Global Housing Markets and Monetary Policy Spillovers: Evidence from OECD Countries*

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Current Version: Dec 2019

*We would like to thank Mario Crucini, Richard Startz and the participants at the 25th SNDE Annual Symposium, 2017 FMA Annual Meeting, Wesleyan University and West Virginia University for their helpful comments.

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Abstract

What are the driving forces of housing market volatilities across countries in the context of financial globalization? To address this broad question, we integrate the Campbell-Shiller decomposition with a dynamic factor model and apply this approach to the housing price-rent ratios in 17 OECD countries. Our novel approach allows us not only to assess geographically the relative importance of global and country-specific factors in explaining the housing market volatilities, but also to distinguish economically between those housing market volatilities attributable to different economic driving forces. We find that the housing market volatility for an average country is mainly driven by the global factors, especially during the years leading up to the 2007-2008 financial crisis. Furthermore, among the global factors, it is the global housing risk premium that is primarily responsible for the housing market volatility. Using a Structural Vector-Autoregressive (SVAR) model identified with the Instrumental Variable (IV) method, we find that an unexpected U.S. monetary policy tightening is typically followed by a persistent and statistically significant rise in the global housing risk premium. Our findings are broadly in line with the credit or risk-taking channel of the monetary policy spillovers from the United States to the global financial markets.

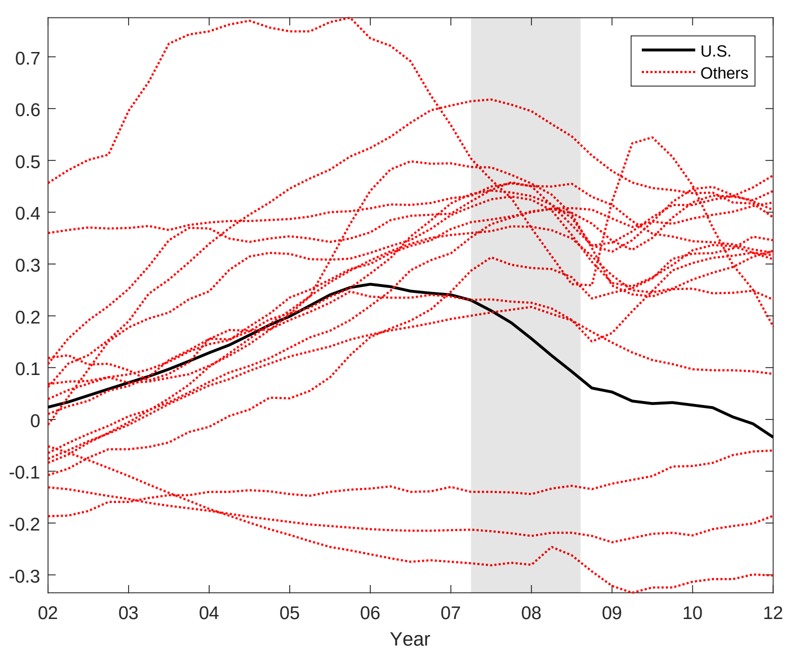
JEL classification: E44, E58, F36, F65, G15, R30

Keywords: global housing markets, housing risk premium, global financial cycle, risk-taking channel, monetary policy spillover, dynamic factor model, Campbell-Shiller decomposition.

1 Introduction

The increasing synchronization of global financial markets, and the resulting policy implications, have received much attention in the academic research work as well as in the policy discussions. Rey (2015) coins the term, "global financial cycle", to refer to the phenomena. Miranda-Agrippino and Rey (2015) further present evidence of a common global asset price movement among international equity and bond markets. Interestingly, much less work has been done to document the degree of co-movement of the global housing markets, despite its importance. Figure 1 plots the time series of housing price-rent ratios[1] from 2002 to 2012 for 17 OECD advanced economies, including the United States. In spite of tremendous heterogeneity, similar boom-burst cycles of housing markets emerge in many countries. For example, the average housing market appreciation (measured by the percentage change of the price-rent ratio) during the 5 years leading up to the U.S. financial crisis was 53.41%, but then dropped to -26.39% over the 5 years following this event.

Figure 1: Housing Market Valuations in 17 OECD Countries around U.S. Financial Crisis



Notes: The housing price-rent ratios are log-scaled and demeaned and the sample period of this graph is from 2002 to 2012.

[1]The price-rent ratio is log-scaled and demeaned, and thus reflects deviations from the long term valuations.

The most recent U.S. financial crisis highlights the crucial role of the housing market in the aggregate economic fluctuations and thus relevant policy discussions [2]. Apart from being treated as a durable consumption good, a house can also serve as a financial asset that provides rental income, as well as potential capital gains. Real estate constitutes one of the most heavily weighted asset classes in household portfolios[3]. Meanwhile, it can be used as a collateral for overcoming borrowing constraints, which has been empirically demonstrated to be affecting both household consumptions and corporate investments through the balance sheet channel (Gan, 2007; Mian and Sufi, 2011, Chaney, Sraer and Thesmar, 2012; Mian, Rao and Sufi, 2013). Furthermore, it also has been shown, through various macroeconomic structural models, that housing sector does have a great impact on macroeconomic fluctuations (Iacoviello, 2005; Iacoviello and Neri, 2010 ; Liu, Wang and Zha, 2013; Walentin, 2014).

As such, we are interested to study the housing markets dynamics, particularly in the context of the globalization of the financial markets, so as to shed light on the propagation mechanism of the external shocks to the national housing markets. Specifically, in this paper we focus on the financial aspect of housing markets, in a coherent framework, seeking for the global and country-specific driving forces of the housing market dynamics. To this end, we integrate the Campbell-Shiller decomposition with a dynamic factor model for the housing price-rent ratios, so as to disentangle global factors from country-specific factors. Moreover, we further decompose the global and country-specific factors into various economic fundamental components including contributions due to the expected rent growth, expected risk free interest rate, and the housing market risk premium components. We have several interesting empirical findings based on our sample covering 17 OECD advanced economies over the last 35 years.

First, similar to bond and equity markets synchronization, documented by Miranda-Agrippino and Rey (2015), we find a significant co-movement of housing markets across OECD advanced economies. Throughout our full sample period, the global factors on average play a relatively more important role than the local (country specific) factors when it comes to accounting for the housing market price-rent volatility[4]. Notably, this

[2] Leamer (2007) finds that the real estate investment is historically a strong indicator for U.S. business cycle, even though the recessions do not always originate from the housing sector like the most recent one.

[3] For international evidences on the concentration of the household's wealth in the real estate, see a recent survey by Badarinza, Campbell and Ramadorai (2016).

[4] In what follows we use price-rent volatility and housing market volatility interchangeably. Also for convenience, the present value of expected future rent growth, interest rate and housing market risk premium are referred to as rent growth component, interest rate component and housing risk premium in this paper except for further notice.

result is largely derived from the few years on the eve of the 2007-2008 U.S. financial crisis.

Second, from an economic perspective, housing risk premium and the interest rate are the main driving forces of housing market volatility; however, the former tends to dominate the latter for an average country, in both local and global factors. In addition, the housing risk premium works through both local and global channels, but the interest rate component works only through the latter one. More importantly, the global housing risk premium is relatively more influential than the local factors in the housing risk premium. These findings are most evident during the decade prior to the 2007-2008 financial crisis. During this period, the contribution of the global housing risk premium to the house price is on average about 58.67%, while during the same period, the impact of the interest rate component at either local or global level is almost close to none.

Our third finding regards the possible driving forces of the global housing risk premium. Using a structural vector autoregressive (SVAR) model, identified with the instrumental variable method, we find that an unexpected U.S. monetary policy tightening is followed by a persistent, and statistically significant, increase of the average global housing risk premium for countries outside the United States. These results corroborates the recent literature that has documented the U.S. monetary policy spillovers to the global financial markets through the credit or risk-taking channel (Bruno and Shin, 2015 ; Miranda-Agrippino and Rey, 2015).

Empirical research on housing markets in an open economy framework is growing in recent years, but still relatively limited. Some attempt to establish links from external shocks to housing market booms and bursts. Aizenman and Jinjarak (2009) find that current account deficits are positively related to housing price appreciations, based on a panel of international data. Using a panel VAR, Sa, Towbin and Wieladek (2014) detect a positive effect of capital-inflow shocks on house prices in advanced economies. Cesa-Bianchi, Cespedes and Rebucci (2015) also provide evidence that house price booms are closely associated with capital inflows and global liquidity with similar method but using a more comprehensive sample. Several other studies also analyze the co-movement of global housing markets. Engsted and Pedersen (2014) uncover the co-movement among housing returns in 18 OECD advanced economies by using the bivariate cross-country correlations measure and the principal components analysis. Based on a similar data set, Hirata et al. (2012) extract the first principle component of housing prices across countries and study its interactions with other macroeconomic variables' first principle components; at the same time Jackson et al. (2016) compare estimation methods for various dynamic factor models and apply those procedures to a large panel of global housing prices data.

Our study belongs to this growing literature but differs from the above studies in a number of important dimensions. First, we integrate the Campbell-Shiller decomposition with an otherwise standard dynamic factor model and apply our decomposition methodology to the housing price-rent ratios, which, arguably, are more informative than the housing price indices alone that have been the primary focus in most existing studies. Our novel decomposition approach allows us to, not only clearly quantify the relative importance of the global and country-specific factors in explaining the housing market dynamics, but also, further decompose these global and local factors into various economic driving forces in order to assess the relative importance of each economic component. Second, the global and country-specific housing risk premia extracted through our decomposition provide a better measure, than the actual returns, of the ex-ante risk compensations in both the global and local housing markets. The extracted global factors, in particular the global housing risk premium, are then used to more clearly identify the spillover effect of the U.S. monetary policy to the global housing markets. Therefore, we can directly investigate the impacts of the U.S. monetary policy shock on the global factors of housing markets. This provides better identification of such effects on the global housing market than an otherwise country-by-country analysis. Last but not least, we are interested in searching for evidence about the credit or risk-taking channel by examining how the global housing risk premia reacts to the U.S. monetary shock. In contrast to Cesa-Bianchi, Cespedes and Rebucci (2015), we use the monetary conditions of the center country (the United States in this study) as a measure of global liquidity shock, as suggested by Rey (2015). This approach also allows us to more accurately identify these shocks using the high frequency market data as external instrumental variables.

This paper also belongs to the burgeoning literature on the global financial cycle and the international monetary policy transmissions, with several notable novel contributions. As Rey (2015) argues, due to the special role of the U.S. dollar as a funding currency in issuing the dollar-denominated debt, the U.S. monetary policy shock tends to affect the balance sheet of global banks and their perceived risk; which in turn, transmits through the credit or risk-taking channel to the global financial markets, often contributing to boom-bust financial cycles. This observation has challenged the traditional view that under the floating exchange rate regime, one individual country ought to be able to maintain its monetary policy independence, and thus have complete control over its domestic financial conditions. Miranda-Agrippino and Rey (2015) extract a common global factor from a large panel of international data on risky assets, mainly consisting of stocks and corporate bonds, and interpret it as an indicator of the risk appetite and uncertainty in worldwide financial markets. Interestingly, they find that the global factor they construct is sensitive to the monetary conditions of the United States. A related finding of Bruno and Shin (2015) documents a negative impact of the U.S. monetary policy tightening on the leverage of global banks[5], the one that, to some extent, reflects the risk attitude of the global banking. These results all point to the crucial role of the U.S. monetary policy in shaping the global financial cycle via its impact on risk-taking behaviors in international financial markets.

Our study contributes to this growing literature in a number of important aspects. As Rey (2016) points out (page 25), "On the asset side, particular attention should be paid to the real estate market, where assets often act as important collateral. Here we have an increasingly conventional toolkit (Loan to Value, Debt to Income...)". As such, the global financial cycle, and the international monetary policy transmission, should manifest itself strongly in the housing markets. To our best knowledge, we are the first to formally examine the spillover effect of the U.S. monetary and financial conditions in global housing markets through risk-taking or credit channel. Because of the global housing risk premium that our approach yields, and a better measure of the ex-ante risk compensations (than actual returns) in the global housing market, we can potentially better identify the impact of the U.S. monetary policy on risk-taking behaviors in global housing markets. The main conclusions from our VAR exercise are strikingly consistent with studies by Rey (2015), Miranda-Agrippino and Rey (2015), and Bruno and Shin (2015). Specifically, we find that the U.S. monetary policy shocks are transmitted around the globe through driving the global housing risk premium.

The rest of the paper is organized as below. Section 2 outlines the modeling framework of our study and section 3 specifies the empirical method we use for decomposing the housing price-rent ratios. Section 4 reports results of variance decomposition to evaluate the relative importance of global and local components in the housing markets. Section 5 focuses on the global housing risk premium and studies its association with the U.S. monetary policy. Section 6 concludes.

2 The Modeling Framework

In our framework, the house is treated as a financial asset that earns returns through capital gains as well as cash flows of rents (explicitly or implicitly through provided

[5] They use U.S. broker and dealer data to proxy global banks given data availability.

housing services). This allows us to apply the method of Campbell and Shiller (1988) to housing returns[6]. In particular, for each country $i = 1, 2 \cdots, N$ at the end of period t, the one-period simple return on the housing asset can be written as $H_{it} = (P_{it} + D_{it})/P_{it-1}$, where P_{it} denotes the real housing price and D_{it} is the associated real rental income for that period. Taking log-linear approximation to the return yields the following dynamic relation:

$$pd_{i,t} = c + \Delta d_{i,t+1} - h_{i,t+1} + \rho \cdot pd_{i,t+1} \tag{1}$$

where c and ρ are some constants, resulting from the log-linearization, the logarithm of variables are denoted in lower case, Δ is a first difference operator and $pd_{i,t}$ refers to the log price-rent ratio ($log(P_{i,t}/D_{i,t})$). The constant $\rho = 1/(1 + e^{-\bar{pd}})$ is usually slightly smaller than 1. Assume the transversality conditions hold, namely, that $\lim_{t \to \infty} \rho^t pd_{i,t} = 0$. Iterating (1) forward whilst taking expectation conditional on information up to time t we have the housing valuation equation as below:

$$pd_{i,t} = \alpha + E_t \sum_{\tau=0}^{\infty} \rho^{\tau} (\Delta d_{i,t+1+\tau} - h_{i,t+1+\tau}) \tag{2}$$

where E_t denotes the conditional expectation operator and α is a constant. In what follows we will ignore α for notational convenience as the focus of this paper is not the level but the dynamics.

The above identity (2) states that the value of a house equals the present value of expected future rent growth and future housing returns. The latter can be further decomposed into the expected future real risk free interest rate and future risk premium (over the risk free rate) required by the housing market investors:

$$pd_{i,t} = \hat{\mathbb{E}}_t \Delta d_{i,t} - \hat{\mathbb{E}}_t r_{i,t} - \hat{\mathbb{E}}_t rp_{i,t} \tag{3}$$

where for conciseness $\hat{\mathbb{E}}_t$ is defined as an operator such that $\hat{\mathbb{E}}_t(x_t) = E_t \sum_{\tau=0}^{\infty} \rho^{\tau} x_{t+1+\tau}$, $r_{i,t}$ and $rp_{i,t}$ refer to the country i's risk free rate and risk premium respectively. Notice that the housing risk premium $rp_{i,t}$ can either reflect risk appetite or financing cost in housing market.

In addition to the Campbell-Shiller decomposition, each component in equation (3) can be further decomposed into a local factor specific to country i and a global factor that affects all markets. Following Stock and Watson (1989), we assume for each component

[6] Some recent similar applications include Campbell et al. (2009), Engsted and Pedersen (2014), Fairchild, Ma and Wu (2015), Kishor and Morley (2015), and Tsang and Sun (2016).

X_{it} the decomposition takes the form of $X_{it} = \tilde{X}_{i,t} + \beta_i^X \bar{X}_t$ where $\tilde{X}_{i,t}$ denotes local factor, and $\bar{X}_t$ is the global factor with a loading β_i^X. This results in the following factor structure of the housing valuation decomposition:

$$pd_{i,t} = \underbrace{\hat{\mathbb{E}}_t \Delta \tilde{d}_{i,t} - \hat{\mathbb{E}}_t \tilde{r}_{i,t} - \hat{\mathbb{E}}_t \tilde{rp}_{i,t}}_{\text{Local Factors}} + \underbrace{\beta_i^d \hat{\mathbb{E}}_t \Delta \bar{d}_t - \beta_i^r \hat{\mathbb{E}}_t \bar{r}_t - \beta_i^{rp} \hat{\mathbb{E}}_t \bar{rp}_t}_{\text{Global Factors}} \tag{4}$$

where β_i^d,β_i^r and β_i^{rp} are loadings on global factors for the present value of expected future rent growth, risk free rate, and the risk premium. Disentangling global and local factors of the housing risk premium is of particular interest to us.

The advantage of the framework we use in this study over more structural models is that behavioral assumptions are kept to the minimum, therefore, permitting less exposure to potential model mis-specifications. Simple as it is, this two-step decomposition can nevertheless allow us to better uncover various driving forces of the housing markets in different countries.

3 Empirical Strategy

To bring the model to data we first need to measure those expectations in (3). Following the finance literature dating back to Campbell and Shiller (1987), Vector Auto-Regressive (VAR) approach is used to obtain our estimates of expectations on risk free interest rate and rent growth. For each country i, the VAR forecasting system is set as below:

$$A_{i,p}(L) Y_{i,t} = \epsilon_{i,t} \tag{5}$$

where $A_{i,p}(L)$ is matrix polynomials in the lag operator L with p lags such that $A_{i,p}(L) = I - A_{i,1}L - A_{i,2}L \cdots - A_{i,p}L^p$, and I is an identity matrix; $Y_{i,t} = (\Delta d_{i,t}, r_{i,t}, g_{i,t}, \pi_{i,t})$ and $\epsilon_{i,t}$ is an error vector. Similar to Campbell et al. (2009) and Fairchild, Ma and Wu (2015), the log real GDP growth $g_{i,t}$ and inflation $\pi_{i,t}$ are included in the information set used to forecast variables that we are interested in. Two lags are used in the VAR following standard information criterion [7].

We denote the associated companion matrix as B_i. Using selection vector e_j that has 1 as the jth element and 0 elsewhere, we can derive the present value of the expected

[7] On average the SIC chooses two lags for the VAR models. We also employ four lags in a robustness study and find that our major results do not change qualitatively. These results are in the online appendix

future real rent growth and real risk free interest rate at each time point:

$$\hat{\mathbb{E}}_t \Delta d_{i,t} = e_1' B_i (1 - \rho B_i)^{-1} Y_{i,t} \quad (6)$$

$$\hat{\mathbb{E}}_t r_{i,t} = e_2' B_i (1 - \rho B_i)^{-1} Y_{i,t} \quad (7)$$

In addition to the baseline VAR model described above, we also consider an expanded VAR by adding log changes of the house prices as one of the forecasting state variables as in Fairchild, Ma and Wu (2015), and meanwhile employing 4 lags in the VAR[8]. The main conclusions from our baseline VAR specification are qualitatively robust to these extensions of the VAR model[9].

We use a dynamic factor model to separate the local and global factors of these expectations. Following Stock and Watson (1989) and Kim and Nelson (1999), the model for the expectation of rent growth rates is set up as below:

$$\hat{\mathbb{E}}_t \Delta d_{i,t} = \hat{\mathbb{E}}_t \Delta \tilde{d}_{i,t} + \beta_i^d \hat{\mathbb{E}}_t \Delta \bar{d}_t \quad (8)$$

$$\Phi_p^d(L) \hat{\mathbb{E}}_t \Delta \bar{d}_t = \varepsilon_t^d \quad (9)$$

$$\Psi_{q,i}^d(L) \hat{\mathbb{E}}_t \Delta \tilde{d}_{i,t} = u_{i,t}^d \quad (10)$$

where $\Phi_p^d(L)$ and $\Psi_{q,i}^d(L)$ are the conventional polynomials in the lag operator L with p and q lags respectively. Similarly for the risk free interest rate component we have:

$$\hat{\mathbb{E}}_t r_{i,t} = \hat{\mathbb{E}}_t \tilde{r}_{i,t} + \beta_i^r \hat{\mathbb{E}}_t \bar{r}_t \quad (11)$$

$$\Phi_p^r(L) \hat{\mathbb{E}}_t \bar{r}_t = \varepsilon_t^r \quad (12)$$

$$\Psi_{q,i}^r(L) \hat{\mathbb{E}}_t \Delta \tilde{r}_{i,t} = u_{i,t}^r \quad (13)$$

We use two lags in all dynamic factor models to keep the model parsimonious as somewhat standard when estimating these dynamic factor models. As standard in this literature (for example, see Stock and Watson (1989)), the error terms for the common and idiosyncratic factors in the dynamic model are assumed to be orthogonal to each other so that the co-movement among all markets is completely captured by the common factor. Also for the

[8] Engsted, Pedersen and Tanggaard (2012) suggest incorporating the current asset price in the information set for the Campbell-Shiller VAR decompositions. However, our VAR specification here differs from theirs since the asset returns are not in our VAR system. But for a robustness check we nevertheless expand the conditioning information set to include the house price growth rate in the VAR. Besides, although 4-lag is not favored according to the model selection information criterion, we take it as a robustness check given that the quarterly data is used.

[9] Details are available in the online appendix.

purpose of identification, the loadings β_N^d and β_N^r are standardized to 1 as suggested by DelNegro and Otrok (2007). Similar procedure is applied to the price-rent ratios to obtain the global and local valuations. Finally, following the convention in finance literature, we back out the time varying housing risk premium using the decomposition identify (4) together with the estimation results of the VAR and dynamic factor models. Notice that this approach is unable to identify β_i^{rp} but for our purposes it suffices to identify $\beta_i^{rp}\hat{E}_t\bar{rp}_t$ as a whole as long as the loading remains constant. The dynamic factor models are estimated with the Maximum Likelihood Estimation (MLE) via Kalman filter by casting the model into its state-space representation. See Kim and Nelson (1999) for estimation details.

The quarterly data of international housing markets, including the price-rent ratios and rent indices (seasonally adjusted), are obtained from the OECD iLibrary Analytical House Price Indicators Dataset. The sample period covers 1980Q1-2015Q4 and 17 OECD countries are included: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom and United States. The choice of these markets and the sample period reflects our desire to establish a balanced panel data on housing markets to cover as many advanced countries as possible for the longest sample period. We use the short-term interest rate (bond or money market rate) as a proxy of the risk free rate in our model. For some countries, such as Denmark, Finland, Ireland, Japan, Netherlands and Sweden, the short-term interest rate data before 1990s is incomplete in the OECD database, and, in this case, the money market rate from the IFS database is used instead[10]. The Consumer Price Index or Consumer Price Level in the OECD database is employed in the analysis, for instance, to obtain the real rent growth and real risk free interest rate. Due to the availability of the inflation rate data, the sample effectively starts from 1981Q1. The real GDP growth rate is also collected from the OECD database. All variables are log-scaled and demeaned before the estimations.

4 Accounting for Price-rent Variability

4.1 Factor Decomposition for Price-rent Ratio

We first present evidence for the relative importance of the global versus country-specific factors in explaining the variations of housing price-rent ratios. These decomposition

[10]The short-term interest rate in the OECD database is close to the money market rate in the IFS database.

results are based on the dynamic factor model applied to the panel of all countries' price-rent ratios[11]. To assess the relative importance of the country-specific factors to the global factor in explaining the variations of the price-rent ratios, we compute the fraction of the valuation variations attributable to the country-specific factors. These decomposition results are presented in Table 1 for all countries during three subsamples (1981Q3-1998Q4, 1999Q1-2007Q4 and 2008Q1-2015Q4) [12] as well as the full sample 1981Q3-2015Q4. The last column of Table 1 indicates a substantial heterogeneity of the relative importance of the contributions of the global factor and, the country-specific factors in the full sample period. The top three countries that are most exposed to the global shocks are Australia, Belgium and Canada. For instance, almost 98% of the house price-rent ratio variation of Australia's housing market is due to the global factor. On the other hand, Italy stands out for being almost completely unaffected by the global factor, with the contribution of the global factor being as small as about 7%. Despite the substantial heterogeneity in this regard, the average contribution of the country-specific factors is only about 36%, indicating that on average the local factor tends to play a relatively less important role than the global factor for the full sample period. This finding is largely in agreement with the finding of Hirata et al. (2012) based on a similar data set, but with a different approach.

A further inspection of the decomposition results over three subsample periods suggests an interesting pattern: the global factor appears to contribute much more during the sample period 1999Q1-2007Q4, the years leading up to the 2007-2008 financial crisis, than the other two subsample periods. This particular subsample appears to have been primarily responsible for the full sample result that global factor explains the bulk of the housing prices variations. In particular, the average contribution of the country-specific factors across all countries is around 33% for the sample period 1999Q1-2007Q4, but more than 80% for either 1981Q3-1998Q4 or 2008Q1-2015Q4. More convincingly, the same pattern also emerges in all individual countries, that is, the contribution of the global factor to each national housing market variations tends to be much higher during the period 1999Q1-2007Q4 than the other two subsample periods. In sum, throughout

[11]Because price-rent ratios in most markets are persistent, we apply the panel unit root test as suggested in Maddala and Wu (1999) to address this concern. The unit root test rejects the null hypothesis and thus suggests that the house price and rent are co-integrated, which is consistent with the finding of Ambrose, Eichholtz and Lindenthal (2013).

[12]The first break point is selected to be around 1999 as in DelNegro and Otrok (2007) and Fairchild, Ma and Wu (2015) which document a stronger co-movement among regional housing markets within the United States and a greater influence of the U.S. monetary policy on U.S. housing markets. It is also the year when the euro was introduced, which marked a crucial step towards the European market integration. The second break point is set to be the starting point of financial crisis.

Table 1: The Local Factor Contribution to Price-Rent Ratios Volatility

Country	1981Q3-1998Q4	1999Q1-2007Q4	2008Q1-2015Q4	1981Q3-2015Q4
Australia	0.2184	0.0530	0.6913	0.0217
Belgium	0.5280	0.0728	0.6219	0.0446
Canada	0.7440	0.0621	0.8935	0.1500
Denmark	0.9379	0.4493	0.9178	0.3575
Finland	0.9219	0.1440	0.8808	0.2546
France	0.9269	0.7415	0.8870	0.4595
Germany	0.9015	0.2061	0.9655	0.3053
Ireland	0.7983	0.3595	0.9635	0.4356
Italy	0.9973	0.9581	0.9979	0.9272
Japan	0.8955	0.0996	0.8392	0.2950
Netherlands	0.7338	0.2324	0.9613	0.3030
Norway	0.8650	0.2083	0.8677	0.1710
Spain	0.9698	0.4795	0.9813	0.5273
Sweden	0.9763	0.3957	0.9609	0.5938
Switzerland	0.9860	0.7030	0.9749	0.7328
United Kingdom	0.9212	0.2506	0.7380	0.2548
United States	0.7197	0.2345	0.9225	0.3279
Average	0.8260	0.3324	0.8862	0.3624
Median	0.9015	0.2345	0.9178	0.3053

Note: This table describes the local (country-specific) factor variance share in the variance decomposition according to $pd_{i,t} = \tilde{pd}_{i,t} + \beta_i^{pd}\bar{pd}_t$ for each country, where $\tilde{pd}_{i,t}$ and $\bar{pd}_t$ are local and global factors obtained by a dynamic factor model as described in the paragraph. The last two rows report the average and median results.

the years leading up to the worldwide financial crisis the global factor appears to have played a more important role in shaping each nation's housing market.

4.2 Understanding Housing Markets Volatilities

Now we take one step further by unraveling the local and global driving forces behind the price-rent ratio variations. More specifically, we apply the variance decomposition (4) to calculate the contributions of the rent growth, risk free interest rate, and the housing risk premium components to the variation of the price-rent ratio at both local and global levels, for each subsample period as well as the full sample period. The focus is on the percentage contributions of all the variance terms [13]. In what follows we will also relate our results to the literature.

Table 2 reports the variance shares of the rent growth, risk free interest rate, and the housing risk premium to the price-rent ratio variations at both local and global levels, for the full sample. We look to discover not only how driving forces such as rent growth, interest rate and housing risk premium components contribute to the price-rent variations, but also whether that driving force is a global or country-specific factor. To our best knowledge the latter has not been formally studied yet in the literature, so we are intended to fill that gap.

Starting with these full sample results, several observations are of interest. Overall, the housing risk premium and interest rate appear to explain the bulk of the price-rent volatility, consistent with the findings of Engsted and Pedersen (2014) based on a similar international data set, and also in line with Campbell et al. (2009) and Fairchild, Ma and Wu (2015) regarding the United States housing market behaviors. This result is also not at odds with Cochrane (2011)'s claim that the expected future returns appear to be of the first order importance to asset pricing, though in the context of international housing markets.

Moreover, the housing risk premium tends to dominate the risk free interest rate in terms of the contribution to the housing market volatility, at both local and global level for an average country[14]. At the same time, the global interest rate component seems

[13]According to (3) and (4) the variance decomposition can be written as $var(pd_{it}) = var(\hat{\mathbb{E}}_t \Delta d_{i,t}) + var(\hat{\mathbb{E}}_t r_{i,t}) + var(\hat{\mathbb{E}}_t rp_{i,t}) - 2cov(\hat{\mathbb{E}}_t \Delta d_{i,t}, \hat{\mathbb{E}}_t rp_{i,t}) - 2cov(\hat{\mathbb{E}}_t \Delta d_{i,t}, \hat{\mathbb{E}}_t r_{i,t}) + 2cov(\hat{\mathbb{E}}_t r_{i,t}, \hat{\mathbb{E}}_t rp_{i,t})$ where the variance terms can be further decomposed to variances at local and global levels. Due to the presence of the covariance terms, the total percentage share of variance terms in the variance decomposition could be different from one. Detailed results regarding the covariance shares in the variance decomposition are not reported but available upon request.

[14]For an average country, the shares of covariance terms $-2cov(\hat{\mathbb{E}}_t \Delta d_{i,t}, \hat{\mathbb{E}}_t rp_{i,t})$, $-2cov(\hat{\mathbb{E}}_t \Delta d_{i,t}, \hat{\mathbb{E}}_t r_{i,t})$ and $2cov(\hat{\mathbb{E}}_t r_{i,t}, \hat{\mathbb{E}}_t rp_{i,t})$ in the variance decomposition are 0.08, -0.44 and -0.13 respectively, while the

Table 2: The Campbell-Shiller Component Volatility Contribution

	Global			Local		
Country	$\Delta\bar{d}$	$\bar{r}$	$\bar{rp}$	$\Delta\tilde{d}$	$\tilde{r}$	$\tilde{rp}$
Australia	0.0000	0.1542	0.4717	0.0008	0.0653	0.0913
Belgium	0.0037	0.3956	0.3257	0.0024	0.0290	0.0963
Canada	0.0000	0.3079	0.2845	0.0002	0.1126	0.3111
Denmark	0.0003	0.0969	0.3254	0.0023	0.2528	0.5078
Finland	0.0064	1.1058	0.2531	0.2196	0.1462	0.6370
France	0.0077	0.2973	0.1718	0.0043	0.0598	0.5263
Germany	0.0129	0.2605	1.4265	0.0091	0.1084	0.3064
Ireland	0.0006	0.0025	0.5321	0.0965	0.0142	0.5485
Italy	0.0100	0.8325	0.3590	0.0632	0.1724	0.9444
Japan	0.0097	0.3838	1.7319	0.0232	0.0600	0.2796
Netherlands	0.0017	0.3182	0.2225	0.0003	0.1304	0.4979
Norway	0.0000	0.0496	0.5335	0.0001	0.0367	0.2961
Spain	0.0004	0.1866	0.1575	0.0100	0.0347	0.4009
Sweden	0.0063	0.0307	0.3076	0.0366	0.0134	0.5333
Switzerland	0.0142	0.1155	0.5168	0.0078	0.0684	0.6940
United Kingdom	0.0083	0.9806	0.2241	0.0702	0.2466	0.6428
United States	0.0044	0.9575	0.2242	0.0022	0.4279	0.3849
Average	0.0051	0.3809	0.4746	0.0323	0.1164	0.4529
Median	0.0044	0.2973	0.3254	0.0078	0.0684	0.4979

Note: This table describes the share of each Campbell-Shiller component variance in the variance decomposition according to (4) for each country. The sample period is 1983Q3-2015Q4. Δd, r and rp refer to rent growth, interest rate and risk premium components respectively. The last two rows report the average and median results.

to be much more important than the local ones. Therefore, the interest rate component tends to primarily work through the international channel, while the housing risk premium works through both channels and also tends to be more influential than the interest rate component for both channels.

Despite some heterogeneity across individual markets, most individual countries' decomposition results lead to a similar conclusion that the interest rate and the housing risk premium are most relevant in explaining the price-rent variations. Their relative importance does differ across countries. For example, the global interest rate component seems to play a more important role than the housing risk premium for the United Kingdom and United States, while for countries such as Sweden and Norway the volatility of the price-rent ratio is about completely explained by the housing risk premium movements. Furthermore, the last two rows of Table 2 show that, on average, the global and local factors share about equal contributions within the housing risk premium components. However, the relative importance of the global and local housing premium varies in different countries. For instance, in Australian market the share of the global housing risk premium is more than five times of the local one, but the local housing risk premium contributes almost three times of the global one for the housing market in Italy.

The decomposition results for the three subsample periods, as reported in Table 3 and Table 4, reveal several more interesting findings. What has been documented above indicates that during the subsample period 1999Q1-2007Q4, the global factors appear to be the main driving forces of the housing market volatility for an average country. Then a natural question to ask is which economic fundamentals especially at the global level are at work during that period. The last two rows of Table 3 suggest that the global housing risk premium combined with the local risk premium account for the majority of the price-rent volatility during that period. Furthermore, the global housing risk premium contributes more than the local housing risk premium on average, which is especially true and decisive for most individual markets. Due to its crucial role, we will turn to the global housing risk premium component in the following section in order to better understand the possible driving forces behind it.

The similar decomposition results for the two subsample periods (1981Q3-1998Q4 and 2008Q1-2015Q4) are reported in Table 4. They are noticeably different from the ones

shares of variance terms $var(\beta_i^{rp}\hat{\mathbb{E}}_t \bar{rp}_t)$ and $var(\hat{\mathbb{E}}_t \tilde{rp}_{i,t})$ are 0.47 and 0.45 as found in the last row of Table 2. So the impact of covariance is either small compared to that of risk premium component, or actually negative, which means the correlation between rent growth and interest rate components, or risk premium and interest rate components, tends to reduce the housing market volatility. These conclusions hold for the subsample analysis as well.

Table 3: The Campbell-Shiller Component Volatility Contribution (1999Q1-2007Q4)

	Global			Local		
Country	$\Delta\bar{d}$	$\bar{r}$	$\bar{rp}$	$\Delta\tilde{d}$	$\tilde{r}$	$\tilde{rp}$
Australia	0.0000	0.0182	0.8013	0.0006	0.0317	0.1004
Belgium	0.0005	0.0469	0.7256	0.0014	0.0264	0.0866
Canada	0.0000	0.0415	0.7325	0.0002	0.0347	0.1092
Denmark	0.0000	0.0102	0.4705	0.0003	0.0401	0.5660
Finland	0.0010	0.1553	0.5613	0.0286	0.0771	0.1577
France	0.0005	0.0174	0.1984	0.0013	0.0186	0.8533
Germany	0.0020	0.0364	0.9881	0.0097	0.0293	0.2337
Ireland	0.0001	0.0003	0.6302	0.0311	0.0010	0.3206
Italy	0.0008	0.0585	0.0320	0.0010	0.0386	1.1194
Japan	0.0017	0.0599	1.1938	0.0009	0.0453	0.0449
Netherlands	0.0003	0.0428	0.5913	0.0004	0.1115	0.0862
Norway	0.0000	0.0058	0.7129	0.0001	0.0381	0.4106
Spain	0.0001	0.0251	0.4056	0.0019	0.0188	0.6034
Sweden	0.0013	0.0056	0.5618	0.0097	0.0059	0.3820
Switzerland	0.0021	0.0157	0.3633	0.0091	0.0100	0.8124
United Kingdom	0.0011	0.1206	0.5017	0.0147	0.1017	0.4723
United States	0.0007	0.1333	0.5041	0.0034	0.2482	0.6543
Average	0.0007	0.0467	0.5867	0.0067	0.0516	0.4125
Median	0.0005	0.0364	0.5618	0.0014	0.0347	0.3820

Note: This table describes the share of each Campbell-Shiller component variance in the variance decomposition according to (4) for each country. The sample period is 1999Q1-2007Q4. Δd, r and rp refer to rent growth, interest rate and risk premium components respectively. The last two rows report the average and median results.

Table 4: Campbell-Shiller Components Volatility Shares (1981Q3-1998Q4 and 2008Q1-2015Q4)

	1981Q3-1998Q1						2008Q1-2015Q4					
	Global			Local			Global			Local		
Country	$\Delta\bar{d}$	$\bar{r}$	$\bar{rp}$	$\Delta\tilde{d}$	$\tilde{r}$	$\tilde{rp}$	$\Delta\bar{d}$	$\bar{r}$	$\bar{rp}$	$\Delta\tilde{d}$	$\tilde{r}$	$\tilde{rp}$
Australia	0.0001	1.1800	0.8305	0.0204	0.8256	1.3215	0.0000	0.0449	0.1134	0.0006	0.0382	0.1646
Belgium	0.0193	1.8720	0.9894	0.0192	0.3624	1.0951	0.0016	0.1156	0.1788	0.0014	0.0328	0.0926
Canada	0.0000	0.8883	0.5837	0.0006	0.5221	1.6584	0.0000	0.1023	0.1914	0.0001	0.0959	0.5720
Denmark	0.0003	0.0897	0.0590	0.0030	0.4314	1.2772	0.0001	0.0250	0.0607	0.0007	0.0875	0.4421
Finland	0.0072	1.1098	0.7026	0.3169	0.2898	2.2477	0.0033	0.3824	0.4501	0.0741	0.2166	0.4694
France	0.0112	0.3851	0.1738	0.0078	0.1692	1.4363	0.0017	0.0428	0.0540	0.0009	0.0173	0.0893
Germany	0.0195	0.3537	0.4939	0.0218	0.3019	0.3488	0.0066	0.0897	0.0306	0.0102	0.0476	0.8722
Ireland	0.0024	0.0084	0.1748	0.6970	0.0949	2.1301	0.0003	0.0008	0.0216	0.0810	0.0034	0.5931
Italy	0.0040	0.2965	0.2077	0.0540	0.1328	0.9711	0.0026	0.1441	0.1251	0.0072	0.0985	0.4888
Japan	0.0154	0.5447	0.7341	0.0747	0.2179	1.2612	0.0055	0.1476	0.0623	0.0040	0.1296	0.1696
Netherlands	0.0069	1.1646	0.6558	0.0036	1.1007	1.8768	0.0008	0.1055	0.1647	0.0004	0.0712	0.4846
Norway	0.0000	0.0774	0.0930	0.0003	0.1524	1.4954	0.0000	0.0143	0.0589	0.0001	0.0123	0.1345
Spain	0.0003	0.1143	0.0683	0.0176	0.0614	0.6413	0.0002	0.0619	0.1056	0.0106	0.0444	0.9072
Sweden	0.0039	0.0172	0.0140	0.0428	0.0160	0.7862	0.0042	0.0137	0.0319	0.0353	0.0222	0.5500
Switzerland	0.0080	0.0580	0.0634	0.0120	0.0485	0.7766	0.0070	0.0386	0.0083	0.0096	0.0299	0.5196
United Kingdom	0.0094	0.9938	0.5957	0.0824	0.5874	1.1016	0.0037	0.2969	0.3459	0.0200	0.1679	0.3631
United States	0.0196	3.8258	2.4638	0.0184	2.9840	2.0558	0.0022	0.3283	0.3961	0.0037	0.2981	0.4173
Average	0.0075	0.7635	0.5237	0.0819	0.4882	1.3224	0.0023	0.1150	0.1411	0.0153	0.0831	0.4312
Median	0.0069	0.3851	0.4939	0.0192	0.2898	1.2772	0.0017	0.0897	0.1056	0.0040	0.0476	0.4694

Note: This table describes the share of each Campbell-Shiller component variance in the variance decomposition according to (4) for each country. The sample periods are 1981Q3-1998Q4 and 2008Q1-2015Q4. Δd, r and rp refer to rent growth, interest rate and risk premium components respectively. The last two rows report the average and median results.

derived from subsample period 1999Q1-2007Q4. In particular, the role of the interest rate component is more pronounced, especially its global factor. On the local level, however, the average impact of the interest rate component remains much smaller than that of the housing risk premium. Interestingly, while the local factors are primarily responsible for the price-rent ratio variations in those two subsample periods, consistent with the results presented in Table 1, within the local factors it is still the housing risk premium that accounts for the bulk of variations.

5 On Housing Risk Premium

5.1 Global and Local Factors in Housing Risk Premium Component

Having documented the critical role of the housing risk premium in explaining the house price volatility, we are thus interested in whether and how the financial or macroeconomic conditions may have affected the housing risk premium. Moreover, the global housing risk premium interests us most, as we have found that the global housing risk premium component constitutes the main driving force behind the housing market volatilities for almost all countries during these years leading up to the 2007-2008 financial crisis.

The housing risk premium that we estimated can be interpreted as approximating expected future excess returns of housing investment over the risk free asset. First and foremost it contains information about risk or risk attitude in the housing market. Accordingly, the time varying housing risk premium can be either partly driven by "perceived" risk - conditional expectation of volatility - or the degree of risk aversion in the housing market. For the latter driving force, there are at least two possible sources. One is time-varying risk aversion for real estate investors themselves [15], for instance, when they become more risk averse, the housing premium would go up as a compensation for their risk-taking behavior.

The other is related to the "perceived" risk aversion of financial intermediaries[16]. Financial intermediary is usually subject to some risk-based constraints such as the Value-at-Risk (VaR). So when the perceived risk goes up, the cost of finance provided by the intermediary could increase accordingly[17]. Given the high leverage nature of the housing

[15] Time varying risk aversions, though unobservable, are usually linked to business cycle condition in theory. See e.g. Campbell and Cochrane (1999).

[16] We use "perceived" risk aversion to indicate that the financial institution may behave as if it is risk averse due to some risk-based constraints even though its preference is linear.

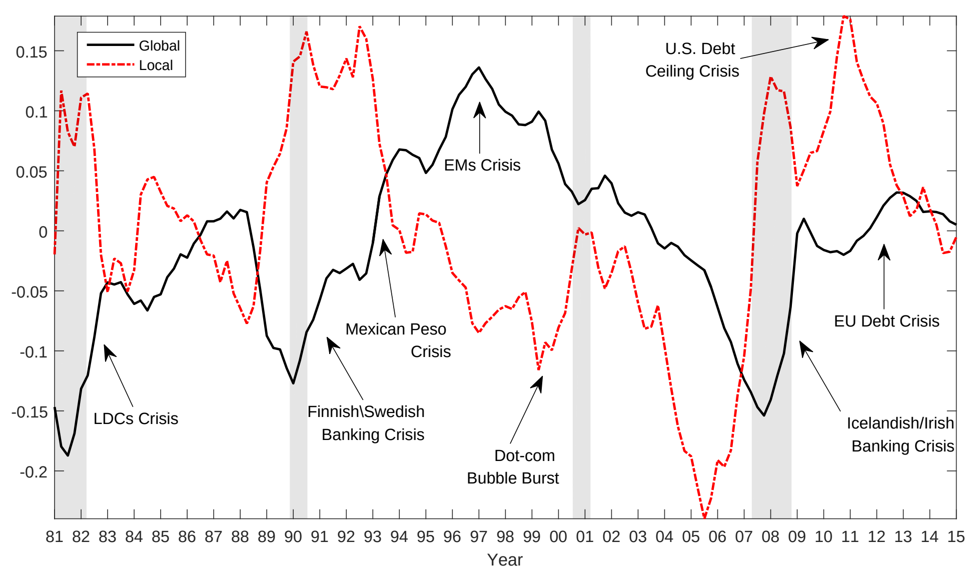
[17] Adrian and Shin (2014) stress the importance of the financial intermediary channel for the propagation of the financial crisis.

investment, the perceived time-varying risk aversion of the financial institution thus potentially has substantial impact on the housing market. For either channel, the housing risk premium reveals some respects of the risk appetite related to the housing market.

On the other hand, the housing risk premium to some extent also reflects the magnitude of the credit cost (spread) in the housing market. It is notable that this cost could be a result of the agency problems between lenders and borrows. That is, for external finance the borrower has to pay a premium to the lender as a compensation for the information asymmetry, while this inefficient deadweight loss may not be due to risk. The evolution of the borrower's net worth or balance sheet then would affect such a cost over time. In literature, terms such as the "financial accelerator", "balance sheet effect" or "collateral channel", have been used to describe this type of mechanism (Kiyotaki and Moore, 1997; Bernanke, Gertler and Gilchrist, 1999).

In the context of financial globalization, both risk or credit cost in global and local housing markets, which may or may not coincide at each time point, can simultaneously affect the housing risk premium. Figure 2 compares the global and local factors in the housing risk premium for the United States over the full sample period 1981Q3-2015Q4. The NBER recession dates are denoted by shaded areas. Additionally, some annotations are added for some notable international and domestic economic/financial turmoils.

Figure 2: U.S. Housing Risk Premium Factor Decomposition

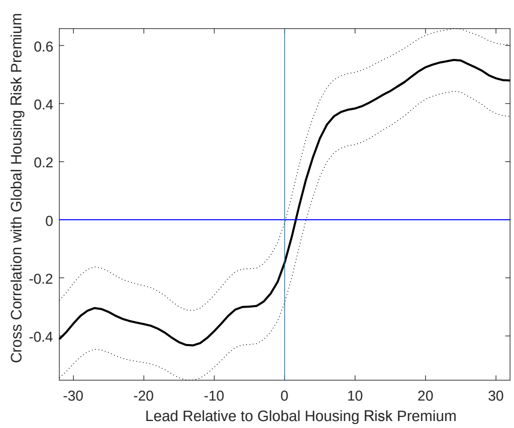


Notes: This figure illustrates the global and local factor in the U.S. housing risk premium from 1981 to 2015. The NBER recession dates are denoted by shaded areas.

The first interesting observation is that the local housing risk premium experiences a sharp run-up about two years before each NBER recession in our sample. This clear pattern implies that the housing market can somehow foresee a recession, given its forward-looking nature, even before the recession materializes.

Secondly, although on average the sample correlation between the global housing risk premium and the local housing risk premium for the United States is insignificant[18], for the time period between late 2001 and 2005 both of them decline sharply[19]. It is noteworthy that the period 2001-2005 is often quoted as a time period for the emergence of U.S. housing market bubble. So it appears that the run-up of the housing prices is not restricted to the U.S. market but rather a worldwide phenomenon.

Figure 3: The Lead-Lag Relation between U.S. Specific and Global Housing Risk Premium



Notes: This figure shows that the local factor in U.S. housing risk premium appears to lead the global housing risk premium. Dotted lines are 90% asymptotic confidence bands.

Last but not least, the local housing risk premium of the United States appears to lead the global housing risk premium. More appropriately, we use the average global housing risk premium components of all countries, other than the United State, as a proxy for the "global housing risk premium", the one that partially reflects the aggregate risk appetite

[18] The two are assumed to be orthogonal to each other in the estimation of the dynamic factor model.

[19] At other times the global and local factors in the housing risk premium often show distinct patterns. For example, during 1991-1994, the global housing risk premium keeps increasing, but not for the local housing risk premium. Notice that this run-up of the global housing risk premium during this period coincides with a series of economic crisis in various countries such as the Finnish and Swedish banking crisis as well as the Mexican Peso crisis during the early 1990s.

in the international housing market[20]. The cross correlations of the U.S. local housing risk premium with the global one at different leads and lags are computed and reported in Figure 3. The correlation peaks when the lead equals around six years, and the associated point estimate of the correlation is about 0.55. Although the lead-lag cross-correlation does not necessarily imply the true causality, the fact that the United States housing risk premium shifting precedes a similar change in the global housing risk premium is still worth noting.

5.2 Effects of U.S. Monetary Policy on Global Housing Risk Premium

Recently, the important role of the United States in shaping international financial market receives growing attention, and it has been found that the liquidity effect brought about by the monetary policy shock in the center country such as the United States is likely to spill over to other countries, through the so-called risk-taking channel or credit channel (see e.g., Bruno and Shin (2015), Rey (2015) and Miranda-Agrippino and Rey (2015)). Few studies, however, have examined the monetary policy spillovers in the global housing markets. Given that we have documented that the global housing risk premium seems to have accounted for the bulk of the global housing prices variations, especially during the years leading up to the most recent financial crisis, it is natural to ask whether and how the U.S. monetary policy may have affected the global housing risk premium. The two transmission channels that previous works document naturally apply to housing markets where leverage or external finance plays a central role.

The risk-taking channel refers to the impact of the monetary policy shock on risk metrics such as the Value-at-Risk (VaR) adopted by banks and its implications on the banks' ability to lend in housing markets. While for the case of credit channel, the borrower (investor) in housing markets is financially constrained due to the agency problems, in which case, the monetary or financial conditions could tighten or relax such constraints through changing the net worth or the collateral value of the borrower. As argued by Rey (2015), Miranda-Agrippino and Rey (2015) and Bruno and Shin (2015), in the context of financial globalization, these channels are also potentially relevant to the spillover effect of the monetary policy from center country such as the United States to the global financial markets, given the central role of dollar finance in the international financial system (Gourinchas and Rey, 2007; Prasad, 2014; McCauley, McGuire and Sushko, 2015). For example, a U.S. monetary policy rate hike followed by a depreciation of the domestic

[20]Notice that in our factor decomposition, each country loads on the same global factor with different constant loadings.

(non-U.S.) currency relative to the U.S. dollar would weaken the bank's balance sheets if the dollar debt is prevalent, therefore tightening its risk-based constraints, widening credit spreads in the domestic housing market, and eventually increasing the housing risk premium.

Our approach, thus can complement existing studies on the global financial cycle in several respects. First, our emphasis is on the global housing markets, where the spillover effects, aforementioned, are probably stronger than other assets markets. Second, we are particularly interested in the working of monetary policy spillovers through risk-taking or credit channel that may manifest itself in terms of housing risk premium variations. Furthermore, the housing risk premium we derive, is the expected future housing market implied risk premia, instead of the realized excess returns that have widely been used in other studies. This subtle difference may become crucial in presence of large news shocks in assets markets, which renders our measure more appealing, conceptually in terms of relating to the ex-ante risk compensations of the risky assets.

Following Rey (2015), we choose the United States as the center country, and focus on the spillover effects of the U.S. monetary policy because of the influential role of the U.S. dollar in international financial markets and banking through cash flow and valuation effects. Specifically, we estimate a Structural Vector Autoregressive Regression (SVAR) model that identifies the impulse response to the monetary policy shock with the instrumental variable method, following the recent work by Stock and Watson (2012) and Mertens and Ravn (2013), so as to assess the effect of the U.S. monetary policy surprise shock on the global housing premium.

As the essential challenge of SVAR model is to identify the unobservable structural shocks that are exogenous to other endogenous variables, carefully selected instrumental variables can be used to extract the exogenous component of policy shocks. As in Gertler and Karadi (2015), we instrument the policy indicator with the surprises in Federal Funds futures within a tight time window around the Federal Open Market Committee (FOMC) announcement. The literature of high frequency monetary policy identification, such as Gurkaynaka, Sackb and Swanson (2005) and Hamilton (2008), finds that surprises in Federal Funds futures around a tight window to be a good measure of the market response to an unexpected monetary policy shock, as the effect of other economic variables is likely to be absent in such a tight time window.

The basic idea of the instrumental variable strategy for the SVAR model is as below. Suppose the policy indicator of interest is a scalar $z_{1,t}$ (monetary policy in our case), and the economic/financial variables are stored in vector $z_{2,t}$. Let $z_t = (z_{1,t}, z'_{2,t})'$ and the corresponding reduced form VAR is:

$$F_p(L)z_t = v_t = D\epsilon_t \tag{14}$$

where $F_p(L)$ is the standard matrix polynomials in the lag operator L with p lags, $\epsilon_t = (\epsilon_{1,t}, \epsilon'_{2,t})'$ refers to structural shocks such that $E[\epsilon_t \epsilon'_t] = I$, and D is the so-called impact matrix. Since we want to find the impulse responses to the policy shock $\epsilon_{1,t}$, only D_1, the first column of D that is associated with policy innovation, needs to be identified. Now suppose the single instrumental variable m_t for the policy indicator satisfies the following standard conditions:

$$E[m_t \epsilon_{1,t}] = \phi \neq 0 \tag{15}$$

$$E[m_t \epsilon_{2,t}] = 0 \tag{16}$$

where E denotes expectation operator and ϕ is an unknown scalar. These conditions, combined with (14), imply that

$$E[m_t v_t] = \phi D_1 \tag{17}$$

which can be further rewritten as

$$D_{11}^{-1} D_{21} = E[m_t v_{1,t}]^{-1} E[m_t v_{2,t}] \tag{18}$$

where $D_1 = (D_{11}, D'_{21})'$ and $v_t = (v_{1,t}, v'_{2,t})'$. Then (18) can be used to identify D_1 up to scale and sign convention[21], given covariances $E[m_t v_{1,t}]$ and $E[m_t v_{2,t}]$. Notice that the right hand side of (18) is equivalent to a standard instrumental variable estimator. To put this method into work, we first obtain estimated residuals $\hat{v}_t = (\hat{v}_{1,t}, \hat{v}'_{2,t})$ and covariance matrix $\hat{\Sigma}_{vv}$ from VAR. To estimate $D_{11}^{-1} D_{21}$, we then conduct two-stage least squared estimation by regressing each variable in $\hat{v}_{2,t}$ on $\hat{v}_{1,t}$ using m_t as the instrumental variable[22]. Finally the estimate of D_{11} can be derived by using results from previous steps, and at this point D_1 is identified up to a sign convention[23]. The instrumental variable identification strategy, outlined above, enables us to exploit the informational content of the high frequency financial data in a conventional VAR framework.

In our SVAR model, the economic variables include standard ones such as the U.S.

[21] Note that that D_{11} is a scalar.

[22] A simple F-test for the first stage regression can be done for evaluating the strength of instruments.

[23] See Mertens and Ravn (2013) and Gertler and Karadi (2015) for more details about this step. An alternative is to neglect scale issue by normalizing D_{11} as in Stock and Watson (2012). The estimated impulse response functions in our study using these two approaches yield almost identical patterns.

industrial production index and consumer price index, both in logs. For financial variables, we use the excess bond premium computed by Gilchrist and Zakrajsek (2012) that reflects investor risk attitudes in the bond market [24] as a complement to our estimates of the housing market implied risk premium components. In addition, the 3-month Treasury bill rate, commercial paper spread and mortgage spread are included to reflect credit costs and possibly risk components in the business as well as real estate sectors.

We also place our estimate of the global housing risk premium in the model as we are ultimately interested in how this variable responds to the U.S. monetary policy shock. Moreover, the present value of the U.S. future housing market implied risk premium derived from the standard Campbell-Shiller decomposition is also added to the model. See Figure 4 for contrasting these two risk premium terms. According to Figure 2, it is evident that the local factor in U.S. housing risk premium alone is a more effective leading indicator for U.S. recessions than the total U.S. housing risk premium that also includes the relevant global factor. Following the convention of the monetary policy literature, the Federal fund rate is used as the monetary policy indicator. Accordingly, we choose current month ahead monthly Federal funds future as the instrument to the policy indicator.

The sample for our SVAR model starts from the seventh month of 1981, and ends with the sixth month of 2012 [25] given the availability of data on instruments. Luckily, our sample allows us to cover part of the post-crisis episode when the behavior of risk premium is of a particular interest. For the period when the Federal funds rate hits the zero lower bound we replace it with the shadow Federal funds rate estimated by Wu and Xia (2016) to get around the issue while maintain consistency with the empirical literature [26]. The SVAR is specified with four lags following standard information criterion while preserving a parsimonious model[27]. We report bootstrapped 90% confidence interval for the impulse responses based on 1000 draws[28].

The impulse response functions of our nine-variable SVAR are shown in Figure 5. The F-statistics for the first stage regression of instrumental variable approach is 25.08, well above the threshold for generating the weak instruments concern as suggested by Stock,

[24] We henceforth denote it as GZ bond premium. For the construction of GZ bond premium see Gilchrist and Zakrajsek (2012).

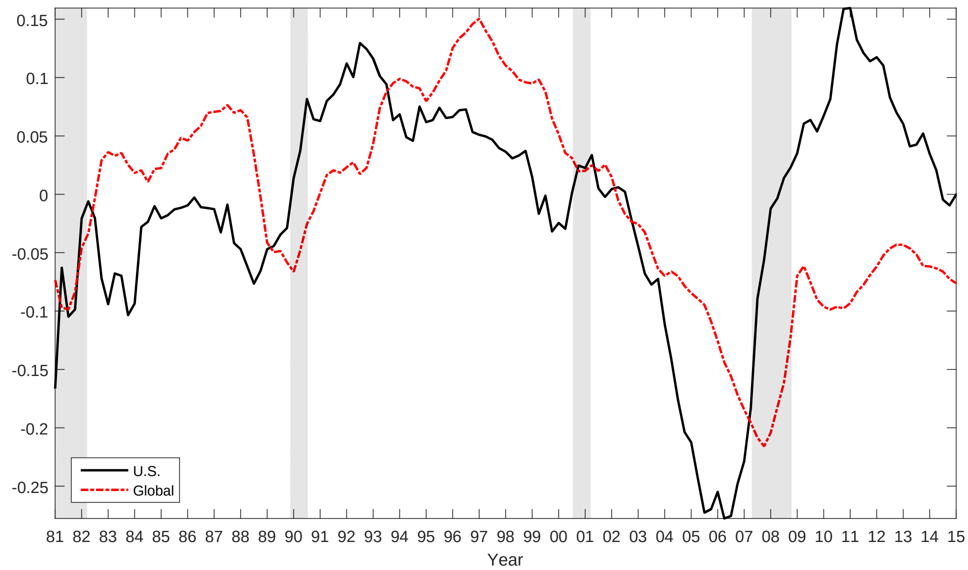
[25] Most data used in our SVAR exercises are obtained from Gertler and Karadi (2015), except for the secondary market 3-month T-bill rate which is downloaded from FRED database. We thank Mark Gertler and Peter Karadi for sharing the data. We transform the quarterly estimates of the risk premia to monthly observations by linear interpolations.

[26] We thank Jing Wu and Fan Xia for sharing their estimated shadow rate.

[27] We include quadratic time trend when estimating the SVAR model.

[28] The impulse response patterns as reported below are little changed when more lags are employed in the VAR.

Figure 4: U.S. Housing Risk Premium and Global Housing Risk Premium

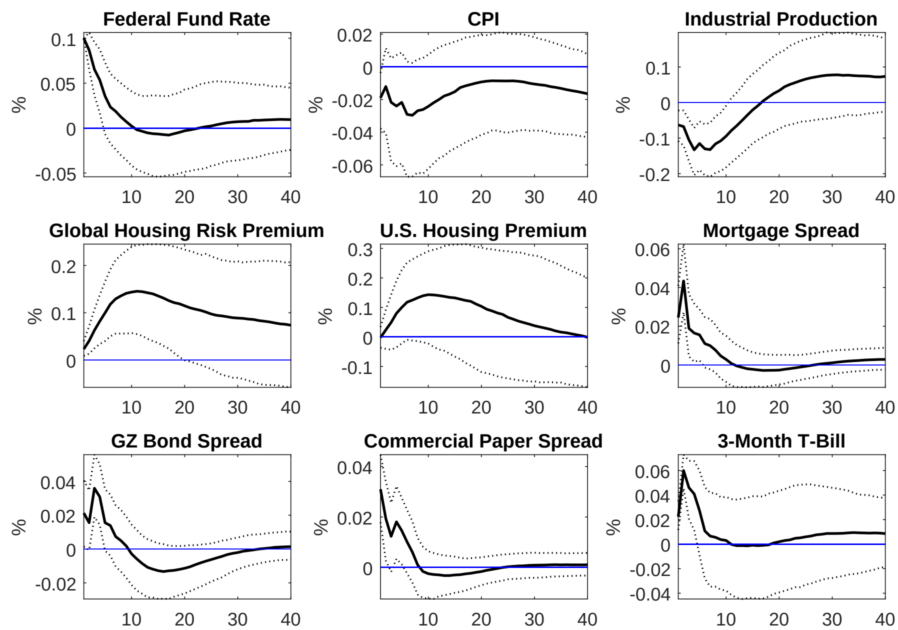


Notes: This figure compares the U.S. housing risk premium and global housing risk premium from 1981 to 2015. The former is obtained by Campbell-Shiller decomposition without dynamic factor model. The latter is measured by the average global factors in housing risk premium among all countries other than the United State. The NBER recession dates are denoted by shaded areas.

Wright and Yogo (2002), and therefore, the model is likely to be well identified. After a monetary policy tightening, measured by a 10-basis points increase in the Federal funds rate, the industrial production significantly declines. While there is a decrease in the CPI, it is not significant. Both of these directional changes are consistent with the standard macroeconomic theory. The Treasury bill rate tends to rise on impact, but then declines. Credit spreads such as the mortgage spread and the commercial paper spread both go up immediately. The response of the GZ bond premium is also positive and significant. These results imply an increase in the credit cost, and possibly the related risk following a monetary tightening.

The global housing risk premium experiences a small increase on impact, and then keeps rising to reach its peak in about 10 months, after which it slowly falls back but remains above the initial level for a long time. The bootstrapped mean response of the global housing risk premium attain its maximum at around 14.5 basis points. We interpret this result as supportive evidence for the spillover effect of the U.S. monetary policy through the risk-taking or credit channel. The increase of the U.S. housing risk premium is less significant and persistent than that of the global housing risk premium.

Figure 5: Effect of U.S. Monetary Policy on Global Housing Risk Premium

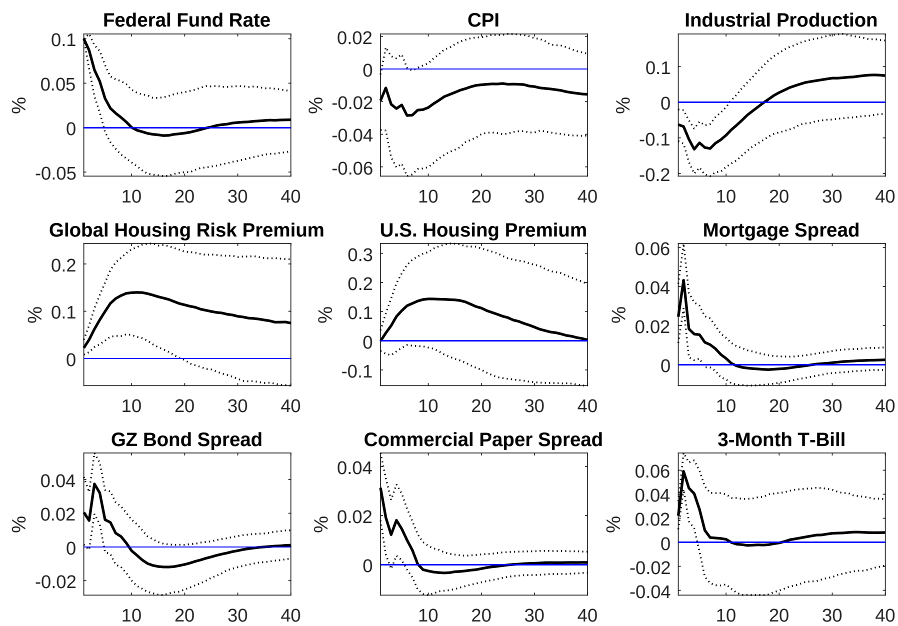


Notes: This figure provides the impulse responses to 10 basis point increase in monetary policy indicator identified through instrumental variable method. The F-Statistics for the first stage regression is 25.08, and R^2 is 8.17%. Dotted lines are 90% confidence bands based on bootstrapping.

Overall, an unexpected U.S. monetary policy tightening tends to increase the housing market implied risk premium at both the domestic and global level, for the latter there will be more discussions below.

We conduct several robustness checks. Multiple instruments are used. That is, in addition to the surprises in the current-month-ahead monthly Federal funds futures, the surprises in the three months ahead Federal funds futures, in the six month, nine month and twelve month ahead Federal funds futures on three month Eurodollar deposits are all included when estimating the impulse responses. These futures contracts are known to be sensitive to the information related to U.S. monetary policy according to Gurkaynaka, Sackb and Swanson (2005). Figure 6 shows that our results are very robust to expanding the set of instruments. Moreover, we use the two-year government bond rate as the monetary policy indicator. As noted by Hanson and Stein (2015), the two-year rate is quite sensitive to the forward guidance announcement. So conceptually, the two-year rate is likely to be informative about the policy stance for the future. The impulse responses

Figure 6: Effect of U.S. Monetary Policy on Global Housing Risk Premium: Multiple Instruments



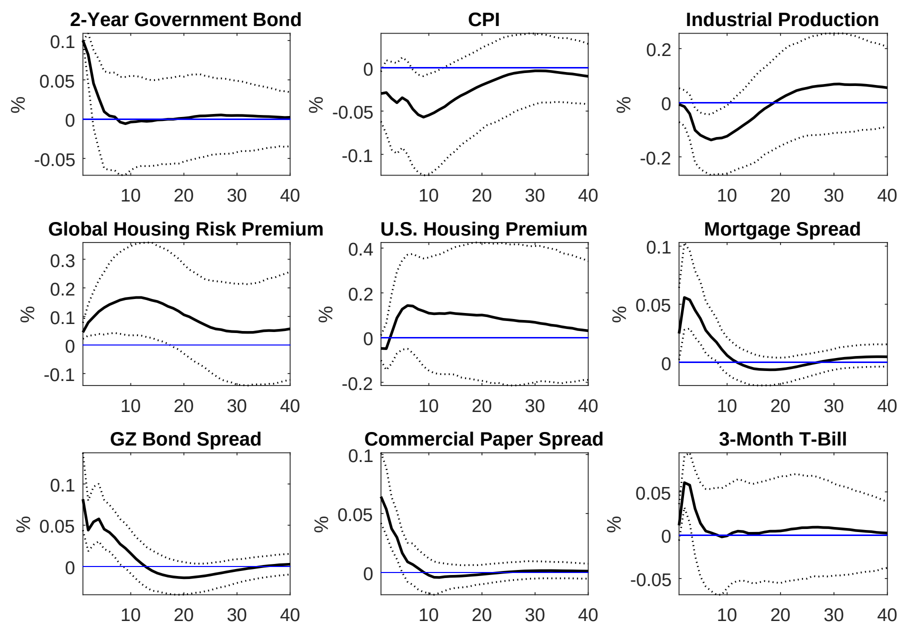
Notes: This figure provides the impulse responses to 10 basis point increase in monetary policy indicator identified through instrumental variable method. Multiple instruments are used. The F-Statistics for the first stage regression is 5.25, and R^2 is 9.04%. Dotted lines are 90% confidence bands based on bootstrapping.

using the two-year Treasury bond rate[29] as policy indicator are illustrated in Figure 7. The responses of the global housing risk premium appears to be less pronounced but remains fairly significant. Notably, the responses of the credit spreads that partially reflect the risk or financial friction in the financial market remain significantly positive.

Next, as a supplementary investigation, we also employ the traditional Cholesky identification strategy for our SVAR model. The business cycle variables such as the CPI and the Industrial Production are ordered first, followed by the Federal funds rate and the T-bill rate. The second group consists of the global housing risk premium and the U.S. housing risk premium, while the last set includes all financial spreads, namely the mortgage spread, GZ bond premium, and the commercial paper spread. Note that although the order of variables does not matter using the instrumental variable approach, it matters a great deal for the Cholesky approach. A common practice in the literature has been placing slow-moving variables before the fast-moving ones, as the latter are more likely

[29] Accordingly we use surprise in the three month ahead Federal Funds future as the instrument to improve the identification.

Figure 7: Effect of U.S. Monetary Policy on Global Housing Risk Premium: 2-Year Bond Rate



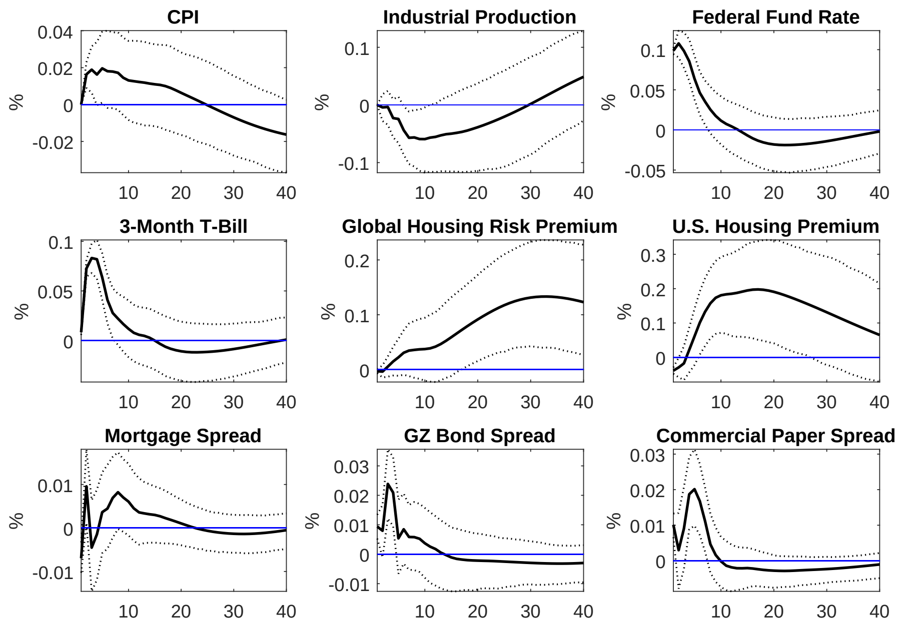
Notes: This figure provides the impulse responses to 10 basis point increase in monetary policy indicator identified through instrumental variable method. 2-year government bond is used as monetary policy indicator. The F-Statistics for the first stage regression is 4.95, and R^2 is 1.81%. Dotted lines are 90% confidence bands based on bootstrapping.

to respond to the contemporaneous variables. Those financial spreads are relatively more fast-moving than business cycle variables. We place the risk premia related to housing market between those two groups, as a house can be either viewed as a tradable asset or durable consumption good, making its price sensitive to market risk appetite, and meanwhile reflect slow-moving fundamentals underlining the real economy.

Figure 8 illustrates the impulse response functions using the recursive VAR outlined above. Comparing Figure 8 and Figure 5, we find that the responses of the business cycle to some extent reflect the well-known "price puzzle", in that, the CPI increases on impact[30]. The positive response of the T-bill rate remains significant but spreads' responses become insignificant. GZ bond premium still responds positively as before but less significantly. Compared to the benchmark case, the response of the global housing risk premium becomes more persistent and statistically significant following the monetary policy shock. Lastly, we re-estimate the benchmark model using the subsample data that

[30] Gertler and Karadi (2015) argue that this is probably due to the failure of the Cholesky approach to appropriately identify monetary policy shocks in the presence of financial variables.

Figure 8: Effect of U.S. Monetary Policy on Global Housing Risk Premium: Cholesky

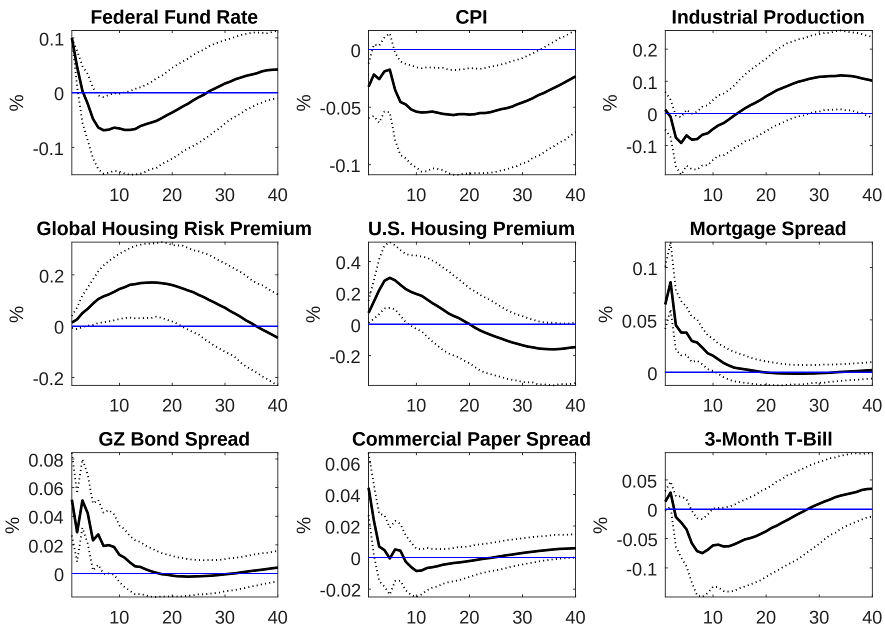


Notes: This figure provides the impulse responses to 10 basis point increase in monetary policy indicator identified through Cholesky scheme. Dotted lines are 90% confidence bands based on bootstrapping.

ends with the last month of 2007, prior to the financial crisis. Figure 9 shows some noticeable differences relative to Figure 5, while the statistically significant and hump-shaped response of the global housing risk premium is largely preserved, albeit weakened, while the U.S. housing risk premium becomes more responsive.

A very robust finding emerging from our SVAR model is that the U.S. monetary policy shock indeed impacts the global housing risk premium as well as the U.S. housing risk premium. In particular, an unanticipated U.S. monetary policy tightening is likely to be followed by a persistent and significant increase in the global housing risk premium. There is a positive response in U.S. housing risk premium as well, but less significant and persistent. These findings based on the global housing markets provide further empirical support of the international spillover effect of the U.S. monetary policy shock in the global financial markets, via the risk-taking or credit channel, complementing existing studies, such as, Bruno and Shin (2015), Rey (2015) and Miranda-Agrippino and Rey (2015). Notably, although the U.S. housing risk premium also reacts to the U.S. monetary policy shock positively, the response is less significant than that of the global housing risk premium. A possible interpretation is that, given the dominant role of the United States in

Figure 9: Effect of U.S. Monetary Policy on Global Housing Risk Premium: Subsample



Notes: This figure provides the impulse responses to 10 basis point increase in monetary policy indicator identified through instrumental variable method. Sample period is 1983M7-2007M4. The F-Statistics for the first stage regression is 12.44, and R^2 is 5.17%. Dotted lines are 90% confidence bands based on bootstrapping.

the international financial and monetary system, it is very likely that most impacts of the monetary policy and financial conditions of the United States turn out to be widespread in the global financial markets, and thus manifest themselves stronger in the global factors.

6 Concluding Remarks

To deepen our understanding of housing market variations in the context of the financial globalization, we build on previous studies to extract the global and country-specific factors in explaining the housing price-rent ratio variations, together with the associated pricing components including the rent growth rate, risk free rate and the risk premium, using a panel of 17 OECD industrial countries. For an average country, the global housing market implied risk premium is the most important determinant of the housing market volatility especially during the years leading up to the 2007-2008 financial crisis. Following the recent literature on the spillover effect of the U.S. monetary policy on financial markets around the world, we document strong empirical evidence that the global housing risk premium is heavily influenced by the U.S. monetary policy through the risk-taking or credit channel.

Our study adds evidence on the global financial cycle with a focus on the international housing markets synchronization, which is found to be largely influenced by the financial spillovers originating from the center country such as the United States. One immediate policy implication of our results is that, for countries with a high degree of exposure to global factors such as Norway or Australia, with an aim to stabilize the domestic housing market some macro-prudential policies seem necessary to contain unwanted risk-sensitive capital flows driven by global financial conditions. Our empirical exercises can also be taken as establishing some stylized empirical facts for further building a fully fledged structural model to conduct macro-prudential policy analyses that would take into account the impact of international credit or risk-taking channel on the domestic housing market. Another direction for future research is to apply our approach to a larger sample covering both advanced and emerging economies[31].

References

Adrian, Tobias, and Hyun Song Shin. 2014. "Procyclical Leverage and Value-at-Risk." *Review of Financial Studies*, 27(2): 373–403.

Aizenman, Joshua, and Yothin Jinjarak. 2009. "Current account patterns and national real estate markets." *Journal of Urban Economics*, 66(2): 75 – 89.

Ambrose, BRENT W., Piet Eichholtz, and THIES Lindenthal. 2013. "House Prices and Fundamentals: 355 Years of Evidence." *Journal of Money, Credit and Banking*, 45(2-3): 477–491.

Badarinza, Cristian, John Y. Campbell, and Tarun Ramadorai. 2016. "International Comparative Household Finance." National Bureau of Economic Research Working Paper 22066.

Bernanke, Ben S., Mark Gertler, and Simon Gilchrist. 1999. "Chapter 21 The financial accelerator in a quantitative business cycle framework." In . Vol. 1, Part C of *Handbook of Macroeconomics*, 1341 – 1393. Elsevier.

Bruno, Valentina, and Hyun Song Shin. 2015. "Capital flows and the risk-taking channel of monetary policy." *Journal of Monetary Economics*, 71: 119 – 132.

[31] Cesa-Bianchi, Cespedes and Rebucci (2015) construct a large panel of house prices data that include both advanced and emerging economies, but the associated housing rent data is absent in their study.

Campbell, John Y., and John H. Cochrane. 1999. "By Force of Habit: A Consumption Based Explanation of Aggregate Stock Market Behavior." *Journal of Political Economy*, 107(2): 205–251.

Campbell, John Y., and Robert J. Shiller. 1987. "Cointegration and Tests of Present Value Models." *Journal of Political Economy*, 95(5): 1062–1088.

Campbell, John Y., and Robert Shiller. 1988. "The Dividend-Price Ratio and Expectations of Future Dividends and Discount Factors." *Review of Financial Studies*, 1: 195–228.

Campbell, Sean D., Morris A. Davis, Joshua Gallin, and Robert F. Martin. 2009. "What moves housing markets: A variance decomposition of the rentCprice ratio." *Journal of Urban Economics*, 66(2): 90 – 102.

Cesa-Bianchi, Ambrogio, Luis Felipe Cespedes, and Alessandro Rebucci. 2015. "Global Liquidity, House Prices, and the Macroeconomy: Evidence from Advanced and Emerging Economies." *Journal of Money, Credit and Banking*, 47(S1): 301–335.

Chaney, Thomas, David Sraer, and David Thesmar. 2012. "The Collateral Channel: How Real Estate Shocks Affect Corporate Investment." *The American Economic Review*, 102(6): 2381–2409.

Cochrane, John H. 2011. "Presidential Address: Discount Rates." *The Journal of Finance*, 66(4): 1047–1108.

DelNegro, Marco, and Christopher Otrok. 2007. "99 Luftballons: Monetary policy and the house price boom across U.S. states." *Journal of Monetary Economics*, 54(7): 1962 – 1985.

Engsted, Tom, and Thomas Q. Pedersen. 2014. "Housing market volatility in the OECD area: Evidence from VA based return decompositions." *Journal of Macroeconomics*, 42: 91 – 103.

Engsted, Tom, Thomas Q. Pedersen, and Carsten Tanggaard. 2012. "Pitfalls in VAR based return decompositions: A clarification." *Journal of Banking and Finance*, 36(5): 1255 – 1265.

Fairchild, Joseph, Jun Ma, and Shu Wu. 2015. "Understanding Housing Market Volatility." *Journal of Money, Credit and Banking*, 47(7): 1309–1337.

Gan, Jie. 2007. "Collateral, debt capacity, and corporate investment: Evidence from a natural experiment." *Journal of Financial Economics*, 85(3): 709 – 734.

Gertler, Mark, and Peter Karadi. 2015. "Monetary Policy Surprises, Credit Costs, and Economic Activity." *American Economic Journal: Macroeconomics*, 7(1): 44–76.

Gilchrist, Simon, and Egon Zakrajsek. 2012. "Credit Spreads and Business Cycle Fluctuations." *American Economic Review*, 102(4): 1692–1720.

Gourinchas, Pierre-Olivier, and Helene Rey. 2007. "From world banker to world venture capitalist: US external adjustment and the exorbitant privilege." In *G7 Current Account Imbalances: Sustainability and Adjustment*. 11–66. University of Chicago Press.

Gurkaynaka, S Refet, Brian Sackb, and Eric T Swanson. 2005. "Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements." *International Journal of Central Banking*, 56–93.

Hamilton, James D. 2008. "Daily monetary policy shocks and new home sales." *Journal of Monetary Economics*, 55(7): 1171 – 1190.

Hanson, Samuel G., and Jeremy C. Stein. 2015. "Monetary policy and long-term real rates." *Journal of Financial Economics*, 115(3): 429 – 448.

Hirata, Hideaki, M. Ayhan Kose, Christopher Otrok, and Marco E. Terrones. 2012. "Global House Price Fluctuations: Synchronization and Determinants." *NBER International Seminar on Macroeconomics 2012*, 119–166. University of Chicago Press.

Iacoviello, Matteo. 2005. "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle." *American Economic Review*, 95(3): 739–764.

Iacoviello, Matteo, and Stefano Neri. 2010. "Housing Market Spillovers: Evidence from an Estimated DSGE Model." *American Economic Journal: Macroeconomics*, 2(2): 125–64.

Jackson, Laura E., M. Ayhan Kose, Christopher Otrok, and Michael T. Owyang. 2016. "Specification and Estimation of Bayesian Dynamic Factor Models: A Monte Carlo Analysis with an Application to Global House Price Comovement." In *Dynamic Factor Models (Advances in Econometrics Volume 35)*. 361–400.

Kim, Chang-Jin, and Charles R. Nelson. 1999. *State-Space Models with Regime Switching.* Cambridge, MA:MIT Press.

Kishor, N. Kundan, and James Morley. 2015. "What factors drive the priceCrent ratio for the housing market? A modified present-value analysis." *Journal of Economic Dynamics and Control*, 58: 235 – 249.

Kiyotaki, Nobuhiro, and John Moore. 1997. "Credit Cycles." *Journal of Political Economy*, 105(2): 211–248.

Leamer, Edward E. 2007. "Housing IS the Business Cycle." National Bureau of Economic Research Working Paper 13428.

Liu, Zheng, Pengfei Wang, and Tao Zha. 2013. "Land-Price Dynamics and Macroeconomic Fluctuations." *Econometrica*, 81(3): 1147–1184.

Maddala, G. S., and Shaowen Wu. 1999. "A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test." *Oxford Bulletin of Economics and Statistics*, 61(S1): 631–652.

McCauley, Robert N., Patrick McGuire, and Vladyslav Sushko. 2015. "Global Dollar Credit: Links to US Monetary Policy and Leverage." BIS Working Paper 483.

Mertens, Karel, and Morten O. Ravn. 2013. "The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States." *American Economic Review*, 103(4): 1212–47.

Mian, Atif, and Amir Sufi. 2011. "House Prices, Home Equity-Based Borrowing, and the US Household Leverage Crisis." *American Economic Review*, 101(5): 2132–56.

Mian, Atif, Kamalesh Rao, and Amir Sufi. 2013. "Household Balance Sheets, Consumption, and the Economic Slump*." *The Quarterly Journal of Economics*.

Miranda-Agrippino, Silvia, and Helene Rey. 2015. "World Asset Markets and the Global Financial Cycle." National Bureau of Economic Research Working Paper 21722.

Prasad, Eswar. 2014. *The Dollar Trap.* Princeton University Press.

Rey, Helene. 2015. "Dilemma not Trilemma: The global Financial Cycle and Monetary Policy Independence." National Bureau of Economic Research Working Paper 21162.

Rey, Helene. 2016. "International Channels of Transmission of Monetary Policy and the Mundellian Trilemma." *IMF Economic Review*, 64(1): 6–35.

Sa, Filipa, Pascal Towbin, and Tomasz Wieladek. 2014. "Capital Inflows, Financial Structure and Housing Booms." *Journal of the European Economic Association*, 12(2): 522–546.

Stock, James, and M. Watson. 1989. "New Indexes of Coincident and Leading Economic Indicators." *NBER Macroeconomics Annual*, 351–393.

Stock, James H., and Mark W. Watson. 2012. "Disentangling the Channels of the 2007-2009 Recession." National Bureau of Economic Research Working Paper 18094.

Stock, James H., Jonathan H. Wright, and Motohiro Yogo. 2002. "A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments." *Journal of Business and Economic Statistics*, 20(4): 518–529.

Tsang, Kwok Ping, and Xiaojin Sun. 2016. "The Impact of Monetary Policy on Local Housing Markets: Do Regulations Matter?" *Empirical Economics*. forthcoming.

Walentin, Karl. 2014. "Business cycle implications of mortgage spreads." *Journal of Monetary Economics*, 67: 62 – 77.

Wu, Jing Cynthia, and Fan Dora Xia. 2016. "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound." *Journal of Money, Credit and Banking*, 48(2-3): 253–291.

A Appendix (Not for Publication)

In this appendix we provide some results of variance decomposition as well as impulse responses to U.S. monetary shocks based on the larger extension VAR model when computing the Campbell-Shiller components as described in the paper.

Table A1: The Campbell-Shiller Component Volatility Contribution

	Global			Local		
Country	$\Delta\bar{d}$	$\bar{r}$	$\bar{rp}$	$\Delta\tilde{d}$	$\tilde{r}$	$\tilde{rp}$
Australia	0.0000	0.3831	0.1859	0.0051	0.1588	0.1461
Belgium	0.0016	0.0088	0.5858	0.0048	0.1512	0.0875
Canada	0.0003	0.0280	0.5430	0.0007	0.0360	0.1622
Denmark	0.0004	0.0018	0.3386	0.0007	0.3081	0.4398
Finland	0.0001	0.4359	0.2773	0.0062	0.2139	0.1451
France	0.0021	0.6726	0.1994	0.0153	0.1448	0.3729
Germany	0.0152	0.0083	2.4507	0.1785	1.4431	1.3346
Ireland	0.0001	0.0004	0.3793	0.0309	0.0650	0.3540
Italy	0.0092	0.0306	0.0634	0.1163	2.1938	3.1751
Japan	0.0092	0.0364	1.3049	0.0781	0.2761	0.6879
Netherlands	0.0006	0.0085	0.4748	0.0010	0.0867	0.2149
Norway	0.0000	0.2060	0.3045	0.0025	0.0377	0.3103
Spain	0.0000	0.0274	0.2269	0.0192	0.2595	0.4844
Sweden	0.0051	0.0756	0.2706	0.0414	0.0399	0.6585
Switzerland	0.0054	0.0087	0.2957	0.0161	0.0135	0.7436
United Kingdom	0.0025	0.5149	0.1270	0.0391	0.1466	0.2908
United States	0.0001	0.3512	0.2034	0.0004	0.2660	0.1917
Average	0.0030	0.1646	0.4842	0.0327	0.3436	0.5764
Median	0.0006	0.0306	0.2957	0.0153	0.1512	0.3540

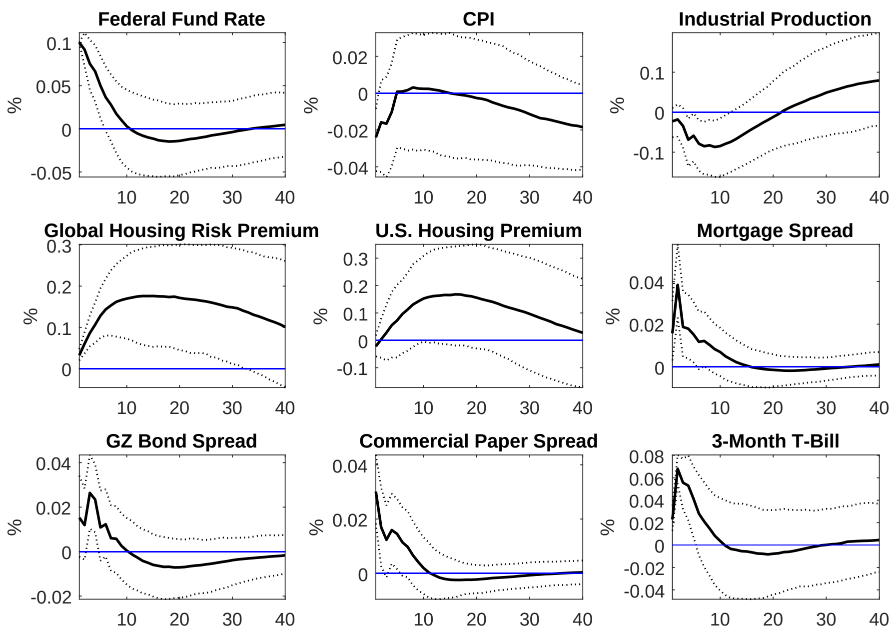
Note: This table describes share of each Campbell-Shiller component variance in the variance decomposition according to (4) for each country, while the larger extension VAR model is used. The sample period is 1983Q3-2015Q4. Δd, r and rp refer to rent growth, interest rate and risk premium components respectively. The last two rows report the average and median results.

Table A2: The Campbell-Shiller Component Volatility Contribution (1999Q1-2007Q4)

	Global			Local		
Country	$\Delta\bar{d}$	$\bar{r}$	$\bar{rp}$	$\Delta\tilde{d}$	$\tilde{r}$	$\tilde{rp}$
Australia	0.0000	0.0376	0.7682	0.0108	0.0528	0.1027
Belgium	0.0001	0.0008	0.8696	0.0025	0.0397	0.1214
Canada	0.0000	0.0024	0.8606	0.0004	0.0240	0.1560
Denmark	0.0000	0.0002	0.5219	0.0008	0.0504	0.6542
Finland	0.0003	1.1252	0.9850	0.0350	0.8946	0.6843
France	0.0001	0.0536	0.1871	0.0225	0.3269	1.2437
Germany	0.0003	0.0002	0.7714	0.0436	0.2036	0.1468
Ireland	0.0000	0.0000	0.6122	0.0780	0.0062	0.3706
Italy	0.0002	0.0009	0.0359	0.0038	0.0587	0.6592
Japan	0.0004	0.0020	0.9028	0.0034	0.0465	0.1019
Netherlands	0.0000	0.0008	0.7177	0.0022	0.1077	0.1415
Norway	0.0000	0.0143	0.6744	0.0022	0.0334	0.4209
Spain	0.0000	0.0027	0.4683	0.0104	0.0205	0.5305
Sweden	0.0003	0.0066	0.5301	0.0166	0.0233	0.4000
Switzerland	0.0003	0.0007	0.2964	0.0094	0.0147	0.6489
United Kingdom	0.0002	0.0631	0.5742	0.0302	0.1195	0.2720
United States	0.0001	0.6767	0.7110	0.0226	1.0572	2.0190
Average	0.0001	0.1169	0.6169	0.0173	0.1812	0.5102
Median	0.0001	0.0024	0.6744	0.0104	0.0504	0.4000

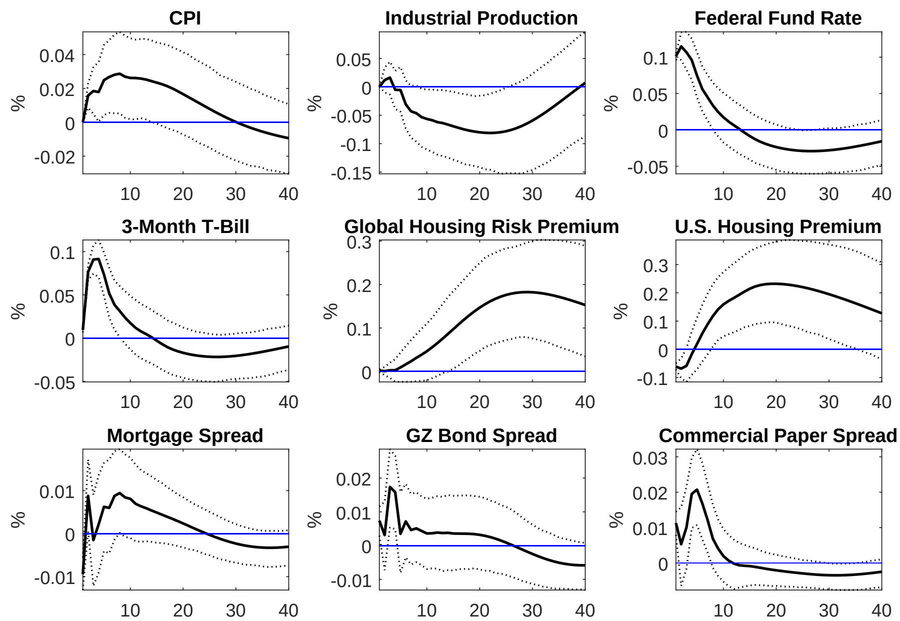
Note: This table describes share of each Campbell-Shiller component variance in the variance decomposition according to (4) for each country, while the larger extension VAR model is used. The sample period is 1999Q1-2007Q4. Δd, r and rp refer to rent growth, interest rate and risk premium components respectively. The last two rows report the average and median results.

Figure A1: Effect of U.S. Monetary Policy on Global Housing Risk Premium



Notes: This figure provides the impulse responses to 10 basis point increase in monetary policy indicator identified through instrumental variable method. The extension VAR is used in estimating risk premium components. The F-Statistics for the first stage regression is 29.38, and R^2 is 9.44%. Dotted lines are 90% confidence bands based on bootstrapping.

Figure A2: Effect of U.S. Monetary Policy on Global Housing Risk Premium: Cholesky



Notes: This figure provides the impulse responses to 10 basis point increase in monetary policy indicator identified through Cholesky scheme. The extension VAR is used in estimating risk premium components. Multiple instruments are used. Dotted lines are 90% confidence bands based on bootstrapping.