Global Liquidity and House Prices: A VAR Analysis for OECD Countries

by

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Summary

Global monetary dynamics has been particularly strong in recent years. At the same time, house prices in many OECD countries increased sharply, significantly outpacing the relatively subdued development in consumer prices. In this paper we argue that different price elasticities on asset and consumer markets help to explain the observed relative price change between assets and consumer goods. Using a VAR analysis and aggregated data for the major OECD countries, our empirical results are supportive of this relationship. Both house and consumer prices are determined by global monetary conditions; however, while global liquidity shocks lead to relatively fast responses in global house prices, significant responses of the global CPI index to money shocks occur only after long time lags. In addition, we find subsequent spillovers from asset prices to consumer prices on a global scale.

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1 Introduction

The quite expansionary monetary policy of the G3 countries (Euro area, US and Japan) in connection with foreign exchange interventions by many Asian countries – especially China with its dollar reserves now standing at 1.5 billion – has contributed to a significant increase of global money balances during the last years. Surprisingly enough, the strong monetary dynamics has not been accompanied by a permanent rise in consumer prices so far. At the same time, however, large parts of OECD countries have experienced very sharp increases in asset prices, such as real estate or share prices. Between 2001 and 2006, e.g., house prices have strongly increased in the US (55%), the euro area (41%), Australia (59%), Canada (61%) and a number of further OECD countries.[1] It cannot be ruled out that this development also has some connection with the abundant liquidity that exists worldwide. Many observers even interpret the increase in asset prices as the result of liquidity spillovers to certain asset markets (Adalid and Detken (2007), Greiber and Setzer (2007)).

So far, the relationship between money growth, consumer prices and asset prices has been little studied in an international context. In this paper we will address this issue more deeply and investigate the extent and some specific macroeconomic impacts of global liquidity in order to identify its interactions with global consumer price and housing price inflation, as suggested by a number of authors, for instance Baks and Kramer (1999), Sousa and Zaghini (2006) and Rüffer and Stracca (2006). For this purpose, we estimate a variety of VAR models including a measure of global liquidity, proxied by a broad monetary aggregate in the OECD countries under consideration (United States, Euro area, Japan, United Kingdom, Canada, South Korea, Australia, Switzerland, Sweden, Norway and Denmark) and analyse

[1] Notable exceptions are Japan where house prices stopped their 15-year fall not earlier than in 2007 and Germany.

the impact of a shock to global liquidity on a number of macroeconomic variables at the level of the world economy.

Our main idea is that different price elasticities of supply lead to differences in the dynamic pattern of price adjustment to a liquidity shock. While goods prices adjust slowly to changing (global) monetary conditions due to the cheap outflow of consumer goods from emerging markets, house prices react much faster since supply of house prices cannot be easily expanded and thus disequilibria on the housing market are generally balanced out by price changes. We come up with the conclusion that the liquidity the Western world has plenty of has – with an eye on the current debate about the subprime crisis not surprisingly – contributed to a significant increase of house prices in recent years.

Our emphasis is on a *global model*, i.e. we do not explicitly deal with spillovers to *national variables*. The main motivation for this procedure is based on recent research according to which inflation appears to be a global phenomenon. For instance, Ciccarelli and Mojon (2005) cannot empirically reject the existence of an error-correction mechanism between national and global inflation. Hence, one can conclude that deviations from the global inflation trend are not sustainable in the long run. Similarly, Borio and Filardo (2007) show that a more globe-centric approach to inflation is by far more adequate, because global factors have become increasingly relevant for empirical realisations of national inflation rates.

The remainder of the paper is organised as follows: we first examine in section 2 some relationships with the existing literature. In section 3 we build a small theoretical model to motivate the presence of different dynamic price adjustments in consumer prices and house prices. In section 4 we turn to an econometric analysis using the VAR technique on a global scale. To ensure robustness we then augment our benchmark model with further variables. Section 5 concludes.

2 Overview of the literature on global liquidity

The concept of "'global liquidity"' has attracted considerable attention in recent years, although the empirical literature regarding this topic is still quite scarce. One of the first important studies in this field is Baks and Kramer (1999) who use different indices of liquidity in seven industrial countries to explore the dimension of the relationship between liquidity and asset returns. The authors find evidence that there are important common components in G7 money growth and that an increase in G7 money growth is consistent with higher G7 real stock returns and lower G7 real interest rates.

Recently, a number of studies have applied VAR models to data aggregated on a global level. Rüffer and Stracca (2006) estimate a VAR model with aggregated G5 data using the same macroeconomic variables as used here in the benchmark specification. They identify and address the "price puzzle", i.e. the initial increase of consumer prices as a reaction to a more restrictive monetary policy, and cannot solve it even when accounting for the impact of commodity prices. They also augment their model with a real asset price index that incorporates property and equity prices. The main difference in their findings compared to those contained in our paper is that the response of the overall price level to a global liquidity shock is even more distinctive, while the real asset price index does not show any significant reaction to global liquidity.

Sousa and Zaghini (2006) also estimate a VAR model for the G5 countries with aggregated data. Moreover, they include a commodity price index and deviate from the standard Cholesky identification scheme in restricting the structural equations. Once again, the "price puzzle" is not solved by making use of the commodity price index. Sousa and Zaghini also find a significant and long-lasting response of the general price level to a global liquidity shock. One caveat with respect to a sound

interpretation of their findings may be that their sample period for estimation ends already in 2001. It is by now well-known that in the post-2001 period the relationship between money and consumer prices was less stable than before – a finding which might challenge the stability of their results if the estimation period is extended beyond theirs.

A prominent role for house prices among other specific kinds of asset prices in the same context is also found at a global scale by Giese and Tuxen (2007). These authors find significant cointegrating relationships which indicate a positive impact of global liquidity on house prices and the global GDP deflator. However, their study is still in progress and so one should be cautious with an interpretation of their results.

One of the most recent country-level studies in this field is Roffia and Zaghini (2007). Using probit regressions for 15 countries, the authors find evidence in favour of the hypothesis that periods of strong money growth are likely to turn into periods of high inflation, especially if they are accompanied by asset price inflation. Given the fact that at least the first and the third condition fit quite well with the situation observed on the world financial markets at least until spring 2007, this scenario has most probably contributed to the more recent positive trend of inflation rates observed in the second half of 2007 for instance in the Euro area.

3 Theoretical considerations

3.1 The global perspective

Not only with respect to global liquidity but also with an eye on global inflation performance, available evidence becomes increasingly stronger that the *global* instead of the *national* perspective is more important when monetary transmission mechanisms have to be identified and interpreted. For instance, Ciccarelli and Mojon (2005) apply a factor analysis to macroeconomic data of 22 OECD countries

and establish that seventy percent of the variance of the inflation rates of these countries can be traced back to a common factor. Moreover, the same authors find some pieces of empirical evidence in favour of a robust error-correction mechanism, meaning that deviations of national inflation from global inflation are corrected over time. They finally conclude that inflation is to a large degree a global phenomenon.

The study by Borio and Filardo (2007) delivers a similar result. Referring to their empirical results, they argue that (a) the traditional way of modelling inflation is too country-centered, (b) a global approach is more adequate and that (c) the importance of global factors has increased significantly more recently. One important global factor, for instance, is certainly represented by the mounting pressure enacted by the ever higher degree of competition on the international goods and labour markets – a phenomenon which has to be mainly ascribed to globalisation. It appears fair to say that it is exactly the globalisation process which certainly has contributed to the decrease of inflation rates since the eighties (and that this puts the significance of the contribution of central banks to price stability on the agenda again). It goes without saying that we do not take the view that the national perspective is completely negligible. Instead, we emphasize that a global model, as estimated in the econometric section of our paper, may deliver additional relevant insights which certainly cannot be gathered if one concentrates solely on the national level and fades out global liquidity developments.

Considering the development of global liquidity over time, the question is often raised whether and to what extent global factors can be made responsible for it. Rüffer and Stracca (2006) investigate this aspect for the G7 countries in the framework of a factor analysis and conclude that around fifty percent of the variance of a narrow monetary aggregate can be traced back to one common global factor. As one prominent example of such a global factor, for instance, the extremely lax monetary policy stance of the Bank of Japan (BoJ) during the last years should be mentioned

here. It has been characterised by a significant accumulation of foreign reserves and by extremely low interest rates – at some time even approaching zero. By means of carry trades, financial investors took out loans in Japan which they invested in currencies with higher interest rates. Such kind of capital transactions, of course, also have an impact on the development of monetary aggregates far beyond the special case of Japan.

In addition, we focus on global instead of national liquidity since national monetary aggregates have become more difficult to interpret due to the huge increase of international capital flows (Papademos, 2007). In the same vein, Sousa and Zaghini (2006) argue that global aggregates are likely to internalize cross-country movements in monetary aggregates – due to capital flows between the different regions – that may make the link between money and inflation and output more difficult to disentangle in the single country case. Moreover, Giese and Tuxen (2007) stress the fact that in today's linked financial markets shifts in the money supply in one country may be absorbed by demand elsewhere, but simultaneous shifts in major economies may have significant effects on worldwide goods price inflation.

3.2 Monetary policy and house prices

While there is some literature available on the impact of house price developments on the macroeconomy[2] and on the role of fundamental factors other than monetary policy for house price developments (Catte et al., 2004, Égert and Mihaljek, 2007), studies specifically dealing with the impacts of monetary policy on house prices are

[2]Monetary policy driven house price booms may fuel consumer spending and thus, aggregate demand and inflation via balance sheet and credit-channel effects – more potential collateral meaning lower risk premia in this context via the Bernanke/Gertler financial accelerator framework. The improvement in lending conditions may in turn lead to an expansion in loans and thus higher money growth. According to Gros (2007), the most direct link between housing prices and domestic demand might be construction activity and in particular the construction of houses (dwellings). However, if house price changes are transmitted to the CPI mainly via the aggregate demand channel, it is sufficient to model the transmission channel via the real GDP variable in our empirical investigation.

still quite scarce. For instance, Goodhart and Hofmann (2007) show that one could use a baseline New Keynesian model as a theoretical benchmark, consisting of a Phillips curve to describe the supply side of the economy and an IS curve to describe the demand side. From a monetary policy perspective, the central parameters are the strength and the significance of the links in the monetary transmission process and the relative importance of backward-looking and forward-looking expectations in the Phillips curve and the IS curve. As is well-known by now, the empirical literature has delivered diverse and highly controversial results on both issues. Hence, in an extended specification, Goodhart and Hofmann include property prices in the case of the IS curve and show that this restores an empirically significant monetary transmission mechanism.

Mishkin (2007), in contrast, stresses the user cost of capital as an important determinant of the demand for residential capital. In this context, lower interest rates in the wake of higher money growth should influence mortgage rates and thus by decreasing the user cost of capital should raise the demand for housing capital. A similar effect should work on the supply side where easier financing conditions tend to stimulate housing construction. However, Mishkin focuses on the effects of interest changes on house price changes and does not explicitly refer to monetary aggregates. He delivers empirical evidence in favour of a stable relation between an interest rate shock and house price developments via the FRB/US model.

3.3 A simple model of price adjustment

Some insights into the relationship between money, house prices and consumer prices can be derived from the dynamic price adjustment to a liquidity shock across the housing sector and the goods market. In the short term, an expansionary monetary policy providing the markets with ample liquidity may trigger an immediate price reaction in the housing sector, but a more subdued price reaction in the consumer

goods market. Over time, however, consumer prices also adjust to the new equilibrium by proportional changes of the consumer price level, i.e. it is plausible to argue that in the long term changes in money supply do not lead to any effects on real money or real output. As will become clear further below, the possibility of different dynamic adjustments of house prices and consumer prices to a monetary shock may also provide an explanation for the recent shift in relative prices between housing and consumer goods. In order to formalize these considerations, the quantity theory of money might serve as a starting point:

$$m_t v_t = p_t y_t \tag{1}$$

where m denotes the money stock, v represents the velocity of money, whereas p and y stand for the price level and real output, respectively. Equation (1) is simply an identity and is valid for all time periods t. Money can be spend either for housing (y^H) or a consumption good (y^C) with prices p^H and p^C, respectively. Different price elasticities of supply are distinguishing features of y^H and y^C.[3] On the one hand, housing is generally assumed to be restricted in supply and cannot be expanded (Japan) and/or all real estate transactions involve high costs (continental Europe) and each piece of real estate is a different case and at least slightly different from even the adjacent plot.[4] Hence, the elasticity of housing supply vis-à-vis house price changes should be quite limited. On the other hand, the supply of consumption goods tends to be characterized by an infinite price elasticity so that additional demand can be satisfied without any price increase. This assumption is motivated with an eye on recent developments in international trade. The emergence of competing low-cost producers in emerging markets and developing countries may have

[3]See Browne and Cronin (2007) for a similar model on the relationship between commodity prices, consumer prices and money.

[4]For a detailed discussion of the relevance of these arguments see Gros (2007), OECD (2005) and Shiller (2005).

prevented firms from raising consumer prices in response to a liquidity shock while supply in housing markets was subject to natural constraints.

Taking these considerations into account, the general price level is a weighted average of the specific prices of both goods:

$$p_t = \lambda p_t^H + (1-\lambda)p_t^C \ , \ 0 < \lambda < 1. \tag{2}$$

Similarly, output consists of the production of both housing and consumer goods:

$$y_t = \lambda y_t^H + (1-\lambda)y_t^C \tag{3}$$

In the following, the effects of a one-off increase (of μ percent) in the money supply in period *t+1* are analysed against this background. Assuming that v is constant and takes a value of one, the relationship between money and the general price level in period *t+1* can be written as follows:

$$(1+\mu)m_t = p_{t+1}y_{t+1} = (1+\mu)p_t y_t \tag{4}$$

Due to a generally high degree of competition in international goods markets and the vast supply of cheap labour in many emerging markets around the world, which weighs heavily on the prices of manufactured goods, consumer prices remain unaffected by the increase in aggregate demand:

$$p_{t+1}^C = p_t^C \tag{5}$$

Rather, the liquidity shock fully translates into an increase in output:

$$y_{t+1}^C = (1+\mu)y_t^C \tag{6}$$

By contrast, housing supply is perfectly inelastic which drives house prices upwards as a result of the liquidity shock, but keeps output in the housing sector constant:

$$p_{t+1}^H = (1+\mu)p_t^H \tag{7}$$

$$y_{t+1}^H = y_t^H \tag{8}$$

Combining equations (1) to (8), the money-price relationship in period *t+1* can be described as follows:

$$(1+\mu)m_t = [(1+\mu)\lambda p_t^H + (1-\lambda)p_t^C][\lambda y_t^H + (1+\mu)(1-\lambda)y_t^C] = (1+\mu)p_t y_t \quad (9)$$

In the long term, however, the theoretical proposition of long-run neutrality must hold, i.e. the increase in money supply affects prices without changing long-run equilibrium real values of our macro variables:

$$p_{t+2}^C = (1+\mu)p_t^C \quad (10)$$

$$y_{t+2}^C = y_t^C \quad (11)$$

$$p_{t+2}^H = (1+\mu)p_t^H \quad (12)$$

$$y_{t+2} = y_t^H \quad (13)$$

$$(1+\mu)m_t = p_{t+2}y_{t+2} = (1+\mu)p_t y_t \quad (14)$$

Figure 1 illustrates the price-quantity changes in the housing and in the consumer goods markets when aggregate demand changes, while P_1 is the equilibrium in the short run and P_2 the equilibirum in the long run. On the goods market (left hand side), one would expect an increase in the production of consumer goods, if the demand for consumer goods increases as a result of a positive liquidity shock. In contrast, housing supply is insensitive to price changes and thus the additional demand for housing is fully reflected in a rise of house prices (right hand side). In the long term, the neutrality of money holds; i.e. any change in the money supply is met with a proportional change in the price level that keeps real money and real output in both sectors unchanged.

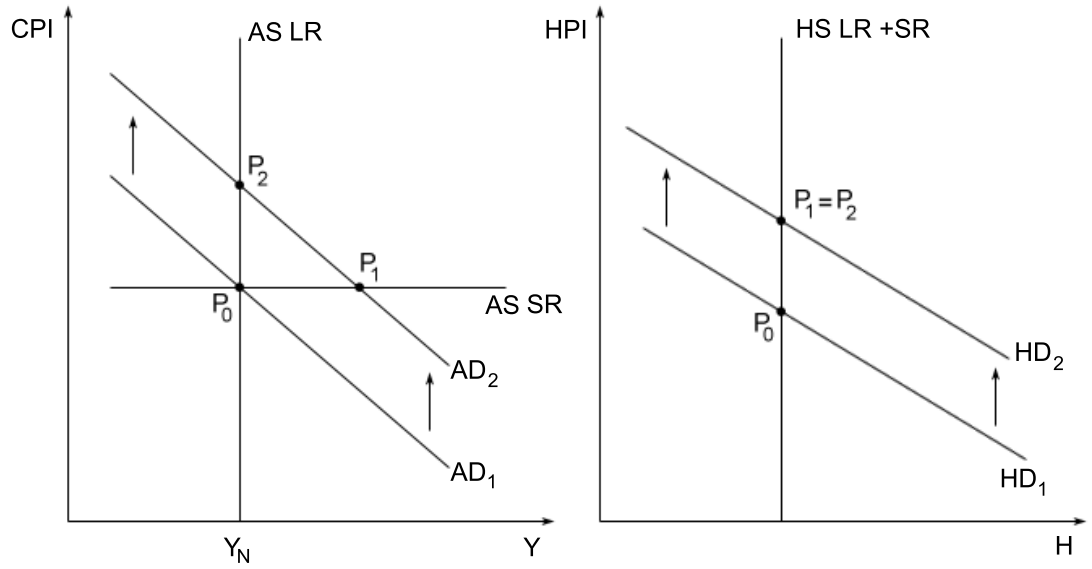

Figure 1: Short- and long-run impact of a liquidity shock to house prices (right-hand side) and consumer prices (left-hand side)

4 Empirical analysis

4.1 Data description and aggregation issues

In the following empirical analysis, we use quarterly time series from 1984Q1 to 2006Q4 for the United States (US), the Euro area, Japan, United Kingdom (UK), Canada, South Korea, Australia, Switzerland, Sweden, Norway and Denmark, so that in our analysis 72,2% of the world GDP in 2006 and presumably a considerably larger share of global financial markets are represented.[5] For the aforementioned countries, we gather real GDP (Y), the consumer price index (CPI), a short term money market rate (IS), a broad monetary aggregate (M) and a nominal house price index (HPI). The monetary aggregate we use is M2 for the US, M3 for the Euro Area, M2 plus cash deposits for Japan, M4 for the UK and mostly M3 for the other countries. The data stem from the IMF, the BIS and the ECB and are seasonally adjusted if available or treated with the X12-ARIMA procedure.[6]

[5]Own calculations based on IMF data.

[6]House price are based on OECD data (see Schich and Weth, 2008).

In the next step, we aggregate the country-specific series to obtain global series considering the principles mentioned by Beyer, Doornik and Hendry (2000) and employing the method as used by Giese and Tuxen (2007) in the same context. First, we calculate variable weights for each country by using PPP exchange rates to convert nominal GDP into a single currency.[7] The weight of a country i in period t is therefore:

$$w_{i,t} = \frac{BIP_{i,t}\, e_{i,t}^{PPP}}{BIP_{agg,t}} \tag{15}$$

Secondly, we take the *growth rates* of the variable in domestic currency and aggregate these to global growth rates by using the weights calculated in 15:

$$g_{agg,t} = \sum_{i=1}^{11} w_{i,t} * g_{i,t} \tag{16}$$

Aggregate levels were then obtained by choosing an initial value of 100 and multiplying with the global growth rates. Hence, the level of the variable v is:

$$index_{v,T} = 100 * \prod_{t=2}^{T} (1 + g_{agg,t}) \tag{17}$$

This method is applied to all variables except the interest rate variable, for which aggregation is performed without calculating growth rates.

The main advantage of this procedure is that it avoids a potential bias resulting from different national definitions of broad money. Given the different definitions of monetary aggregates across countries, the building of a simple sum of national monetary aggregates – a method frequently applied in the related literature – would under-represent countries with narrower definitions of the monetary aggregate and vice versa. A second problem that is avoided by us is the "dollar bias" resulting from converting national monetary aggregates by means of actual (instead of PPP) exchange rates into USD and taking the simple sum to obtain global money. In this case the recent fall of the dollar would contribute to an overestimation of global monetary growth.[8]

[7] As the base year for the PPP exchange rates we have chosen 1999.

[8] See Commerzbank (2007), p. 3.

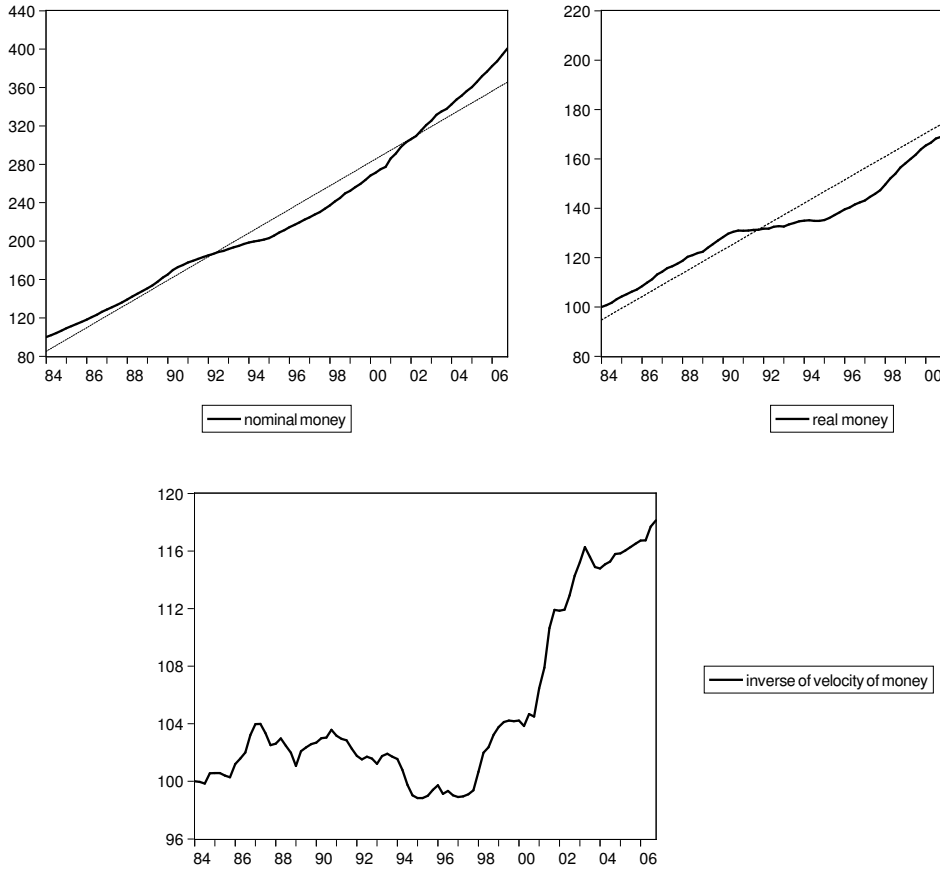

Figure 2: Developments of global liquidity since 1984

To illustrate the development of global liquidity since 1984, Figure 2 shows global monetary aggregates in absolute and relative terms. For nominal and real money, a simple regression on an intercept and a linear time trend is performed. Both series find themselves above their time trend since about 2001 when monetary policymakers turned to a more expansionary policy in the course of the rapid downturn in stock markets and a number of further shocks such as September 11. Money growth remained strong throughout the last years, as indicated by the persistent growth of the ratio of nominal money to nominal GDP. This measure is equal to the inverse of the income velocity of money and is commonly used as an indicator of excess liquidity.[9]

[9]See *inter alia* Belke et al. (2004) and Rüffer and Stracca (2006).

Overall, a first graphical inspection provides some first glance for the view that global liquidity is indeed at a high level and that the term excess liquidity can be justified rather easily when analyzing the most recent period.

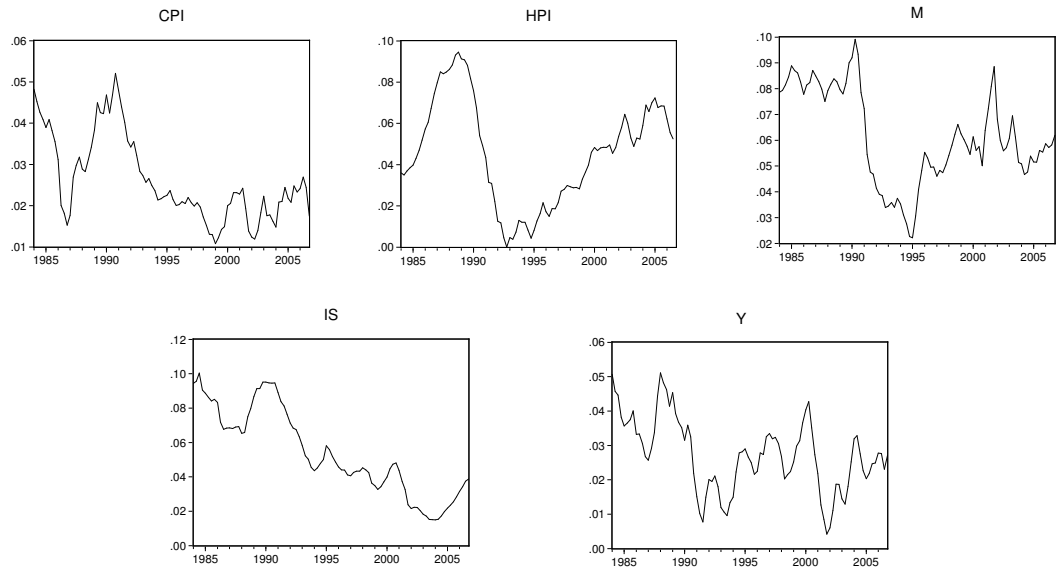

Figure 3: Global series, 4-quarter moving averages of growth rates, except interest rate which is displayed in levels; 1984Q1 - 2006Q4

Figure 3 displays the development of our global time series investigated. The consumer price series clearly elucidates the moderate inflation which started to emerge around the mid-90s and has persisted in the recent years of global excess liquidity. The growth of house prices has been increasingly distinctive not only in the last 5 years lending support, to some extent, to the popular asset price inflation hypothesis in the real estate sector), but also at the end of the 1980s. Interestingly, both of these periods were accompanied by a sharp rise in liquidity. Global short-term interest rates were at a historically low level from 2002 to 2005, since the monetary policy stance was extremely loose during this period.[10] Let us now turn to a more formal econometric analysis of the issues at hand.

[10]One might regard the deviation from an estimated Taylor rate as a more accurate measure in this respect. However, these numbers create a rather similar picture. See International Monetary Fund (2007), Chapter 1, Box 1.4.

4.2 The VAR Methodology

The econometric framework employed by us is a vectorautoregressive model (VAR) which allows us to model the impact of monetary shocks on the economy while taking care of the feedback between the variables since all of them are treated as endogenous.[11] Consider first the traditional reduced-form VAR model:

$$\Gamma(L)\, Y_t = C Z_t + u_t \tag{18}$$

where Y_t is the vector of the endogendous variables and $\Gamma(L)$ is a matrix polynomial in the lag operator L for which $\Gamma(L) = I + \sum_{i=1}^{p} A_i L^i$, so that we have p lags. Z_t is a matrix with deterministic terms, C is the corresponding matrix of coefficients, and u_t is the vector of the white noise residuals where serial correlation is excluded, so that:

$$E(u_t) = 0 \tag{19}$$

$$E(u_t u_s') = \begin{cases} \Sigma & : \quad t = s \\ 0 & : \quad t \neq s \end{cases} \tag{20}$$

Since Σ is not a diagonal matrix, contemporaneous correlation is allowed. In order to model uncorrelated shocks, a transformation of the system is needed. Using the Cholesky decomposition $\Sigma = PP'$, taking the main diagonal of P to define the diagonal matrix D and premultiplying (18) with $\mathcal{A} := DP^{-1}$ yields the structural VAR (SVAR) representation:

$$K(L) Y_t = C^* Z_t + e_t \tag{21}$$

$$K(L) = \mathcal{A} + \sum_{i=1}^{p} A_i^* L^i \tag{22}$$

The contemporaneous relations between the variables are now directly explained in $\mathcal{A}$, which is a lower triangular matrix with all elements of the main diagonal being

[11] Of course, one could model exogenous variables as well, but this option is not used here. One reason is that we consider a world model, where there are no exogenous variables by definition. Moreover, from an econometric point of view, we refer to our point estimates. They reveal that no variable is weakly exogenous. Instead, all variables cannot be rejected to be endogenous.

one. The innovations e_t are by construction uncorrelated since $E(e_t e_t') = \mathcal{A}\Sigma\mathcal{A}' = \mathcal{A}PP'\mathcal{A}' = DP^{-1}PP'P^{-1'}D' = DD'$. Similarly, the Cholesky decomposition is used to construct orthogonal innovations out of the moving average representation of the system which is the cornerstone of the impulse response analysis.

Furthermore, the use of the Cholesky decomposition implies a recursive identification scheme which involves restrictions about the contemporaneous relations between the variables. The latter are given by the (Cholesky) ordering of the variables and might considerably influence the results of the analysis. Therefore, different orderings are used to prove the robustness of our results.[12]

Since the macroeconomic variables included in the analysis are likely to be nonstationary the question arises whether one should take differences of the variables in order to eliminate the stochastic trend. Sims, Stock and Watson (1990) show that Ordinary Least Squares estimates of VAR coefficients are consistent under a broad range of circumstances even if the variables are nonstationary. Here, we follow strictly this approach and estimate the VAR model in levels.

4.3 Empirical findings

4.3.1 The basic model

The conceptual approach of our VAR analysis is as follows: First, a benchmark model for the traditional macroeconomic variables output (Y), consumer price index (CPI), (short-term) interest rate (IS) and the (broad) monetary aggregate (M) is estimated. Second, if the dynamics of the system is found to be plausible at the global level, this is considered by us as a confirmation of our global approach, and the house price variable HPI is added to the system. The basic specification is given by the following vector of endogenous variables (along with the corresponding Cholesky ordering):[13]

$$x_t = (y\ cpi\ IS\ m)_t'$$

[12] See section 4.4.

[13] Lower case variables are taken in logarithms.

The Cholesky ordering of the basic specification follows the principle that monetary variables should be ordered last, since they are supposed to react faster to the real economy than vice versa (Favero, 2001). Variables are taken in log-levels except the short-term interest rate. In addition, a constant is added to the model.[14] We apply the usual criteria to determine the lag length.[15] Most of the criteria point at a lag length of 2, which is also sufficient to avoid serial correlation among the residuals and seems to be appropriate in order to estimate a model which is as parsimonious as possible.[16] While this is true not only for the benchmark specification but also for the following models we will continue with two lags for the whole analysis.

Figure 4 shows the whole array of impulse responses obtained from the basic specification. Most importantly, and in line with the theoretical predictions by our small model, consumer prices react only with significant time lags to a liquidity shock. In addition, consumer prices move upwards through an innovation to the output variable which might give support to the consideration of the output gap in assessing inflationary pressures. Output increases with a liquidity shock and declines with an interest rate shock which is in line with expectations, however only the latter is significant at the 5% level (after six quarters). In the case of the interest rate shock, the reaction of the consumer price level yields the "price puzzle" which often occurs in the VAR analysis and which was also faced by Rüffer and Stracca (2006) as well as Sousa and Zaghini (2006) in the same context.

The emergence of the "price puzzle" is sometimes thought to be caused by the lack of a variable which captures inflation expectations. Monetary policy makers are supposed to raise interest rates when inflation expectations rise. When their policy cannot stop inflation from rising, the system may identify the rise of interest

[14]Previous literature has additionally included a time trend in the VAR model (see, e.g., Rüffer and Stracca 2006). This implies, however, the possibility of a quadratic trend in the series which appears to be rather unrealistic in this context (Lütkepohl 2006, p. 91).

[15]To be explicit, we used the Likelihood Ratio test, the Final Prediction Error, the Akaike information criterion, the Schwarz criterion and the Hannan-Quinn criterion.

[16]To test for autocorrelation of the residuals, we performed the Lagrange Multiplier test.

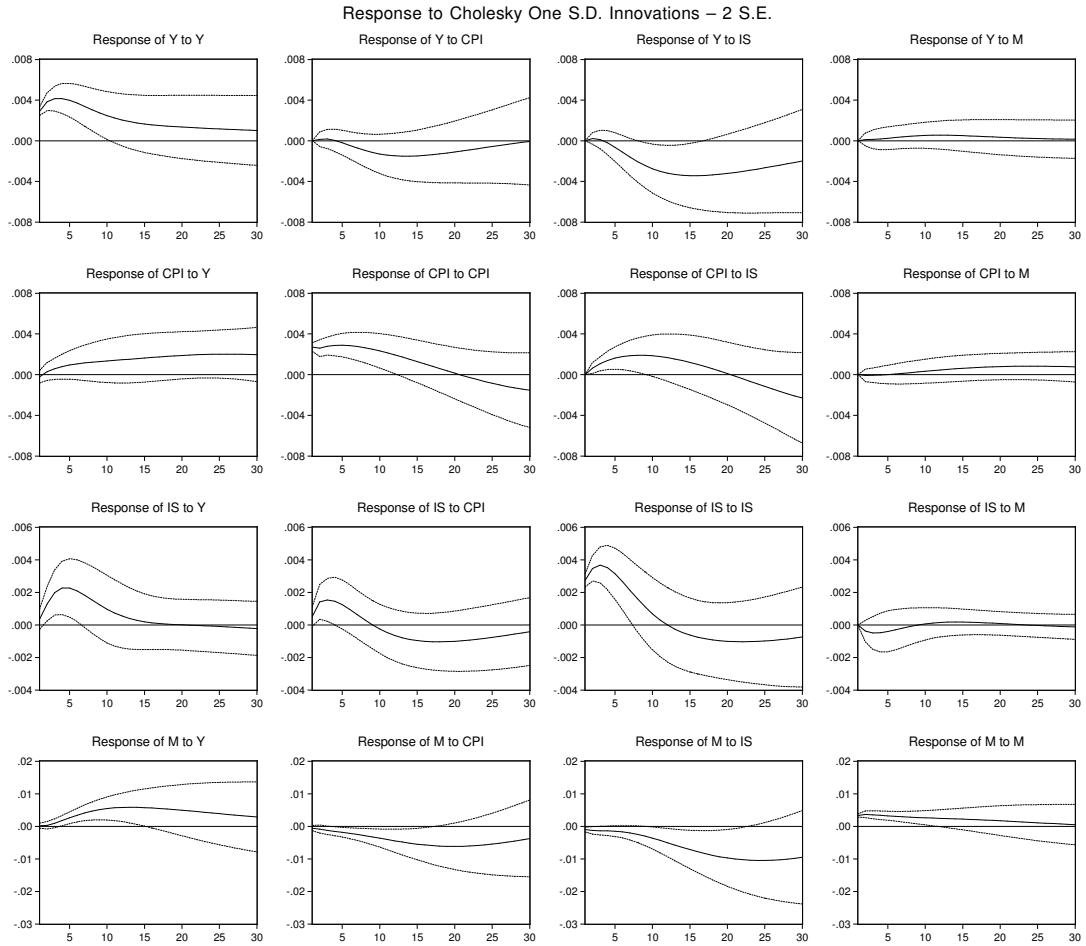

Figure 4: Impulse response analysis; basic model without house prices

rates as a trigger of the increase in the price level. To solve this problem Favero (2001) recommends to use an additional variable such as the commodity price index that could capture inflation expectations to some degree. However, considering this alternative and adding a commodity price index (or, alternatively, the oil price) to our system, did not solve the "price puzzle".[17] Later on, there will be further discussion of the implausible reaction of inflation to interest rate changes in the context of the augmented model, where the house price index helps us to cope with the "price puzzle".

The short-term interest rate moves up significantly as a result of an output shock and a consumer price shock, but does not show a significant reaction to a

[17]Rüffer and Stracca (2006) as well as Sousa and Zaghini (2006) come up with similar findings.

money shock (3rd row of figure 4. The latter result may occur, because either the system captures only the monetary policy stance in the short run which could be dominated by the business cycle or because the monetary policy instrument might be difficult to model from a global perspective where different central banks with different strategies exist. The responses of money show, in line with standard money demand considerations, a positive response of money to an output innovation and a decline of liquidity with growing interest rates. The latter effect might be caused, among others, by rising opportunity costs of money holdings.

Overall, the results of the benchmark model provide a good starting point for the subsequent analysis in which the additional inclusion of house prices might add up to the explanatory power of the global model.

4.3.2 Augmenting the VAR with house prices

The next step in our VAR analysis is to augment our baseline model with the global house price index (HPI). In the Cholesky ordering, we put house prices just behind the consumer price index, so that we are working with the following vector of endogenous variables:

$$x_t = (y\ cpi\ hpi\ IS\ m)'_t$$

The resulting impulse responses of the extended model are in line with our theoretical consideration set out in section 3 (Figure 5): House prices react relatively fast to a global liquidity shock (panel 5 in row 3), which supports the view that loose monetary policy and ample global liquidity have contributed to the bull market in the real estate sector. By contrast, the reaction speed of consumer prices to the same shock is much lower (panel 5 in row 2), though clearly significant in the long run. Thus, both house prices and consumer prices cannot be rejected to be determined by monetary conditions although at different time horizons. It is also interesting to see that output reacts initially positive to a global liquidity shock, which is in line

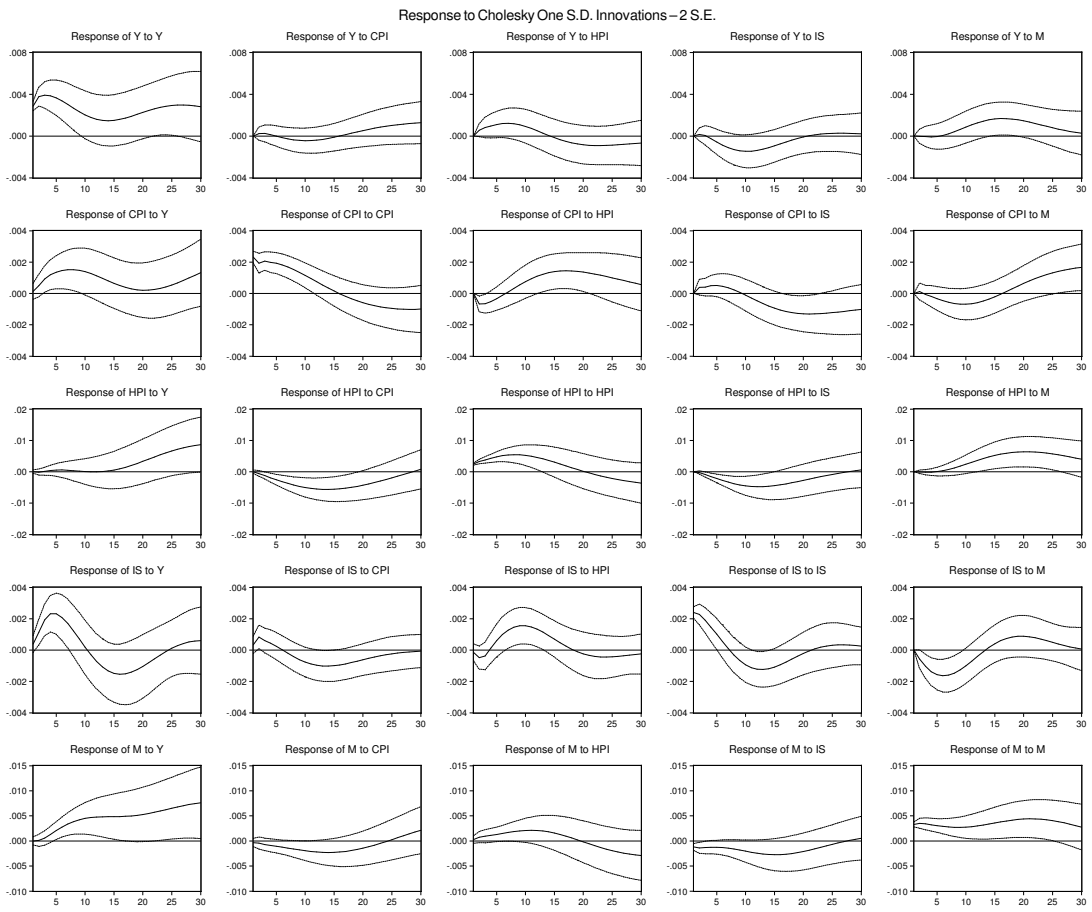

Figure 5: Impulse response analysis; model including house prices

with the view that in the short run an aggregate demand shock leads to a boost in production due to favourable supply conditions on global goods markets. In the long run, however, i.e. about the same time when consumer prices start to react, GDP declines towards its previous equilibrium value.

Analysing a house price shock, which may be especially relevant in the current scenario of the subprime crisis, gives some additional insights. Interestingly, a house price shock leads to a significant increase in consumer prices, a result which could be due to wealth effects or balance sheet effects and which is also in line with the results found by Goodhart and Hofmann (2007). Furthermore, a house price shock raises liquidity which may not least be due to rising credit demand. This piece of evidence is not surprising given the cointegration relationship between money and

house prices found by Greiber and Setzer (2007) for the Euro area and the US, and renders further support to the claim that housing should be considered in money demand models. More surprisingly, a house price shock causes a rise in interest rates (last row, column 3). Since it has not yet been generally acknowledged until now that monetary policy makers are reacting directly to house price developments,[18] this again raises the question to what degree house prices are linked with inflation expectations or forecasts, respectively.

In addition, and in the same way as in the baseline model, monetary policymakers react to output and consumer prices (row 4). Note that the initial interest rate response to a positive money shock is negative, This may lend some support to the idea that the money shock rather represents a supply shock than a demand shock.

The 4th column shows the effects emanating from a positive shock to the short-term interest rate. Like in the benchmark model, this kind of shock causes output and money to decline over relatively long periods. It is also interesting to see that the "price puzzle" disappears (row 2, column 4) which supports the view that house prices are essential for our model and otherwise an omitted variable bias might occur. Alternatively, we would like to argue that house prices and inflation expectations might be correlated, since the lack of an inflation expectation variable is often supposed to be the reason for the existence of the "price puzzle". The remaining results are also in line with economic theory. For example, consumer prices, house prices, money and interest rates all react to an output shock in the expected fashion (first column).

Seen on the whole, thus, our small theoretical model derived in section 3.3 is corroborated by our VAR analysis. On the goods market, there is an increase in the production of consumer goods, since the demand for consumer goods grows as a result of a positive liquidity shock. In contrast, the data hint to the fact

[18]For now, the subprime crisis ought to contribute to a changing behaviour in this respect.

that housing supply proves to be inelastic to price changes. They tell us that the additional demand for housing is fully reflected by a rise of house prices. In the long term, the neutrality of money again holds; i.e. the positive liquidity shock is fully absorbed by a change in the consumer price index.

4.4 Robustness checks

To check for the robustness of our results, we additionally estimated several alternative versions of our model. First, we changed the lag lengths, the Cholesky ordering of the variables and the kind of impulse response analysis. For instance, the interest rate is sometimes ordered behind the money variable in similar VAR based studies, so that we also tried this option although with nearly no consequences for the results. Additionally, the quality of our results is robust to a permutation in the ordering of house prices and consumer prices. The same is true for the use of generalized impulse response analysis.[19]

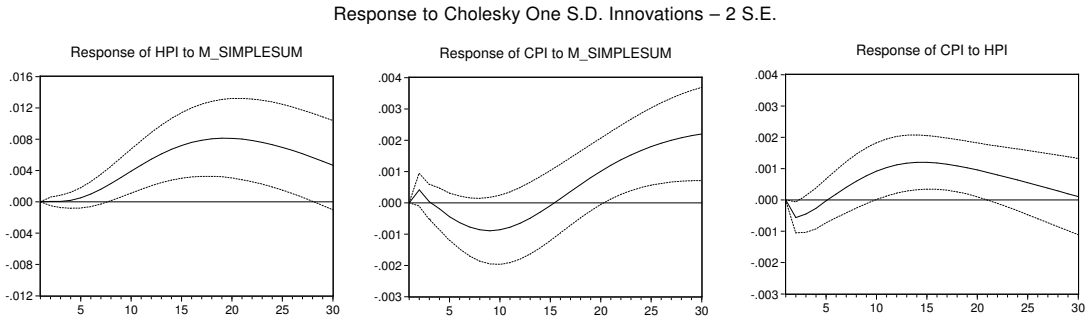

Figure 6: Impulse response analysis; alternative global liquidity measure

Second, we changed the definition of our monetary aggregate. Notwithstanding our considerations regarding the aggregation scheme in section 4.1, we formed a simple sum of national monetary aggregates to generate a global index again using PPP exchange rates:

$$M_{glo,t} = \sum_{i=1}^{11} M_{i,t} * e_{i,t}^{PPP} \tag{23}$$

[19] See Pesaran and Shin (1998) for theoretical derivations of generalized impulse response analysis.

As displayed by Figure 6, our main empirical finding is not affected by this variation.

Third, additional variables were used in the model, i.e. a commodity price index (like already mentioned earlier), the oil price (as an alternative for the commodity price index) and a long-term interest rate (specified by 10-year government bond yields). Both former variables were involved in only very few significant impulse responses with the most interesting of them being a short-term rise of the interest rate to a commodity price shock. The other findings of our model, in particular the money-price relationship, again proved to be stable. As commodity and oil prices neither solve the "price puzzle" nor show significant effects on the price level, we dropped them from the analysis illustrated above not least in order to save degrees of freedom.

We added the long-term interest as a substitute of the short-term rate and as a complement of our system as well. In the former case, results were very similar to those generated by the model including the short-term rate. In particular, no evidence was found that global liquidity fuels bond markets. When using both interest rates signs of duplications were found. For instance, shocks to both rates caused a decline of the consumer price index and the house price index. Notwithstanding the fact that the long-term interest rate might contain additional information, the relationship to the short-term interest rate seems to be close enough such that the more parsimonious model may be more adequate in order to prevent the VAR from over-parameterization.

Finally, as a fourth robustness check, we restricted the sample to the period from 1991 on. This is motivated by the insight that the widespread capital account and trade liberalization since 1991 should even emphasize the different dynamics in the price-money relationship. As is revealed by Figure 7, this is confirmed by the data. House prices now react even faster to a liquidity shock (after two quarters), while consumer prices adjust only with long time lags to the monetary impulse. Again, there are significant transmission mechanisms reaching from housing markets to consumer markets.

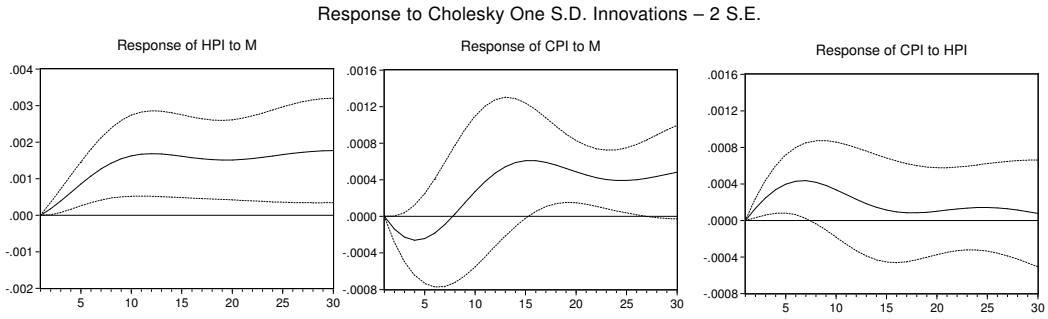

Figure 7: Impulse response analysis; restricting the sample to 1991Q1 - 2006Q4

5 Conclusions

This paper has analyzed the relationship among money, consumer prices and asset prices on a global level. The main empirical results are the following. At a global level, we find support of the conjecture that monetary aggregates may convey useful information on variables such as house price and consumer price inflation. In line with theoretical considerations, the price reaction of the housing market takes place much faster than the corresponding price increase in the goods market. Hence, we conclude that liquidity growth is a useful indicator of house price inflation and also of a more generally defined inflationary pressure at the global level. Therefore we would like to argue that global liquidity deserves the same attention as the worldwide level of interest rates has received in the recent intensive debate on the world savings versus liquidity glut hypothesis, if not possibly more.

Against the background of our results the still high level of global liquidity has to be interpreted as a threat for future stable and low inflation and financial stability. Since global excess liquidity is found to be an important determinant of house prices, there might be at least two implications for the adequate conduct of monetary policy. First, monetary policy has to be aware of different time lags in the transmission from money to different categories of prices. In particular, strong money growth might be a good indicator of emerging future bubbles in the real estate sector. However,

this pattern should, on the contrary, also be taken into account when assessing the consequences of a slowing down or smooth reversal in global excess liquidity (e.g., the risks and options in the light of Bretton Woods II). Second, the results of our VAR analysis indicate that house prices might well serve as indicators of future inflationary pressures on goods markets.

Moreover, we see two potential ways to reduce world excess liquidity in the future. The first is a tightening of monetary policy oriented at the development of the world's nominal income. This strategy will not solve the current problem immediately but should anyway diminish the long-run risks. However, among other problems this option again raises the issue of the need of enhanced international coordination of monetary policies in order to avoid beggar-thy-neighbor attitudes. Second, fostering strong and sustainable global economic growth will on average dampen negative effects especially with respect to potentially bursting bubbles.

As always, a couple of important questions has remained unanswered in this paper. Let us just enumerate two of them. First, over the last 30 years, the euro area index of house prices has tended to follow that of the US quite closely, but with a lag of around 18 months. Given that the US market turned in mid-2006, one could thus expect that the Euro area market is likely to do the same as 2007 turns into 2008 (Gros, 2007). Will the world excess liquidity in the end be capable to stop this trend?

Second, the focus of our analysis was solely directed to the *global perspective*. Still, with a view on recent findings that inflation might be an increasingly global phenomenon, the potential threats for future price stability which can be derived from the evidence generated by this paper and the related literature appear to be also *relevant on a country level*. Some country-level studies that include asset prices of different varieties find empirical evidence in a similar direction.[20] They basically

[20]See Goodhart and Hofmann (2000), Greiber and Setzer (2007), Adalid and Detken (2007), Congdon (2005) and Roffia and Zaghini (2007).

support the major finding of our paper, namely that global liquidity fuels house price inflation and that there might be subsequent spillovers to consumer prices.

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