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Liquidity Shocks & Asset Price or Bust Cycles

Carsten Detken

Ramon Adalid

EUROPEAN CENTRAL BANK

EUROSYSTEM

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In 2007 all ECB publications feature a motif taken from the €20 banknote.

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2 European Central Bank, Directorate General Operations, Kaiserstrasse 29, D-60311 Frankfurt am Main, Germany; e-mail: Ramon.Adalid@ecb.int. The research work has been conducted while Adalid was working in the Directorate General Research of the ECB.

3 European Central Bank, Directorate General Research, Kaiserstrasse 29, D-60311 Frankfurt am Main, Germany; e-mail: Carsten.Detken@ecb.int.

Address
Kaiserstrasse 29
60311 Frankfurt am Main, Germany

Postal address
Postfach 16 03 19
60066 Frankfurt am Main, Germany

Telephone
+49 69 1344 0

Internet
http://www.ecb.int

Fax
+49 69 1344 6000

Telex
411 144 ecb d

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Abstract:

We provide systematic evidence for the association of liquidity shocks and aggregate asset prices during mechanically identified asset price boom/bust episodes for 18 OECD countries since the 1970s, while taking care of the endogeneity of money and credit. Our derivation of liquidity shocks allows for frequent shifts in velocity as they are derived as structural shocks from VARs in growth rates. Residential property price developments and money growth shocks accumulated over the boom periods are able to well explain the depth of post-boom recessions. We further suggest that liquidity shocks are a driving factor for real estate prices during boom episodes. During normal times however, the relative predictive power of liquidity shocks seems to shift from asset price inflation to consumer price inflation. The results only hold for broad money growth based liquidity shocks and not for private credit growth shocks.

Key Words: liquidity shocks, asset price booms, money and credit aggregates, role of money, monetary policy, real estate prices

JEL classification: C33, E41, E51, E58

Non-technical summary

There is an ongoing discussion on whether central banks should at times of perceived rising financial imbalances consider tightening the monetary policy stance more than what is required to keep consumer price inflation on target over a short to medium term horizon (‘leaning against the wind’ policy). The reason would be the attempt to contain, or at least not accommodate, booming financial markets in order to reduce the costs, both in terms of inflation variability and real growth, resulting from a possible bust of asset prices.

One important element of the discussion is in how far potentially harmful asset price boom/bust episodes are associated with cycles in money and credit aggregates. The ECB has been repeatedly arguing that if that association is real, its monetary analysis could implicitly (though not mechanistically) support such a ‘leaning against the wind’ policy. The monetary policy tightening triggered by strong money growth during asset price boom episodes might be the optimal reaction to maintain price stability in the medium to long run. With respect to the information content of money and credit, the interesting broad issues are a) whether there really is systematic evidence for association between growth in money and credit aggregates and (harmful) asset price boom/bust cycles, and b) whether strong money and credit growth might even be a cause for asset price booms and not just an endogenous reflection of the business cycle and asset price developments.

We identify 42 aggregate asset price boom episodes for 18 OECD countries with quarterly data since the 1970s. We then compute the average behaviour over the boom-bust cycles for a host of macroeconomic variables. In particular, we focus on differences between benign (low-cost in terms of post-boom real GDP growth) and serious (high-cost) boom episodes. These stylised facts suggest the importance of real estate prices and money and credit developments for the boom-bust derailment.

We then cleanse broad money and private credit growth rates from endogenous developments due to business or asset price cycles by means of VAR technology. This allows us to confirm and elaborate on hypotheses suggested by the observed differences between high and low-cost boom episodes by means of regression analyses. Money growth shocks during the boom and pre-boom periods contribute to explaining the depth of post-boom recessions even if one controls for housing price developments during the boom and in the post-boom phase, and for the monetary policy stance during the boom and in the post-boom phase (measured by deviations from a Taylor-rule). Real residential property price developments during the boom and in the post-boom phase are an important and robust factor to explain post-boom recessions.

Part of the information content of money to explain post-boom recessions does indeed come from the possibly causal effect of liquidity shocks on real residential housing prices during boom periods. This is shown by a panel analysis explaining housing price developments, where the different boom episodes constitute the cross-section dimension.

While all these results hold for broad money growth, nearly no informational content is found for private credit growth.

The panel analysis using the whole sample, i.e. all boom and non-boom periods available for each country, shows a much weaker relationship between liquidity shocks and asset price inflation than when focusing on asset price boom periods. Other more standard variables like income and interest rates gain in relative importance in normal times. Switching the endogenous variable from the change in real housing prices to consumer price inflation reveals the opposite pattern. Liquidity shocks seem to contribute to explaining consumer price inflation for the whole sample but not at all during boom episodes.

The contribution of this paper is twofold. First, according to our knowledge, it is the first systematic evidence across countries and time periods establishing a robust positive association between money and aggregate asset price booms while taking care of endogeneity issues. Our sample has a broad country coverage and the methodology is designed for *focusing on asset price boom episodes*. Second, by using liquidity shocks allowing for *frequent permanent shifts in velocity* and cumulating these liquidity shocks over a fixed horizon to capture the concept of *slowly building imbalances*, we combine two recently advocated concepts to detect information content in money. Macroeconomic data series associated with asset price boom/bust episodes are likely to exhibit volatile, non-standard and non-linear behaviour. By using *different empirical methods*, among which robust and quantile regressions for the cross-section analysis, and different estimation techniques for the panel analysis increases confidence in the results. In our view, the current results are important enough to trigger further research to investigate the potential role of money as an early warning indicator for eventually deflationary boom/bust episodes.

Nevertheless, the provided evidence on causality running from liquidity shocks to asset prices has to be taken with a grain of salt, first of all, due to the small sample of boom/bust episodes but also due to the fact that no econometric identification scheme can claim to perfectly resolve the endogeneity problem. The case for association between money and asset prices certainly remains much stronger than the one for causality.

1. Introduction

The motivation for this paper stems from the ongoing discussion on whether central banks should at times of perceived rising financial imbalances consider tightening the monetary policy stance more than what is required to keep consumer price inflation on target over a short to medium term horizon. The reason would be the attempt to contain, or at least not accommodate, booming financial markets in order to reduce the costs, both in terms of inflation variability and real growth, resulting from a possible bust of financial market exuberance. In its 2006 Annual Report, the Bank for International Settlements (BIS) warns against risks for the world economy should recent booming asset price developments at the global level, possibly triggered by too loose monetary policy stances, as measured by exceptionally low interest rates and strongly growing credit and money stocks, be swiftly reversed. This way of thinking about asset prices and monetary policy has been influenced by several studies at the (BIS), see e.g. Borio and Lowe (2002), Borio, English and Filardo (2003) or White (2006) as well as Cecchetti, Genberg, Lipsky and Wadhwani (2000). These studies clearly advocate some kind of the above described policy, which is also known as "leaning against the wind", "extra action"[4] or "pro-active policy"[5] with respect to booming asset prices[6]. This policy recommendation clearly deviates from the orthodox central banker's view or the "conventional policy framework"[7] that asset prices should influence monetary policy only indirectly in as far as they affect the outlook for inflation through effects on aggregate demand via a wealth (consumers) or balance sheet (firms) channel. A more critical view on the "extra action" policy has been provided by Bordo and Jeanne (2002) and Gruen, Plumb and Stone (2005). These authors derive "leaning against the wind" as the optimal policy in theory but then show that the informational requirements to successfully conduct such policy are very heavy[8].

Careful discussions of the pros and cons of reacting to asset prices from a central banker's point of view are to be found in Issing (2003), Trichet (2005) and Papademos (2006). For a more sceptical view see Kohn (2006).

One important element of the discussion is in how far potentially harmful asset price boom/bust episodes are associated with cycles in money and credit aggregates. The ECB has been repeatedly arguing that if that association is real, its monetary analysis could implicitly (though not mechanistically) shadow a leaning against the wind policy as recommended by

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[4] See Kohn (2006) arguing against "extra action" and in favour of the "conventional strategy".

[5] Bordo and Jeanne (2002).

[6] A more extreme view is to directly include asset prices in the price index used by the central bank to achieve its objective of price stability, see Alchian and Klein (1973). This view has received much criticism, see e.g. ECB (2005). Goodhart (2001) argues instead for an inclusion of only housing prices rather than equity prices.

[7] See White (2006).

[8] For a more detailed survey of this literature see Detken and Smets (2004).

[9] Issing (2002) first mentioned this aspect of the ECB's monetary policy strategy. See also ECB (2005).

several of the above mentioned authors[9]. The monetary policy tightening triggered by strong money growth during asset price boom episodes might be exactly the "extra action" required to maintain price stability in the medium to long run. With respect to the information content of money and credit, the interesting broad issues are a) whether there really is systematic evidence for association between growth in money and credit aggregates and (harmful) asset price boom/bust cycles, b) whether liquidity shocks might even be a cause for asset price booms and not just an endogenous reflection of the business cycle and asset price developments and c) whether monitoring money and credit aggregates in real time provides information on the nature of the asset price boom, which could be used for monetary policy purposes.

The rest of the paper will address issues a) and b) while leaving c) for a more systematic evaluation of future research. The paper is structured as follows. While this paper is a purely empirical exercise, Section 2 will nevertheless provide a brief overview of some theoretical approaches which could explain the link between money, credit and asset price booms. Section 3 provides some descriptive statistics of what are the most distinctive macroeconomic features of asset price boom/bust cycles, refining the approach used in Detken and Smets (2004), by e.g. using quarterly instead of annual data for the sample of 18 OECD countries since the 1970s[10]. Despite the improved methodology and extended data set, this section mainly confirms previous findings. For example we show again a strong association between money growth and those aggregate asset price booms, which lead to more costly recessions in the bust phase. This exposition of stylised facts drawing explicitly on correlations, raises the issue of causality and leads to the formulation of several hypothesis, which are then explored below. Section 4 derives structural money and credit growth shocks of 18 country VARs. Section 5 performs a *cross-section bust analysis*. We use 41 boom episodes as cross-sections and see whether liquidity shocks during the boom episodes can explain the size of the post-boom recessions. We conclude that liquidity shocks, if derived with reference to broad money, contribute to explaining post-boom recessions. Section 6 conducts a *panel boom analysis*. The cross-section elements are again the identified boom episodes, while the period starting four quarters prior to the boom until the final quarter of the boom constitute the time dimension. We investigate whether liquidity shocks contributes to explain real residential property price developments during the boom episodes and find that it is actually the most robust explanatory factor. Comparing these panel boom estimates with panel estimates where the cross-section dimension is countries and the time series dimension is the whole sample from 1972 until 2004, shows that here liquidity shocks are only one among several explanatory variables and economically less important. This strengthens the argument that

[10] We use the BIS data on aggregate asset prices appropriately weighting equity, residential and commercial property prices for 18 OECD countries. See the data annex for more details.

some particular information value is inherent in money during asset price boom episodes. Section 7 concludes.

The contribution of the paper is twofold. First, according to our knowledge, it is the first systematic evidence across countries and time periods establishing a robust positive association between money and aggregate asset price booms while taking care of the endogeneity of money. The paper's objective is similar to Gouteron and Szpiro (2005). By finding a significant link between liquidity and asset prices, we reach opposite conclusions than they did most likely because our country sample is broader and our methodology is designed for focusing on asset price boom episodes. Furthermore, analysing real estate prices instead of equity prices could explain the differences in results compared to previous papers[11]. Second, by deriving money growth and credit growth shocks allowing for frequent permanent shifts in velocity[12] and cumulating lagged measures of these shocks to capture the concept of building imbalances[13], we combine two recently advocated concepts to detect information content in money and credit. By using different empirical methods, among which robust and quantile regressions for the cross-section analysis, and different estimation techniques for the panel analysis increase confidence in the results. In our view, the current results are important enough to trigger further research to investigate the potential role of money as an early warning indicator for eventually deflationary boom/bust episodes.

Nevertheless, the provided evidence on causality running from liquidity shocks to asset prices has to be taken with a grain of salt, first of all due to the small sample of boom/bust episodes but also due to the fact that no VAR identification scheme and no instrumental variable approach can claim to perfectly resolve the endogeneity issue. Therefore, the case for association between money and asset prices certainly remains much stronger than the one for causality.

2. Theoretical approaches linking liquidity and asset prices

The purpose of this section is to briefly survey what are the available theoretical approaches explaining a positive link between liquidity and asset prices in general and asset price bubbles in particular.

The most prominent theory of a link between monetary policy and asset prices is of course monetarism. A monetary policy shock will affect the quantity and marginal utility of money relative to other assets (as well as to consumption and production). The money holding sector will restore equilibrium by changing several relative prices not only but also in asset

[11] See e.g. Machado and Sousa (2005).
[12] See Reynard (2006).
[13] See Borio and Lowe (2002).

portfolios[14]. Monetarists have interpreted real money balances capturing the many channels of monetary transmission via a host of asset returns. Money has been attributed the role of an index for the whole spectrum of interest rates measuring substitution rather than wealth effects. In particular money might proxy for physical asset returns like property, which are also more difficult to measure. For a review of these kind of arguments the reader should consult Nelson (2003, pp. 1048).

With regard to other financial institutions, increases in the supply of money are thought to trigger a rebalancing of the liquidity/asset ratio compatible with optimal portfolio allocation of each institution, which leads to a higher demand for assets and thus asset price increases. Congdon (2005) stresses the importance of broad money instead of the traditional monetarist focus on narrow money and argues that it is exactly the behaviour of (non-bank) financial institutions that matters for the determination of asset prices. Thus, it would not necessarily be a money supply shock narrowly defined which is driving asset prices but rather strong broad money growth as a reflection of financial institutions portfolio choices[15]. In a similar vein Adrian and Shin (2006) argue that the empirically observed 'leverage targeting' behaviour of banks can create a mutually reinforcing, positive association between money and asset prices. Rising asset prices will trigger a rise in bank indebtedness, which might easily show up in marketable instruments included in the definition of broad money. The additional funds available to banks might then spur additional demand for assets.

Another important aspect stressed by monetarist literature is the property of monetary aggregates to be a summary statistics of the degree of uncertainty about future developments of asset prices and the nature of monetary or other kinds of shocks, e.g. with respect to the persistence of these shocks[16]. A large liquidity share held by financial institutions could be a sign of uncertainty of future asset price developments. Such fluctuations in broad money demand would at some point be corrected by the described increase in asset demand, possibly foremost in more durable assets like housing, rather than bonds[17], as real estate is a better hedge in times of fears of future inflation. This rebalancing of financial portfolios[18] with lots of liquidity waiting to be invested in less liquid assets could potentially reinforce emerging trends in asset prices.

[14] Meltzer (1995). The portfolio idea is also found in Friedman (1988), although there he attempts to explain money demand by using stock prices as additional explanatory variables, while here the focus is on the reverse causality.

[15] Congdon (2005, p. 17) acknowledges that his analysis seems more Keynesian than monetarist in spirit. He writes that "…in effect, the whole paper is an analysis of the empirical significance of the speculative demand for money."

[16] See Brunner and Meltzer (1971).

[17] Meltzer (1995) explicitly mentions the effect of liquidity on land and housing prices as being of particular importance for the US and Japan in the 80s and 90s.

[18] This of course would not lead to more equity or housing assets and less money circulating in the economy, but simply to relative price adjustments.

Some of the other traditional monetary transmission mechanisms, like the bank lending channel or the balance-sheet channel, basically reinforce the above effects by establishing a link between credit and asset prices. Here asymmetric information and costly enforcement of contracts create agency problems in financial markets[19]. Under quite restrictive assumptions, the bank lending channel links bank deposits (as determined by monetary policy) to bank loans[20]. Recently, Diamond and Rajan (2006) have introduced the "liquidity version" of the bank lending channel relaxing some of the restrictive assumptions. The authors instead assume a significant degree of impatience of investors in order to provide a role for liquidity. In the balance-sheet channel lending and thus investment is increasing when looser monetary policy reduces the adverse selection and moral hazard problem so that the external finance premium is lowered[21]. Bernanke and Gertler (1995) stress that the balance-sheet channel could not only apply to firms but equally to consumers and affect their housing purchases. Mishkin (1978) describes the "liquidity-effects view" of the balance-sheet channel and argues that the impact of monetary policy on lending rests not only on the lenders desire to lend but the consumers desire to borrow. The latter depends on the likelihood consumers attribute to the possibility of finding themselves in financial distress, which in turn affects their relative demand for liquid and for durable assets such as housing.

More recently Christiano, Motto and Rostagno (2003) have introduced money besides several financial frictions in a medium-scale dynamic stochastic general equilibrium model. This model can be used to show that broad monetary aggregates are useful in providing the central bank with information on the type and persistence of shocks hitting the economy. The reason is that due to a cash-in-advance constraint, broad money growth reflects the expected path of future consumption. Thus if agents are better able than the central bank to extract information on the nature of shocks affecting consumption and asset prices, broad money will be positively correlated with asset prices, e.g. in times of permanent productivity shocks. In another paper Christiano, Motto and Rostagno (2006) show how a stock market boom/bust cycle would be positively associated with (narrow) money and credit cycles. A central bank which takes into account liquidity developments conducts in this model a welfare enhancing monetary policy.

There exist several theories explaining how loose monetary policy could actually trigger asset price bubbles, which would reinforce the above mentioned mechanisms. Some of these approaches are briefly described below.

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[19] See Mishkin (1995).
[20] See Kashyap and Stein (1997).
[21] See Bernanke and Gertler (1989).

First of all, authors of the Austrian school have argued (see exposition in White (2006)) that if the market lending rate is below the natural rate of interest, defined as the real rate which maintains price stability in the long run, previously marginal investment projects will be financed and credit will expand[22]. This leads to an investment and asset price boom. At some point these marginal projects turn out to be unproductive. Overcapacities will lead to a severe and possibly long lasting recession and an asset price bust.

Allen and Gale (2000a) develop a model where investors borrow to invest in assets in fixed supply (an assumption particularly relevant for housing or even equity in the medium run). Risk shifting, due to the non-convexity of the investors' pay-off structure combined with the inability to observe the risk of actual investments, allows for assets being priced above their fundamental value. The authors show that credit expansion and the expectation of future credit expansion critically affects today's asset price. Uncertainty about the future course of monetary policy and credit might be particularly high during periods of financial liberalisation[23]. Illing (2000) provides a variation of the Allen and Gale (2000b) model where an asset price bubble is triggered by an asymmetric reaction function of the central bank. If the central bank would supply liquidity in a crisis, but is expected to be hesitant to withdraw it after a crisis is avoided, a bubble can occur even without agency problem, uncertainty about future credit, or irrational exuberance on the side of investors.

Herring and Wachter (2003) analyse the reasons for bubbles in the real estate market and stress some *behavioural characteristics* of bank management as being important to create a mutual relationship between real estate prices and bank credit. Higher asset prices increase the value of banks' own assets and the value of potential collateral. Together with disaster myopia and the perverse incentives of bank managers, this can trigger real estate bubbles. Disaster myopia is the tendency over time to underestimate the probability of low-frequency shocks[24]. Perverse incentives can prevail as even prudent lenders might be forced to accept weaker borrowing standards or have to withdraw from the market, once competition from disaster myopic banks becomes tougher, which is often the case during a boom. Furthermore, Herring and Wachter also stress the risk-shifting incentives for bank managers. The types of behaviours mentioned by the authors are more likely to become relevant in times of rising real estate prices, which in turn are more likely in an environment with falling and low interest rates.

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[22] Borio, English and Filardo (2003) argue that a combination of reduced pricing power of firms due to globalisation, positive productivity shocks and well anchored inflation expectations, mislead central banks to maintain interest rates too low for too long and thus help trigger asset price overvaluations.
[23] In a more realistic setting, restrictions on short sales of the asset would be required for the results to hold, see Allen and Gale (2000a, p. 252). Again this is a feature applying to real estate (see Herring and Wachter (2003).
[24] Guttentag and Herring (1984).

In a similar vein Rajan (2005 and 2006) conjectures that low interest rates and ample liquidity supply could reinforce certain characteristics of fund managers' behaviour which are conducive to asset price bubbles and financial instability. Among the characteristics mentioned by Rajan are, again, risk-shifting due to the incentive structures provided by fund managers' contracts, tail-risk seeking including attempts to hide tail-risk from fund investors, herding and illiquidity seeking. In times of ample liquidity supplied by the central bank, it becomes more difficult for investment managers to earn excess returns by providing liquidity to markets of otherwise illiquid assets. Their investments will then concentrate in less and less liquid and possibly more risky assets. Rajan concludes that such a behavioural transmission mechanism of monetary policy could work entirely through institutions outside the banking system and be poorly captured when only looking at credit developments.

Recently Adam, Marcet and Nicolini (2006) show that introducing learning in a standard consumption based asset pricing model can produce excess volatility and low frequency deviations from rational expectations asset prices. Moreover, in this model, expansionary monetary policy, i.e. low interest rates are associated with increased asset price volatility as long as agents are sufficiently risk averse.

Some of the above arguments would support the finding that the booming asset prices are more likely to be durable assets such as real estate rather than equity or bonds[25].

Could all or some of those theoretical channels be equally valid across countries and across different financial regimes? Meltzer (1995) mentions that the monetarist channel does not depend on the degree of financial market sophistication or the availability of financial instruments of a country at any particular point in time. This would be an important aspect in light of the following empirical analysis, as we attempt to find common patterns across a variety of boom episodes across countries and time periods and are thus implicitly dealing with a variety of financial system structures. Eventually though, correlations between asset prices and liquidity measures are not always independent of the prevailing financial system. One example is the observation that for the euro area since about 1998 non-monetary financial intermediaries (investment funds, pension funds, insurance corporations etc.) contribution to annual M3 growth is becoming significant (recently contributing as much as 2 percentage points from the roughly 8 percentage points M3 growth in the euro area). This is

[25] Helbling and Terrones (2003) though show that equity price booms are more frequent than real estate price booms. However, the economic consequences of a bust in real estate prices are more severe than busts in stock price booms. Bordo and Jeanne (2002) also find that although there are overall more equity booms than real estate booms, there are relatively more real estate price booms, which are followed by a bust phase (52.5% for property versus 12.5% of equity booms). On the importance of housing price booms see also Calverly (2004) and Cecchetti (2006).

most likely due to the fact that non-monetary financial intermediaries can use financial derivatives such as swaps or future contracts to take positions in a particular asset, while the underlying assets are deposits, which are included in M3[26]. This could be one reason for an association between asset prices and broad money, which of course could not have played an important role in earlier asset price boom episodes, due to the unavailability of financial instruments and the lack of sophisticated risk management capabilities. This observation should be taken as a caveat for the following analysis in the sense that the reported significant cross-section and panel results do eventually not alleviate the burden to further analyse the reason for these findings on a country by country basis, taking into account the specifics of the respective financial systems.

3. Some stylised facts about asset price boom/bust episodes

In order to investigate the association between money and credit developments and asset price booms, we systematically identify boom episodes using the real aggregate asset price indices provided by the BIS for 18 OECD countries between 1970 Q1 and 2004 Q4. The asset price indices combine consumer price deflated residential property prices, commercial property prices and equity prices according to the (infrequently updated) actual weights in each economy[27]. Our method to identify boom periods is a refined version of the one suggested in Detken and Smets (2004), since here we use quarterly instead of annual data. An asset price boom is defined as the consecutive periods (minimum 4 quarters) in which the real aggregate asset price index exceeds its trend by at least 10%. The trend is estimated using a very slow adjusting HP-Filter (λ=100000), which is estimated recursively, i.e. taking into account only data available at the time[28]. We then classify the 42 identified boom episodes, which are of variable length, into high and low-cost booms, depending on the average real GDP growth in the three years following the boom compared to the average growth during the boom[29].

[26] See ECB (2006).

[27] See Borio, Kennedy and Prowse (1994).

[28] See Borio and Lowe (2002). For example, the trend of the aggregate asset price index in Japan in 1986 Q2 has been estimated using only information up to exactly 1986 Q2. The percentage difference to the actual index has been 11.5%, which exceeds 10%. Successively adding one observation and computing the trend and the gap until the gap falls bellow the 10% threshold, resulted in the 16 quarter boom (up to 1990 Q1), which is listed in Table 1. There certainly exist alternative methodologies to identify boom periods. A similarly mechanic one would be to use the Bry and Boschan (1971) algorithm to detect local peaks and throughs, as used for business cycle dating. Bordo and Jeanne (2002) use moving averages of growth rates and compare to the historical trend. Alternatively and much more challengingly, one could try to approximate the fundamental value of asset prices in each period and compute the gap to current prices. See also Machedo and Sousa (2006).

[29] Some additional conditions are used for boom identification and classification to avoid unreasonable results. Fist of all, if there are less than four quarters between two boom periods, we

In this way we identify 20 high cost booms (annualised change at least -2.4 p.p.) and 22 low-cost booms (annualised drop smaller than 2.4 p.p.). Table 1 shows the identified boom periods for each country.

Table 1: Aggregate asset price booms in selected industrial countries (1970-2004)

High cost			Low cost		
1988Q3-1990Q1 (7)		Australia	1979Q4-1981Q4 (9)	2003Q2- (7)**	
		Belgium	1988Q2-1990Q3 (10)	1998Q1-1999Q3 (7)	
1988Q1-1990Q1 (9)		Canada			
1988Q2-1990Q1 (8)		Switzerland	1999Q1-2001Q1 (9)		
1989Q3-1990Q3 (5)	1999Q3-2000Q3 (5)	Germany			
1983Q4-1986Q4 (13)		Denmark	1997Q1-2001Q3 (19)		
1986Q2-1991Q2 (21)		Spain	1998Q1-2001Q2 (14)		
1980Q1-1989Q3 (39)	1997Q1-2000Q3 (15)	Finland			
1988Q4-1990Q3 (8)		France	1999Q1-2001Q2 (10)		
1972Q3-1973Q4 (6)	1985Q4-1990Q1 (18)	United Kingdom	1999Q1-2000Q4 (8)		
1987Q1-1990Q3 (13)		Ireland	1977Q4-1979Q3 (8)	1995Q4-2001Q3 (24)	
		Italy	1980Q4-1981Q3 (4)	1989Q2-1991Q3 (10)	1999Q1-2001Q2 (10)
1973Q1-1973Q4 (4)	1986Q2-1990Q1 (16)	Japan			
1988Q3-1990Q3 (9)	1993Q4-2000Q4 (29)	Netherlands	1976Q3-1978Q2 (8)		
		Norway	1973Q2-1974Q2 (5)	1981Q2-1987Q3 (26)	1996Q4-2001Q2 (19)
1983Q3-1984Q2 (4)	1986Q2-1987Q3 (6)	New Zealand	1994Q3-1996Q4 (10)		
1986Q3-1990Q2 (16)		Sweden	1996Q2-2000Q3 (18)		
		United States	1986Q1-1987Q3 (7)	1996Q1-2000Q4 (20)	

Number of high-cost booms	*20*
Total number of quarters	*253*
Average number of quarters	*12.7*
Median number of quarters	*9*

Number of low-cost booms	*22*
Total number of quarters	*262*
Average number of quarters	*11.9*
Median number of quarters	*10*

*Figures in parentheses refer to the number of quarters of the particular boom.
**For Australia 2004Q4 was identified as a boom quarter.

In 16 out of our 20 identified high-cost booms, real GDP growth is actually declining in at least one of the three post boom years. This is only the case for 6 out of the 21 available low-cost booms. The average real GDP growth during the post-boom period is 0.8% for high-cost and 1.8% for low-cost booms. Thus not all boom/bust cycles have really detrimental consequences.

In a first step we use the identified boom episodes to compare the behaviour of a large number of macroeconomic variables for high-cost and low-cost booms for time periods defined relative to the beginning or the ending of the boom. The time periods depicted in the following graphs and Table A1 refer to the periods immediately before the boom (one and two years before the boom, i.e. “Pre1” and “Pre 2”, respectively), during the boom (first boom year, “B1”, the year prior to the asset price peak, “Peak” and the last boom year, “Last”) and immediately after the boom (one year, “Post1”, and two years, “Post2”, after the end of the boom)[30]. For each of these periods we compute the annual growth rates or the deviations from their recursive HP-trend for the depicted variables (the latter we call a “gap”). The charts show for each period and variable the median of the respective group of high or

bridge this period and identify one common boom. In case a cumulated drop in real aggregate asset prices during the boom exceeds 8%, the boom episode is terminated. If the average real GDP growth in the three post-boom years is larger than 2.5%, the boom cannot be classified as high-cost (independent of the size of the relative growth reduction). The 1986-1990 boom in Japan, although not reflected in our relative growth condition, was eventually followed by a period of prolonged low growth (“the lost decade”), which is why we classify it as high-cost.

[30] The Peak-Pre2 column in Table A1 refers to the cumulated change between these two periods.

low-cost booms[31]. In order to test whether the differences in the medians are actually significant, we report the outcome of the rank based Wilcoxon/Mann-Whitney test[32]. The size of the columns visualises the degree of significance for rejecting the null of no differences in populations (medians, ceteris paribus) between high and low-cost booms.

With regard to the aggregate asset prices and their available subcomponents, residential property and share prices, it is important to observe that there is fairly no difference between high and low-cost booms for the aggregate asset price gap as depicted in Chart 1 (although aggregate asset prices fall significantly more for high cost boom episodes in the first post boom year, see Table A1). For high-cost booms we though find a significantly more negative real residential property price gap (Chart 2) and, correspondingly, a larger drop in real residential property prices in the two post-boom years (Table A1)**.** The development of real housing prices during the bust is the main distinguishing feature of high and low-cost aggregate asset price booms (the gap and the growth rates provide the same highly significant and consistent message, see Table A1)[33].

There also seems to be a stronger increase in the real estate price gap in the peak year and the last year of aggregate asset price booms, but these differences are not significant. When comparing real money and real private credit growth (Charts 3 and 4), the message is that money growth is significantly higher during high-cost boom episodes in the pre-boom phase and during the boom, while private credit is not. For the bust phase the difference in money growth is not so large although statistically significant, while private credit growth definitely collapses compared to low-cost boom episodes in both post-boom years. Chart 5 demonstrates mainly that our boom identification scheme works as intended and differences in growth performances between high and low-cost booms are significant (except for Pre1 and Post2). Chart 5 also warns that the issue of endogeneity with respect to the business cycle of money and credit variables during boom episodes is likely to be relevant. Charts 7 and 8 show real growth in total investment and housing investment, respectively. Interestingly, total investment growth is higher in low-cost boom episodes and significantly so for the second year before the boom and the first boom year, while housing investment is to the contrary larger during high-cost booms and significantly so during the peak year. This, again, stresses the major importance of housing price boom-bust cycles for the real economy.

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[31] Bordo and Jeanne (2002) provide similar charts reporting the mean of inflation, the output gap and private credit. They average over 19 property price and 24 equity price booms for OECD countries between 1970 and 2001. They do not distinguish between high and low-cost booms and do not perform tests of differences between equity and real estate booms.

[32] The four column sizes (from the tallest to the smallest) refer to the significance of differences in populations at the 1%, 5%, 10% and 20% significance levels, respectively. The test is non-parametric thus does not rely on any particular distributional assumptions.

[33] Cecchetti (2006) presents similar findings. His evidence shows that housing booms, contrary to equity booms, reduce expected growth prospects and increase the risk of very bad growth outcomes. Equity booms only deteriorate the worst outcomes.

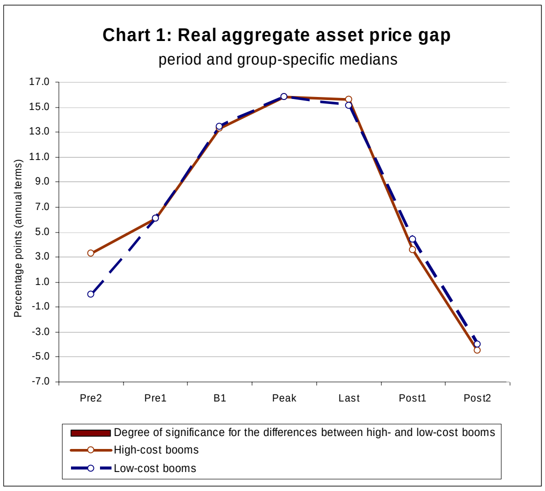

Chart 1: Real aggregate asset price gap
period and group-specific medians

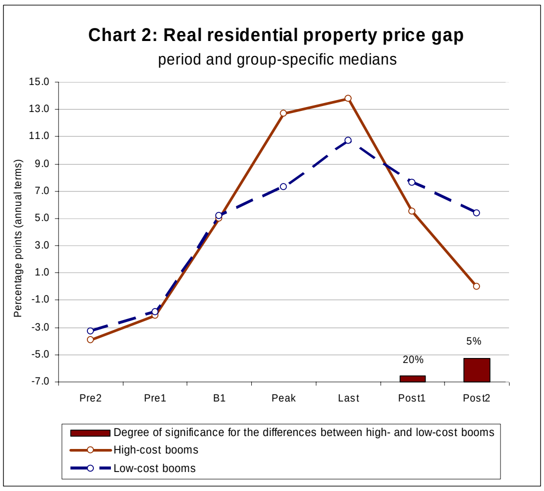

Chart 2: Real residential property price gap
period and group-specific medians

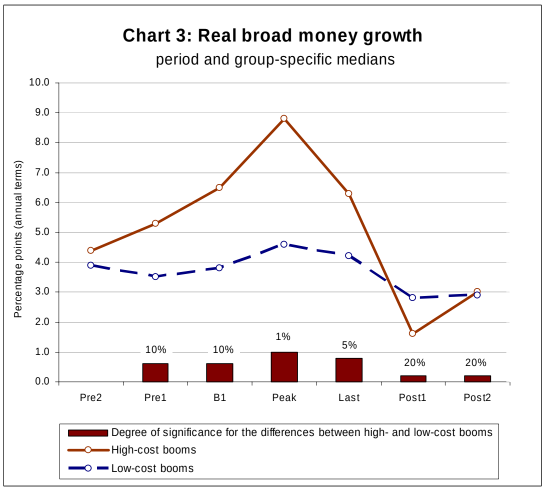

Chart 3: Real broad money growth
period and group-specific medians

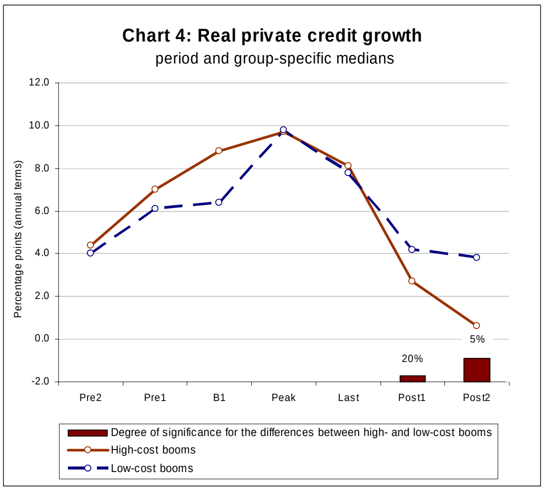

Chart 4: Real private credit growth
period and group-specific medians

Chart 6 depicts the respective medians for Taylor-rule gaps, i.e. the deviations of the short-term interest rate from the recommendation of a standard Taylor-rule[34]. Importantly, there has been a strong relaxation of monetary policy over the high-cost boom episodes, which is significantly different from the typical low-cost development[35].

This loosening is only found with respect to the Taylor-rule. Nominal short interest rate gaps are actually rising during the high and low-cost booms (see Table A1), but apparently not sufficiently once business cycle dynamics are taken into account. Given the many problems associated with the computation of Taylor-rules in general and this calibrated version in particular, the evidence provided by Chart 6 is only suggestive. Chart 6 nevertheless fuels the

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[34] We use an outcome based, real-time Taylor rule, where the equilibrium values are computed with the recursive trends. The coefficients on the output and inflation gaps are set at 0.5 each for all countries (see Annex for more details). For each period we depict the average gap over four quarters.

[35] Usually evidence on the monetary policy stance during boom episodes is more of the event type of analysis. See e.g. Jonung et al. (2005) who confirm that the Finish and Swedish boom/bust cycles in the late 80s and early 90s were considerably worsened by procyclical monetary policies.

suspicion that the differences between high and low-cost booms might be related to the evolvement of the stance of monetary policy.

Table A1 reveals some more interesting stylised facts of aggregate asset price boom-bust episodes. For example, the private credit gap seems to be particularly low in the two pre-boom years for low-cost boom episodes. The inflation gap is significantly lower during the two pre-boom years and significantly higher for the last year of the boom and the first post-boom year for high-cost boom episodes.

Chart 5: Real GDP growth
period and group-specific medians

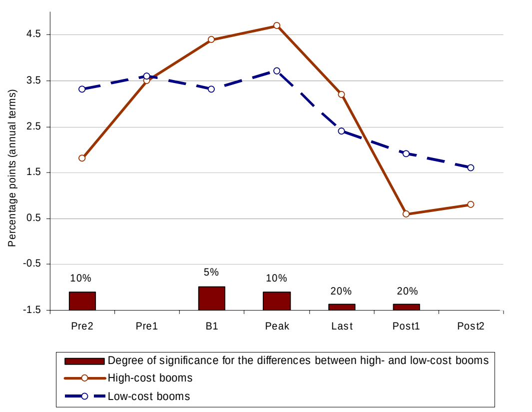


Chart 6: Taylor-rule gaps
period and group-specific medians

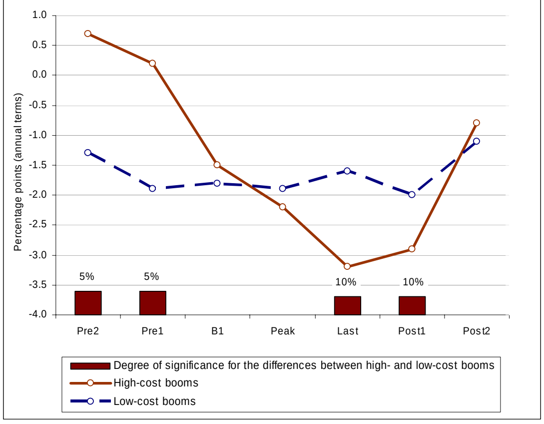


Chart 7: Real total investment growth
period and group-specific medians

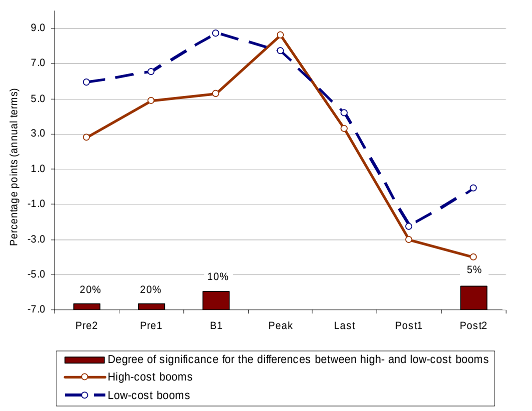
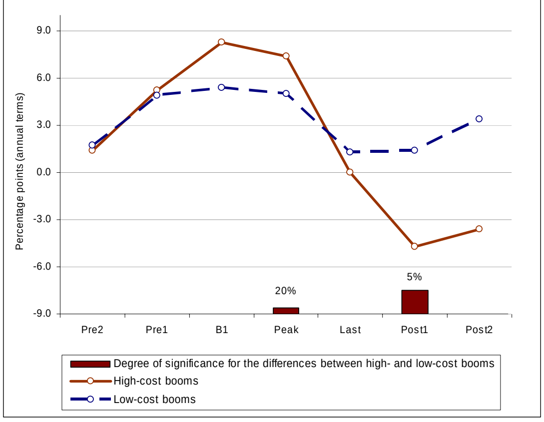


Chart 8: Real housing investment growth
period and group-specific medians



The spread between long and short term interest rates is significantly lower during all considered periods (except Pre1) for high-cost booms. The latter might be related to the existence of excessive liquidity and few attractive investment opportunities (see Rajan (2006) as mentioned above). Government net lending as ratio to GDP does not seem to play a decisive role in the distinction between high and low-cost booms[36].

The above stylised facts do not allow interpretation in terms of causality. For example, money growth or credit growth could trigger the residential property price boom or be simply a

[36] On fiscal policy during boom and bust episodes see Jaeger and Schuhknecht (2004).

reflection of endogenous responses of loans and mortgages triggered by an (exogenous) asset price boom and/or the related business cycle.

The Charts 1-8 and the associated tests for significant differences between high and low-cost boom episodes lead to some hypothesis and questions, which we found worthwhile investigating in the rest of the paper by means of more formal regression analysis.

Real residential property price developments seem to be key to explain post-boom recessions. It might be that already the size of the housing price boom has information content for the following reduction in real growth during the bust phase. Real broad money growth seems to be the better indicator than real private credit growth to determine whether the current asset price boom will be followed by a period of low real growth. The endogeneity of broad money and private credit growth with respect to both the business and the asset price cycles is a serious concern for the kind of analysis attempted here. It is not clear whether the focus on money and credit growth would add information value compared to simply evaluating the stance of monetary policy, as measured by a Taylor-type interest rate rule.

If the association of money and/or credit and the asset price cycles will be robust to corrections for the endogeneity of the former, the issue would be whether there is evidence for a causal interpretation. As the causality is likely to work via the effect of liquidity shocks on asset and in particular on housing prices such a relationship would need to be shown for the boom episodes. Furthermore, we will analyse whether there is anything special to asset price boom periods as compared to the whole sample with respect to the effects of liquidity shocks.

4. VAR based liquidity shocks

Excess liquidity is generally defined as an excess of money or credit, which is not in line with price stability in the long run[37]. The few measures, which are commonly employed, are all based on the quantity equation of money. These excess liquidity measures are the price gap or real money gap, the nominal money gap, the monetary overhang, the money or credit to GDP ratio or the latter two deviations from their trend values[38]. The basic difference between these measures is the way the equilibrium stock of money is determined and how past price and output changes are allowed to affect today's equilibrium money stock. They have in common the basic monetarist notion of a stable money demand, and long run neutrality of money

[37] Gouteron and Szpiro (2005, p. 4)

[38] See Gouteron and Szpiro (2005) and Polleit and Gerdesmeier (2005) for a detailed description of measures of excess liquidity.

implying that the excess liquidity will be absorbed by a rise in the price level, usually interpreted as the consumer price level. Our approach is closest related to the concept of monetary overhang, although with an important difference. We allow for permanent shifts in velocity very much in the spirit of Reynard (2006) as further explained below. We define liquidity shocks as unusually high money or credit growth with reference to the prevailing economic situation based on a broad set of variables. We do not take a stance whether liquidity growth is unusually high because of the monetary authority's ample supply of liquidity or the money holding sector's exceptionally strong money demand or simply because the economic environment has been changing swiftly so that agents did not yet adjust their portfolios. Our measure is a broad indicator of disequilibrium in the money market, in this respect comparable to the monetary overhang. Our sole purpose of deriving liquidity shocks is to solve or at least alleviate the endogeneity problem of broad money growth to test whether liquidity might affect real estate prices. In order to achieve this we run for each of our 18 countries the following VAR.

$$Z_t = B_0 + B_1 Z_{t-1} + B_2 Z_{t-2} + \ldots + B_q Z_{t-q} + C_0 X_t + C_1 X_{t-1} + C_2 X_{t-2} + \ldots + C_q X_{t-q} + u_t \quad (1)$$

where Z is a k-dimensional vector of endogenous variables, B_0 a k-dimensional vector of constants and B_1 -B_q are k x k – dimensional autoregressive coefficient matrices. X_t – X_{t-q} in our case represent k-dimensional vectors of the exogenous variable, C_0-C_q are k-dimensional coefficients vectors. u_t is a k-dimensional vector of normally distributed, serially uncorrelated error terms with constant variance. The vector Z contains the following variables.

money: $Z = (\pi_{cpi}, y_r, \Delta i_s, nrp, equ, m, rex)'$

credit: $Z = (\pi_{cpi}, y_r, \Delta i_s, nrp, equ, pc, rex)'$

both with $X = com$

The vector Z comprises consumer price inflation (π_{cpi}), real GDP growth (y_r,), the first difference in the short term nominal interest rate (Δi), the growth rate of nominal private residential property prices (*nrp*) as well as the rate of change of nominal equity prices (*equ*), nominal money growth (*m*) or alternatively nominal private credit growth (*pc*), and the rate of change of the real effective exchange rate (*rex*), in this order. As exogenous variables, we always add the contemporaneous as well as lagged rate of change of commodity prices in US dollars (*com*)[39]. The lags of the VAR are automatically determined by the Hannan-Quin criteria, which typically resulted in lags of order 1 or 2.

[39] Only for the US do we include commodity prices among the variables in the VAR but order it first.

The VARs are then used to derive structural money and credit growth shocks. We do not label the money shock a monetary policy shock as we use broad money, i.e. M3, which by definition is strongly influenced by portfolio shifts between liquid and less liquid assets and because we do not have any theoretical prior to what might be the origin of incommensurate liquidity. The structural shocks are obtained by Cholesky decomposition. We order money or credit second to last - just before the real effective exchange rate. The farther behind a variable is ordered, the more endogenous the variable is in this system, as it also depends contemporaneously on all the previously ordered variables. This means that the common contemporaneous shocks to money or credit and to all other variables (except for the exchange rate) are attributed to shocks to these other variables and not to money or credit growth. Our intention is to be conservative with respect to solving the endogeneity problem of money and credit growth. The liquidity shock is thus unusual money or credit growth after lagged and contemporaneous business cycle, interest rate and asset price developments have been taken into account. We do not intend any other structural interpretation of the derived liquidity measures. The exchange rate is ordered last, as we do want to allow for the possibility of capital inflows, which are most likely associated with an appreciating exchange rate, to be recorded as a liquidity and not as an exchange rate shock[40].

Most of the literature estimates these type of VARs in levels rather than differences. Recently Marcet (2005) has shown that the common fear of over-differencing in VARs (when variables in levels are already stationary) is unjustified[41]. A VAR to any stationary process provides the correct moving average representation. Marcet argues that a VAR in differences might even be the more robust alternative than testing for unit roots and eventually estimating Vector Error Correction models. The more important issue about estimating in growth rates is not the econometric specification but rather the economic interpretation of our shocks. Contrary to the monetary overhang, which would resemble monetary shocks derived from a VAR in levels[42], using money growth rate shocks implicitly assumes an extreme bygones are bygones position. The previous quarter's money demand/supply disequilibrium plays no role in this quarter's derivation of the liquidity shock. One thus implicitly assumes that money demand is subject to permanent level shifts on a quarterly basis. This is an extreme assumption and we alleviate it to some degree in the following analyses. For the cross-section approach we cumulate the VAR money growth shocks over the period starting two years before the boom up to the year preceding and including the peak quarter of the boom. Effectively this amounts to normalising a monetary overhang measure to zero, two years before each boom episode. In

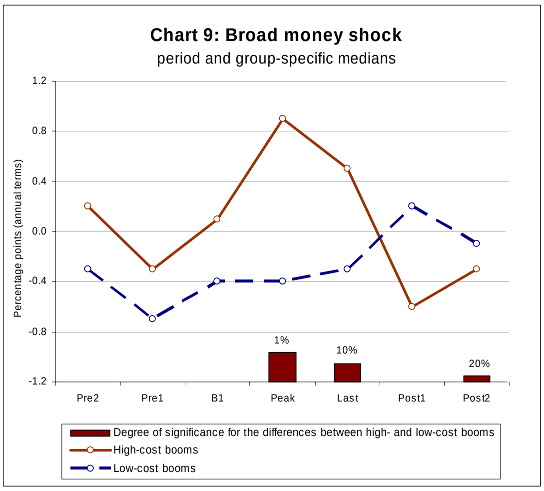
[40] See the Annex for a description of results with different VARs, also excluding the exchange rate.
[41] This is in contradiction to common wisdom as exposed by e.g. Hamilton and many others, see Marcet (2005) for several citations.
[42] Including portfolio adjustment costs due to the lagged level of the money stock.

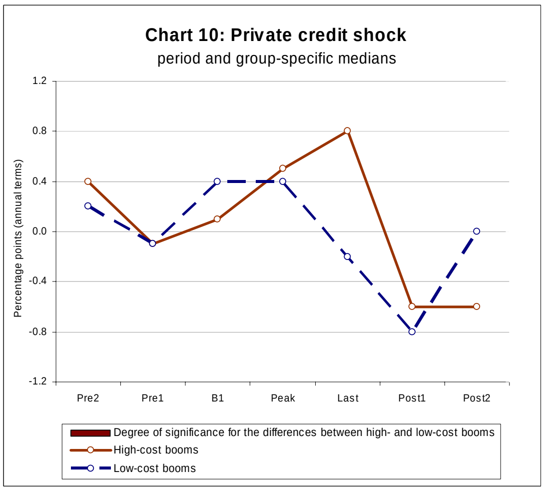
other words our liquidity measure is unaffected by velocity fluctuations during non-boom periods up to two years before each boom episode. In accumulating liquidity shocks we capture possibly slowly building monetary imbalances but with a restricted historical memory. Similarly, in the panel boom approach we use six quarter moving averages of our money growth rate shocks. Also here the implicit assumption is that what is relevant for driving asset prices are liquidity shocks over the last six quarters[43]. We believe this methodology is more robust to innovations in the financial sector over time, which can make velocity both very volatile in the short run and susceptible to permanent low frequency level shifts. Recently Reynards (2006) has used an adjustment for equilibrium shifts in velocity based on similar reasoning in order to establish a positive role for money growth in predicting inflation for the US and the euro area for a sample including the 80s and 90s, where usually such a relationship would break down. According to Reynards (2006) the important adjustment of money growth rates is due to the change in interest rates associated with the disinflation period. Nelson (2003) has argued in a similar vein. We thus believe that allowing for velocity shifts related to interest rate movements is a crucial aspect of finding information content in monetary aggregates.

It is difficult to judge in how far this VAR technology has been successful in cleaning our monteray shocks from endogenous developments in the economy and foremost from the business and real estate price cycles. The impulse responses of GDP and real estate prices on money have in most cases the expected positive sign so that during asset price boom periods, the derived money growth shocks are actually smoother than the actual money growth rate [44].

Charts 9 and 10 apply the methodology of section 3 and depict the median of high and low-cost booms for the money and private credit based liquidity shocks. In Charts 9 and 10 shocks are cumulated over 4 quarters to be compared with the annualised figures in the previous charts in section 3. These Charts already provide a first impression that broad money might be a better indicator to explain post-boom recessions than private credit as the latter does not reveal significant differences across high and low-cost boom episodes.

[43] See results for other accumulation lags in the Annex.
[44] Among the few exceptions, only 1 boom (Spain 1986-1991) is actually part of the panel boom analysis in section 6. However, excluding this particular boom even strengthens our results for money growth shocks.





5. Cross-section bust analysis

Our first approach is to run regressions to test whether liquidity shocks during boom periods helps explain the post-boom recession, while also controlling for other developments. This is a cross-section analysis where the sections are the boom episodes identified in Table 1. In order to check for robustness due to our small sample of boom episodes[45], we use robust regressions[46] and quantile regressions[47] besides standard OLS and IV methods.

Basically we estimate the following set of cross-section equations:

$$y_r\ (post\text{-}boom)_n = \beta_0 + \beta_1\ y_r\ (boom)_n + \beta_2\ boom\ length_n + \beta_3\ rrp_n^i + \beta_4\ \Delta\ Taylor\ gap_n^j + \beta_6\ cumulated\ liquidity_n^l \qquad (2)$$

[45] Subtracting the most recent boom in Australia, which was ongoing in 2004 Q4, so that we cannot determine the post-boom phase, leaves us with a sample of 41.

[46] Robust regression is a method which could be described as iteratively re-weighted least squares with the purpose to reduce the weights on outlier observations. The Stata procedure we use performs an initial screening based on Cooks distance and then performs Huber iterations followed by bi-weight iterations (see Stata manual for details). Compared to least squares robust regression offers protection against outlier data at the cost of some efficiency when the errors are normally distributed.

[47] Quantile regression minimises a weighted sum of absolute residuals and does not rely on the normality of error terms. See Koencker, R. (2005), “Quantile Regression”, Econometric Society Monographs, Cambridge University Press. For lack of space we only report the 20% quantile regression, which is an arbitrary but qualitatively non-crucial choice. The reason for focusing on lower quantiles is that we are particularly interested in capturing those recessions, which come closer to crises. By focusing on the 20% quantile we obtain a regression, which has 80% positive and only 20% negative residuals. It thus focuses on those booms, where post-boom growth was a particularly negative outlier with respect to the prediction of the right hand side variables. We use bootstrapped standard errors from 500 repetitions.

n are the 41 identified boom episodes. y_r *(post-boom)* is average real GDP growth in the 8 quarters following the boom period[48], y_r *(boom)* is the average real GDP growth during the boom period [GDP growth av. boom in Tables 2-4 and A2-A5 in the annex], *boom length* is the length of the boom period in quarters, rrp^i can be either the cumulated rates of growth in real private residential property prices over the boom period [Housing growth cum] or the rate of change in the first post-boom year [Housing growth Post1]. *Taylor gap*^{j} is either the change in the Taylor gap between the year finishing the peak quarter of the boom and the first year before the boom (Δ Taylor gap boom) or the change in the Taylor gap between the second post-boom year and the peak quarter of the boom (Δ Taylor gap post). *Cumulated liquidity*^{l} stands alternatively for our previously derived liquidity shocks, i.e. the money and credit shocks cumulated over the period starting two years before the boom until the year finishing in the peak quarter of the aggregate asset price boom. We also show results for the simple cumulated real broad money and real private credit growth rates for comparison.

In Tables 2-4 and Tables A2-A5 in the annex, the VAR liquidity shock measures are labelled, 'money shock cum' and 'credit shock cum'. We always control for the average real GDP growth during the boom, which in some sense proxies for time and country specific (fixed) effects, and the length of the boom in years. Generally, the longer the boom lasts, the more severe the GDP loss afterwards.

The first important result of Tables 2-4 and Tables A2-A5 is that the monetary shock is negative and significant. The larger the liquidity shocks accumulated over the boom phase, the more lackluster is real GDP growth in the post-boom phase. Neither the cumulated private credit growth rate nor the private credit shocks are significant in any of the specifications of Tables 2-4 and Tables A2-A5, except for private credit growth in equation a3.4. Money based liquidity shocks add 7 percentage points of adjusted R^2 with least square estimation, see Table 2, equation 2.3, 14 p.p. with the robust regressions, see Table A2, equation a2.3, and 15 p.p. with the 20% quantile regressions, see Table A3, equation a3.3 to the respective baseline specifications excluding liquidity shocks.

Second, cumulated real estate price growth over the boom period is an important and robust variable to explain the post boom recessions.
Third, money based liquidity and boom real estate price growth are, to some degree, collinear. Both coefficients are slightly smaller and less significant when included jointly. The money shock variable even looses significance in the robust regressions, see Table A2, once the boom real estate price growth variable is included. Nevertheless, both real estate and money

[48] In the regression analyses, unlike for the graphical presentation of the stylised facts, we do not need any arbitrary classification of boom episodes into high and low-cost.

based liquidity shocks remain significant and money still contributes depending on the estimation method 3 and 11 percentage points of adjusted R^2 to the regression including boom housing price growth, see Tables 2 and A3, for least squares and the quantile regressions, respectively.

Table 2: Regressions explaining the average real GDP post-boom growth

Dependent variable: GDP growth av. post-boom

Equation	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
GDP growth av. boom	0.51***	0.65***	0.53***	0.55***	0.51***	0.49***	0.58***	0.51***	0.50***	0.49***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.003)	(0.001)	(0.003)	(0.002)	(0.004)
Boom length	-0.32**	-0.15	-0.24**	-0.22	-0.32**	-0.07	-0.01	-0.06	-0.05	-0.07
	(0.047)	(0.234)	(0.031)	(0.206)	(0.046)	(0.645)	(0.926)	(0.692)	(0.750)	(0.641)
Housing growth cum						-0.04**	-0.03*	-0.03*	-0.04**	-0.04**
						(0.025)	(0.074)	(0.067)	(0.030)	(0.027)
Money growth cum.		-0.03*					-0.02			
		(0.052)					(0.159)			
Money shock cum.			-0.10**					-0.08**		
			(0.020)					(0.027)		
Priv. credit growth cum.				-0.01					0.00	
				(0.362)					(0.731)	
Priv. Credit shock cum.					0.00					0.00
					(0.896)					(0.939)
Adjusted R-sq.	0.32	0.37	0.39	0.32	0.30	0.39	0.40	0.42	0.38	0.37
Pseudo R-sq		-	-	-	-		-	-	-	-
N. of instruments		-	-	-	-		-	-	-	-

*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively. P-values in parentheses, derived from White heteroskedasticity-consistent standard errors.*

Fourth, even when controlling for the drop in real residential property prices in the first post-boom year (Housing growth Post1) the money growth shocks remain significant. The post-boom drop in housing prices is instrumented by last boom period inflation, and the real estate price gap during the peak boom year (see Table 3). Interestingly, in the least square equations (Tables 2 and 3) the simple money growth rate looses significance when we control for any of the two types of housing price measures, contrary to the money growth shock variable. This could be interpreted as further evidence confirming the importance of the endogeneity of money growth with respect to housing prices. Certainly there is more information in our money shocks than can be captured purely by real estate price developments.

Table 4 tests whether liquidity shocks contribute in explaining post-boom recessions even if one controls for another measure of the monetary policy stance. We expect tightening monetary policy during the boom to have a beneficial effect on real GDP growth in the post-boom phase. Δ Taylor gap boom should thus have a positive sign, as it is the case. We also control for monetary policy in the post boom phase itself (Δ Taylor gap post). The sign of Δ Taylor gap post should be negative as loosening policy in the bust phase is most likely the optimal policy reaction to support growth. Monetary policy in the post-boom phase is instrumented by last boom period inflation, the real estate price gap during the peak boom year and Taylor gap in the last boom quarter.

Tables 4, A4 and A5 prove that the signs of the Taylor gaps are all as expected and significant (except for Δ Taylor gap boom in the quantile regressions, which is of the correct sign but not significant). Most importantly, the money growth shocks always remain significant and the size of the coefficients are very stable across methods. This result is interesting in itself as it suggests that the New Keynesian approach of focusing on policy rules only featuring inflation and output gaps would neglect possibly important information, at least during asset price boom periods[49]. Again credit growth shocks are not useful in explaining post-boom recessions.

Table 3: Regressions explaining the average real GDP post-boom growth

Dependent variable: GDP growth av. post-boom

Equation	3.1	3.2	3.3	3.4	3.5
Estimation method	TSLS	TSLS	TSLS	TSLS	TSLS
GDP growth av. boom	0.54***	0.60***	0.55***	0.55***	0.54***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Boom length	-0.34***	-0.26**	-0.28***	-0.31**	-0.34***
	(0.003)	(0.043)	(0.004)	(0.016)	(0.004)
Housing growth Post1	0.11**	0.1*	0.09*	0.10**	0.11**
	(0.028)	(0.069)	(0.070)	(0.049)	(0.031)
Money growth cum.		-0.02			
		(0.323)			
Money shock cum.			-0.07**		
			(0.045)		
Priv. credit growth cum.				0.00	
				(0.752)	
Priv. Credit shock cum.					-0.01
					(0.823)
Adjusted R-sq.	0.52	0.52	0.53	0.50	0.50
Pseudo R-sq	-	-	-	-	-
N. of instruments	4	5	5	5	5

*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively. P-values in parentheses, derived from White heteroskedasticity-consistent standard errors.*

Overall, the size of the money based liquidity shock coefficients are about -0.10, which is not trivial. Assuming for the sake of argument broad money would grow at 8% p.a. during a 3 year asset price boom, while given economic conditions it should grow at 4.5% p.a. in equilibrium. Liquidity shocks would accumulate to 10.5% in this boom episode. The coefficient of 0.1 reveals that the post-boom drop in GDP due to this partial liquidity shock effect in this example is about 1% per annum for each of the two years following the boom.

[49] Nelson (2003) has argued that money might influence inflation solely via aggregate demand. Thus a New Keynesian model with no explicit role for money in the IS curve might still be compatible with inflation being a monetary phenomenon. The evidence presented here refers to the additional information content of money as an indicator of future worries for the real economy.

Table 4: Regressions explaining the average real GDP post-boom growth										
Dependent variable: GDP growth av. post-boom										
Equation	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10
Estimation method	OLS	OLS	OLS	OLS	OLS	TSLS	TSLS	TSLS	TSLS	TSLS
GDP growth av. boom	0.61***	0.72***	0.62***	0.63***	0.61***	0.53***	0.68***	0.56***	0.56***	0.53***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Boom length	-0.29**	-0.15	-0.22**	-0.23	-0.29**	-0.29*	-0.10	-0.18*	-0.20	-0.28*
	(0.015)	(0.213)	(0.017)	(0.180)	(0.017)	(0.062)	(0.436)	(0.079)	(0.264)	(0.065)
Δ Taylor gap boom	0.12***	0.11***	0.11***	0.12***	0.12***					
	(0.007)	(0.005)	(0.005)	(0.007)	(0.007)					
Δ Taylor gap post						-0.10*	-0.10*	-0.12*	-0.09*	-0.10*
						(0.086)	(0.078)	(0.060)	(0.099)	(0.082)
Money growth cum.		-0.03**					-0.04**			
		(0.050)					(0.033)			
Money shock cum.			-0.09**					-0.12***		
			(0.019)					(0.008)		
Priv. credit growth cum.				-0.01					-0.01	
				(0.572)					(0.474)	
Priv. Credit shock cum.					-0.01					-0.01
					(0.890)					(0.767)
Adjusted R-sq.	0.40	0.43	0.45	0.39	0.38	0.34	0.41	0.43	0.34	0.33
Pseudo R-sq	-	-	-	-	-	-	-	-	-	-
N. of instruments	-	-	-	-	-	5	6	6	6	6

*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively.*
P-values in parentheses, derived from White heteroskedasticity-consistent standard errors.

The *major differences between the money and credit based liquidity shocks* deserve some comments. The fact that money growth shocks outperform private credit growth shocks could be due to several reasons. First, the data quality of the private credit series could be worse than for the broad money series. Private credit growth is definitely more volatile than broad money growth, which hinders finding a lot of significance. On the other hand, to the extent that higher volatility is not due to data errors but an intrinsic feature of credit data, this would justify relying more on money data for policy analysis. Second, the information content of money in boom episodes is simply higher because changes in net external assets and marketable instruments, which might affect asset prices, are reflected in money but not in credit[50]. Adrian and Shin (2006) have recently argued that leverage targeting behaviour of banks can lead to a mutually reinforcing positive association between asset prices and money but not with credit, which is recorded at book value. Third, the VAR technology possibly manages to clean private credit much better than money from business and asset price cycles. But then we would expect the simple private credit growth rate to have a significant influence, which is not the case (except in equation a3.4). Fourth, total domestic credit might be the more appropriate credit measure than domestic private credit. Total domestic credit performs better than private credit in the cross section analysis although still significantly worse than money. But in light of the possible theoretical channels discussed in Section 2, it is difficult to find a reason why one should prefer total domestic over private credit. There is also no other supporting evidence that government deficits during the boom affect the depth of the post-boom recessions (see last row Table A1). The only reason might be that the break

[50] E.g. capital inflows could increase net external assets of the domestic banking system as well as broad money while leaving domestic credit unchanged. These funds, previously invested abroad, might fuel a domestic housing price boom or bubble.

down of domestic credit into private and government credit is of very low quality. Using domestic credit could then capture private credit more accurately than the wrongly measured series for the subcomponent. Last but not least, if the monetarist channel of portfolio adjustments and the possible characteristic of money as aggregate index of investor uncertainty have some value, this will also favour money versus credit based liquidity shocks. We interpret the empirical results to suggest that what matters is a mixture of endogenous financial sector behaviour - and thus a temporary instability of broad money demand (conventionally measured) - and the monetary policy stance, which provides information content to a broad monetary aggregate[51].

6. Panel boom analysis

The previous cross-section analysis has shown that there still seems to be some collinearity between housing price developments and liquidity shocks during boom periods. In order to investigate whether the reason could be that liquidity is driving housing prices, we organised our data in a panel structure. The cross-section dimension is constituted by the identified booms. The time series dimension is the length of each boom episode.

Gouteron and Szpiro (2005) pursue a similar objective. They run three variable country VARs or VECMs with real GDP, the real stock price or housing price level and the broad money to GDP or credit to GDP ratios for the euro area, US, UK and Japan. The authors check the impulse responses of their excess liquidity measures on real stock and real estate prices. Their conclusion is that, except for the UK with respect to housing prices, there is no robust influence of excess liquidity on asset prices. The contrast of this finding with ours, despite the fact that methodologies are also different, might well reflect the fact that we focus on aggregate asset price boom episodes.

The explanatory power of liquidity shocks during boom episodes, of course, does not address the issue what triggered the asset price booms in the first place. Our intention is to test whether our liquidity shocks play a systematic, common role in explaining the housing price increases during the boom periods. However, other causes - inherent to each particular boom episode and potentially unobservable - may also be affecting their development. A simple, reasonable way to control for these effects while keeping attention to the common cause we want to investigate is the fixed effects model. It is well known, however, that such a model, if combined with lagged dependent variables, would render the estimated coefficients biased (although consistent if the number of periods becomes large with respect to the number of

[51] The empirical results presented in this paper hold for M3, not for M1, not for M3-M1.

cross-sections), since it implies a non-zero correlation between the lagged dependent variable and the differentiated error term. Nickell (1981) shows that the order of magnitude of the bias is inversely proportional to the number of periods included in the estimation.

The econometric literature has proposed several alternatives to overcome this problem. Perhaps the most popular recommendation has been the use of instrumental variables and GMM techniques. The Anderson-Hsiao estimator falls under the first class. Anderson and Hsiao suggested to differentiate the model and to use a previous lag of either the difference or the level of the endogenous variables as instruments. The original Arellano-Bond (1991) estimator and its successors, Arellano-Bover (1995) and Blundell and Bond (1998), make use of additional moment conditions and thus can handle different number of instruments for each observation. These estimators, although more efficient than those of the Anderson-Hsiao class, have been designed for an environment of very short time dimension and large cross-section dimension, and they lack consistency if this condition does not hold. Additionally, a central problem with any estimator involving the use of instruments is that the quality of the estimation very much depends on the correlation between the instruments and the instrumented variables.

Given the characteristics of our dataset, 42 boom episodes of different length, up to 39 quarters, the use of an Arellano-Bond type estimator does not seem advisable from an econometric point of view, as N is small and T too large. The Anderson-Hsiao and the fixed effects plus lagged dependent variable methods would be more recommended if the number of periods we are dealing with were sufficiently large relative to the number of cross-sections. In such a case we would be confronted with a trade-off between the size of the bias of the fixed effects estimator and the poor efficiency of the Anderson-Hsiao estimator. Beck and Katz (2004) perform several Monte Carlo experiments to study this trade-off. They conclude that while the Anderson-Hsiao estimator is unbiased, its performance in terms of root mean square error is very poor. On the other hand, the bias of the fixed effects estimator very quickly enters a region where it can be considered tolerable. In particular, for the case of about 20 cross-sections, 30 periods and a true coefficient of the lagged dependent variable of about 0.2, the upward bias of the coefficient of the explanatory variable is only about 2%[52].

Against this background we decided to use the fixed effects and lagged dependent variable model and to focus on the longer boom episodes, adding the first year before the booms, in order to increase the number of time periods and thus contain the bias in the coefficient

[52] Kiviet (1995) and Bun and Kiviet (2003) propose to estimate the bias of the fixed effect estimator and use it to correct its estimates. This approach, although theoretically appealing, presents some practical problems, especially because the formula to estimate the bias requires knowledge of the true parameters. Bruno (2005a and 2005b) provides the basis for correcting also unbalanced panels. Importantly, he also showed that the size of the bias is still mainly determined by a function proportional to 1/(average T), and that the degree of unbalancedness also increases the bias.

estimates discussed above. Thus the panel estimates discussed below use only those booms with a length of at least 3 years, leaving us with 16 boom episodes[53].

We estimate the following set of panel regressions:

$$rrp_{n,t} = \sum_{a=1}^{6} \beta_a \, rrp_{n,t-a} + \gamma \, x'_{n,t-1} + \eta_n + \lambda_t + \nu_{n,t} \tag{3}$$

and $n = 1,\ldots,16$; $t = bq_{-4}, bq_{-3}, \ldots, bq_{last}$

where *rrp* stands for the quarterly growth rate in real private residential property prices. The cross-section dimension *n* is constituted by the 16 boom episodes of at least three years length. The time dimension *t* starts four quarters before the boom period (*bq*=boom quarters) and lasts up to the last quarter of the aggregate asset price boom. As booms are of different length we have an unbalanced panel. We later compare the boom panel results with panel estimates including the whole sample (overall panel) where the cross-section dimension, *i* is formed by the 18 countries and the time dimension runs from 1972 Q1 up to 2004 Q4, as specified in equation (4).

$$rrp_{i,t} = \sum_{a=1}^{8} \beta_a \, rrp_{i,t-a} + \gamma \, x'_{i,t-1} + \eta_i + \lambda_t + \nu_{i,t} \tag{4}$$

and $i = 1,\ldots,18$; t = 1972Q1,…,2004Q4

All variables in the *k*-dimensional vectors of explanatory variables $x_{n,t}$ and $x_{i,t}$ are lagged by one quarter. The vector includes the following variables, the six quarter moving average of quarterly real GDP growth (@ GDP growth)[54], the change in the nominal long term interest rate (Δ long term interest rate) and alternating the money and credit based liquidity shocks, as

[53] The results do not change a lot once we double the number of booms by considering all booms which last at least 2 years. We would then be left with 30 booms. Unfortunately this reduces the average number of time periods from 20 to 15 and according to Beck and Katz (2004) increases the bias to about 3.5% (we have to rely on a table with constant N=20). This is likely to be a lower boundary of the increase in the bias as the increasing degree of unbalancedness is not taken into account.

[54] Instead of GDP we alternatively used a cumulated change in the unemployment rate. Results were similar to a degree that they are not worth reporting. We also used different lags for the accumulation of liquidity shocks and GDP growth. The money growth shock coefficients reported in Table A11 in the Annex reveal that the principle of accumulating imbalances is important and that the results are robust with respect to lag length. Coefficient size and significance is though stronger for lag 6 than for smaller lags.

well as real money and real private credit growth rates. The liquidity shocks are derived as before only that here we use the six quarter moving average (indicated by @ in the tables). E.g. '@ money shock' is the six quarter moving average of the structural M3 shock derived from the VAR shown in equation (1). By averaging we first of all smooth the information contained in liquidity growth and second we relax our extreme assumption that velocity shift bygones are bygones on a quarterly basis. In order to capture the dynamics of housing prices we use six lags of the endogenous variable for the boom panel estimates and eight lags for the whole sample panel estimates. This specification guarantees well behaved residuals across all different models.

In the output tables we show besides the pooled estimations for comparison, results using cross-section fixed effects (CS; λ_t=0 in (3) and (4)) and either in addition period fixed effects (CS+P) or real time fixed effects (CS+RT; here λ_t=0 but we add dummies for calendar years). Period fixed effects here assume that there is a common period effect on the growth of real estate prices, depending on the specific quarter of the boom, for example the first or last quarter of the boom. Alternatively, one could assume that there exists a real time fixed effect, which means that there is a common effect on property price growth rates with respect to the calendar time, which is relevant when several booms happen at the same time in different countries and asset prices are driven by some joined, unobserved event like financial liberalisation at the international level. This is likely to be important as several of our booms occurred either in the late 80s or the late 90s. By allowing for what we call real time fixed effects[55] we safeguard against the possibility that (common) global trends drive our results. We do not report the real time fixed effects dummies for the sake of readability of our tables but it should be noted that usually for the years 1983-1990 and sometimes also in 1999 they are highly significant and positive. This confirms the importance of controlling for real time effects. We also give particular importance to the cross section plus real time fixed effects model, as several authors have highlighted that money growth was unusually strong in the disinflationary period due to the trend reduction in interest rates[56]. We safeguard against the possibility of spurious correlation between liquidity and asset prices by, first of all, correcting for among other things the change of interest rates in our derivation of liquidity shocks as explained in Section 4 and second by including the mentioned real time dummies.
The standard errors reported are the SUR panel corrected standard errors as recommended by Beck and Katz (1995).

The panel estimates for the boom episodes show that the effect of the money growth shocks is sizable and significant across all estimated models (Tables 5, A6 and A7). Money based

[55] We include time dummies which are annual in the sense that we have one dummy for the four quarters of 1980, 1981 etc, until the year 2000.
[56] See e.g. Nelson (2003) and Reynard (2006).

liquidity shocks are significant at the 1% level for most of the models. The moving average of the structural VAR shock has a coefficient between 1.2 and 1.5 (abstracting from the pooled OLS and System GMM estimations, where the coefficient is close to 1). This means that if the average money growth shock over the last six quarters has been 1 percent, real residential property prices will grow between 1.2% and 1.5% the next quarter, which is again a sizable effect. The contribution of liquidity shocks to the adjusted R^2, once we control for GDP and the change in nominal long term interest rates, is though small, which means between 1 and 2 percentage points. This though should not be surprising give the fact that this is a panel estimation with highly significant lagged endogenous variables in the equation. Furthermore, we are explaining an asset return. The credit based liquidity measure is only significant for the two least preferred models, i.e. the pooled and simple cross-section fixed effects specifications, with coefficients half the size of the money shocks. The credit shocks are never significant in the more reliable period or real time fixed effects specifications. Interestingly, the change in the long-term interest rate is only significant for the pooled and the cross-section plus period fixed effects specifications in which case GDP is not. Vice versa, in the cross-section plus real time fixed effects model (and the system GMM estimations) interest rates are not significant but GDP is. This pattern suggests that the significance of interest rates might only be due to the disinflation and financial liberalisation periods.

Table 5: Regressions explaining real housing price growth during boom episodes

Dependent variable: housing price growth

Equation	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	5.10
Estimation method	CS+P	CS+P	CS+P	CS+P	CS+P	CS+RT	CS+RT	CS+RT	CS+RT	CS+RT
Housing price growth (-1)	0.18**	0.16**	0.16**	0.18**	0.18**	0.15*	0.13	0.12	0.14*	0.15*
	(0.029)	(0.049)	(0.048)	(0.033)	(0.024)	(0.063)	(0.105)	(0.105)	(0.070)	(0.056)
Housing price growth (-2)	-0.04	-0.06	-0.05	-0.05	-0.04	-0.02	-0.04	-0.03	-0.03	-0.02
	(0.636)	(0.491)	(0.505)	(0.578)	(0.623)	(0.810)	(0.622)	(0.691)	(0.742)	(0.816)
Housing price growth (-3)	0.03	0.01	0.01	0.02	0.03	-0.02	-0.04	-0.03	-0.03	-0.02
	(0.705)	(0.935)	(0.887)	(0.841)	(0.695)	(0.785)	(0.542)	(0.639)	(0.657)	(0.793)
Housing price growth (-4)	0.27***	0.25***	0.26***	0.25***	0.26***	0.25***	0.23***	0.24***	0.24***	0.25***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Housing price growth (-5)	-0.23***	-0.24***	-0.23***	-0.25***	-0.24***	-0.21***	-0.22***	-0.20***	-0.23***	-0.22***
	(0.005)	(0.003)	(0.006)	(0.003)	(0.004)	(0.008)	(0.004)	(0.008)	(0.004)	(0.006)
Housing price growth (-6)	-0.10	-0.11	-0.1	-0.12	-0.09	-0.14*	-0.15*	-0.13	-0.15*	-0.13
	(0.217)	(0.174)	(0.244)	(0.163)	(0.261)	(0.088)	(0.061)	(0.100)	(0.059)	(0.103)
@ GDP growth (-1)	0.71	0.57	0.71	0.57	0.60	1.15*	1.06*	1.24**	1.06*	1.09*
	(0.140)	(0.234)	(0.133)	(0.236)	(0.204)	(0.051)	(0.070)	(0.035)	(0.069)	(0.061)
Δlong term interest rate (-1)	-0.46**	-0.43*	-0.43*	-0.48**	-0.49**	-0.24	-0.24	-0.25	-0.26	-0.27
	(0.048)	(0.070)	(0.067)	(0.040)	(0.034)	(0.318)	(0.319)	(0.310)	(0.273)	(0.263)
@ Money growth (-1)		0.39**					0.52**			
		(0.036)					(0.016)			
@ Money shock (-1)			1.16***					1.36***		
			(0.009)					(0.005)		
@ Priv. credit growth (-1)				0.25					0.25	
				(0.192)					(0.167)	
@ Priv. Credit shock (-1)					0.65					0.52
					(0.120)					(0.218)
Adj. R-squared	0.26	0.27	0.28	0.26	0.27	0.19	0.20	0.20	0.19	0.19
N. of observations	386	386	386	386	386	383	383	383	383	383
Av. N. of periods	24	24	24	24	24	24	24	24	24	24
N. of cross sections	16	16	16	16	16	16	16	16	16	16

The @ sign stands for six-quarter moving average.
CS+P: LS cross-section and period fixed effects; CS+RT: LS cross-section and real-time fixed effects.
*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively. P-values in parentheses.*
Cross-section SUR (PCSE) standard errors used for both CS+P and CS+RT estimations.

The money growth shock variable is the only variable which remains significant across all specifications – besides real money growth, which though suffers from the endogeneity problem.

Simply for the sake of comparison, we also run system GMM estimations (Blundell and Bond (1998)) with all 42 boom episodes, while reducing the number of time periods by aggregating the quarterly into annual observations and starting with the first year before the boom. We intend to render the time dimension as small as possible compared to the cross-section dimension[57]. As here we deal with several short booms and due to the fact that we use annual data (aggregated growth rates over 4 quarters), we use the contemporaneous shock variables as right hand side variables[58]. The results reported in Table A7 show more or less the same features as reported above. The private credit shock as opposed to the money growth shock is again not significant. In general though, the GMM estimations appear little robust, depending on the chosen instruments and sample periods. The brief discussion above explained why for this purpose we do not rely on these estimates to investigate the effects of liquidity shocks on housing prices.

It is interesting to compare these estimates with the pooled, cross-section fixed effects and cross-section and period fixed effects models for the whole sample period as shown in Tables 6 and A8. Here the cross-sections are the 18 countries and the sample period runs from 1972 Q1 (due to lags of the endogenous variable) until 2004 Q4. Only the money and not the credit shock is significant and this holds again for all models. Still there are important differences. The size of the money based liquidity coefficients is four to five times smaller than for the boom panel models. The marginal contribution in terms of adjusted R^2 is zero. The significance of the control variables, GDP and interest rates strongly increases for the whole sample estimates. Now both of them are always significant at the 1% level. The size of the control coefficients remains about the same or even slightly increases. This suggests that overall real estate prices can be better explained (adjusted R^2 between 0.31 and 0.34) when normal times are included in the sample and the usual suspects like income and interest rates are really important. During aggregate asset price boom periods, real property price growth is more difficult to account for (adjusted R^2 between 0.20 and 0.28) but liquidity shocks play a relatively more important role while the standard variables lose in importance[59].

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[57] We use a correction to the two-step covariance matrix derived by Windmeijer (2005) according to Roodman (2005) (XTABOND2 Stata module). Without this correction, the two-step estimates of the standard errors tend to be severely downward biased in small samples.
[58] According to the GMM estimation method, all the variables are dynamically instrumented with their own level lags and lagged differences (lag 2 in our particular case).
[59] The difference between boom episodes and the whole sample is slightly diminished once shorter booms of at least two years are also included in the boom panel. So it could be that these differences are mainly due to longer booms which generate their own dynamics and where asset prices are likely to be more detached from fundamentals. We also use the Stata routine provided by Bruno (2005b) to

Table 6: Regressions explaining real housing price growth (overall sample)					
Dependent variable: housing price growth					
Equation	6.1	6.2	6.3	6.4	6.5
Estimation method	CS+P	CS+P	CS+P	CS+P	CS+P
Housing price growth (-1)	0.36***	0.35***	0.35***	0.35***	0.35***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Housing price growth (-2)	0.00	0.00	-0.01	0.00	-0.01
	(0.945)	(0.946)	(0.714)	(0.959)	(0.788)
Housing price growth (-3)	0.03	0.02	0.03	0.03	0.02
	(0.341)	(0.422)	(0.372)	(0.353)	(0.385)
Housing price growth (-4)	0.20***	0.20***	0.20***	0.20***	0.20***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Housing price growth (-5)	-0.15***	-0.15***	-0.14***	-0.15***	-0.14***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Housing price growth (-6)	-0.05*	-0.05*	-0.04	-0.05*	-0.04
	(0.095)	(0.065)	(0.128)	(0.090)	(0.151)
Housing price growth (-7)	0.00	0.00	0.00	0.00	0.00
	(0.937)	(0.949)	(0.982)	(0.912)	(0.949)
Housing price growth (-8)	0.13***	0.12***	0.12***	0.12***	0.12***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
@ GDP growth (-1)	0.83***	0.74***	0.91***	0.82***	0.93***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Δlong term interest rate (-1)	-0.45***	-0.45***	-0.46***	-0.46***	-0.47***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
@ Money growth (-1)		0.15**			
		(0.015)			
@ Money shock (-1)			0.30*		
			(0.056)		
@ Priv. credit growth (-1)				0.02	
				(0.709)	
@ Priv. Credit shock (-1)					0.05
					(0.679)
Adj. R-squared	0.34	0.34	0.34	0.34	0.34
N. of observations	2354	2338	2269	2354	2285
Av. N. of periods	131	130	126	131	127
N. of cross sections	18	18	18	18	18

The @ sign stands for six-quarter moving average.
CS+P: LS cross-section and period fixed effects.
*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively.*
P-values in parentheses, derived from cross-section SUR (PCSE) standard errors.

Finally, we investigate whether liquidity shocks would also explain consumer price inflation over the whole sample or during asset price boom episodes in Tables A9 and A10. We used the same set of regressors, except for the long-term interest rate, which was not significant and had a wrong (positive) sign[60]. Over the whole sample period, both money and credit growth shocks have a significant positive impact on inflation in the next quarter. They also add considerable explanatory power to the baseline regressions[61]. This is independent of the estimation method chosen, although we only report the cross-section plus period fixed effects model in Table A10. Interestingly, the link between liquidity shocks and consumer price inflation completely breaks down for the boom episodes (see Table A9). Assumingly, this is due to the fact that during boom episodes liquidity shocks are mainly unwound via its effects

correct the bias from least square dummy variable (LSDV) estimations for unbalanced panels. The results and the significance is again very similar to the results described in this paper. Therefore and because the routine is designed for 1 lagged dependent variable while we have six, we do not report these results.

[60] The change in the short term rates also has a positive sign, so we omitted interest rates altogether.

[61] See Rüffer and Stracca (2006) who find effects of global excess liquidity on inflation.

on rising asset prices as argued above. This suggests the hypothesis that there exists a trade-off of liquidity shocks' explanatory power with respect to consumer price and asset price inflation, the nature of which depends on whether the economy is in a boom or non-boom phase. The results presented in Tables A9 and A10 support this hypothesis of course only up to the degree one lends credence to in-sample analyses. Investigating this issue further, e.g. by means of regime switching models or coefficient constraints in SUR estimations using real-time data is beyond the scope of the current paper.

We conclude this section with one final remark on the different effects of credit based and money based liquidity shocks. There is some evidence, at least for the euro area, that especially the more permanent swings in broad money growth are particularly correlated with private credit growth, narrow money growth, and also money growth of the household sector. Under the hypothesis that liquidity shocks should rather drive the transitory and not the permanent component of real housing prices, this would potentially provide an additional explanation why credit growth does not contribute to predict housing returns. This hypothesis requires further investigation.

7. Conclusions

We identify 42 aggregate asset price boom episodes for 18 OECD countries since the 1970s. We then compute the average behaviour over the boom-bust cycles for a host of macroeconomic variables. In particular, we focus on stylised differences between benign (low-cost in terms of post-boom real GDP growth) and serious (high-cost) boom episodes. These stylised facts suggest the importance of real estate prices and money and credit developments for the boom-bust derailment. After mechanically cleaning broad money and private credit growth rates from all kinds of endogeneity problems due to business or asset price cycles by means of VAR technology, we then use a suite of econometric techniques among which a cross-section bust analysis employing standard OLS and IV, quantile regression and robust regression, and a panel boom analysis mainly relying on a fixed-effect cum lagged dependent variable model (LSDV-model). The regression analyses allow us to confirm and elaborate on the hypothesis derived from the results on significant differences between high and low-cost boom episodes. Money growth shocks during the boom and pre-boom periods contribute to explaining the depth of post-boom recessions even if one controls for housing price developments during the boom and in the post-boom phase, and for the monetary policy stance measured by means of deviations from a Taylor-rule during the boom and in the post-boom phase. Real residential property price developments during the boom and in the post-boom phase are an important and robust factor to explain post-boom recessions. Part of the information content of money to explain post-boom recessions does indeed come from the effect of liquidity shocks on real residential housing prices during the boom period. While all these results hold for broad money growth, nearly no informational content is found for private credit growth. These results are derived conditional on experiencing an aggregate asset price boom. A panel analysis using the whole sample, i.e. all boom and non-boom periods available for each country, shows a much weaker relationship between liquidity shocks and asset price inflation and other more standard variables like income and interest rates gain in relative importance. Switching the endogenous variable from the rate of change of real housing prices to consumer price inflation reveals the opposite pattern. Liquidity shocks seem to contribute to explaining consumer price inflation only for the whole sample but not when restricting to the boom episodes.

Due to the well known problems of econometric identification, caution is nevertheless warranted wherever a causal interpretation is suggested. The paper is purely empirical. A combination of pragmatic monetarism, allowing for frequent shifts in velocity and focusing on broad money, possibly reinforced by agency problems between financial market participants though might provide an - in terms of its microfoundations loose - theoretical explanation for our findings. Further research would have to show whether these findings would prove to be useful for central banks implementing policy in real time. At this stage, the findings seem to support the importance the ECB attaches to its monetary analysis in general and to the analysis of broad money growth in particular in its quest to maintain price stability over the medium to long term.

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Table A1: Stylised facts on the asset price boom episodes

Period	Pre2			Pre1			B1			Peak			Last			Post1			Post2			Cum Peak-Pre2		
	H	L	p-val	H	L	p-val	H	L	p-val	H	L	p-val	H	L	p-val	H	L	p-val	H	L	p-val	H	L	p-val
Real agg. asset price growth	2.7	4.8	0.232	4.9	8.2	0.213	10.6	14.4	0.061	13.9	17.2	0.222	2.9	2.8	0.831	-11.3	-7.2	0.141	-6.3	-5.0	0.593	36.1	34.7	0.641
Real agg. asset price gap	3.3	0.0	0.385	6.1	6.1	0.850	13.3	13.4	0.950	15.8	15.8	0.772	15.6	15.1	0.753	3.6	4.4	0.557	-4.5	-4.0	0.764	11.0	18.0	0.537
Real equity price growth	3.7	7.0	0.458	15.9	14.3	0.831	22.5	18.2	0.890	19.9	24.1	0.734	0.4	-3.8	0.831	-20.3	-21.6	0.772	-1.5	-12.4	0.341	62.9	57.3	0.990
Real equity price gap	27.9	7.5	0.128	21.1	14.3	0.428	29.2	28.4	0.623	31.7	32.7	0.678	23.7	20.3	0.521	-5.2	-8.0	0.606	-10.8	-27.4	0.506	13.3	25.2	0.262
Real residential property price growth	1.1	0.3	0.930	2.5	3.4	0.791	6.1	6.3	0.870	11.3	8.1	0.641	3.2	5.2	0.308	-5.0	1.9	0.000	-2.3	2.0	0.022	24.8	18.6	0.308
Real residential property price gap	-3.9	-3.3	0.606	-2.1	-1.9	0.678	5.0	5.2	0.831	12.7	7.3	0.273	13.8	10.7	0.413	5.5	7.6	0.186	0.0	5.4	0.024	12.7	11.3	0.385
Real broad money growth	4.4	3.9	0.396	5.3	3.5	0.080	6.5	3.8	0.072	8.8	4.6	0.008	6.3	4.2	0.028	1.6	2.8	0.188	3.0	2.9	0.303	20.3	12.5	0.012
Broad money/GDP ratio (detrended)	0.8	0.3	0.442	2.2	-1.3	0.026	2.3	-1.1	0.026	3.7	0.7	0.029	3.6	0.7	0.019	2.6	0.8	0.188	1.0	3.3	0.990	1.4	-0.2	0.080
Real private credit growth	4.4	4.0	0.930	7.0	6.1	0.930	8.8	6.4	0.623	9.7	9.8	0.623	8.1	7.8	0.659	2.7	4.2	0.148	0.6	3.8	0.038	27.5	25.0	0.345
Private credit/GDP ratio (detrended)	0.2	-4.2	0.094	1.4	-2.2	0.155	3.6	-0.7	0.358	5.9	3.7	0.428	6.5	6.6	0.696	5.2	4.9	0.886	2.2	5.1	0.235	3.8	5.7	0.659
Real GDP growth	1.8	3.3	0.057	3.5	3.6	0.772	4.4	3.3	0.020	4.7	3.7	0.057	3.2	2.4	0.141	0.6	1.9	0.121	0.8	1.6	0.279	13.8	11.5	0.203
Real private consumption growth	2.4	3.2	0.094	3.5	3.5	0.772	3.8	3.3	0.489	4.2	4.0	0.970	2.6	3.2	0.678	1.0	2.0	0.109	0.9	1.5	0.257	13.3	12.1	0.696
Real total investment growth	2.8	5.9	0.170	4.9	6.5	0.489	5.3	8.7	0.094	8.6	7.7	0.890	3.3	4.2	0.831	-3.0	-2.3	0.368	-4.0	-0.1	0.014	23.7	24.7	0.623
Real housing investment growth	1.4	1.7	0.831	5.2	4.9	0.715	8.3	5.4	0.554	7.4	5.0	0.116	0.0	1.3	0.473	-4.7	1.4	0.024	-3.6	3.4	0.235	22.6	15.2	0.148
Δ Unemployment rate	0.0	-0.1	0.162	0.0	-0.1	0.296	-0.1	-0.1	0.753	-0.2	-0.2	0.458	-0.1	-0.1	0.170	0.2	0.1	0.163	0.2	0.2	0.070	-1.5	-1.4	0.970
CPI inflation gap	-1.3	-0.1	0.104	-1.0	0.0	0.029	-0.1	0.3	0.606	0.3	0.2	0.950	1.4	0.7	0.155	1.7	0.7	0.020	0.1	0.6	0.426	1.7	0.7	0.162
Long-term interest-rate gap	-0.9	-0.4	0.489	-1.6	-0.7	0.222	-1.5	-0.7	0.203	-1.2	-0.6	0.273	0.1	0.2	0.571	0.2	0.1	0.969	0.2	0.2	0.990	0.4	-0.1	0.950
Short-term interest-rate gap	-1.3	-2.0	0.554	-1.4	-1.3	0.930	-0.9	-0.7	0.734	-0.6	-0.4	0.772	1.2	1.3	0.910	1.2	0.7	0.315	0.2	0.3	0.969	0.7	1.4	0.358
Real short-term interest-rate gap	-0.2	-1.5	0.028	-0.2	-1.4	0.099	-0.4	-1.3	0.811	-0.9	-0.6	0.641	0.1	-0.1	0.358	-0.8	-0.6	0.134	0.0	-0.6	0.825	-0.8	0.5	0.054
Term spread	0.8	1.5	0.099	0.9	1.0	0.385	0.3	1.0	0.036	-0.2	1.0	0.026	-0.6	0.3	0.043	-0.9	0.4	0.002	-1.0	1.3	0.006	-0.8	-0.4	0.537
Taylor rule gap	0.7	-1.3	0.014	0.2	-1.9	0.043	-1.5	-1.8	0.696	-2.2	-1.9	0.521	-3.2	-1.6	0.094	-2.9	-2.0	0.052	-0.8	-1.1	0.804	-2.5	-0.7	0.040
Government deficit (as % of GDP)	-3.6	-2.9	0.911	-2.7	-2.8	0.842	-2.7	-1.8	0.597	-0.7	-0.6	0.769	0.2	-0.5	0.966	-1.7	-0.3	0.663	-3.6	-2.2	0.598	2.3	2.4	0.738

The H and L column depicts the period and group specific median of high and low-cost booms, respectively. P-val shows the p value of the Wilcoxon/Mann-Whitney test. The null hypothesis is that there is no difference in populations across H and L cost booms. Shaded areas show significant differences at least at the 20% level.

Table A2: Regressions explaining the average real GDP post-boom growth: Robust regressions

Dependent variable: GDP growth av. post-boom

Equation	a2.1	a2.2	a2.3	a2.4	a2.5	a2.6	a2.7	a2.8	a2.9	a2.10
Estimation method	Rreg	Rreg	Rreg	Rreg	Rreg	Rreg	Rreg	Rreg	Rreg	Rreg
GDP growth av. boom	0.47***	0.64***	0.53***	0.52***	0.50***	0.50***	0.59***	0.53***	0.51***	0.50
	(0.000)	(0.000)	(0.001)	(0.003)	(0.003)	(0.002)	(0.001)	(0.001)	(0.003)	(0.002)
Boom length	-0.10	-0.14	-0.23*	-0.17	-0.25**	-0.02	0.01	-0.01	0.01	-0.03
	(0.420)	(0.334)	(0.060)	(0.335)	(0.043)	(0.905)	(0.940)	(0.931)	(0.979)	(0.871)
Housing growth cum						-0.04**	-0.04	-0.04*	-0.04*	-0.04**
						(0.039)	(0.115)	(0.084)	(0.064)	(0.041)
Money growth cum.		-0.03*					-0.02			
		(0.064)					(0.232)			
Money shock cum.			-0.10**					-0.08		
			(0.046)					(0.139)		
Priv. credit growth cum.				-0.01					0.00	
				(0.471)					(0.820)	
Priv. Credit shock cum.					0.00					0.00
					(0.986)					(0.920)
Adjusted R-sq.	0.20	0.33	0.34	0.23	0.22	0.33	0.35	0.37	0.30	0.31
Pseudo R-sq	-	-	-	-	-	-	-	-	-	-
N. of instruments	-	-	-	-	-	-	-	-	-	-

*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively. P-values in parentheses.*

Table A3: Regressions explaining the average real GDP post-boom growth: Quantile regressions

Dependent variable: GDP growth av. post-boom

Equation	a3.1	a3.2	a3.3	a3.4	a3.5	a3.6	a3.7	a3.8	a3.9	a3.10
Estimation method	Q(20)	Q(20)	Q(20)	Q(20)	Q(20)	Q(20)	Q(20)	Q(20)	Q(20)	Q(20)
GDP growth av. boom	0.27	0.71***	0.40**	0.58**	0.27	0.53**	0.76	0.63***	0.61**	0.58**
	(0.330)	(0.001)	(0.039)	(0.025)	(0.298)	(0.024)	(0.000)	(0.001)	(0.015)	(0.026)
Boom length	-0.40	-0.01	-0.22	-0.18	-0.33	0.06	0.16	0.10	-0.03	0.07
	(0.145)	(0.957)	(0.166)	(0.444)	(0.220)	(0.781)	(0.238)	(0.525)	(0.876)	(0.719)
Housing growth cum						-0.06***	-0.03*	-0.05**	-0.02	-0.05*
						(0.008)	(0.073)	(0.012)	(0.396)	(0.032)
Money growth cum.		-0.06***					-0.05**			
		(0.005)					(0.045)			
Money shock cum.			-0.12**					-0.10**		
			(0.017)					(0.043)		
Priv. credit growth cum.				-0.04**					-0.03	
				(0.049)					(0.207)	
Priv. Credit shock cum.					-0.07					-0.06
					(0.405)					(0.416)
Adjusted R-sq.	-	-	-	-	-	-	-	-	-	-
Pseudo R-sq	0.15	0.34	0.30	0.23	0.18	0.27	0.40	0.38	0.28	0.29
N. of instruments	-	-	-	-	-	-	-	-	-	-

*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively.*
P-values in parentheses, derived from bootstrapped standard errors with 500 iterations.

Table A4: Regressions explaining the average real GDP post-boom growth: Robust regressions

Dependent variable: GDP growth av. post-boom

Equation	a4.1	a4.2	a4.3	a4.4	a4.5
Estimation method	Rreg	Rreg	Rreg	Rreg	Rreg
GDP growth av. boom	0.61***	0.74***	0.63***	0.64***	0.61***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Boom length	-0.26**	-0.12	-0.21*	-0.20	-0.23**
	(0.021)	(0.366)	(0.073)	(0.224)	(0.032)
Δ Taylor gap boom	0.13**	0.12**	0.12**	0.12**	0.13**
	(0.020)	(0.025)	(0.027)	(0.028)	(0.023)
Money growth cum.		-0.03*			
		(0.089)			
Money shock cum.			-0.09*		
			(0.070)		
Priv. credit growth cum.				-0.01	
				(0.565)	
Priv. Credit shock cum.					-0.01
					(0.871)
Adjusted R-sq.	0.36	0.42	0.43	0.37	0.36
Pseudo R-sq	-	-	-	-	-
N. of instruments	-	-	-	-	-

*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively. P-values in parentheses.*

Table A5: Regressions explaining the average real GDP post-boom growth: Quantile regressions					
Dependent variable: GDP growth av. post-boom					
Equation	a5.1	a5.2	a5.3	a5.4	a5.5
Estimation method	Q(20)	Q(20)	Q(20)	Q(20)	Q(20)
GDP growth av. boom	0.58**	0.88	0.45**	0.67	0.62**
	(0.019)	(0.000)	(0.048)	(0.008)	(0.014)
Boom length	-0.42*	0.03	-0.25	-0.28	-0.44*
	(0.051)	(0.849)	(0.102)	(0.319)	(0.057)
Δ Taylor gap boom	0.12	0.05	0.04	0.07	0.13
	(0.140)	(0.346)	(0.559)	(0.429)	(0.136)
Money growth cum.		-0.05***			
		(0.007)			
Money shock cum.			-0.10*		
			(0.064)		
Priv. credit growth cum.				-0.02	
				(0.452)	
Priv. Credit shock cum.					0.03
					(0.800)
Adjusted R-sq.	-	-	-	-	-
Pseudo R-sq	0.24	0.38	0.32	0.25	0.24
N. of instruments	-		-		-

*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively.*
P-values in parentheses, derived from bootstrapped standard errors with 500 iterations.

Table A6: Regressions explaining real housing price growth during boom episodes										
Dependent variable: housing price growth										
Equation	a6.1	a6.2	a6.3	a6.4	a6.5	a6.6	a6.7	a6.8	a6.9	a6.10
Estimation method	OLS	OLS	OLS	OLS	OLS	CS	CS	CS	CS	CS
Housing price growth (-1)	0.24***	0.23***	0.22***	0.24***	0.24***	0.21***	0.19**	0.18**	0.20***	0.21***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.014)	(0.014)	(0.007)	(0.004)
Housing price growth (-2)	0.05	0.03	0.03	0.04	0.04	0.03	0.00	0.01	0.01	0.02
	(0.390)	(0.564)	(0.547)	(0.423)	(0.410)	(0.715)	(0.999)	(0.943)	(0.860)	(0.744)
Housing price growth (-3)	0.06	0.04	0.04	0.05	0.05	0.03	0.00	0.01	0.01	0.03
	(0.281)	(0.463)	(0.417)	(0.361)	(0.306)	(0.635)	(0.990)	(0.889)	(0.940)	(0.669)
Housing price growth (-4)	0.33***	0.31***	0.31***	0.32***	0.32***	0.3***	0.27***	0.28***	0.27***	0.29***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Housing price growth (-5)	-0.17***	-0.18***	-0.16***	-0.18***	-0.18***	-0.18**	-0.20**	-0.18**	-0.22***	-0.19**
	(0.004)	(0.002)	(0.004)	(0.002)	(0.002)	(0.020)	(0.010)	(0.020)	(0.006)	(0.013)
Housing price growth (-6)	-0.10*	-0.11*	-0.10*	-0.11**	-0.10	-0.12	-0.13*	-0.11	-0.15**	-0.12
	(0.068)	(0.053)	(0.081)	(0.046)	(0.070)	(0.122)	(0.076)	(0.127)	(0.048)	(0.132)
@ GDP growth (-1)	0.43*	0.12	0.41	0.29	0.35	0.74	0.54	0.74	0.52	0.62
	(0.094)	(0.677)	(0.110)	(0.316)	(0.176)	(0.124)	(0.251)	(0.115)	(0.273)	(0.195)
Δlong term interest rate (-1)	-0.35*	-0.32	-0.35*	-0.37*	-0.38*	-0.28	-0.26	-0.27	-0.31	-0.32
	(0.078)	(0.110)	(0.076)	(0.065)	(0.059)	(0.197)	(0.237)	(0.217)	(0.159)	(0.150)
@ Money growth (-1)		0.29**					0.55***			
		(0.019)					(0.004)			
@ Money shock (-1)			0.86***					1.50***		
			(0.005)					(0.001)		
@ Priv. credit growth (-1)				0.12					0.35**	
				(0.256)					(0.022)	
@ Priv. Credit shock (-1)					0.48*					0.72*
					(0.086)					(0.071)
Adj. R-squared	0.18	0.19	0.20	0.18	0.19	0.17	0.19	0.20	0.18	0.18
N. of observations	386	386	386	386	386	386	386	386	386	386
Av. N. of periods	24	24	24	24	24	24	24	24	24	24
N. of cross sections	16	16	16	16	16	16	16	16	16	16

The @ sign stands for six-quarter moving average.
OLS: OLS pooled estimation; CS: LS cross-section fixed effects.
*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively. P-values in parentheses.*
Cross-section SUR (PCSE) standard errors used for the CS estimations.

Table A7: Regressions explaining real housing price growth during boom episodes

Dependent variable: housing price growth (annual frequency)					
Equation	a7.1	a7.2	a7.3	a7.4	a7.5
Estimation method	SysGMM	SysGMM	SysGMM	SysGMM	SysGMM
Housing price growth (-1)	0.49***	0.38***	0.43***	0.35***	0.46***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDP growth	1.08**	0.55	0.85*	0.92**	1.10**
	(0.039)	(0.303)	(0.080)	(0.049)	(0.025)
Δlong term interest rate	-0.39	0.14	-0.39	0.15	-0.02
	(0.650)	(0.867)	(0.640)	(0.868)	(0.983)
Money growth		0.45**			
		(0.042)			
Money shock			1.00**		
			(0.028)		
Priv. credit growth				0.24*	
				(0.083)	
Priv. Credit shock					-0.48
					(0.202)
N. of groups	42	42	42	42	42
N. of observations	156	156	154	156	155
Av. N. of periods	4	4	4	4	4
N. of instruments	54	69	69	69	69
Test of 1st. order serial corr. (p-value)	0.030	0.041	0.021	0.049	0.026
Test of 2st. order serial corr. (p-value)	0.874	0.888	0.586	0.569	0.804
Test of overid. restrictions (p-value)	0.955	0.997	0.997	0.999	0.991

SysGMM: system GMM.
*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively.*
P-values in parentheses, derived from Windmeijer's corrected two-step covariance matrix.

Table A8: Regressions explaining real housing price growth (overall sample)

Dependent variable: housing price growth										
Equation	a8.1	a8.2	a8.3	a8.4	a8.5	a8.6	a8.7	a8.8	a8.9	a8.10
Estimation method	OLS	OLS	OLS	OLS	OLS	CS	CS	CS	CS	CS
Housing price growth (-1)	0.39***	0.38***	0.38***	0.39***	0.38***	0.38***	0.37***	0.38***	0.38***	0.38***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Housing price growth (-2)	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.00	0.02	0.01
	(0.345)	(0.528)	(0.743)	(0.390)	(0.652)	(0.527)	(0.717)	(0.879)	(0.573)	(0.805)
Housing price growth (-3)	0.05**	0.04	0.05**	0.04*	0.05**	0.04	0.03	0.04	0.04	0.04
	(0.042)	(0.105)	(0.033)	(0.053)	(0.038)	(0.135)	(0.248)	(0.112)	(0.156)	(0.120)
Housing price growth (-4)	0.21***	0.21***	0.22***	0.21***	0.21***	0.21***	0.21***	0.21***	0.21***	0.21***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Housing price growth (-5)	-0.14***	-0.15***	-0.14***	-0.15***	-0.14***	-0.15***	-0.15***	-0.14***	-0.15***	-0.14***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Housing price growth (-6)	-0.05**	-0.06**	-0.04*	-0.05**	-0.04*	-0.05**	-0.06**	-0.04*	-0.06**	-0.04
	(0.017)	(0.011)	(0.051)	(0.012)	(0.056)	(0.044)	(0.032)	(0.098)	(0.034)	(0.104)
Housing price growth (-7)	0.00	0.00	0.00	-0.01	0.00	-0.01	0.00	0.00	-0.01	0.00
	(0.855)	(0.886)	(0.871)	(0.755)	(0.877)	(0.839)	(0.859)	(0.853)	(0.758)	(0.854)
Housing price growth (-8)	0.13***	0.13***	0.13***	0.13***	0.13***	0.13***	0.13***	0.13***	0.13***	0.13***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
@ GDP growth (-1)	0.61***	0.49***	0.64***	0.56***	0.64***	0.70***	0.55***	0.71***	0.65***	0.73***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Δlong term interest rate (-1)	-0.52***	-0.5***	-0.53***	-0.52***	-0.53***	-0.52***	-0.5***	-0.53***	-0.52***	-0.53***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
@ Money growth (-1)		0.22***					0.23***			
		(0.000)					(0.000)			
@ Money shock (-1)			0.30**					0.30*		
			(0.038)					(0.052)		
@ Priv. credit growth (-1)				0.05					0.05	
				(0.182)					(0.251)	
@ Priv. Credit shock (-1)					0.05					0.05
					(0.618)					(0.687)
Adj. R-squared	0.31	0.32	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
N. of observations	2354	2338	2269	2354	2285	2354	2338	2269	2354	2285
Av. N. of periods	131	130	126	131	127	131	130	126	131	127
N. of cross sections	18	18	18	18	18	18	18	18	18	18

The @ sign stands for six-quarter moving average.
OLS: OLS pooled estimation; CS: LS cross-section fixed effects.
*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively. P-values in parentheses.*
Cross-section SUR (PCSE) standard errors used for the CS estimations.

Table A9: Regressions explaining consumer price inflation during boom episodes										
Dependent variable: consumer price inflation										
Equation	a9.1	a9.2	a9.3	a9.4	a9.5	a9.6	a9.7	a9.8	a9.9	a9.10
Estimation method	CS+P	CS+P	CS+P	CS+P	CS+P	CS+RT	CS+RT	CS+RT	CS+RT	CS+RT
Consumer price inflation (-1)	0.24***	0.25***	0.24***	0.24***	0.24***	0.04	0.05	0.04	0.04	0.04
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.572)	(0.512)	(0.590)	(0.547)	(0.574)
Consumer price inflation (-2)	0.13*	0.14*	0.13	0.13*	0.13*	0.00	0.00	-0.01	0.00	-0.01
	(0.098)	(0.071)	(0.100)	(0.099)	(0.098)	(0.947)	(0.964)	(0.931)	(0.947)	(0.943)
Consumer price inflation (-3)	-0.04	-0.03	-0.04	-0.03	-0.04	-0.16**	-0.15**	-0.16**	-0.15**	-0.16**
	(0.578)	(0.709)	(0.585)	(0.675)	(0.584)	(0.019)	(0.030)	(0.019)	(0.031)	(0.022)
Consumer price inflation (-4)	0.5***	0.51***	0.50***	0.51***	0.50***	0.44***	0.44***	0.43***	0.44***	0.44***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Consumer price inflation (-5)	-0.25***	-0.23***	-0.25***	-0.23***	-0.25***	-0.19**	-0.18**	-0.19**	-0.18**	-0.19**
	(0.003)	(0.005)	(0.003)	(0.006)	(0.003)	(0.014)	(0.018)	(0.013)	(0.021)	(0.015)
Consumer price inflation (-6)	-0.01	0.01	-0.01	0.01	-0.01	-0.01	0.00	-0.01	0.00	-0.01
	(0.944)	(0.940)	(0.946)	(0.893)	(0.948)	(0.912)	(0.985)	(0.904)	(0.972)	(0.933)
@ GDP growth (-1)	0.17*	0.16	0.17*	0.15	0.17*	0.05	0.05	0.05	0.04	0.05
	(0.092)	(0.129)	(0.092)	(0.141)	(0.093)	(0.610)	(0.655)	(0.617)	(0.723)	(0.617)
@ Money growth (-1)		0.06					0.03			
		(0.195)					(0.494)			
@ Money shock (-1)			0.01					-0.02		
			(0.943)					(0.866)		
@ Priv. credit growth (-1)				0.05					0.03	
				(0.267)					(0.386)	
@ Priv. Credit shock (-1)					0.01					0.02
					(0.950)					(0.783)
Adj. R-squared	0.61	0.61	0.61	0.61	0.61	0.66	0.66	0.66	0.66	0.66
N. of observations	375	375	375	375	375	372	372	372	372	372
Av. N. of periods	23	23	23	23	23	23	23	23	23	23
N. of cross sections	16	16	16	16	16	16	16	16	16	16

The @ sign stands for six-quarter moving average.
CS+P: LS cross-section and period fixed effects; CS+RT: cross-section and real-time fixed effects.
*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively.*
P-values in parentheses derived from cross-section SUR (PCSE) standard errors.

Table A10: Regressions explaining consumer price inflation (overall sample)					
Dependent variable: consumer price inflation					
Equation	a10.1	a10.2	a10.3	a10.4	a10.5
Estimation method	CS+P	CS+P	CS+P	CS+P	CS+P
Consumer price inflation (-1)	0.27***	0.25***	0.26***	0.27***	0.26***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Consumer price inflation (-2)	0.12***	0.14***	0.13***	0.11***	0.13***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Consumer price inflation (-3)	0.11***	0.13***	0.11***	0.12***	0.13***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Consumer price inflation (-4)	0.14***	0.17***	0.18***	0.14***	0.18***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Consumer price inflation (-5)	-0.06***	-0.06**	-0.07**	-0.06**	-0.07***
	(0.007)	(0.012)	(0.013)	(0.018)	(0.010)
Consumer price inflation (-6)	0.06***	0.04	0.04	0.07***	0.04
	(0.007)	(0.111)	(0.109)	(0.003)	(0.146)
Consumer price inflation (-7)	-0.03	-0.04	-0.04	-0.03	-0.03
	(0.223)	(0.159)	(0.169)	(0.237)	(0.247)
Consumer price inflation (-8)	0.13***	0.14***	0.15***	0.13***	0.15***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
@ GDP growth (-1)	0.16***	0.14***	0.17***	0.11***	0.19***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
@ Money growth (-1)		0.05***			
		(0.010)			
@ Money shock (-1)			0.11**		
			(0.034)		
@ Priv. credit growth (-1)				0.04***	
				(0.000)	
@ Priv. Credit shock (-1)					0.08**
					(0.028)
Adj. R-squared	0.69	0.73	0.74	0.7	0.74
N. of observations	3004	2576	2259	2927	2275
Av. N. of periods	167	143	126	163	126
N. of cross sections	18	18	18	18	18

The @ sign stands for six-quarter moving average.
CS+P: LS cross-section and period fixed effects.
*Stars (***, **, *) denote the significance of the t-test at the 1%, 5% and 10% level, respectively.*
P-values in parentheses derived from cross-section SUR (PCSE) standard errors.

Robustness test for panel boom analysis with respect to lag length of money growth shocks

Table A11: Robustness of liquidity shock (@money shock(-1) coefficient) across estimation methods

	CS	CS+P	CS+RT
Lags accumulated	@money shock(-1)	@money shock(-1)	@money shock(-1)
1	0.16 (0.275)	0.14 (0.399)	0.10 (0.496)
2	0.45* (0.073)	0.27 (0.326)	0.29 (0.275)
3	0.97*** (0.002)	0.74** (0.026)	0.83** (0.012)
4	0.88*** (0.008)	0.62 * (0.078)	0.76** (0.036)
5	1.10*** (0.006)	0.78 * (0.058)	0.93** (0.037)
6	1.50*** (0.001)	1.16*** (0.009)	1.36*** (0.005)

CS: LS cross-section fixed effects; CS+P: LS cross-section and period fixed effects; CS+RT: LS cross-section and real-time fixed effects.
Stars (***,**,*) denote the significance of the t-test at the 1%, 5% and 10% level, respectively. P-values in parenthesis derived from cross-section SUR (PCSE) standard errors.
The accumulated lags for the control variable real GDP growth (not reported) always corresponds to the number of lags for the money growth shocks. The lags of the endogenous variable (not reported) were kept constant at 6.

The Wilcoxon-Mann-Whitney Test

The Wilcoxon-Mann-Whitney test is a non-parametric test for differences in populations. The assumptions are simply that each sample is a random sample from the population it represents, that the two samples are independent from each other and that the measurement scale is at least ordinal.
To derive the test statistic one first combines the two series and then orders all observations by size. Then one computes the sum of the ranks (in the combined series) for the two samples. The null hypothesis that there is no difference between the two populations will be rejected when the sum of the ranks of the two samples is relatively different. If the number of observations in at least one of the two samples exceeds 10 (see e.g. Newbold et al., 2003), which is always true in our case, the test statistic quickly approaches a normal distribution. The test statistic used for a two-sided test is

$$z = \frac{W_x \pm 0.5 - m(N+1)/2}{\sqrt{mn(N+1)/12}}$$

, where W_x is the sum of the ranks of the smaller sample, m and n are the number of observations in the smaller and larger sample, respectively and $N=m+n$.
Under the additional assumption that the only difference between the two populations is the mean, the Wilcoxon-Mann-Whitney test can be interpreted as a test for equality of means. Even in this case it is more powerful than a standard two sample *t*-test for small samples as it does not require the normality assumption.

Alternative VARs

We checked for robustness of results by running two different types of VARs including the following variables in order to derive alternative liquidity shocks.

Alternative 1

money: $Z = (\pi_{cpi}, y_r, \Delta i_s, m)'$

credit: $Z = (\pi_{cpi}, y_r, \Delta i_s, pc)'$

Alternative 2

money: $Z = (\pi_{cpi}, y_r, \Delta i_s, m, rex)'$

credit: $Z = (\pi_{cpi}, y_r, \Delta i_s, pc, rex)'$

always with X = com, thus including the change in commodity prices as exogenous variable.

The first alternative set of VARs excludes the exchange rate as well as the asset prices (equity and residential property) and is thus closer related to a standard money demand based liquidity measure. The second alternative set of VARs only excludes the two types of asset prices but also considers changes in the exchange rate. The qualitative results using these measures are unchanged. The typical result for the cross-section analysis is that the less variables are included in the VAR, the more significant and the larger is the coefficient of the money growth shock variable. This suggests that some of the correlation between money growth and asset prices is indeed due to the endogeneity of money growth and that we are on the conservative side when reporting the long VAR including asset prices.
With respect to the panel boom analysis there is not such a clear pattern for the three types of VARs. The money based variables are usually all significant, while in some specifications the alternative 1 variable for credit also significantly contributes to explaining the rate of change in real housing prices, although not for our preferred specification, the cross-country and real time fixed effects model.

Data

We use quarterly data for 18 OECD countries covering a period that ranges generally from 1970Q1 until 2004Q4.

List of countries:

Australia, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, Ireland, Italy, Japan, The Netherlands, Norway, New Zealand, Sweden, the United States and the United Kingdom.

List of variables:

The following table relates the variables used in the paper and the corresponding data sources.

Economic concept	Series and source	Series code
Broad money	Money supply, broad definition (M3 or M2), from OECD Economic Outlook. Monetary aggregate M3, from ECB, for the euro area countries.	MONEYS
Private credit	Private credit, from the International Financial Statistics (IFS, IMF).	Line 32D
GDP	GDP, volume, market prices, from OECD Economic Outlook. *GDP at market prices, from the BIS for Germany pre-91*	GDPV RHGB
Private consumption	Private consumption expenditure, volume, from OECD Economic Outlook. *Consumption, private, from the BIS for Germany pre-91*	CPV RCGB
Total investment	Gross total fixed capital formation, volume, from OECD Economic Outlook. *Investment, gross fixed, total, from the BIS for Italy and Germany pre-91*	ITV RJBB
Housing investment	Private residential fixed capital formation, volume, from OECD Economic Outlook. *Gross fixed capital formation - Construction, from INE, for the Spanish case.* *Total construction investment, from the BIS, for Switzerland.*	IHV RFBA, RFBB
Unemployment rate	Unemployment rate, from OECD Economic Outlook.	UNR
CPI inflation	Consumer price, from OECD Economic Outlook. Consumer price, harmonised, from OECD Economic Outlook, for the UK. *International Financial Statistics (IFS, IMF) for Switzerland*	CPI

		Line 64
Long-term interest rate	Long-term interest rate on government bonds, from OECD Economic Outlook.	IRL
Short-term interest rate	Short-term interest rate, from OECD Economic Outlook.	IRS
Real effective exchange rate	Real effective exchange rate, from OECD Main Economic Indicators.	CCRETT01.IXOB
Government deficit	Government net lending, as a percentage of GDP, from OECD Economic Outlook.	NLGQ

The asset price indices have been kindly supplied by Steve Arthur ad Claudio Borio from the BIS (See Borio, Kennedy and Prowse (1994) and Borio and Lowe (2001) on these indices). The aggregate indices are weighted by the (infrequently updated) shares of the asset components (equity, residential property, commercial property) in the respective economy. We used real asset price indices as deflated by consumer prices by the BIS.

The credit series displayed huge structural breaks. Whenever the IFS documentation signalled a structural break and simultaneously the TRAMO software indicated a level shift (based on the time series characteristics), we let TRAMO estimate the size of the break and used the (backward) corrected data.

Long and short-term interest rates are backward extended with data coming from the IFS when data from the OECD Economic Outlook are not available. Exceptions are the long-term interest rate for Spain and Switzerland, which have been backward extended using BIS data.

Money for Denmark has been constructed as follows:

- from 1993Q1-2004Q3: OECD-Main Economic Indicators, code MABBMM301.ST
- 1981Q1-1992Q4: International Financial Statistics (IFS, IMF), line 39m
- before 1981: International Financial Statistics (IFS, IMF), line 34 + line 35

Data on public deficits have been interpolated from the corresponding annual series for the following countries: Belgium, Denmark, Spain, Italy and Norway.

The recursive trends have been derived by extending the window for the HP filter period by period. A starting window with 24 quarters of length is defined for the first (non-recursive) estimates.

Taylor gaps are defined as follows, where *i* is the nominal interest rate, *r* the real interest rate, π the inflation rate, *y* real GDP and variables with star denote trend values:

Taylor gap R: $i_t - [r_t^* + \pi_t + 0.5(\pi_t - \pi_t^*) + 0.5(y_t - y_t^*)]$, where r*, π* and y* are the recursive HP trends derived with λ=1000.

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