Housing Markets' Linkage between China and Taiwan

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Abstract

This paper examines the linkage of regional housing markets between Taiwan and China as increasing economic integration, and two time-varying estimations of cointegration tests, Gregory-Hansen (1996) cointegration test with structural break and the recursive coefficients of cointegration (Hansen and Johansen, 1993) are applied to trace the possible dynamic linkage of cross-border regional housing prices between Taiwan and China. Our main findings are as follows. First, the estimating results of the long-run relationships show that increasing housing prices in Beijing and Shanghai decrease Taipei's housing prices, while Shenzhen and Chengdu have converse effects. The technologies' levels of Taiwanese industries surrounding the cities in China will affect the direction of the linkage of regional housing prices between the two economies. Second, in light of causalities of these five housing prices' changes, Beijing and Shanghai lead Taipei, and Shanghai leads Chengdu, which in turn leads Shenzhen. Additionally, a fluctuation in Shanghai housing prices causes the greatest influence on other cities' housing price fluctuations in China. Finally, the results of time-varying cointegration tests show that some critical economic and political incidents changed the linkages of house prices between Taipei and the four cities in China.

Keywords: Economic Integration; Housing Markets; Cointegration; Taiwan; China

1. Introduction

Taiwan and China have historically been related. Though political disputes over the issue of sovereignty between the two economies across the Taiwan Strait promise no easy solution, trade and investment relationships between them have been very prosperous. Over the past two decades, trade and investment interactions between China and Taiwan have been fruitful for sides, causing closer economic ties and continuously deepening the interconnectedness of the two. If the interrelationship between the two economies shows closer economic integration, then housing market cycles between them could be more similar.

Although a house is a non-traded good which difficultly substituted across geographic areas, there are three channels to cause co-movement in international housing prices (Vansteenkiste & Hiebert, 2011). First, co-movement of housing prices across different countries could be the by-effect of common movements in normal housing markets' fundamentals across countries. Next, financial innovations and higher financial integration, resulting in a highly synchronized easing in borrowing restraints, also could cause international co-movements of housing prices. Third and finally, housing-specific factors, especially those related to some convergence of house risk premium and the returns of a house as an asset, could cause convergence in housing price cycles across countries (Vansteenkiste & Hiebert, 2011).

However, some factors, such as language and cultural differences, could limit co-movements of cross-broader housing prices, but this is not the case between Taiwan and China, as both have roughly the same ancestry and share the same culture, language, customs, and traditions. Hence, in an integrated economic and cultural region, as well as in a neighboring area, such as for Taiwan and China, housing prices can be expected to exhibit some extent of co-movement. Co-movement may bring about spillovers as powerful dynamics in country-specific housing price changes. More specifically, co-movements of housing prices in neighboring economies, whether rising or moving higher, could possibly fuel more housing price expectations and some firms to develop in other countries, increasing housing demand and prices in those neighboring economies (Gupta et al., 2015). Although there are expected and limited "direct" spillovers of country-specific housing shocks - for instance, through capital or people moving across borders - diffusions via "indirect" channels could arise even in the case of small economies. As such co-movement of cross-border housing prices could be mostly relevant in an integrated economic region. Increasing regional economic integration causes not only a convergence of economic behavior, but also less structural differences among different countries. Thus, developments among various housing markets could be more similar (Kasparova & White, 2001).

Based on the hypothesis that shocks to regional housing prices "ripple out" across an economy, there is a voluminous amount of empirical literature examining this topic through various methodologies for different economies (Meen, 1999; Johns et al., 2004; Cook, 2003; Holmes, 2007; Johns and Leishman, 2006; Canarella et al., 2012). Some other papers have examined the linkages between private and public housing markets (Ong and Sing, 2002; Sing et al. (2006), among others). Another important line of empirical literature encompasses co-movement of cross-border housing prices, with some empirical works having examined the linkages between cross-border housing prices in Europe. Kasparova & White (2001) did not confirm the integration of housing markets across European Union countries from 1970 to 1998 by applying unit root and cointegration tests. However, other researchers have found some extent of integration within cross-border housing markets in Europe. Vansteenkiste and Hiebert (2011) applied coingetration and impulse response functions, and their empirical results indicated limited cross-border diffusions of housing prices in Euro area. Yang et al. (2005) used cointegration and generalized forecast error variance decompositions to study dynamic relationships of public real estate markets among nine European countries from January 1994 to June 2002. Their empirical results present that the European Monetary Union has been advantageous considering higher integration of real estate markets for the more advanced countries. Alvarez et al. (2010) applied correlation analysis to explore the relationship between housing cycles in the four largest countries of the Euro area from 1980Q1 to 2008Q4, noting that co-movement in these cycles is weaker than co-movement in their GDP, but synchronization has increased during the period of monetary union. Applying a multivariate unobserved component model to examine common cycles of housing prices, Ferrara & Koopman (2010) failed to find a common cycle among these countries, but confirmed a solid linkage of housing price cycles between France and Spain.

Aside from the Euro area, some papers have targeted other advanced economies. Applying asymmetric ratio unit root tests and cointegration, Stevenson (2004) studied the linkages among cross-border housing prices between Ireland and Northern Ireland, finding the existence of long-run relationships within the two cross-border housing markets. Holly et al. (2011) used a spatial-temporal impulse response analysis, and their empirical results showed that London housing prices would directly be affected by New York housing prices. Using a causality test based on a stationary Factor Augmented VAR model for 1980Q1 to 2008Q4, de Bandt *et al.* (2010) indicated that U.S. housing price developments influence housing prices of some other OECD countries.

Although some empirical works examined the linkages between cross-border housing prices in Europe and the U.S., few studies have investigated the linkages between cross-border housing prices in Asia. The East Asia region has witnessed fast growth and economic integration at an astonishing speed and depth. The signing of the Economic Cooperation Framework Agreement (ECFA) has achieved closer economic integration between Taiwan and China. If the interrelationship between the two economies shows closer economic integration, then regional housing market cycles between them could be more similar. Though some papers have studied diffusions of regional housing prices in Taiwan (Chien, 2010; Chen et al., 2011) or China (Huang et al., 2010), to date no study in the literature has looked at the linkages of cross-border housing prices between Taiwan and China. This is an interesting topic insofar as housing price integration has implications for wealth effects that feed into consumer expenditure in both Taiwan and China.

To discuss how the regional housing prices of China influence the housing price of Taiwan, this work applies cointegration and Toda and Yamamoto (1995) Granger causality tests to estimate the interrelationships of cross-border housing prices between one city in Taiwan (Taipei) and four cites in China (Beijing, Shanghai, Shenzhen, and Chengdu). Moreover, little attention has been paid to the time-varying linkage of regional housing markets as time passes. Hence, this paper will use two time-varying estimations of cointegration tests, Gregory-Hansen (1996) cointegration test with structural break and the recursive coefficients of cointegration (Hansen and Johansen, 1993) to trace the possible dynamic linkage of cross-border regional housing prices between Taiwan and China.

The other parts of the paper are as the followings. Section 2 analyses economic integration in Taiwan and China. Section 3 presents the development of housing markets in China and Taiwan. Section 4 discusses the methodology. Section 5 is the empirical results, and the last section presents the conclusions and suggestions.

2. Economic Integration between Taiwan and China

Taiwan and China have historically been related, and trade and investment relationships between them have been very flourishing in past three decades. Some theorems look to explain the integration between Taiwan and China. The first one follows the cultural integration theorem (Chao, 2003), which discusses that both are of the same ancestry and share the similar cultures. The second theorem of integration refers to economics. Reviewing the experience of the European Union (EU), economic integration can cause spillover effects. The third one relates to political reasons. As China becomes more powerful and important in the global economy, nations and sub-national regions in the continental neighborhood are naturally being sucked into its orbit, essentially almost turning into its satellites. However, there are closer economic ties and continuously deepening the interconnectedness between China and Taiwan as increasing trade and investment interactions of the two.

Economic relations between China and Taiwan have improved after the two governments resumed quasi-official talks in 1998 and after both entered the WTO. Over the past two decades, trade and investment relationships between Taiwan and China have been prosperous, causing closer economic ties and continuously deepening the economic dependence between Taiwan and China. The extent of economic integration between them can be evaluated by discussing the relationships of trade and investment flows. We first shed light on the trade relationships between Taiwan and China. Table 1 reports the statistics of cross-strait trade. The proportion of Taiwan’s total trade to China increased approximately seven times from 7.3% in 2000 to 42.6% in 2013. China is the number one export destination for Taiwan and the second largest import source. For China, Taiwan is the third largest import source, and the fifth largest total trade partner in 2013. According to the statistics of Taiwan's customs, in 2013 the amount of China's trade to Taiwan was respectively US$42.59 billion for export, and US$82.79 billion for import. The trade figures show that China has significantly intensified its trade relationship with Taiwan. The driver, causing closer Taiwan-China economic integration, has been mainly based on the business interests of entrepreneurs, each side's national economic development policy, and the global economic trend, rather than any set arranged cross-strait economic cooperative mechanism.

A second observation, in light of the foreign direct investment relationships between the two, is that their geographical and cultural proximity has helped attract investment from Taiwan to China. The movement of hi-tech, agricultural, and financial enterprises from Taiwan to the mainland has never ceased over the last three decades. Initial investments from Taiwan to China were mainly in labor-intensive industries, with small- and medium-size enterprises as the main investors. By the mid-1990s, many large, publicly-listed companies that are capital and technology-intensive industries also actively invested on the mainland (Yuan, 2005). According to the statistics of Taiwan's Investment Commission, the amount of Taiwan's yearly outward investment in China was US$0.17 billion in 1991, but then hit a record high of US$14.6 billion (see Table 1) in 2010, after ECFA was initiated that year. The average proportion of Taiwan's outward investment in China to total outward investment is over 60% from 1991 to 2013, meaning that China is the number one outward investment destination for

Taiwan for the past two decades.

For China, if Honk Kong and British Virgin Islands are excluded from the list,[1] then Taiwan is the fourth largest foreign direct investor over the period from 1979 to 2013, behind Japan, the U.S., and Singapore. Incontrovertibly, capital from Taiwan has played a big role in China's recent economic success.

3. Housing Markets in China and Taiwan

According to the 2010 Population and Housing Census of Taiwan, the average home ownership rate and housing unit vacancy rate are 79.2% and 19.6%, respectively, which are both higher than the average rates of most other countries. As the political and economic center of Taiwan, Taipei is the country's most important housing market. Facing the international tide of free trade and competition from low-cost countries in other parts of Asia, particularly coastal regions in China, many traditional industrial firms in Taiwan have relocated their manufacturing plants to China, while advanced service industries and corporate headquarters are still located in Taipei. Hence, Taipei is a nodal city for cross-border connections, resulting in close interactions for housing prices between Taipei itself and China's major cities.

To investigate and compare how Taiwan's housing price is influenced by urban housing prices in China, we choose three cities in eastern China, Shanghai, Beijing, and Shenzhen, as all three have received an overwhelmingly big share of Taiwan's foreign direct investment

[1] There is unquestionably a high percentage of capital routed through Hong Kong (China) and British Virgin Islands from other parts of the world that flows into China.

(FDI) across the strait. Because many Taiwanese firms shifted their FDI inland from the eastern region after 2009, we also include Chengdu, as a political and economic center in western China, in our model. We note the characteristics and economic developments of these four cities as follows. First, Shanghai, as China's economic center, is nearly fully integrated into the world economy and has unparalleled economic status domestically. In 1990, enthusiasm grew for establishing industrial zones and raising FDI nearby, the Yangtze River Delta (YRD) region, and Taiwan's IT industry soon redistributed a large part of its manufacturing from the Pearl River Delta (PRD) to YRD. Second, Shenzhen is located in PRD, the southern region of China, and was the first area to open up to outside investment. Shenzhen tended to receive more FDI due to its cultural connections and geographical proximity to Hong Kong. Third, Beijing, as China's political center, is located in the Bohai Rim Area and is the next fastest growing place after PRD and YRD. Finally, Chengdu is the provincial capital city of Sichuan Province and located in the eastern Chengdu Plain. After 1992, Chengdu's economic growth rapidly increased, and the level of economic development there is at the top in western China.

Table 2 lists some fundamental economic figures in these four cities, illustrating some significant differences among them. Housing prices in China have presented dramatic growth over the past two decades. In light of the average price of residential units (Table 2) among these four cities, from 2005 to 2015 Shanghai displays the fastest price appreciation: its average price grows from 7,019 RMB/square meter in 2006 to 21,501 RMB/square meter in

2015, or a 205% increase over the 10-year period. By contrast, Beijing, Shenzhen, and Chengdu have appreciation rates of 202%, 180%, and 89%, respectively. As to GDP from 2006 to 2015, except for Beijing with its 183% growth rate, the other three cites exhibit growth of more than two times that of GDP. Table 2 also presents the population level of each city over the same period. All four cities have population growth rates between 12% and 35% from 2006 to 2015, meaning that population growth is not the reason to cause such high housing prices appreciation.

We now compare the ratios of housing prices to income in these four cities. In Beijing and Shanghai, housing price growth has been exceeding the quick individual income growth in the previous few years. In 2010, the price-to-income ratio of Beijing rose to 17.4 times. Shanghai and Shenzhen also experienced rising price-to-income ratios, with both ratios around 15 times. On the other hand, urban incomes have been increasing at higher rates than housing prices in Chengdu, whose price-to-income ratio of 8.4 times is not as high as the other cities' ratios.

4. The Theoretical Model and Methodology

4.1 Theoretical Framework

Economic relations between China and Taiwan improved somewhat after the two governments resumed quasi-official talks in 1998 and after both entered the World Trade Organization (WTO). Over the past two decades, trade and investment relationships between the two countries have been prosperous, bringing about closer economic ties and continuously deepening their economic dependence upon each other. It is widely known that GDP is calculated by applying an 'expenditure approach', no matter if exports or investments make up one component of GDP. Higher bilateral trade and FDI between Taiwan and China are changing the incomes of both economies, which further can impact housing prices in both economies. Moreover, bilateral trade and bilateral FDI could interact with each other, with the interaction effect also affecting incomes and housing prices.

Figure 1 presents how bilateral trade is the associated transmission mechanisms of housing prices between Taiwan and China, and the process goes as follows.

(1) Increasing incomes affect housing prices, because the changes in income lead to existing homeowners to be under-housed and therefore raise their housing demand for moving to the new equilibrium levels, which also impacts housing prices in both economies. Many related papers show that a long-run equilibrium exists between housing prices and income (Abraham and Hendershott, 1996; Malpezzi, 1999; Meen, 2002).

(2) Changes to housing prices in Taiwan could affect Taiwan's GDP and thus alter bilateral trade and investment with China, which further impact GDP and housing prices in China. Correspondingly, if housing prices in China change, there is similar transmission process on housing prices from China to Taiwan.

Case (2000) and Sutton (2002) displayed that fundamentals like GDP, which drive housing markets, are internationally correlated. Bardhan et al. (2008) indicated that a higher degree of economic openness, such as growing international trade, could improve local output and further bring about increasing derived demand for a housing market, which finally causes an upsurge in housing prices. Vansteenkiste & Hiebert (2011) also showed that co-movement of housing prices in different economies is the by-effect of common movements in housing markets' fundamentals, such as income, across countries.

As Figure 1 illustrates, increasing bilateral trade and FDI between Taiwan and China cause higher income and further lead to closer linkages of housing prices between the two economies. We use equation (1) to represent the theoretical model of regional housing prices between Taiwan and China, and the mathematical derivation process of it is shown in the appendix.

$$TP = \Pi\ (BJ, SH, SZ, CDU), \qquad (1)$$

where TP is Taipei's housing prices, BJ is Beijing's housing prices, SH is Shanghai's housing prices, SZ is Shenzhen's housing prices, and CDU is Chengdu's housing prices.

4.2 Granger causality tests of Toda and Yamamoto (1995)

The approach used in this paper is a modified version of the Granger causality test proposed by TY (1995), which is applicable whether VARs are stationary, integrated of an arbitrary order, or cointegrated of an arbitrary order (Toda & Yamamoto, 1995). When the traditional estimation is applied, it requires pre-tests for unit-roots and cointegration, but most economic time series are not very informative about whether or not there is a unit root, or equivalently, the powers of many tests for a unit root are known to be very low, causing the integration orders of the variables to be possibly misleading.. This procedure of TY (1995) could be used without considering the limitations of previous methodologies where all variables must be integrated of order one.

To carry out the TY version of the Granger non-causality test, we use five regional house prices in the following VAR system:

$$Y_t = \Gamma_0 + \Gamma_1 t + \Gamma_2 t^2 + \Psi_1 Z_{t\text{-}1} + \ldots + \Psi_k Y_{t\text{-}k} + U_t,\ t = 1, \ldots T, \qquad (2)$$

where $U_t \sim N(0,\Omega)$; $Y_t = (TP_t, BJ_t, SH_t, SZ_t,, CDU_t)$, and *t* symbolizes a deterministic time trend. Economic hypotheses can be expressed as restrictions on the coefficients in the model in accordance with the following:

$$H_0{:}F(\psi) = 0\,, \tag{3}$$

where $\psi = vec(P)$ is a vector of the parameters in equation (1); $P = (\Psi_1 \ldots \Psi_k)$; and $F(\cdot)$ is a twice continuously differentiable m-vector-valued function. TY provided a simple method of testing for Granger non-causality in level VARs, which is estimated by OLS with integrated variables. The augmented *(k+d)* VARs are estimated, where d is the maximal order of integration.

To examine the above hypothesis, $H_0{:}F(\psi) = 0$, TY confirmed that the Wald statistic converges in distribution to an χ^2 random variable with m degrees of freedom no matter whether the process Y_t is stationary or whether it is cointegrated. However, utilizing the TY procedure derives the usual test statistic for Granger causality with the standard asymptotic distribution where valid inferences can be made. In other words, the TY method can estimate level VARs and test general restrictions on the parameter matrices even if the processes may be integrated or cointegrated of an arbitrary order, which reduces the risks to misidentify the orders of integration of the series, or the existence of cointegration, while additionally reducing the possibility of distorting the test size that is caused by pre-testing.

4.3 Recursive cointegration

To examine the time-varying linkage of regional house markets in these five cities as time passes, we apply the recursive cointegration of Hansen and Johansen (1993) which is a recursive estimation based on Johansen (1988) cointegration tests. The model of Johansen tests is shown as the vector autoregressive (VAR) system below.

$$\Delta Y_t = \sum_{i=1}^{n-1} \Phi_i + \omega\, Y_{t-1} + \varepsilon_t \tag{4}$$

$$\Phi_i = -I + \omega_1 + \cdots + \omega_i, \qquad \omega = -(I-\omega_1-\omega_2 \ldots -\omega_k)$$

In equation (3), $t=1,\ldots,N$, *and* $i=1,..,m-1$, and Y_t is a vector covering five regional house prices. The symbol $\omega=\alpha\beta'$, where β is a matrix covering the cointegrating coefficients, and α is the short-run adjustment coefficients' matrix.

The trace statistic is used by the recursive cointegration of Hansen and Johansen (1993) to test the number of the rank of the matrix ω in equation (3). The trace statistic is as equation (5).

$$\lambda \mathrm{tr}(\gamma) = -N \sum_{i=r+1}^{k} \ln(1-\hat{\lambda}_i), \tag{5}$$

where $\hat{\lambda}_i$ are the eigenvalues of ω.

The conventional cointegration tests covering structural breaks usually allow changes in the short-run coefficient α, but the long-run coefficient β is fixed. Differently, Hansen and Johansen (1993) set up two models allowing changes in the long-run coefficient β. The first model is as equation (6).

$$Z_{0t} = \alpha\beta' Z_{1t} + \gamma Z_{2t} + e_t, \tag{6}$$

where $Z_{0t} = \triangle Y_t$, $Z_{1t} = Y_{t-1}$, $Z_{2t} = (\triangle Y'_{t-1}, \ldots, \triangle Y'_{t-m+1}, 1)'$.

The second model assumes that coefficient β will change but coefficient α is fixed. The maximum likelihood estimation of this model is based on a reduced-rank regression of Z_{0t} on Z_{1t}, and the residuals R_{0t} and R_{1t} are shown as the followings:

$$R_{0t} = Z_{0t} - M_{02}M_{22}^{-1}Z_{2t} \quad (7)$$

$$R_{1t} = Z_{1t} - M_{12}M_{22}^{-1}Z_{2t} \quad (8)$$

where $M_{ij} = \sum_{t=1}^{T} Z_{it}Z'_{jt}$, and then the regression equation is estimated as equation (9).

$$R_{0t} = \alpha\beta' R_{1t} + \tilde{e}, \ t = 1,2,\ldots,T \quad (9)$$

The two models, equations (6) and (9), are applied to execute recursive cointegration estimations.

5. Empirical Illustration

5.1 The Unit-root Tests

This empirical analysis applies housing prices of Taipei (TP), the political and economic center in Taiwan, and four regional housing prices of China, including the four mega-cities of Beijing (BJ), Shenghai (SH), Shenzhen (SZ), and Chengdu (CDU), from April 2006 to April 2015. All variables used are in natural logarithms. The data of Taiwan are obtained from the housing index database of Sinyi Real Estate Development Company, and the data for China are the sales price indices of newly constructed commercialized buildings, collected from the

National Statistical Bureau of China.[2]

We first examine the presence of a unit root in all variables using the DF-GLS (Elliott et al., 1996) and KPSS (Kwiatkowski et al., 1992) unit root tests. We employ the DF-GLS tests, which apply GLS detrending yields' power gains for unit root tests. We also apply KPSS jointly for confirmation of other unit-root tests, because it reverses the typical testing framework, but assumes a null hypothesis of stationarity. According to Table 3, the integration orders of all variables are I(1) processes for all tests at the 5% significant level.

5.2 The Long-Run Relationships of House Prices between Taiwan and China

To estimate the long-run linkages of regional housing prices between Taiwan and China, we perform two tests of the Johansen (1988) cointegration, the trace and the maximum eigenvalue (λ_{max}),to examine the number of cointegrating vectors. The results of λ_{max} and the trace in Table 4 show the existence of one cointegrating vector (r=1), which confirms that a long-run unique cointegrating relationship exists among these five regional housing prices.

To discuss how the regional house prices of China affect the long-run house price of Taipei, the vector of cointegration is estimated. We normalize the cointegration vector around Taipei's house price, and the result is denoted as equation (10).

$$TP_t = -0.59 \times BJ_t - 1.07 \times SH_t + 0.27 \times SZ_t + 6.44 \times CDU_t + 18.22 \qquad (10)$$

[2] The Sinyi housing price index includes apartment buildings and high-rise buildings, and it is a constant quality index, applying a hedonic housing price model to control for changes in the quality and location of houses sold. The sales price indices of newly constructed commercialized buildings of China present the average selling price of commercialized buildings and also control for changes in the quality and location of houses sold.

Equation (10) presents that increasing housing prices in BJ and SH will decrease TP's housing prices, or vice versa, while growing housing prices in SZ and CDU will boost TP's housing prices. What brings this about? In the past few decades, Taiwan has had to come to terms with the rise of China. Initial investments from Taiwan to China were mainly in labor-intensive industries, but many large, publicly-listed companies that are in capital and technology-intensive industries also actively invested there after the mid-1990s. Currently, most top high-tech firms in Taiwan have either set up production or R&D divisions of their own or signed strategic associations with their partners in China, causing the scale of China's information and communication technology (ICT) industry to rapidly expand and the industry chain to become more mature (Hung, 2008). Taiwan's own ICT industry has been facing a serious threat from China's supply chain over the past few years.

The technologies adopted by Taiwanese industries surrounding Shanghai or Beijing are more advanced, implying the economic structures of these two regions are now strong competitors to Taipei. Some exports of advanced ICT products in Shanghai and Beijing are now substitutes for the exports of Taiwan's domestically-made products. Hence, higher exports in Beijing or Shanghai can cause higher income and housing prices in those cities, but lower income and housing prices in Taipei, because such higher exports lead to decreasing exports in Taipei. Therefore, there is a negative linkage of housing prices between Taipei and Beijing (or Shanghai) because of the competitive international trade relationship between Taipei and the two cities.

As to Shenzhen and Chengdu, the technologies adopted by Taiwanese industries surrounding these two cities are from traditional manufacturing enterprises, and investments by Taiwan in these two regions show the effects of specialization through a horizontal division of labor. Thus, for Taipei, these two cities are economic cooperators. Hence, higher exports in Shenzhen (or Chengdu) increase the exports of intermediate goods from Taiwan to China, thus further bringing about higher income and then rising housing prices in Taipei and Shenzhen (or Chengdu) at the same time. Based on the above analysis, the long-run relationship of housing prices between Taipei and these four cities in China is positive or negative, depending on the technology levels of the Taiwanese industries surrounding each city in China.

5.3 The Short-Run Linkages of House Prices between Taiwan and China

To present the short-run linkages of regional house prices between Taiwan and China, TY (1995) Granger causality test and generalized forecast error variance decomposition are used to estimate the short-run relationships of these five regional house prices.

5.3.1 Toda and Yamamoto (1995) Granger Causality Test

Even as the results of Table 3 show that all variables are I(1) processes for all unit-root tests, some papers have indicated a low power of unit-root tests to tell apart the unit-root null from nearby stationary alternatives in finite samples (Diebold & Kilian, 2000). Because TY (1995) avoided those problems inherent in hypothesis testing caused by the existence of unit roots of VAR processes, we apply TY (1995) causality tests among the regional housing prices. Table 5 summarizes the results of equation (1), including all results of TY (1995) causality tests. First, in light of the causalities between the regional housing prices of Taipei (TP) and the four cities in China, Beijing (BJ) and Shanghai (SH) significantly lead TP. Second, as to the causalities of housing prices between the four cities in China, there are unidirectional relationships running from SH to CDU; CDU leads SZ, but there are no causalities between Beijing and Shanghai. In short, Shanghai leads Chengdu, while Chengdu leads Shenzhen. However, Shanghai plays a leading role in the ripple effects of regional housing prices in China, whereas Beijing shows no causality with the other three cities in China.

5.3.2 Generalized Forecast Error Variance Decomposition

This section uses generalized forecast error variance decomposition (GVDC) to estimate the relative short-run influence and the volatility of these five housing prices. Table 7 shows the results of GVDC for the first 3 months and the 12th month in order to trace the impacting pattern as time passes. In Table 8, the other areas explain that the fluctuations in Taipei's housing prices are less than 3% after 12 months, showing Taipei's housing prices to be the most exogenous and implying that its housing market is not easily impacted by the housing prices of most cities in China.

If we focus on the housing price diffusions among the four cities in China, then the results of GDVC show that Shanghai's market has a greater important influence on the other three cities in China. For those three cities, they all receive the same largest shock from Shanghai, respectively at 25.06% to Beijing, 29.06% to Shenzhen, and 26.68% to Chengdu. Obviously, housing prices in Shanghai, which is China's most vital economic center, have the greatest influence on housing prices' fluctuations in other cities of China.

The portion of Shanghai's fluctuations explained by its own shock is 76.77% after 12 months, meaning that Shanghai's housing prices are not easily impacted by other areas' housing price fluctuations in China. Conversely, housing prices in Chengdu are undoubtedly the most endogenous of these five cities, because the portion of its fluctuations explained by its own shock is 51.93%, implying that the other areas can cause 48% of Chengdu's price fluctuations after 12 months. In other words, Chengdu's housing market is deeply impacted by the housing prices of other cities.

5.4 Robustness Analysis

We execute the robustness tests by applying the sub-sample from September 2009 to April 2015. We utilize Johansen's cointegration test of the five housing prices to examine the relationships among the sub-sample data. From Table 7, the results confirm that a stable long-run equilibrium relationship exists among these five regional housing prices. The result of the cointegrated vector is from equation (11). Equation (11) presents that rising housing prices in BJ, SZ, and CDU lead to increasing housing prices in TP, while the housing prices in SH have a negative impact on TP.

$$TP_t = 1.65 \times BJ_t - 11.19 \times SH_t + 8.05 \times SZ_t + 5.71 \times CDU_t - 14.93 \qquad (11)$$

Comparing equation (11) with equation (10), the coefficients' signs of SH, SZ, and CDU are the same for the two equations, but the linkage between TP and BJ is different, from negative to positive, implying the long-run relationship between TP and BJ changes as time passes.

Table 8 summarizes all empirical results of the TY (1995) tests for the sub-sample data. First, at the 10% significant level there are unidirectional relationships running from SH and SZ to CDU, and CDU is a leading variable of BJ, while BJ leads SZ. In short, Shanghai lead Chengdu, Chengdu leads Beijing, and then Beijing leads Shenzhen, implying that Shanghai still plays a leading role for having ripple effects throughout regional housing prices in China, which is the same as the results for the full sample (Table 5). Beijing plays an intermediate role for the sub-sample, which is different from the results of the full sample (Table 5). A noteworthy point is that TP shows no causality with all four cities in China for the sub-sample, but there is causality between TP and the four cities in China as time passes.

Table 9 shows the results of GVDC for the sub-sample, which is similar with the findings of the full sample in Table 6. However, the Johansen cointegration and TY causality tests present some different results for the sub-sample, and therefore we employ the time-varying methodology to examine the linkage in the next section.

5.5 The Time-Varying Linkages of Housing Prices between Taiwan and China

There are some fluctuant phases over our sample period in China and Taiwan. To study the time-varying nature of cointegration as time passes, we use two time-varying estimations of cointegration tests, Gregory and Hansen (1996) cointegration test with structural break and the recursive coefficients of cointegration (Hansen and Johansen, 1993) to capture the possible dynamic long-run linkages of these five regional house prices.

5.5.1 Gregory and Hansen Cointegration Test with Structural Break

The Gregory and Hansen (1996, hereafter GH) test is a generalization of the usual residual-based cointegration test, and the null is no cointegration against the alternative hypothesis of cointegration considering a regime break.[3] Using TP as the dependent variable, the results of the GH test are in Table 10.[4] Except for the result of Z_{α}^{*} for model C, all of the results of ADF^{*}, Z_{α}^{*}, and Z_{t}^{*} reject the null at the 10% significant level; in other words, there is a cointegrating relationship with a structural break between TP and the four housing prices in China.

Table 10 also presents that the main structural breaks around two periods (from 2007 to 2009, and from the end of 2010 to 2011) impacted the stability of the linkage between the housing markets of Taiwan and China. The first structural break from 2007 to 2009 is caused by the global financial crisis, which began in the summer of 2007. As to the second break, it is affected by the signing of the Economic Cooperation Framework Agreement (ECFA) between

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[3] The three models are a level shift (model A), a level shift with trend (model B), and a regime shift to allow the slope shift (model C).

[4] GH has developed versions of the cointegration ADF tests of Engle and Granger (1987) and the Z_t and Z_{α} tests of Phillips-Quliaris (1990), modifying them according to the alternative considered.

Taiwan and China on June 29, 2010. It is a preferential trade agreement (PTA) that has opened up a wide gate for the establishment of closer economic ties between the two. It has also affected the relationships of housing prices between Taipei and those four cities.

5.5.2 The Recursive Coefficients of Cointegration Vector

The estimated coefficients of the cointegration vector as equation (1) show how the five markets' house prices are related in the long run, but the coefficients could change, which is caused by some events. To capture the time-varying convergence of these five housing prices as time passes, we use the recursive coefficients of Johansen cointegration (Hansen and Johansen, 1993) to investigate the dynamic linkages of five housing prices between Taiwan and China during different sub-sample periods.

The recursive coefficients of the cointegration vector, β, are estimated using using 48 observations at first and by adding one observation to the end as time increasing. With the cointegration vector being normalized around the Taipei housing price, Figures 2(a) to 2(d) display the estimating results of the recursive coefficients of β, containing Beijing, Shanghai, Shenzhen, and Chengdu housing prices. All four coefficients are significant in much of the period after 2008.

From Figure 2(a), Beijing's housing price positively affects Taipei's housing price before the second half of 2014, while the relationship turns negatively and significantly after the second half of 2014. Shanghai's housing price, in Figure 2(b), shows a negative impact on

Taipei's housing price over the full period but this impact becomes insignificant after the second half of 2014. Figure 2(c) displays the effect of Shenzhen is similar with Beijing's effect. Conversely for the results of Beijing's, Shenzhen's and Chengdu's housing prices, Figure 2(d) display negative effects on Taipei's housing price before the second half of 2014, but the relationships turn positive after the second half of 2014.

Generally, the results of Figures 2(a) to 2(d) show that the main structural breaks around the second half of 2014. On March 2014, there is a political incident of the Sunflower Movement in Taiwan, which caused rapid deterioration cross-straits relations after the second half of 2014. However, after the second half of 2014, only Chengdu's housing price can have significantly[5] positive effect on Taipei's housing price, and other three cities' effects are insignificant over much of this period.

6. Conclusions and Suggestions

This paper investigates economic integration and the linkage of regional housing markets between China and Taiwan. We apply two time-varying estimations of cointegration tests - the GH cointegration test with structural break and the recursive coefficients of cointegration - to trace the possible dynamic relationships of regional housing prices between China and Taiwan. Our main findings and some policy suggestions are as follows.

[5] If the 95% confidence interval (the interval between two dash lines) of recursive coefficient β covers the value of zero, then β is insignificantly different from zero. Conversely, if the 95% confidence interval does not cover the value of zero, then β is significantly different from zero.

First, the estimating results of the long-run relationships, after applying Johansen's (1988) cointegration test, show that higher housing prices in Beijing and Shanghai will decrease Taipei's housing prices, while rising housing prices in Shenzhen and Chengdu will boost Taipei's housing prices. These four cities' housing prices in China positively or negatively affect Taipei's housing prices, depending on the technology levels of the Taiwanese industries surrounding each city in China.

Second, in light of the causalities of regional housing prices' changes between Taiwan and China, we note that the prices of Beijing and Shanghai lead Taipei, Shanghai leads Chengdu, and Chengdu leads Shenzhen. Moreover, housing prices fluctuations in Shanghai exhibit the greatest influence on other cities' housing prices fluctuations in China.

Third, the results from time-varying estimations of cointegration tests find that two events, the 2007-2009 global financial crisis and the signing of the Economic Cooperation Framework Agreement (ECFA) in 2010, caused structural breaks and changed the linkages of housing prices between Taipei and the four cities in China. These two big events structurally changed the economic relationships between Taiwan and China.

From our empirical results, we offer some suggestions below. First, the four mega-cities' housing prices in China do impact Taipei's housing prices. Therefore, if there are some significantly huge fluctuations of housing prices in China, then policymakers in Taiwan should adopt some response actions to better manage the cross-broader ripple effects of housing prices' fluctuations from China to Taiwan. Second, housing prices fluctuations in Shanghai take a leading role to affect other housing prices' fluctuations in China. Hence, for policymakers in China, the key target for stabilizing housing prices domestically is to control Shanghai's housing price fluctuations. Finally, over a longer-term period, some events, such as those that are economic and political, could change the linkages of regional housing prices between Taiwan and China. Thus, government policymakers and investors should pay more attention to dynamic changes in the two economies' housing markets.

Our empirical evidence overall displays the existence of integration among the regional housing markets of Taiwan and China. For the longer-term future, increasing economic integration between China and other Asia countries will result in greater and more diversified cross-border housing markets and pools of investors. The aims of a generalizable analysis may be attained if data on other countries in Asia can be collected for further empirical analysis.

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Appendix Theoretic Model of Regional Housing Prices

It is well known that GDP is estimated by the commonly used 'expenditure approach'. The expenditure approach of GDP (is denoted by Y) is as follows:

$$Y = C + I + G + X - M \qquad (a1)$$

where C is the consumption; I is the capital formation; G is government expenditure; X is export and M is import. To discuss the transmitted mechanisms from bilateral trade and FDI between China and Taiwan, equation (a1) is rewritten as following function:

$$Y = \Theta\,(TB, I, A) \qquad (a2)$$

where TB = X-M, TB is the trade balance, and A = C+G. I is investment (capital formation), and it can be rewritten as equation (a3)

$$I = Y - TB - A \qquad (a3)$$

Replace equation (a3) into equation (a2) to obtain

$$Y = \Theta\,(TB, Y - TB - A, A) \qquad (a4)$$

In equation (a4), Y in the left side can be moved to the right side, and equation (a4) can be rearranged as equation (a5)

$$Y = F\,(TB, A) \qquad (a5)$$

GDP is an important variable to affect housing prices, and the function of housing prices (HP) can be shown as follows:

$$HP = \rho\,(Y) \qquad (a6)$$

Replace equation (a5) into equation (a6) to get

$$HP = \rho\,[F\,(TB, A)] = H\,(TB, A) \qquad (a7)$$

To simplify analysis, A is assumed to be exogenous variable, and the inverse function of equation (a7) can be written as follows:

$$TB = H^{-1}(HP) = \Omega(HP) \qquad (a8)$$

Applying equation (a8) to set up the model of the linkage of regional house prices covering two economies, China and Taiwan, and the model can be shown as the followings:

$TB_C = \Omega_1(HPc)$ (a9)

$TB_{TW} = \Omega_2(P_{TW})$ (a10)

The subscripts C and TW represent China and Taiwan, respectively. The bilateral trade between China and Taiwan (BiTB) can be the explanatory variable of the function of TB_C and TB_{TW}, and the function of TB_C and TB_{TW} can rewritten as

$TB_C = K_1 (BiTB)$ (a11)

$TB_{TW} = K_2(BiTB)$ (a12)

Then, we make the inverse functions of equation (a11) and equation (a12) to get the followings:

$BiTB= K_1^{-1}(TB_C)$ (a13)

$BiTB= K_2^{-1}(TB_{TW})$ (a14)

Replace equation (a11) and equation (a12) into equation (a13) and equation (a14), respectively, and the two equations are rearranged as equation (a15) and (a16).

$BiTB= K_1^{-1}[\Omega_1(HPc)] = L_1 (HPc)$ (a15)

$BiTB= K_2^{-1}[\Omega_1(HPc)] = L_2 (HP_{TW})$ (a16)

The right side of equation (a15) and equation (a16) is same, and we can substitute equation (a15) into equation (a16) to get the following

$L_2 (HP_{TWi}) = L_1 (HPc_i)$ (a17)

and then the inverse function of equation (a17) is made to obtain equation (a18)

$HP_{TWi} = L_2^{-1} [L_1 (HPc)] = \Pi (HPc)$ (a18)

We select Taipei housing prices (TP) as the proxy of HP_{Twi} , and four regional house prices of Beijing (BJ), Shenghai (SH), Shenzhen (SZ), and Chengdu (CDU) are selected as the proxies of HPc_i, and put these five regional housing prices into equation (a18) to get

$TP =\Pi (BJ, SH, SZ, CDU)$ (a19)

Hence, the equation (19) can be estimated to examine the relationship of regional housing prices between Taiwan and China.

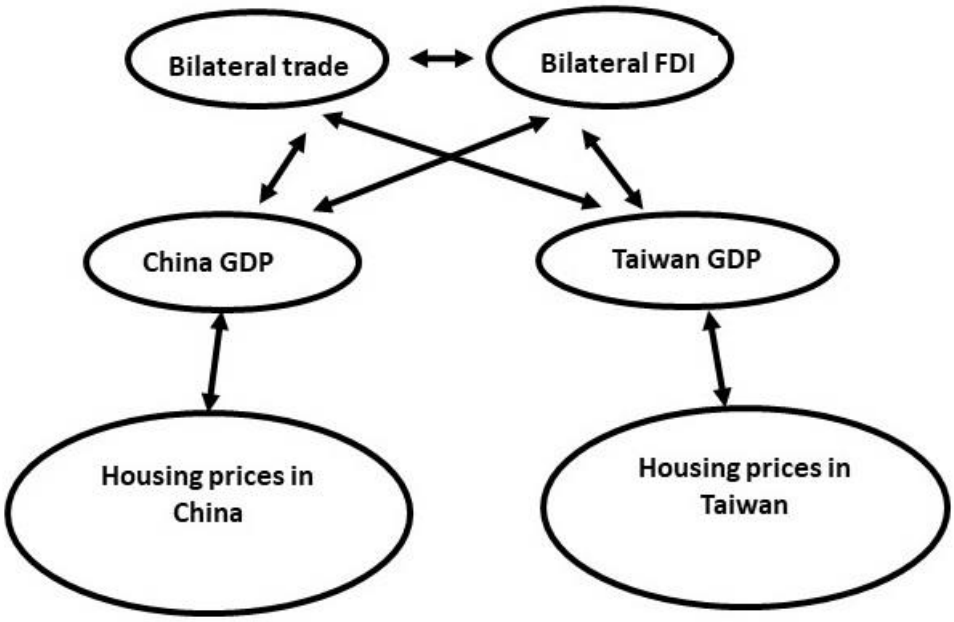

Figure 1 Conceptual Framework of the Linkage of Housing Prices between Taiwan and China

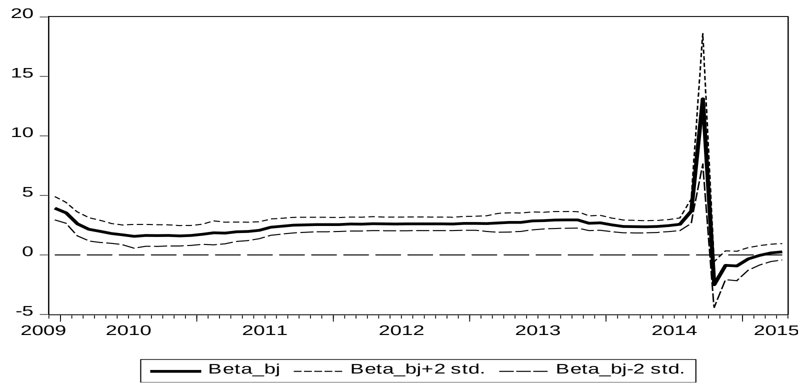

Figure 2(a). Recursive coefficients of cointegration vector β (Beijing)

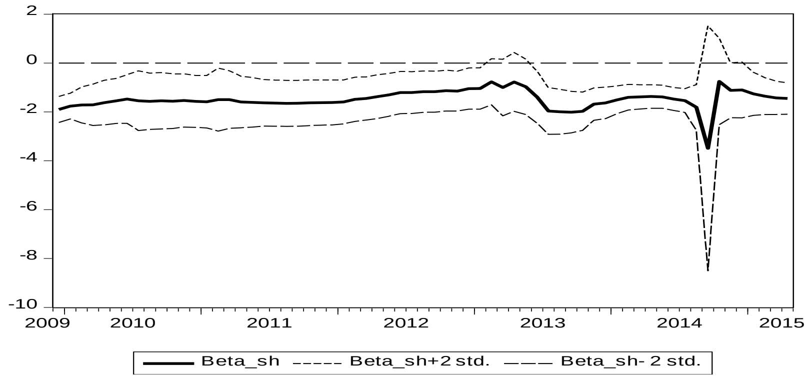

Figure 2(b). Recursive coefficients of cointegration vector β (Shanghai)

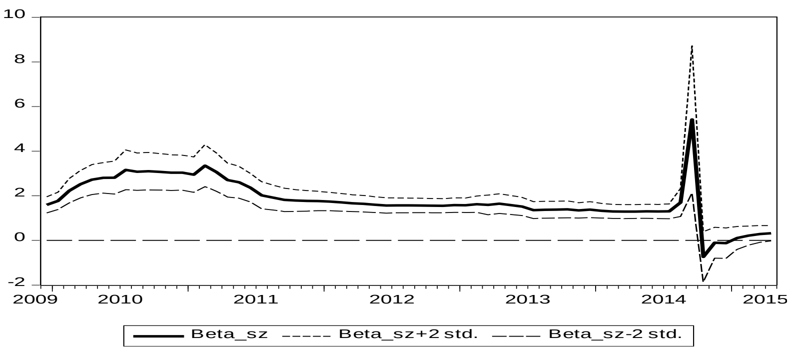

Figure 2(c). Recursive coefficients of cointegration vector β (Shenzhen)

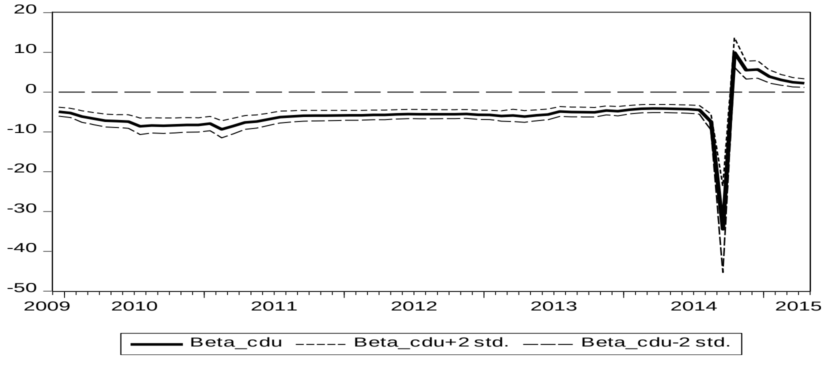

Figure 2(d). Recursive coefficients of cointegration vector β (Chengdu)

Table 1 Trade and Outward Investment between Taiwan and China

Year	Taiwan's Trade to China[1] (as % of Taiwan's total trade)		Taiwan's Outward Investment to China[2]	
	Exports	Imports	Amount (US$ bn)	As % of Taiwan's Total Outward Investment
2000	2.9%	4.4%	2.6	-
2001	3.9%	5.5%	2.8	-
2002	7.8%	7.0%	6.7	66.6%
2003	15.2%	8.6%	4.6	53.7%
2004	19.9%	10.0%	6.9	67.2%
2005	22.0%	11.0%	6.0	71.1%
2006	23.1%	12.2%	7.6	63.9%
2007	25.3%	12.8%	10.0	60.7%
2008	26.2%	13.1%	10.7	70.5%
2009	26.6%	14.0%	7.1	70.4%
2010	28.0%	14.3%	14.6	83.8%
2011	27.2%%	15.5%	14.4	79.6%
2012	26.8%	15.1%	12.8	61.2%
2013	26.8%	15.8%	9.2	63.7%

Sources: 1. Customs Statistics, R.O.C.

2. Investment Commission, MOEA, R.O.C.

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Table 2 Regional Patterns among the Four Cities in China

Item		Beijing	Shanghai	Shenzhen	Chengdu
Average Residential Unit Price (RMB/square meter)	2006	7,375.41	7,039	8848.04	3498.95
	2015	22,300	21,501	33,661	6,584
	Appreciation (2006-2015)	202%	205%	180%	89%
GDP (1 billion RMB)	2006	811.7	924.7	581.3	275.0
	2015	2301.4	2512.3	1,750.2	1080.1
	GDP growth (2006-2015)	183%	271%	201%	293%
Population (1,000)	2006	16,010	19,640	8,711	11,034
	2015	21,710	24,150	11,378	12,280
	Population growth	35.6%	22.9%	30.6%	12.2%
Ratio of price to income in 2010		17.4	15.4	15.6	8.4

Source: The ratio of price to income is from Zhang and Zhang (2012), p. 96, and the other data are from the website of the National Bureau of Statistics of China.

Table 3 Results of Unit-root Tests

Country	DF-GLS	KPSS
Level		
TP	0.9561(3)	1.2081(9)**
BJ	0.7513(5)	1.1794(9)**
SH	0.1148(2)	1.1079(9)**
SZ	0.3053 (1)	0.9670(9)**
CDU	-0.1316(2)	1.1357(9)**
First-Difference		
TP	-2.3284(6)**	0.1397(4)
BJ	2.2363(2)**	0.1190(8)
SH	-2.6133(3)**	0.0489(8)
SZ	-2.3029 (5)**	0.0647(7)
CDU	-3.2403(1)**	0.2736(8)

*Notes: The regressions include an intercept. The lag parameters are selected on the basis of the Modified AIC and are in parentheses. The numbers in parentheses are the lag order in the DF-GLS tests. The bandwidths are for the Newey-West method of the KPSS tests in parentheses. ** and * signify that the test rejects the null at the 5% and 10% level, respectively.*

Table 4 Johansen's Cointegration Test

	Max-Eigen		Trace	
	Statistic	10% Critical Value	Statistic	10% Critical Value
r=0	76.60*	72.77	35.49**	32.16
r=1	41.10	50.52	19.74	26.12
r=2	21.36	32.26	10.74	20.05
r=3	10.61	17.98	5.35	13.90
r=4	5.26	7.55	5.26	7.55

*Note: The number of lags is 1. ** and * signify that the test rejects the null at the 5% and 10% level, respectively.*

Table 5 Granger Causality Test of Toda and Yamamoto

Independent variable / Dependent variable	TP	BJ	SH	SZ	CDU
TP		4.1517** [0.0186]	4.3971** [0.0148]	1.6687 [0.1938]	0.3405 [0.7122]
BJ	0.9302 [0.3979]		1.2507 [0.2908]	0.2450 [0.7831]	0.9063 [0.4074]
SH	1.9303 [0.1506]	0.3575 [0.7003]		1.1182 [0.3310]	1.4584 [0.2376]
SZ	0.4071 [0.6667]	0.2450 [0.7832]	1.4840 [0.2318]		3.6162** [0.0305]
CDU	1.0560 [0.3518]	1.4919 [0.2300]	9.3595*** [0.0002]	1.7799 [0.1741]	

*Note: The superscripts *** and ** indicate significance at the 1% and 5% levels, respectively.*

Table 6 Generalized Forecast Error Variance Decomposition

Dependent variables	Quarter	Percentage of forecast variance explained by innovations (in %) of each independent variable				
		DTP	DBJ	DSH	DSZ	DCDU
DTP	1	100	0	0	0	0
	2	98.8325	0.6866	0.0215	0.4426	0.0168
	3	98.4937	0.8073	0.0912	0.5492	0.0587
	12	97.4329	0.9868	0.6244	0.8054	0.1506
DBJ	1	6.7209	93.2791	0	0	0
	2	9.0421	86.1767	2.7033	0.8965	1.1814
	3	8.7041	79.6055	6.9818	2.4432	2.2654
	12	6.5693	57.1861	25.0628	7.1910	3.9908
DSH	1	0.4582	25.3913	74.1504	0	0
	2	1.8716	21.1747	75.6831	0.6294	0.6412
	3	1.8221	18.8343	76.4803	1.64324	1.2202
	12	1.5682	14.0588	76.6636	5.2072	2.5023
DSZ	1	0.2622	2.3276	15.1886	82.2215	0
	2	0.4066	2.2994	18.8852	77.2702	1.1387
	3	0.3931	2.3959	21.6636	73.6053	1.9421
	12	0.4562	2.8027	29.0691	64.7630	2.9090
DCDU	1	0.4638	4.9208	4.8500	0.1215	89.6438
	2	1.1418	7.4599	9.7054	4.2379	77.4551
	3	1.3118	8.5992	13.9769	7.3352	68.7769
	12	1.3750	8.9113	26.6894	11.0887	51.9357

Table 7. Johansen's Cointegration Test of sub-sample (2009M9~2015M4)

	Max-Eigen		Trace	
	Statistic	10% Critical Value	Statistic	10% Critical Value
r=0*	35.06**	32.16	88.78**	72.77447
r=1	22.12	26.12	53.72	50.52532
r=2	15.52	20.05	31.59	32.26837
r=3	9.39	13.90	16.06	17.98038
r=4	6.67	7.55	6.67	7.556722

*Note: The number of lags is 2. ** signify that the test rejects the null at the 5% level.*

Table 8. Granger Causality Test of TY of sub-sample (2009M9~2015M4)

Dependent variable \ Independent variable	TP	BJ	SH	SZ	CDU
TP		1.32585 [0.2762]	1.4910 [0.2280]	0.8930 [0.4511]	1.5157 [0.2216]
BJ	0.6995 [0.5567]		0.2003 [0.6837]	0.7972 [0.5011]	2.33821* [0.0714]
SH	1.3752 [0.2608]	0.2231 [0.8799]		2.0694 [0.1158]	1.3295 [0.2750]
SZ	1.2455 [0.3029]	3.5766** [0.0201]	1.9332 [0.1359]		0.1412 [0.9348]
CDU	05654 [0.6403]	1.5590 [.2107]	4.2447*** [0.0094]	3.4863** [0.0222]	

*Note: The superscripts ***, ** and * indicate significance at the 1% , 5%, and 10% levels, respectively.*

Table 9. Generalized Forecast Error Variance Decomposition of sub-sample (2009M9~2015M4)

Dependent variables	Quarter	Percentage of forecast variance explained by innovations (in %) of each independent variable				
		DTP	DBJ	DSH	DSZ	DCDU
DTP	1	100	0	0	0	0
	2	98.0296	0.7382	0.1974	1.0053	0.0292
	3	94.8306	2.4942	0.3761	0.9632	1.3355
	12	93.4659	2.6540	0.7479	1.3991	1.7329
DBJ	1	6.2478	93.7521	0	0	0
	2	7.9983	87.7132	3.0664	0.7536	0.4683
	3	6.8900	78.5053	8.5422	1.6511	4.4112
	12	4.7224	56.8227	22.1995	7.9696	8.2856
DSH	1	0.5813	25.5687	73.8498	0	0
	2	1.9447	25.6872	70.8872	0.4862	0.9945
	3	1.6043	23.1277	72.3817	1.7290	1.1570
	12	1.1143	17.9328	73.1967	6.3209	1.4350
DSZ	1	0.0048	1.6943	13.8758	84.4249	0
	2	0.6277	4.3859	19.0263	74.4261	1.5337
	3	0.9275	4.0220	24.6355	68.6020	1.8128
	12	0.7771	3.5014	30.2961	63.2576	2.1675
DCDU	1	0.2912	6.2981	6.3417	0.2518	86.8170
	2	0.5644	6.7193	22.3737	1.8385	68.5038
	3	0.4453	11.38	22.9516	5.7922	59.4308
	12	0.6777	12.9776	26.5108	13.9675	45.8662

Table 10. Result of Gregory-Hansen Test

Test statistic	A	B	C
ADF*	-5.966^{***} [2011M06]	-6.218^{***} [2007M07]	-6.241^{**} [2009M09]
Z_{α}^{*}	-53.172^{*} [2011M06]	-56.417^{*} [2010M12]	-56.991 [2009M09]
Z_{t}^{*}	-5.993^{***} [2011M06]	-6.240^{***} [2007M05]	-6.259^{**} [2009M09]

Notes: A, B, and C denote model types. The numbers in brackets are the estimated structural break times. ***, **, and * show significance at the 1%, 5%, and 10% level.