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Dynamic Analysis of House Price Diffusion across Asian Financial Centres

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ABSTRACT

The aim of this paper is to explore effects of macroeconomic variables on house prices and also, the lead-lag relationships of real estate markets to examine house price diffusion across Asian financial centres. The analysis is based on the Global Vector Auto-Regression (GVAR) model estimated using quarterly data for six Asian financial centres (Hong Kong, Tokyo, Seoul, Singapore, Taipei and Bangkok) from 1991Q1 to 2011Q2. The empirical results indicate that the global economic conditions play significant roles in shaping house price movements across Asian financial centres. In particular, a small open economy that heavily relies on international trade such as – Singapore and Tokyo - shows positive correlations between economy's openness and house prices, consistent with the Balassa-Samuelson hypothesis in international trade. However, region-specific conditions do play important roles as determinants of house prices, partly due to restrictive housing policies and demand-supply imbalances, as found in Singapore and Bangkok.

Keywords: House Price, Diffusion, GVAR

JEL Classifications: R31, R32

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1. INTRODUCTION

The standard theories in financial economics (Capital Asset Pricing Model (CAPM) and the Modern Portfolio Theory (MPT)) suggest that a diversified portfolio can reduce risk due to shock from one market will not transmit to other markets if these markets are uncorrelated. However, the economic linkages between countries have become much stronger over last two decades due to multitude of factors i.e. financial deregulation, advancement of information technology, and growth of global financial transaction volume. Numerous empirical studies have showed that there are less diversification opportunities in international stocks or bonds due to the possibility of co-movement across countries.

However, for real estate markets, because of locational attributes that cannot be substituted easily across regions, one may expect diversification benefits of market segmentation between areas. International financial system, innovations in real estate investment, and global financial activity has become closely interlocked and clustered together in a small number of financial centres. Explanations for the house price diffusion over different regions may be sought through several possibilities. First, an increase in correlation among economies in these cities may cause the diffusion of housing price movements. Second, people move to different areas affecting the demand for housing, and the migration may contribute to diffusion effect as a determinant of house prices. There are other reasons including information asymmetries, structural differences and housing wealth effect in regional markets that may cause house prices to increase or fall first in one area, then followed by other areas with a time lag.

Furthermore, with the growth of Asian financial activity, important financial centres in Asia come under fierce competition for business location and investment flow. The housing markets across the major Asian financial centres have been experiencing strong growth in activities in all aspects of the market. For example, the population in Taipei has decreased gradually in recent 20 years, while the housing price index has almost doubled since in 1991. In addition, the Taipei land price appears almost 4 to 6 times higher than other cities in Taiwan, but the price is similar to those in Tokyo. The difference in house prices between Taipei and non-Taipei cities indicates the feature of

Taipei-non Taipei divide in Taiwan. The gap has widened between Taipei and non-Taipei but narrowed in international financial centres. It indicates existence of lead-lag relationship of housing prices in these markets.

The aim of this paper is to explore dynamics of the macroeconomic variables on house prices and lead-lag relationships of real estate markets across Asian financial centres. The results not only provide important macroeconomic impacts on house price fluctuations but also an analysis of the diffusion of these fluctuations from one housing market onto other financial centres. In order to examine these issues, this paper will apply the global VAR model. This method combines domestic variables and country-specific foreign variables in individual country vector auto-regressive systems. This technique also measures the generalized impulse response functions to estimate house price diffusion across both space and time. Although the diffusion effect on house prices have received more attention across developed countries, there is limited research on Asian financial cites. The contribution of this paper not only offers investors knowledge to implement investment strategies but also has essential implication for policy-makers to understand causal relationships across these financial centres' housing markets. The flurry of investment activities and ever-changing macroeconomic dynamics in these markets provide an interesting natural experiment to test domestic as well as global macroeconomic influences in the housing market.

The structure of the paper is as follows: in Section 2 and Section 3, related literature and theories are briefly reviewed respectively. Section 4 offers empirical framework including the data and the GVAR model to investigate the house price dynamics. Finally section 5 provides concluding remarks.

2. LITERATURE REVIEW

2.1. Diversification Opportunity Across Areas

Diversification has become an important issue since Sharpe (1964) developed Capital Asset Pricing Model (CAPM) and Ross (1976) introduced arbitrage pricing theory (APT). Gilmore and McManus (2002) investigate integration of the US and the Central European equity markets, and they also prove that the Central European markets provide diversification opportunities for the US investors. For real estate market, due to the characteristics of product differentiation, some research also suggests that international property markets are segmented. For instance, Eichholtz (1996) reports lower correlations among international real estate returns than common stock or bond returns, and possibility of more effective international real estate diversification compared to that of stock and bond portfolios.

However, various factors including liberalisation of the financial systems, advancement in information technology, and the innovations in financial products contribute to the strong inter-linkages among global financial markets recently. Increased cross-border investment flows and capital mobility make stock markets throughout the world more integrated causing financial instability due to the possibility of a collapse in one country transmitting to other countries more easily and rapidly (Hasan, Saleem, & Shoaib, 2008; Sharma, 2010). A number of studies have provided evidence that with rapid economic integration, stock markets were interdependent not only across the developed countries but also across emerging Asian economies (Ghosh et al., 1999; Masih and Masih, 2001; Phylaktis et al., 2002; Bessler et al., 2003; Choudhry et al., 2007).

2.2. Synchronization of International Property Markets

Several studies have found out that there is synchronization of international property markets in last two decades. Myer et al. (1997) examine the US, Canada and the UK property markets from 1987 to 1992 finding evidence of co-integration for the commercial real estate in three countries. Eichholtz et al. (1998) also note that real estate returns in European and North American are affected by continental factors implying less diversification opportunities in their own continent. Other research also applies some insights from the cyclical behaviours of house prices. For example, Chen et al. (2004) investigate the cyclical movements in Asian property markets including Hong Kong, Singapore, Tokyo and Taipei by using structural time series methodology. The empirical findings suggest that there exist similar trends and cyclical behaviours over one year, two to four years and seven to ten years in these house prices series. Liow (2007) also indicates that the Hong Kong and Singapore real estate stock prices share the same major cycle of 29.7 months, while Japan and the

UK have the similar cycle for 44 months from 1990 to 2004. Gerlach et al. (2006), on the other hand, examine the impact of structural break on the co-integration among Asia-Pacific real estate markets which show, consistent with previous studies, that the 1997 Asian financial crisis did influence property markets in the East Asia Region, causing the interdependence between these property markets.

2.3. Determinants of House Price Co-movements

The synchronised trend has raised questions about what drives co-movements of house prices. Kim and Bertrand (2009) point out that the changes in global economy, innovation in mortgage products and expectation of rising house prices drives the international house price movements. Most of all, the development of securitised market and competition among mortgage lenders offer various financial funding and mortgage products strengthening the link between housing markets and credit supply across nations. Goodhart and Hofmann (2008) also agree that the substantial credit expansion may account for house price changes. Similarly, Vansteenkiste and Hiebert (2011) suggest that co-movement in housing market fundamentals including income and interest rate may account for convergence of housing price cycles across countries. Lizieri et al. (2000) believe that there exists a systematic risk when the correlation between property and financial markets becomes integrated. They argue that innovation in real estate investment and the growing real estate securitisation not only fragments the ownership of real estate globally but also makes international investors exposed to significant financial market risk. Thus, if financial crisis happens in one area of the property market, the ripples and co-integrated effects are likely to ensue across the regions.

Recent research (Adams and Füss, 2010; Goodhart and Hofmann, 2008) use panel VAR to examine the linkage of international housing prices and the macro economy. Adams and Füss (2010) employ data for 15 countries over a period of 30 years, and select macroeconomic variables including economic activity, long-term interest rate and construction costs to discover their dynamics on international housing prices. The result shows that house price, economic activity and construction costs have positive correlation while the long-term interest rate has a negative impact on housing prices.

Goodhart and Hofmann (2008) apply panel co-integration estimation for 17 industrialized countries from 1970 to 2006, and also have the similar finding that the interactions between house price changes, monetary variables and the macroeconomic conditions have become stronger since 1980 compared to the early 1970s. Egert and Mihaljek's (2007) dynamic panel VAR analysis reveals that house prices in central and Eastern Europe are affected by conventional fundamentals such as GDP per capita, real interest rates, housing credit and demographic factors. Another research by Glindro et al. (2011) apply Cappozza et al. (2002) mean reversion method with panel data in 9 Asia-Pacific countries from 1993 to 2006, and their findings indicate that supply elasticity and business environment are likely to be determinants of house prices.

2.4. Diffusion in Housing Markets

International financial system has become more interlinked in the last two decades and this may have caused global financial businesses to concentrate in a small number of cities in the world, namely international financial centres. In other words, an increase in correlation of economy among these cities may lead to the ripple effect of movements of housing price. According to Giussani and Hadjimatheou (1991a) and Meen (1999), ripple effect refers to a spatial diffusion of house prices rising first in one area, and then spread gradually to the rest of the country with specific time lag. Giussani and Hadjimatheou (1991a) points out that people migrate to less expensive areas in terms of house prices to take advantage of spatial arbitrage causing regional lead-lag relations. In addition, it is believed that real estate markets are inefficient because of product differentiation and high transaction cost. Thus, signals by lagged house prices may play an important role in current prices, and these lagged prices include both own and contiguous areas.

Moreover, the densely populated regions with informational scale economies lead house price movements in other areas. (Clapp and Tirtiroglu, 1994; Clapp et al., 1995) Pollakowski and Ray (1997) also find out that a non-spatial diffusion process takes place when there are economic interrelationships between regions, which are not necessarily in neighbouring localities. Another explanation for the diffusion effect between regions may be found from the wealth effect by Oikarinen (2004). Due to housing wealth effect, people feel richer and will consume more imported products, and this may improve income and employment in export regions generating growth in housing demand and prices. Consequently, through this process, a rise in house price in one area will probably exert upward pressure on house prices in other areas with time lags. However, Meen (1999) argues that although economic conditions have significant impacts on regional housing prices, different regional structures are important causes of ripple effects on housing markets.

The empirical research in house price spill-over effects in different countries or regions has grown enormously. Stevenson (2004) and Oikarinen (2006) use vector error correction models (VECM) to investigate the diffusion of house prices in Ireland and Finland. Guirguis et. al. (2007) and Lee (2009) on the other hand examine house price volatility to capture spill-over in Spain and Australia. Their empirical findings remain consistent with previous studies suggesting that there exist positive price diffusion between large cities and small cities. The relatively recent analysis including Vansteenkiste and Hiebert (2011) and Brady (2011) apply alternative econometric methods to estimate the dynamics of housing diffusion across regions. Vansteenkiste and Hiebert (2011) follow the GVAR model to examine diffusion effects on Euro area countries, and they find that changes in country-specific housing prices have positive correlations in the long-term in Euro countries, but country-specific factors also play essential roles in house price spill-over across countries. Brady (2011)'s spatial impulse response functions also reveals the dynamic diffusion of regional housing prices across space and time in 31 Californian counties.

3. THEORETICAL FRAMEWORK

The changes in macroeconomic variables may drive movements of real estate price. When there is economic expansion, the economic activity and construction will increase leading to a positive impact on real estate markets. If the national economy is in recession, then a reduction in economic activity and specifically in constructions sector may ensue, thereby decreasing real estate prices. The co-movements could be seen as diffusion process of house price development across countries, and the possible explanations might be sought through two related routes: Balassa-Samuelson effect and housing wealth effect.

I. Balassa-Samuelson Effect

Balassa (1964) and Samuelson (1964) point out that in the long-term the purchasing power parity would be invalid because of the differences of productivity of trade sectors across countries. A higher degree of open economy will have greater productivity of tradable sectors due to economies of scale including greater market size, learning effects and advancement in technology. However, the price of tradable goods is determined by international competition, so the small open economies may not have significant price effect. In addition, when there is growth in productivity of tradable sectors generating an increase in wage level, it would have a greater impact on prices of non-tradable goods resulting from the relatively inelastic supply. Consequently, a positive change in wage may raise relative prices of non-tradable goods. On the other hand, low mobility of labour across countries, and spatial fixity of real estate sector and characteristics of non-tradable goods add to market imperfections.

We apply Balassa-Samuelson framework to explain difference in house prices. As Bardhan et al. (2004) indicate, urban rents and openness of the economy are positively correlated, thus supporting the Balassa-Samuelson hypothesis that openness has a significant impact on property prices (as the non-tradable sector). Wang et al. (2011) also suggest that when the economy is increasingly integrated with the global market, the real estate price will be likely to go up. Thus, with growing international trade activity and integrated financial markets, cross-border investment and developments in real estate sectors, the international trade may have significant impacts on movements of the house prices.

II. Housing Wealth Effect Chains

According to permanent income hypothesis and the life-cycle model, consumption of households depends on their lifetime wealth constraints. If there is an increase in housing price, homeowners may expect income growth and feel wealthier to spend more through realised wealth effect- refinancing or selling the house or unrealised wealth effect based on higher expected wealth. However, even if high housing prices will not imply an increase in net wealth effect (Ciarlone, 2011), it may still have a strong influence on credit supply and demand via collateral effects. Goodhart and Hofmann (2008) point out that when houses are a form of collateral available to liquidity-constrained homeowners, an increase in house price not only has wealth effect but there is also collateral effect on consumption.

Holinski and Vermeulen (2011) argue that in an open economy, wealth changes have impacts on demand for both of domestic and imported goods and services. In other words, asset price shocks may cause changes not only in domestically produced goods and services but also in trade balance through the transmission of consumption, and this process is referred to as the international wealth channel. Oikarinen (2006) instead suggests that housing wealth effect may contribute to a causal relationship in some housing markets with economic interdependence. Pollakowski and Ray (1997) also believe that the non-spatial diffusion process may occur between non-neighbouring regions if there are economic interrelationships.

With growing integration of economies, housing prices are not only affected by the local economy but by global factors as well. The financial deregulation reduces the barrier to capital flows generating international trade and investment which have significant impact on domestic economic activity. As Case et al. (1999) showed that international real estate markets become integrated partly resulting from common exposure to global GDP fluctuation. Moreover, innovation in financial vehicles including REITs and securitisation changed the fragmentation of ownership and lending in the real estate sector. They allow investors to hold global property portfolios and real estate developers to obtain finances through capital market vehicles globally. These links between the real estate industry and capital markets increases international housing markets' exposure to global economic shocks.

4. EMPIRICAL ANALYSIS

4.1. Methodology

Although many studies attempt to apply the conventional approach such as the VAR and the VECM to assess the short-run and long-run relations among variables, there are considerable challenges. Pesaran and Smith (2006) argued that the VAR approach is limited to a small number of variables. Some may use a closed economy model concentrating on few domestic variables to solve the problem. However, it is insufficient to ignore the interaction relations across countries when the international interdependences have been increasing. Also, in an unrestricted VAR, it is difficult to identify restrictions on the co-integrating relations if there is no clear macroeconomic theory to support. The problem will become more complicated when there are two or more co-integrating relationships.

In addition, Dees et al. (2007) argue that international transmission of business cycles can follow through many channels particularly through common observed global shocks such as movements of oil prices. Moreover, these common observed factors could generate global unobserved factors including the spillover effects of technology or regional policy, and these factors are essential in modelling. However, it is difficult to identify these unobserved factors. Therefore, in order to investigate such co-movements and impacts in the world economy, Dees, di Mauro, Pesaran, and Smith (2007) and Pesaran, Schuermann, and Weiner (2004) introduced the global vector autoregressive model (GVAR). The GVAR is based on VAR augmented with weakly exogenous interdependence of domestic variables and their foreign counterpart variables to compose a global vector autoregression. In the system, each individual country-specific model links to corresponding foreign variables, so the developments in foreign countries play important roles in determining the macroeconomic movements of each country.

In this system[2], suppose there are N countries, indexed by $i = 1, 2, \ldots, N$, and it is formed by each individual country-specific variables related to their country-specific foreign variables. The country-specific foreign variables consist of weighted averages of the corresponding county-specific variables for all other countries. Therefore, each

[2] This discussion is drawn from Pesaran et al. (2004), Garrat et al. (2006), Dees et al. (2007).

country i can be seen as a first-order VAR augmented by weakly exogenous variables, namely VARX model as follows:

$$x_{it} = a_{io} + a_{i1}t + \Phi_i x_{i,t-1} + \Lambda_{i0}x^*_{i,t} + \Lambda_{i1}x^*_{i,t-1} + u_{it} \quad t = 1, 2, ..., T \text{ and } i = 1,\ldots,N \qquad (1)$$

Where x_{it} is a $k_i\times 1$ vector of country-specific (domestic) variables, and x_i^* is the $k_i^*\times 1$ vector of foreign variables specific to the country i. Φ_i is a $k_i \times k_i$ matrix of coefficients related to lagged domestic variables, while Λ_{i0} and Λ_{i1} are $k_i \times k_i^*$ matrices of coefficients associated to foreign variables. a_{i0} and a_{i1} are $k_i \times 1$ vector of fixed intercepts, and the deterministic time trend, and u_{it} is a $k_i \times 1$ vector of country-specific shocks. The shock u_{it} is supposed to be serially uncorrelated with mean zero and non-singular covariance matrix as $\Sigma_{ii} = (\sigma_{ii,ls})$ where $\sigma_{ii,ls} = cov(u_{ilt}, u_{ist})$, or $u_{it} \sim iid(0, \Sigma_{ii})$. The foreign-specific variables x_{it}^* for country i can be expressed as:

$$x_{it}^* = \sum_{j=1}^{N} w_{ij}x_{jt}, \text{ with } w_{ii} = 0, \sum_{j=1}^{N} w_{ij} = 1 \qquad (2)$$

Where w_{ij}, $j = 1,\ldots, N$. The weights are based on cross-country trade flows to capture the linkage between domestic macroeconomic developments and other foreign countries.

Each VAR model is calculated separately and treating x_i^* as weakly exogenous. It suggests that compared to the rest countries in the world, specific country is relatively small, so there is no long-run feedback from domestic variables to foreign variables. However, there exist short-run impacts between these variables. The GVAR also allows a cross-country interaction among idiosyncratic shocks. It can not only investigate the contemporaneous dependence of domestic variables with foreign-specific variable and with their lagged values but also the contemporaneous correlation of shocks across countries.

In order to solve the GVAR model, it can start from the equation (1), the country specific VAR models, to rewrite as

$$A_i z_{it} = a_{i0} + a_{i1t} + B_i z_{i,t-1} + u_{it} \qquad (3)$$

Where

$z_{it} = (x_{it}, x_{it}^{*})'$, $A_i = (I_{ki}, -\Lambda_{i0})$, $B_i = (\Phi_i, \Lambda_{i1})$

The estimation can use the link matrices W_i, which are from the trade weights w_{ij} to obtain the identity,

$$z_{it} = W_i x_t \qquad (4)$$

Where $X_t = (X_{0t}, X_{1t}, \ldots, X_{Nt})'$ is the $k \times 1$ vector which consists of all the endogenous variables of the system, and W_i is a $(k_i + k_i^{*}) \times k$ matrix with $k = \sum_{i=0}^{N} k_i$

Then, the equation (3) can be shown by using equation (4) as

$$A_i W_i z_{it} = a_{i0} + a_{i1}t + B_i W_i z_{i,t-1} + u_{it}, \text{ for } i = 1,2, \ldots, N$$

Therefore, the GVAR(1) model is built for each country model X_t as:

$$G_t = a_{10} + a_1 t + Hx_{t-1} + u_t \qquad (5)$$

$$G = \begin{pmatrix} X_1 W_1 \\ X_2 W_2 \\ . \\ . \\ X_N W_N \end{pmatrix} \quad H = \begin{pmatrix} B_1 W_1 \\ B_2 W_2 \\ . \\ . \\ B_N W_N \end{pmatrix}$$

$$a_0 = \begin{pmatrix} a_{10} \\ a_{20} \\ . \\ . \\ a_{N0} \end{pmatrix} \quad a_1 = \begin{pmatrix} a_{11} \\ a_{21} \\ . \\ . \\ a_{N1} \end{pmatrix} \quad u_t = \begin{pmatrix} u_{1t} \\ u_{2t} \\ . \\ . \\ u_{Nt} \end{pmatrix}$$

4.2. Data Description

The data employed in this study are quarterly from 1991 Q1 to 20011 Q2. Variables including house price index, gross domestic product, money supply, interest rate, private consumption, openness, share of housing in the GDP and trade balance, are used to form the GVAR model. All data are obtained from Bloomberg, Datastream and national sources (See Appendix A for details). All variables except for interest rate, openness and share of housing in the GDP are included as percent change in real data and seasonally adjusted using the Census X12 procedure.

[INSERT TABLE 1 HERE]

Table 1 provides the description of statistics for real house price growth, real GDP growth, real money supply growth, interest rate, real private consumption growth, open, share of housing in the GDP and real trade balance growth. The average of changes in real house price in Tokyo shows negative indicating the weak house prices in Tokyo. The volatilities of house price growth are also higher than other macro variables implying notable heterogeneity of house price fluctuations across these Asian cities. In addition, the openness demonstrates the importance of international trade to the major Asian economies. Except for Japan and South Korea, trade activities accounted for relatively larger shares in the GDP in Hong Kong, Singapore, Taiwan and Thailand. In Hong Kong and Singapore, the openness is 2 to 3 times of GDP implying their heavy dependence on international activities. It may contribute to these two regions' vulnerability to external economic fluctuations.

4.3. Estimation of the GVAR Model

This study uses Dees, di Mauro, Pesaran, and Smith's (2007) GVAR approach to capture the global interdependences across countries. It also follows the reduced form which establishes the long-run housing market equilibrium. First, a basic model is based on the supply and demand function determining housing price given as:

$$H^s = H^d = f\,(P, GDP, r, m, c, housing) \quad (6)$$

Where H^s and H^d indicate housing supply and demand. P means house price; r is interest rates; c is private consumption; m is money supply and *housing* means shares of housing in the GDP.

Apart from above variables, changes in consumption and shares of housing in the GDP may also have significant impacts on housing prices. In addition, global unobserved common factors such as foreign variables and oil prices are considered as weakly exogenous in evaluating the spill-over effects from shocks to other endogenous variables in the model. Therefore, this basic framework consists of country-specific variables including house price, GDP, interest rate, money supply, private consumption and share of housing in the GDP, and their corresponding foreign variables. In this study, there are six regions including Hong Kong, Japan, Korea, Singapore, Taiwan and Thailand. Therefore i = 1, 2, …, 6. For region i, consider VAR(1,1) as

$$x_{it} = \mathrm{a}_{io} + \mathrm{a}_{i1}t + \Phi_i x_{i,t-1} + \Lambda_{i0} x^*_{i,t} + \Lambda_{i1} x^*_{i,t-1} + \mathrm{u}_{it} \qquad (7)$$

$$where,\ x_{it} = (hp_{it}, y_{it}, r_{it}, m_{it}, c_{it}, housing_{it})',\ x^*_{i,t} = (hp^*_{it}, y^*_{it}, r^*_{it}, m^*_{it}, c^*_{it})'$$

$$hp^*_{it} = \sum_{j=1}^{N} w_{ij}\, hp_{jt};\ y^*_{it} = \sum_{j=1}^{N} w_{ij}\, y_{jt};\ m^*_{it} = \sum_{j=1}^{N} w_{ij}\, m_{jt};\ r^*_{it} = \sum_{j=1}^{N} w_{ij}\, r_{jt};\ c^*_{it} = \sum_{j=1}^{N} w_{ij} c_{jt}$$

Where *hp* is financial centre's house price indices; *r* is interest rates; *m* is money supply; *c* is private consumption and *housing* is the share of housing in the GDP; and the star * represents their specific foreign variables. Moreover, the county-specific foreign variables hp^*_{it} , y^*_{it}, r^*_{it}, m^*_{it} and c^*_{it} were specified with fixed trade weights computed by average trade flows over the three years from 2006 to 2009, and these set of foreign variables are treated as weakly exogenous.

Secondly, if the dynamics of the basic model is found to be reasonable, the GVAR model will be augmented with openness variable $open_{it}$ to investigate the Balassa-Samuelson effect indicating more open economy with higher housing prices. However, there is a lack of precise definition of openness, and different measures of openness may lead to various results. Harrison (1996) points out that openness is the concept of neutral in trade policy, and the neutrality means "incentives are neutral between saving a unit of foreign exchange through import substitution and earning a unit of foreign exchange trough export". Yanikkaya (2003) argues that openness is likely to symbolise "free trade", which implies there is no existence of barrier to trade. Although there are a large number of measures of openness, this study will use trade shares (the sum of exports and imports) in GDP as the openness variable. The VAR(1,1) in equation (7) can be augmented as

$$x_{it} = a_{io} + a_{i1}t + \Phi_i x_{i,t-1} + \Lambda_{i0} x^*_{i,t} + \Lambda_{i1} x^*_{i,t-1} + u_{it} \quad (8)$$

$$x_{it} = (hp_{it}, y_{it}, r_{it}, m_{it}, c_{it}, housing_{it}, open_{it})', x^*_{i,t} = (hp^*_{it}, y^*_{it}, r^*_{it}, m^*_{it}, c^*_{it})'$$

The next step in our GVAR analysis is to augment our basic model with trade balance tb_{it} variables to examine the diffusion effect through housing wealth effect chains. In order to capture the demand for foreign goods and services via consumption, trade balance is selected. Therefore, the VAR(1,1) can be expressed in equation (8) as

$$x_{it} = a_{io} + a_{i1}t + \Phi_i x_{i,t-1} + \Lambda_{i0} x^*_{i,t} + \Lambda_{i1} x^*_{i,t-1} + u_{it} \quad (9)$$

$$x_{it} = (hp_{it}, y_{it}, r_{it}, m_{it}, c_{it}, housing_{it}, open_{it}, tb_{it})', x^*_{i,t} = (hp^*_{it}, y^*_{it}, r^*_{it}, m^*_{it}, c^*_{it})'$$

This paper begins by conducting the ADF unit root test to test stationarity. Then co-integration tests are assessed and VAR models are estimated. The generalised impulse response is also estimated to examine the spill-over effects of shocks to any endogenous variables, and to investigate how the shocks have impacts on each region.

The trade weight matrix illustrated in Table 2 is based on the trade shares of exports and imports in the six countries. It suggests the trade relationships across economies and is used to compute the weights of country-specific foreign variables. It can be seen that high shares of trade weights between Japan and the other regions particular in South Korea. It also shows over 20% of trade shares in Hong Kong, Singapore and Taiwan showing heavy trade interdependences between these regions.

[INSERT TABLE 2 HERE]

In order to investigate the short run and long run relations of macroeconomic movements across regions, we employ the unit root test to check that series in each country-specific models are integrated of order one. The Augmented Dickey Fuller (ADF) tests (with varying specification in terms of trend and differences) show that domestic and foreign variables are $I(0)$ and $I(1)$ respectively.

When the endogenous and weakly exogenous variables are determined in each country-specific model, the rank of cointegrating in each GVAR model can be estimated. First of all, the lag lengths of domestic variables in the county-specific models are selected by Akaike information criterion. Therefore, except for Hong Kong, Singapore and Taiwan in the basic model with first order, the optimal lag order for the other regions appears to be two. However, lag order of domestic and foreign variables are allowed to be different, and the first order of foreign variables are used in all countries in this paper. Then, the rank of the cointegrating relationships for the models is based on Johansen's procedure. Table 3 shows the number of cointegrating relationships across 6 regions. The cointegrating relationships exist from 3 to 7, but the number of cointegration for the most regions is from 3 to 4.

[INSERT TABLE 3 HERE]

4.4. Analysis

To investigate the dynamics of house price and macroeconomic movements across regions, this study relies on the Generalized Impulse Response Function (GIRF) as introduced by Koop, Pesaran and Potter (1996) for non-linear models and adapted further in Pesaran and Shin (1998). The GIRF is different from Sims (1980) Orthogonalized Impulse Responses, which requires specifying the ordering of the variables and/or countries based on economic theory. However, it is difficult to determine a suitable ordering of variables in a complex economic system when there are more than three or four variables. The GIRF provides useful measures of diffusion effects which considers shocks to individual errors and does not take into account effects of other shocks by using a historical variance-covariance matrix of the errors without any orthogonalisation.

I. Global Macro Shocks Based on the Basic Model

Figure 1, 2 and 3 show the dynamics of house price across regions following a positive shock to different global macro variables including global GDP, interest rate and oil prices. The empirical finding suggests that when a positive global shock to real GDP occurs, most Asian financial cities except Singapore would see positive reactions of around 0.02% up to 1.2% on housing markets following the shock in 2 quarters. Hong Kong and Taipei have relatively high positive responses around 1.18%

and 0.5% in the first 2 quarters. Seoul and Tokyo also see an increase of range from 0.3% to 0.4%. In addition, apart from Tokyo, Taipei and Bangkok, given a positive shock to global interest rate, the changes in house price exhibit initial negative responses in the range of 0.2% to 0.8% after 2 quarters. Hong Kong and Singapore have relatively strong negative impacts on housing markets. This may be attributed to their financial market liberalisation. Moreover, since oil price is an important global factor causing significant impacts on global economy and housing markets, we investigate the dynamic responses between oil price and Asian housing markets. Therefore, one standard deviation positive shock to oil prices is examined in our model. This shock exerts considerable increase in change in house prices in Singapore and Bangkok.

[INSERT FIGURES 1, 2 AND 3 HERE]

It is not surprising that the house prices in Hong Kong react rapidly in response to global increases in world market, and it could result from a high degree of openness of the Hong Kong market. It may also serve as indirect evidence of heavy reliance on foreign investment in Hong Kong making it more vulnerable to external economic conditions such as Asian financial crisis in late 90s or global financial turmoil in 2008-09. In contrast, Singapore, being another financial centre with an open economy, corresponds to different housing market dynamics partly due to restrictions on housing policies. There is over 80% of housing stock owned by the Singapore government, so public policies largely determined the house price movements. It can be seen as a self-determined market because Singapore’s housing policies control the movements of residential market (Tu and Wong, 2002). However, we found that changes in interest rates lead to long-run negative impacts of around 0.5% on Singapore house prices and the relatively higher interest rate elasticity of house prices, possibly indicating Singapore’s financial market liberalisation.

II. Openness Shocks Based on Balassa-Samuelson Hypothesis

Figure 4 reports the responses of house price to a one standard deviation positive shock in openness in each of the six financial centres. Taipei house prices show significantly positive relationship with openness around 0.8% in first quarter. In addition, the shock is relatively persistent ranging from 0.3% to 0.4% over 10 quarters in Tokyo and Singapore housing markets. It suggests that a high degree of trade interaction, for example, the average share of trade in the GDP in Singapore is around 2 times, would see a relatively strong positive response of house prices. These correlations between house prices and openness provide evidence of the Balassa-Samuelson hypothesis indicating the effect of openness on non-tradable sectors such as housing markets. However, changes in Hong Kong, Taipei and Seoul house price become insignificant after 2 quarters.

[INSERT FIGURE 4 HERE]

III. House Price Shocks Based on Housing Wealth Effect Chain Model

The diffusion of house prices across Asian financial centres will be estimated by a positive shock to each of the six cities' house prices. First, it examines the responses to private consumption and the trade balance from the shock. Then we investigate the ripple effect of house prices between regions via housing wealth effect chains: increases in house price raise consumption and imports (decreases in the trade balance) and this housing wealth effect causes upward movement of house prices in the export country. The generalised impulse responses in Figure 5 show the housing wealth effect chains across cities.

[INSERT FIGURE 5 HERE]

The left column indicates responses to changes in consumption and the trade balance from a standard error positive shock to house price changes, and the right column shows house price movements across cities. The positive shock to house price changes result to a relatively strong consumption of around 0.4% in Hong Kong, 0.2% in Japan and Taiwan after 2 quarters. In addition, only the Japan's trade balance reveals statistically significant responses to a positive change in house price up to approximate 0.7% over 10 quarters following the shock. It implies that Tokyo provides evidence of housing wealth effect via consumption through the international wealth channel.[3] However, there is no impact on trade balances in South Korea,

[3] Holinski and Vermeulen (2011) point out that change in asset price transmit into the trade

Thailand and Singapore, while those in Hong Kong and Taiwan show slightly negative impact of around 0.2% after 3 or 4 quarters.

The next is to investigate the diffusion of house prices through the wealth effect chains from Tokyo, Hong Kong and Taipei. There are relatively strong initial impacts of around 0.5% in Hong Kong, Seoul and Taipei housing markets over the first 2 quarters following the shock to Tokyo house price changes. Seoul house price also shows a strong long-run response of 1% over 10 quarters. However, we do not find significant diffusion effect on the Singapore and Bangkok housing markets. When a positive unit shock to changes in Hong Kong house price occurs, the Taipei and Seoul housing markets show a positive co-movement from 0.4% to 1.8% in the first 2 quarters, and Taipei house prices also have an impact of about 0.5% over 10 quarters. Furthermore, one standard error positive shock to changes in house price in Taipei entail influences of around 0.2% on Tokyo and Seoul housing markets.

These findings suggest that the shock to changes in Tokyo house prices appear to have relatively strong transmission to Hong Kong, Seoul and Taipei possibly due to the high economic linkages between these regions. In fact, apart from US and China, Japan remains the third largest trade partner in Hong Kong, South Korea and Taiwan. However, the dynamic responses in Bangkok tend to be a relatively low magnitude partly due to market-specific conditions i.e. housing polices, housing market structure and institutions. Bangkok's heterogeneity might result from local market structures such as high vacancy rate and political instability problems. In particular, there exists significant oversupply in Bangkok's residential market because of various types and classes of housing stock that cannot be completely substituted. Therefore, the Bangkok housing market cannot eliminate the surplus and adjust itself to a new equilibrium by market forces (Manotham, 2010).

5. CONCLUSION

In this paper, we investigate the diffusion effect on house prices across six major Asian financial centres by following the GVAR model over the period 1991Q1 to 2011Q2. The generalised impulse response function is used to estimate the dynamics

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balance via consumption and investment can be seen as international wealth channel.

of housing price movements. We first empirically test the responses of changes in house price to a positive global shock including global GDP, interest rate and oil prices.

We find that the Hong Kong housing market reacts rapidly in response to global increases in world market, while only Singapore shows a significant response to interest rates. Secondly, openness of each region is examined to test the Balassa-Samuelson hypothesis. Tokyo and Singapore, which show a positive correlation between openness and house prices providing evidence of the Balassa-Samuelson effect and suggesting that a rise in openness increases relative price of non-tradable goods and service i.e. the housing sector. Finally, the ripple effects from shocks to individual housing price changes to other regions are assessed by observing the correlations of housing prices among different regions via housing wealth effect chains. There are evidence of wealth effects in the Tokyo, Hong Kong and Taipei housing markets. These markets show that an increase in house price raises consumption and imports (i.e. decreases in the trade balance) and these housing wealth effects cause upward movement of house prices of the export countries. On the other hand, the spill-over effects on housing markets in Singapore and Bangkok could be driven by the market-specific conditions suggesting that the local housing market structure may have significant role in changing the course and dimension of the diffusion effects.

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Table 1 Descriptive Statistics

	Hong Kong	Japan	South Korea	Singapore	Taiwan	Thailand
Real house price growth						
Mean	0.0118	-0.0076	0.0014	0.0176	0.0088	0.0000
Std. Dev.	0.0636	0.0237	0.0359	0.0516	0.0379	0.0404
Skewness	-0.0445	-0.4783	0.0678	2.7582	-0.2638	0.1430
Real GDP growth						
Mean	0.0068	0.0000	0.0120	0.0141	0.0091	0.0099
Std. Dev.	0.0191	0.0108	0.0189	0.0260	0.0193	0.0235
Skewness	-0.0289	-0.9030	-1.6125	-0.7565	-0.9374	0.1178
Real money supply growth						
Mean	0.0234	0.0159	0.0195	0.0224	0.0184	0.0160
Std. Dev.	0.0575	0.0206	0.0392	0.0292	0.0262	0.0296
Skewness	0.6501	2.9669	-1.2600	0.6553	0.3546	0.5966
Interest rate						
Mean	0.0171	0.0069	0.5431	0.0140	0.0146	0.0259
Std. Dev.	0.0040	0.0036	0.0996	0.0015	0.0053	0.0076
Skewness	0.0415	1.6461	0.2524	1.7291	-0.3174	0.3862
Real private consumption growth						
Mean	0.0079	0.0015	0.0130	0.0176	0.0104	0.0095
Std. Dev.	0.0207	0.0104	0.0246	0.0215	0.0151	0.0217
Skewness	-0.1132	-0.7874	-3.9636	-0.2151	0.7070	0.6322
Openness						
Mean	2.7607	0.2030	0.6166	1.9524	0.9301	0.9254
Std. Dev.	0.5475	0.0559	0.1471	0.2482	0.1875	0.2140
Skewness	0.5078	0.7879	0.9432	0.7986	0.6165	-0.0288
Share of housing in GDP						
Mean	0.0874	0.0399	0.0548	0.0314	0.1081	0.0358
Std. Dev.	0.012005	0.008002	0.013099	0.006117	0.019093	0.024306
Skewness	0.390399	0.194693	0.504135	-0.094475	0.708811	0.986883
Real trade balance growth						
Mean	-0.0078	-0.0040	-0.0034	-0.0019	-0.0066	-0.0043
Std. Dev.	0.0227	0.0360	0.0840	0.0813	0.0423	0.0691
Skewness	-0.5793	0.7153	-0.0629	-0.3808	0.1368	0.6861

Note: Real housing growth indicates the growth rate of real house price indices in Hong Kong, Tokyo, Seoul, Singapore, Taipei and Bangkok.

Table 2: Trade Weights

	Hong Kong	Japan	Korea	Singapore	Taiwan	Thailand
Hong Kong	-	0.349	0.147	0.207	0.219	0.076
Japan	0.151	-	0.313	0.116	0.248	0.171
South Korea	0.137	0.548	-	0.119	0.139	0.056
Singapore	0.284	0.241	0.137	-	0.161	0.176
Taiwan	0.257	0.428	0.152	0.107	-	0.056
Thailand	0.135	0.449	0.112	0.195	0.108	-

Source: Bloomberg.

Note: Trade weights are calculated as shares of exports and imports showed in rows and sum to one

Table 3: VAR* Order and Number of Cointegration in the Country-Specific Models

	Basic Model			Balassa-Samuelson Effect Model			Housing Wealth Effect Chain Model		
	VAR* (p_i,q_i)			VAR* (p_i,q_i)			VAR* (p_i,q_i)		
Country/Region	p_i	q_i	Number of cointegration	p_i	q_i	Number of cointegration	p_i	q_i	Number of cointegration
Hong Kong	1	1	4	2	1	3	2	1	3
Japan	2	1	3	2	1	4	2	1	4
South Korea	2	1	3	2	1	2	2	1	4
Singapore	1	1	4	2	1	5	2	1	6
Taiwan	1	1	3	2	1	3	2	1	5
Thailand	2	1	4	2	1	6	2	1	7

p denotes the lag order of domestic variables, and q denotes the lag order of foreign variables.

Figure 1

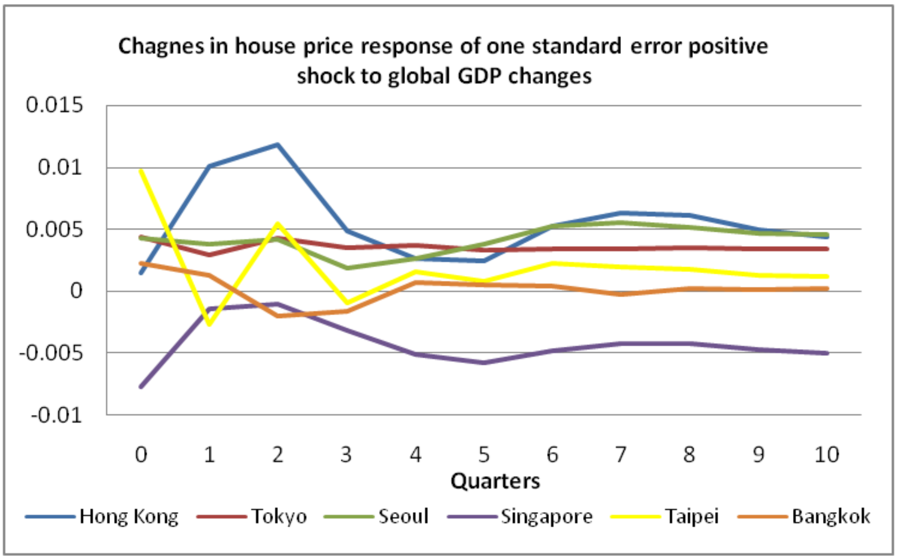


Figure 2

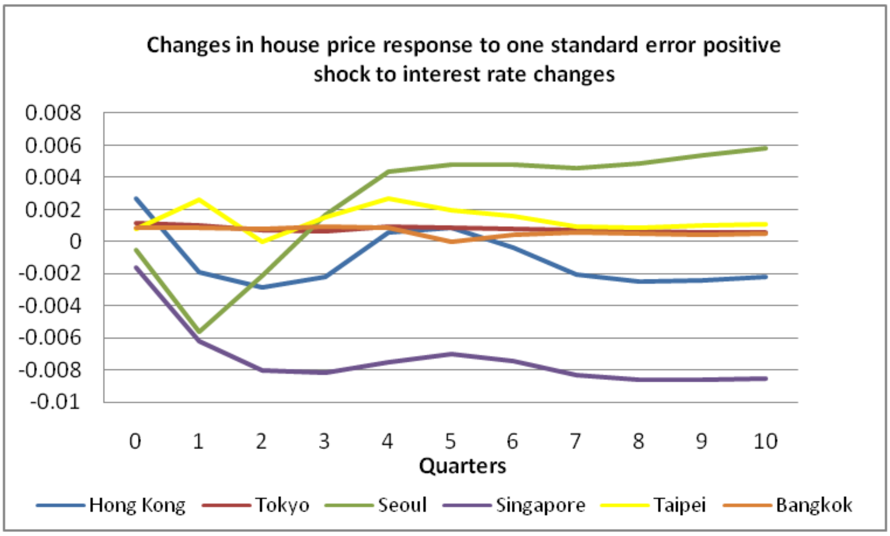


Figure 3

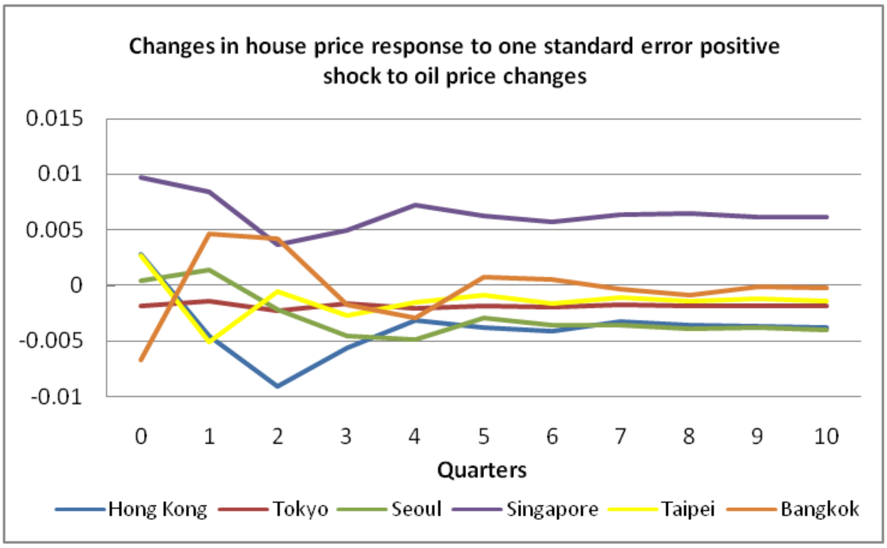


Figure 4

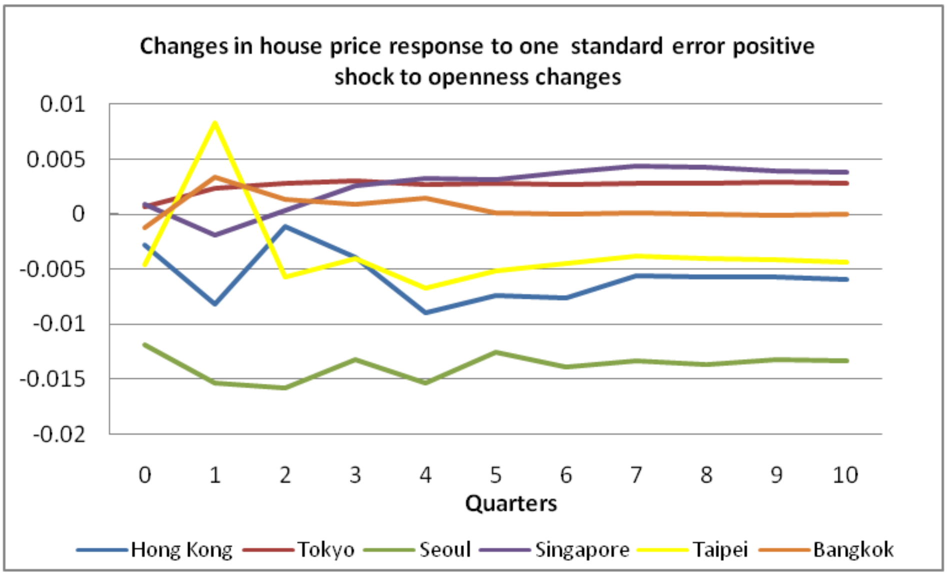
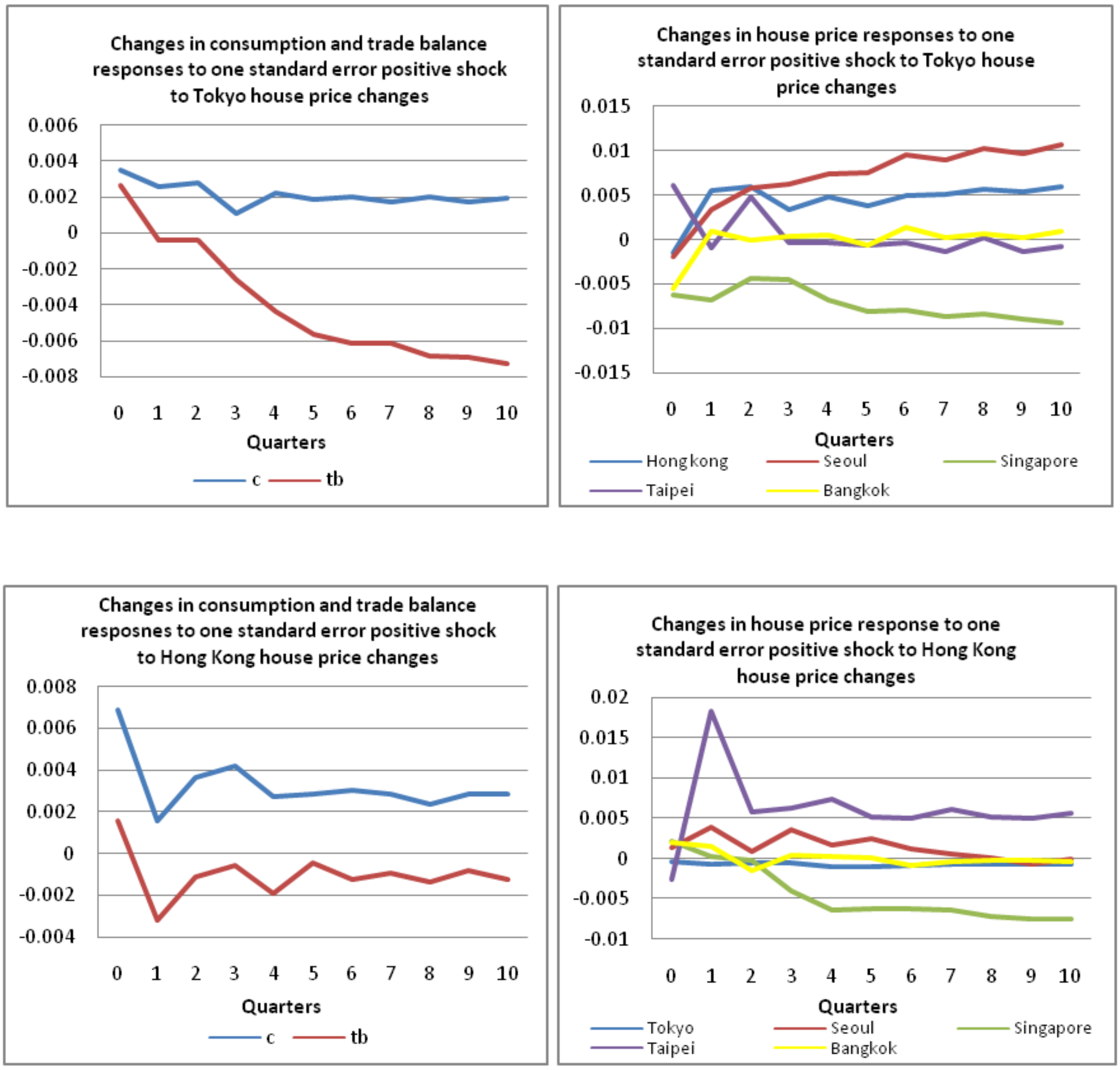
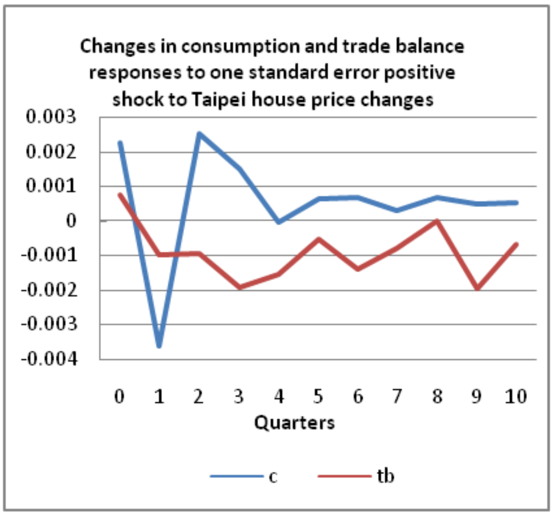
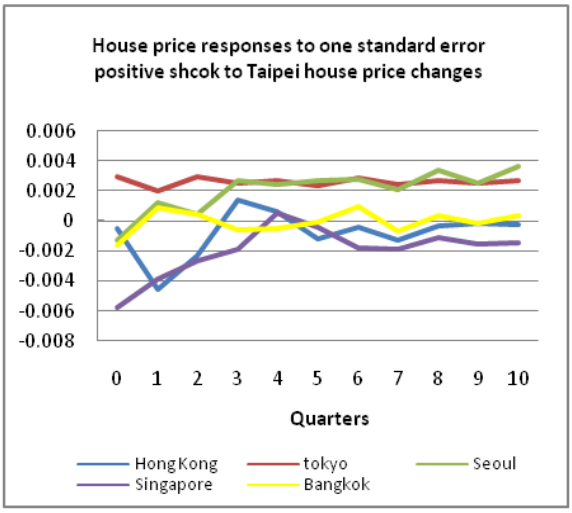
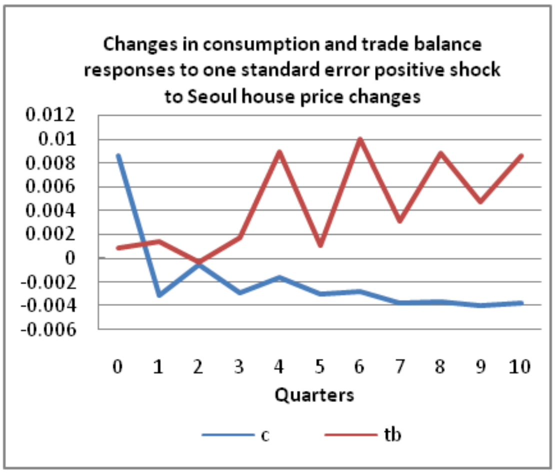


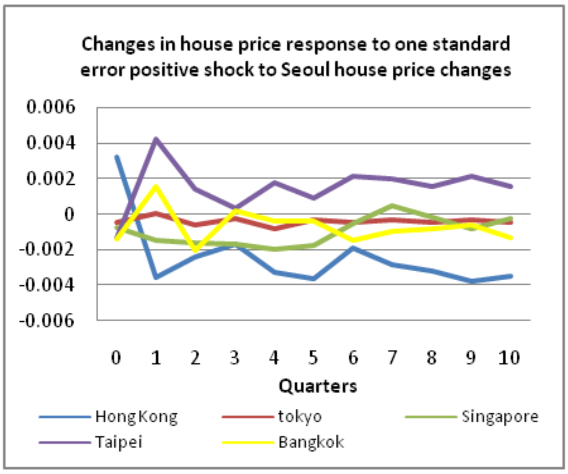
Figure 5

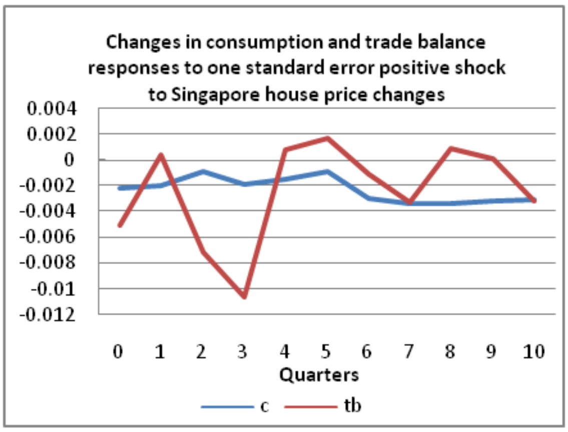


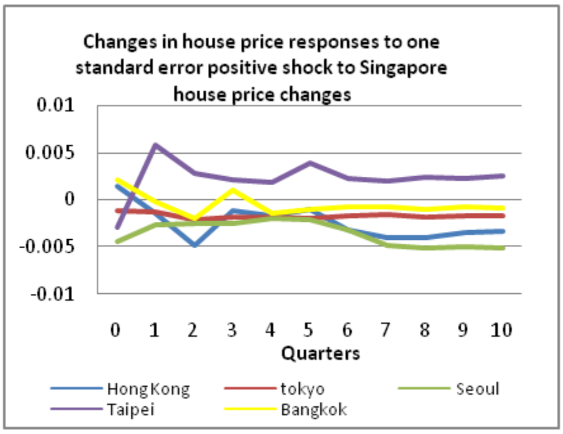

Changes in consumption and trade balance responses to one standard error positive shock to Taipei house price changes
0.003
0.002
0.001
0
-0.001
-0.002
-0.003
-0.004
0 1 2 3 4 5 6 7 8 9 10
Quarters
c
tb

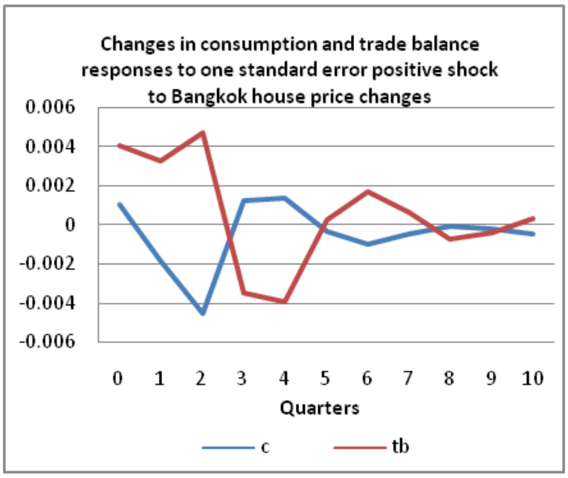

House price responses to one standard error positive shcok to Taipei house price changes
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
0 1 2 3 4 5 6 7 8 9 10
Quarters
HongKong
tokyo
Seoul
Singapore
Bangkok


Changes in consumption and trade balance responses to one standard error positive shock to Seoul house price changes
0.012
0.01
0.008
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
0 1 2 3 4 5 6 7 8 9 10
Quarters
c
tb


Changes in house price response to one standard error positive shock to Seoul house price changes
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
0 1 2 3 4 5 6 7 8 9 10
Quarters
HongKong
tokyo
Singapore
Taipei
Bangkok


Changes in consumption and trade balance responses to one standard error positive shock to Singapore house price changes
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
-0.01
-0.012
0 1 2 3 4 5 6 7 8 9 10
Quarters
c
tb


Changes in house price responses to one standard error positive shock to Singapore house price changes
0.01
0.005
0
-0.005
-0.01
0 1 2 3 4 5 6 7 8 9 10
Quarters
HongKong
tokyo
Seoul
Taipei
Bangkok


Changes in consumption and trade balance responses to one standard error positive shock to Bangkok house price changes
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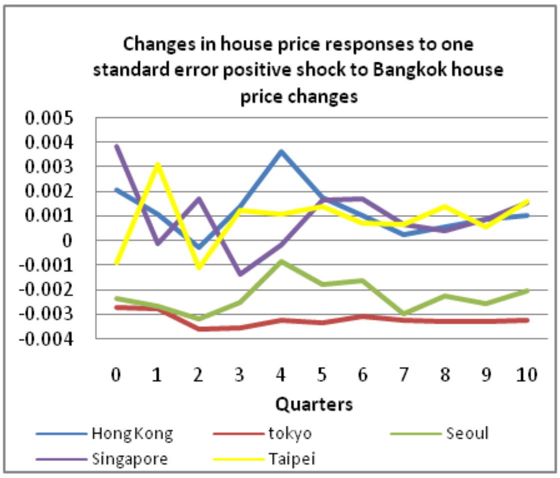
0.004
0.002
0
-0.002
-0.004
-0.006
0 1 2 3 4 5 6 7 8 9 10
Quarters
c
tb


Changes in house price responses to one standard error positive shock to Bangkok house price changes
0.005
0.004
0.003
0.002
0.001
0
-0.001
-0.002
-0.003
-0.004
0 1 2 3 4 5 6 7 8 9 10
Quarters
Hong Kong
tokyo
Seoul
Singapore
Taipei

Appendix

Data Source

Hong Kong	Price index of existing dwellings; weighted average of transactions; quarterly data 1991Q1-2011Q2. (source: Rating and Value Department of Hong Kong)
Tokyo	Price index of existing dwellings; adjusted actual transaction price with Hedonic Regression method; quarterly data 1991Q1-2011Q2. (source: IPD Japan)
Seoul	Price index of existing apartments; quarterly data 1991Q1-2011Q2. (source: Datastream)
Singapore	Price index of existing dwellings; weighted average of public residential transactions prices; quarterly data 1991Q1-2011Q2. (source: Housing and Development Board of Singapore)
Taipei	Price index of existing dwellings; quarterly data 1991Q1-2011Q2, based on transaction prices by using pooling model and hedonic price method. (source: Sinyi Real Estate)
Bangkok	Price index of existing dwellings; quarterly data 1991Q1-2011Q2. (source: Bank of Thailand)

Gross Domestic Product

Quarterly data of M1 from 1991Q1-2011Q2 in Hong Kong (source: Hong Kong Census and Statistics Department), Japan (source: Datastream), South Korea (source: Datastream), Singapore (source: Datastream), Taiwan (source: National Statistics Taiwan) and Thailand. (source: Bank of Thailand) Annual data 1991-1992 in Thailand (source: Bank of Thailand) interpolated based on the average procedure.

Money Supply Data

Quarterly data of M1 from 1991Q1-2011Q2 in Hong Kong (source: Hong Kong Census and Statistics Department), Japan (source: Datastream), South Korea (source: Bank of Korea), Singapore (source: Department of Statistics Singapore), Taiwan (source: Central Bank of R.O.C.) and Thailand (source: Bank of Thailand)

Interest Rate Data

Quarterly data of prime rate from 1991Q1-2009Q4 in Hong Kong (source: Hong Kong Census and Statistics Department), Japan (source: Bank of Japan), Singapore (source: Department of Statistics Singapore) Taiwan (source: Central Bank of R.O.C.) and Thailand. (source: Bank of Thailand) Quarterly data of yields of national housing bounds (5 years) from 1991Q1-2011Q2 in South Korea (source: Bank of Korea)

Private consumption

Quarterly data of private consumption from 1991Q1-2011Q2 in Hong Kong, Japan, South Korea, Singapore, Taiwan and Thailand (source: Datastream)

Exports and Imports Data

Quarterly data of exports and imports from 1991Q1-2011Q2 in Hong Kong, Japan, South Korea, Singapore, Taiwan and Thailand (source: Datastream)

Share of housing in the GDP

Housing data divided by GDP data. Details on the housing data series

Hong Kong	Building and construction in public and private sectors; quarterly data 1996Q1-2011Q2. (source: Hong Kong Census and Statistics Department); annual data 1991-1995(source: Hong Kong Census and Statistics Department) interpolated based on the average procedure.
Tokyo	Private dwellings; quarterly data 1991Q1-2011Q2. (source: Datastream)
Seoul	Residential buildings; quarterly data 1991Q1-2011Q2. (source: Bank of Korea)
Singapore	Ownership of dwellings; quarterly data 1991Q1-2011Q2. (source: Bloomberg)
Taipei	Construction in public and private sectors; quarterly data 1991Q1-2011Q2. (source: source: National Statistics Taiwan)
Bangkok	Private dwellings; annual data 1991Q1-2011Q2 interpolated based on the average procedure. (source: Bank of Thailand)