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Global liquidity, house prices and policy responses

Chiara Banti and Kate Phylaktis*†

Abstract

The paper investigates the impact of global liquidity on house prices around the world using a novel proxy measured by the funding availability to global banks in the main financial centers. We find supporting evidence that global conditions from the financial centers are transmitted to local banks through bank flows. Focusing on the repo markets in the US, Europe, and the UK, over the period 2000-2014 and using a panel VAR, we find that liquidity shocks impact house prices in both emerging and advanced economies. However, countries' exposure to liquidity shocks can be mitigated by monetary policy, and by various general and house market specific macroprudential policies. We document strikingly different effectiveness of these policies in advanced and emerging markets.

Keywords: global liquidity, house prices, repos, macroprudential policies.

JEL classification: G15.

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"We are all Macroprudentialist now. In the wake of the crisis the concept has risen with breathtaking speed from virtual obscurity to currency in the policymaking world" (Borio, 2011).

1 Introduction

In the last decade, house prices around the world have registered a sustained upward trend, increasing in the advanced economies by around 60% from 2000 until the recent financial crisis (Figure 1, plot a). This pattern has been rather similar to that of cross-border bank flows, encouraged by benign funding conditions in major financial systems (Figure 1, plot b). The increasing trend in both house prices and bank flows inverted during the recent financial crisis, when key financial markets experienced severe liquidity dry-ups and credit conditions worsened around the world. The responses of monetary authorities to the subsequent economic downturn have unleashed unprecedented amounts of liquidity and, in the aftermath of the Global Financial Crisis (GFC), house prices resumed their upward trend. As these cycles evolved, countries have responded by developing policy frameworks, such as a variety of macroprudential policies to tackle potential vulnerabilities to financial stability and economic growth (Figure 1, plot c). Advanced economies have tightened their monetary policy in the run up to the GFC, while house prices and bank flows were increasing sharply. With rates at low levels in the aftermath of the financial crisis, they have been using increasingly macroprudential policy, corresponding to the second phase of house price growth. Emerging markets, on the other hand, relied on macroprudential policy earlier on, prior to the financial crisis, and resumed their implementation following the crisis, again when facing rising house prices and bank flows (Shim, Bogdanova, Shek, and Subelyte, 2013). This paper investigates the effectiveness of these policies to tackle and mitigate the exposure of housing markets around the world to global liquidity, that is the liquidity that crosses the border and affects directly, or indirectly credit conditions in the recipient economies. Following the increasing popularity of macroprudential policy,

a nascent strand of the literature investigates its effectiveness on house prices, together with the impact of bank credit and bank flows, providing mixed evidence. We contribute to this discussion by focusing on countries' exposure to *global* shocks instead of *domestic* credit conditions. Thus, we ask first whether the global conditions impact house prices and secondly, whether countries by using macroprudential policy to restrain the local banking sector and housing market are able to effectively shield economies from global liquidity. To offer a comprehensive analysis of policy responses, we consider the effectiveness of monetary policy and capital controls as well.

Countries have adopted different policies at different times. Indeed, monetary authorities may respond to house price pressure by raising their short-term rates to make financing more costly and thus control credit growth (Sa, Towbin, and Wieladek, 2011). To tackle the growth of bank credit triggered by the funding channel, countries may adopt policies directly targeted at the local banking sector, thereby increasing the cost of lending and banks' resilience to financial stability shocks. Importantly, these policy measures are effective on the local banks and subsidiaries of foreign banks, leaving foreign banks' branches and nonbanks unaffected, which could make certain policies ineffective.[1] To mitigate the effects of bank flows and domestic bank credit growth on house prices, countries may decide to target the housing market directly, by increasing the cost or limiting banks' housing-related lending activity and/or by making it more expensive and difficult for borrowers to access housing loans. In targeting foreign credit in particular, countries may adopt controls on foreign-currency lending. Finally, countries, which are especially concerned with foreign investors may rely on capital controls, especially those targeted at foreign investors in the real estate sector. Figure 2 offers a graphical representation of these transmission channels and

[1]Cerutti, Claessens, and Laeven (2017a) and Cizel, Frost, Houben, and Wierts (2016) find that nonbank credit increases when macroprudential policy is implemented across a large sample of countries. Employing bank-level data for the UK, Aiyar, Calomiris, and Wieladek (2014) find that tightening capital requirements on regulated banks (domestic and foreign subsidiaries) results in greater lending by unregulated banks (foreign branches).

how macroprudential policy can intercept them.

We contribute to the literature by investigating the role of policy tools that countries may adopt to tackle the exposure of their housing market to *global* shocks as opposed to domestic credit conditions. A recent strand of literature has emerged, which analyses the effectiveness of macroprudential policy to mitigate episodes of house price growth, with mixed evidence (Akinci and Olmstead-Rumsey, 2018; Cerutti et al., 2017a; Vandenbussche, Vogel, and Detragiache, 2015; Zhang and Zoli, 2016; Craig and Hua, 2011; Igan and Kang, 2011). Moreover, the evidence on the role of macroprudential policy on domestic credit growth is also mixed, with few papers documenting a significant effect (Cerutti et al., 2017a; Tovar, Garcia-Escribano, and Martin, 2012). However, Beirne and Friedrich (2014) document that this effectiveness is weaker for countries with an open banking sector, suggesting a key role for global conditions. But when targeted specifically towards foreign credit, macroprudential policy can effectively reduce cross-border credit (Bruno, Shim, and Shin, 2017; Ostry, Ghosh, Chamon, and Qureshi, 2012). Given the mixed evidence and some success of macroprudential policy to mitigate cross-border bank flows, we study whether these policies are effective in shielding countries' housing markets from global shocks, either by reducing bank flows and affecting the housing market directly, or else preventing foreign investments from reaching the local market.

In order to capture the global liquidity dynamics relevant for house prices, we introduce a new proxy for global liquidity, which focuses on the private component of liquidity of the major wholesale funding markets for financial intermediaries, that is the repurchase agreement (repo) market not only in the US, but also in the UK and Europe.[2] The literature has concentrated on a set of supply-side factors to measure global liquidity, such as bank leverage measures, the US TED

[2]Funding liquidity has been measured by repos in other works in different contexts e.g Banti and Phylaktis (2015); Mancini Griffoli and Ranaldo (2011); Adrian, Etula, and Shin (2010); Coffey and Hrung (2009).

spread, and the VIX (Chudik and Fratzscher, 2011; Shin, 2012; Cerutti, Claessens, and Ratnovski, 2014; Bruno and Shin, 2015). In line with this literature, we also consider supply factors, and we focus on the changing conditions of the wholesale funding markets. Employing a panel vector autoregression model (PVAR) over the period 2000-2014 on a group of advanced and emerging economies, we document that global liquidity triggers house price movements around the world, in line with previous findings (Darius and Radde, 2010; Tillmann, 2013; Cesa-Bianchi, Cespedes, and Rebucci, 2015; Cesa-Bianchi, Ferrero, and Rebucci, 2018).

Although we find global liquidity to impact house prices, the question arises whether it is sufficiently large to elude macroprudential policy measures and weaken the effectiveness of domestic monetary policy. In this respect, we show that domestic governments can use monetary policy, in the form of interest rate changes, to mitigate the impact of global liquidity on house prices in advanced and emerging markets. Importantly, using an interactive PVAR we find that the adoption of macroprudential policy frameworks reduces countries' exposure to global shocks. This is especially evident in advanced economies, especially for housing measures and a few banking policy measures that shield countries from global shocks. In emerging markets, we find that banking and some housing macroprudential policy measures mitigate but do not offset the effects of global shocks. Nonetheless, we show that emerging markets can successfully rely on restrictions to non-resident investments in the local real estate sector to shield their house prices from liquidity shocks. These findings have policy implications for countries, which would like to limit their exposure to global liquidity.

In the next section we review the related literature. In section 3, we describe the data and provide some preliminary analysis. We present the empirical analysis of the impact of changes in funding liquidity on house prices in section 4. Section 5 investigates the impact of domestic monetary policy on house prices and compares its impact to that of global liquidity. Section

6 investigates the role of macroprudential policy on the exposure of countries to global shocks. Finally, section 7 concludes and reports some policy implications.

2 Literature Review

Our work draws from two strands of literature, the first relates to the impact of global liquidity on house prices, while the second relates to the effectiveness of macroprudential policy to curb credit and house price growth.[3]

Shin (2012) shows that permissive financing conditions are transmitted globally via cross-border banking and global banks leverage. In their model of the international banking system, Bruno and Shin (2015) contend that bank flows are affected by changes in the leverage of global banks. This implies that financing conditions in the main financial systems are transmitted across borders to the local banking sector. Departing from a US-based approach, Cerutti et al. (2014) show that financing conditions originating in Europe, UK, and Japan in addition to the US are determinants of cross-border bank debt. They consider global factors and include a measure of uncertainty in the global financial markets, such as the VIX, and the US TED spread in addition to bank leverage as measures of financing conditions. They also document a role for local country factors on the extent to which global conditions affect cross-border bank flows. Finally, the importance of funding considerations is documented in Cetorelli and Goldberg (2011). Employing a difference-in-difference approach, they study the shock transmission mechanism from banks in advanced to banks in emerging countries. They find the main transmission mechanism to be the funding channel to the banks in emerging countries as opposed to the cross-border direct lending or local lending

[3]The literature on house prices is vast. In this review we focus on the strand of the literature that studies house price dynamics in the context of global liquidity, which is relevant for our work. See Agnello and Schuknecht (2009), Duca, Muellbauer, and Murphy (2010) and Favilukis, Kohn, Ludvigson, and Van Nieuwerburgh (2011) for more general recent reviews on the determinants of house prices.

by foreign banks' subsidiaries. Investigating the effect on Peruvian banks of Russia's 1998 default, Schnabl (2012) document that foreign lending amplifies external shocks while foreign ownership mitigates them. In the light of this literature, we focus on funding aggregate measures in the main financial centers to capture the global liquidity conditions impact on cross-border bank flows.

Few studies have looked at the impact of global liquidity on the housing market. Focusing on a panel of Asian countries, Tillmann (2013) find an overall positive effect of capital flows on house prices, which is however different across countries. Empirical work on the relationship between monetary liquidity and house prices provide mixed evidence. While Darius and Radde (2010) and Belke, Orth, and Setzer (2010) document for the G7 and the OECD countries respectively a positive impact of liquidity on house prices, only a limited effect is found in Brana, Djigbenou, and Prat (2012) for a group of emerging markets.

Using a broader sample of countries, which includes both advanced and emerging economies, and focusing on funding costs, such as the US TED spread, Cesa-Bianchi et al. (2015) investigate the effect of global liquidity on the macroeconomy and the housing market. Applying a PVAR framework for the period 1990-2012, they document a stronger impact of cross-border bank flows on house prices in emerging compared to advanced markets. To identify the effect of global liquidity, they employ a US-based set of instruments related to global factors, including the TED spread and VIX. Focusing on shocks to US dealers' leverage, Cesa-Bianchi et al. (2018) also employ a PVAR framework and find a persistent effect of international credit supply shocks on house prices in a group of advanced and emerging countries. Similarly to the above works, we investigate the reaction of house prices to liquidity in a PVAR setting of 40 countries, which includes both advanced and emerging economies, but extend the work in several dimensions as explained earlier.

The literature on macroprudential policy impact on house prices is relatively recent. Following an increase in its implementation, researchers have started to look into its effectiveness. The findings

are mixed.

First of all, it is important to note that advanced and emerging markets use the measures differently. Banking macroprudential policy is used to target credit growth in emerging markets, whereas housing macroprudential policy is used to target house prices directly in advanced economies (Akinci and Olmstead-Rumsey, 2018).

A number of papers have studied the effectiveness of banking macroprudential measures to curb house price growth with mixed findings. In particular, the literature provides evidence of successful implementation of limits to interbank exposure (Cerutti et al., 2017a; Vandenbussche et al., 2015) and taxation on financial institutions activities for both developed and emerging markets (Cerutti et al., 2017a). In emerging markets, foreign currency reserve requirements and capital buffers are found to be significant in controlling house prices in emerging Europe (Vandenbussche et al., 2015), and foreign currency reserve requirements and limits to foreign currency loans in Asia (Zhang and Zoli, 2016). Conversely, Akinci and Olmstead-Rumsey (2018) find no significant role of either capital buffers or reserve requirements.

Similar mixed evidence arises from the studies focusing on housing macroprudential policy. While extensively used, there is limited evidence on the effectiveness of limits to loan-to-value (LTV). This measure is found to be effective on house prices in Asia, but not in other regions (Zhang and Zoli, 2016; Cerutti et al., 2017a; Craig and Hua, 2011; Igan and Kang, 2011; Cerutti, Correa, Fiorentino, and Segalla, 2017b; Kuttner and Shim, 2016). To account for differences across countries, Akinci and Olmstead-Rumsey (2018) find that its effectiveness depends directly on the relative importance of banks in the financial system. Looking at other tools, Zhang and Zoli (2016) find that housing taxes reduce house prices in Asia, whereas Kuttner and Shim (2016) show that taxes actually increase house prices across various specifications and methodologies. Akinci and Olmstead-Rumsey (2018) find that other measures, such as debt-service-to-income limits, capital

buffer for housing loans, and limits to banks' exposure to housing, affect house prices in a broad set of countries, whereas Vandenbussche et al. (2015) document that they are not significant in Central and Eastern European countries.

A related strand of the literature looks at the impact of macroprudential policy on bank credit and bank flows. While not looking specifically at house prices, these studies are relevant because they investigate a channel through which global liquidity affects house prices, as documented in the review of the first strand of the literature above. Hence, we review this nascent literature briefly as well.

In general, macroprudential policy reduces bank credit, more so in emerging markets (Cerutti et al., 2017a; Tovar et al., 2012) and relatively closed economies (Cerutti et al., 2017a), but increases non-bank credit (Cizel et al., 2016), foreign branches credit (Aiyar et al., 2014; Reinhardt and Sowerbutts, 2015), and cross-border bank credit in open economies, especially with flexible currency regimes (Cerutti et al., 2017a). Similarly, the effectiveness of macroprudential policy on bank credit is reduced by more open banking sectors (Beirne and Friedrich, 2014).

Looking at specific measures, those unrelated to housing are relatively ineffective to curb bank credit growth (Zhang and Zoli, 2016; Forbes, Fratzscher, and Straub, 2013; Ostry et al., 2012), whereas housing-specific measures are generally effective (Zhang and Zoli, 2016; Bruno et al., 2017; Lim, Columba, Costa, Kongsamut, Otani, Saiyid, Wezel, and Wu, 2011; Cerutti et al., 2017a; Akinci and Olmstead-Rumsey, 2018; Kuttner and Shim, 2016). Furthermore, measures specifically oriented towards foreign currency loans or foreign residents successfully reduce bank flow to emerging markets (Beirne and Friedrich, 2014; Bruno et al., 2017; Ostry et al., 2012). In Asia, Bruno et al. (2017) find that these specific measures reduce the impact of VIX on bank flows. Focusing on Romania, Epure, Mihai, Minoiu, and Peydro (2018) document a similar dampening effect of these measures on the exposure of household credit to the VIX and foreign monetary policy.

We contribute to the above discussion on the effectiveness of macroprudential policy measures by investigating their effectiveness when countries are exposed to global shocks as opposed to domestic credit conditions.

3 Data

3.1 Measuring global liquidity with repurchase agreements

Global liquidity is generally defined as the easing of financing conditions across borders (BIS, 2013). In line with the literature, we abstract from the demand-side considerations of credit creation, and we focus on shifts in the supply of financing at global level measured by the availability of collateralized funding to financial institutions in the main financial systems. Looking at wholesale funding markets, we measure global liquidity as the amount outstanding of repos in the US, UK, and Europe.

This measure is related to other global liquidity proxies previously employed in the literature. Looking at their behaviour in Figure 3, we can see that our measure of funding liquidity exhibits a similar trend to the bank leverage measure proposed by Bruno and Shin (2015) and employed to investigate the effects of credit supply on house prices, among other variables, in Cesa-Bianchi et al. (2018). Looking at the repo market, our proxy is specific to the availability of collateralized funding for investments to the key players in the markets. Although our proxy is an important source of wholesale funding for banks (International Monetary Fund, 2015), other important financial institutions, such as hedge funds and real estate investment trusts, rely on repos to finance their operations (Baklanova, Copeland, and Mccaughrin, 2015). The focus of our analysis, however is on the banking channel and we provide supporting evidence, which shows that global liquidity impacts bank flows.

Other two widely used measures of global liquidity are the VIX and the TED spread (Cerutti

et al., 2014; Cesa-Bianchi et al., 2015). The VIX is a measure of implied volatility in S&P500 options that captures risk aversion in global markets and thus the willingness of banks to extend credit across borders. The TED spread is a measure of funding costs and is calculated as the difference between three-month interbank interest rates and government yields, again generally measured in the US. Cesa-Bianchi et al. (2015) use these measures as part of a set of instruments to investigate the impact of global liquidity on the macroeconomy and house prices. As Figure 3 shows, the VIX increases sharply as our proxy for funding availability declines not only during the crisis, but also in the aftermaths during episodes of market uncertainty. Looking at funding costs, the TED spread has been extraordinarily high during the recent financial crisis, making the variable more a proxy for the crisis episode than a measure of funding liquidity over time. In this respect, we consider the pattern of funding aggregates to capture more closely the evolution of funding availability through time. Also, while the TED spread relates to unsecured markets, our measure incorporates developments in market conditions, given the presence of collateral in repo contracts. Nevertheless to test the robustness of our analysis, we also employ banks' leverage, the VIX and the TED spread as alternative measures for global liquidity in section 4.1.

Data on repos is available from Central Banks' websites in domestic currency and converted in USD with the IFS monthly exchange rates. The US data is the bilateral repos reported weekly by primary dealers to the Federal Reserve Bank of New York. [4] Data on the repo positions of monetary and financial institutions in the UK is reported monthly by the Bank of England. Monthly data on repos of credit institutions in the Euro Area is available from the European Central Bank. The

[4]It is important to note that there is no comprehensive collection of data on repo contracts. As such, the data we rely on does not capture the amount outstanding of contracts in the repo markets as a whole, but those reported by US primary dealers. Given that these are primary dealers, we consider developments in their operations to be representative of other market participants, while acknowledging the data limitation.

sample period starts in January 2000, up until the end of 2014.[5]

Table 1 (Panel a) reports the descriptive statistics of the repo data. The US repo market is the largest, with an average amount outstanding of nearly $2tn, followed by the European repo market with $673bn. The amount outstanding in the UK market is around $123bn. The repo markets in these countries exhibit very strong comovement, with correlation coefficients between amounts outstanding of over 70%.

3.2 House price data

To measure house prices, we employ the Bank for International Settlements (BIS) dataset of residential house. Our sample includes both advanced and emerging markets.[6] Advanced countries include Australia, Canada, Denmark, Hong Kong, Iceland, Israel, Japan, Korea, New Zealand, Norway, Singapore, Sweden, Switzerland, and Taiwan. The emerging market subsample consists of Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Czech Republic, Estonia, Hungary, India, Indonesia, Latvia, Lithuania, Malaysia, Mexico, Peru, Philippines, Poland, Russia, Serbia, Slovak Republic, Slovenia, South Africa, Thailand, and Uruguay. We supplement the BIS dataset with the FRED residential house price indexes[7] and other sources when longer time series are available. We report the details of sources and data sample availability in Table 1A in the Appendix. All series are converted to 2010 base year, adjusted for seasonality, and deflated with the CPI. The sample period starts in January 2000, up until the end of 2014.

Table 1 (Panel b) reports descriptive statistics of changes in house prices. The average quarterly change in house prices for the period is around 0.7%, with larger changes in advanced economies at 0.8% on average than emerging markets at 0.5% on average. Overall, house prices exhibit great variation in both advanced and emerging markets, with standard deviations of 2.1% and 3.4%,

[5]The sample period is determined by the availability of macroprudential policy indicators.

[6]Classification of countries according to the World Economic Outlook of the IMF, 2000.

[7]The authors acknowledge use of the dataset described in Mack and Martinez-Garcia (2011).

respectively.

3.3 Macroprudential policy

In order to investigate the effectiveness of countries' responses to global shocks and house price dynamics, we rely mainly on the publicly available database of prudential instruments developed by Cerutti et al. (2017b). Prudential policy tools are non-monetary measures targeted at financial stability that can be directed at individual institutions or are system wide. Macroprudential policy comprises measures adopted to limit the risks to financial stability arising at systemic level. These include requirements on capital, provisioning, liquidity, and loan eligibility (Galati and Moessner, 2013). Data on macroprudential measures is available for all countries in our sample at quarterly frequency from 2000 to 2014. In addition to its comprehensiveness in terms of countries and time period, we rely on this database because its accuracy and completeness have been reviewed by staff from Central Banks participating in the International Banking Research Network and the IMF. We supplement the database with data from Kuttner and Shim (2016) and Cerutti et al. (2017a), where necessary. We give details on sources and construction of the indicators in Table 2A in the Appendix. We divide the macroprudential policy measures into those targeting the banking sector, those targeting foreign investors, and those targeting the housing market directly.

Macroprudential banking policy

Banking policy measures are those macroprudential instruments that target the banking sector directly. Among these, we focus on *liability side measures*, such as reserve requirements.[8] Reserve requirements are the fraction of account deposits in local currency to be held as deposit with the Central Bank or cash. Moreover, we look at *capital and provisioning requirements*, such as capital

[8] Although included in macroprudential databases by Kuttner and Shim (2016) and Cerutti et al. (2017b), reserve requirements are also part of monetary policy (Borio and Shim, 2007; Crowe, Dell'Ariccia, Igan, and Rabanal, 2011; Akinci and Olmstead-Rumsey, 2018).

buffers, limits to bank concentration, limits to interbank exposure, and bank leverage ratios. Capital buffers are requirements for banks to hold capital in proportion to their risk-adjusted total assets, as determined by the Basel Accord.[9] Limits to interbank exposure and bank concentrations are defined by the Basel Committee at or above 10% of eligible bank capital towards a counterparty. The bank leverage ratio is a fixed minimum leverage ratio. Finally, we consider *taxation on activities* that are taxes and levy on revenues of financial institutions. We aggregate all series related to banking in a country and form the *banking policy index* for the country.

Macroprudential foreign currency policy

Some macroprudential policy tools are directly targeting foreign investors (Bruno et al., 2017). As opposed to capital controls, these measures are generally perceived to be more market-friendly and they have been employed extensively since the East Asian financial crisis of the 1997-8 (Ghosh and Qureshi, 2016). We consider foreign currency reserve requirements, i.e., reserve requirements on foreign currency-denominated accounts, and limits to foreign currency loans.

Macroprudential housing policy

Some macroprudential measures adopted are directly targeted at the housing market. The goal to restrict or slow the growth of housing market can be pursued with policies targeting the demand or the supply for housing credit. Targeting the demand for housing credit, *borrower-oriented measures* limit household leverage specific to housing loans irrespective of the type of lender. They include caps to LTV, caps to debt service to income (DSTI), and housing-related taxes. Caps on LTV are limits to the maximum amount a borrower can borrow against the real estate collateral. Caps on DSTI are limit to the monthly payments on housing loans over income. Housing related taxes

[9] As evidence of blurred boundaries between policy tools, capital buffers may consider also as microprudential policy (Cerutti et al., 2017b).

are taxes on capital gains, wealth, subsidies for first time buyers, stamp duty, and tax-deductible mortgage payments. From the supply side, *housing credit supply measures* are directed at lenders, specifically domestic banks and comprise capital buffers for housing loans, limits to banks' exposure to housing, and loan loss provision (LLP) for housing loans. Capital buffers for housing loans are a subset of the indicator for bank capital requirements that are specific to housing loans. Limits to banks' exposure to housing are limits to the supply of housing loans and generally expressed as a % of equity, whereas LLP for housing loans are provisions for impaired housing loans. We aggregate all series related to housing in a country and form the *housing policy index* for the country.

We take indicators of quarterly changes for all instruments. We then follow the literature and cumulate the series since the first quarter of 2000 to capture the macroprudential stance in our sample period with respect to each instrument (Akinci and Olmstead-Rumsey, 2018). The cumulated indexes for banking (including foreign currency measures) and housing policy are shown in Figure 1, Plot c. The group measures for the advanced and emerging markets are obtained by averaging the indexes for the countries in each of the group. It is important to note that these cumulated indexes capture the paths of policy implementation relative to the 2000 level. Hence, caution must be used, because countries may have started in 2000 at different levels (Cerutti et al., 2017b). Noting this limitation of the database, the plots show that there has been a general upward trend in the use of macroprudential policy. Looking at banking macroprudential policy, advanced economies have adopted this policy after the recent financial crisis. In contrast, emerging markets have relied on this policy since the early 2000s, with a temporary sharp retraction during the financial crisis. Capital buffer accounts for most banking policy actions in advanced economies, whereas local currency (LC) and foreign currency reserve requirements account for the majority of policy actions in emerging markets (Table 2).[10]

[10]For comparability, in Table 2 we turned the series of number of policy actions into indicators of 1 for tightening,

Turning to housing policy, emerging markets have increasingly adopted this policy, with a retraction during the financial crisis. In contrast to banking policy, advanced economies have relied on housing policy also in the period leading to the financial crisis. Caps to LTV have been employed extensively both in advanced and emerging markets, followed by house taxation, and housing-specific capital buffers for emerging markets (Table 2).

Table 2 show that advanced economies mostly relied on housing measures, with 115 policy actions from 2000 to 2014, versus 52 banking policy actions. Emerging markets have used extensively all policy tools, especially banking measures with 286 policy actions in our sample period, followed by 140 policy actions in housing policy and 106 actions in foreign currency measures.

Comparing the individual policy measures adopted by the countries, the average correlation of banking policy measures is low at -1%.[11] However, it is important to note that correlation coefficients between policy pairs vary widely, from 29% between capital buffers and limits to interbank exposures, to -29% between limits to interbank exposures and concentration exposures. Turning to housing policy measures, the average correlation is 20%. In this case, almost all correlation coefficients are positive, with correlation coefficients as high as 68% for caps to LTV and caps to DSTI, and as low as 3% and -26% for capital buffers for housing loans versus caps to DSTI and housing taxes, respectively. Hence, while some measures are likely to be adopted together, that is not always the case.

3.4 Other policy measures - monetary policy and capital controls

Countries may use monetary policy and controls on capital account convertibility to reduce vulnerability to global shocks.

-1 for loosening and 0 for no changes in the policy in the quarter. Then the number of actions is calculated as the sum of the absolute value of the indicators, and summed within country groups.

[11] This value is calculated as the average of the correlation coefficients between pairs of policy measures cumulated for each country at December 2014.

In order to measure monetary policy outcomes, we employ short-term interest rates. Money market rates are available for most countries from the IFS (IMF). For those countries with no information on money market rates, we employed other proxies for short-term rates.[12]

With respect to capital controls, we consider controls to real estate investments by foreign residents that take the form of required authorization, approval, permission, clearance, and ceiling limits, as indicated in AREAER reports of the IMF. We employ the indicator from Fernández, Klein, Rebucci, Schindler, and Uribe (2015). Moreover, we consider general controls on capital account convertibility, the KAOPEN index by Ito and Chinn (2006). We report details on the construction of these measures in Table 2A in the Appendix.

4 Do funding liquidity conditions affect house prices?

Our implied model of the channels of how global liquidity affects house prices is shown graphically in Figure 2. In essence the local and foreign owned local banks in the domestic countries reach to the global banks in the various financial centers for funding resulting in cross-border bank flows, which enable the banks to lend to the domestic market and part of this credit will find its way to the housing market. Thus, liquidity conditions of the global banks, which is captured in our framework by the amount of repos will be transmitted to the housing market through cross border bank flows. There are also the institutional investors, such as REITs, who might tap the repo market directly, as well as the foreign real estate investors who might be investing in the housing market contributing to the rise in house prices. As it can be seen, the various channels can be intercepted by macroprudential policies. Our first task is to investigate whether shocks in funding conditions in the major financial centers have an impact on bank flows and house prices.

[12] In particular, discount rates from the IFS (IMF) are used for Chile, China, and India, and deposit rates from the IFS (IMF) are used for Croatia. For Norway, we used the short-term interest rates from the OECD. For Taiwan, we use short-term rates from the Central Bank.

For that purpose we estimate a PVAR model of funding liquidity and house prices, including global variables such as global output as a proxy of global demand for liquidity, and domestic variables such as bank flows, real GDP growth, and short term interest rates as proxies for local demand factors for housing, as follows:

$$X^s_{i,q} = \sum_{n=1}^{N} \beta_i X^s_{i,q-n} + \epsilon_{i,q} \qquad s = [AGGR, US, UK, EU], \tag{1}$$

where $X^s_{i,q} = [Liq^s_q, WorldGDP_q, bank_{i,q}, GDP_{i,q}, sr_{i,q}, Price_{i,q}]$, Liq is the funding liquidity conditions in financial system s, $WorldGDP$ is the world real GDP growth, $bank$ is the bank flows measured in country i, GDP is real GDP growth in country i, sr is the short term interest rate in country i, and $Price$ are house prices in country i. All variables except for GDP growth, bank flows and interest rates are in logs.[13] We determine the number of lags n with the Schwarz criterion and it ranges between 1 to 2 lags.[14]

We focus on the impact of one standard deviation shock on funding liquidity in each of the main financial centers on the local house prices of countries in advanced and emerging markets. To avoid imposing restrictions on the slope coefficients of house prices across various countries, we employ the mean group estimator of Pesaran and Smith (1995). In essence, this is a dynamic panel estimation approach that allows for full country heterogeneity. We estimate a VAR for each country individually via OLS and estimate the impulse response functions (IRFs) by employing the Cholesky decomposition of the covariance matrix of the VAR residuals. Since we consider funding conditions in the main financial systems to be exogenous to domestic conditions and local house prices, we order our funding variables first. Moreover, we put house prices last in the order to allow for bank flows, short-term interest rates, and GDP growth to impact house prices. To exclude

[13] Description and sources of the data are given in Table 1A in the Appendix.

[14] We allow a maximum of 2 lags to account for the relatively short time period of data for some countries in our sample.

that our results are driven by this ordering, we also compute the IRFs with alternative orderings. We confirm that placing our funding liquidity variable last in the order, or just before house prices, does not alter the results. In unreported results, we also find weak correlation coefficients between VAR innovations, leading us to confirm that the contemporaneous correlation among shocks in the system is negligible.[15] We measure the average effect of the shock across countries by averaging cross-country responses at each forecasting horizon, excluding the top and bottom 1%. The standard errors of such measures are calculated as the cross-country variance of the responses at each forecasting horizon, divided by the number of countries minus one (Pesaran and Smith, 1995).

We report the IRFs of house prices to shocks to funding liquidity originating in the US, EU, and UK in Figure 4 for advanced economies (Panel a) and emerging markets (Panel b). Overall we find that liquidity shocks affect both advanced and emerging markets. In advanced economies, house price responses increase to 0.4% on average and they are short-lived, turning insignificant within one year. The responses are stronger and more persistent in emerging markets, where they increase to 0.6% after one year and turn insignificant after over two years. We find similar responses to shocks originating in the US alone. This is in line with the results of Cesa-Bianchi et al. (2015), who employ a US based set of instruments and document a stronger and longer lasting impact of global liquidity shocks on house prices in emerging markets than advanced economies. Finally, house prices also respond to shocks originating in the EU and UK, although the impact in advanced economies peaks at only 0.2%, around half the peak response to US shocks. House price responses in emerging markets are overall comparable irrespective of the origins of the shock. This brings out the importance of considering the impact of global liquidity originating in financial centers other than the US.

[15] Results are unreported for brevity, but they are available from the authors upon request.

Turning to bank flows, we find that global liquidity shocks affect bank flows in advanced and emerging markets (Figure 4, Panels a and b, respectively). When liquidity increases unexpectedly, bank flows increase in all countries, signalling the important role that banks play in the transmission of global shocks to the real economy. We document that bank flows are quick to respond to global liquidity shocks and the impact is short-lived, with responses that last up to one quarter in advanced economies and two quarters in emerging markets. Then, this relatively quick effect gets channelled across borders and, as credit enters the local banking sector, it triggers longer lasting effects in domestic housing markets.

4.1 Robustness tests

We perform two robustness exercises in order to test the validity of the VAR model by using other proxies employed in the literature and by investigating the stability of our results to the crisis period.

4.1.1 Alternative sources of global liquidity shocks

In addition to measuring global liquidity as funding availability to financial intermediaries in the main financial centers, we turn to other factors that may capture global liquidity. First, we consider the leverage of broker dealers in the US as a proxy for financing conditions of global banks. Second, we employ the VIX to proxy for the global conditions that may affect banks' willingness to extend funding across border. Finally, we consider the cost of funding for financial intermediaries in the US and employ the TED spread.

We report the results in Figure 5. Overall, we confirm that global liquidity shocks affect house prices employing these alternative liquidity proxies. House price responses to US banks' leverage shocks are comparable in shape and persistence to the IRFs to aggregate funding liquidity shocks documented above, but the responses are lower in magnitude for advanced economies, with peak

at 0.25%. The VIX and TED spreads have longer lasting impact on house prices in advanced economies, with responses turning insignificant after over one year. Looking at emerging markets, the responses to shocks to US banks' leverage and the VIX are comparable, while they are weaker for shocks to TED spreads.

4.1.2 The global financial crisis

In the period leading up to the global financial crisis, countries experienced large bank flows coupled with increasing house prices. In this section, we look at the impact of global conditions on house prices during this period and estimate the VAR model in equation (1) up to 2008. In Figure 6 we document the pre-crisis responses, which are stronger and more persistent for both advanced and emerging markets, as compared to the IRFs for the whole sample period. In advanced economies (Panel a) house prices increase to 0.8% after three years on average, whereas in emerging markets (Panel b) house prices increase to 0.9% in the first year after the liquidity shock. The impact is persistent and turns insignificant only after around five years. These findings are consistent with the key role that banks played in the dynamics of global liquidity in the period leading up to the crisis. Indeed, they highlight the consequences of this role for the exposure of housing markets around the world to global liquidity.

We do not estimate the PVAR for the periods during and post crisis due to the relatively short time period resulting in a low number of observations. Nonetheless, we check the structural stability of our VAR estimations employing the maximal OLS cumulative sum (CUSUM) test for coefficient stability. The test cannot reject the null of coefficient stability for 78% of the equations in the VAR. Hence, we document that our findings are robust across our sample period.

5 Impact of domestic monetary policy on house prices

Countries can adopt monetary policy to offset the impact of global shocks on the domestic housing market.[16] Looking at the impact of one standard deviation shock of the domestic short-term interest rates on local house prices in Figure 7, we document a negative reaction of house prices in both advanced and emerging markets to a contractionary domestic monetary policy. The responses are not immediate, and house prices decline in both advanced and emerging markets by around -0.4% and -0.3% respectively after one year from the one standard deviation shock in monetary policy. Similarly to liquidity shocks, the responses are relatively more short lived in advanced economies, where they turn insignificant after two years. Although the average responses to global liquidity shocks and monetary policy are comparable in advanced economies, in emerging markets house prices respond less to monetary policy shocks than global liquidity shocks (-0.4% and -0.3% versus 0.6%). This suggests that monetary policy may not be fully effective to counter global liquidity shocks in emerging markets as opposed to advanced economies.

5.1 Forecast error variance decomposition

We now perform forecast error variance decomposition to assess the relative role of global liquidity versus domestic monetary policy on house price developments. In particular, we compute the contribution of shocks to global liquidity and domestic short-term rates to the forecast error variance of house prices for VAR models estimated for each country in the sample as reported in equation (1). We employ recursive re-formulation of the VAR model and use the Cholesky decomposition to achieve orthogonal structural shocks.

Although we have found global liquidity to impact house prices, the question arises whether it is sufficiently large to weaken the effectiveness of domestic policy in the presence of increased

[16] For a detailed analysis of the impact of monetary policy on house prices see Sa et al. (2011).

global liquidity. An unanticipated increase in short term domestic interest rates constitutes a contractionary monetary policy, which has been found as expected to have a dampening effect on house prices. On the other hand an increase in global liquidity has a positive impact on house prices.

Table 3 shows the percentage of the total forecast error variance of house prices at horizons of n={1,4,8,12,16,20} quarters that can be ascribed to global funding and to domestic interest rate shocks. The variance decomposition reveals a different pattern for advanced and emerging markets. For the advanced economies 17% of the forecast error variance 20 quarters ahead can be ascribed to global liquidity shocks and 15% to domestic monetary policy shocks. That implies that monetary policy is potentially quite effective in advanced markets in moderating the impact on house prices arising from global liquidity. This finding is in line with the results of Darius and Radde (2010), who using a monetary aggregate definition of global liquidity find that liquidity lost predictive power of asset prices completely, including house prices in the G7 countries during the 2000s. Their explanation is that this is due to the expansionary monetary policies, which played a much greater role than global factors in house price developments.

Looking now at emerging markets 21% of the forecast error variance 20 quarters ahead can be ascribed to global liquidity shocks and 17% to domestic monetary policy shocks. Similarly for the emerging markets as well domestic monetary policy is effective and might mitigate the impact of global liquidity shocks on house prices.

6 Can macroprudential policy mitigate the impact of global liquidity on house prices?

Having established that domestic monetary policy is effective in both groups of countries in mitigating the countries' exposure to liquidity shocks, we now turn our attention to macroprudential

policies, that have been increasingly used by all countries, to examine their effectiveness in moderating the impact of global liquidity on house prices.

Following Towbin and Weber (2013) and Sa et al. (2011), who study the effect of certain country characteristics on countries' exposure to external shocks, we use macroprudential policy variables as indicators and condition the global liquidity shocks on house prices to the intensity of the macroprudential policy stance adopted by countries. To do so, we interact global liquidity with the macroprudential policy indicators in the VAR models in equation (1). The interacted term allows us to exploit the time and cross-section variation of the macroprudential policy indicators and compute the IRFs of global liquidity shocks on house prices as outlined in Section 4, conditional on the macroprudential policy stance.[17] We set the threshold levels for tight and loose macroprudential policy stances at 75% and 25%, respectively, and we compute the average IRFs for countries in each group. By examining the differences between the IRFs for tight and loose macroprudential policy states across countries and time, we can determine whether the policy measures are potential drivers of the exposure of the housing markets to global liquidity. We conduct this exercise for each policy measure.

Countries may also reduce their exposure to global shocks by imposing controls on their capital account. Thus, we investigate the role of a specific capital control policy targeted at foreign investors and relevant to the housing market, such as controls on real estate investments by foreign residents. In addition, we consider the effectiveness of general capital controls. We follow the same procedure described above to calculate the impact of liquidity shocks on house prices for countries with stronger and weaker capital controls.

Figures 8 - 10 report the IRFs of house prices to liquidity shocks for loose macroprudential policy stances in the top row, tight macroprudential policy in the middle row, and their mean

[17] We do not censorize the responses to calculate the average IRFs due to limited cross sections.

difference in the bottom row, for the each type of macroprudential policy. The effectiveness of the policy measures is also summarized in Table 4. We assess each type of policy below, starting with the macroprudential banking policy indicators:

Banking policy (Figure 8): For advanced economies in Panel a, we find capital requirements and leverage ratios to shield countries from global liquidity shocks, with positive responses of house prices that last beyond five years in the case of loose capital requirements and leverage ratios, and mostly insignificant responses for tight policies. The mean differences of the responses are significant as well in the short-term. LC reserve requirements do not have a significant effect on global liquidity shocks, since responses for loose and tight requirements are not significantly different from each other. This also applies to other banking-related measures, such as limits to bank concentration and limits to interbank exposure. Finally, taxes on bank activities are only rarely used in advanced economies.

Turning to emerging markets in Panel b, we find that capital requirements, limits to bank concentration, limits to interbank exposure, and taxes on bank activities reduce the impact of global liquidity shocks on house prices, but do not shield countries from them. Indeed, IRFs are generally positive and persistent irrespective of the policy stance, but the mean differences between loose and tight policies are generally positive and significant, with 1 or 2 percentage points of difference in the peak house price responses. The evidence on LC reserve requirements is not conclusive, with no significant responses for either loose or tight policies and with differences that are negative at first and turn positive later on.

These findings are indicative of the important role that the domestic banking sector plays in the transmission of global shocks to housing markets (Cesa-Bianchi et al., 2015), especially in emerging markets. As global financing conditions improve, bank flows may lead to greater availability of resources for domestic banks. The subsequent availability of domestic credit leads to

house price increases. However, the imposition of macroprudential measures increases the cost and limits banks' operations thus reducing the extent to which easing global conditions are reflected in growing domestic credit conditions (see Figure 2 for a graphical scheme of this barrier to the transmission of global shocks to local housing markets).

Housing policy (Figure 9): In advanced economies in Panel a, housing-specific measures appear most effective to shield domestic housing markets from the effects of global liquidity. Indeed, when measures such as caps to LTV and DSTI and housing-related capital requirements are tight, house price responses are mostly insignificant, whereas the responses for loose policies are positive and significant. The mean differences are also positive and significant for both caps to LTV and DSTI and capital requirements. Among the most used measures, housing taxation does not appear to reduce the impact of global liquidity shocks as tight measures are significant at longer horizons and mean differences are not statistically significant. This also applies to relatively less used instruments such as limits to banks' exposure to housing and provisions for housing loans for the responses for loose and tight limits and housing provisions for housing loans are not significantly different from each other.

Turning to emerging markets in Panel b, the widely used borrower-oriented measures (caps to LTV and taxation on housing) reduce the impact of global shocks on local house prices. Although house price responses are significant for both loose and tight policy stances, the mean differences are positive and significant, especially for housing taxation. Measures oriented towards housing credit supply do not appear to shield countries successfully from global liquidity shocks for the responses for loose and tight measures are not significantly different.

These findings are consistent with the conclusions of the literature that housing-related measures generally reduce house prices and bank credit growth (Lim et al., 2011; Kuttner and Shim, 2016; Zhang and Zoli, 2016; Akinci and Olmstead-Rumsey, 2018; Bruno et al., 2017). To note that while

the literature finds that caps to LTV are unable to affect house prices directly (Zhang and Zoli, 2016; Cerutti et al., 2017b; Craig and Hua, 2011; Igan and Kang, 2011; Cerutti et al., 2017a; Kuttner and Shim, 2016; Vandenbussche et al., 2015), we show that this measure is effective in reducing countries' exposure to global liquidity shocks. Another measure extensively used, housing taxation, successfully reduce the effects of global shocks in emerging markets, in line with Kuttner and Shim (2016) who document that tightening of housing taxation significantly reduces house prices. In conclusion, we find general support for the effectiveness of measures targeting both borrowers and lenders in mitigating the exposure of housing markets to global liquidity shocks.

Foreign currency measures (Figure 10): Whilst not used in advanced economies, emerging markets rely on foreign-currency measures. In Panel b, we show that house price responses in emerging markets are stronger when foreign currency reserve requirements and limits to foreign currency bank loans are loose, especially in the short run. Consistently, the literature has documented that these instruments significantly reduce bank flows to emerging markets (Ostry et al., 2012; Bruno et al., 2017), and their benefits extend beyond countries to the region (Beirne and Friedrich, 2014). Foreign currency measures are thus effective in mitigating the effects of foreign credit on local housing markets (see Figure 2).

Capital controls on foreign investors (Figure 10): The IRFs in Panel a show that house prices in advanced economies are affected by global liquidity shocks irrespective of the capital account policy. Conversely, in Panel b we can see that house prices in emerging markets are positively and significantly affected by global liquidity shocks only when general and real estate specific capital controls are looser. Indeed, the responses are insignificant in the middle row, when both capital controls are tight. The differences between the mean IRFs is positive and significant for the real estate specific capital controls, whereas it is negative for general capital controls. Thus, we document that capital controls targeted specifically at foreign investments in real estate prove

effective in mitigating the impact of changes in global financing conditions on the local housing market in emerging markets. In particular, adopting restrictions on foreign investments in real estate measures significantly restrict the entrance of foreign investors, which is one of the channels through which global financing conditions affect the housing markets (Figure 2).

In conclusion, we document that the adoption of macroprudential policy can reduce the exposure of countries to global liquidity shocks. In particular, we find that housing policy tools are more effective in advanced economies than emerging markets. Conversely, banking policy measures are more effective in emerging markets. This is in line with the evidence that countries adopt policies for different reasons. Akinci and Olmstead-Rumsey (2018) suggest that advanced economies use housing-related macroprudential policy to tackle house price dynamics, whereas emerging markets rely on general macroprudential policy for credit growth. Interestingly, we document that widely used measures such as caps to LTV are effective to reduce the impact of global liquidity shocks in both advanced and emerging markets.

7 Conclusion

The paper investigates the impact of global liquidity on house prices around the world and the effectiveness of government policies to tackle this exposure. We introduce a new measure of global liquidity, which focuses on the private component of liquidity on the major wholesale funding markets for financial intermediaries, that is the repurchase agreement (repo) market not only in the US, but also in the UK and Europe. Changes in the availability of financing in the main financial systems may affect house prices via the funding channel that transmits global conditions into the local banking sector through bank flows. In line with previous findings we document that global liquidity triggers house price movements around the world (Darius and Radde, 2010; Tillmann, 2013; Cesa-Bianchi et al., 2015). However, our analysis adds insights to this linkage. Indeed, we

find that the effect does not only originate from the US, but also from the other systematically important financial systems.

After establishing the exposure of countries to global shocks, we turn to the analysis of the effectiveness of macroprudential and monetary policy. Indeed, we ask whether these tools may reduce countries exposure to global shocks. While a nascent literature has investigated the effect of macroprudential policy on house prices and credit growth, this is to the best of our knowledge the first study to look at its ability to shield countries from global shocks. Interestingly, we document a strikingly different effectiveness of these policies in advanced and emerging markets. While both advanced and emerging markets can employ monetary policy to mitigate the exposure of their housing markets to global shocks, macroprudential policy tools have different effectiveness. Advanced economies can rely on macroprudential instruments, especially housing-related and a few banking measures, to shield their housing markets from global shocks. On the other hand, we find banking macroprudential instruments in emerging markets to be effective in reducing the exposure but not in shielding countries from global liquidity shocks. We show that only specific housing tools that target borrowers can reduce the impact of global shocks on house prices, namely caps to LTV and housing taxes. Importantly, emerging markets can adopt not only foreign currency macroprudential policy measures, such as reserve requirements on foreign currency accounts and limits to foreign currency loans, but also focused restrictions to non-resident investments in the local real estate sector, which have been found to be effective in limiting the liquidity impact on house prices.

Our analysis has shown that governments have a number of policy instruments at their disposal to mitigate of global liquidity on their real estate sector.

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Appendix

Table 1A: Description of the variables included in the analysis

Variables	Data source
Global liquidity proxies	
Amount outstanding of repos in the US	Federal Reserve Bank of New York
Amount outstanding of repos in the UK	Bank of England
Amount outstanding of repos in EU	European Central Bank
US broker dealer leverage	Board of Governors of the Federal Reserve System
VIX	CBOE
TED spread for US, UK, and EU	FRED database, Bank of England and Datastream
House prices	
Brazil (from 1Q2001), Canada, Chile (from 1Q2002), Colombia, Czech Republic (from 1Q2008), Estonia (from 3Q2003), Hong Kong, Iceland, Indonesia (from 1Q2002), Israel, Korea, Lithuania, Malaysia, Mexico (from 1Q2005), New Zealand, Norway, Peru, Philippines (from 1Q2008), Poland (from 3Q2006), Russia (from 1Q2001), Serbia, Singapore, South Africa, Sweden, Switzerland, Thailand	BIS dataset of residential house prices
Australia, Croatia, Denmark	FRED residential price indexes
Argentina (from 4Q2006)	Buenos Aires Statistics and Census
Bulgaria (from 2001)	EUROSTAT
China (from 2000)	National Bureau of Statistics of China
Hungary	Central Bank
India (from 2001)	National Housing Bank
Japan, Slovak Republic (from 1Q2005)	OECD
Latvia (from 2000), Slovenia (from 2003)	ECB
Taiwan (from 1Q2001)	Sinyi
Uruguay	National Institute of Statistics
Other variables	
Bank flows measured by external claims (deposits and loans) of reporting banks vis-à-vis banks of each country	BIS Locational statistics
Domestic short-term interest rates	IMF IFS and OECD
Real GDP growth rates (for each country and the world)	IMF WEO

Table 2A: Description of the macroprudential policy indicators and capital controls

Variables	Description	Data source
Macroprudential policy		
Local currency reserve requirements, Foreign currency reserve requirements	Indicator of intensity of change in the policy with numerical positive and negative integers assigned each quarter. Available for all countries from 2000 to 2014.	Cerutti et al. (2017b)
Capital buffer, Capital buffer for housing loans*	Indicator of 1 for implementation and 0 for no change in the quarter. There is no -1 for undo of the implementation of the Basel accord. Available for all countries from 2000 to 2014, except capital buffer for Uruguay.	Cerutti et al. (2017b)
Limits to interbank exposure, Limits to bank concentration, Caps to LTV*	Indicators of 1 for tightening, -1 for loosening, and 0 for no change in the quarter. Available for all countries from 2000 to 2014, except interbank exposure for Brazil, China, Denmark, Hungary, Iceland, Japan, Korea, Malaysia, New Zealand, Norway, Poland, Serbia, South Africa, Taiwan, and Uruguay; and except bank concentration for Denmark, Hungary, Korea, Malaysia, New Zealand, South Africa, Sweden, Taiwan, Thailand, and Uruguay.	Cerutti et al. (2017b)
Leverage ratio, Taxation on activities, Limits to foreign currency loans	Indicator of 1 when the policy is in place, and 0 otherwise. We build indicator of changes to the policy by taking the first difference. Available for all countries except Denmark, Taiwan and Uruguay from 2000 to 2013.	Cerutti et al. (2017a)
Caps to DSTI*, Housing related taxes*, Limits to banks' exposure to housing*, Loan loss provision for housing loans*	Indicator of the number of policy actions taken in a month. We sum the indicator for the months in each quarter to obtain the quarterly series. Available for all countries from 2000 to 2012.	Kuttner and Shim (2016)
Banking policy index, Housing policy index*	Aggregated index. We make the series comparable and turn each measure into indicators of 1 for tightening, -1 for loosening and 0 for no changes in the policy in the quarter. We then sum all related series.	Own calculations
Capital controls		
Capital controls on real estate purchase and sale by nonresidents	Indicator of 1 when controls are in place, and 0 otherwise. Available for all countries except Croatia, Serbia and Taiwan from 2000 to 2013.	Fernández et al. (2015)
General capital controls	Index normalized to take values between 0 and 1 and it is the first principal component of proxies for regulatory controls of both current and capital account transactions, for the existence of multiple exchange rates, and for requirements on export proceeds. Available for all countries except Serbia and Taiwan until 2013.	Ito and Chinn (2006)

Notes: * indicates housing specific macroprudential policy measures.

Table 1: Descriptive statistics

	Panel a. Repo amount outstanding		
	US	UK	EU
Levels ($mil)			
mean	1,904,527	123,430	672,660
median	1,866,380	120,073	581,437
st dev	446,552	34,437	187,779
max	2,687,617	224,015	1,095,294
min	1,199,624	63,175	440,076
Changes (%)			
mean	1.2	1.4	1.1
median	1.5	3.6	1.0
st dev	4.3	11.6	5.2
max	12.6	30.3	11.1
min	-16.7	-41.2	-11.6

	Panel b. Changes in house prices (%)	
	Advanced economies	Emerging markets
mean	0.8	0.5
median	0.7	0.6
st dev	2.1	3.4
max	6.2	8.9
min	-5.2	-9.7

Notes: Descriptive statistics are reported for the funding liquidity measures for each financial system in Panel a. These systems are US, UK, and EU. Panel b reports the descriptive statistics of quarterly changes in house prices for the countries in our sample. Statistics are first calculated for each country and then averaged within subsamples. The advanced subsample comprises Australia, Canada, Denmark, Hong Kong, Iceland, Israel, Japan, Korea, New Zealand, Norway, Singapore, Sweden, Switzerland, and Taiwan. The emerging subsample includes Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Czech Republic, Estonia, Hungary, India, Indonesia, Latvia, Lithuania, Malaysia, Mexico, Peru, Philippines, Poland, Russia, Serbia, Slovak Republic, Slovenia, South Africa, Thailand, and Uruguay. Changes refer to the average quarterly change over the sample period. The sample starts in January 2000 to December 2014.

Table 2: Macroprudential policy actions

	Total	Advanced economies	Emerging markets
Banking policy	338	52	286
LC reserve req.	223	8	215
Capital req.	67	27	40
Bank concentr.	23	6	17
Interbank exp.	15	8	7
Leverage ratios	4	2	2
Taxes	6	1	5
Foreign currency (FC) measures	114	8	106
FC reserve req.	108	6	102
Limits FC loans	6	2	4
Housing policy	255	115	140
LTV cap	83	48	35
DSTI cap	32	17	15
Housing tax	61	28	33
Housing cap req.	45	15	30
Limits housing exp.	10	2	8
Housing LLP	24	5	19

Notes: Number of policy actions per quarter taken by each country aggregated at country group. For comparability, the series of the number of policy actions were turned into indicators of 1 for tightening, -1 for loosening and zero for no changes in the policy in the quarter. Specifically, these series are domestic and foreign reserve requirements, caps to DSTI, housing taxation, housing LLP, and housing limits bank exposure. The number of policy action is calculated as the sum of the absolute values of the indicators, aggregated within subsamples. The advanced subsample comprises Australia, Canada, Denmark, Hong Kong, Iceland, Israel, Japan, Korea, New Zealand, Norway, Singapore, Sweden, Switzerland, and Taiwan. The emerging subsample includes Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Czech Republic, Estonia, Hungary, India, Indonesia, Latvia, Lithuania, Malaysia, Mexico, Peru, Philippines, Poland, Russia, Serbia, Slovak Republic, Slovenia, South Africa, Thailand, and Uruguay. The sample is from January 2000 to December 2014.

Table 3: Forecast error variance decomposition

	Advanced economies		*Emerging markets*	
quarters	Liquidity shock	Rate shock	Liquidity shock	Rate shock
1	8.36	2.18	4.69	5.78
4	11.73	10.17	11.84	10.11
8	13.58	13.69	16.74	14.75
12	15.09	14.33	19.27	16.09
16	16.36	14.53	20.26	16.58
20	17.19	14.72	20.72	16.69

Notes: The table reports the forecast error variance decomposition of house prices of to shocks in funding liquidity and short-term interest rates. All VARs include funding liquidity, world output, bank flows, real GDP growth, short-term interest rates, and house prices. Funding liquidity is measured by aggregate repos. All variables except bank flows, short-term rates and GDP are in logs. The advanced subsample comprises Australia, Canada, Denmark, Hong Kong, Iceland, Israel, Japan, Korea, New Zealand, Norway, Singapore, Sweden, Switzerland, and Taiwan. The emerging subsample includes Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Czech Republic, Estonia, Hungary, India, Indonesia, Latvia, Lithuania, Malaysia, Mexico, Peru, Philippines, Poland, Russia, Serbia, Slovak Republic, Slovenia, South Africa, Thailand, and Uruguay. The sample is from January 2000 to December 2014.

Table 4: Do macroprudential policy measures reduce the exposure of house prices to global liquidity shocks?

	Advanced economies	Emerging markets
Banking policy		
LC reserve req.	not effective	not conclusive
Capital req.	effective	effective
Bank concentr.	not effective	effective
Interbank exp.	not effective	effective
Leverage ratios	effective	NA
Taxes	NA	effective
Housing policy		
LTV cap	effective	effective
DSTI cap	effective	not effective
Housing tax	not effective	effective
Housing cap req.	effective	not effective
Limits housing exp.	not effective	not effective
Housing LLP	not effective	not effective
Foreign currency (FC) measures		
FC reserve req.	NA	effective
Limits FC loans	NA	effective
Capital account controls		
KA control	not effective	effective
Real estate cap. controls	not effective	effective

Notes: The table reports the effectiveness of macroprudential and capital control policies to reduce the impact of global liquidity shocks on house prices. In particular, policies are indicated with *effective* when the impact of global liquidity shocks on house prices is reduced by the implementation of tight policy, as opposed to loose policy, and *not effective* when the impact with tight and loose policy is not significantly different as indicated by the mean differences of the responses. *not conclusive* indicates policies for which effectiveness could not be determined. NA indicates policies that are not widely used and for which effectiveness could not be determined.

Figure 1: **House prices, bank flows, global liquidity, and policy.** The figure reports the quarterly series of house prices (plot a), cross-border bank flows (plot b, left axis - black line) and funding liquidity (plot b, right axis - blue line), and the macroprudential policy index for banking and housing related measures (plot c, left axis - black solid and dotted lines, respectively) , and monetary policy (plot c, right axis - blue line). House prices are averaged within countries in the subsamples and are indexed to 100 in 2010. Bank flows are external claims of BIS reporting banks vis-à-vis the banking sector aggregated across countries and measured in billions of US$. Funding liquidity is the aggregated average monthly amount outstanding of repos in US, UK and EU and measured in trillion of US$. The macroprudential policy indexes are cumulated, aggregated banking and housing related measures averaged across countries in the subsamples. The monetary policy is the short term interest rate averaged across countries in the subsamples. The advanced subsample comprises Australia, Canada, Denmark, Hong Kong, Iceland, Israel, Japan, Korea, New Zealand, Norway, Singapore, Sweden, Switzerland, and Taiwan. The emerging subsample includes Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Czech Republic, Estonia, Hungary, India, Indonesia, Latvia, Lithuania, Malaysia, Mexico, Peru, Philippines, Poland, Russia, Serbia, Slovak Republic, Slovenia, South Africa, Thailand, and Uruguay.

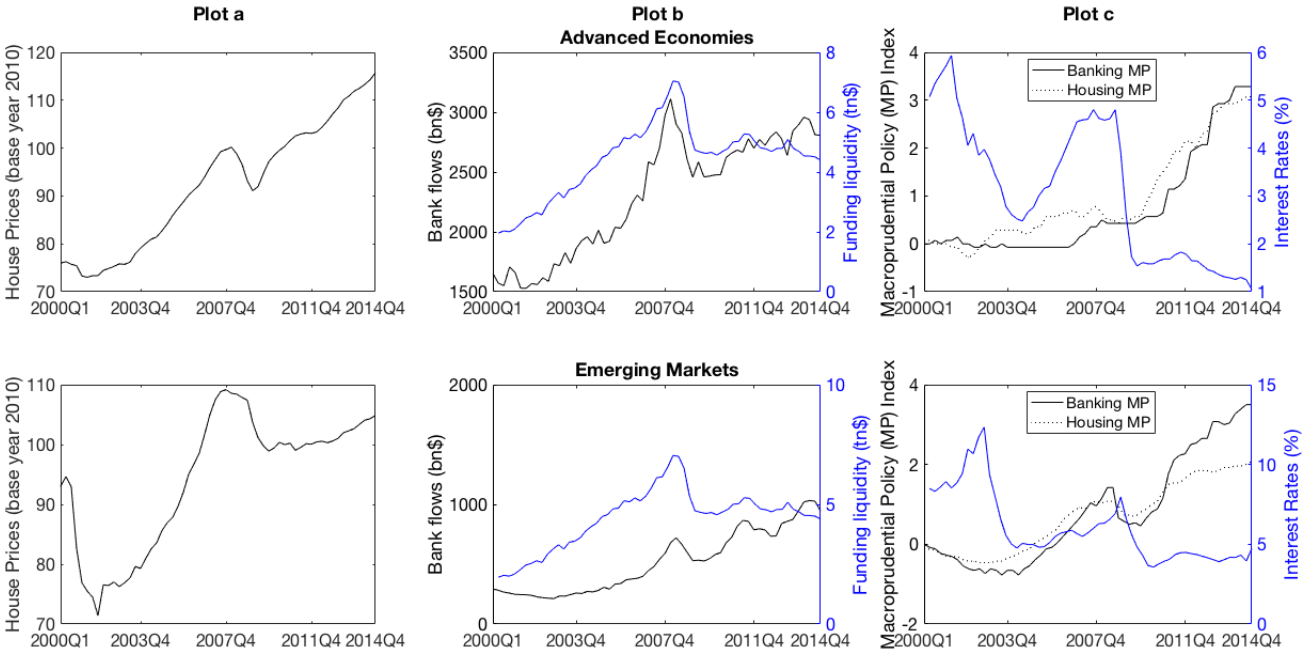


Figure 2: **Global liquidity and house prices - transmission channels and macroprudential policy.** The figure shows the scheme of the transmission channels of the impact of global liquidity on house prices and the role of different types of policy. "Bank MPP" indicates banking-specific macroprudential policy measures, "Housing MPP" indicates the housing-specific macroprudential policy measures,"FC MPP" indicates macroprudential policy measures that target foreign currency lending, "Real estate capital controls" indicates controls on real estate investments by foreigners, and finally REITs stands for real estate investment trusts.

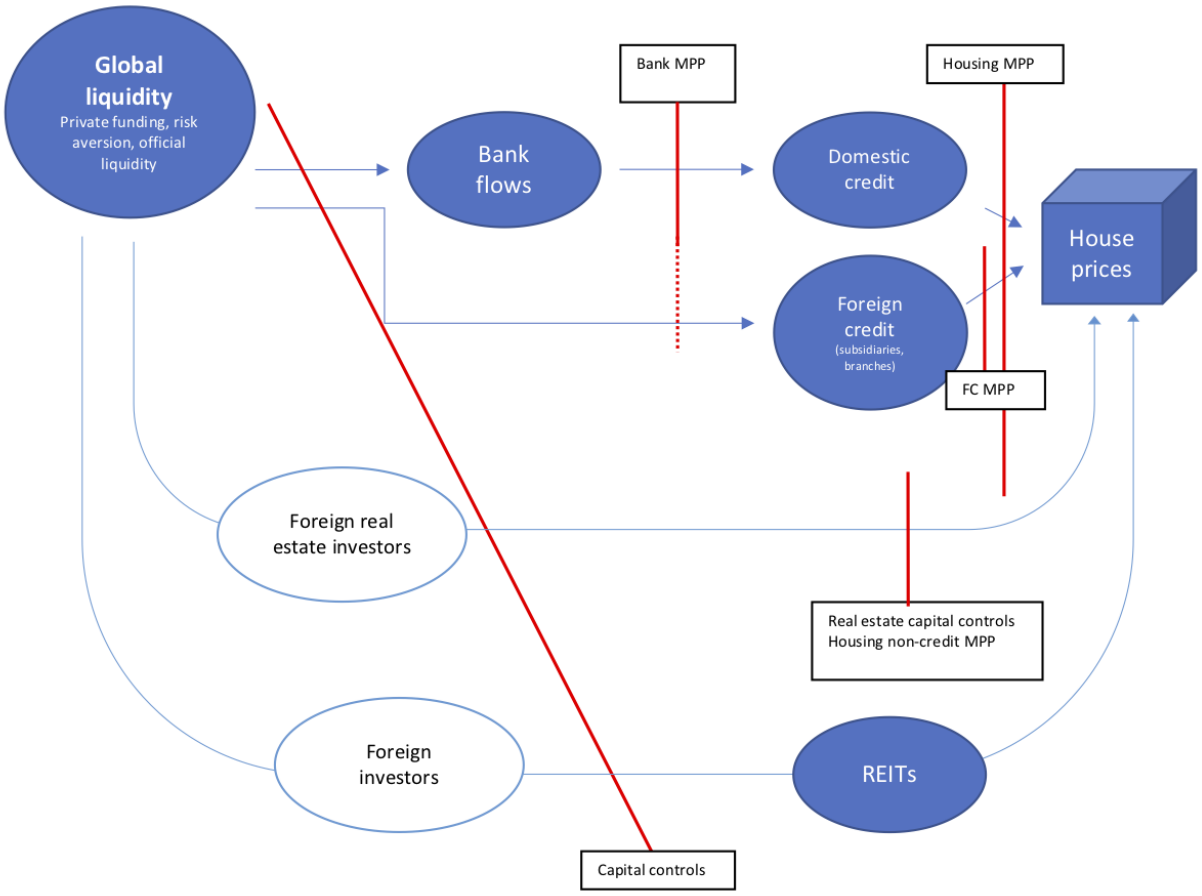


Figure 3: **Global liquidity.** The figure shows the evolution of global liquidity employing a series of measures that capture directly or indirectly funding conditions across borders. *Repos* is funding availability in global financial markets measured by the amount outstanding of repurchase agreements in the US, EU, and UK in trillions US$ (plotted on the left axis - solid line), *TED spreads* are funding cost in the US measured by the difference between the 3-month US LIBOR and Treasury yields in % (plotted on the left axis - dashed line), *Leverage ratio* is the leverage ratio of US broker dealers (plotted on the right axis - dotted line), and the VIX is risk aversion in global markets measured by the implied volatility in S&P500 options (plotted on the right axis - dash-dot line).

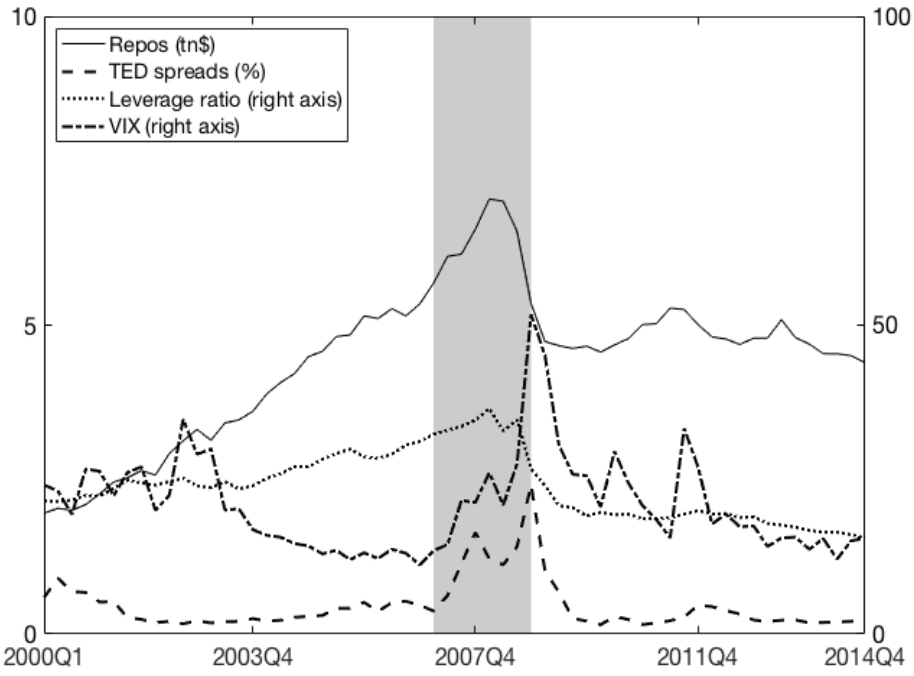
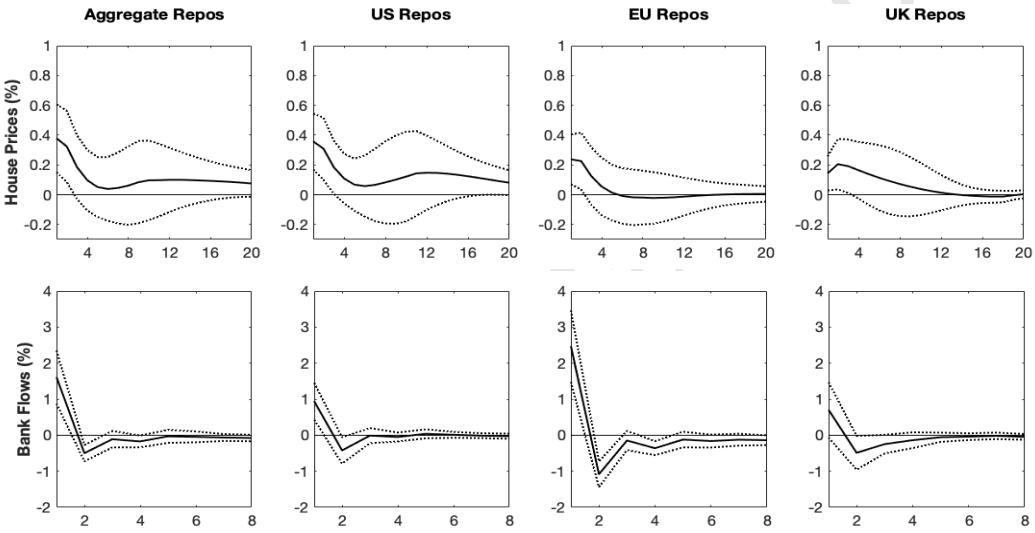


Figure 4: **Global liquidity shocks: Impact on house prices and bank flows.** The solid black lines are IRFs of house prices and bank flows to a one-time shock of one standard deviation in funding liquidity. The IRFs are averaged across countries in advanced economies in Panel a, and in emerging markets in Panel b. The dotted lines are two standard error confidence bands. The VAR models comprise global liquidity, world output, bank flows, real GDP growth, short term interest rates, and house prices, are estimated with 1 or 2 lags and a time trend.

Panel a. Advanced economies



Panel b. Emerging markets

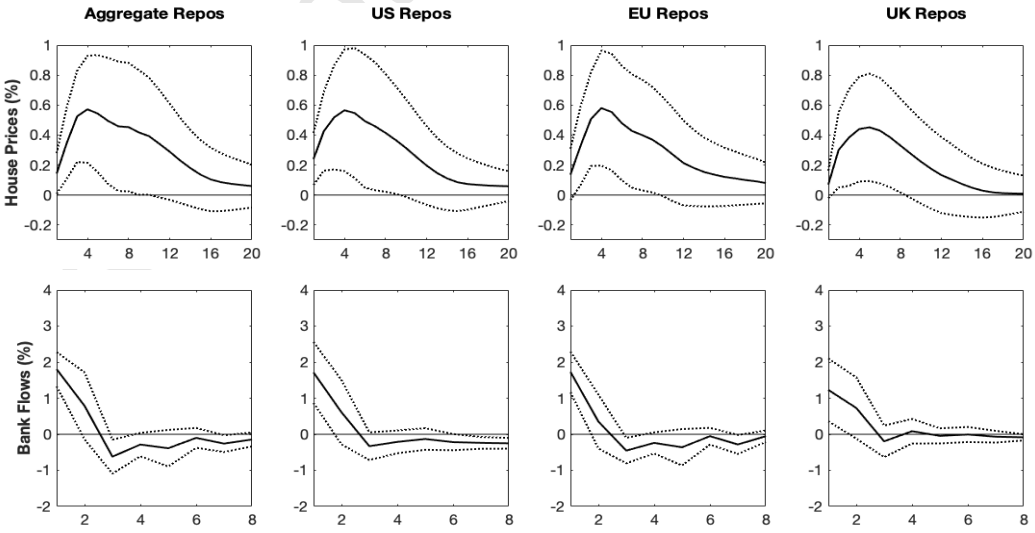
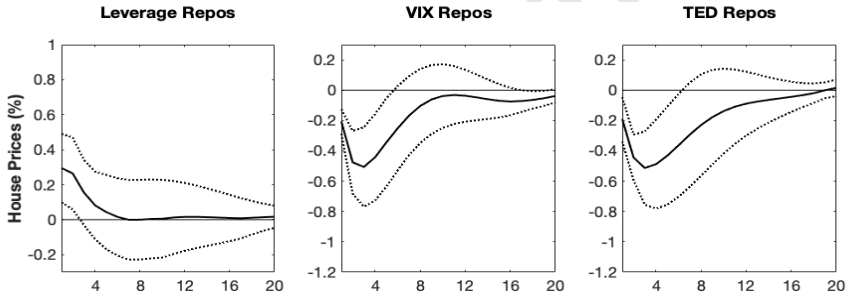


Figure 5: **Alternative sources of global liquidity shocks: impact on house prices.** The solid black lines are IRFs of house prices to a one-time shock of one standard deviation in funding liquidity. The dotted lines are two standard error confidence bands. The VAR models comprise global liquidity, world output, bank flows, real GDP growth, short term interest rates, and house prices, are estimated with 1 or 2 lags and a time trend.

Panel a. Advanced economies



Panel b. Emerging markets

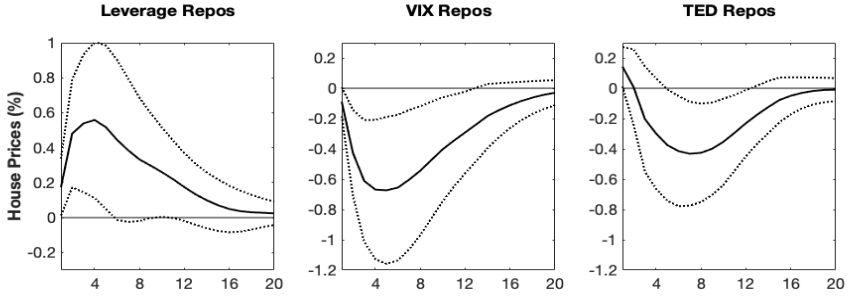
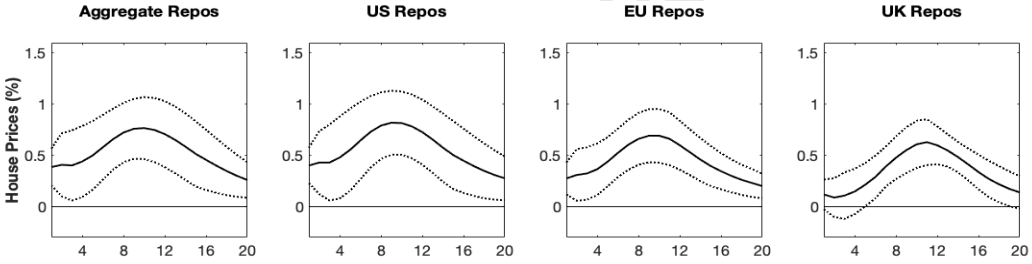


Figure 6: **Global liquidity shocks in the pre-crisis period.** The solid black lines are IRFs of house prices to a one-time shock of one standard deviation in funding liquidity. The dotted lines are two standard error confidence bands. The VAR models comprise global liquidity, world output, bank flows, real GDP growth, short term interest rates, and house prices, are estimated with 1 or 2 lags.

Panel a. Advanced economies



Panel b. Emerging markets

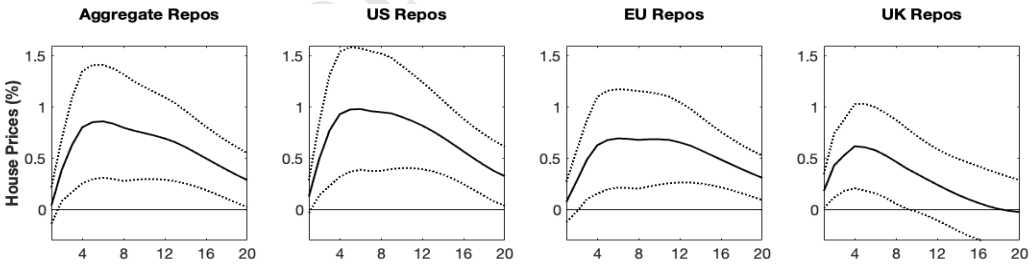


Figure 7: **Domestic monetary policy shocks.** The solid black lines are IRFs of house prices to a one-time shock of one standard deviation in short-term interest rates, averaged across countries in each country group. Country groups are reported in the title, with AEs for advanced economies and EMs for emerging markets. The dotted lines are two standard error confidence bands. The VAR models comprise global liquidity as aggregate repos, world output, bank flows, real GDP growth, short term interest rates, and house prices, are estimated with 1 or 2 lags and a time trend.

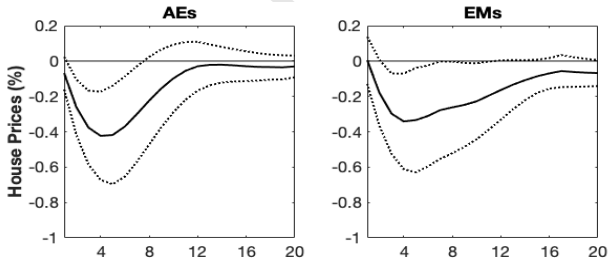
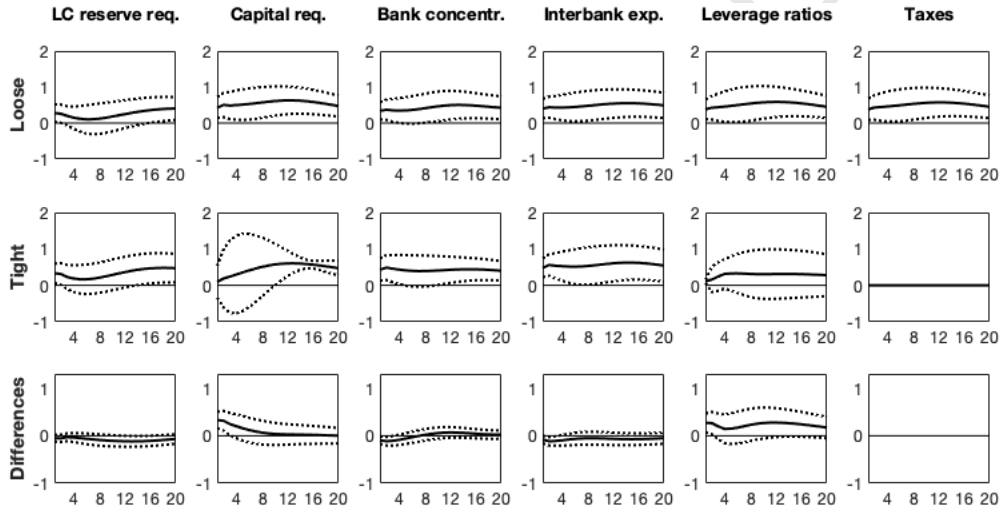


Figure 8: **Policy effect on the impact of global liquidity shocks on house prices (in %): Macroprudential banking policy.** The solid line represents the IRFs of house prices (in %) to a one time shock of one standard deviation in global liquidity. In the top row, the responses are averaged across the bottom 25% of each policy indicator (loose macroprudential policy), in the middle row the responses are averaged across the top 75% of each policy indicator (tight macroprudential policy), and in the bottom row the mean differences (loose minus tight) are reported. The dotted lines are two standard error confidence bands. All VAR models have funding liquidity interacted with the macroprudential policy indicator, together with world output, bank flows, real GDP growth, short-term interest rates, and house prices. Policy measures are noted in the titles of the plots and include: local currency reserve requirements (*LC reserve req.*), capital requirements (*Capital req.*), limits to bank concentration (*Bank concentr.*), limits to interbank exposure (*Interbank exp.*), the fixed minimum leverage ratio (*Leverage ratios*) and taxes on banks (*Taxes*).

Panel a. Advanced economies



Panel b. Emerging markets

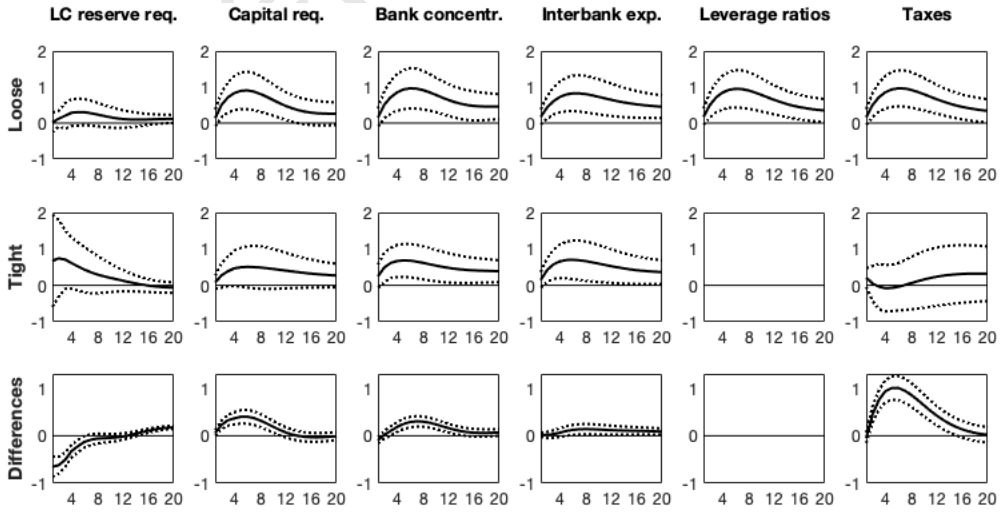
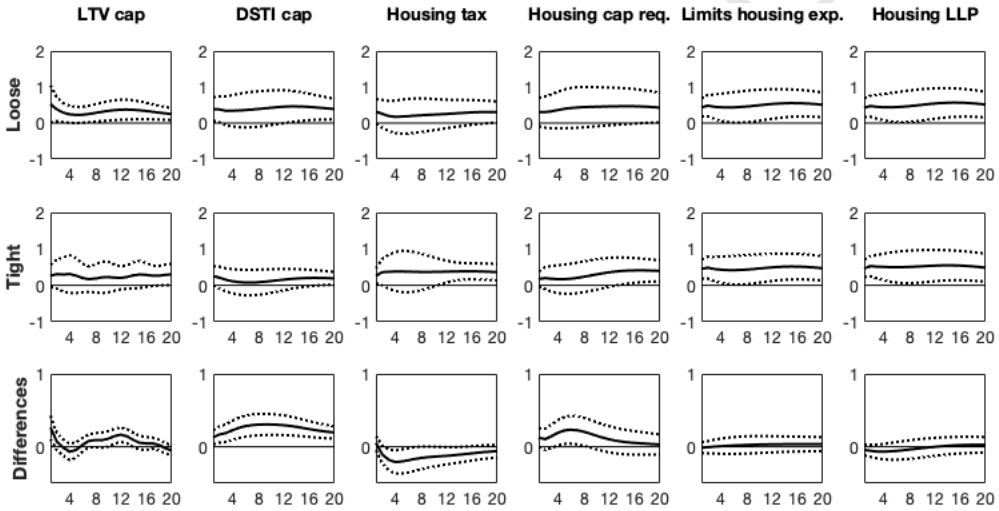


Figure 9: **Policy effect on the impact of global liquidity shocks on house prices (in %): Macroprudential housing policy.** The solid line represents the IRFs of house prices (in %) to a one time shock of one standard deviation in global liquidity. In the top row the responses are averaged across the bottom 25% of each policy indicator (loose macroprudential policy), in the middle row the responses are averaged across the top 75% of each policy indicator (tight macroprudential policy), and in the bottom row the mean differences (loose minus tight) are reported. The dotted lines are two standard error confidence bands. All VAR models have funding liquidity interacted with the macroprudential policy indicator, together with world output, bank flows, real GDP growth, short-term interest rates, and house prices. Policy measures are noted in the titles of the plots and include: caps to LTV (*LTV cap*), caps to DSTI (*DSTI cap*), housing related taxation (*Housing tax*), capital requirements for housing loans (*Housing cap req.*), limits to banks' exposure to housing (*Limits housing exp.*), and provisions on housing loans (*Housing LLP*).

Panel a. Advanced economies



Panel b. Emerging markets

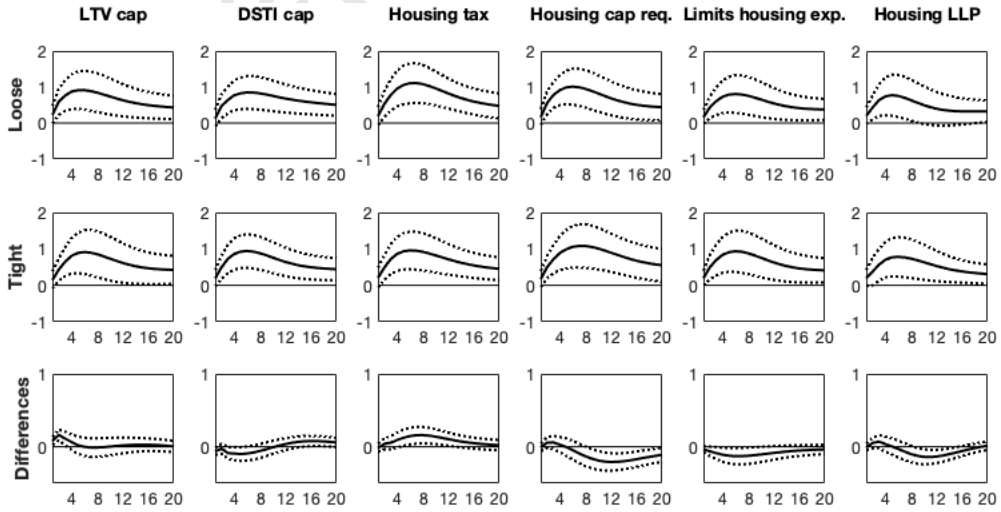
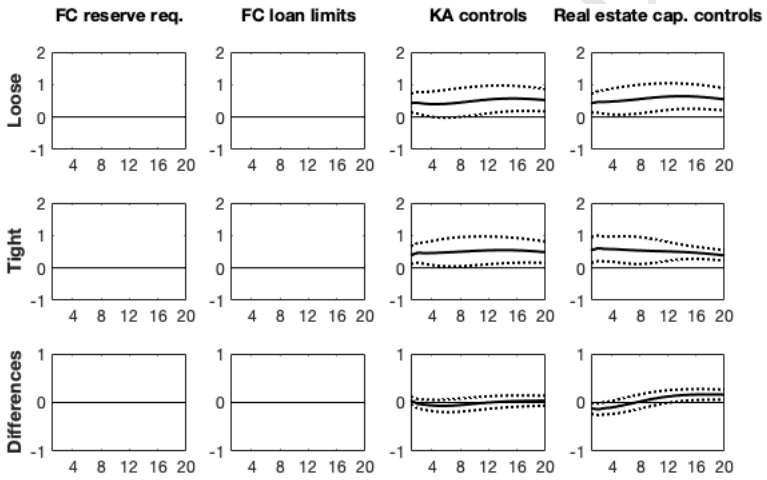


Figure 10: **Policy effect on the impact of global liquidity shocks on house prices (in %): Macroprudential foreign currency policy & capital controls.** The solid line represents the IRFs of house prices (in %) to a one time shock of one standard deviation in global liquidity. In the top row the responses are averaged across the bottom 25% of each policy indicator (loose macroprudential policy), in the middle row the responses are averaged across the top 75% of each policy indicator (tight macroprudential policy), and in the bottom row the mean differences (loose minus tight) are reported. The dotted lines are two standard error confidence bands. All VAR models have funding liquidity interacted with the macroprudential policy indicator for each policy measure, together with world output, bank flows, real GDP growth, short-term interest rates, and house prices. Policy measures are noted in the titles of the plots and include: reserve requirements on foreign currency deposits (*FC reserve req.*), limits to foreign currency loans (*FC loan limits*), capital account controls (*KA controls*), and controls on real estate investments by foreigners (*Real estate cap. controls*).

Panel a. Advanced economies



Panel b. Emerging markets