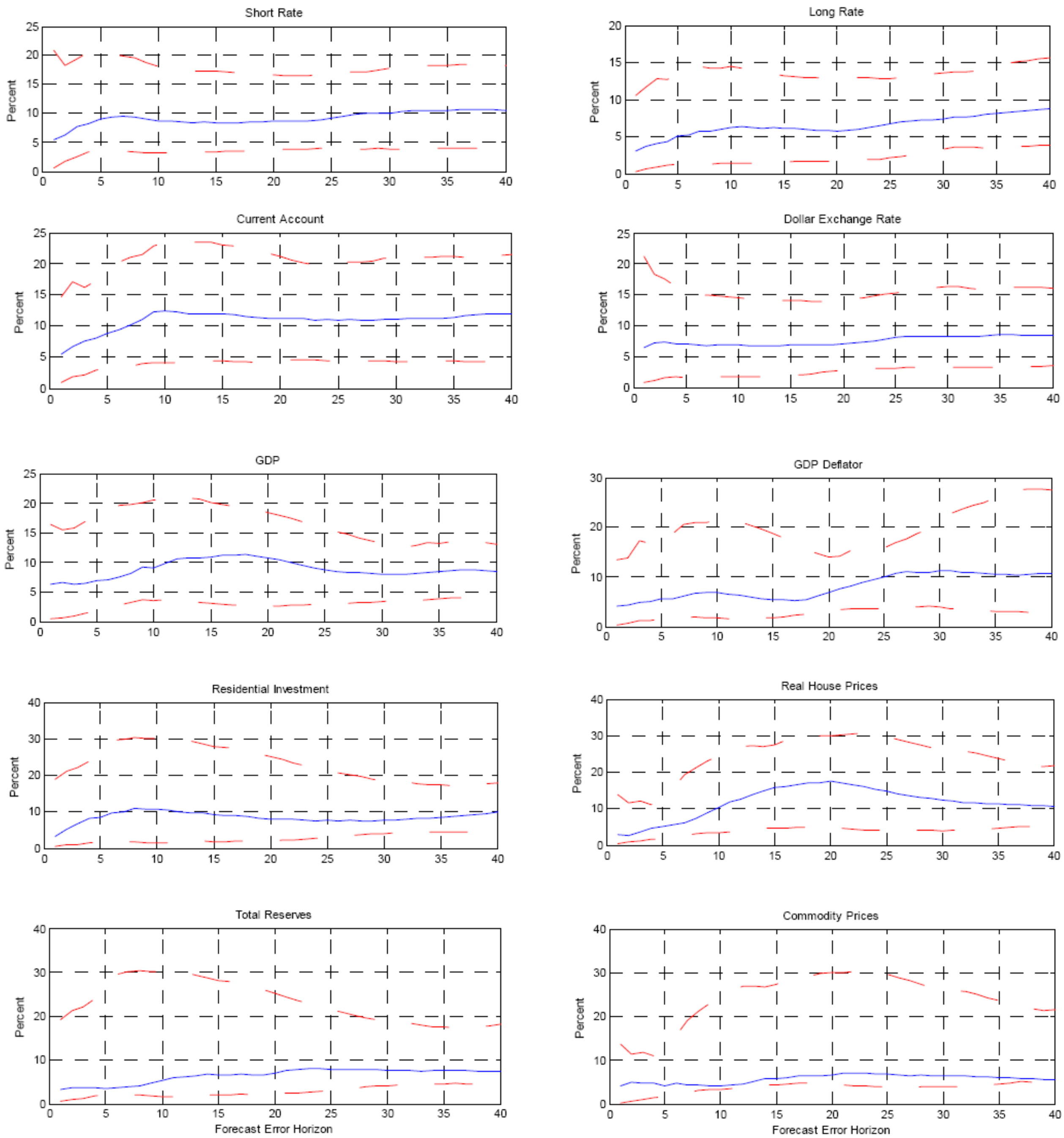


Chart 8 (b): Model with foreign variables – variance decompositions for capital flows shocks



The results from the extended model do not differ significantly from the ones reported in the previous sections. Chart 7 shows that residential investment and house prices increase in response to increases in capital inflows but do not respond significantly to monetary policy shocks. The variance decompositions, reported in Chart 8, confirm that capital flows shocks explain a larger fraction of the variation in residential investment and house prices than monetary policy shocks.

The counterfactuals, shown in Chart 9, suggest that house prices would have been lower if the current account to GDP ratio had remained constant at its 1998 Q4 level than if short-term interest rates had remained constant or had followed the path implied by the Taylor rule.

Chart 9 (a): Model with foreign variables – constant interest rate counterfactual

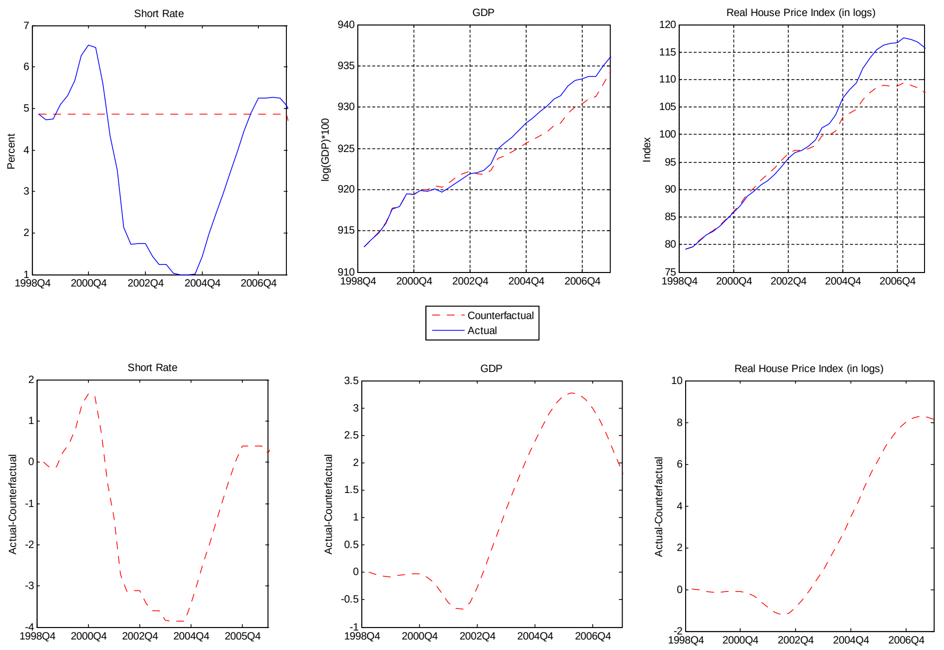


Chart 9 (b): Model with foreign variables – constant Current Account/GDP counterfactual

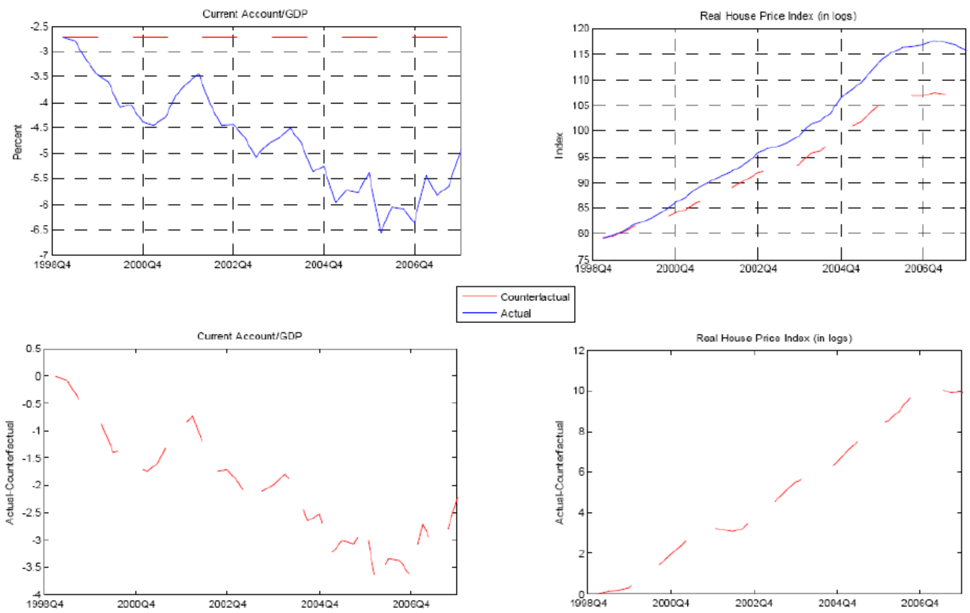
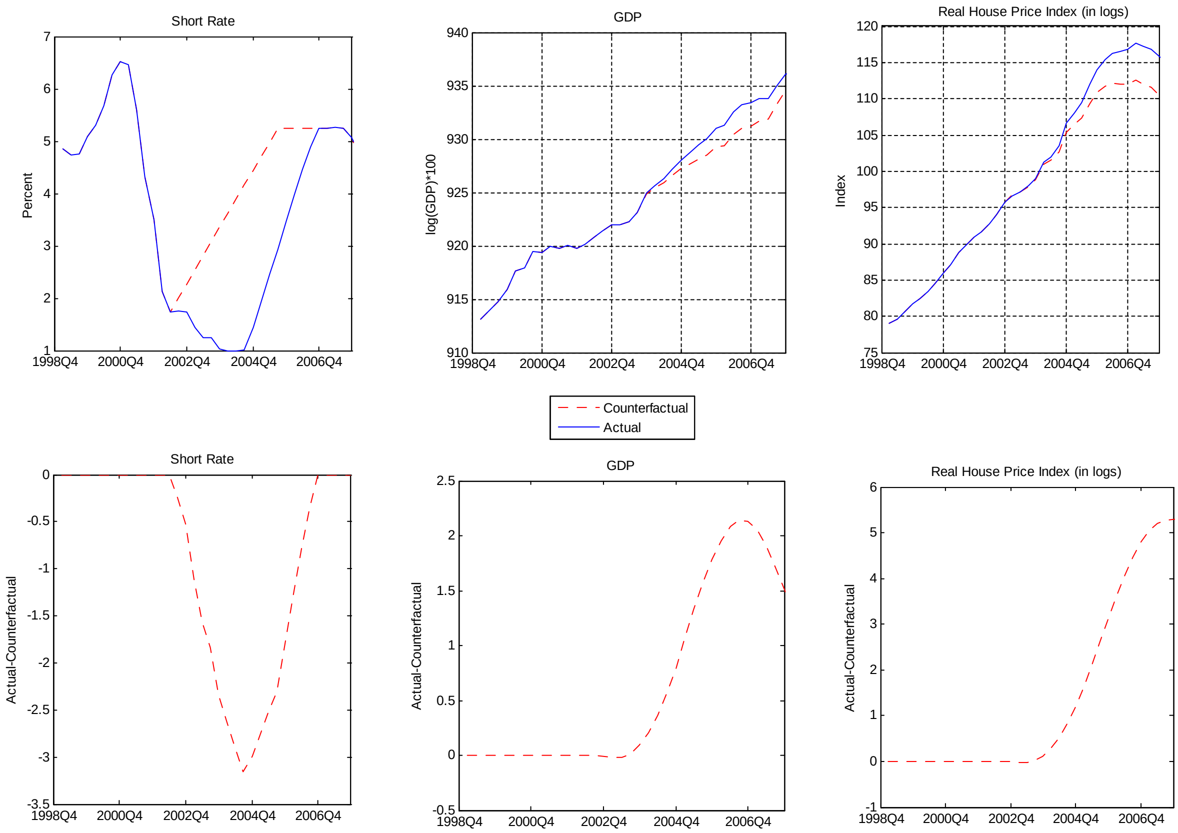


Chart 9 (c): Model with foreign variables – Taylor rule counterfactual



7 Conclusions

Prior to the crisis, academics and commentators alike worried about the sustainability of the US current account deficit and focused on the dollar depreciation that would be required to balance the current account. Here we look at imbalances from a different perspective, focusing on their role in driving down long-term real interest rates and encouraging a house price boom.

Our results suggest that the increase in net capital flows to the United States played a bigger role in driving up house prices than the Federal Reserve's loose monetary policy. The effect of capital inflows shocks on US house prices and residential investment is about twice as large and substantially more persistent than the effect of monetary policy shocks. Results from variance decompositions suggest that, at a forecast horizon of 20 quarters, capital flows shocks explain 15% of the variation in real house prices, while monetary policy shocks explain only 5%. Perhaps more intuitive than the results of variance decompositions are the counterfactual exercises. We use our model to simulate the path of house prices if the ratio of the US current account balance to GDP had remained constant at its 1998 Q4 level (−2.7%). We find that house prices would have been 13% lower at the end of 2007. We then do similar counterfactuals for monetary policy. In one exercise we keep interest rates constant since 1998 Q4 (at about 5%). In another, we impose the path of interest rates implied by the Taylor rule. We find that real house prices would have been 8% lower at the end of 2007 with constant interest rates and 5.5% lower with the Taylor rule. These numbers are smaller than for the constant current account ratio counterfactual suggesting that capital flows played a larger role in the housing boom than loose monetary policy. This result would lend support to calls for the development of policies to prevent the build-up of large current account imbalances in the future.

We are working on a cross-country version of the model used in this paper. The house price boom was not exclusive to the United States. In other countries, such as Spain and the United Kingdom, house prices have also increased dramatically since the late 1990s. We are interested in studying whether the determinants of the increase in house prices in these countries were the same as in the United States. In addition, since the degree of financial regulation varies across countries, the panel VAR allows for an extra margin of variability that can be explored to study the role of financial deregulation, which this paper has left unaddressed.

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