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# **The importance of global shocks for national policymakers – Rising challenges for central banks\***

by

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## **Abstract**

We analyze the importance of global shocks for the global economy and national policy makers. More specifically, we investigate whether monetary policy has become less effective in the wake of financial globalization. We also examine whether there is increasing uncertainty for central banks due to globalization-driven changes in the national economic structure. A FAVAR framework is applied to derive structural shocks on a worldwide level and their impact on other global and also national variables. We estimate our macro model using quarterly data from Q1 1984 to Q4 2007 for the G7 countries plus the euro area. According to our results, global liquidity shocks are a driving force of the global economy and various national economies. However, some other shocks originating in house prices, GDP, technology and long-term interest rate shocks play a role at the global level as well. These results prove to be robust across different specifications. Structural break tests indicate that global liquidity shocks have recently become more important as a determinant for house prices. In general, global variables have become more powerful over time in driving national variables.

*JEL codes:* C22; E31; E32, F42

*Keywords:* Global shocks, international business cycle; international policy coordination and transmission, factor augmented vector autoregressive (FAVAR) models, common factors.

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## 1. Introduction

Global economic integration has been spreading markedly in recent years. This is both true for goods and financial markets. Macroeconomic variables in one country should therefore increasingly reflect events occurring in the rest of the world. Even the housing sector, which is usually regarded as a national phenomenon, has seemingly become more synchronized across countries. As indicated by the latest events, strong rises in residential property prices in the US and some parts of Europe were followed by rapid declines. As national economies become more interconnected, a thorough understanding of the global economy and its effects on domestic economic activity is crucial. The ability to gauge the timing and the magnitude of international spillovers is of particular relevance, since it contributes to a better assessment of the development in one country or region.

The rapid speed of globalization on goods and financial markets is beneficial, but may also have drawbacks for national policymakers. International spillovers and global shocks can limit the autonomy of national monetary and fiscal policy. For example, international capital flows are influencing national monetary conditions, thereby curtailing the ability of central banks to influence national real activity and prices.

The questions we are investigating in this contribution are therefore threefold. First, what are the major shocks and transmission channels which are driving the global economy? Second, to what extent have global factors affected the determination of key macroeconomic variables in the G-7 countries? We quantify the speed and size of spillovers that occur following a shock originating from the global economy. Third, what **can** national economic policy do in the light of international spillovers and what **should** national policymakers do? More specifically, we investigate whether there is increasing uncertainty for monetary policy in the wake of globalization and whether there is a negative time trend in the effectiveness of national monetary policy when trying to steer national liquidity.

The paper proceeds as follows. In section 2, we relate our contribution to the literature and develop the global perspective before we turn to the selection of the data and variables in section 3. In section 4, we briefly explain the Factor-Augmented Vector Autoregression (FAVAR) methodology. In section 5, we display our estimation results

and the results of some tests for structural breaks and some robustness checks. Section 6 finally concludes with some policy recommendations.

## **2. “Going global” – global variables and a global perspective on shocks**

In this paper, we investigate the co-movements among some macro variables across the G7 and the euro-area countries with the aim to uncover the common driving forces shaping international macroeconomic dynamics and the features of their transmission mechanisms. For this purpose, we make use of a modified version of the Stock and Watson (2005a) Factor-Augmented Vector Autoregression (FAVAR) model. Our approach allows a more straightforward economic interpretation of the unobservable global factors. Our work is, on the one hand, related to the literature on global VARs (GVARs) and, on the other hand, to the research done on international business cycle co-movement.

### **2.1 FAVARs, GVARs and international business cycle co-movement**

Let us first delineate the notion of a SFAVAR against that of a GVAR model. A GVAR model is a compact model of the world economy designed to explicitly estimate the economic and financial interdependencies at national and international levels. Individual country/region specific vector error-correcting models are estimated, where the domestic variables are related to corresponding foreign variables constructed exclusively to match the international trade pattern of the country under consideration. The individual country models are then linked in a consistent manner so that the GVAR model is solved for the world as a whole. The degree of regional interdependence is investigated via generalized impulse response functions that portray the effects of shocks to a given variable in a given country/market on the rest of the world (Pesaran, Schuermann and Weiner, 2004, and Dees, di Mauro, Pesaran and Smith, 2007). In our FAVAR, the econometric approach is less complicated and perhaps more straightforward. All global variables are modeled as endogenous in a structural VAR context. Spillover effects from global to national variables are possible, since there is a direct link between the global and the national level via the factor loadings. Global forces are regarded as exogenous to

domestic variables with no feedback effects possible.<sup>1</sup> Finally, in contrast to Pesaran et al. (2004), we choose the weighting in the construction of the common factors by using principal components analysis.

Another series of papers has empirically checked the existence and significance of common patterns in the international dynamics of macro variables. The focus has been on the changes over time of business cycle synchronization across the most important economies originating in common global disturbances. Assessing international business cycle co-movement is mainly an empirical task and the main drivers of the development may shift over time. Usually, this literature has taken into account only a limited set of real quantities such as output, consumption and investment, which is, however, sometimes researched for a large number of countries (Stock and Watson 2005).

When a broader range of variables is included in the analysis, the focus of the literature tends to switch from the common driving forces of fluctuations to the spillover of shocks. Many authors have investigated these issues.<sup>2</sup> Most of them detected a tendency for national business cycles to converge over the period of the second globalization. Artis and Okubo (2008) provide a long-run historical perspective which, by revisiting the era of the first globalization before the First World War, demonstrates a tendency for globalization to produce a high degree of synchronization in national business cycles. Stock and Watson (2005) conclude from their analysis that co-movement has fallen during the 1984–2002 period relative to 1960–83 due to the absence of common shocks. In this paper, we adopt a wider perspective and study co-movements among the G7-countries plus the euro area, using a larger data set than previously employed in the literature, including both real and nominal variables.

In the seminal contribution of Kose, Otrok and Prasad (2008), more than 100 countries are analyzed over the 1960-2005 period. Fluctuations in economic activity are decomposed into global, country group and country specific factors. During the second period of globalization (1985-2005), business cycles have converged among the group of

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<sup>1</sup> Not too different from our approach but in contrast to Bagliano and Morana (2009) who model all variables as endogenous from the outset, Dees, di Mauro, Pesaran and Smith (2007) model each country separately, with foreign variables treated as weakly exogenous.

<sup>2</sup> See for example Artis and Zhang (1997), Kose, Otrok and Whiteman (2003), Artis, Krolzig and Toro (2004), and Canova, Ciccarelli and Ortega (2006).

advanced economies and among the group of emerging market economies. But at the same time, the relative importance of the global factor has declined. Hence, there is evidence of cyclical convergence within each group, but for decoupling between them. Overall, there has been little change in the degree of international synchronization as measured by the joint contribution of the global and group-specific factors. However, this feature is quite consistent with an increased importance of common shocks as a driving force of international output fluctuations: the smaller magnitude of the shocks occurred since the early 1980s can explain a broadly constant pattern of correlations among GDP growth rates across countries (Bagliano and Morana, 2009, p. 432). In contrast to our study which imposes some structure on the global and national level, Kose, Otrok and Prasad (2008) do not make use of any structural model. Moreover, they confine themselves to the use of factor analysis. In our study, we move one step further by using FAVAR analysis, i.e. by integrating factor analysis into a VAR framework.

As a stylized fact from the literature, common components appear to play a larger role in business cycles in those advanced economies which are the focus of our paper. In contrast, country specific factors are relatively more important for emerging market economies (Kose, Otrok and Whiteman, 2003). One reason for this result might be that many emerging market economies in contrast to the industrialized countries have only reached intermediate levels of financial integration, i.e. they have not been able to achieve improved risk sharing over the globalization period (Kose, Prasad and Terrones, 2007).

Our work is related to that conducted by Bagliano and Morana (2009). In their paper, international co-movements among a set of key real and nominal macroeconomic variables in the US, UK, Canada, Japan and the euro area have been investigated for the 1980–2005 period, using a factor vector autoregressive approach. They deliver empirical evidence that co-movements in macroeconomic variables do not only concern real activity, but are an important feature also of stock market returns, inflation rates, interest rates and, to a smaller extent, monetary aggregates. Both common sources of shocks and similar transmission mechanisms explain international co-movements, with the only exception of Japan, where the idiosyncratic features seem to dominate. Finally,

concerning the origin of global shocks, evidence of both global supply-side and demand-side disturbances is found.

However, our work differs from Bagliano and Morana (2009) in three major aspects. First, we explicitly analyze the structural relationship between various global variables in order to get a better understanding of the world economy. This part is missing in Bagliano and Morana (2009). Instead, the authors concentrate on four global factors which they label “inflation factor”, “output growth factor”, “stock return factor” and “oil price factor”. For example, the inflation factor contains not only inflation rates but also interest rates as well as monetary aggregates. In our approach, the relationships between such common forces are *explicitly disentangled* via a structural model on a global level. We use a total of seven global factors, including a “house price factor”. The latter enables us to investigate to what extent other global variables contributed to the strong rise in property prices until the start of the financial crisis.

Second, we examine spillover effects from global to national variables using structural VARs for the G-7 countries plus the euro area. In contrast to Bagliano and Morana (2009), we do not estimate one model with all national variables taken as endogenous but implement separate VARs for each country or region. Hence, we intentionally neglect feedback effects between countries. Bagliano and Morana identify structural idiosyncratic shocks by imposing exclusion restrictions on their contemporaneous impact on all national variables across countries, estimating a total of 43 parameters in each equation (including the four factors). Our main motivation to apply an approach different from theirs is that modeling both global and all national variables in one complete structural framework would have been too costly in terms of degrees of freedom. Hence, the typical empirical trade-off between using a “sufficient” number of structural factors on a global level and establishing structural links between national variables for various countries emerges once again.<sup>3</sup>

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<sup>3</sup> We use seven factors with a lag length of 2, thereby leading to the estimate of fourteen coefficients on the global level (plus a constant and a deterministic component). Our sample covers the period from Q1 1984 to Q4 2007. Bagliano and Morana base their specification on four factors with only one lag (sample Q1 1980 – Q2 2005).

Third, we are examining whether structural breaks emerge on a global level but also in the relation between global and national variables. In our view, this is of special interest for national policy-makers, as they are supposed to react in a timely and consistent manner when national economies are hit by global shocks.

## **2.2 Global variables and a "theory" of global shocks**

Let us now turn to why we make use of specific global variables and to adhere to a theory of global shocks in the context of our paper. In most of the literature, there is a focus on commodity prices and real GDP when defining global shocks. However, we would like to argue that it can also make sense to think in terms of other macroeconomic and financial variables as global ones. More specifically, we investigate whether and to what extent international co-movements concern not only real economic activity but also nominal variables like, for example, monetary aggregates and interest rates and provide an economic interpretation for the sources of common dynamics. We feel legitimized to do so by keeping an eye on the main empirical pattern of the most recent financial and economic crisis which is commonly modeled as a global demand shock and has been characterized by a synchronous downturn of house prices (Federal Reserve Bank of Kansas City, 2009). Our main focus in this paper is on the concept of global monetary liquidity and of global short-term interest rates. Nevertheless, we also find significant global house price shocks, technology shocks and long-term interest rate shocks. Let us first address global monetary liquidity.

It is usually argued that there is a global money market only under a fixed exchange rate system. By pegging the value of domestic currency to a foreign currency, central banks make foreign currency a perfect substitute for domestic currency on the supply side. Should the monetary authority in one country increase the money supply, the domestic money supply would exceed domestic money demand. As a result, money flows out through the balance of payments. The domestic balance-of-payments deficit must be matched by a balance-of-payments surplus abroad. Thus, money supplies abroad must also increase. Flexible exchange rates are assumed to eliminate this source of monetary interdependence. National money becomes a non-tradable asset whose relative price (the exchange rate) is assumed to be determined freely in foreign exchange markets. In



contrast with the fixed exchange rate system in which each country's money supply was endogenous, it is determined exogenously by monetary authorities. Under flexible rates, the balance of payments is always zero, i.e. there is no net money flow between central banks. Flexible rates therefore make currencies perfect non-substitutes on the supply side. However, the insular property of floating exchange rates may break down when there is currency substitution. Some investors might consider domestic and foreign currencies as relatively close substitutes. Currency substitution suggests that the demand for domestic money is dependent on external factors. If domestic residents hold portfolios containing both foreign and domestic assets and reallocate these portfolios according to changes in the relative opportunity costs of these assets, foreign monetary shocks will alter the relative costs of holding a given portfolio. This in turn induces residents to reallocate their portfolios between domestic and foreign assets. The readjustment of currency holdings enables monetary shocks to be transmitted via money demand from one economy to another even in a world of flexible exchange rates.

In addition, Ruffer and Stracca (2006) argue that apart from currency substitution money has to be characterized as endogenous. For this purpose, they modify the standard portfolio balance model by assuming that the key rate of the central bank is exogenous and domestic money holding is endogenous, i.e. money-demand driven (and dependent on foreign interest rates, as investors hold foreign bonds). Hence, one can think of direct spillover effect in monetary aggregates from abroad if the national *money supply is endogenous*, i.e. driven by money demand and not by money supply via central banks.

Consider the case of an expansionary monetary policy in the foreign country which we capture by a reduction in foreign interest rates. As a first consequence, foreign investors shift out of foreign bonds and into foreign money due to the reduced opportunity costs of monetary balances. As a second step, the reduction in foreign interest rates raises the relative attractiveness of domestic money and bonds for domestic agents. If the elasticity of the demand for money with respect to the foreign interest rate is larger than the elasticity of the demand for domestic bonds, then the money holdings in the domestic country increase.

Monetary liquidity spillovers across countries could have serious implications for central banks and national macroeconomic and financial variables as well. For example, monetary liquidity spillovers may lead to a global cycle in house prices. The same could be true for a common pattern in inflation and share prices.

According to Lane and Milesi-Ferretti (2007), the dramatic increase in international financial integration has been one of the salient global economic developments in recent years. Countries have accumulated substantial cross-border holdings and there have been sizable shifts in the composition of asset and liability positions. The size of countries' external portfolios is now such that fluctuations in exchange rates and asset prices cause very significant reallocations of wealth across countries. This creates a huge potential for international capital flows, thereby influencing monetary conditions in other countries as well. We now briefly address our concept of a "global short-term interest rate".

Of course, there is no world central bank which sets the short-term interest rate for many countries. However, from this quite trivial insight, it cannot be concluded that interest rate shocks cannot be identified on a global level. If a global cycle exists in the world economy and in housing markets, the money market rates should move synchronously as well, since national monetary policies react directly or indirectly to global developments: directly, in the sense that global variables enter the central bank's reaction function (via world GDP and/or global excess liquidity); indirectly, if monetary policy does not react until global variables have an effect on national patterns (global excess liquidity spills over into national monetary aggregates). Our "global interest rate shocks" can then be interpreted as unexpected changes in this reaction pattern. In the literature, common beliefs and peer pressure are mentioned as additional reasons for a similar reaction pattern of central banks, i.e. national monetary policies react quite similarly across borders via meetings and the exchange of information among central banks (implicit policy coordination). For example, the establishment of inflation targeting regimes in the majority of industrialized countries might serve as an example of "common beliefs" in this respect.

### 3. Data and variables

In our FAVAR analysis, we use quarterly time series from Q1 1984 to Q4 2007 for the G7-countries plus the euro area, i.e. the US, Japan, the UK and Canada and the EMU. Hence, 48.9% of global GDP in 2007 is represented in our empirical analysis.<sup>4</sup> In principle, one could argue that emerging markets have become increasingly important for the global economy and international financial markets. However, we opted for a focus on major industrialized countries for three reasons. First, the majority of emerging markets have a fixed exchange rate regime which makes monetary spillover effect likely, according to the traditional trilemma view. The motivation of our study is to examine whether such monetary spillovers can also occur despite flexible exchange rates. Second, there are data availability problems even for bigger emerging markets. Third, as already mentioned in section 2, common components appear to play a larger role in business cycles in advanced economies than in emerging market economies, where country-specific factors tend to be more important.

Why are global liquidity shocks important in our context and by far no artifact? Some critics might argue that global liquidity, as measured in one currency, can only change in quantitative terms if one assumes a fixed exchange rate system worldwide. Note, however, that international liquidity spillover effects may occur regardless of the exchange rate system. Under pegged exchange rate regimes, official foreign exchange interventions result in a transmission of monetary policy shocks from one country to another. In a system of flexible exchange rates, the validity of the "uncovered interest rate parity" (UIP) relationship should in theory prevent cross-border monetary spillover. According to this theory, the expected appreciation of the low-yielding currency in terms of the high-yielding currency should be equal to the difference between (risk-adjusted) interest rates in the two economies.

However, the violation of the UIP - often referred to as the "forward premium puzzle"- is a common empirical finding in the literature on macroeconomics and finance. The enduring existence of carry trades can be taken as evidence that exchange rates diverge from fundamentals for lengthy periods, as the exposure of a carry trade position

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<sup>4</sup> Own calculations based on IMF PPP data.

involves a bet that UIP does not hold over the investment period. Moreover, currency substitution may enable international liquidity spillovers in a framework of flexible exchange rates. These international adjustments of money holdings allow the transmission of monetary shocks from one economy to another (via money demand) even in a system of flexible exchange rates.

The time series for the G7 plus the euro zone are drawn from a variety of sources, including various national statistical offices, central banks and the OECD. Most time series are provided by professional databanks like Thomson Datastream, Feri and Bloomberg. Since EMU series at a quarterly frequency are often available only for a relatively short time-span, we partly rely on the Area-Wide Model database by Fagan, Henry and Mestre (2001) who provide backdated time series. Hence, some caution is warranted, as there are methodological differences across euro-zone countries in collecting the data. Moreover, data availability on a national level becomes increasingly scarce when moving back in time. Historical house prices for the EMU stem from Gros (2007).

We estimate our baseline FAVAR model including the following variables for the G7-countries plus the non G7-member euro-area countries: real GDP, four inflation measures (CPI, PPI, import prices and GDP deflator), 3-month short-term interest rates, broad monetary aggregates (typically, M2 or M3), two commodity price indices (HWWI and CRB), house prices and share prices (national MSCI). A complete data list with sources can be found in Table A7 in the appendix.

#### **4. The FAVAR methodology**

The empirical value added from our approach stems from the use of a Factor Augmented VAR (FAVAR). A FAVAR is the combination of a standard VAR model with factor analysis. Global variables were derived by using factor analysis. We regard this procedure as superior compared to a simple aggregation of national variables for two reasons. Simple sum aggregation implicitly assumes that the included national variables are perfect substitutes. However, given differences in national measurement, this does not need to be true. For example, the monetary aggregate M2 in the US is not a perfect

substitute for M3 in the euro zone. In contrast, factors are latent variables which measure the "underlying process". The rationale is that the behavior of several (national) variables is driven by a few common (global) forces, the factors. Hence, the latter can provide an exhaustive summary of the information included in data across countries and regions.

Moreover, and in contrast to simple aggregation, factor analysis allows the distinction between common forces and idiosyncratic shocks, i.e. the amount in the measured data which is not considered to be part of the underlying global forces. Idiosyncratic components mean that the measured variables can include changes which are exclusively the result of a national data-generating process. Instead, if global variables are derived by aggregation, the distinction between idiosyncratic and global shocks is blurred. Any idiosyncratic shock stemming from one (major) country will inevitably influence the global aggregate and will therefore be counted as a common shock across countries. Global and idiosyncratic shocks are presumed to have the same influence, although idiosyncratic shocks should not influence the common movement in an economic sense.

The use of the FAVAR methodology is especially appealing in the light of spillovers and global shocks, since it allows both examining the interaction of global variables and their effects on national variables. For example, it is possible to derive the impact of a global liquidity shock on global GDP, global commodity, house and share prices, global inflation, etc. Different types of shocks can therefore be put to some kind of a "horse-race": Is a global liquidity shock more important for the global economy than a global commodity price or global interest rate shock? At the same time, the response of every national variable included in the respective global factor (national CPI, national money supply, interest rate, share price, etc.) due to a global shock (liquidity, GDP, commodity, etc.) can be examined.

The problem in expanding the external sector (in a VAR model) is that there is a rapid increase in the number of parameters that need to be estimated with the addition of each economy as well as the addition of each sector of the respective economy. The established approach adopted to circumvent this problem of over-parameterization is to

specify latent factors which capture the overall dynamic features of the international economies (Fry, 2004).

Recent work with Factor-Augmented Vector Autoregression (FAVAR) suggests that standard VAR analysis can be improved by incorporating the information in a large number of macroeconomic series. A general formulation of the dynamic factor model is  $X_{it} = \lambda_i(L)f_t + \varepsilon_{it}$  with  $X_{it}$  as the observed data for the macroeconomic time series  $i$  at time  $t$  for  $i = 1, \dots, N$  and  $t = 1, \dots, T$ . If the lag polynomials  $\lambda_i(L)$  are assumed to have finite orders, the equation can be written in static form:  $X_t = \Lambda F_t + \varepsilon_t$ . Hence, the factor  $F_t$  can be thought of as a weighted average of the variables in a data set. The factor loadings  $\Lambda$ , i.e. the weights, can be either positive or negative and reflect how correlated each variable is with the factor.  $F_t$ ,  $\Lambda$  and  $\varepsilon_t$  are not directly observable and have to be estimated. To separate factors from idiosyncratic disturbances, the following identifying assumptions are made (Justiniano, 2003):

- Orthogonality of idiosyncratic errors, i.e.  $\varepsilon_t^i \perp \varepsilon_t^j \forall i, j = 1, \dots, N$  and  $i \neq j$ . Usually, the assumption of no cross-correlation is relaxed. The model is then said to have an approximate factor structure.
- Orthogonality of factors, i.e.  $f_t^j \perp f_t^k \forall k, j = 1, \dots, K$  and  $k \neq j$ . However, factors can be correlated in time.
- Idiosyncratic errors are orthogonal to factors, i.e.  $\varepsilon_t^i \perp f_t^j \forall i = 1, \dots, N$  and  $j = 1, \dots, K$ .

These assumptions imply that all co-movements across variables are attributed exclusively to a set of orthogonal factors. Stock and Watson (1998, 2002) show that the factors in a model of the form  $X_t = \Lambda F_t + v_t$  can be consistently estimated by principal component analysis when the time series dimension (T) and the cross-section dimension (N) are large. The factors are extracted in a sequential fashion, with the first factor explaining the most variation in the data set, the second factor explaining the next most variation (not explained by the first factor), and so on.

The dynamic factor model in VAR form (FAVAR) can be obtained by combining factor analysis (equation 1) with a VAR model (equation 2):

$$(1) \quad X_t = \Lambda F_t + D(L)X_{t-1} + v_t$$

$$(2) \quad F_t = \Phi(L)F_{t-1} + G\eta_t$$

where  $q \leq r \leq qp$  with  $r$  static factors  $F_t$  and  $q$  dynamic factors.  $\Lambda$  is a  $n \times r$  matrix,  $D(L)$  is a  $n \times n$  matrix lag polynomial of order  $p$ ,  $\Phi(L)$  is a  $r \times r$  matrix lag polynomial of order  $p$ ,  $G$  is  $r \times q$ ,  $\eta_t$  is a  $r$ -variate vector of global shocks driving the common factors,  $v_t$  equals a  $n$ -variate vector of idiosyncratic shocks. Substituting the factor evolution equation (2) into equation (1) and collecting terms yields the complete FAVAR form:

$$(3) \quad \begin{bmatrix} F_t \\ X_t \end{bmatrix} = \begin{bmatrix} \Phi(L) & 0 \\ \Lambda\Phi(L) & D(L) \end{bmatrix} \begin{bmatrix} F_{t-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{F_t} \\ \varepsilon_{X_t} \end{bmatrix} \quad \text{where} \quad \begin{bmatrix} \varepsilon_{F_t} \\ \varepsilon_{X_t} \end{bmatrix} = \begin{bmatrix} I \\ \Lambda \end{bmatrix} G\eta_t + \begin{bmatrix} 0 \\ v_t \end{bmatrix}.$$

The FAVAR contains the exclusion restriction implied by factor analysis, i.e.  $X_t$  does not predict  $F_t$  given  $\Phi(L)F_{t-1}$ . Restrictions of this form closely resemble the assumption of exogenous world variables which are used to identify global shocks in open economy VARs. The FAVAR can be estimated via a two-step principal component approach. In the first step, the common components  $F_t$  are estimated using the first  $r$  principal components of  $X_t$ . In the second step, a VAR is estimated on these common components. Bernanke, Boivin and Elias (2005) point out that this two-step approach implies the presence of “generated regressors” in the second step. However, the uncertainty in the factor estimates should be negligible when  $N$  is large relative to  $T$ .

In the first step, estimates of the common factors are obtained by dividing the data set  $X_t$  into categories of variables. These categories are capturing different dimensions of the economy across countries ( $X_t^1, X_t^2, \dots, X_t^l$ ): economic activity as reflected by real GDP; inflation which include consumer prices, producer prices, import prices and the GDP deflator; commodity prices which include the HWWI and the CRB commodity price index in domestic currency; house prices; monetary liquidity which include broad

monetary aggregates, like M2 or M3; short-term interest rates which include 3M interest rates; and share prices which include the MSCI share price index in domestic currency. Estimates for the global factors are obtained as the first principal component for each sub-set (category) of series. Each segment of  $X_t$  is therefore explained by exactly one factor. For example, global monetary liquidity is estimated as the first principal component from the set of monetary aggregates in the G-7 countries plus the euro zone.

$$(4) \quad \begin{bmatrix} X_t^1 \\ X_t^2 \\ \dots \\ X_t^I \end{bmatrix} = \begin{bmatrix} \Lambda_1 & 0 & \dots & 0 \\ 0 & \Lambda_2 & \dots & 0 \\ \dots & \dots & \dots & \dots \\ 0 & 0 & \dots & \Lambda_I \end{bmatrix} \begin{bmatrix} F_t^1 \\ F_t^2 \\ \dots \\ F_t^I \end{bmatrix} + \begin{bmatrix} e_t^1 \\ e_t^2 \\ \dots \\ e_t^I \end{bmatrix}$$

In the second step, a VAR with the estimated  $(F_t^1, F_t^2, \dots, F_t^I)$  is implemented. The innovations in the VAR model can be identified by applying standard procedures, like a Cholesky decomposition. However, a simple recursive ordering may not be appropriate in an international context. Given its low level of flexibility, one has inevitably to make extreme assumptions about the interaction between global variables. For example, if one puts global money before the global short-term interest rate, the interest elasticity of global money demand is constrained to be zero. In contrast, if the global interest rate is predetermined for global money, money supply's interest elasticity is assumed to be zero (Leeper and Roush, 2003). As a result, the derived monetary policy shocks might be contaminated. Non-recursive schemes allow for more general contemporaneous interactions among variables than recursive orderings. A global structural FAVAR (SFAVAR) postulates more reasonable economic structures and reflects better the complexities of international policy-making.

We see two major advantages by implementing a FAVAR in our context. First, it is possible to derive structural shocks on a worldwide level and their impact on other global variables. For example, global money demand shocks can be disentangled from global money supply shocks. Second, it is possible to derive the effects of each global shock on specific national variables (cf. equation 3). Hence, impulse response functions can be constructed for any variable included in the informational data set ( $X_t$ ).



## 5. Empirical results

### 5.1. Baseline FAVAR

The common factors are estimated by principal component analysis. As is common in factor model applications, the variables are initially de-trended and standardized. Apart from the short-term interest rates, all  $X_t$  are log first-differenced. For the short-term interest rates only, first differences are calculated. Afterwards, all the de-trended variables are standardized so that each of them has a mean of zero and a variance of one. Otherwise, the results would have been systematically affected by cross-country differences in variability.

For each global variable, the proportion of the total variance of the series attributable to each principal component is calculated. For the first principal component (PC1) to suitably qualify as a factor capturing international co-movement, one important condition must be met. PC1 should explain a sufficiently large fraction of the total variance of the relevant data set in comparison to the remaining principal components of higher order. As can be seen in the table below, the requirements are met for all of the common factors. For example, in the case of global money, a significant part of the total variance (48.6%) can be attributed to the first principal component. In contrast, PC2 accounts for only 18%. Even for the inflation factor which includes four different measures of inflation for each country or region (CPI, PPI, import prices and the GDP deflator), the first principal component's share is 31.8% compared to 16.9% for PC2. With 55.9% and 74.3%, the PC1's share for commodity and share prices is clearly the highest.

Table 1 - *Share of variance explained by first three principal components*

	PC1	PC2	PC3
Real GDP	36.5	23.0	17.0
Inflation	31.8	16.9	9.6
Commodity prices	55.9	27.8	7.9
House prices	33.2	26.9	15.5
Broad money	48.6	18.0	15.0
3M interest rate	42.8	19.7	18.5
Share price	74.3	12.1	6.4

Note: Calculations based on first standardized differences

We conclude that common forces exist which qualify as global factors in the global economy and on international financial markets. The seven global factors are therefore used for estimating a SFAVAR in levels including a constant and a time trend.<sup>5</sup> Since the global factors have been obtained in first-differences, they are "re-constructed" in levels by setting each global factor equal to zero in the first quarter of 1984 and calculating the cumulative sum of the first principal components. In order to identify the global structural shocks, the following assumptions are made:

$$(5) \quad \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & a_{23} & 0 & 0 & 0 & 0 \\ a_{31} & 0 & 1 & a_{34} & a_{35} & a_{36} & a_{37} \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ a_{51} & a_{52} & 0 & 0 & 1 & a_{56} & 0 \\ 0 & 0 & a_{63} & a_{64} & a_{65} & 1 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{bmatrix} \begin{bmatrix} \eta_t^{YR} \\ \eta_t^{PI} \\ \eta_t^{CP} \\ \eta_t^{HP} \\ \eta_t^M \\ \eta_t^{SR} \\ \eta_t^{SP} \end{bmatrix} = \begin{bmatrix} u_t^{YR} \\ u_t^{PI} \\ u_t^{CP} \\ u_t^{HP} \\ u_t^M \\ u_t^{SR} \\ u_t^{SP} \end{bmatrix}$$

with  $\eta$  as the vector of errors in the reduced-form equations and  $u$  as the global structural shocks. The global GDP (YR) and the global house price factor (HP) are not influenced contemporaneously by any other global variable. The global inflation factor (PI) is affected contemporaneously only by the commodity price factor (CP). The latter is affected at the same time by all other common factors apart from inflation. The global money factor is influenced contemporaneously by the global GDP and inflation factor and by the short-term interest rate (SR) as well. For the reaction function of central banks' worldwide, it is assumed that they react contemporaneously to commodity prices, the global house price factor and global money, but not to the global activity and inflation factor due to time lags in publication. Given the forward-looking nature of financial markets, share prices (SP) respond to all other global variables at the same time.

To determine the lag length, we apply the usual criteria such as the Likelihood Ratio test, the Final Prediction Error, the Akaike information criterion, the Schwarz criterion and the Hannan-Quinn criterion. Most of the criteria point at a lag length of two, which is also sufficient to avoid serial correlation among the residuals and seems to be

---

<sup>5</sup> Since we now impose some structure on the global economy, we introduce the notion of a SFAVAR instead that of a pure FAVAR analysis.

appropriate in order to estimate a model which is parsimonious where possible. The LR test for overidentified VARs suggests that our short-run restrictions cannot be rejected at any conventional confidence level. The statistic is equal to 5.1 and the corresponding p-value is 0.17.

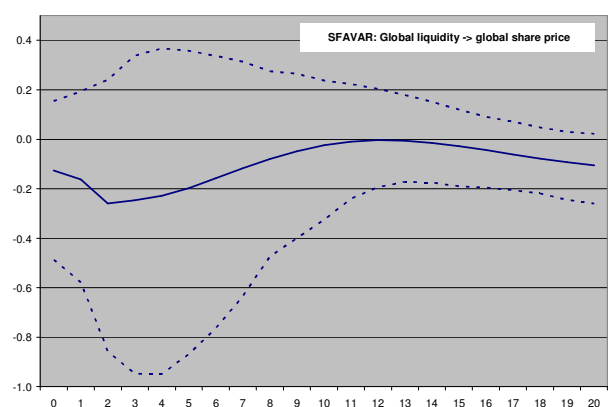
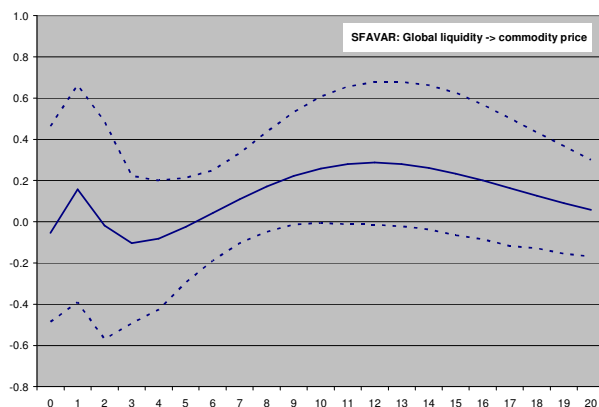
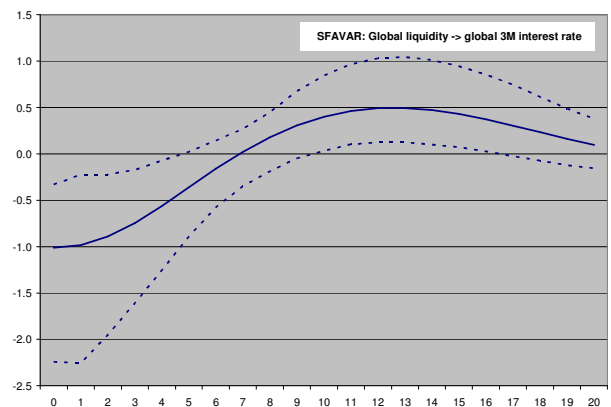
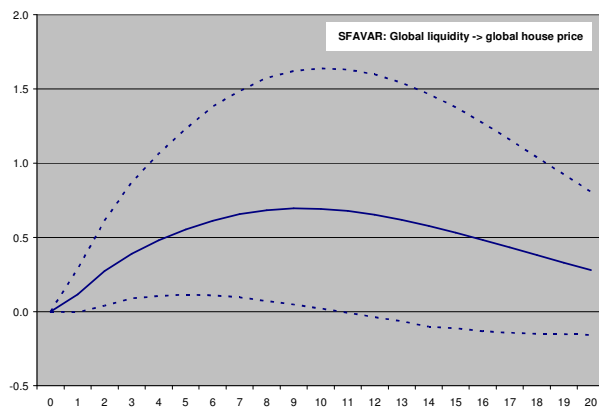
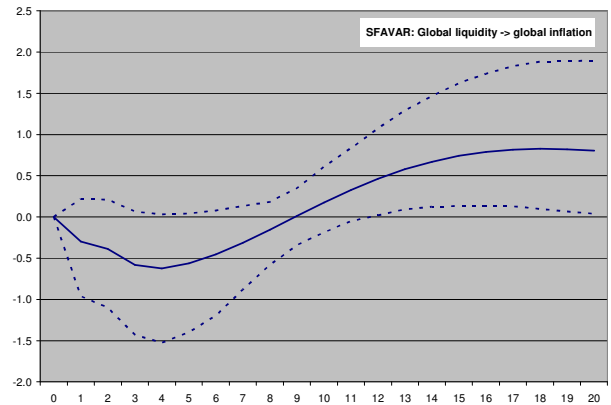
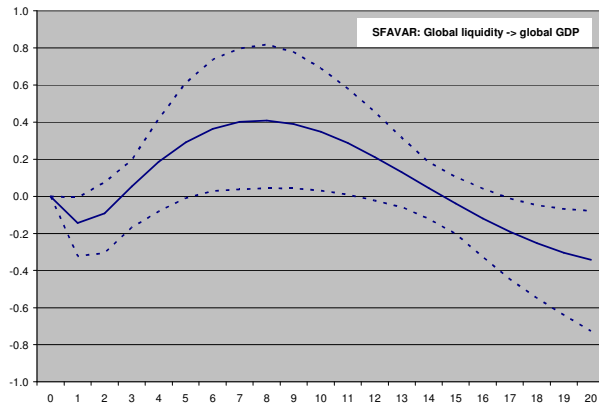
The major result of our structural factor augmented vector autoregression (SFVAR) model is that *global liquidity shocks are driving forces of the global economy and various national economies*. Moreover, the outcomes of our empirical analysis are in line with economic theory, since frequently emerging puzzles as, for example, the "price puzzle" and the "liquidity puzzle" do not appear in our case. As can be seen in the charts below, a global liquidity shock has a significant positive impact on global GDP after six quarters. As always, the solid line in each chart represents the response to a one-standard deviation shock, again measured in standard deviations. The dashed lines represent the 95% confidence intervals bootstrapped by ourselves based on a standard residual bootstrap procedure with 500 draws (Enders, 2004).

Furthermore, global inflation responds significantly with a considerable time lag of 11 quarters to a global liquidity shock. However, in contrast to our findings for global GDP, the inflationary effect is far more persistent. Strong responses can also be found for the common house price and the short-term interest rate factor. The global house price factor rises strongly and persistently without any delay. This may indicate that excess liquidity on a worldwide level has contributed to the phase of exceptionally high increases in residential property prices across countries. Global liquidity shocks also lead to a marked liquidity effect, driving short-term interest rates down by up to one standard deviation.

All in all, our impulse response analysis seems to confirm the results found by Ruffer and Stracca (2006) and Belke, Orth and Setzer (2008) on the basis of global VARs. Common liquidity disturbances are influencing major macro variables on an international level. However, with respect to asset prices, our results show some marked differences versus previous empirical work. We are not able to find any significant impact both on commodity and share prices, whereas Belke, Orth and Setzer (2008) report a significant response of commodity prices after a global liquidity shock. A recent

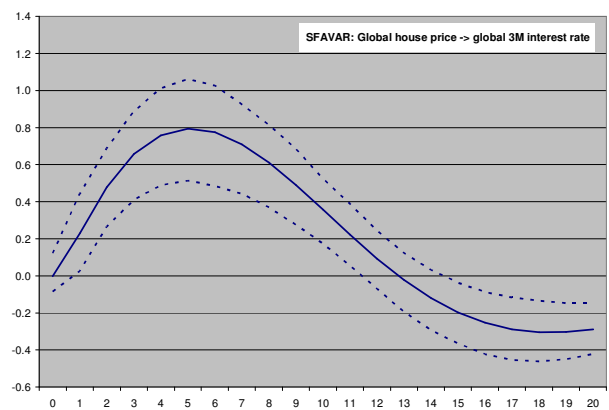
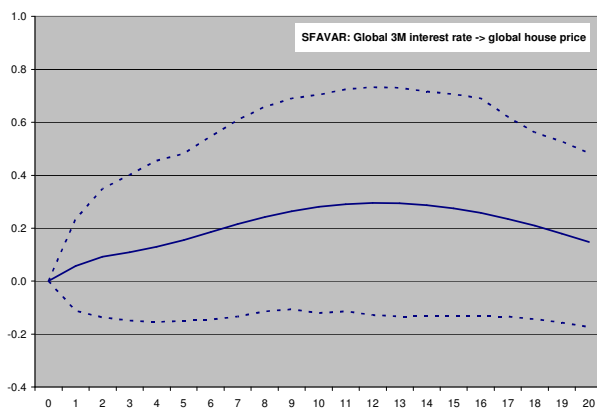
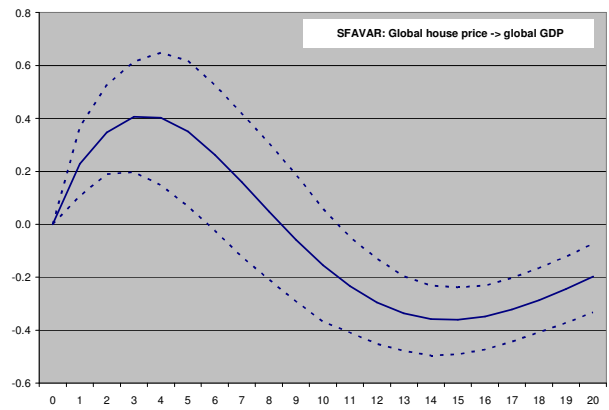
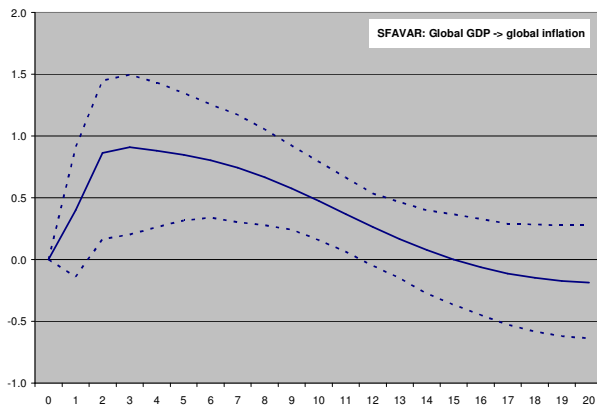
study conducted by Alessi, Detken (2009) finds that global measures of liquidity, like the M1 gap and the private credit gap, are useful early warning indicators for aggregate asset price booms in OECD countries. Their asset price measure includes house prices as well as commercial property and share prices.

Chart 1 - *Impulse response analysis in SFAVAR (global liquidity shock)*



Apart from a common liquidity driving force, global demand and house price shocks prove to be important as well. For example, a sudden change in the global GDP disturbance leads to temporary higher inflation from quarter two to quarter eleven. Significant responses of common factors can also be found after a global house price shock. In contrast, the common short-term interest rate is not a driving but a driven force in the global economy. For example, an interest rate shock does not trigger any significant response of the common house price factor. Instead, a sudden change in the disturbance of residential property prices leads to an increasing short-term interest rate. The same insignificant results are found for the inflation factor and commodity and share prices (see Table A1 for more results).

Chart 2 - Impulse response analysis in SFAVAR (various global shocks)



In order to investigate the effects of global and idiosyncratic structural shocks on national variables, we estimate equation (3), using a separate VAR for each country or region. The variables in levels are again “re-constructed” by calculating the cumulative sum of the standardized national variables. This is necessary to be fully consistent with our approach on the global level. Since a national economy can be hit by both global and idiosyncratic shocks, one has to distinguish between these two effects. We do so by regressing  $\varepsilon_{X_t}$  which consists of global and idiosyncratic disturbances on the global structural shocks ( $u_t$ ) derived from equation (5). On the basis of the obtained idiosyncratic components, restrictions can be imposed for exact identification on a national level (Bagliano and Morana, 2009). Again, we refrain from using a Cholesky decomposition and implement structural relationships between the respective variables as follows:

$$(6) \quad \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & a_{26} & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & 0 & 1 & a_{45} & a_{46} & 0 \\ 0 & 0 & a_{53} & a_{54} & 1 & a_{56} & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 & a_{67} \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{bmatrix} \begin{bmatrix} v_t^{YR} \\ v_t^{PI} \\ v_t^{HP} \\ v_t^M \\ v_t^{SR} \\ v_t^{ER} \\ v_t^{SP} \end{bmatrix} = \begin{bmatrix} z_t^{YR} \\ z_t^{PI} \\ z_t^{HP} \\ z_t^M \\ z_t^{SR} \\ z_t^{ER} \\ z_t^{SP} \end{bmatrix}$$

with  $v$  as the vector of errors in the reduced-form equations and  $z$  as the idiosyncratic structural disturbances. Our restrictions on a national level largely resemble the assumptions we made for global variables. For example, GDP (YR) and house prices (HP) are not influenced contemporaneously by other national variables. The inflation figure (PI) equals consumer prices and is affected only by the real effective exchange rate (ER) at the same time. The latter variable and share prices (SP) are assumed to respond contemporaneously to all other variables.

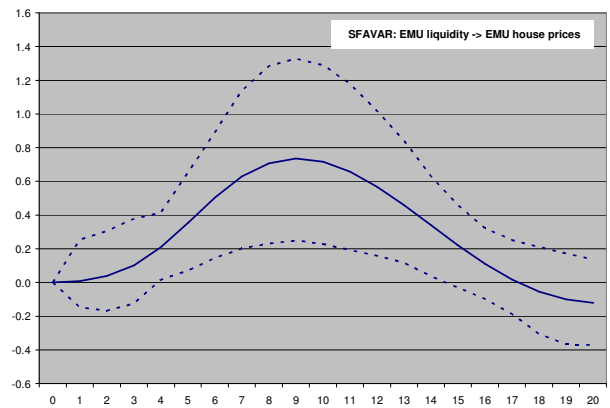
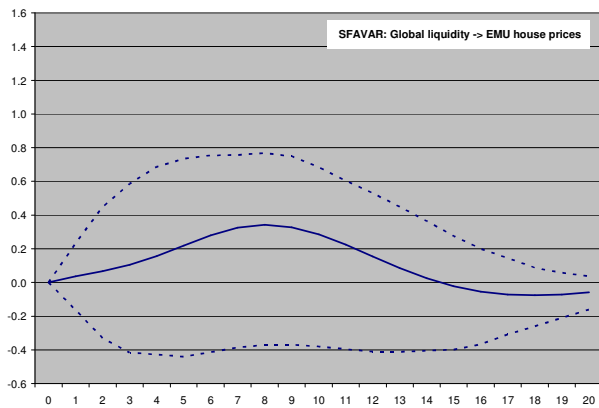
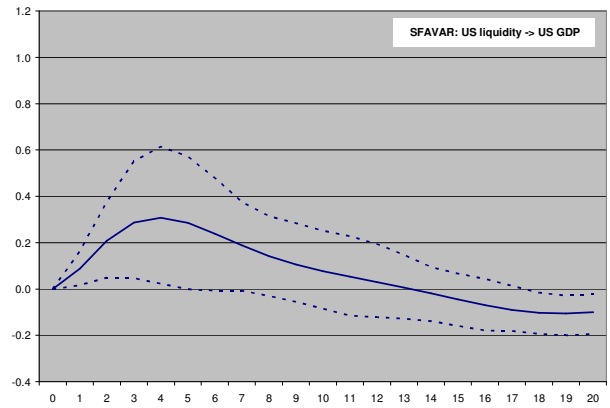
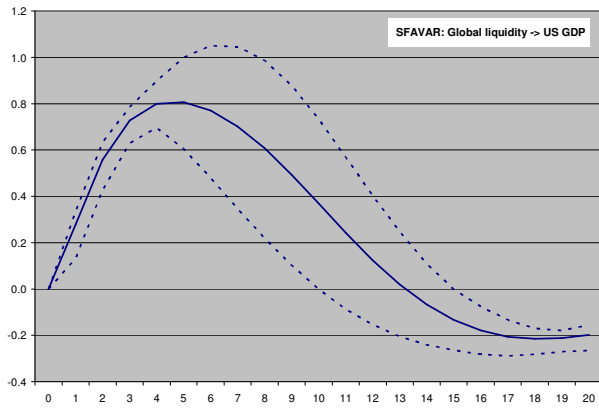
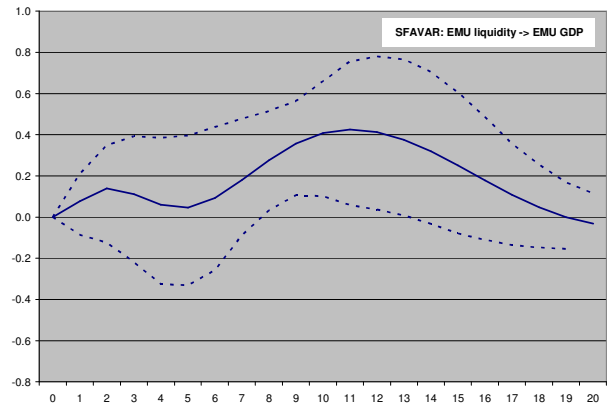
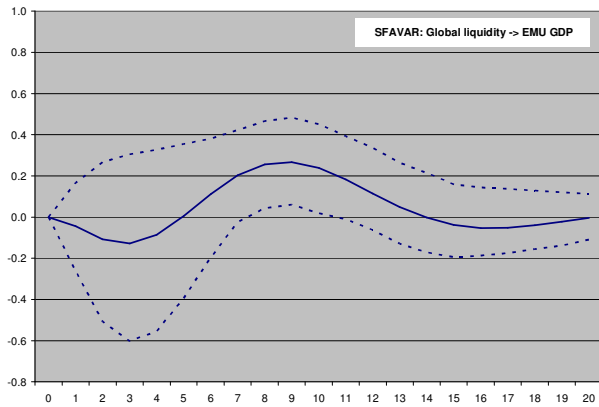
Before presenting the structural impulse response functions, some cautionary remarks in interpreting the results seem to be appropriate. The identification pattern in equation (6) is used for all countries included in the sample, although they differ markedly in economic size. In addition, various institutional settings in national monetary

and fiscal policy exist. Second, deriving the impact of global shocks on national variables is rather costly in terms of degrees of freedom. Since our SFAVAR contains seven factors and seven national variables with two lags each, 30 parameters (including a constant and a deterministic component) have to be estimated per equation. Bagliano and Morana (2009) estimate a total of even 43 coefficients by using a sample (only) ranging from Q1 1980 to Q2 2005.

In the following, we focus on the effects of global money supply (or what we label “global liquidity shocks”) on national variables. As has been the case before, we bootstrap the confidence bands on the basis of a residual bootstrap with 500 draws. Accordingly, global liquidity disturbances have a significant impact on broad national monetary aggregates in the US, the EMU and Canada. However, the effects differ, thereby indicating that various national transmission mechanisms are at work. In the UK and Japan no significant impact of global liquidity shocks on national money supplies can be found.

Global liquidity shocks also trigger significant responses of other major macroeconomic variables in some countries, like real GDP, consumer prices, house prices and short term interest rates. A detailed overview on a country level is included in Table A2 in the Appendix. For example, real GDP in the euro area reacts positively after a time lag of seven quarters. In order to get a yardstick, we derive the response of EMU GDP after a structural idiosyncratic money supply shock as well. The impulse response function displays a rather similar dynamic but is somewhat more pronounced in its impact on real GDP. House prices in the US are strongly affected by global liquidity shocks, whereas national money supply disturbances play a comparatively small role. Hence, we suspect that the bubble in the US residential property market in recent years can not only be explained by exceptionally low short term and long term interest rates but by excessive global liquidity as well. Interestingly, global liquidity shocks do not seem to be a major driver for the housing market in the euro area. In contrast, idiosyncratic disturbances to the money supply lead to strongly rising residential property prices in the EMU.

Chart 3 - Response of national GDP and house prices after global and idiosyncratic liquidity shocks





## 5.2. Additional global shocks

Our SFAVAR focuses on global forces, like monetary liquidity, inflation, share prices, etc. However, there could be other variables which also play a role in the global economy. Hence, we look for the influence of two other forces which may influence our SFAVAR approach: technology and long-term interest rates. The importance of technology shocks is stressed in the real business cycle theory (RBC) and in the endogenous growth literature. There may be international knowledge spillover effects, like the import of goods that embody new technologies, FDI flows, joint ventures and the migration of key personnel (Klenow, Rodriguez-Clare 2004). Especially trade-related new-good externalities could be central in transmitting new technologies from one country to another. New goods of higher quality are introduced and then imitated by other companies worldwide.

The second global force which could be interesting is the behavior of long-term interest rates. Instead of global excess liquidity, the shortage of financial assets could have played a central role in shaping the global economy in recent years (Caballero, 2006). Emerging markets' FX reserves have been surging under the so-called Bretton Woods II system. Given increasing global demand for financial assets and limited supply by industrialized countries, long-term interest rates fell to historically low levels. In addition, the phenomenon of petrodollar recycling from commodity-exporting countries exerted further downward pressure on real interest rates. This in turn could have contributed to the strong rise in house prices in many countries.

In order to derive technology shocks, we use the identification pattern proposed by Galí (Galí 1999). This procedure has been discussed intensively in the last few years in the RBC literature. Accordingly, there are technology and non-technology shocks which are orthogonal to each other. Galí's basic identifying assumption is that technology innovations are the only shocks which have an effect on the long-run level of labor productivity. Assuming that both variations in the log productivity ( $x_t$ ) and log hours ( $n_t$ ) are integrated of order one, one gets the following expression:

$$(7) \quad \begin{bmatrix} \Delta x_t \\ \Delta n_t \end{bmatrix} = \begin{bmatrix} C^{11}(L) & C^{12}(L) \\ C^{21}(L) & C^{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_t^z \\ \varepsilon_t^m \end{bmatrix}$$

where  $\varepsilon_t^z$  and  $\varepsilon_t^m$  equal the technology and the non-technology innovations, respectively. Since Galí (1999) assumes that the unit root in productivity stems exclusively from technology shocks, the matrix of long-run multipliers is lower triangular ( $C^{12}(1) = 0$ ). In order to estimate this approach on a global level, the following five-step procedure is pursued. First, labor productivity figures for the G-7 plus euro zone are calculated by subtracting the log of total employee hours from the log of GDP for each country or region.<sup>6</sup> Second, the obtained figures for labor productivity and total employee hours are standardized on the basis of first differences with a mean of zero and a variance of one. Third, global forces for labor productivity and hours worked are estimated by deriving the first principal component (PC1) each. Accordingly, for labor productivity the proportion of the total variance attributable to PC1 is 26.1% compared to 22.5% for PC2. For total hours worked, PC1's share is 38.3% (PC2: 22.7%). Fourth, we “re-construct” the two first principal components in levels by setting each global factor zero in Q1 1984 and calculating the cumulative sum. Fifth, we apply a battery of unit root tests (Dickey-Fuller; Phillips-Perron; Kwiatkowski, et. al., Elliot et. al.; Ng and Perron) for global productivity and global hours worked. Accordingly, the majority of unit root tests indicates that global productivity is integrated of order one. With respect to global hours worked, the empirical evidence is more mixed, with some tests indicating integration of order one or being stationary. Hence, concerning hours, equation (7) is estimated both in levels and first differences. All lag criteria point lag to a length of one. After deriving the global technology innovation, the following equation is estimated:

$$(8) \quad u_t = c_0 \varepsilon_t^z + c_1 \varepsilon_{t-1}^z + c_2 \varepsilon_{t-2}^z + c_3 \varepsilon_{t-3}^z + c_4 \varepsilon_{t-4}^z$$

with  $u_t$  as global structural shocks derived from our SFAVAR (cf. equation 5) and  $\varepsilon_t^z$  as global technology shock. Wald F-tests are done with the null hypothesis that the technology innovations do not have an impact on the global structural shocks within the first four quarters, i.e.  $c_0$ ,  $c_1$ ,  $c_2$ ,  $c_3$  and  $c_4$  are jointly equal to zero. A constant in

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<sup>6</sup> A series for total hours worked in the EMU is not available to our knowledge. We therefore construct the EMU figure as the sum of hours worked in the following countries: Germany, France, Italy, Spain, the Netherlands, Belgium, Ireland and Finland. On basis of PPP weights provided by the IMF, our measure covers 89% of total EMU GDP in 2007.

equation (8) is neglected since its influence proved to be non-significant. The results indicate that the null hypothesis is rejected for five of the seven global innovations. Apart from the global money and the short-term interest rate shock, all innovations in the FAVAR are contaminated by technology shocks. This is true independent of whether total hours worked are modeled as stationary time series or integrated of order one. Interestingly, the coefficient signs are not always in line with economic theory. For example, global technology shocks have a positive impact on global inflation. It is not clear whether this result is triggered by another common force behind technological innovations or due to the specification suggested by Galí (1999).

Table 2 - Testing for omitted global technology shocks in the SFAVAR

Global structural shocks	Hours (I(1))	Significant Coefficients	Hours (I(0))	Significant Coefficients
GDP	3.04**	$c_0=-0.15^{**}; c_1=0.14^{**}; c_2=0.12^*$	3.29***	$c_0=-0.16^{**}; c_1=0.14^{**}; c_2=0.13^*$
Inflation	2.04*	$c_1=0.61^{**}$	2.25*	$c_0=0.54^{**}; c_1=0.64^*$
Commodity prices	1.95*	$c_1=0.34^*$	2.22*	$c_0=0.40^{**}; c_1=0.35^*$
House prices	2.39**	$c_1=-0.15^{**}; c_3=0.11^*$	1.96*	$c_1=-0.11^*$
Monetary liquidity	1.82	---	1.37	---
3M interest rates	1.16	---	1.26	---
Share prices	2.96**	$c_0=-0.28^*; c_1=-0.40^{**}; c_2=0.40^{**}$	2.83**	$c_0=-0.30^*; c_1=-0.35^*; c_2=0.41^{**}$

Note 1: F-statistics from Wald tests

Note 2: \*\*\* Indicates significance at 1% level, \*\* at 5% level, \* at 10% level

The same type of Wald tests in equation (8) are repeated for long-term interest rate shocks. Hence, a principal component analysis for 10Y government bond yields is done.<sup>7</sup> Accordingly, PC1 amounts to a high 66% (PC2: 13.9%). Again, we “re-construct” the PC1 in levels by setting the global interest rate factor zero in Q1 1984 and calculating the cumulative sum. An equation is estimated with the global interest rate factor as dependent variable and the common forces used in the SFAVAR (GDP, inflation, commodity, house prices, liquidity, short-term interest rates and share prices) as independent ones. As is the case in our baseline FAVAR, a lag length of two is chosen. The obtained residuals are taken as a proxy for the global interest rate disturbance for the Wald tests. Accordingly, common long-term interest rate shocks seem to play an important role in the global economy. Of the seven common disturbances in the SFAVAR, five are significantly influenced by long-term interest rate shocks. This stands

<sup>7</sup> In the case of Japan, the average maturity for government bonds is used for data availability reasons.

in stark contrast to the negligible effects of non-systematic variations in the global short-term interest rate factor.

Two additional results are worth noting. First, our derived common liquidity shock is at least partly driven by changes in the long-term interest rate disturbance. Our FAVAR therefore contains not only a pure common money supply shock but some interest-rate sensitive elements as well. In line with theory, the obtained coefficient is negative, i.e. there is an inverse relationship between the shock components of the common money and the long-term interest rate factor. Second, the global house price disturbance is not driven by long-term interest rate shocks. This is a surprising result, given the discussion of the interest rate conundrum's impact on the boom and bust of residential property prices. Independent of the concrete reasons, we regard both the role of international knowledge spillovers and the global long-term interest rate factor as an interesting field for further empirical research.

Table 3 - *Testing for omitted long-term interest rate shocks in SFAVAR*

Global structural shocks	Long-term interest rate	Significant Coefficients
GDP	1.72	---
Inflation	5.59***	$c_0=0.65^{***}$
Commodity prices	6.69***	$c_0=0.56^{***}$
House prices	0.24	---
Monetary liquidity	2.28*	$c_0=-0.17^{***}$
3M interest rates	4.00***	$c_0=0.23^{***}$
Share prices	2.48**	$c_0=-0.36^{***}$

Note 1: F-statistics from Wald tests

Note 2: \*\*\* Indicates significance at 1% level, \*\* at 5% level, \* at 10% level

### 5.3. Structural breaks

In the last 25 years, the global economy and international financial markets underwent a number of profound changes. For example, world trade increased by 658% between 1984 and 2007. According to Lane and Milesi-Ferretti (2007), cross-border holdings of financial assets in the G-7 countries rose from 116% of GDP in 1990 to 261% in 2004 (last available data point)<sup>8</sup>. Moreover, there may have been regime switches in central bank behavior. Apart from structural time variations (propagation), the variance of

<sup>8</sup> The world trade statistic and the readings for financial cross-border holdings stem from the IMF and Lane and Milesi-Ferretti (2007), respectively. Both figures are our own calculations.

exogenous shocks could have changed as well. All in all, it is rather unlikely that the data generating process in 1984 is the same as in 2007. This in turn could undermine the stability of our SFAVAR. We therefore examine three types of structural breaks: in the factor dynamics ( $\Phi$ ), in the global shocks ( $G\eta_t$ ) and in the factor loadings ( $\Lambda$ ).<sup>9</sup>

$$(9) \quad F_t = \Phi(L)F_{t-1} + G\eta_t \text{ where } \Phi(L)F_{t-1} = \begin{cases} \Phi_1(L), t \leq \kappa \\ \Phi_2(L), t > \kappa \end{cases} \text{ and } \text{var}(\eta_t) = \begin{cases} \sigma_1^2, t \leq \tau \\ \sigma_2^2, t > \tau \end{cases}$$

Equation (9) allows the global SFAVAR coefficients and the global structural shocks to break at potentially different dates ( $\kappa$  and  $\tau$  respectively).

$$(10) \quad X_t = \Lambda F_t + D(L)X_{t-1} + v_t \text{ where } X_t = \begin{cases} \Lambda_1 F_t, t \leq \upsilon \\ \Lambda_2 F_t, t > \upsilon \end{cases}$$

In equation (10), it is allowed for a break in the factor loadings at date  $\upsilon$ .

We start by testing jointly for the stability of all the coefficients on the lags of a given global variable using the Andrews-Quandt structural breakpoint test. In contrast to the traditional Chow test, this structural change test does not assume any prior knowledge about potential break dates. Instead, the Andrews-Quandt sup-F statistic is the maximum of a sequence of traditional Chow tests for structural change each based on a different potential breakpoint. As is common in the literature, we applied a heteroskedasticity-robust version of the Andrews-Quandt test (Stock, Watson 2002). The range of the sample is trimmed by 15% from each side. Of the seven tests performed, none rejects the null hypothesis of stability at conventional confidence levels. Moreover, additional Andrews-Quandt tests are implemented separately for three variables in each of the seven SFAVAR equations: global monetary liquidity, global GDP and global house prices. Given the previously obtained empirical evidence, we regard these three variables as short-run driving forces of the global economy. Only in the global liquidity equation do signs of structural instability emerge. In contrast, the null hypothesis of structural stability in the remaining equations is not rejected.

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<sup>9</sup> The dynamics  $D(L)$  on a national level and the idiosyncratic errors  $v_t$  may undergo profound changes as well. These types of time variation are neglected in our work.

Table 4 - *Andrews-Quandt breakpoint tests for SFAVAR coefficients*

FAVAR equations	All coefficients		Global liquidity		Global GDP		Global house prices	
	Date	Max LR F	Date	Max LR F	Date	Max LR F	Date	Max LR F
Global GDP	1990 Q2	3.88	1988 Q2	8.09	1990 Q2	4.72	1990 Q2	6.48
Global inflation	2001 Q3	3.73	1990 Q3	3.32	1990 Q3	3.73	2001Q3	3.17
Commodity prices	1996 Q2	2.92	1998 Q1	2.90	1990 Q3	2.83	1999Q2	1.99
Global house prices	1991 Q3	3.17	1989 Q2	5.46	1989 Q2	8.05	1989Q2	5.26
Global liquidity	1997 Q3	5.46	1990 Q3	19.10***	1990 Q3	20.11***	1990 Q3	17.24***
Global 3M interest rates	1988 Q3	4.53	1988 Q3	8.08	1988 Q3	8.78	1988 Q3	3.66
Global share prices	1999 Q4	2.40	2002 Q2	8.50	1995 Q2	9.11	2002 Q2	11.11*

Note 1: Heteroskedasticity-robust version of Maximum LR test for 'propagation'

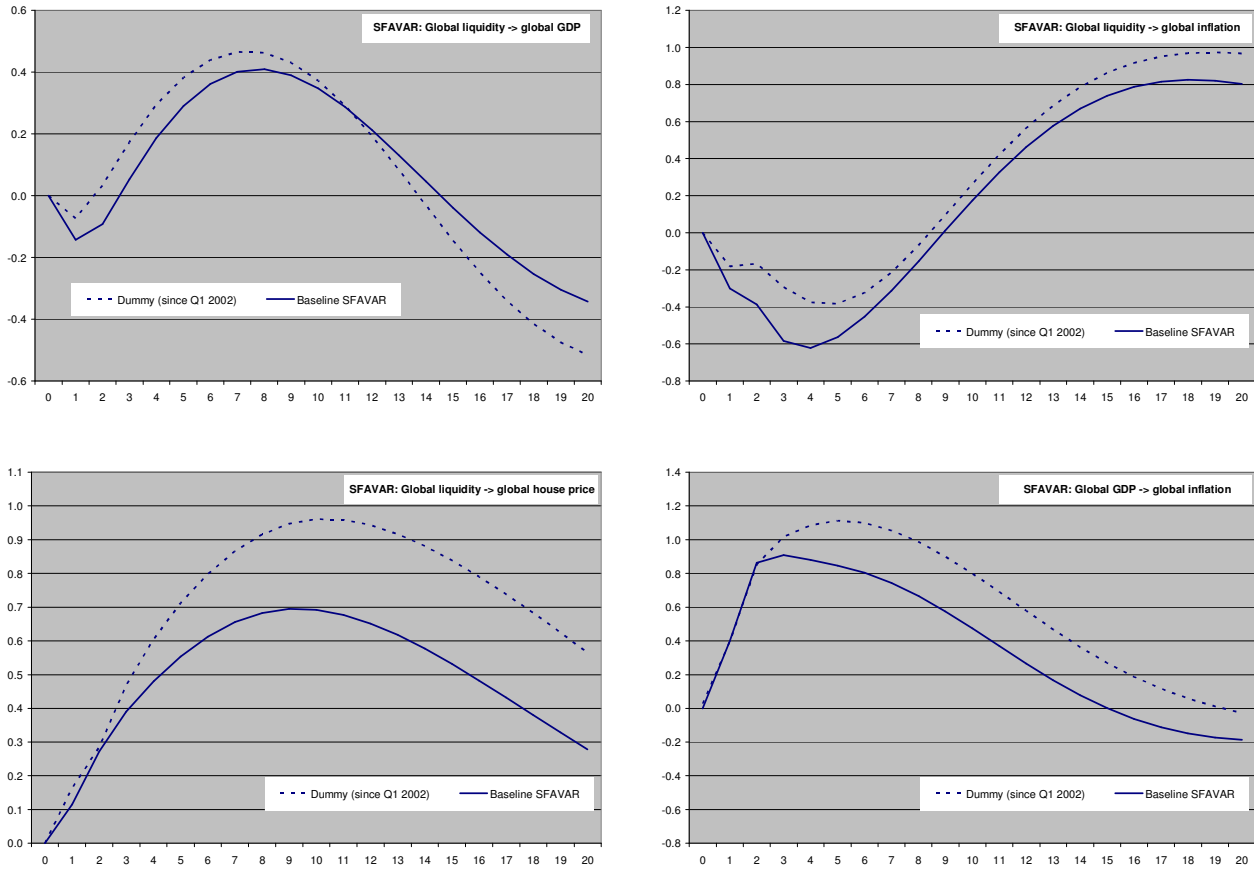
Note 2: \*\*\* Indicates significance at 1% level, \*\* at 5% level, \* at 10% level

Due to our trimming exercise, 15 percent of the sample period gets lost both at the start and the end of the sample period. Hence, the most recent years from 2004 to 2007 in the run-up to the global financial crisis are excluded from the Andrews-Quandt tests above. As an alternative for detecting structural breaks, we opted for estimating the following dummy approach (Boivin and Giannoni, 2008):

$$(11) \quad F_t = \Phi(L)F_{t-1} + \Phi^d(L)d_t F_{t-1} + G\eta_t$$

where  $d_t$  takes the value 0 for the period Q1 1984 – Q4 2001 and 1 afterwards. The coefficients on the global factors are equal to  $\Phi(L)$  for Q1 1984 – Q4 2001 and to  $\Phi(L) + \Phi^d(L)$  thereafter. We regard our dummy approach as an interesting alternative to the data-consuming Andrews-Quandt tests. Accordingly, the effects of global liquidity shocks have seemingly become stronger from 2002 to 2007. Interestingly, the most pronounced impact can be found on global house prices. After three quarters, the effect of a global liquidity shock gets stronger and more persistent in comparison to the baseline SFAVAR. On average, the impact on global house prices from Q3 to Q20 increases by 50%. We take this as a first indication that the propagation mechanism in the global economy may have changed in recent years and the importance of global money supply shocks has risen. In addition, global demand shocks have also played a more important role as the impact on inflation has risen.

Chart 4 - Impulse response analysis in SFAVAR (dummy approach)



In the next step, we examine the stability of the global structural shocks. Under the null hypothesis that there is no break in the variance,  $E|\eta_t(\tau)|$  is constant. We therefore test for a break by implementing the Quandt-Andrews test in the regression of  $|\eta_t(\tau)|$  against a constant, using homoskedastic standard errors (which are valid under the null). Accordingly, apart from the short-term interest rate innovations, there is no indication of sharp structural breaks. The estimated break date for global interest rate shocks is Q1 1991. Given that such a sharp break may still be part of an ongoing trend, we additionally test for more gradual changes in the global short-term interest rate shocks. The regression is augmented with a time trend (Stock, Watson 2002). The null hypothesis of no sharp break is not rejected again. The coefficient sign of time trend is significantly negative, thereby reflecting that the magnitude of the shocks is decreasing over time.

Table 5 - *Andrews-Quandt breakpoint tests for SFAVAR shocks*

Global structural shocks	Date	Max LR F	Max LR F (trend)
GDP	1988 Q2	6.20	---
Inflation	1998 Q4	2.40	---
Commodity prices	1988 Q4	3.01	---
House prices	1991 Q3	5.95	---
Monetary liquidity	2003 Q4	2.99	---
3M interest rates	1991 Q1	18.65***	6.62 (-)
Share prices	1991 Q2	3.41	---

Note 1: Sign of trend, if significant, in parentheses

Note 2: \*\*\* Indicates significance at 1% level, \*\* at 5% level, \* at 10% level

The same procedure is repeated for factor loadings in order to examine whether the transmission mechanism between global factors and national variables has changed over time. The lag length in the lag polynomial  $D(L)$  is set uniformly to two which is sufficient to avoid autocorrelation.<sup>10</sup> 15 of the 30 implemented Andrews-Quandt breakpoint tests indicate a sharp break in the respective factor loading on the basis of conventional significance levels. Especially prone to instability is the relation between global and national GDP with breaks in the US, the EMU, Japan and the UK. Only in Canada can no structural variation be found.

The relations between global factors and national variables are also unstable with respect to money and house prices with three of five possible breaks each. It is important to note that the breaks typically do not occur at approximately the same time across countries. For example, the break between global and EMU money is in Q2 1994, whereas it is in Q1 2002 for the US. The same irregular pattern can also be found for house prices and GDP. In our view, this argues against a big bang in economic and financial globalization with the G-7 countries and the euro zone influenced by global forces at approximately the same time. Instead, the global factors seemingly started influencing national variables differently at various points in time.

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<sup>10</sup> The results prove to be robust when different lag specifications are tried.



Table 6 - *Andrews-Quandt breakpoint tests for factor loadings*

Relation between ...	US	EMU	Japan	UK	Canada
global and national GDP	12.63*** (1994 Q4)	10.45** (1990 Q2)	11.55** (1989 Q3)	8.37* (1995 Q2)	2.40 (2000 Q2)
global inflation and national CPI	4.53 (2003 Q4)	0.81 (1989 Q2)	5.88 (1994 Q1)	7.59* (1990 Q3)	5.87 (1988 Q2)
global and national house prices	62.79*** (2004 Q1)	2.38 (1988 Q4)	9.52** (1991 Q2)	1.91 (1990 Q1)	18.77*** (1999 Q1)
global and national money	9.67** (2001 Q1)	14.81*** (1994 Q2)	8.02* (1992 Q4)	2.03 (1997 Q3)	3.42 (1999 Q1)
global and national 3M interest rates	14.07*** (2001 Q1)	4.81 (1992 Q4)	1.22 (2001 Q3)	14.38*** (1993 Q2)	3.41 (1990 Q1)
global and national share prices	2.78 (1998 Q4)	5.45 (1990 Q3)	5.91 (1992 Q3)	7.19* (1994 Q3)	9.94** (1993 Q4)

Note 1: Heteroskedasticity-robust version of Maximum LR test

Note 2: \*\*\* Indicates significance at 1% level, \*\* at 5% level, \* at 10% level

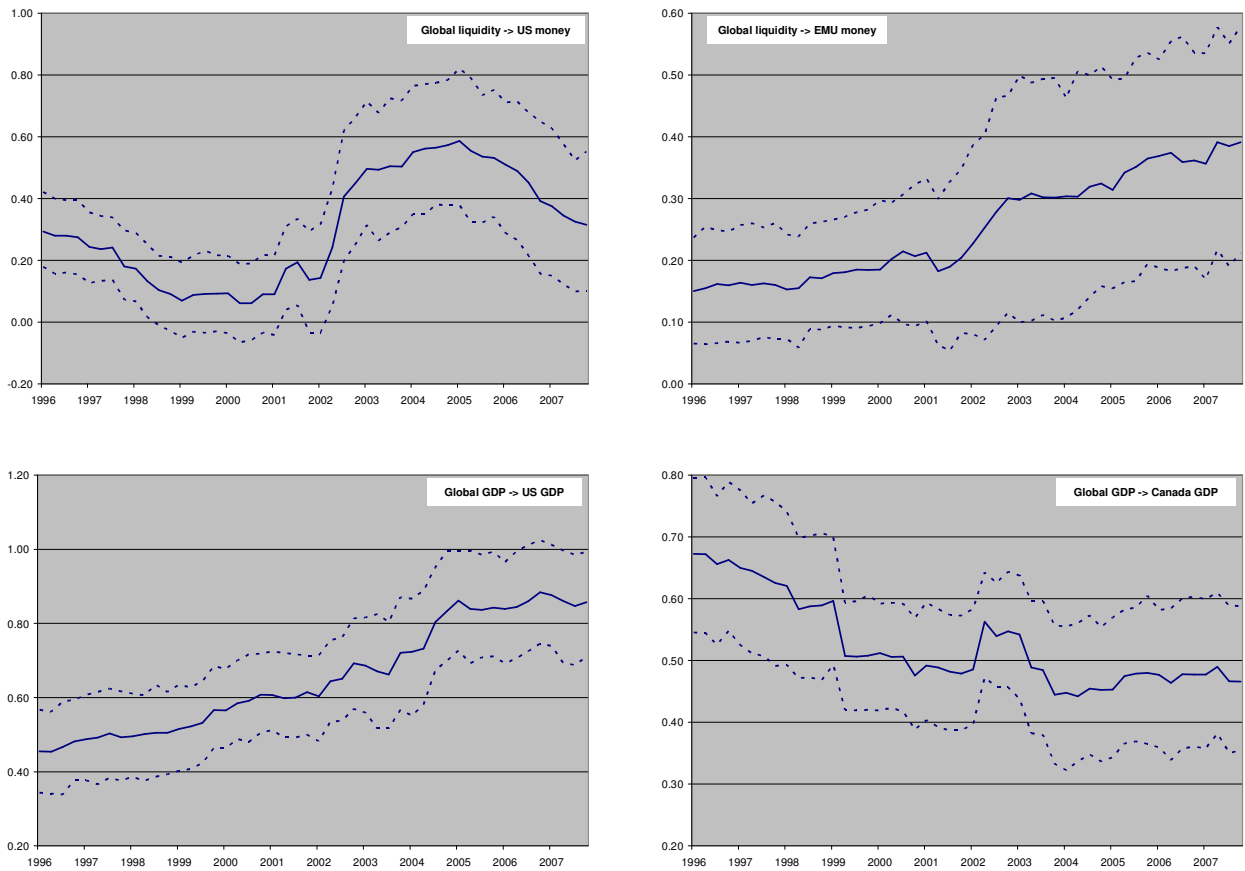
However, as already noted, the Andrews-Quandt test focuses on rather simple one-off breaks. Such an assumption is not justified, if gradual changes in coefficients and residuals occur. In addition, there can be temporary outbursts of volatility. Tests for a single change in volatility are then misleading, as the one-off break will be dated either at the beginning or at the end of the extremely volatile time period. We therefore estimate rolling regressions for factor loadings, concentrating on GDP, money and house prices. Given that our sample covers a comparatively short time span of 24 years, we opted for a rolling 12-year window.

Selected results can be found in the following charts in which the solid line equals the factor loading and the two dashed lines are the 95 percent intervals obtained by a simple residual bootstrap with 500 draws (see also Tables A3 to A5 in the Appendix). For example, the figures for Q1 2000 are the results based on the rolling regression from Q1 1988 to Q4 1999. A clear-cut pattern across countries and variables does not emerge. In some cases, the factor loadings increase over time, in some not or even decline. Concerning global liquidity, the factor loading for EMU M3 more than doubles, whereas the impact on US M2 also rises but less markedly. The same diverse pattern also holds for the relation between national and global GDP and national and global house prices, respectively.

Interestingly enough, US variables in general seem to be influenced increasingly by common forces. For example, the US factor loadings both for global GDP and house prices have risen significantly. However, at this point, it is not clear whether the US has really become more prone to influences from abroad. We will deal with this issue in the

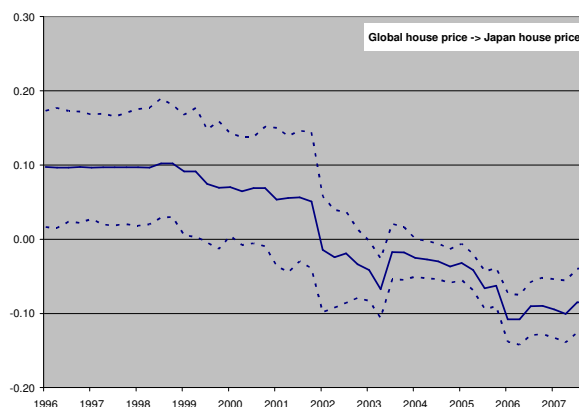
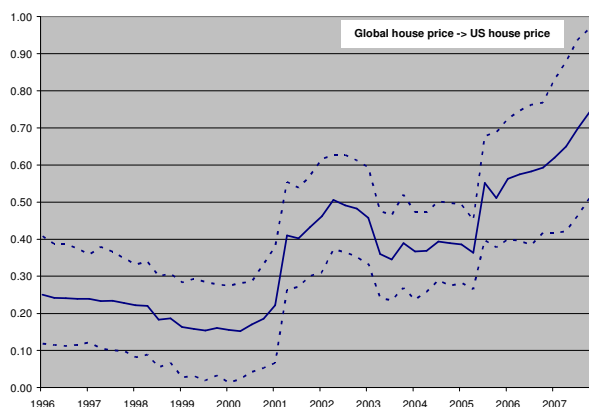
next chapter by conducting several robustness checks.<sup>11</sup> In contrast, the effect from globalization on national GDP seems to have diminished for such a small economy like Canada. Not surprisingly, national developments also play a more important role in the case of Japan, given the special circumstances after the bursting of the housing and equity bubble at the beginning of the 1990s.

Chart 5 - Rolling regressions for factor loadings



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<sup>11</sup> Given the fact that our common forces for money, GDP and house prices are estimated on the basis of only five variables, the reverse causality may hold, i.e. development in the US has recently become more important for the global economy.



#### 5.4. Robustness checks

We apply three robustness checks in order to test whether our results hold in general independent of variations in the specification. One important robustness check is the “cross-sectional” stability of the global forces. In dynamic factor analysis, it is usually assumed that the cross-sectional dimension of the dataset is large, even possibly larger than the temporal dimension. Hence, the exclusion of one country or variable should not influence the results markedly. However, this may not be true in our approach, since we focus on a rather limited set of countries (G-7 countries plus euro zone) often with only one variable per country. For example, for broad monetary liquidity, a total of five figures are used (M2 in the US and Canada, M2CD in Japan, M3 in the EMU and M4 in the UK) to estimate the common monetary liquidity force. The same is true for other variables, like house and share prices or GDP. It is therefore conceivable that the exclusion of one variable may significantly alter the results received from principal component analysis.

In order to assess how vulnerable our results are, we estimate each global variable excluding one country. Afterwards, the co-movement between the global force including all five countries and the global force based on four countries is estimated. If the correlation coefficient does not change markedly, it is concluded that the global variable is symmetric, i.e. it is not overly influenced by one country. Our results indicate that this is the case, as the co-movement is comparatively high. Interestingly, this is even true when the US is excluded from the dataset. This may point in the direction that the global economy may be less asymmetrically influenced by the US than usually thought.

However, it is important to stress that a simple correlation analysis cannot distinguish between shocks and propagation.

Table 7 - *Co-movement between global force and global force ex respective country*

Global force excluding ...	GDP	Inflation	House prices	Liquidity	3M interest rate	Share price
US	0.90***	0.95***	0.91***	0.98***	0.93***	0.99***
EMU	0.97***	0.98***	0.81***	0.96***	0.97***	0.99***
Japan	1.00***	0.98***	0.99***	0.98***	0.98***	0.99***
UK	0.93***	0.97***	0.86***	0.96***	0.96***	0.99***
Canada	0.86***	0.99***	0.81***	0.96***	0.93***	0.99***

Note 1: Correlation coefficients

Note 2: \*\*\* Indicates significance at 1% level, \*\* at 5% level, \* at 10% level

Another robustness check is the estimate of alternative versions of our SFAVAR. First, we change the lag length from two to four lags with little consequences for our results. Global liquidity, house and GDP shocks remain driving forces of the world economy. In addition, we use different assumptions for identifying the global structural shocks. In contrast to equation (5), we assume that the global short-term interest rate reacts contemporaneously to global GDP and inflation but not to commodity prices, global house prices and global liquidity. This change seems to be the most obvious one for us, since monetary policy may have knowledge of the development of GDP and inflation within the quarter. The impulse response functions in the FAVAR remained very stable, apart from the responses after a global liquidity shock for which we find some changes. For example, the common inflation factor rose significantly without any time delay, thereby not being in line with economic theory. We interpret this result as confirmation of our chosen identification strategy.

## 6. Policy conclusions

In this contribution, we have investigated whether there is increasing uncertainty for monetary policy in the wake of globalization and whether central banks have become less effective in influencing national liquidity conditions. In brief, our answer to both questions is a clear “yes”. Hence, we feel legitimized to derive at least four policy conclusions emerging from our analysis. First, global liquidity conveys additional information about monetary conditions not summarized by national money and short-term interest rates. Second, global liquidity restricts national monetary policy in its ability

to influence nominal and real variables, caused by, for example, the effect of global liquidity on short-term interest rates. As a consequence, the influence of central banks on domestic money supply is weakening. Third, national monetary policy is faced with an increasing degree of uncertainty and might feel forced to act according to the so-called Brainard conservatism principle. Fourth, the old question of optimal monetary policy among interdependent economies powerfully reappears on the surface. In the following, we elaborate a bit more on the third and the fourth policy conclusion.

Our third policy conclusion is that national monetary policy is faced with an increasing degree of uncertainty. Needless to say, monetary policy always operates in an environment of uncertainty. Sometimes, for instance, it is not unambiguously clear for central banks how to interpret new incoming macroeconomic data. Moreover, there are uncertainties about the concise monetary transmission mechanism. However, our empirical results indicate that the fog of uncertainty has indeed become denser due to structural changes in the transmission process between global and national variables. Among other common forces, this seems to be also true for global liquidity, which has an increasingly stronger effect on monetary aggregates in some but not all countries. This “Knightian uncertainty” or model uncertainty may have significant implications for the behavior of central banks.

According to the Brainard conservatism principle, uncertainties about major model parameters can change the incentives facing central bankers, thereby leading them to use their policy instruments less vigorously. The reason is that uncertainties about the elasticity between global and national money is amplified into the economy the more monetary policy reacts to this relation. Since the Brainard conservatism introduces a motive for caution in optimal central bank behavior, financial globalization and its corresponding structural changes may be important reasons for central banks not fighting against strong rises in monetary and credit aggregates in the last few years.

In contrast, Borio and Filardo (2007) explain excessive monetary policy accommodation not by rising uncertainties but by favorable supply side developments triggered by globalization. This in turn dampened inflationary pressure and allowed the reduction of short-term interest rates to exceptionally low levels. If structural breaks and

the higher potential for making mistakes make up for the underlying reasons for too prudent central banks behavior, it is not clear whether this will change in the years to come. Both financial markets and the global economy may undergo even more profound modifications after the unprecedented financial crisis.

Our fourth policy conclusion concerns the question of the optimal design of monetary policy among interdependent economies. Should open “spillover-driven” economies adopt rules designed to fit specific features of more open and more closed economies? This is old wine in new bottles and is closely related to the popular debates about inward-looking versus outward-looking monetary policy and commitment versus discretion, respectively.

The Chicago School saw a flexible exchange rate as a way of insulating domestic developments from foreign economic disturbances, including foreign monetary policy. There is no need, they argued, for central banks to coordinate their monetary policies. All that is needed is flexible exchange rates. Does the existence of global liquidity mean that we need coordination or even a world central bank? International coordination might be needed to keep global liquidity shocks as low as possible, since structural changes between global and national liquidity cannot be influenced by central banks. One reason is that monetary competition between central banks might cause a free-rider problem without any coordination. If a national central bank, let’s say the Bank of Japan, is inclined to conduct a lax monetary policy, liquidity spillovers occur and foreign central banks have to bear parts of the burden. Another reason is that there may be multiplier effects that occur when several countries all turn their monetary policy in the same direction. The crucial issue is how best to prevent further excessive, synchronized shifts in the world money stock. However, policy coordination would bring greater predictability, but at the risk of all countries simultaneously choosing the wrong set of policies. International policy coordination would merely elevate to the global level the shortcomings that are now apparent at the domestic level.

While we have come up with some additional empirical evidence supporting the view that monetary policy has become less effective as a consequence of globalization, the question remains unsolved whether central banks need to adapt their monetary policy

strategies in order to cope with the challenges of globalization. We leave this task for further research.

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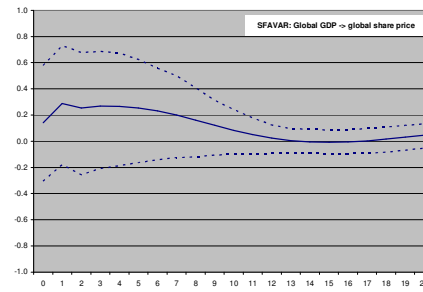
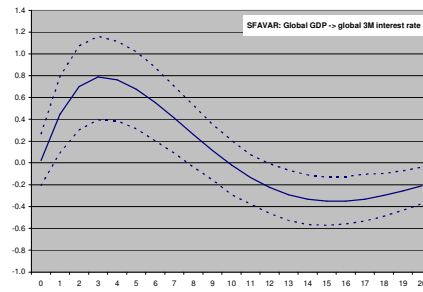
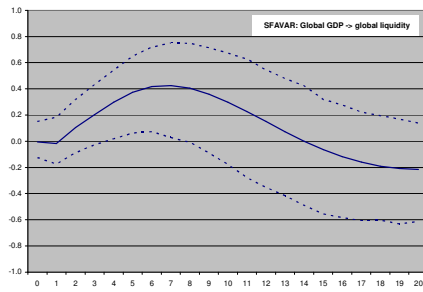
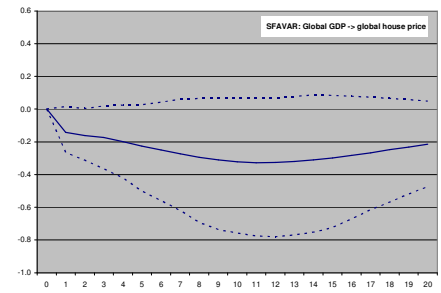
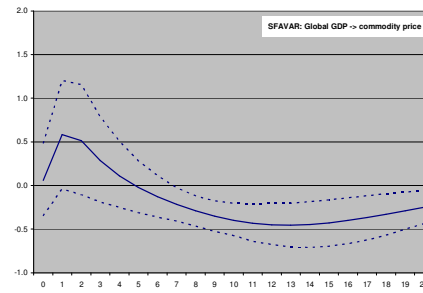
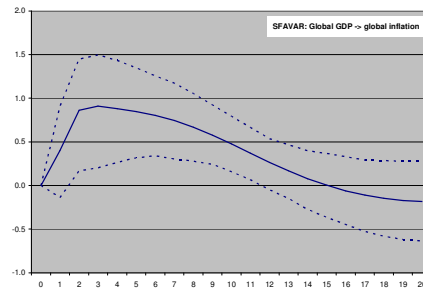
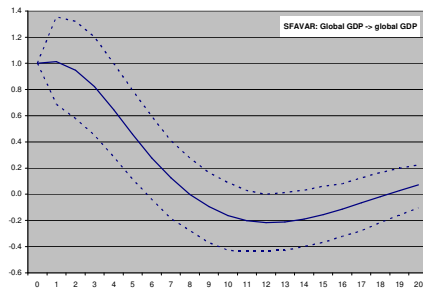
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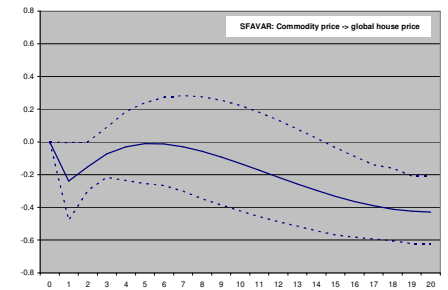
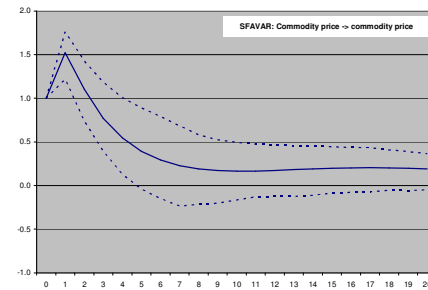
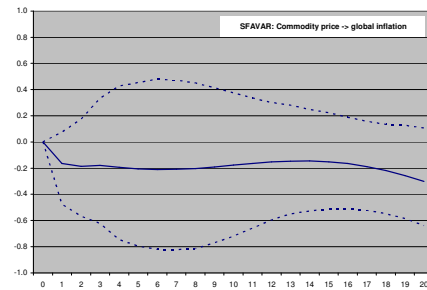
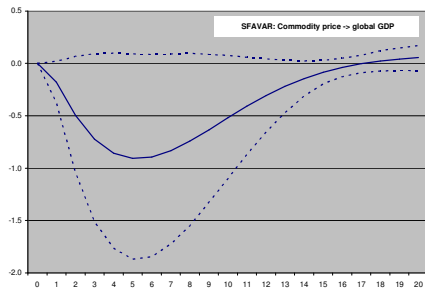
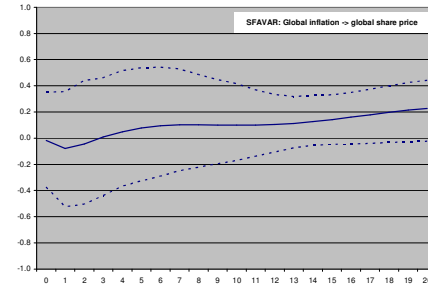
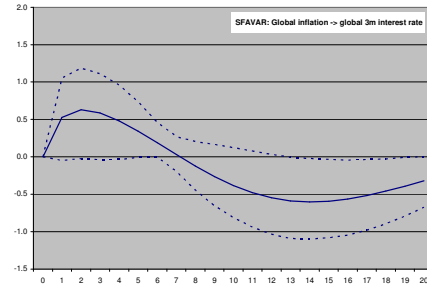
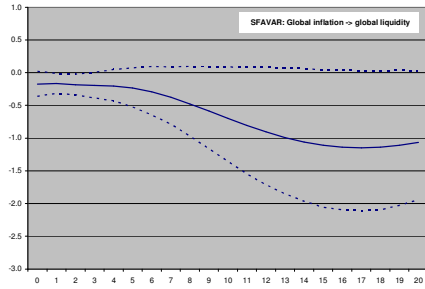
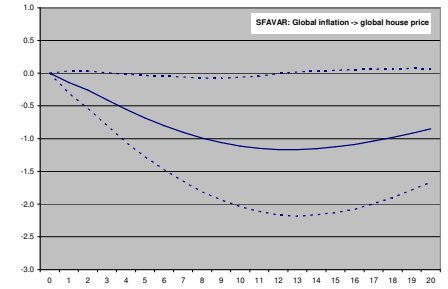
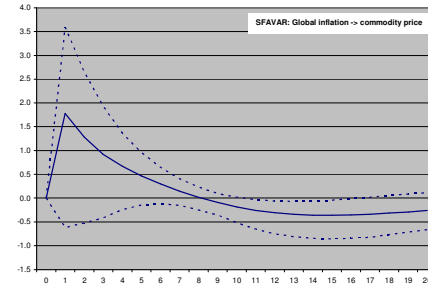
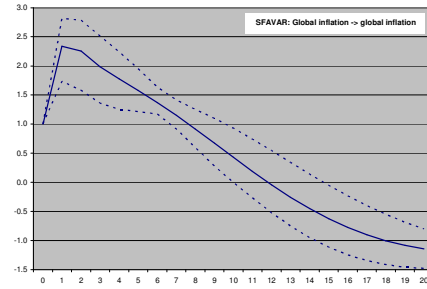
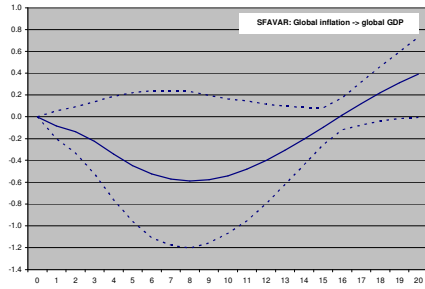


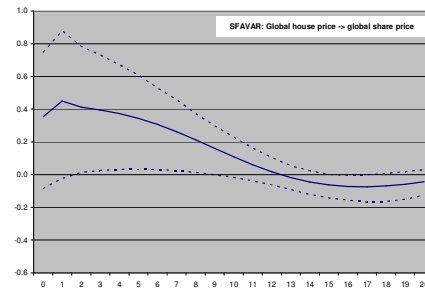
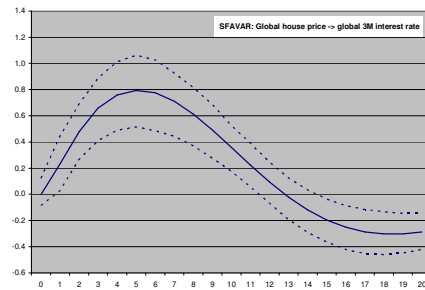
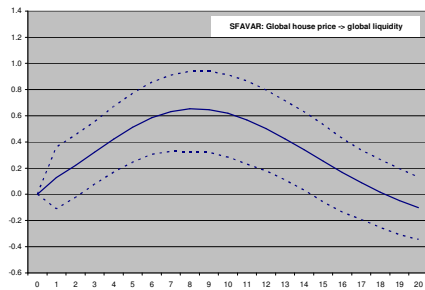
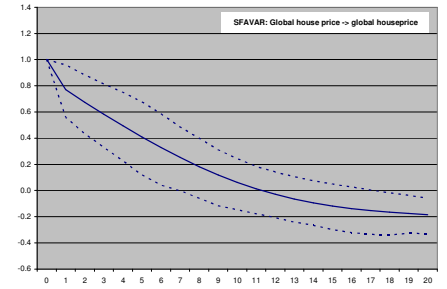
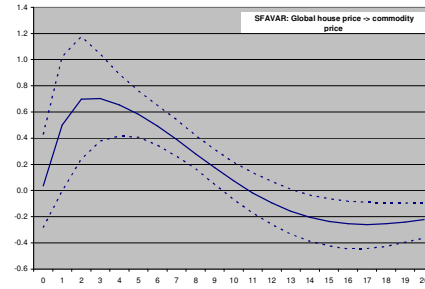
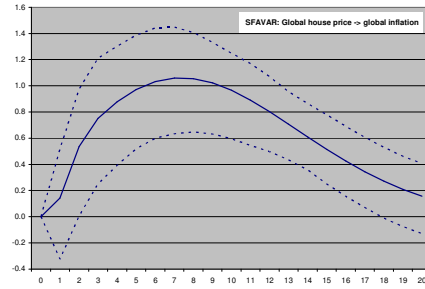
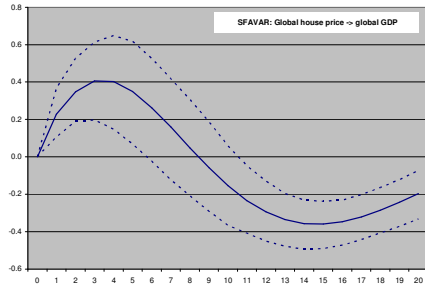
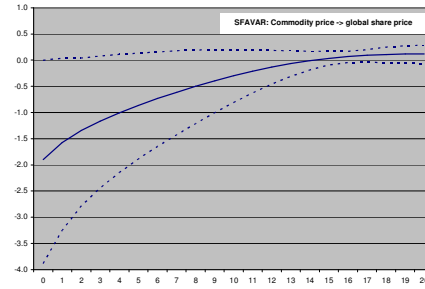
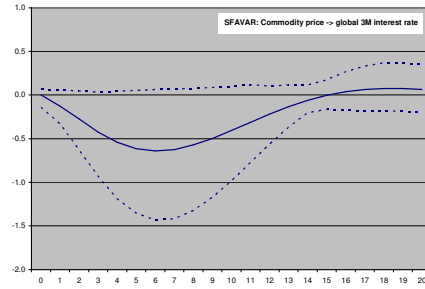
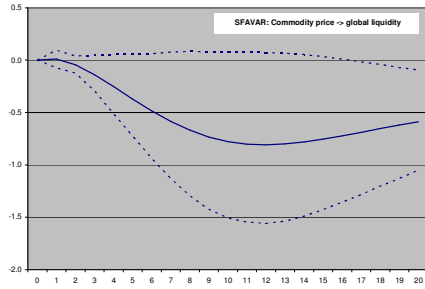
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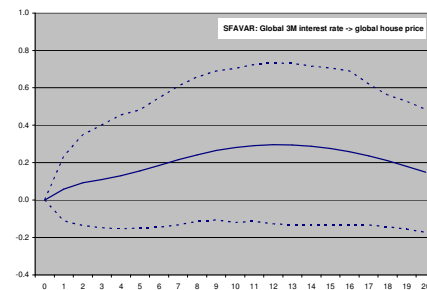
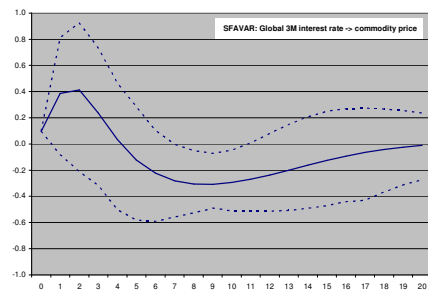
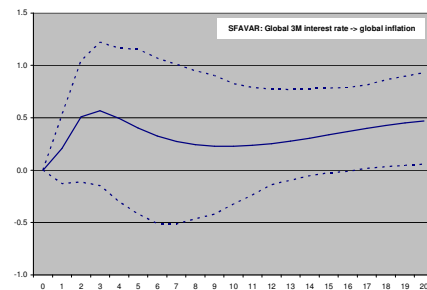
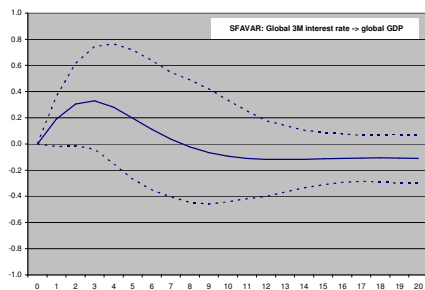
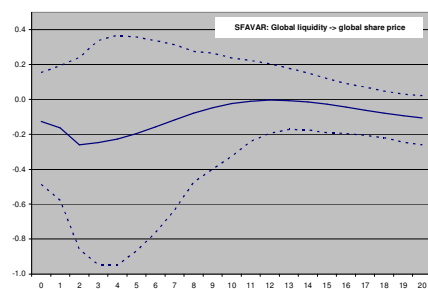
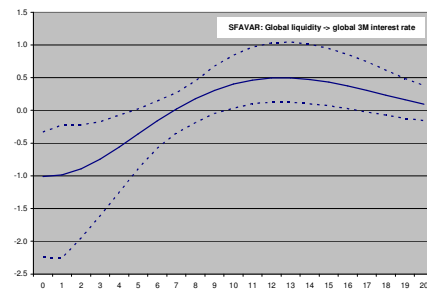
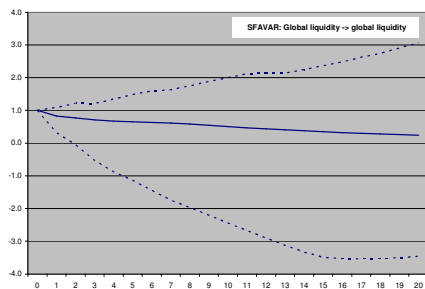
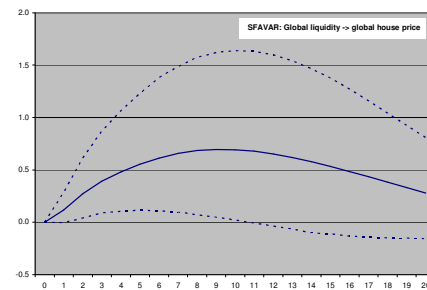
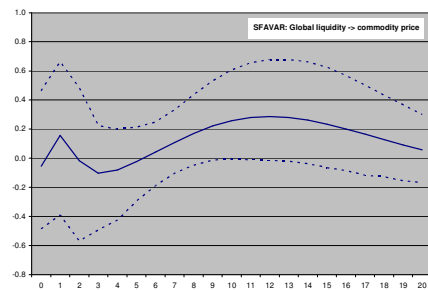
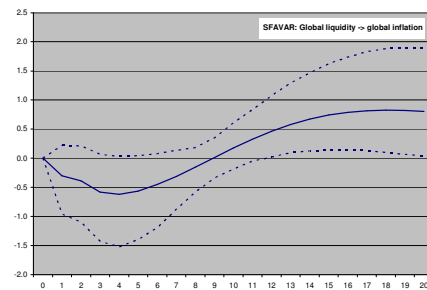
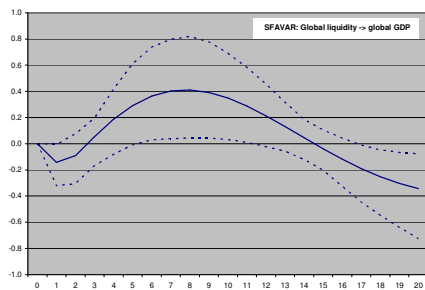
# Appendix

Table A1 - *Impulse responses for baseline SFAVAR (global level)*









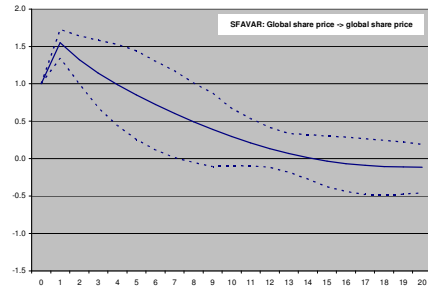
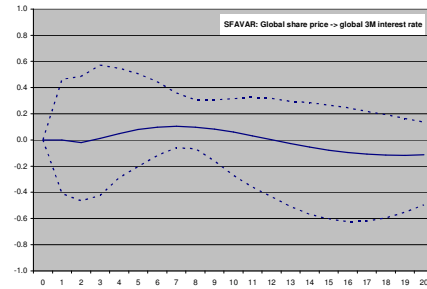
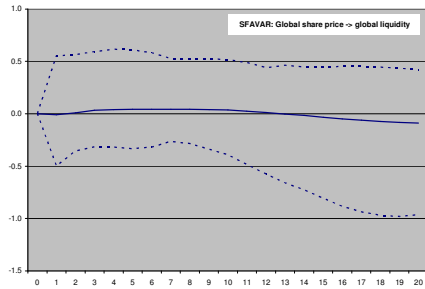
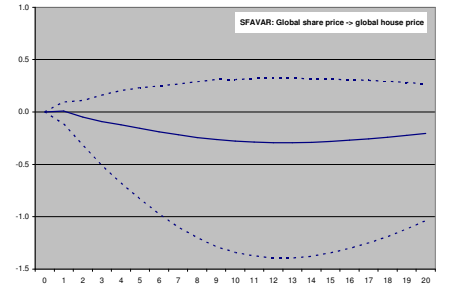
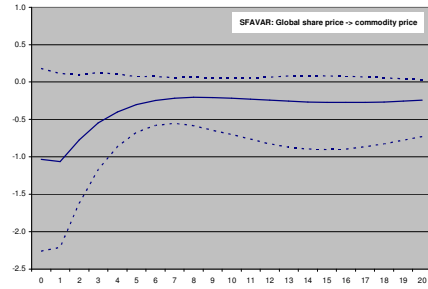
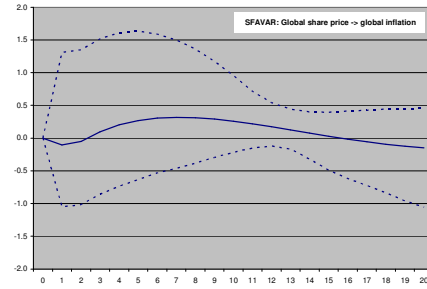
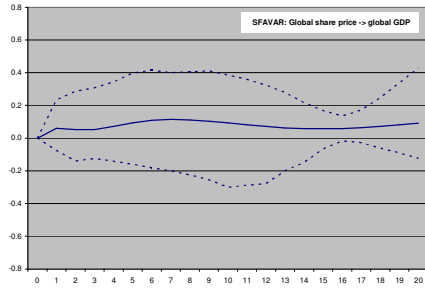
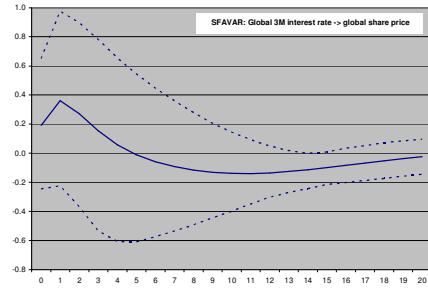
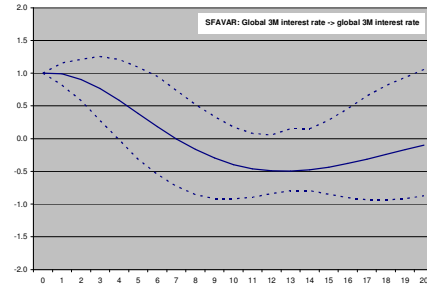
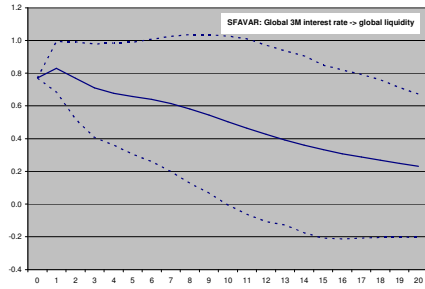
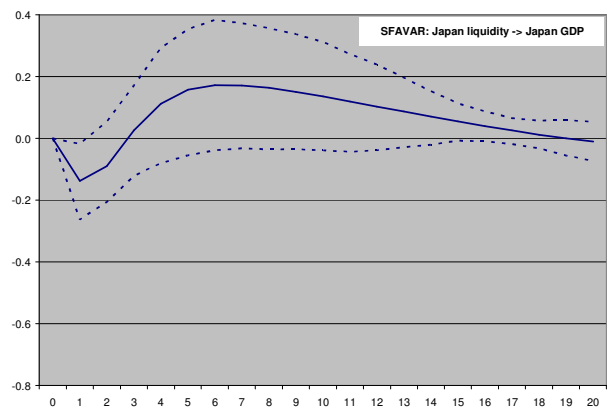
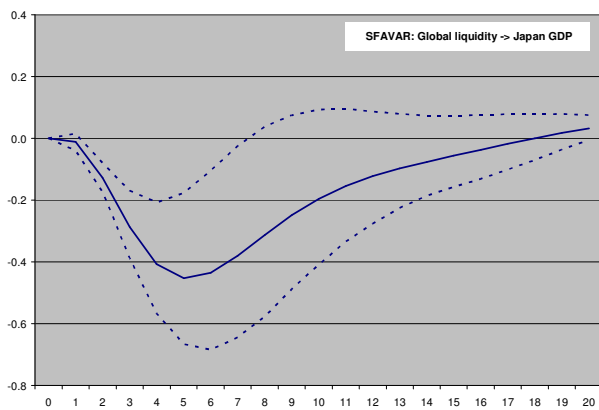
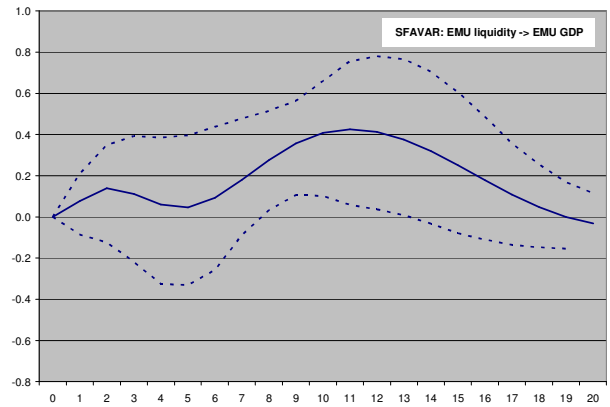
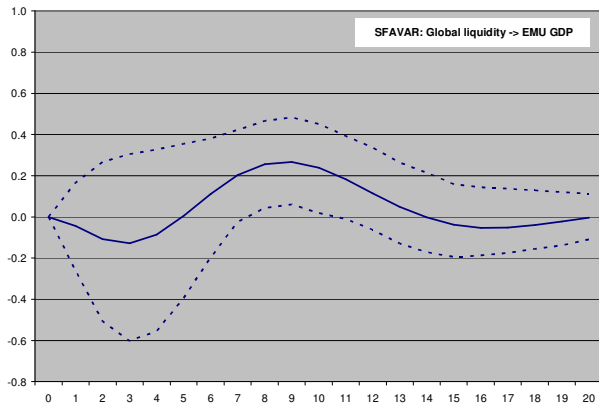
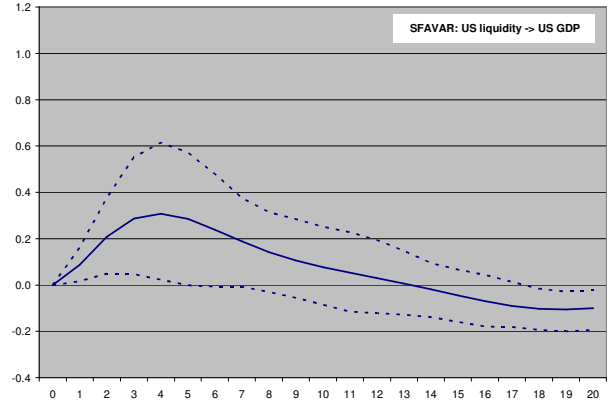
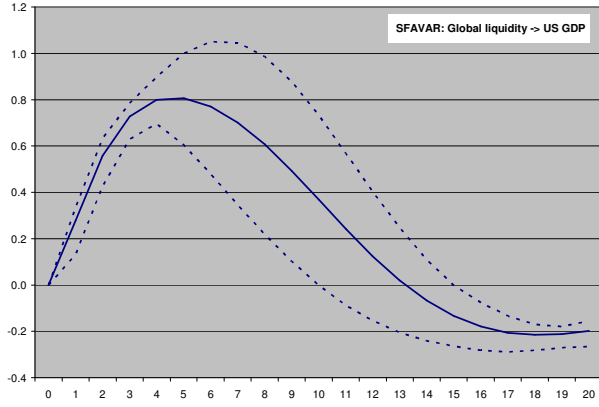
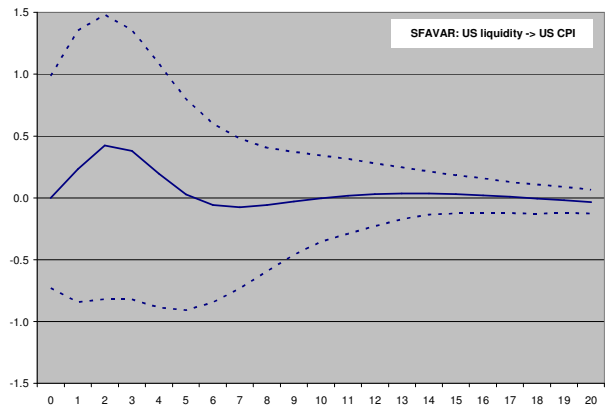
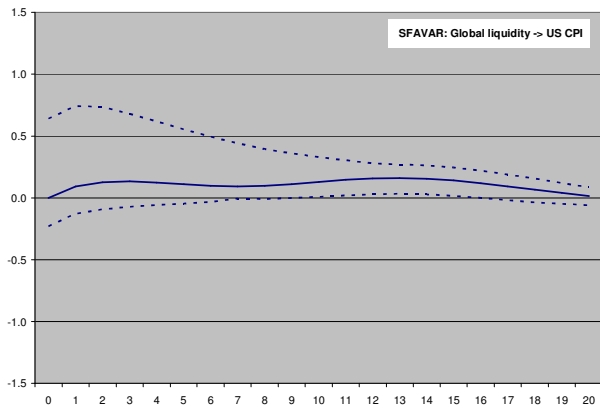
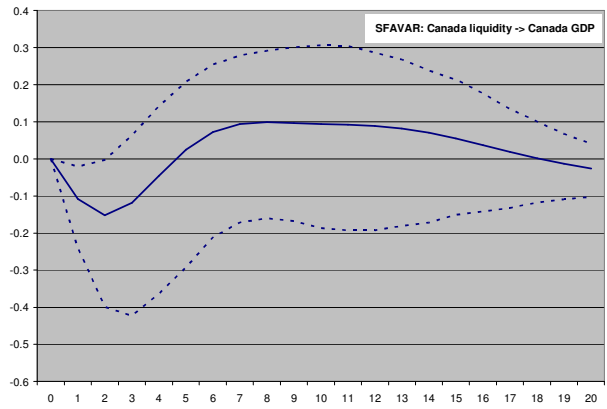
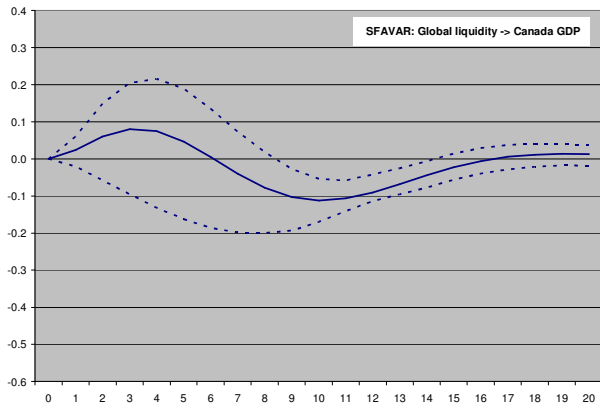
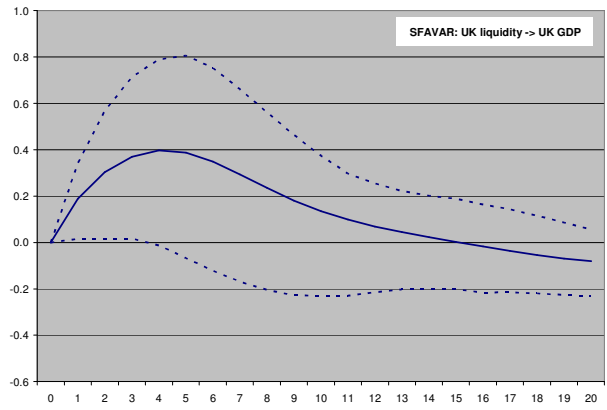
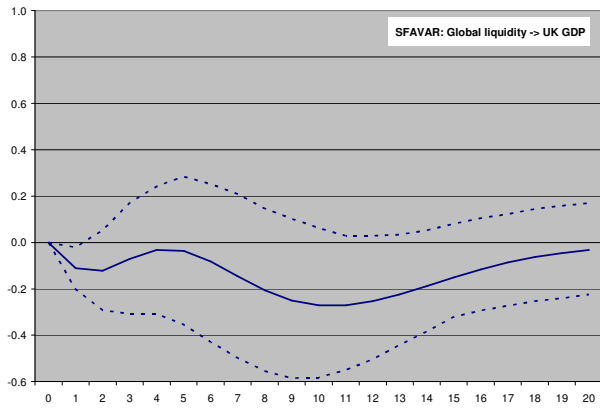
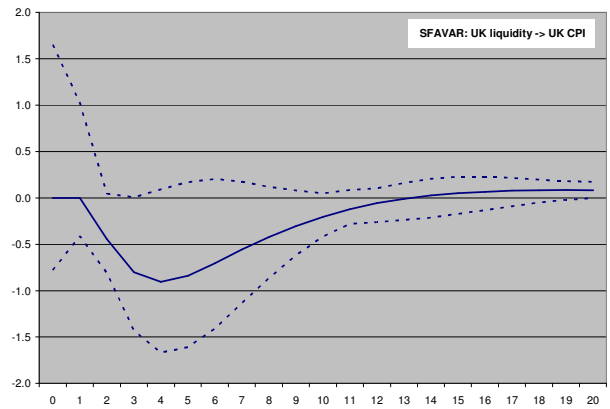
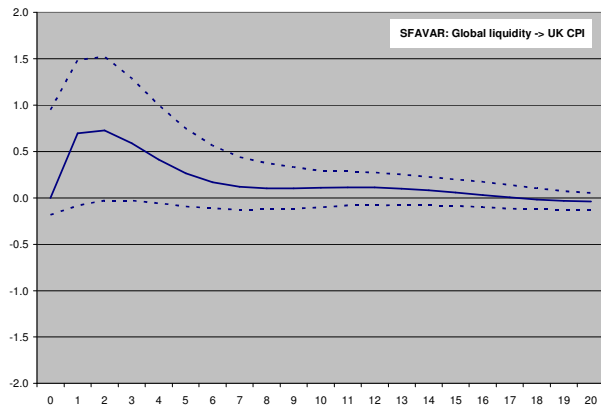
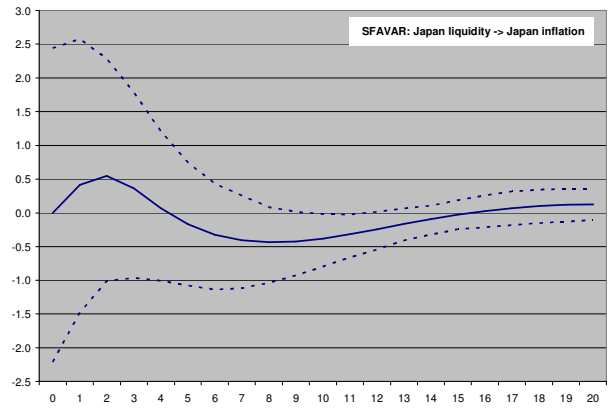
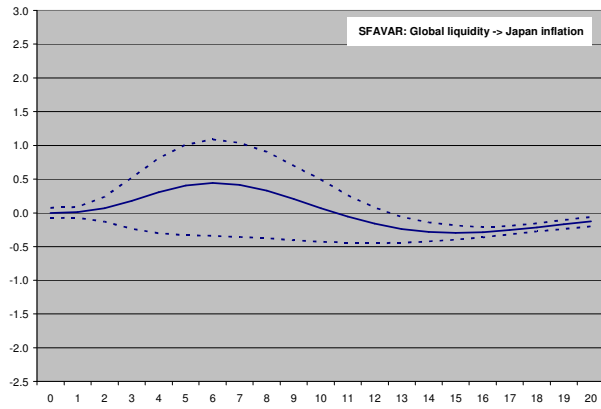
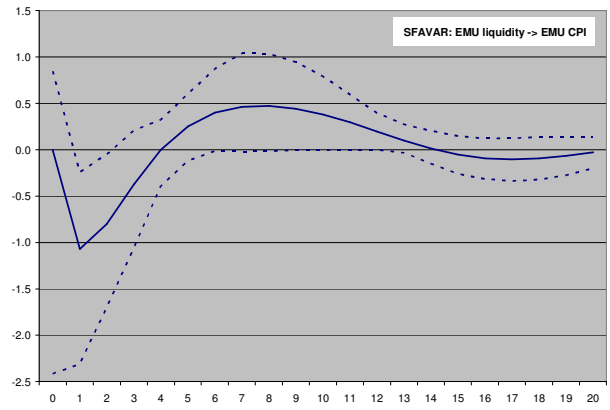
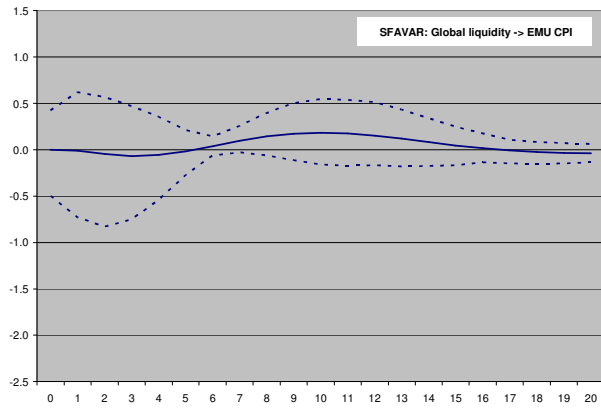


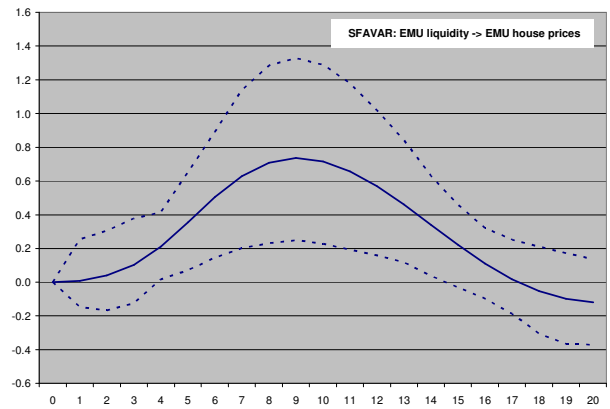
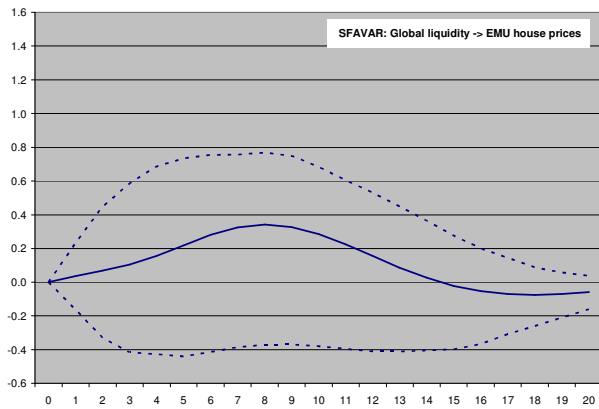
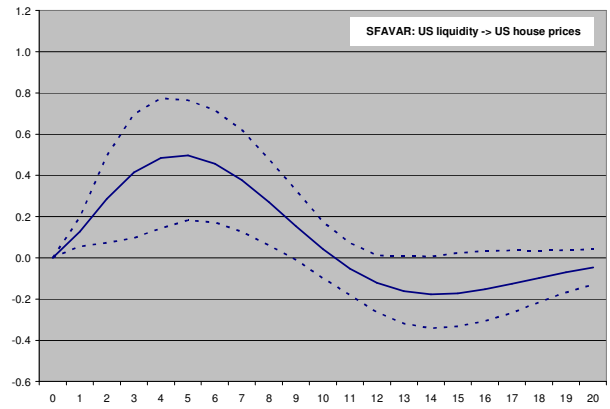
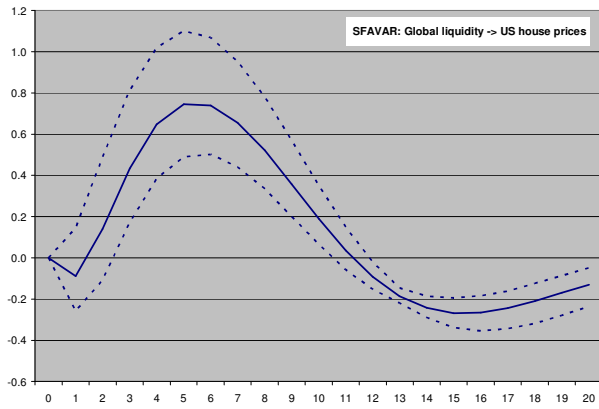
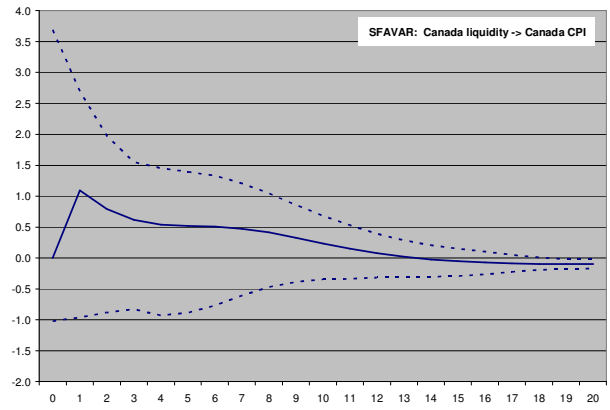
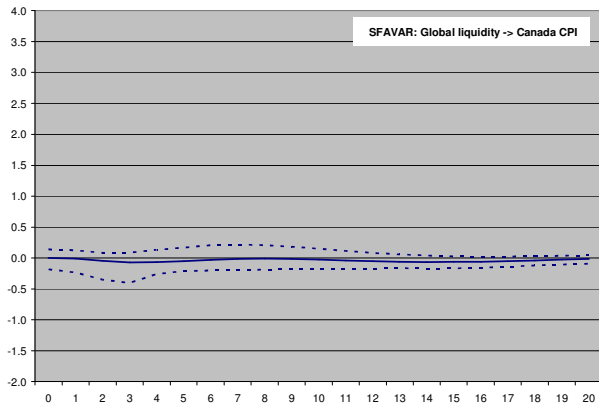
Table A2 - Selected impulse response analysis for SFAVAR (national level)

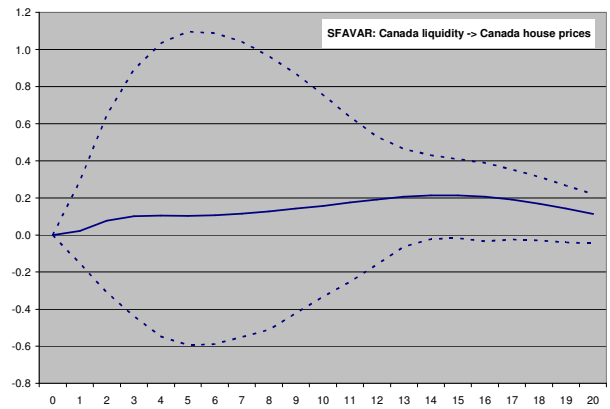
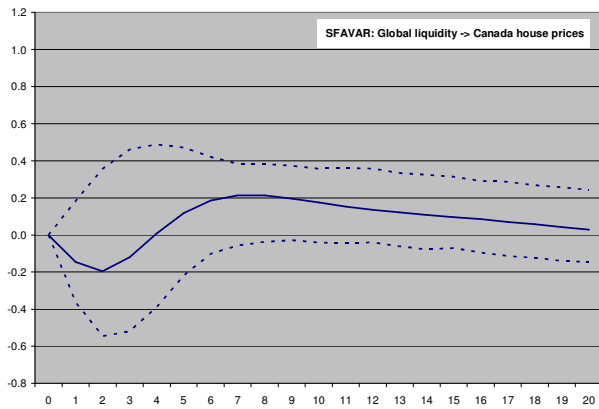
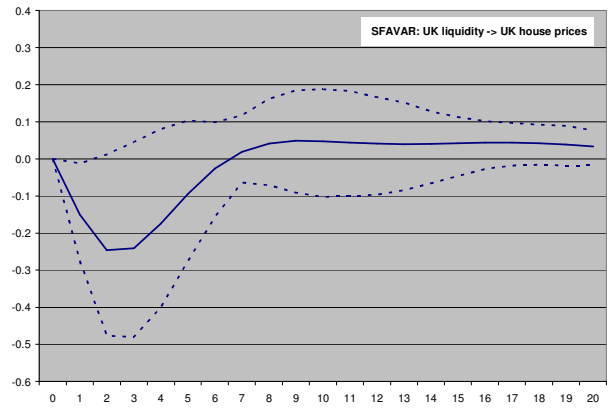
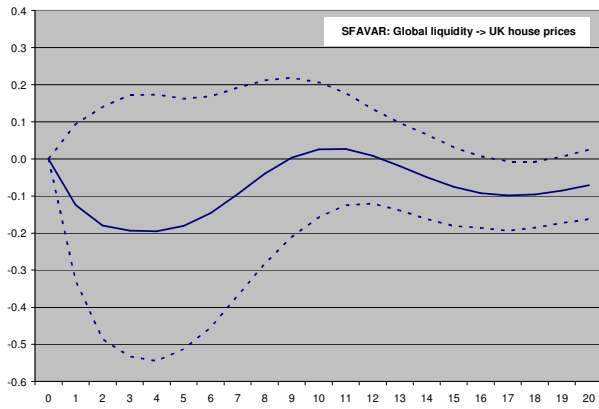
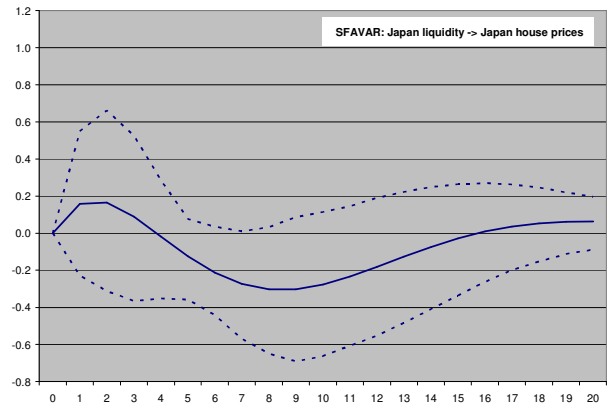
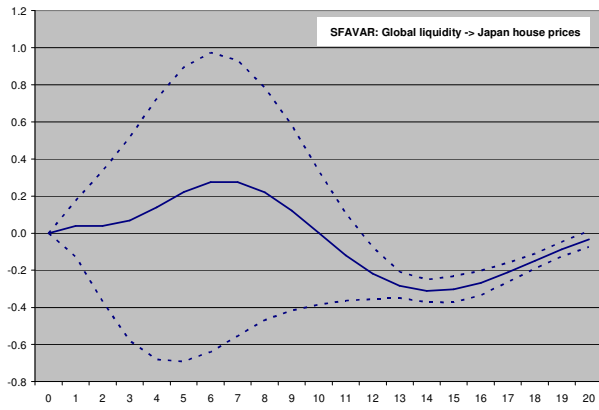


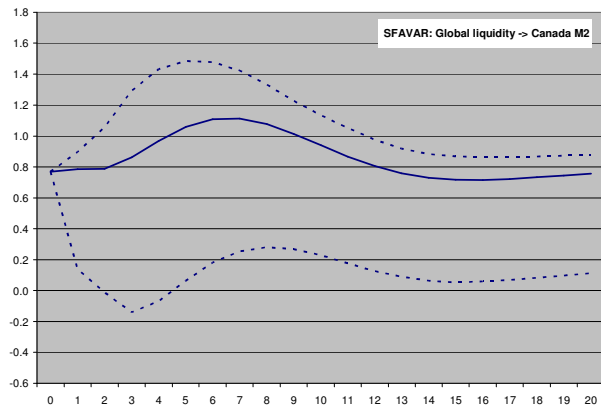
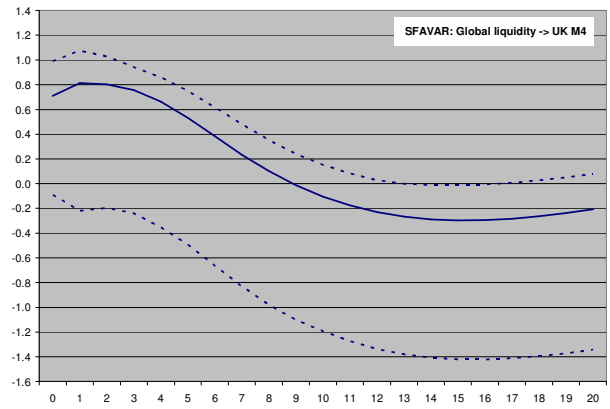
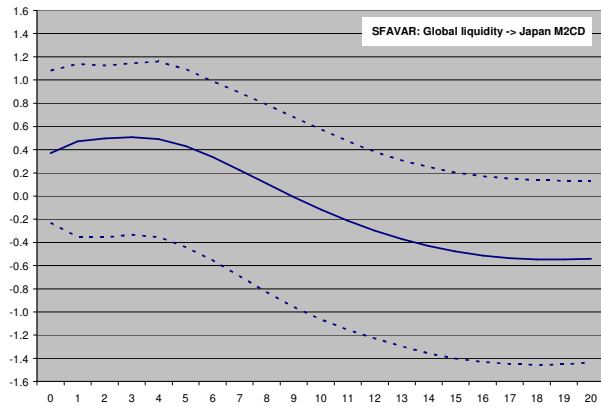
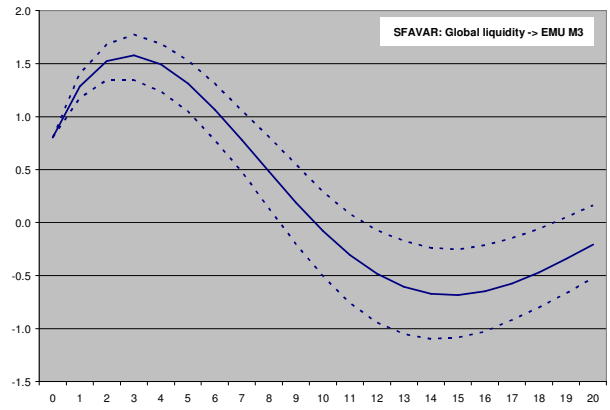
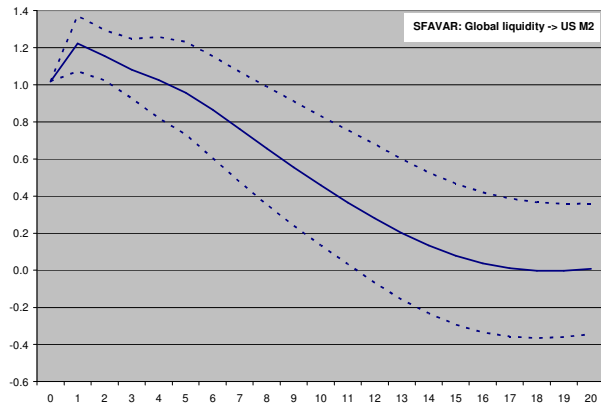


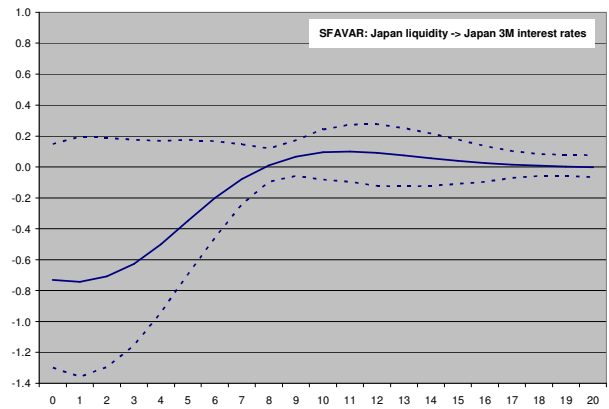
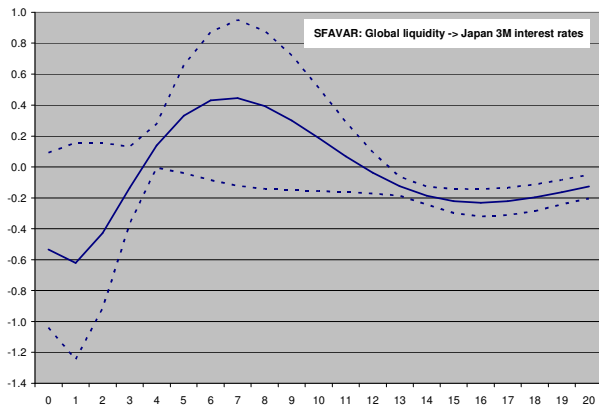
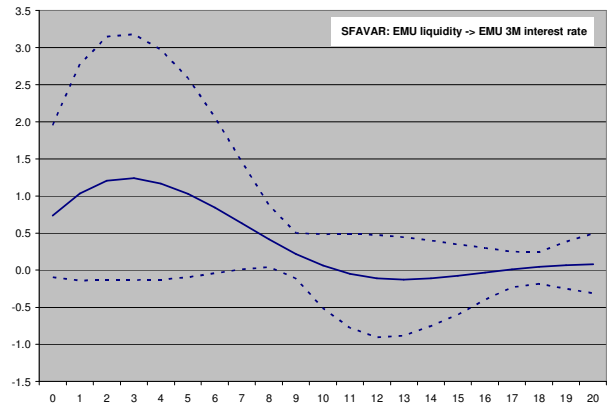
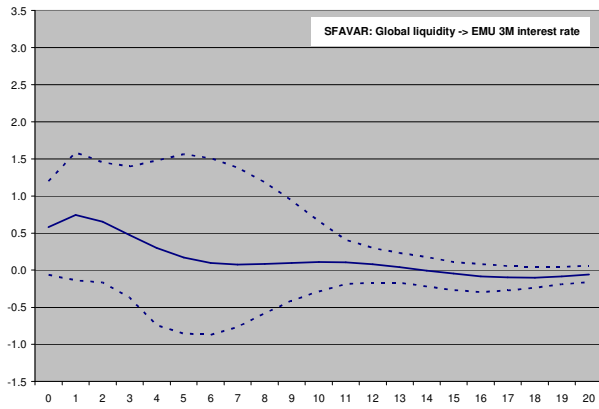
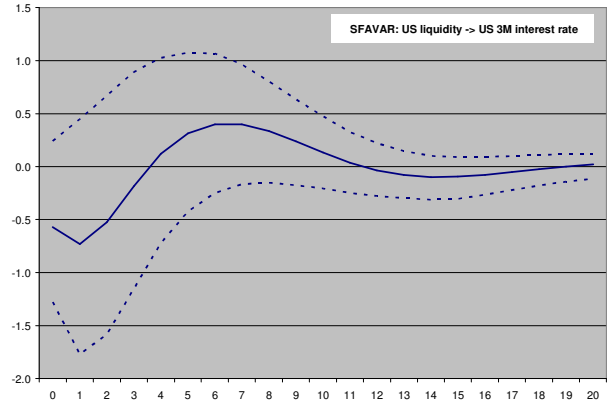
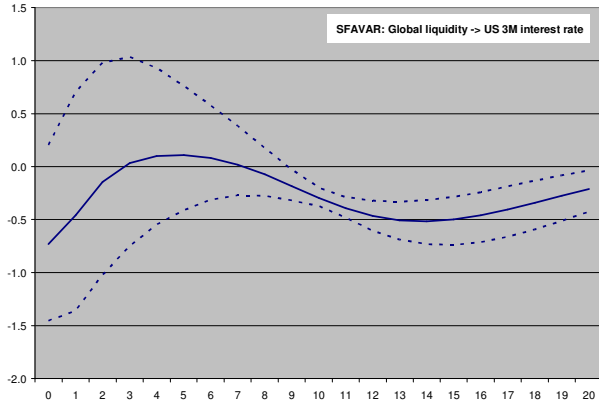












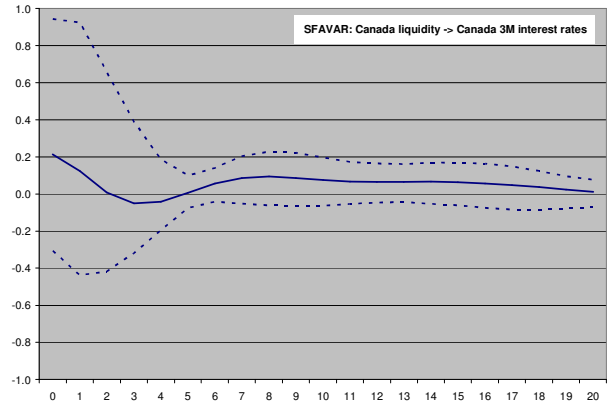
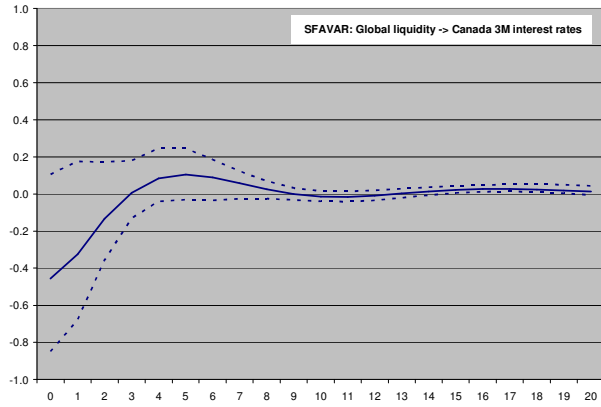
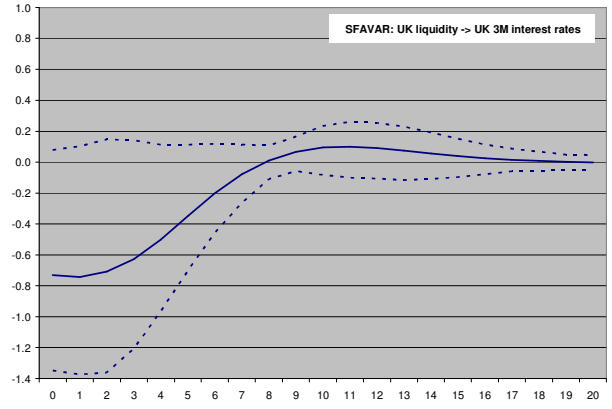
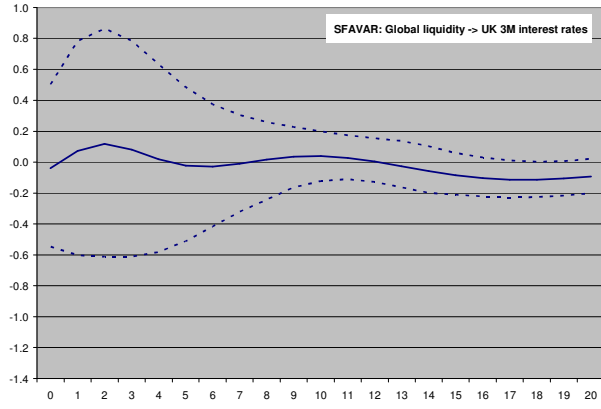


Table A3 - Rolling regressions for factor loadings (money)

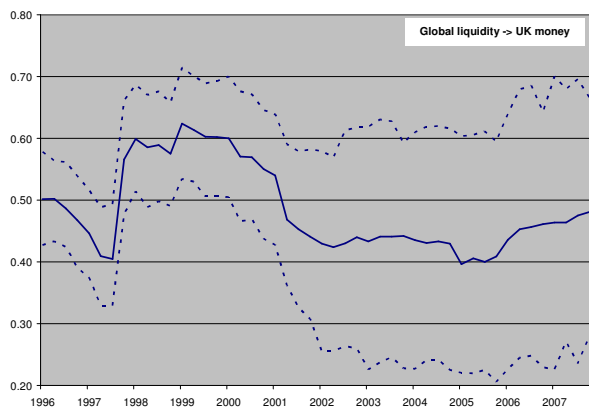
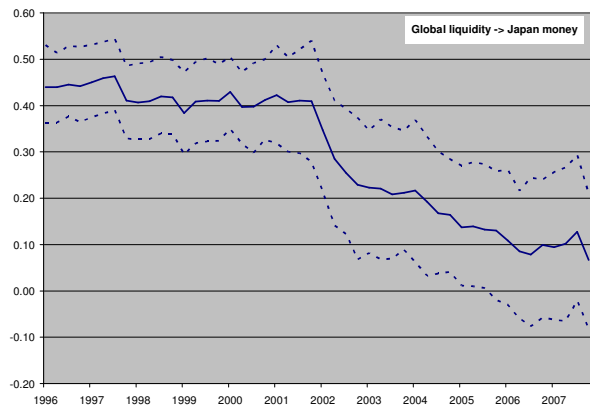
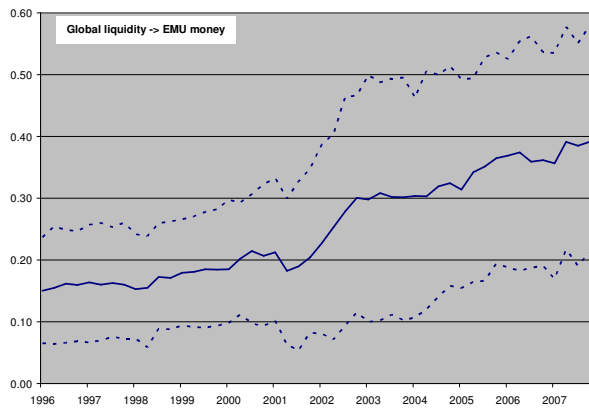
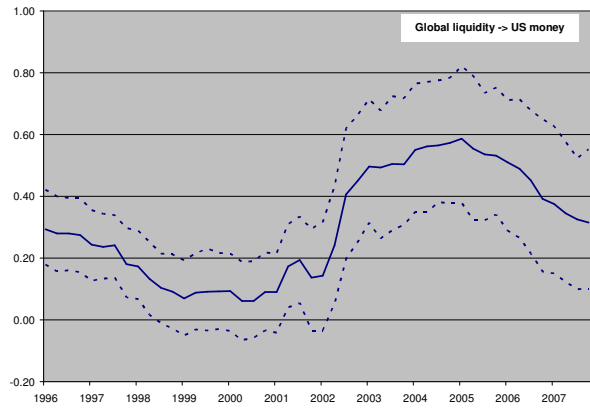
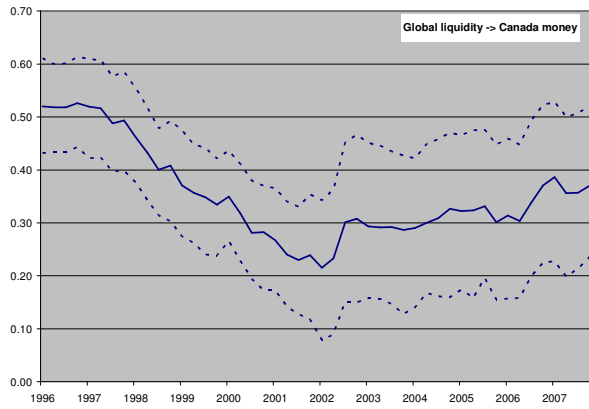


Table A4 - Rolling regressions for factor loadings (GDP)

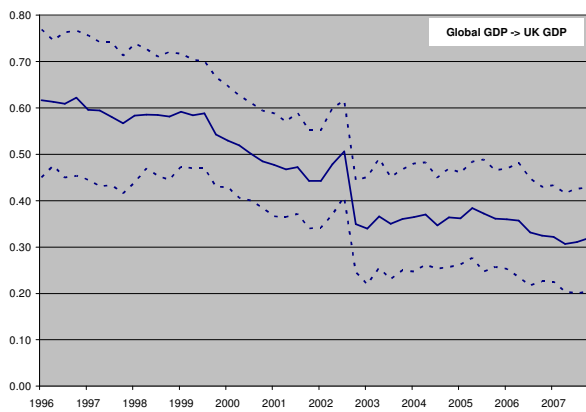
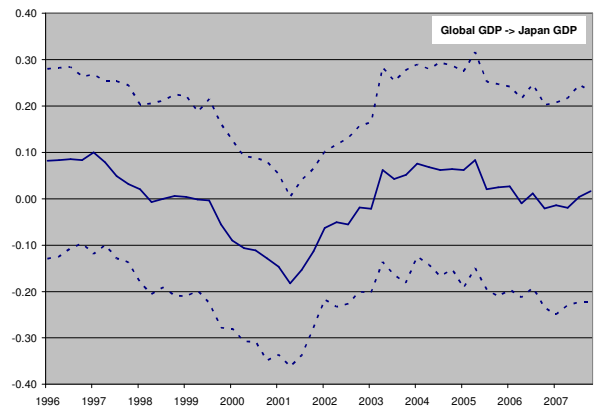
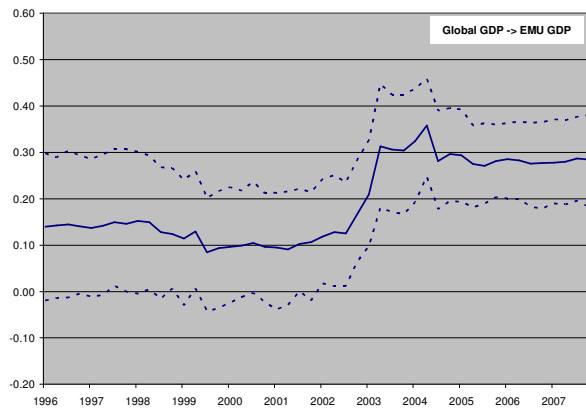
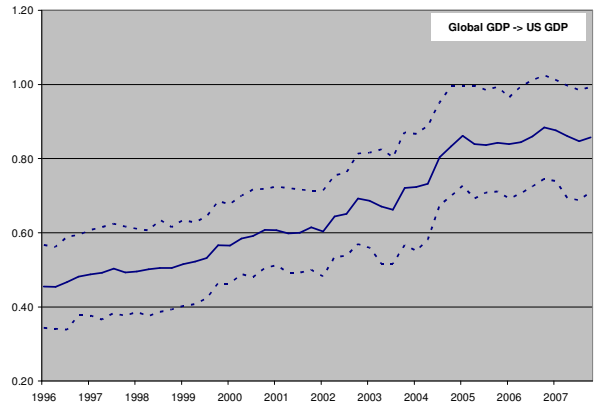
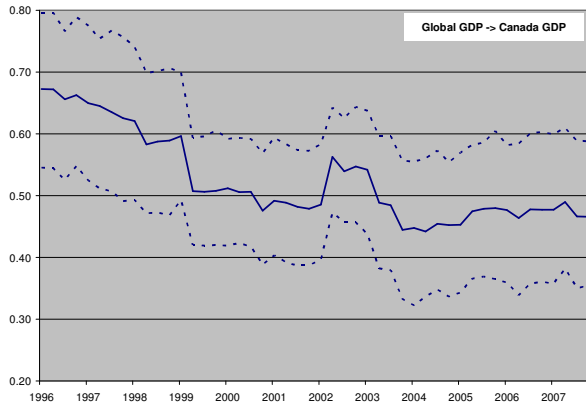
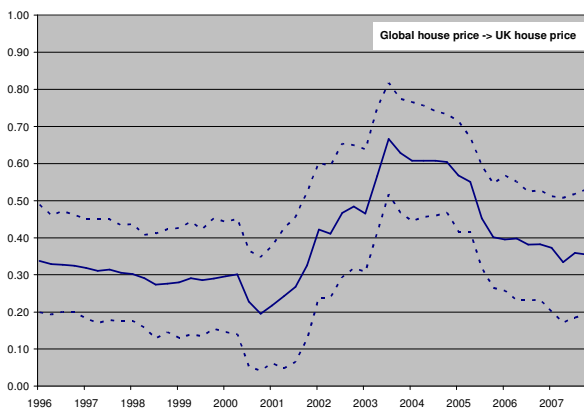
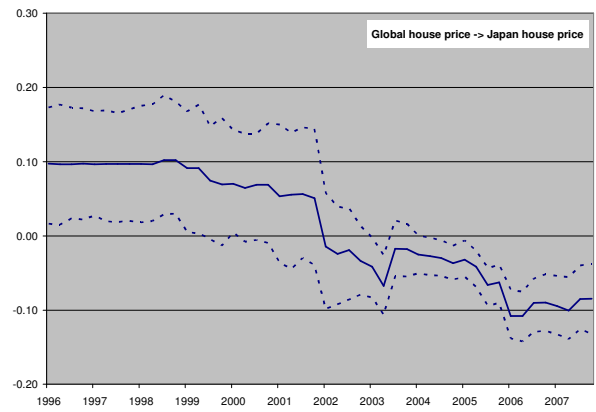
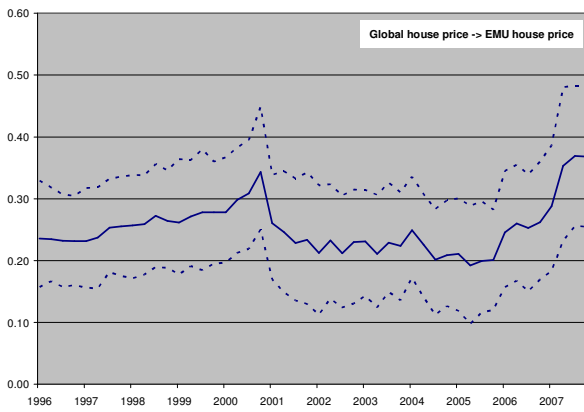
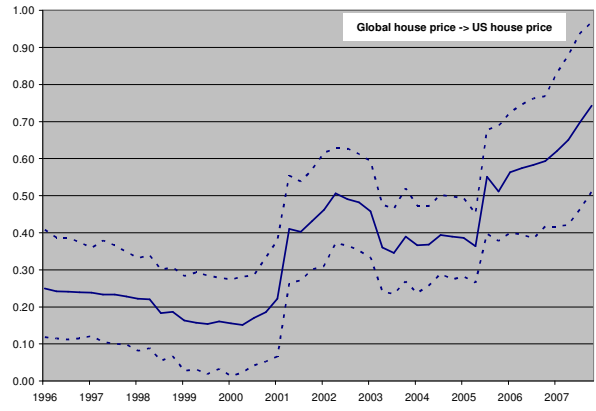
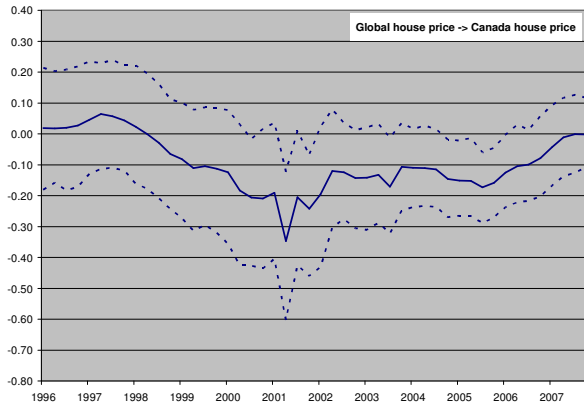




Table A5 - Rolling regressions for factor loadings (house price)



## Data

In order to display the data sources, we have chosen the following format: series number; data span, series description; original source and database provider.

### ----- Monetary aggregates

1	1984:1-2007:4	US money supply M2	Federal Reserve Board	Feri
2	1984:1-2007:4	EMU money supply M3	OECD	Feri
3	1984:1-2007:4	Japan money supply M2 plus cash deposits	Bank of Japan	Feri
4	1984:1-2007:4	UK money supply M4	OECD	Feri
5	1984:1-2007:4	Canada money supply M2	Bank of Canada	Bloomberg

### ----- GDP

6	1984:1-2007:4	US real GDP	Bureau of Economic Analysis	Feri
7	1984:1-2007:4	EMU real GDP	ECB, Eurostat	ECB, Feri
8	1984:1-2007:4	Japan real GDP	Economic and Social Research Institute	Feri
9	1984:1-2007:4	UK real GDP	Office for National Statistics	Feri
10	1984:1-2007:4	Canada real GDP	Statistics Canada	Feri

### ----- Short-term interest rates

11	1984:1-2007:4	Yield 3M US treasury bill	Federal Reserve Board	Feri
12	1984:1-2007:4	3M EMU interbank rate	ECB	ECB, Feri
13	1984:1-2007:4	Yield 2M Japanese treasury bill until 1995, afterwards 3M interbank rate	Japanese Bankers Association, Bank of Japan	Bank of Japan, Feri
14	1984:1-2007:4	Yield 3M UK treasury bill	Bank of England	Feri
15	1984:1-2007:4	Yield 3M Canada treasury bill	Bank of Canada	Feri

----- **Inflation**

16	1984:1-2007:4	US consumer prices	Bureau of Labor Statistics	Feri
17	1984:1-2007:4	EMU consumer prices	ECB, Eurostat	ECB, Feri
18	1984:1-2007:4	Japan consumer prices	Japanese Statistics Bureau	Feri
19	1984:1-2007:4	UK consumer prices	Office for National Statistics	Feri
20	1984:1-2007:4	Canada consumer prices	Statistics Canada	Feri
21	1984:1-2007:4	GDP deflator	Bureau of Economic Analysis	ECB, Feri
22	1984:1-2007:4	GDP deflator	ECB, Feri	ECB, Feri
23	1984:1-2007:4	GDP deflator	Economic and Social Research Institute	Feri
24	1984:1-2007:4	GDP deflator	Office for National Statistics	Feri
25	1984:1-2007:4	GDP deflator	Statistics Canada	Feri
26	1984:1-2007:4	Import prices	Bureau of Labor Statistics	Feri
27	1984:1-2007:4	Import prices	ECB, Eurostat	ECB, Feri
28	1984:1-2007:4	Import prices	Bank of Japan	Feri
29	1984:1-2007:4	Import prices	IMF	Feri
30	1984:1-2007:4	Import prices	Statistics Canada	Feri
31	1984:1-2007:4	Producer prices	Bureau of Labor Statistics	Feri
32	1984:1-2007:4	Producer prices	Eurostat	Feri
33	1984:1-2007:4	Producer prices	Bloomberg	Bloomberg
34	1984:1-2007:4	Producer prices	OECD	Feri
35	1984:1-2007:4	Producer prices	Statistics Canada	Feri

----- **Exchange rate**

36	1984:1-2007:4	US real effective exchange rate (CPI based)	OECD	Feri
37	1984:1-2007:4	EMU real effective exchange rate (CPI based)	OECD	Feri
38	1984:1-2007:4	Japan real effective exchange rate (CPI based)	OECD	Feri
39	1984:1-2007:4	UK real effective exchange rate (CPI based)	OECD	Feri
40	1984:1-2007:4	Canada real effective exchange rate (CPI based)	OECD	Feri

----- **Share prices**

41	1984:1-2007:4	US MSCI share price index (local currency based)	Morgan Stanley Capital International	Feri
42	1984:1-2007:4	EMU MSCI share price index (local currency based)	Morgan Stanley Capital International	Feri
43	1984:1-2007:4	Japan MSCI share price index (local currency based)	Morgan Stanley Capital International	Feri
44	1984:1-2007:4	UK MSCI share price index (local currency based)	Morgan Stanley Capital International	Feri
45	1984:1-2007:4	Canada MSCI share price index (local currency based)	Morgan Stanley Capital International	Feri

----- **House prices**

46	1984:1-2007:4	US house prices	National Association of Realtors	Datastream
47	1984:1-2007:4	EMU house prices	Gros, various national sources	Gros, Datastream
48	1984:1-2007:4	Japan house prices	Gros, Japan Real Estate Institute	Gros, Bloomberg

49	1984:1-2007:4	UK house prices	Nationwide Building Society	Bloomberg
50	1984:1-2007:4	Canada house prices	Gros, OECD	Gros, Datastream

----- **Commodity prices**

51	1984:1-2007:4	CRB commodity futures index on US dollar basis	CRB	Feri
52	1984:1-2007:4	CRB commodity futures index on EUR basis	CRB, own calculations	Feri
53	1984:1-2007:4	CRB commodity futures index on JPY basis	CRB, own calculations	Feri
54	1984:1-2007:4	CRB commodity futures index on GBP basis	CRB, own calculations	Feri
55	1984:1-2007:4	CRB commodity futures index on CAD basis	CRB, own calculations	Feri
56	1984:1-2007:4	HWWI commodity price index on US dollar basis	HWWI	Feri
57	1984:1-2007:4	HWWI commodity price index on EUR basis	HWWI, own calculations	Feri
58	1984:1-2007:4	HWWI commodity price index on JPY basis	HWWI, own calculations	Feri
59	1984:1-2007:4	HWWI commodity price index on GBP basis	HWWI, own calculations	Feri
60	1984:1-2007:4	HWWI commodity price index on CAD basis	HWWI, own calculations	Feri

----- **Long-term interest rates**

61	1984:1-2007:4	10Y government bond yield, US	Federal Reserve Board	Feri
62	1984:1-2007:4	10Y government bond yield,	Eurostat	Feri

		EMU,		
63	1984:1-2007:4	Government bond yield average maturity, Japan	Bank of Japan	Feri
64	1984:1-2007:4	10Y government bond yield, UK	OECD	Feri
65	1984:1-2007:4	10Y government bond yield, Canada	Bank of Canada	Feri

----- **Hours worked**

66	1984:1-2007:4	Hours worked total economy, US,	OECD, own calculations	Feri
67	1984:1-2007:4	Hours worked total economy, EMU	OECD, own calculations	Feri
68	1984:1-2007:4	Hours worked total economy, Japan	OECD, own calculations	Feri
69	1984:1-2007:4	Hours worked total economy, UK	OECD, own calculations	Feri
70	1984:1-2007:4	Hours worked total economy, Canada	OECD, own calculations	Feri