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Are House Prices Driven by Capital Flows? Evidence from Singapore

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This paper investigates whether real house price appreciations can be attributed to the surge in real capital inflows into Singapore. We proxy capital flows by using the amount of Foreign Direct Investments (FDI) to real estate capturing the foreign purchases of property in Singapore which we deflate by the private residential property price index. Notwithstanding the absence of a cointegrating relationship, our results support the hypothesis that lagged short term fluctuations in capital inflows are positively associated with the growth rates of house prices over the last decade. We also provide evidence that macroprudential measures implemented by Singapore reduced the impact of capital inflows on house price appreciation by more than half, suggesting the effectiveness of such market cooling measures in weakening the credit growth channel.

Keywords: Capital inflows; house prices; macroprudential policy.

JEL Classifications: F32, F21, E44

1. Introduction

The importance of the housing market in the macroeconomy is well appreciated by now.[1] As was clearly witnessed in the United States (US) during the global financial crisis (GFC), the collapse of a house price bubble can lead to financial market distress and destabilize the economy. However, economists have debated the role of unfettered international capital flows in explaining fluctuations in house prices. For instance, Glindro *et al.* (2011) emphasized the role of institutional factors in determining house

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[1] Theoretical approaches for analyzing the role of housing in the macroeconomy include the life cycle model and the financial accelerator model that relate consumption to housing wealth.

price dynamics, whereas Tomura (2010) shows that expectation-driven boom-bust cycles in house prices can occur only if the economy is open to international capital flows.

Cross-border capital flows to Asia surged in the run up to the GFC as well as in the post-GFC period, despite collapsing during the GFC. As documented in Balakrishnan *et al.* (2012), net capital inflows to Asia rose at a record pace from a trough in early 2009 to a peak in mid-2010 within five quarters. Capital in search of high-yielding investments found Asia to be an attractive destination because of the growth and interest rate differentials between the region and the advanced economies (see Ahmed and Zlate, 2015). In particular, the direct effects of the GFC were much less severe and short-lived in the Asian economies which in turn encouraged inflows from the global liquidity surge[2] that resulted from the expansion of the monetary base by major central banks such as the US Federal Reserve, European Central Bank and Bank of Japan (CGFS, 2011). Various studies including Fratzcher (2012) and Cerutti *et al.* (2015) have shown the state of liquidity in the developed countries is an important push factor that drives capital flows to emerging markets in general.

More recently, an event study by Rai and Suchanek (2014) reveals that the tapering of large scale asset purchases by the Federal Reserve resulted in sharp withdrawals of private capital flows from some emerging markets in the region such as China, India, Indonesia, Korea, Malaysia, Philippines, Taiwan and Thailand. In fact, markets of late have been focussed on when the Federal Reserve will raise the Fed funds rate and depart from its zero interest rate policy. Policymakers in Asia (and elsewhere) are thus concerned about the repercussions of potential capital reversals arising from monetary policy normalisation in the US (see Kynge and Blitz, 2015). After all, quantitative easing in the advanced economies is shown to influence prices of a broad range of assets including bonds, equities and currencies in Asian markets, see *inter alia* Chen *et al.* (2012). Should a sudden large-scale capital reversal occur, the attendant sharp correction in asset prices will adversely impact the economy.

Given this background, this paper sheds some light on the importance of international capital flows in shaping house price dynamics by focusing on the Singapore housing market. Singapore is an archetypal small open economy that witnessed a dramatic rise in the price of residential properties in the last decade. Although house prices in Singapore took a dive at the outbreak of the GFC, they bounced back soon after the global financial panic, with the private residential Property Price Index (PPI) touching a historic high in 2013Q3. During the same year, Singapore experienced strong capital inflows due to the low external interest rate environment as well as the surge in global liquidity. To address the question of whether the observed rise in house prices was driven by the inward surge of foreign capital, we estimate the effect of capital inflow on private residential property prices in Singapore.

[2] The Committee on the Global Financial System (CGFS) (2011) provides an extensive discussion on the measurement, drivers and policy implications of global liquidity.

A number of studies have been conducted to investigate the association between house prices and capital flows but the empirical evidence is somewhat mixed.[3] Based on a large cross-section of advanced and emerging market economies, Aizenman and Jinjarak (2013) found using dynamic panel regressions that real estate appreciations were related to the lagged increases in current account deficits of the sample countries, both before and after the GFC. Nonetheless, when the current account balance — the counterpart of net capital inflows — was replaced by gross capital flows or disaggregated flows, the linkages with real estate valuation turned out to be weak or not statistically significant. In another study, Favilukis *et al.* (2012) also used the current account deficit as the broad measure of capital inflows for a wide panel of economies and found that current account deficits did not explain house price fluctuations. Instead, they found that the key causal factor for house price movement was the extent of financial market liberalisation.

Focusing on the OECD countries specifically, Sá *et al.* (2011) used non-residential investments as the proxy for capital flows. Results from a panel Vector Auto Regression (VAR) model showed that shocks to capital inflows (and to monetary policy) had a substantial impact on property prices and other housing variables. Adopting a similar econometric approach, Tillman (2013) examined the impact of net capital inflows on house prices in six Asian economies. The study established that a positive shock to net capital inflows generated substantial and persistent rise in house prices in the sample countries studied. Contrasting results were found by Kim and Yang (2011) who also used a panel VAR to investigate the impact of gross capital inflows and gross portfolio inflows on land prices in five Asian economies. They showed that only a small portion of land price variation was accounted by shocks to either gross capital inflow or gross portfolio inflow identified through a recursive scheme.

Overall, we find that the relatively recent related literature tends to study the impact of international capital flows on house prices for the region as a whole, mainly due to data constraints. However, the findings from a panel approach may mask variations across the individual economies. Turning to studies on individual Asian economies, Kim and Yang (2009) applied VAR models with a recursive identification scheme to Korean data. They showed property prices in Korea did not respond to gross capital inflow shocks or gross portfolio inflow shocks, even though the latter had an impact on stock prices. The paper closest to ours is by Yiu and Sahminan (2015) which examined nominal house price growth in five Asian economies individually including the case of Singapore. They found through dynamic regression analysis that portfolio inflows, after accounting for domestic Gross

[3] One possible explanation for opposing results across various studies is the different time periods under review, particularly whether the sample periods include or exclude the GFC period. The adoption of differing econometric approaches as well as different measures of capital flows in the various studies could also have led to contrasting results.

Domestic Product (GDP) growth, had a positive impact on house price appreciation in both Indonesia and Singapore.[4]

In this paper, we examine the effect of capital inflows specifically on the Singapore housing market.[5] Since our concern is on financial stability issues, we avoid the use of net capital inflows as our measure of foreign capital flows. After all, it is questionable that a country is able to remit its external assets swiftly when it experiences sudden capital outflows. Some of the aforementioned studies which use gross capital flows as their measure of capital flows do so because they can have an indirect impact on house prices, say through an increase in domestic liquidity. Nevertheless, gross capital inflows in Singapore are generally dominated by the "other investments" category which is largely driven by huge flows between onshore and considerably larger offshore banking sectors. Hence, gross capital flows is not particularly relevant for the analysis of house prices in the case of Singapore. Instead, we use the capital flow data most relevant for studying house prices which is the variable measuring Foreign Direct Investment (FDI) flows to Singapore's real estate sector.

Another point of departure from the existing literature is that we investigate the empirical association between real house prices and real capital inflows, in place of nominal flows. Hence, the variable FDI flows to real estate is first deflated by the private PPI before we estimate its impact through econometric analysis. Specifically, we employ the error correction representation of the Autoregressive Distributed Lag (ARDL) model that allows us to differentiate between short-run and long-run relationships. To preview the main results, the Pesaran bounds test indicates that a long run effect is not supported in the current sample. Nonetheless, we find through dynamic regression models that fluctuations in real capital inflows do have a significant positive impact on short-term dynamics of house prices, after controlling for other factors. In addition, we detect the presence of momentum effects in house price inflation which tends to result in huge swings in house prices.

Taking into account that house price swings can have a destabilizing effect on the economy, the Singapore authorities implemented macroprudential measures targeting the housing sector in order to contain risks to the financial system. An empirical investigation of the effectiveness of these measures in inhibiting the impact of real capital inflows on house prices has not been done yet, which this paper attempts to do. Though some papers such as Zhang and Zoli (2014) and Darbar and Wu (2015) tend

[4] Our study is similar in terms of the focus on an individual economy and the use of single equation models. Three key points of differentiation are, in our paper (i) we use real instead of nominal variables; (ii) we consider more control variables including spillover effects from the stock market; and (iii) we quantify the effectiveness of macroprudential measures on mitigating the impact of capital flows.

[5] In a related study, Chow and Choy (2009) use a factor augmented VAR model to show that monetary policy shocks have a significant effect on house prices. However, that study does not examine the impact of foreign capital on house prices and the sample period under review does not include the GFC.

to focus on how well macroprudential policies abate house price accelerations and curb the volume of housing transactions or housing loans, due to the short time span of available data, these analyses tend to be more descriptive in nature. Our study makes a contribution to the empirical literature quantifying the effects of capital inflows on house prices due to a tighter macroprudential policy stance.

The remainder of this paper is organized as follows. Section 2 examines the trajectory of house prices and the pattern of FDI flows to real estate in Singapore. An empirical analysis of the linkage between real house price fluctuation and real capital inflows, controlling for other macroeconomic and financial factors is presented in Sec. 3. This is followed by Sec. 4 which discusses the macroprudential policy measures implemented in Singapore and provides an empirical assessment of their effectiveness in mitigating the impact of foreign capital on domestic residential property prices. Section 5 concludes.

2. Recent Trends in House Prices and Capital Inflows in Singapore

The Singapore real estate market is marked by several uncommon features. First, the housing market is dominated by public housing which makes up more than three quarters of the total housing stock. The Housing Development Board (HDB) is the government agency that builds flats on government allocated land and sells the apartments to eligible Singapore citizens at a highly subsidized rate. These flats can be resold in the HDB resale market to eligible citizens or permanent residents after a minimum occupancy period.[6] Second, since the 1990s, home ownership rate in Singapore has been very high at around 90%. This is largely due to the policy of allowing high mandatory savings to be used for housing finance. Third, the government intervenes rather extensively in the housing market by regulating supply and demand of residential property in both the public and private segments. Phang (2015) provides a comprehensive review of Singapore housing policies over the past five decades.

The Singapore private PPI, published by the Urban Redevelopment Authority of Singapore is shown in Fig. 1. The index is constructed using a stratified hedonic regression method[7] that is able to control for differences in housing characteristics including size and age of the property as well as its distance to the Mass Rapid Transit (MRT) train station. The uptrend in the index accelerated from 2006 but collapsed during the GFC. This is followed by a sharp pickup in the immediate aftermath of the

[6] As pointed out in Liao *et al.* (2015), foreign liquidity tends to flow into high-end properties and those in the central district. Price shocks are then transmitted to the other segments of the property market and houses in the non-central districts. The consequent broad base rise in private housing prices is, in turn, followed by an increase in public housing prices particularly those in the HDB resale market.

[7] The hedonic regression is a revealed preference method of estimation. It decomposes the house price into its constituent characteristics such as tenure, age, property type, location and other property attributes, and obtains estimates of the contributory value of each characteristic.

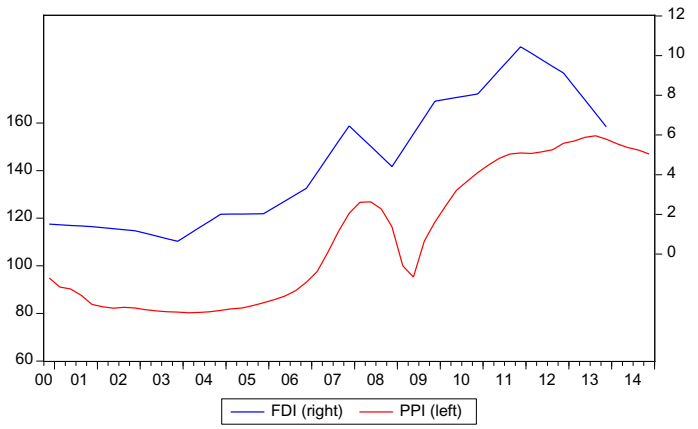

Figure 1. Singapore private PPI and FDI to real estate (in S$ billion).
Source: CEIC and Singapore Department of Statistics, respectively.

GFC along with the rapid recovery in foreign investor interest in the high-end residential segment of the property market. Domestic factors contributing to the acceleration in house prices post-GFC include rapid population increases and the low interest rate environment.

We see in Fig. 1 that the private residential PPI reached a peak of 154.6 index level in mid-2013, a new historic high in the private property price level, surpassing the previous historic peak of 129.7 index level in 1996. The private residential PPI overshot the pre-crisis peak substantially, rising by a steep 17.6% in 2010.[8] This prompted the government to increase land sales and introduce a series of market-cooling measures from September 2009 to December 2013. A discussion of these measures as well as their effectiveness is found in Sec. 4 of this paper. The growth rate of the PPI moderated from 2011 onwards to only 2.8% in 2012 as the government interventions took effect. By 2014, the property market was reporting a decline of −4%.

Turning to capital flows, the Singapore economy has persistently recorded current account surpluses and is a net exporter of capital. As an international financial center, Singapore has free capital mobility. Since 1978, all forms of exchange controls and restrictions on inflows and outflows have been dismantled to aid the development of offshore financial markets. Even the restrictions to limit the offshore use of the Singapore dollar in order to prevent currency speculation have been gradually eased over the years (Chow, 2010). In particular, no restriction is placed on capital flows between the domestic banking system and its significantly larger offshore banking sector known as the Asian Dollar Market. It is thus unsurprising that gross capital inflows in Singapore are dominated by the "other investment" category which is

[8] In comparison, Singapore's stock market index did not recover to the pre-crisis level even though it did recover after the crisis.

driven by the lively interactions between the onshore and offshore deposit-taking institutions.

The capital flows variable relevant for studying house prices is the one measuring FDI flows to the real estate sector in Singapore, which is also plotted in Fig. 1. Purchases of property in Singapore by foreigners are classified under FDI to the real estate sector. We note that the latter does not include foreign developers' purchases to develop property for sale as these flows are classified under a separate construction category. It is discernible from the chart that this capital inflow measure has a general upward trend. Foreign investor participation in the Singapore property market has been rising since the economic recovery from the Asian Financial Crisis (AFC). Indeed, there is a threefold increase in the stock of FDI to real estate between 2000 and 2012. Such active foreign participation could generate transmission of shocks in capital flows to the recipient country's financial markets. We observe from Fig. 1 that the two series move in a similar pattern over time, with the FDI series exhibiting a lead over the PPI series.

Other types of foreign capital flows including portfolio flows to real estate and bank loans to real estate are expected to exert an impact on house prices as well. However, data on these variables are not available. Data are available for gross capital inflows and gross portfolio inflows instead. In general, an increase in either variable may have an indirect impact on residential property prices, say through an increase in domestic liquidity or a lower interest rate. However, as noted earlier, the gross capital inflows variable in Singapore is dominated by the "other investments" category which in turn is largely driven by gross bank loan inflows. As illustrated in Fig. 2, the evolution of gross bank loan inflows is just a broad mirror image of gross bank loan outflows, reflecting active interactions between the onshore and offshore banking sectors. The presence of a very large offshore banking sector and its close linkages with the domestic banking sector means that the bank flows are mostly flows between these two

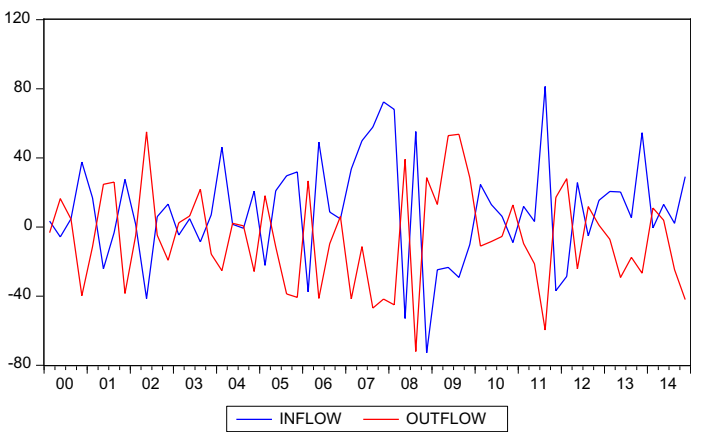

Figure 2. Gross bank loans inflows and outflows (S$ billion).
Source: CEIC

sectors. Hence, it comes as no surprise that we could not detect a significant impact on house prices when we replicate our empirical analysis with gross bank loan inflows as our measure of capital flows.[9]

3. Methodology, Data and Empirical Results

This section analyses the impact of foreign capital on Singapore's housing market by applying an ARDL model to Singapore data. In comparison to a VAR model or a Vector Error Correction (VEC) model, a single equation model is more parsimonious and thus, more suited for our analysis given the limited data. For valid statistical inference, however, we need to ensure there is no two way causality between the house price index and the inflows of capital. Robustness checks are carried out and they do not provide empirical support for reverse feedback during the sample period under review.[10]

3.1. *Econometric framework*

We use the following ARDL model to capture the influence of the level of capital inflows and control variables on house price level:

$$\text{RPPI}_t = \beta_0 + \sum_{j=1}^{p} \phi_j \text{RPPI}_{t-j} + \sum_{j=0}^{q} \beta_j \text{flow}_{t-j} + \sum_{i=1}^{k} \sum_{j=0}^{r_i} \theta_{i,j} X_{i,t-j} + \varepsilon_t. \quad (1)$$

Here, the real house price index (RPPI_t) is explained by its own past values, current and lagged values of real capital inflow (flow_t) as well as current and past values of k control variables. The number of past values to include in the equation i.e., $(p, q, r_1, r_2, \ldots, r_k)$ are not necessarily the same for the different variables and are selected based on the Schwarz Information Criterion (SIC).

In order to distinguish between short term adjustment of and long run impact on the house price index, the ARDL model is written in the following error correction form. This alternative expression of the model allows us to separate the long-run relationship between the levels of the variables from the dynamic adjustments around the equilibrium.

$$\begin{aligned} \Delta\text{RPPI}_t = & \sum_{j=1}^{p-1} \delta_j \Delta\text{RPPI}_{t-j} + \sum_{j=0}^{q-1} \gamma_j \Delta\text{flow}_{t-j} + \sum_{i=1}^{k} \sum_{j=0}^{r_i-1} \theta_{i,j} \Delta X_{i,t-j} \\ & + \alpha_0 + \alpha_1 \text{RPPI}_{t-1} + \alpha_2 \text{flow}_{t-1} + \sum_{i=1}^{k} \alpha_{i+2} X_{i,t-1} + \varepsilon_t, \end{aligned} \quad (2)$$

[9] Similarly, when we use gross portfolio inflows as our measure of capital flows, we do not obtain a statistically significant impact of the flow variable on house prices.

[10] Following Aizenman and Jinjarak (2013), we swap the two variables in the ARDL model so that capital inflows become the dependent variable. As an explanatory variable, the house price index does not exhibit a statistically significant effect on capital inflows. In addition, the results from applying Hausman test of endogeneity to the final dynamic regression model in Table 1 suggest the change in capital inflows is an exogenous variable.

where Δ is the first difference operator. The terms in first differences, such as ΔRPPI_t and Δflow_t, as well as their lagged values represent short run movements of the variables. In this dynamic specification, the short run adjustments in the house price index is explained by its own past inflation rates, variations in the current and past capital inflows, as well as current and past changes in the control variables. In particular, the γ_j coefficients in Eq. (2) measure the short-run impact of changes in capital inflows on growth rates of the house price index.

The variables in levels namely $\text{RPPI}_{t-1}, \text{flow}_{t-1}, X_{1,t-1}, X_{2,t-1}, \ldots$ and $X_{k,t-1}$ in Eq. (2) represent the long-run relationship among the variables. When the model is expressed in the error correction form, we can perform hypothesis testing for the presence of cointegration. We apply the bounds testing approach by Pesaran *et al.* (2001) that has the advantage of not requiring the pre-testing of variables for order of integration conformity. In particular, using the parameters from Eq. (2), we test the null hypothesis of no cointegration by setting $H_0 : \alpha_i = 0$, for all $i = 1, 2, \ldots, k+2$. Such a test is based on the magnitude of the F test statistics and is valid even when the regressors have different orders of integration, i.e., I(0) or I(1).

However, the critical values vary depending on the unit root properties of the variables, with them being larger for I(1) variables than for I(0) variables. The decision rule is as follows: when the F-test statistic exceeds the upper critical value, we reject the null hypothesis of no cointegration and when the F-test statistic falls below the lower critical value we do not reject the null hypothesis of no cointegration. Otherwise, when the F-test statistic falls in between the two critical values, the test is deemed to be inconclusive because the conclusion depends on the order of integration of the variables. Due to our small sample size, we are not able to use the critical values found in Pesaran *et al.* (2001) that are generated for large sample sizes of 500 and beyond. Rather, we use the critical values provided in Narayan (2005) that are generated for smaller sample sizes from 30 to 80. In particular, we use the critical values associated with a sample size of 50 which is the approximate number of observations used for estimating our ARDL model.

3.2. *Data and estimation issues*

Our capital flows variable is FDI flows to the real estate sector. However, the series measuring FDI flows to real estate is only available on an annual basis. Limiting ourselves to annual observations in such a short sample period will result in degree of freedom problems such as inefficient parameter estimation of the model. Hence, we use the cubic spline method to interpolate this series into quarterly frequency.[11] Unlike most studies in related literature, we use real capital flows in place of nominal flows in

[11] Favilukis *et al.* (2012) also carried out interpolation to quarterly frequency of the annual series on net foreign liability position of the US which is the main measure of capital inflows to the US used in their study.

our study. That is, the FDI flows to the real estate sector are first deflated by the PPI. Moreover, capital inflows enter in the empirical model as a percentage of the trend component of real GDP which is extracted using the Hodrick–Prescott filter. Similarly, we deflate the nominal PPI with the Consumer Price Index (CPI) in order to estimate foreign capital's impact on the real PPI (RPPI).

To isolate the partial effect of capital inflows, there is a need to control for other factors that also have an influence on house prices. House price movements are known to be closely associated with macroeconomic variables such as economic growth, inflation and the mortgage rate. For instance, a higher income as captured by the real GDP variable tends to increase demand for new housing and encourage upgrading to better housing. Further, strong growth in the economy raises expectations of rising house prices which leads to a higher demand, thereby inflating house prices further. Another control variable is the CPI and we expect real house prices to be negatively related to inflation. Finally, the mortgage rate is included since it affects the financing capacity of home buyers and tends to be negatively related to house prices.[12] Hence, we use real gross domestic product (GDP_t), consumer price index (CPI_t), mortgage rate (i_t) and real stock price index (STI_t) as our control variables $X_1, X_2, \ldots$ and X_k respectively in Eqs. (1) and (2).

We note that these control variables included in the model could also have an indirect impact on house prices through the capital flows channel in addition to their direct effects. For instance, in the case of real GDP, the improvement in economic conditions will also attract foreign capital flows to the housing market so that there is an indirect impact through the capital flows channel. Nonetheless, the control variables have at least in part a direct effect on residential property prices. By contrast, there are other variables such as the volatility index VIX that impact house prices largely through the capital flows channel. Since the capital flows variable is already represented in the model, such variables are thus omitted.

It has been shown in the literature that spillover effects often occur from the domestic stock market to the housing market (see *inter alia* Anoruo and Braha, 2008). On the one hand, there can be a positive linkage between asset prices due to wealth effects. For instance, a boom in the stock market increases investors' capacity to further invest in the housing market, thereby driving up property prices. On the other hand, a negative relationship is predicted by a substitution effect. For instance, a boom in the stock market might cause investors to invest in stocks rather than houses. In order to capture the net spillover effect, we include in our model the real Straits Times Index. The latter is a capitalization-weighted stock market index that tracks the top 30 companies on the Singapore Exchange and is the benchmark index for the Singapore stock market.

[12] Institutional factors are omitted since we are not dealing with cross-country variations. We acknowledge there could be other variables that influence house prices but given the limited data availability we choose to keep our model parsimonious.

All macroeconomic data series, except the capital inflows data, are from the CEIC database. These include the private residential PPI, seasonally adjusted CPI, seasonally adjusted real GDP, housing loan rate and the Straits Times index. The capital inflows variable is obtained from the Singapore Department of Statistics. Subject to the time span available for this series, our sample period is from 2000Q4 to 2013Q4. Although this time period omits earlier boom-bust episodes of residential property prices, they allow us to focus on the impact of increased capital inflows arising from extremely loose monetary policy stance in the US and other advanced economies. All data series are tested for seasonality and none require seasonal adjustment since the variables that typically exhibit seasonal patterns such the GDP and the CPI are seasonal adjusted at source. We take the log transformation of all variables except for capital flows and interest rates.

3.3. *Empirical results*

Initially, we estimate the ECM with all four control variables. The number of lagged terms in the model $(p, q, r_1, r_2, r_3, r_4)$ are determined by minimizing the SIC which gives us (1, 4, 1, 1, 1, 3). The model is estimated with 49 observations after taking into account the lag lengths in the variables and it yields a F-statistic value of 3.87 for the Pesaran bounds test. The 5% lower and upper critical values for a sample size of 50 and five regressors are 2.90 and 4.22, respectively. Hence, we cannot conclude from the Pesaran bounds test results that there is a cointegrating relationship amongst the variables. Further, the short-term coefficient estimates of the two control variables — consumer price inflation and the change in mortgage rates — are not significant at the 5% significance level. It appears that house price inflation in Singapore is not sensitive to movements in these two variables.

A priori, one expects the mortgage rate will affect house price appreciation given the heavy reliance on mortgage financing in the Singapore housing sector. The model's inability to detect its impact is likely due to the sample period under consideration. Prior to 2007, most mortgage rates in Singapore were set periodically by the banks and not linked to the short-term interest rate. Although mortgage rates became pegged to the Singapore Interbank Offer Rate (SIBOR) after 2007, the latter followed the US interest rate to fall sharply at the onset of the GFC and stayed flat at less than 1% as US interest rates hit a lower bound.[13] Consequently, changes in the mortgage rate series occur as step jumps so that that there is not much variation in this data series. This is a plausible explanation why the estimated model is unable to pick up the mortgage rate's effect on house prices.

These findings lead us to estimate an ARDL model without the two control variables, CPI and the mortgage rate. The optimal number of lagged terms (p, q, r_1, r_4) in

[13] With reference to its policy trilemma configuration, Singapore opts for free capital mobility and a managed exchange rate trading off control over the domestic interest rate. Hence, interest rates in Singapore move closely in tandem with US interest rates.

this smaller model is found to be (4, 4, 0, 3) and the model is estimated with 49 observations. The corresponding 5% lower and upper critical values for a sample size of 50 and three regressors are 3.50 and 4.70, respectively. Since the F-test statistic for this model turns out to be 3.28 which is smaller than the lower critical value, no cointegration is detected by the Pesaran bounds test in this smaller model. In spite of the statistically significant coefficients estimates of the variables in first differences, we do not interpret them to make inference on short term dynamics since the ECM is incorrectly specified when a long run relation is absent.

To estimate the short run relationship, we run the following dynamic regression of real house price inflation against changes in real capital inflows, real GDP growth and changes in the real STI index. That is, we focus only on short-run dynamics since the variables are not cointegrated.

$$\Delta \mathrm{RPPI}_t = \sum_{j=1}^{p-1} \delta_j \Delta \mathrm{RPPI}_{t-j} + \sum_{j=0}^{q-1} \gamma_j \Delta \mathrm{flow}_{t-j} + \sum_{j=0}^{r_1-1} \lambda_j \Delta \mathrm{GDP}_{t-j} + \sum_{j=0}^{r_4-1} \kappa_j \Delta \mathrm{STI}_{t-j} + \alpha_0 + \varepsilon_t. \tag{3}$$

The optimal lag lengths (p, q, r_1, r_4) in Eq. (3) based on SIC turn out to be (2, 3, 2, 2) and the estimated model is recorded in Table 1. Recursively dropping the irrelevant lags gives us the best fit model with an even lower SIC, that is also recorded in the same table.

Table 1. Dynamic regression models for Singapore real house price index.

	$\Delta \mathrm{RPPI}_t$		$\Delta \mathrm{RPPI}_t$	
	Coefficient	Std. error	Coefficient	Std. error
$\Delta \mathrm{RPPI}_{t-1}$	0.298**	0.107	0.248**	0.092
$\Delta \mathrm{flow}_t$	−1.908	1.250		
$\Delta \mathrm{flow}_{t-1}$	3.563*	2.085	0.894***	0.289
$\Delta \mathrm{flow}_{t-2}$	−1.924	1.328		
$\Delta \mathrm{GDP}_t$	0.161	0.172		
$\Delta \mathrm{GDP}_{t-1}$	0.403**	0.155	0.357***	0.153
$\Delta \mathrm{STI}_t$	0.031	0.031		
$\Delta \mathrm{STI}_{t-1}$	0.128***	0.035	0.144***	0.030
Intercept	−0.002	0.001	−0.001	0.001
Adjusted R-square	0.706		0.680	
SIC	−6.023		−6.200	

Note: ***, ** and * indicate 1%, 5% and 10% statistical significance.

We see from the final model in Table 1 that changes in FDI in Singapore's real estate sector exert a one-quarter lagged effect on house price inflation. The coefficient estimate of the capital inflow variable is positive and has a high statistical significance at the 1% level. Aggregate output changes which reflect domestic economic conditions also have a significant positive one-quarter lagged effect on house price appreciations. Intriguingly, the economic importance of capital inflows is greater than that of economic growth as reflected in the larger magnitude of the coefficient estimate of the *flow* variable relative to that of the GDP variable. Similarly, the lagged STI also registered a significant positive impact on the growth rate of house prices, but this spillover effect has less economic significance compared to the capital inflows and output growth variables. In other words, we find foreign capital flows have a greater explanatory power on Singapore house price appreciation than domestic factors like output growth and spillover effect from the local stock market.

Finally, it is also evident from Table 1 that the current house price appreciation is influenced by its own past quarter value. The coefficient estimate of the lagged dependent variable is statistically significant with a positive effect of 0.25. This means house price inflation in Singapore exhibits cyclical patterns and is subject to momentum effects. Hence the Singapore housing market could also be subject to expectation-driven boom-bust cycles that delink house prices from fundamentals (Adam *et al.*, 2011). This finding provides support for the authorities' implementation of macroprudential measures that target the housing market.

In summary, even though no long run relationship is detected, our empirical analysis reveals that the surge in real capital inflows is strongly associated with real house price appreciation in Singapore. Further, this short term impact of foreign capital flows seems more sizeable relative to the influence of domestic macroeconomic and financial market conditions as represented by real economic growth and real stock price inflation respectively. Likewise, Aizenman and Jinjarak (2013) found current account variations representing net capital inflows to be more economically important in determining real estate valuation than variables such as domestic credit and equity market valuation. Our results also support the presence of momentum effects in the Singapore housing market, although it is not as strong relative to the impact exerted by foreign capital flows.

3.4. *Impulse response analysis*

We next use impulse response analysis to further uncover the dynamics between house prices and the explanatory variables determined in the previous sub-section. To this end, the following VAR model is employed:

$$\Delta y_t = \beta_0 + \sum_{k=1}^{s} \beta_k(L) y_{t-k} + \varepsilon_t, \tag{4}$$

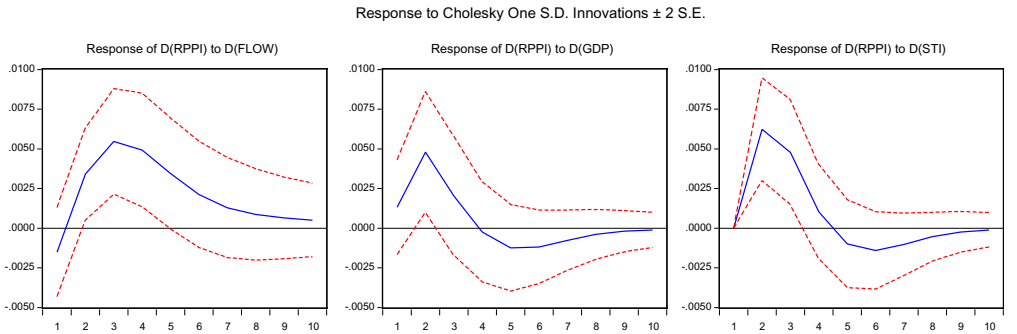

Figure 3. Impulse response functions of RPPI.
Source: Authors' calculations.

where $\Delta y_t = (\Delta\text{RPPI}_t, \Delta\text{flow}_t, \Delta\text{GDP}_t, \Delta\text{STI}_t)'$; $\beta_k(L)$ is a 4×4 matrix of lag polynomials, and β_0 is a vector of constants.[14] For parsimony, we use a VAR model with lag length (s) one. The VAR framework allows us to derive impulse response functions that trace the dynamic effects on the real house price index arising from shocks to each explanatory variable.

In order to interpret the structural shocks, we apply Cholesky decomposition with the following causal ordering of the variables ($\Delta\text{GDP}_t, \Delta\text{flow}_t, \Delta\text{RPPI}_t, \Delta\text{STI}_t$) that reflects their level of exogeneity. In any case, robustness checks reveal the impulse response functions are robust to different causal ordering of variables due to the weak correlations of the error terms in the VAR model. Figure 3 plots the impulse responses of the real house price index along with the 95% confidence bands to innovations in the individual variables — changes in FDI in real estate sector, output growth and stock price inflation — in turn. We observe from the plots that an unanticipated shock in each case elicits significant positive responses in house price inflation within the year. This finding concurs with the results from the ARDL model that the real house price index in Singapore is positively correlated with lagged values of capital inflows as well as the control variables.

4. Effectiveness of Macroprudential Measures

The presence of momentum effects in house price inflation means homebuyers tend to base their expectations of future house prices on past experiences, extrapolating further increases even when property prices have risen to high levels (see *inter alia* Case *et al.*, 2003). The consequent persistent hikes in house prices not only raise concerns on issues of housing affordability but also portend the formation of house price bubbles. House price bubbles are characterized by persistent increases in house prices

[14] We use a VAR model in differences instead of in levels due to the non–stationarity of the variables. The Phillips-Perron unit root tests results are available from the authors upon request.

and often occur in periods of easy credit and high leverage. They are caused by speculative activity and not fully justified by fundamentals, thereby posing a threat to financial stability. Hence, there is a need for policymakers in Singapore to lean against an overvaluation of house prices and to stabilize the housing market.

One measure undertaken by the authorities to moderate house price inflation is to release more land parcels for residential development through the Government Land Sale program. In addition to raising the supply of residential units, there is also a heavy reliance on macroprudential policies. As an international financial center, Singapore has to maintain an open capital account and not impose capital flow management measures. Rather, the Monetary Authority of Singapore (MAS) — which has the mandate to promote financial stability — uses prudential tools designed to limit systemic vulnerabilities and these are specifically targeted at the housing sector. Overall, the macroprudential policy measures are focussed on the more speculative segments of the property market and are heavier on purchases made by foreigners and permanent residents. A wide range of market cooling measures imposed by the authorities since 2009 is listed in Appendix A of this paper.

In general, the authorities eschew outright bans or price controls but opt for quantitative market-oriented measures instead. One of these measures is the Loan to Value (LTV) limit which indicates the maximum size of a loan against the value of the property it is secured by. Since 2010, the LTV caps have been repeatedly lowered especially for second (and beyond) mortgages and those with high tenures. For instance, for second properties bought by individuals, the LTV limit is adjusted downwards from the original 80% to 70% in August 2010, then to 60% in January 2011 and finally to 50% in January 2013. Such incremental adjustments reflect the authorities continual monitoring and response to market conditions. Another instrument employed is the Total Debt Servicing Ratio (TDSR) threshold that takes into account the borrowers' income level and outstanding debt obligations to assess loan repayment capability. This is tightened so as to reduce overleveraging by borrowers and to deter speculators. The debt to income ratio limit is also introduced in 2013 as another way to cap the maximum loan size and discourage overleveraging.[15]

Apart from these loan-related measures aimed at reducing the availability of easy credit, additional real estate taxes for buyers are introduced and stamp duties for sellers are raised. For instance, the additional buyer stamp duty for foreigners is imposed at 10% in December 2011 and raised to 15% in January 2013. The corresponding tax rates for citizens (permanent residents) buying second properties are 0% (3%) and 7% (10%). Meanwhile, sellers' stamp duties are designed to penalize short-sales with the rates following a step function of 16%, 12%, 8% and 4% for properties sold in the first, second, third and fourth year, respectively.

[15] As regards public housing loans, the HDB mortgage servicing ratio is first lowered from the original 40% of borrowers' gross monthly income to 35% in January 2013 and then to 30% in August 2013. In addition, loan tenure rules such as reducing the maximum tenure of HDB loans from 30 to 25 years are imposed.

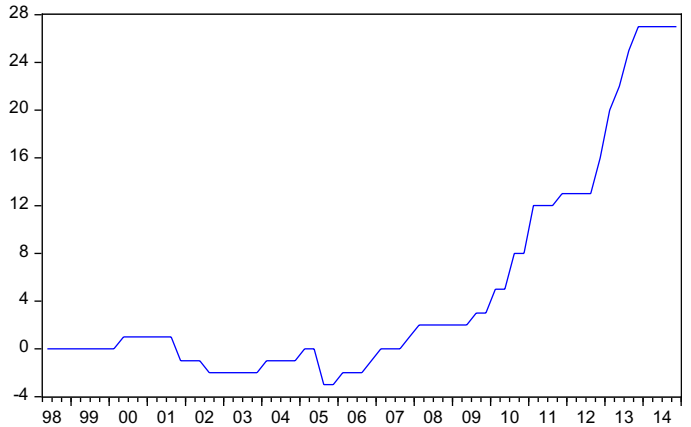

Figure 4. Singapore macroprudential policy stance.
Source: Adapted from Lee and Xie (2015, p. 3).

The macroprudential policy stance in Singapore can be traced using an index proposed by Lee and Xie (2015) which is plotted in Fig. 3.[16] This index cumulates the policy actions on the Singapore housing market over time. It is an overall index that sums across nine sub-indices, each representing a different category of housing policy namely ownership, capital gains tax, seller stamp duty, buyer stamp duty, central provident fund,[17] bank regulations, loan-to-value ratio, debt-to-income ratio and others. In the construction of each sub-index, the authors differentiate between tightening and loosening policy measures so that a positive value of one is added (subtracted) whenever a restriction is imposed (relaxed). Hence, a positive (negative) value of the overall index indicates a tightening (loosening) of housing regulations on a net basis.

We see from Fig. 4 that the overall index takes on negative values in the first half of 2000s which signals the general loosening of housing policies in that period. The Singapore housing market was in the doldrums when the economy was hit by two major shocks, namely the burst in the dotcom bubble and the Southeast Asia Respiratory Syndrome (SARS) epidemic in Asia in 2001 and 2003, respectively. In order to boost housing demand, the authorities relaxed various restrictions such as widening the types of residential property that foreigners can own in Singapore. Since 2009, the index exhibits a steep climb reflecting the substantial tightening of the macroprudential policy stance in the post-GFC period.

Consistent with the general findings in the literature, the macroprudential measures designed to lower credit risks at the financial institutions, also serve to lean against the buildup of house price bubbles. Indeed, more recent data on house prices reveal that the nominal private residential PPI has continued on its downward trend declining by 5% between 2013Q3 and 2014Q4. However, the cooling measures taken are

[16] This index is similar to the macroprudential policy index developed in Zhang and Zoli (2014). A major difference is the former encompasses more categories of Singapore housing regulation policy.
[17] This is a government-administered mandatory retirement fund that can be partially withdrawn for home purchase.

incremental as the authorities fine tune them in response to market conditions and house price inflation started to moderate only in 2011. There is consequently insufficient data to statistically test for the negative correlation between the overall index and house price index. Nonetheless, Lee and Xie (2015) found the overall index has a counter-cyclical impact on private residential sales as well as the volume of private house transactions. Indeed, according to MAS (2013), annual new home sales fell by a third in 2013 and by half in 2014.

In view of the economically significant role foreign capital flow plays in determining house prices in Singapore, we examine whether a tighter macroprudential policy stance helps to lower the impact of capital inflows. The excessive inflow of foreign capital in general leads to a rise in domestic liquidity as well as low domestic interest rate that in turn accelerates credit growth in the economy. In particular, due to the benchmarking of the mortgage rate against SIBOR, the low interest rate environment post-GFC has encouraged leveraging in the Singapore housing market. Indeed, mortgage debt as a ratio of GDP increased from 48% in 2008 to 56% in 2014. The concern is the eventual hike in US interest rates that will be followed by higher interest rates in Singapore which will adversely affect borrowers in their mortgage servicing. Macroprudential instruments, particularly those that tighten credit availability, could plausibly have weakened the credit growth channel thereby dampening the impact of capital inflow on house prices.

To investigate, we split the sample period into two sub-periods, before and after 2009Q3 which is the point of introduction of macroprudential policies. This is done by using a dummy variable denoted by dum that takes the value one from 2009Q3 onwards and zero otherwise. We augment the dynamic regression of real house price inflation in Eq. (3) by including the *dum* variable as a slope dummy for the capital inflow variable.[18] In this way, we can estimate the extent to which the effect of capital inflow on house prices is altered due to the implementation of macroprudential policy measures. Table 2 records the estimation results of the augmented dynamic regression model along with the previously estimated model for ease of comparison.

We see from the table that the inclusion of the dummy variable produces only slight changes in the coefficient estimates so that the qualitative results of the original model remain the same. Importantly, the coefficient estimate of the interaction term is negative and statistically significant at the 10% level. Despite retaining an overall positive explanatory power, capital inflow's effect on house price movement is reduced by more than half with the implementation of market cooling measures in the post-GFC period. This finding suggests that the recent macroprudential measures implemented by the authorities effectively mitigate the effect of capital inflows on house price dynamics in Singapore.

[18] The dummy variable is statistically insignificant at the conventional levels when it enters the model as an intercept dummy.

Table 2. Augmented dynamic regression model for house price inflation.

	ΔRPPI		ΔRPPI	
	Coefficient	Std. error	Coefficient	Std. error
ΔRPPI_{t-1}	0.261*	0.147	0.248**	0.092
Δflow_{t-1}	1.042***	0.262	0.894***	0.289
$\Delta\text{flow}_t \times \text{dum}$	−0.657*	0.398		
ΔGDP_{t-1}	0.349**	0.147	0.357***	0.153
ΔSTI_{t-1}	0.138**	0.047	0.144***	0.030
Intercept	−0.006**	0.001	−0.001	0.001
Adjusted R-square	0.680		0.680	
SIC	−6.147		−6.200	

Note: ***, ** and * indicate 1%, 5% and 10% statistical significance.

5. Conclusion

This paper investigates whether the recent house price appreciation in Singapore can be attributed to the observed surge in capital inflows. We estimate the impact of real capital inflows as measured by FDI to real estate, on Singapore's real private residential PPI. Notwithstanding the absence of a cointegrating relationship, our results support the hypothesis that lagged short term fluctuations in capital inflows are positively associated with the growth rate of house prices over the last decade. In fact we find that capital inflows have a greater explanatory power than the momentum effects in the housing market and are more economically important than domestic factors like output growth and spillover effects from the local stock market.

The detection of a momentum channel in Singapore house prices raises housing affordability issues as well as financial stability concerns. Past increases in house prices will tend to entrench home-buyers' expectations of even higher prices going forward, giving rise to persistence and wide swings in property cycles. This finding provides support for the series of market cooling measures introduced by the Singapore authorities to lean against overvaluation of house prices. Could animal spirits be tamed by the regulatory environment? Our result suggests the post-GFC tightening of macroprudential policy stance reduces the impact of capital inflow on house price appreciation by more than half. We infer that macroprudential measures have been effective in weakening the credit growth channel, thereby dampening the impact of foreign capital flows on house prices in Singapore.

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Appendix A. Macroprudential Policy Measures

Effective date	Major cooling measures targeted at residential property market
14-Sep-09	1. Interest absorption scheme (deferment of instalments until TOP) and interest-only housing loans (interest payment only until TOP) were scrapped for all private properties.
20-Feb-10	1. Introduction of Seller's Stamp Duty (SSD) for residential property and land sold within one year of purchase. 2. LTV ratio lowered to 80% from 90% on all housing loans except HDB loans.
30-Aug-10	1. Holding period for imposition of SSD increased to three years from one. 2. Minimum cash payments raised to 10% from 5% for buyers with one or more outstanding housing loans. 3. LTV lowered to 70% from 80% for second properties.
14-Jan-11	1. Holding period for imposition of SSD increased to four years from three. 2. SSD rates raised to 16%, 12%, 8% and 4% for properties sold in the first, second, third and fourth year respectively. 3. LTV lowered to 60% from 70% for second property. 4. LTV for non-individual residential purchasers capped at 50%.
8-Dec-11	1. Additional Buyer Stamp Duties (ABSD) introduced for further cooling measures: — Foreigners and non-individuals pay 10%, PRs buying second and subsequent property pay 3%, Singaporeans buying third and subsequent property pay 3%. 2. Developers purchasing more than four residential units and following through on intention to develop residential properties for sale would be waived ABSD — To qualify, developers have to produce proof of development and sale within five years.
6-Oct-12	1. Mortgage tenures capped at a maximum of 35 years. 2. For loans longer than 30 years or for loans that extend beyond retirement age of 65 years: LTV lowered to 60% for first mortgage and to 40% for second and subsequent mortgages. 3. LTV for non-individuals lowered to 40%.
12-Jan-13	1. ABSD: Citizens pay 7% (10%) on second (third) purchase from 0 (3%); PRs pay 5% (10%) for first (second) purchase from 0 (3%); foreigners and non-individuals' now pay 15% from 10%. 2. LTV for second (third) loan now 50% (40%) from 60%; non-individuals' LTV now 20% from 40%. 3. Mortgage Servicing Ratio (MSR) for HDB loans now capped at 35% of gross monthly income (from 40%); MSR for loans from financial institutions capped at 30%. 4. PRs no longer allowed to rent out entire HDB flat.
29-Jun-13	1. TDSR: Financial institutions are required to consider borrowers' other outgoing debt obligations when granting property loans. His total monthly repayments of his debt obligations should not exceed 60% of his gross monthly income. 2. In particular, MAS requires: — borrowers named on a property loan to be the mortgagors of the residential property for which the loan is taken; — "guarantors" who are standing guarantee for borrowers otherwise assessed by the financial institutions at the point of application for the housing loan not to meet the TDSR threshold for a property loan to be brought in as co-borrowers; and — in the case of joint borrowers, that financial institutions use the income-weighted average age of borrowers when applying the rules on loan tenure.

Appendix A. (*Continued*)

Effective date	Major cooling measures targeted at residential property market
27-Aug-13	1. Singapore Permanent Resident (PR) households need to wait three years from the date of obtaining PR status, before they can buy a resale HDB flat. 2. Maximum tenure for HDB housing loans is reduced from 30 years to 25 years. The MSR limit is reduced from 35% to 30% of the borrower's gross monthly income. 3. Maximum tenure of new housing loans and re-financing facilities granted by financial institutions for the purchase of HDB flats (including DBSS flats) is reduced from 35 years to 30 years. News loans with tenure exceeding 25 years and up to 30 years will be subject to tighter LTV limits.
9-Dec-13	1. Reduction of cancellation fees from 20% to 5% for Executive Condominiums (EC). 2. Resale levy for second-timer applicants — Formerly second timers are not required to pay a levy. This is applicable to only new EC land sales which are launched on or after 9th December 2013. 3. Revision of mortgage loan terms — From a previous MSR level of 60% to now 30% of a borrower's gross monthly income. The MSR cap will apply to EC purchases from 10th December 2013 onwards.

Source: Monetary Authority of Singapore (MAS); Urban Redevelopment Authority (URA); Housing Development Board (HDB).

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