THE DYNAMICS OF COMOVEMENTS AND CORRELATIONS IN PUBLIC PROPERTY MARKETS: EVIDENCE FROM GREATER CHINA AND INTERNATIONAL LINKAGES

Zhou Xiaoxia

(B.Sc. Shanghai Uni.of Finance and Economics)

A THESIS SUBMITTED

FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF REAL ESTATE

NATIONAL UNIVERSITY OF SINGAPORE

2014

Declaration

I hereby declare that this thesis is my original work and it has been written by me in its entirety. I have duly acknowledged all the sources of information which have been used in the thesis.

This thesis has also not been submitted for any degree in any university previously.

Zhou Xiaoxia

30 June 2014

Acknowledgements

I would like to express my deep gratitude to Professor Liow Kim Hiang and Associate Professor David Ho Kim Hin, and Associate Professor Muhammad Faishal Bin Ibrahim, my research supervisors, for their patient guidance, enthusiastic encouragement and useful critiques of this research work. Special thanks should be given to my supervisor - Professor Liow Kim Hiang, for introducing me to this research area and patiently guiding me for my research work. His willingness to give his time so generously has been very much appreciated.

I am particularly grateful for Associate professor Liao Wen-Chi, Professor Tu Yong, Professor Ong Seow Eng, Professor Sumit Agarwal, Professor Simon Stevenson and associate professor Fu Yuming, for their insightful comments, suggestions on my thesis and helpful advices for my academic career.

I wish to acknowledge the help provided by my friends and my postgraduate peers, I received their selfless help for me to finish this research work within limited time. They are included but not limited: Tang Cheng Keat, Zhang Yao, Guo Yan, Wang Yourong, Li Qing, Ye Qing, Zhao Daxuan, He jia, Qiu leiju, He yajie, Lin Shudong and etc.

I would like to thank National University of Singapore and China Scholarship Council for offering me scholarship and chances to pursue my PH.D study.

Finally, I wish to thank my parents for their support and encouragement throughout my study.

Table of contents:

Summary

Owning real estate overseas has been considered as a good way to hedge against local real estate risk and economic recession. However, due to regulations and other difficulties, an alternative way of involving in real estate investment activities is to invest in international public real estate market. Under the background of rapid development of global real estate securitization and increasing international investment, the extend of interdependence among public property markets arouse the interest of extensive academic studies. However, fewer studies have covered Greater China market and less formal studies evaluate the relative importance of "real estate" factors in explaining the cross-sectional and time series variation of correlations across national public real estate markets. Therefore, this thesis aims (a)to provide an overall examination of the relationships among Greater China public real estate market with other five public real estate markets from both correlation, co-movement and co-cyclical angles; (b) to detect possible economic, financial and real estate explanation for it.

The first chapter (chapter 3) studies to what extend Greater China public property markets with other five public property markets are correlated or co-moved and how the relationships evolve during research period especially during financial crisis period. Both long-term and short-term relationships are examined using Co-movement Box and ADCC-GARCH respectively. Both the long term and short term empirical results document relative higher level of codependence relationship within GC markets than that with other five real estate markets, indicating a regional integration rather than a global integration. In additional, securitized real estate asset return co-movements increase significantly during crisis, which is consistent with the presence of financial contagion. However, the long-term cointegration levels for most research pairs are still low which are far less than fully integrated. Therefore, investors can still gain diversification benefits from investing on GC markets and the rest securitized real estate markets.

Using dynamic conditional correlation estimated from chapter 3, chapter 4 further studies the driving forces including real estate factor, financial market factor and macroeconomic factor of the correlation structure in international securitized real estate market. The empirical results indicate that five included real estate factors are significant in influencing cross-market real estate securities return correlations in different degree. Given the plentitude of variables available to international investors, this research thus becomes important for them to consider only those "real estate" and "control" factors that are particularly useful for modeling the changes in the international co-movement of real estate securities markets.

The objective of Chapter 5 is to examine the coherent relationship of GC public real estate market cycles with other five public real estate market cycles from a new angle and to detect the possible impact of business cycle synchronization of these markets on it. Using bilateral concordance index as well as a multilateral GMM based test, empirical results indicate that a common cycle exists in almost every bilateral real estate and macroeconomic correlation pairs. Multilateral public real estate cycles within GC markets and with other five real estate markets are also strongly synchronized. Besides, panel regression results indicate that business cycle synchronization in the eight markets does have an explanation power for securitized real estate market cycle coherence.

In summary, this thesis conducts an overall study on international real estate investment and linkage among Greater China public real estate market with real economy and equity market. The results have an implication on the efficiency of diversification investment strategy for investors and studies on securitized real estate cycle synchronization offer informative references for investors who make decision based on price changes.

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Background and Motivation

Undertaking international real estate investment has been a common business strategy for recent multinational companies and institutions. Owning real estate overseas has been considered an effective way to hedge against local real estate risk and economic recession. However, owing to regulations and other difficulties, an alternative and feasible way of involving real estate investment activities is to invest international real estate securities, because the price of real estate securities can reflect the value of their underlying properties. Co-investors for real estate stocks are often local, thereby offering another benefit of investing in indirect real estate market via reducing information costs and monitoring cost (Eichholtz and Koedjik, 1996a). With the rapid development of real estate securitization worldwide and increasing international capital flows, investment in public real estate markets becomes feasible and significant.

Equities in emerging markets are now well-known for its extinguish features from equities from mature markets. In the work of Bekaert and Harvey (1997), at least four features of emerging market returns: Higher sample average returns, high volatility, more predictable returns and low correlations with developed market returns. This thesis will focus on the last point by studying the codependence relationship among Greater China market and its evolvement through research period. Though this codependence relationship between GC market with other mature real estate market would be considered low in the past, but with the increasing trade and financial openness, this codependence relationship is expected to be changed gradually. The effect of changing codependence could be duo. On one hand, the openness of the global financial system would allow investors to easily trade financial products in a larger financial markets. That is, investors would have variable opportunities to increase their returns in the long run. On the other hand, increasing codependence relationship would reduce benefits from diversification. In this case, this paper would specially focus on possible negative effect from codependence relationship.

The US securitized real estate market is the biggest market in the world, increasing from USD 12.5 billion in 1995 to USD 987.1 billion in 2011 (measured in terms of market capitalization) (source: MSCI real estate). The Asian market also experienced tremendous high growth rate. The total market capitalization of the Asian securitized real estate market has grown by more than 3 folds from USD$78.2 billion in first quarter of 1995 to USD$244.6 billion in first quarter of 2012 (source: MSCI Real Estate). Such an Asian market coincided with the rapid development of the Asian REIT markets which first started in 2001 in Japan, before being established in Singapore, Hong Kong, Malaysia, Taiwan, South Korea and Thailand. Asia is considered one of the biggest securitized markets in the world, with 12% market share for its securitized real estate, which is comparatively larger than the mature markets of US (6%), UK (5%) and France (6%). (Source: EPRA, 2008). The increasing availability of Asian real estate debt and equity instruments to international investors has intensified the interest and involvement of international investors.

With the establishment of trade treaties and the expansion of the World Trade Organization1, another observation is the intensification of intra-trade and investment flows between countries, leading to shifts in national boundaries for the demand for inputs, including real estate. All these activities have led to the increased involvement of international investors. For instance, foreign direct investment in real estate towards Asia (China, Hong Kong and Taiwan) has grown from USD$5.2 billion from 1997 to USD$24.1 billion in 2010.

---

[1]Hong Kong, China and Taiwan have become members of WTO in 1995, end of 2001 and beginning of 2002 respectively

There has been a dearth of research on the possible linkage among public real estate market in Greater China market (Mainland China, Hong Kong and Taiwan). This thesis is especially interested in this region and its main trade partners (US, UK, Australia, Japan and Singapore) for the following reasons. Firstly, gross economy in mainland china develops rapidly since implication of the reform and open policy, thus a varying change in linkages within Greater China area or with other partners will be expected. Besides, mainland China gradually opens its financial market to foreign investors; for example, relaxation on conditions of QFII (qualified foreign institutional investors). With the increasing availability of its financial assets, it is important to understand financial market of China better for the benefit of international investors. Moreover, real estate capitalization has experienced dramatic growth not only in mainland China market but also in Taiwan and Hong Kong. The REITs are firstly listed in Taiwan on March of 2005 and in Hong Kong on November of 2005 respectively. Therefore, the importance of public real estate market in Greater China is increasing and also arouses my interest in studying this region.

Along with fast securitization in the real estate industry and increasing international investment, extensive studies are carried out to analyze the interdependent relationship among international financial assets including real estate securities. The close linkage of the international stock market has become impossible to be ignored especially during the recent global financial crisis. Compared with the broad common stock markets, the correlations among national real estate indices often showed significantly lower levels than the correlations among the national common stock and bond indices (Eichholtz, 1996). The listed real estate securities sector has now been recognized as an "essential" asset class in mixed-asset portfolios (Dhar and Goetmann, 2006). The trend of interdependence is crucial to international investors and fund managers. Because lower interdependence indicates feasibility of international diversification, higher interdependence between the securitized real estate markets means useless of international diversification. Besides, increasing interdependence relationship would greatly enlarge the risk of cross-section contagion effect[2]. Therefore, the extent to which international securitized real estate markets are integrated as well as how the interdependence relationship evolves during crisis has been widely discussed by scholars. Along with this trend of studies, this thesis further discusses the interdependence relationship and its changes of international public property markets from a new perspective.

To date there is extensive academic literature on the extent to which global (common) stock markets are correlated and to a lesser extent, the fundamental factors that influence the correlation variation in developed and emerging stock markets. However and to my knowledge, less formal studies evaluate the correlation dynamics and the relative importance of "real estate" factors in explaining the cross-sectional and the time series variation of correlations across national securitized real estate markets. Therefore, the second step of this thesis is to examine the driving forces of dynamic correlations across international public property markets with special focus to "real estate" factors. There are reasons to expect that the specific examination of real estate securities might lead to different findings, in comparison to those studies that have considered the broader equity markets. First, listed property is a hybrid of a real (property) and a financial (share) asset. As a result, the investment characteristics of real estate and shares as well as the markets in which they operate are different from each other in many aspects. Second, since real estate securities behave like stocks and direct properties, one might reasonably expect that not only do macroeconomic and stock market variables contribute to the correlation structure of national real estate securities market returns, the real estate factors also play an important role. This broad

[2] Contagion effect, in finance literature, is broadly defined as an increase in financial market co-movements during periods of financial turbulence.

reasoning provides the justification for us to focus on the real estate dimension of real estate securities market correlation structure by considering only those factors that are particularly relevant to the modeling of correlation changes in the international securitized real estate markets. On further reflection, our understanding is in line with Pretorius (2002)'s argument that some features of emerging common stock markets such as market capitalization, industrial structure and volatility affect co-movement. Therefore, it might be important to incorporate some industry-specific factors such as market size and volatility when we examine a single industry such as the listed securitized real estate sector. However my intuition on this topic still remains an empirical question since economic theory does not provide a priori information on the signs and magnitudes of the coefficients for the selected correlation factors in real estate securities markets.

Though a lot of researches focus on correlations relationship among international stock or real estate returns, and to date, there is much less literature studies co-cyclical behavior of public real estate markets and its relationship with the business cycles as well as with the financial cycles. Since investors always make profits by selling high (bull market) and buying low (bear market), this constitutes another important aspect concerning the investment in the global property security markets in order to study their co-cyclical behavior. Co-cyclical or the synchronization of two cycles refers to the coherence of upturns and downturns in the cycles. Similar to correlation studies, the coherence of upturns and downturns in international securitized real estate markets is also a major concern for portfolio managers to make timely investment decisions, because the high synchronization of real estate cycles indicates the ineffectiveness of the international diversification strategy.

As a special category in equity markets, the securitized real estate market is influenced by both by its underlying property and the broad equity markets. More specifically and for the household, the aggregate economy can have an impact on real estate markets through the wealth effect of increasing income (Quigley, 1999) and mortgage payment. Second, the synchronized global economy could create common shocks to investment in the domestic real estate industry and the broader equity markets through credit channel. Thirdly, the contagion effect would increase the level of real estate market coherence. These are reasons that could arouse another interesting topic of finding out the possible linkage between the global business cycle synchronization and the international real estate cycle coherence. That is, whether the worldwide business cycle synchronization could be one possible explanation for the co-cyclical behavior of international public real estate market.

1.2 Research Objectives

This thesis aims to provide an overall examination of the relationship among the international securitized real estate markets for both the co-movement and co-cyclical behavior and the possible economic, finance and real estate explanations for them. Specifically, the four objectives are:

1) To examine the interdependence relationship of the securitized real estate markets among the GC[3] (Greater China) area and their relationship with other developed real estate markets in the world.

2) To analyze the contagion effect of securitized real estate markets by comparing the co-movement relationship during the crisis and tranquil period.

[3] GC market includes China mainland, Hong Kong and Taiwan

3) To study the driving forces including the real estate factor, the financial market factor and the macroeconomic factor for the correlation structure in the international securitized real estate market.

4) To examine the coherent relationship of the GC (Greater china) public real estate market cycles and other mature public real estate market cycles (like Japan, Singapore, Australia, UK and US), and to detect the possible impact of the business cycle synchronization of these markets on it.

1.3 Theoretical Framework

This section presents a conceptual framework on stock/real estate securities market linkages and integration and what influences correlations between markets. Economic theory has provided *a priori* information on the signs of some major influences but not to their magnitudes. Pretorius (2002) has summarized them into three groups of theories why stock markets co-move. First, "economic integration" theory suggests that the more the economies of two countries are integrated, the more interdependent their financial and stock markets will be. Economic integration includes not only trade relationships, but also co-movement in other economic indicators that influence financial asset returns, including interest rates, money supply, inflation and foreign direct investment. Additionally, since securitized real estate is a component part of stock market in many countries, the underlying stock market co-movement could also influence the correlation of the two corresponding securitized real estate markets due to the influence of some common factors (Liow et al, 2009). From the convergence perspective, economic theory suggests since key macroeconomic variables can influence real estate market performance, thus whether the two real estate securities markets will converge (diverge) over time might also depend on the extent to which these macroeconomic variables in the two countries have converged (diverged). For example, the stronger the bilateral trade links between two countries, the higher the degree of co-movement should be between their stock/real estate securities markets. Second, "contagion" theory defines that part of the market correlations that cannot be explained by economic fundamentals; but instead is likely due to crisis. For example, the average level of stock market correlation was generally much higher during the recent global financial crisis (GFC) compare to the pre-crisis period. Third, stock market theory recognizes some specific industry characteristics influence the extent of market interdependence such as market size, market volatility and industrial similarity. In general, the extent of industrial similarity between the two stock markets increases the extent of their co-movement.

Guided by these three theories, some possible fundamental economic factors which could influence expected returns in a national stock/real estate securities market have emerged from prior studies (Chen et al, 1986; McCue and Kling, 1994; Brooks and Tsolacos, 1999). The first set includes real gross domestic product growth, actual inflation, real interest rates and term structure premium. These variables represent different aspects of a country‘s macroeconomic performance which are able to affect expected cash flow and/or discount rates in that national market and thus have a significant bearing on the market's expected returns (Bracker and Koch, 1999). Over time, if there is greater divergence in the macroeconomic behavior across countries, then the absolute value of the macroeconomic performance differential is expected to be negatively with the extent of their stock /real estate stock market correlations. Accordingly, smaller divergence in the macroeconomic behavior across economies should lead to greater correlation across stock/real estate securities markets; thus implying negative coefficients for the four macroeconomic differential factors.

The second set includes other potential macroeconomic factors that may directly influence international stock/ real estate equity correlations. First, bilateral trade conditions can impact national stock returns for two trading partners and is expected to explain some of the correlation or co-movement between their stock markets. For example, Bracker and Koch (1999) use "trade" and "trade gap" variables to proxy for bilateral trade conditions. In this study, I use a bilateral trades as the sum of total bilateral trade as percentage of GDP in market i and total bilateral trade as percentage of GDP in market j. Second, bilateral exchange rate returns may influence bilateral trade/investment conditions and thus national equity and real estate equity returns. A potential negative influence on the correlation is expected. Third, the variance of bilateral exchange rate is a possible source of volatility which may dampen economic and stock market integration. Fourth, money supply is a relevant economic force that can impact stock return and stock market integration due to its possible impact on portfolio rebalancing or increased inflation uncertainty (Bodurtha et al, 1989).

Regarding the industry-specific characteristics, economic theory suggests there are at least two stock market forces that could potentially influence the extent of market co-movements. First, due to the asymmetric behavior of the correlation structure, the return on a world market portfolio may display a negative relationship with the stock market correlation structure over time. Second since real estate securities markets' correlations are significantly and positively linked to stock markets' correlations (correlation dependence), the stock market correlation variable can be a theoretical proxy for the underlying cross-stock market integration.[4]

The second set of industry-specific variables consists of some "real estate" variables. Economic theory suggests the likely candidates could include: real estate securities market size differential, real estate securities market volatility differential, underlying direct real estate market return performance differential, REIT influence

---

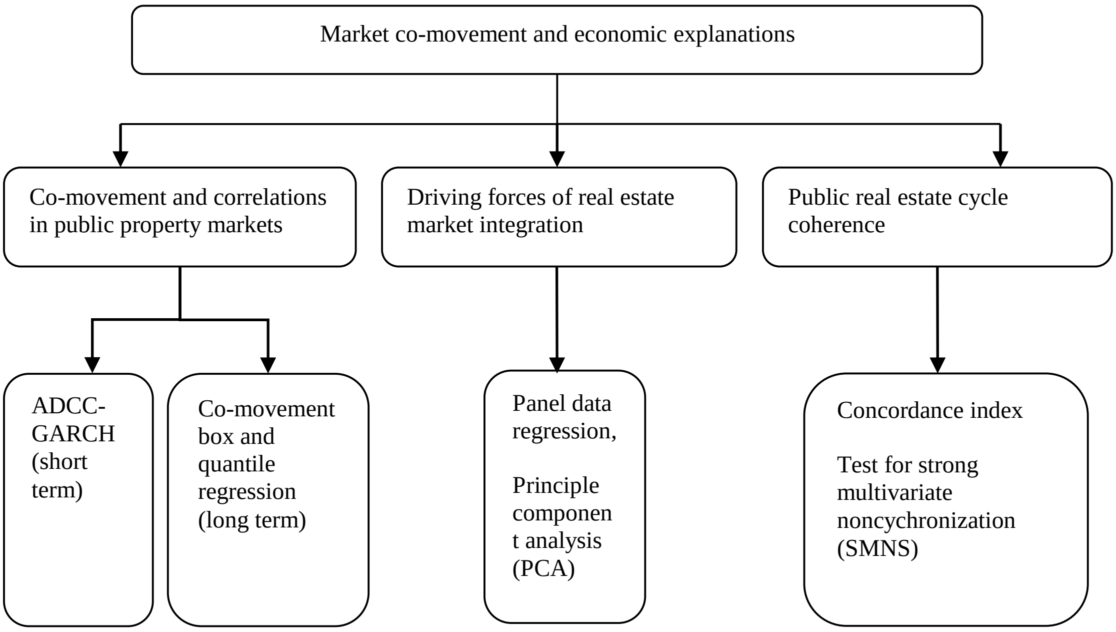
[4] In this real estate securities market research, this "stock market correlation" factor is considered as an independent (explanatory) variable; in contrast this variable was treated as the dependent variable in stock market studies.

and global real estate securities market volatility. First, the size of a national real estate securities market (relative to its GDP) may indicate its growth, maturity and importance of the real estate securities market in the national economy. Moreover, the relative size of a national real estate securities market could affect its return performance due to differential information, transaction costs and trading liquidity. Hence two national real estate securities markets with a small size disparity may imply smaller differences in market microstructure and may thus be more correlated, thereby implying a negative coefficient for the size factor. Second, the return of a real estate securities market is a function of its volatility. Thus two markets with the same volatility should receive the same returns. Accordingly, their share prices should converge (diverge) if market volatilities converge (diverge). Third, cross real estate securities market correlations could also be affected by the domestic real estate market's performance because real estate firms have a fundamental asset: real estate. This argument justifies a "direct real estate" factor to proxy for the real estate market performance in each economy. Because there is lack of a reliable direct real estate performance benchmark in many economies, an orthogonal real estate securities return factor is derived. Specifically, by regressing each economy's real estate securities returns against the stock market's returns, I estimate an "unsecuritized" or "direct" real estate return factor which is statistically independent of the underlying stock market effects since it has now been purged of their contemporaneous general stock market influences. This orthogonal approach was also used by McCue and Kling (1994). In the present context, the absolute value of the direct real estate market return performance differential between the two economies should be negatively correlated with their real estate securities market correlations. Fourth, the development of REIT–like vehicles is a unique feature of securitized real estate markets in many countries during the last two decades. In particular, several developed stock markets such as Japan, Singapore, France, Hong Kong and the UK established a REIT market structure at different points in time since

2001, and promoted greater real estate securitization level in these stock markets. Accordingly it is possible that two real estate securities markets may be more interdependent due to the co-existence of a REIT influence in the corresponding two stock markets at a given point. Thus the correlation between two real estate securities markets that have a REIT structure during quarter t may be higher than that of two markets that behave otherwise. As the establishment of REIT structure in many economies is still relatively new, its real impact on the securitized real estate market integration is not clear and still remains an unknown question. Finally, world market volatility is an important determinant of correlations across national markets (Longin and Solnik, 1995). Higher volatility of global real estate securities portfolio may force international real estate investors to demand higher rates of returns that could result in higher correlations across different pairs of national real estate securities markets.

1.4 Research Design

This section will provide an overall review about the linkage among following chapters and briefly introduce the methodology that this study uses to achieve the research objectives, the detail of methodology will be elaborated in Chapter 3, 4 and 5.



To achieve the goal of measuring the dynamic interdependence level among listed property markets and seeking economic, financial and real estate explanations for it, the thesis contains two main parts. The first part is to examine the level of interdependence from both co-movement and co-cyclical perspectives. The dynamic interdependent level that I access from the first part will then be used in second part as independent variable, while macroeconomic, financial and real estate factors are dependent variables to explain the dynamic changes of independence.

Measurement of interdependence in literature usually uses correlation as a proxy and traditional mean-variance relationship is proposed to measure the effectiveness of real estate assets in a portfolio. However, as pointed by Forbes and Rigobon (2002), the conventional correlation test will be biased upward during a crisis when stock market volatility increases due to heteroscedasticity in asset returns. Thus, both ADCC-GARCH model and a co-movement box method are introduced in this thesis to examine the relationship of international real estate securities.

Firstly, Asymmetric Dynamic Conditional Correlation (ADCC)-GARCH model of Cappiellio, Engle and Sheppard (2006) can be used to estimate high frequency conditional correlation value for daily property returns after taking asymmetric effect of financial data into account. Thus ADCC-GARCH model can enable investors to understand the short term dynamic changes between different financial markets. Then I used the quantile based co-movement box to examine the interdependence over a long-term period. The co-movement box measures the possibilities of two series are above (below) their conditional quantiles at the same time and it does not need to rely on any assumptions of data distribution. It can represent the long-term relationship because the interdependent level is estimated for each quantile of data for a long period of time. Both ADCC-GARCH model and co-movement box are robust to heteroskedasticity and are complementary for each other.

The time-varying conditional correlations estimated from ADCC-GARCH model are then used in the study of economic, financial and real estate driving forces. Only time series from ADCC-GARCH model is used because the required data frequency needs to be more than quarterly in this study. The research strategy is as followed. Firstly, the conditional correlations is regressed on five selected real estate variables, macroeconomic, stock market, institutional quality and crisis dummy variables using pooled cross-section time series regression with random effect, feasible generalized least square (FGLS) and a dynamic generalized method of moment (GMM). Secondly, principle component analysis (PCA) is employed to identify dominant "real estate" and other "control" variables form independent variables. The importance of real estate factors is further addressed in stepwise regressions by using principle components derived from PCA. Unconditional correlations are also used as a robustness check.

After examining the co-movement relationship and explanations for dynamic interdependence, the co-cyclical behavior among international listed property markets is studied by using both concordance index and a test for strong multivariate noncychronization (SMNS). These two methods are applied to cycles that identified by turning points and expressed by two phases – expansion phase and contraction phase. Concordance index is used to measure the degree of bilateral cycle's synchronization. The SMNS test is based on generalized method of moments (GMM) approach and is further extended by Candelon et al (2008) based on the work of Harding and Pagan (2006). The SMNS is a multivariate test whose null hypothesis is two or more cycles have a common cycle among them. At last, using the common cycle value derived from rolling SMNS, the linkage of public real estate cycles coherence with business cycles synchronization is examined by panel regression with random effect, FGLS and GMM.

1.5 Significance of the Research

This study has conducted an overall examination about the interdependence relationship among GC and other mature public real estate markets and has detected the real estate industry, the macroeconomic and financial explanations for this relationship. This study makes several contributions to the public real estate market literature. First, this study enhances the understanding of international indirect real estate investment literature by examining both the dynamic interdependence relationship of returns and the co-cyclical behavior of prices. Second, with virtually no published real estate study covering the GC market, this study provides a comprehensive analysis of the relationship of the GC securitized real estate market and their fundamental economic indicators over a relatively long period. Third, this study complements the awareness of the explanation of the dynamic changes of the interdependence relationship in the securitized real estate market.

More specifically, the significance for each chapter is as follows. The study of the long term and short term interdependence of the international real estate markets (Chapter

3) is hoped to provide a new angle for this topic by adopting the co-movement box method to observe the different levels of the tail dependence among these securitized real estate markets and the different changes of the tail dependence, caused by the financial crisis. The short term relationship is examined by the ADCC-GARCH model.

The study of the determinants of the dynamic interdependence relationship (Chapter 4) was cast into a wider net in terms of the state variables in the study of the correlation determinants. In addition to some usual macroeconomic and common stock market state variables, which are considered to be the “control” variables in the previous study, five “real estate” state variables are included to assess whether or not they are significant and the extent of their importance in explaining the across-market real estate securities return correlations. Panel random effects, the feasible GLS estimators and the Arellano-Bond dynamic GMM are all used to examine the significance of these determinants, proving the validity of this model. At the last, the importance of the real estate state variables is addressed by the PCA (principle component analysis).

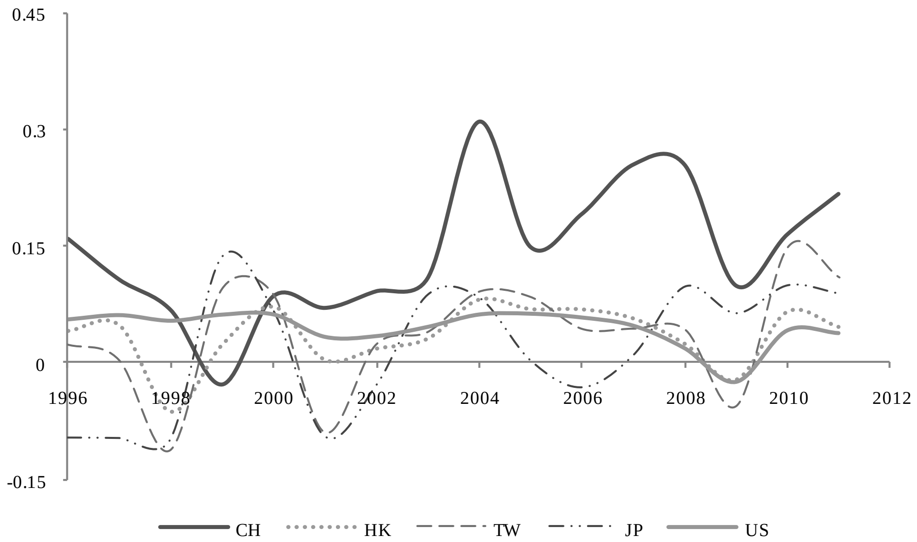
The co-cyclical behavior of the GC securitized real estate market and of the other mature real estate market (chapter 5) provide a new methodology in the real estate literature by adopting the “common” synchronization index and by using a test for strong multivariate non-synchronization (SMNS). The empirical result is also hoped to shed some light on the possible explanation of the public real estate cycle coherence.

1.6 Greater China Market Review

The China mainland, Hong Kong and Taiwan have a long history of a close relationship in all aspects of geography, politics and trade. In general, all the three markets are closely related in physical distance and have dramatic economic growth recently. They have been considered as the Chinese economic area (CEA), this rising entity cannot be ignored because their combined GDP may be at par with that of the US and Western Europe in the early 21st century (Peng et al, 2001).As can be seen from Figure 1

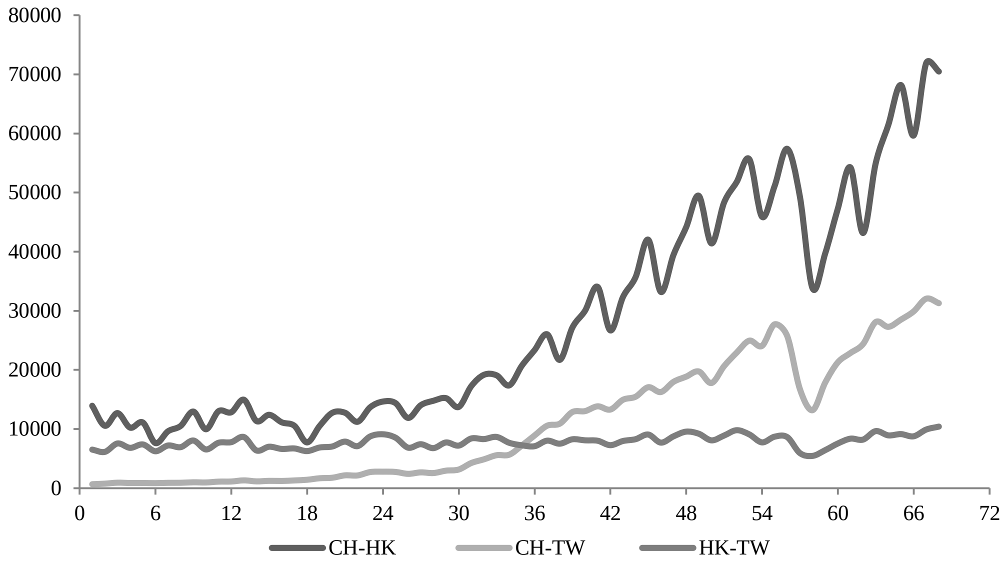
(Annual GDP (nominal) Growth Rate for GC Market and Japan, US from 1996 to 2011) , Even after taking exchange rate effect off, the growth rate of GDP in mainland China has surpassed most major economic entities for the recent decade. The domestic economy in Taiwan also soars to a very high level in the research period and the growth rate is higher than that of US in recent years.

Figure 1. Annual GDP (nominal) Growth Rate for GC Market and Japan, US from 1996 to 2011 (million USD).



The Chinese government regained sovereignty over Hong Kong since 1997 while the China mainland and Taiwan have signed a series of agreement to encourage economic cooperation between the two markets. Hong Kong joined the WTO (world trade organization) in 1995 after about 5 years. The China mainland and Taiwan became members of the WTO in succession. Then the trade amount among the three markets and with the rest of the world has increased year by year (see Fig 2). Until the third quarter of 2011, the amount of total exports and imports among the three markets have reached USD350 billion while the amount of total trade of the China mainland with the US, UK, Japan, Singapore and Japan has surged to USD750 billion. Therefore, the CEA has become too big to ignore as a fast growing integrated economic entity in the world market. However, not much of the literature focuses on the GC markets in both the economic and financial literature.

Figure 2 Total trade values among China mainland, Taiwan and Hong Kong from 1994q4-2011q3



For the Chinese financial market, the Current Account and the exchange rate were under strict policy regulation. For instance, only qualified foreign investors can invest in the Chinese financial market and that the exchange rate was subject to a fixed rate system. Recently, the regulation on foreign direct investment (FDI) has been more and more relaxed. FDI is one of the most important measurements of financial openness of one country and with the FDI increasing in inflow and outflow wise. Such a trend indicates a stronger financial linkage with the rest of the world. FDI to the real estate sector reflects the degree of openness of the national real estate markets. That is, a large amount of FDI to real estate would make the national real estate markets more reliant on foreign investment, which also means being more vulnerable to changes in international capital flow. Usually, international capital would flow to the more profitable markets, where abnormal return is attainable.

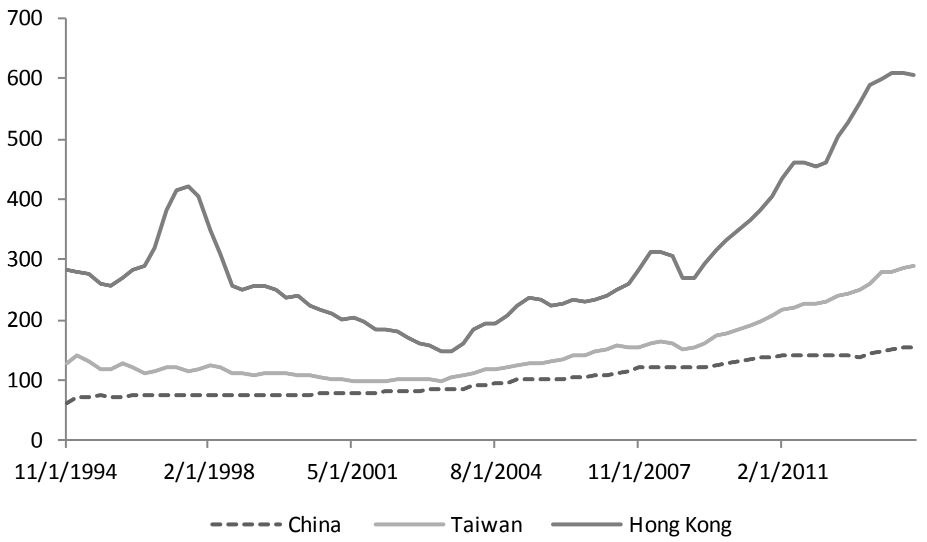
As can be seen from Table 1 (FDI on Real Estate Sector from 2004 to 2010 (Million US Dollar) that during years 2004 to 2010, FDI to real estate of the China mainland and Hong Kong has increased steadily, owing mainly to higher returns there and to the increasingly lenient policy of the Chinese financial market. FDI to the China mainland in 2010 is almost 4 times than that in 2004 while the FDI in 2010 to Hong Kong is about three times than that in 2004. Taiwan, as one of the emerging markets, has also doubled the amount of FDI in 2010 from 2004. Meanwhile, all the developed countries including the United States, United Kingdom, The Netherlands, Germany and Japan have shown relatively weak FDI growth to the real estate markets during the 7 years, and with even some negative values appearing for Japan, Netherlands, UK and the US. Especially, during the global financial crisis in the period between 2007 and 2008, the FDI to real estate for the GC markets has shown an increasing trend, while the US and Japan has suffered from a sudden drop of foreign capital investment. We can see that as one of the emerging economy entities, the GC real estate market has drawn much attention from global investors, especially during the global crisis. Besides, huge FDI flows to the China mainland and to the Hong Kong real estate markets could even exceed the total sum for the rest of the important real estate markets, as observed in Table 1.

Table 1FDI on Real Estate Sector from 2004 to 2010 (Million US Dollar)

	China mainland	Hong Kong	Taiwan	Australia	Japan	Germany	Netherlands	UK	US
2004	5950.2	250200	74.6	245.7	211.7	1180.3	818.7	1736.9	1042.0
2005	5418.1	305900	106.4	1256.1	-18.2	1149.6	944.6	1236.1	666.0
2006	8229.5	482100	53.6	899.2	70.5	2136.3	-4320.3	-369.9	1467.0
2007	17088.7	856300	62.2	1025.8	1440.2	5149.9	-1107.5	-590.4	3885.0
2008	18590.0	540000	135.1	795.0	576.5	2717.8	87.7	327.8	-1480.0
2009	16796.2	609600	251.5	1089.5	-63.1	1122.5	1253.1	229.2	4324.0
2010	23985.6	720500	136.1	4060.7	226.8	866.2	568.2	463.4	-249.0

Along with the increasing in foreign direct investment on real estate, Chinese real estate market has experienced highly growth rate over the last 20 years, has a national wide growth rate of 147.4% from fourth quarter of 1994 to fourth quarter of 2013.Started in first tier city like Shanghai and Beijing, now the booming in real estate sector has extended to the third tier city. The real estate market in Taiwan also increased a lot over the past ten years, so does the Hong Kong market. The housing market in Hong Kong dropped greatly after reunification in 1997, but the price reached to a much higher level at the end of 2013 than that of 1997.

Figure 3 Real Estate Price Index in Mainland China, Taiwan and Hong Kong from 1995-2013



Source: Oxford Economics

For the stock market in GC area, Shanghai and Shenzhen opened stock exchange trading in 1990 and 1991, and GC market including Shanghai, Shenzhen, Hong Kong and Taiwan stock exchange has boomed ever since. For example, the total trading values of the year 1997 for the Taiwan stock was 1310.2billion USD, 453.6 billion USD for Hong Kong stock exchange and 353.2 billion for mainland change stock markets. At the same time, the trading values for Korea, Singapore and Thailand stock markets were 170.7 billion USD, 74.1 billion USD and 28.8 billion USD respectively. Especially for mainland China and Taiwan exchange market, high turnover rate and PE ratio are their features. At end of 2014, a new policy called Stock Connection has helped to build a link between Shanghai stock exchange and Hong Kong stock exchange. A greater codependence relationship would be expected between the two markets. The securitized real estate market in the GC area is also of a great size. In total, 359 real estate securities are active in 2014 and 96 of them have a market capitalization over USD1 billion. The China mainland and the Hong Kong securitized real estate markets are much larger than the Taiwan market. Over half of the listed property companies in China have a market cap over USD500 million. More and more Chinese enterprises have sought listings on the Hong Kong stock exchange, so does some Taiwan firms. For 177 property companies in China, as shown in Table 2 (Number of Real Estate Securities in GC Market),about 37 of 177 are listed on the Hong Kong stock exchange and about 3 are listed on the Singapore stock exchange. About 4 of the 142 Hong Kong real estate companies are traded on the Singapore stock exchange.

Table 2 Number of Real Estate Securities in GC Market

market	total number of property company stocks	number of property company stocks	
		>$1 billion	>$500million
China	177	50	109
Hong Kong	142	42	54
Taiwan	40	4	12
Total	359	96	175

Source: Bloomberg

For the three members in Greater China market, both bilateral trade and foreign direct investment on real estate increases a lot during research period. Along with the increasing international investment, the house price in the three markets also increases for a quite long period. During this period, the size of real estate securitization also enlarged in the three markets and cross listing exists in the three listed property markets.

1.7 Thesis Organization

The remaining part of this thesis proceeds as follows. Chapter 2 provides the related literature review for the whole story and a review of the GC market. The long term and short term interdependence relationships of the GC securitized real estate market and the other mature real estate market is examined in Chapter 3. Chapter 4 includes the study of the determinants for the interdependence relationship examined in the previous chapter. Chapter 5 examines the relationship of the co-cyclical behavior among the GC market and the other mature real estate market as well as the linkage with the business co-cyclical relationship. Chapter 6 concludes the thesis, provides the limitations of this study and suggests future research.

Chapter 2: Literature review

This chapter will provide an in-depth literature review on the issues about international real estate investment. Section 2.1 discusses the current studies and techniques on direct and indirect real estate investment. The topic covers the correlations among real estate returns and co-cyclical behavior in international real estate market. Section 2.2 then reviews the existing research methodology for diversification strategy, which supports the differences of this study to others. Section 2.3 further discusses the relationships between macroeconomics and real estate market, providing a theoretical reference for this study. Section 2.4 briefly covers current relevant studies in GC markets. Section 2.5 provides a description of the research samples and some preliminary examination on the relationships among research samples.

2.1 International Real Estate Investments

This study is closely related to the international real estate investment issue, involving the direct or indirect real estate indices, and a large body of the literature has examined this area. Summarized by Sirmans and Worzala (2003), the majority of studies on international real estate investments adopt the traditional mean-variance portfolio analysis and they have found that the international real estate markets are not perfectly correlated but that the degree of similarity varies, depending on the countries studied. For example, using indirect real estate returns, Liu and Mei (1997) found that investing on international real estate related securities would provide additional diversification benefits over that associated with international stock markets. Accordingly, property share returns were found to be unstable for certain period (Eichholtz, 1996) and Asian-pacific markets offered better opportunities of diversification for international investors (Eichholtz et al, 1998). Overall, the results indicate that the international diversification strategy of the real estate market is still beneficial to the portfolio manager. Prior studies have met problems with limited data resources and a shorter time span, while later studies with the longer data period and with wider sample ranges, have applied a variety of advanced techniques to address this issue. For example, Ling and Naranjo (2002) estimated real estate monthly returns from 28 countries over 15 years via adopting the factor model. They found that real estate securities may still provide international diversification opportunities. Similarly, using monthly securitized real estate data from 238 constituent companies, Bond et al (2003) found the country-specific market risk factor to be highly significant, especially for real estate indices in the Asia-Pacific markets, and implying a higher diversification benefit in this area. Furthermore, by combining factor analysis and the canonical correlation, Liow and Webb (2009) have compared the linkage of the US, UK, Singapore and Hong Kong securitized real estate markets with their economies. They have concluded that the potential for portfolio diversification in the international securitized real estate remains good. Considering the effect of volatility on high frequency data, Michayluk *et al*. (2006) adopted the Asymmetric GARCH model and the daily REITs returns of the US and UK market, attesting to the asymmetric influences from the US market to the UK market. Since international equity market correlations show a strong possibility of being time-varying, while Cotter and Stevenson (2006) and Liow *et al*. (2009) adopt the VAR-GARCH (in full name please) model and the DCC-GJR-GARCH (in full name please) model respectively. They have found that the conditional correlation returns are still lower than those in the broader common stock market, indicating a better chance of the diversification of real estate securities than equities.

Though a large body of the existing literature have investigated the international investment diversification issue using real estate returns and their correlations. Less of the literature on the ICAMP and GARCH models have studied the co-cyclical patterns of the global public real estate markets, except for the studies by Wilson and Okunev (1999) and the Liow (2007). This might be owing to the traditional thought, originating from FAMA (1965), that the common stock price has a random walk and that the price has no cyclical pattern. However, as for the securitized real estate market, its value would reflect the underlying property market situation. Research studies also prove that the pricing behavior is relatively strongly transmitted from the indirect to the direct property markets with varying time lags and indirect correlations between the direct real estate markets in Asia (Kallberg *et al*., 2002). Therefore, it can be expected that the cyclical pattern of the direct real estate market would reflect the indirect real estate market. Not like Wilson and Okunev (1999) and Liow (2007) that adopt spectral analysis to identify the cycles and co-cycles between the de-trended securitized real estate market returns, Harding and Pagan (2006) have developed a method to measure and test for the synchronization based on classical cycles. Spectral density analysis is built on the transition component of a continuous random variable, Y_t, although the nature of the transition component that determines the characteristics of the cycle is still not the cycle itself. Adopting the classic "turning points" cycle identification, they have derived a GMM (in full name please) estimator to test the hypothesis of the multivariate non-synchronization (SMNS) for the industrial production index and the common stock index. However, because the hypothesis of Harding and Pagan (2006) is quite strict of being either perfectly synchronized or perfectly non-synchronized, Candelon *et al.* (2009) have a more relaxed null hypothesis – from SMNS to the strong multivariate synchronization (SMS) of order, ρ_0. The degree ρ_0 of a strong multivariate synchronization is estimated by the GMM based procedure. A blocked bootstrapped version of test statistics is deployed to fix the small sample distortion that exist in this multivariate test. Applying this technique together with a structural break to five Asian common stock markets, Candelon *et al*. (2008) have detected an increase in synchronization, mainly after the Asian crisis and they have argued that the common stock market cycles and their propensity towards synchronization do contain useful information for investors, policy makers and financial regulators.

2.2 Measurement of Financial Market Interdependence

The most traditional measurement for interdependence relationship among different stock markets is conventional correlation study. International financial market interdependence would increase along with increasing correlations over time. This strand can be traced back to Panton, Lessig and Joy (1976) who found stability in the relationship of international financial market. Using data with longer period, more recent researches found instability in the relationship (e.g., Fischer and Palasvirta, 1990; Longin and Solnik, 1995). These authors show that correlations has grown since 1960s which leads to smaller diversification benefits. However, as stated by Forbes and Rigobon (2002), the conventional conditional correlation test will be biased upward during a crisis when stock market volatility increases due to heteroscedasticity in asset returns. Accordingly, Goetzmann et al. (2005) study stock market correlations using 150 years of data and find that the average correlations is higher during world war II. And this increase is caused by high volatility instead of increasing codependence.

Another trend of studying interdependence relationship is cointegration test. Cointegration test has been evolved from Engle and Granger method to more sophisticated Johansen cointegration test. Usually, this kind of cointegration test can only test cointegration relationship bilaterally. Recently, researchers are more prone to detect multiple cointegration relationships. For example, Gilmore and McManus (2002) found evidence of multiple integration relationship for U.S. with central European markets.

However, almost all the above techniques can only detect a relatively fixed integration process. A more recent developed method being used is expected to apply to dynamic process of financial integrations, because the interdependence relationship would vary in different time periods, especially during financial crisis time. A variety of measurements have been employed for this dynamic problem. One strand of this kind of research is to use an ARCH or GARCH framework to estimate the variance-covariance transmission mechanisms between countries. This kind of method would also be used to test the transmission of volatility. For example, Edwards (1998) examines the linkages between bond markets after the Mexican peso crisis and show that there were significant spillovers from Mexico to Argentina. Other kind of researches can also been used to detect dynamic integration facts, such as Aggarwal, Lucey and Muckley (2003) use dynamic cointegration methodologies and find that there has been a significant increase in integration among European area.

As pointed by Bekaert and Harvey (1995), the risk premium on equities is time-varying indeed. So the dynamic price-based integration test would be superior to static integration test. In this research, I would use a new developed time-varying model – the bilateral co-movement box which provides a long term average of the co-movements between any two financial market returns across two distinct sub-periods. The method proposed by Cappiello, Gérard and Manganelli (2005) has two advantages compared with other tools to analysis the integrations: (a) Contrary to standard correlation measures, it is robust to time varying volatility and departure from normality. (b) It offers a simple and intuitive visual measure of integration. Following this method, Cappiello, Gérard and Manganelli (2006) find that the degree of integration of the new EU member states with the euro zone has increased in their process towards EU accessions. Besides, the global factor significantly increases co-movements.

2.3 Relationships between Fundamental Economics and the Securitized Real Estate Market

A number of common stock market papers have investigated the relationships between fundamental economic factors and common stock market correlations. Chan and Zhang (1997) find that the common stock market co-movement is correlated positively with the extent of trade with the explanatory power of trade ranging between 5% and 40% of the variation in the correlation, depending on the measure of the correlation used. Bracker and Koch (1999) find that the degree of common stock market interdependence, as measured by the magnitude of correlation, is a positive function of market volatility and a trend as well as a negative function of the exchange rate volatility, the term structure differential, real interest rate differential and the return on the world market index. In another study, Bracker *et al.* (1999) specify a set of macroeconomic variables that characterize and influence the degree of co-movement for each pair of common stock markets (US and eight other developed countries' stock markets) via adopting a pooled time series regression model. Their significant factors include bilateral trade dependence, real interest rate differential, market size differential and a time trend. Using co-movement box with quantile regression methodology developed by Cappiello et al. (2005), Beine et al (2010) found that financial liberalization increases co-movement for seventeen mostly developed countries and this effect is much stronger for left tails (extreme negative returns). Also lower exchange rate volatility increase the likeliness of a joint crash in all markets. A recent paper by Walti (2011) focuses on the monetary integration within a European context that affect the bilateral correlations across 15 mature common stock markets between 1975 and 2006. Walti finds that both monetary and trade integration have contributed to increasing the common stock market correlations. Similarly, Pretorious (2002) has pointed out that institutional investors need to understand the forces behind the common stock market interdependence in emerging countries because such driving forces are still largely unexplored in the case of the emerging common stock markets. Pretorious (2002) and in citing Bekaert and Harvey (1997), recognize that "*it might be completely different factors that drive integration in emerging stock markets since it is well known that equities from emerging markets have vastly different characteristics than equities from developed markets* ". Using a sample of 10 emerging common stock markets from the

Emerging market Database (EMDB) from 1995Q1 through to 2000Q4, Pretorious (2002) finds only two factors (i.e. bilateral trade and the industrial production growth differential) to be significant in explaining the bilateral correlations on a cross-sectional basis. Finally, using daily data on the common stock returns of 25 emerging markets to compute an annual estimate of the cross-country realized correlation, Beine and Candelon (2011) have established the importance of trade and financial liberalization in increasing the common stock market co-movement annually over the 1990-2004 period.

While the academic real estate literature has explored the inter-relationship between and among real estate market returns across national boundaries (e.g. Guerts and Jaffe, 1996; Ling and Naranjo, 1997; Hoesli *et al.* 2004) as well as the time-varying correlation and volatility dynamics of the securitized real estate markets (e.g. Michayluk *et al*, 2006; Cotter and Stevenson, 2006; Liow et al, 2009; Case et al. 2011), there is still inadequate research in examining the main determinants of real estate returns/correlations from the macroeconomic/international economic perspective. Some notable exceptions include the studies by McCue and Kling (1994), Brooks and Tscolacos (1999), Ling and Naranjo (1997) and Bardhan *et al.* (2008). McCue and Kling (1994) have examined the relationship between real estate returns to some pre-specified macroeconomic shocks using a transformed real estate return series that exclude the common stock market effect on equity data. They have found that the selected macroeconomic variables explain about 60% of the variation in the equity REITs series and that nominal interest rates are the most significant variables. In the UK context, Brooks and Tsolacos (1999) find that unexpected inflation and the interest rate term spread have explanatory powers for the property market returns. Ling and Naranjo (1997) conclude that the growth rate in real capita consumption, the real Treasury Bill rate, the term structure of interest rates and the unexpected inflation have systematic influences on commercial real estate returns. Using a dataset of 946 firms from 16 countries from 1995 to 2002, Bardhan *et al.* (2008) examine whether or not globalization and increasing economic and financial integration have affected the rate of return of their sample of global public real estate firms. Their economic variables include real GDP growth, exchange rate change, exchange rate forward, interest rate differential and economic openness. In contrast, none of the previous real estate papers has assessed the impact of increasing globalization of financial/economic activities on the international real estate market correlation structure, although Liow and Newell (2012) have found that the average conditional correlations between the three GC real estate securities markets have outweighed their average conditional correlations with the US securitized real estate market. Their study supports closer integration between the GC markets owing to geographical proximity and closer economic links. Finally, Liow (2012) provides an analysis of some volatility measures that influence the degree of real estate securities return co-movement. He includes the relative volatility of real estate securities with the respective local, regional and global stock markets as well as the lagged correlations. However, he did not study the impact of macroeconomic and the common stock market factors as well as other real estate factors.

Despite less literature on the co-cyclical behavior of the international securitized real estate markets, several studies have examined the relationship between the real estate market cycles with the real economy cycles. Pyhrr *et al.* (1999) did a great job in reviewing the linkage of the national economy with the property market. They summarize that the domestic aggregate economic phases are closely related with the construction cycle and that they lead the dynamic changes in real estate construction. Especially and classifying REIT data from the different business cycle phases, Sagalyn (1990) have found that all real estate stocks performed best when the economy is on the upswing and performed worse when economy is on the downswing. Quigley (1999) studied endogenous relationship between real estate prices and economic fundamentals and found that local economic conditions are important determinants of the course of housing prices. More recently, Claessens *et al*. (2012) have used classic cycle identification and the concordance index to examine the relationship of the business cycles with the financial market and asset prices. Using data from 44 countries over the period 1960 to 2007, they have found that advanced countries display a higher degree of synchronization between output cycles and house prices than the emerging countries and that house prices have a higher synchronization level with output than equity markets. Hirata *et al*. (2012) used data from 18 advanced economies over the past 40 years and the concordance index together with FAVAR (full name please). They have found that the degree of house price synchronization has increased over time and that the synchronization of house prices has coincided with the degree of synchronization of the national business cycles across the advanced economies.

2.4 Greater China Studies

In the past, research on Greater China area was largely relegated to the domain of are studies. Recently, both Political and economic relationships of the GC market members are gaining much interest these days. Due to the dramatic rise of mainland China and their increased economic performance of Hong Kong, Taiwan and increasing integration with rest of the world, many researcher have found it is impossible to ignore the dynamics of Greater China. However, not so much of the literature focuses on this emerging integration group. Some analyses of Greater China markets are basically about the economy's integration and trade linkage with the China mainland, Taiwan and Hong Kong. For example, Ash and Kueh (1993) have found that the integration among the three markets would ironically have a fissiparous effect on China's domestic economy. On the contrary, Wang and Schuh (2002) have demonstrated that the three Chinese economies would benefit greatly from further integration by means of liberalizing trade policies. Poncet (2003) have compared the degree of integration between Chinese provinces with the rest of the world. He has found that the Chinese markets rely more on the country specific factor rather than the global factor. Meanwhile, more analyses are concentrated on the dynamic interdependence of the financial markets of the China mainland, Taiwan and Hong Kong.

Including the three GC markets, Kim *et al*. (2009) have studied different degrees of capital mobility and financial market integration in the East Asia region. By investigating the saving-investment relationship, they have found that huge international capital flows between major industrial countries and the East Asian economies have not really been a meaningful source of domestic investment in East Asia. Instead, the regional financial cooperation and integration are more important to this area, indicating that the East Asian markets are more integrated within the region than with the global market.

Moreover, the integration of the emerging East Asia's common stock markets including the GC market has received more attention in recent years given the relatively progressive phase of market developments and the ongoing financial liberalization in this region. However, empirical evidences in this area remain limited. Some studies examine both long-run and short-run interdependencies among the Asian financial markets and the major developed markets. In general, such studies have supported the observation that the Asian common stock market integration has gradually increased over time, in particular, during and after the Crisis periods (Hashmi and Liu 2001, Ratanapakon and Sharma 2002, and Yang et al, 2003).

However, Anders *et al.* (2009) have indicated that there is an integrated long-run relationship among the Greater China (GC) markets while some short-run spillover effects exist. Both mainland China and Hong Kong are affected by mean spillover effects from Taiwan. On the contrary, Johansson and Ljungwall (2009) have found no long-run relationship among the three GC common stock markets but that there are short-run spillover effects in both the returns and the volatility, indicating that there are significant interdependencies among the three markets. Cheng and Glascock (2005) use both GARCH and ARIMA model found that there is a week nonlinear relationship among the three markets and they are not integrated with Japan and US market. As can be seen, no consistent conclusions have been reached about the long-term trend and the short-term trend relationship among the GC equity markets.

Relatively fewer studies are concerned with the GC securitized real estate market. Extending research to the emerging securitized real estate markets including the GC markets, Liow (2008) has investigated the changes in the long-run and short-run linkages among the US, UK and the eight securitized Asian real estate markets, and he has found that the global financial crisis increases the degree of interdependence in the Asian real estate markets. Liow and Graeme (2010) have studied the volatility spillover and the correlation dynamics among the GC real estate markets via adopting the TGARCH (full name in brackets please), the VAR-BEKK-MGARCH (full name in brackets please) models and the correlations. They have found that the volatility linkages and the correlations among the GC real estate markets have outweighed those relationships with the US market, but that the cross-market volatility interactions is still lower while a higher level of spillover is found during the crisis periods. Therefore, a potential diversification opportunity between the developed and the emerging GC securitized markets still exists. However, the contagion effect owing to the crisis cannot be neglected.

2.5 Research Sample and Data

The securitized real estate markets in the GC market, five other developed markets (US, UK, Australia, Japan and Singapore) are investigated in this study. Chapter 3 and 4 include these markets' Standard & Poor's daily closing total real estate stock return indexes and stock market return indexes from 1995Q1 to 2011Q4, while both real estate and stock price index are used in chapter 5.The sample size of the data is 4434 and returns are continuously computed. The US has the world's largest real estate market, which is also the most transparent securitized real estate market. Listed real estate companies have a long history in Europe, with the UK being the largest European public real estate market. In the Asia-Pacific region, Japan as a major world economy has a long tradition of listed real estate. Together with the US, Australia is one of the two most mature public real estate markets, with its listed property trusts (LPTs) as a highly successful securitized real estate investment vehicle. Hong Kong, Singapore and Taiwan have a track record of listed real estate companies that have been playing a relatively important role in the respective stock market indexes. The REITs market in mainland China is still under construction, while listed property companies have taken more and more important role in broad equity market. To adjust for non-synchronous returns of US and UK market, the correlations of US and UK with other markets are computed with 1 day difference.

Data descriptive statistics for asset and stock data and sample characteristics are given in table 3 (Descriptive Statistics of Daily Returns on Securitized Real Estate and Stock Indices). For the listed property data, in terms of average returns, China real estate market has the highest daily average returns of 0.0002, while Taiwan has the lowest of -0.0002. The median or the value of 0.5 quantile for all the real estate markets are near zero, which implies that most negative value of returns are on left tail. Over the full period, consisting with highest average return, the emerging real estate market of China is the most volatile with a daily standard deviation at 2.54% and Australian real estate market is the most stable with a standard deviation of 1.16%. Almost all Asian real estate markets are right skewed except for Taiwan and Australia, while US and UK real estate markets are left skewed. Most data have a higher than normal kurtosis value. Especially for US market the value of kurtosis has reached 26.08, indicating a slim tall shape than normal distribution. In additional, J-B test for normality has been rejected for all the eight time series. Combined the results of skewness, Kurtosis and Jarque-Bera normality test, all the samples show a clear sign of non-normality.

Table 3 Descriptive Statistics of Daily Returns on Securitized Real Estate and Stock Indices
This table reports the summary statistics of the daily returns for the eight market indices from Jan 2, 1995 to Dec 31, 2011. Data are from the Standard & Poor database and the returns are continuously compounded. * and ** denote the 5% and 1% significance levels respectively..

	China	Hong Kong	Taiwan	Australia	Japan	Singapore	US	UK
Mean	0.000245	0.000144	-0.000196	0.000008	-0.000001	0.000017	0.000191	0.000095
Median	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00012
Maximum	0.1358	0.2149	0.1237	0.0713	0.1407	0.2579	0.171	0.0919
Minimum	-0.1266	-0.1442	-0.2538	-0.1074	-0.1202	-0.138	-0.2184	-0.1019
Std. Dev.	0.0252	0.0187	0.0214	0.0116	0.0197	0.0191	0.0179	0.0131
Skewness	0.0123	0.3138	-0.2373	-0.8495	0.1911	0.9582	-0.2401	-0.2076
Kurtosis	6.27	12.62	8.51	14.77	7.23	17.08	26.08	10.65
J-B	2048.328**	17755.85**	5847.48**	27024.73**	3446.06**	38625.13**	101934**	11235.36**
Observations	4589	4589	4589	4589	4589	4589	4589	4589

	China	Hong Kong	Taiwan	Australia	Japan	Singapore	US	UK
Mean	0.000114	0.000132	-0.000113	0.000203	-0.000155	-0.000105	0.000203	0.00011
Median	0.00040	0.00035	0.00001	0.00047	-0.000001	0.00007	0.00076	0.00046
Maximum	0.1364	0.1530	0.0842	0.0590	0.1285	0.1701	0.1075	0.0891
Minimum	-0.1238	-0.1418	-0.0952	-0.0876	-0.1011	-0.1001	-0.0975	-0.0870
Std. Dev.	0.0201	0.0155	0.0160	0.0101	0.0137	0.0142	0.0130	0.0115
Skewness	0.1921	-0.0973	-0.1030	-0.4794	-0.2241	0.3138	-0.2948	-0.1822
Kurtosis	8.54	12.65	5.25	9.39	9.10	13.14	10.23	9.17
Jarque-Bera	5416.50**	16360.87**	894.10**	7330.25**	6570.39**	18142.80**	9246.92**	6701.61**
Observations	4589	4589	4589	4589	4589	4589	4589	4589

For the stock data, US and Australia have the highest average return value of 0.000203 among all eight markets, while Japan has the lowest average return of -0.000155. All the medians of returns are positive except Japan market. Among all stock markets, as an emerging market, the stock returns in China are the most volatile as expected, followed by another emerging market - Taiwan. Contrary to real estate data, most of stock returns are left skewed and the kurtosis value is higher than normal. Besides, JB test for normality has rejected the hypothesis that the time series is normal distributed.

Combined the results of skewness, kurtosis and Jarque-Bera test, the stock returns are all rejected to be normality.

Table 4 Correlation Matrix of Daily Returns on Securitized Real Estate Indices

This table reports the unconditional correlation matrix of the eight markets during whole research period **(Jan 2, 1995 – Dec 31, 2011),** crisis time **(Jun 2, 1997- Dec 31, 1997; Jun 25, 2007 – Mar 31, 2009)** and tranquil days.

Panel A: full period

	China	Hong Kong	Taiwan	Australia	Japan	Singapore	US	UK
China	1.000	0.393	0.171	0.233	0.203	0.279	0.047	0.147
Hong Kong		1.000	0.209	0.325	0.338	0.597	0.076	0.247
Taiwan			1.000	0.138	0.186	0.184	0.023	0.121
Australia				1.000	0.290	0.268	0.021	0.245
Japan					1.000	0.300	0.008	0.191
Singapore						1.000	0.086	0.230
US							1.000	0.290
UK								1.000

Panel B: Crisis Days

	China	Hong Kong	Taiwan	Australia	Japan	Singapore	US	UK
China	1.000	0.600	0.348	0.362	0.416	0.520	0.007	0.202
Hong Kong		1.000	0.296	0.425	0.486	0.672	0.050	0.315
Taiwan			1.000	0.271	0.313	0.346	-0.015	0.180
Australia				1.000	0.458	0.428	-0.030	0.306
Japan					1.000	0.502	-0.022	0.310
Singapore						1.000	0.050	0.333
US							1.000	0.242
UK								1.000

Panel C: Tranquil Days

	China	Hong Kong	Taiwan	Australia	Japan	Singapore	US	UK
China	1.000	0.314	0.126	0.165	0.122	0.210	0.077	0.119
Hong Kong		1.000	0.188	0.271	0.276	0.578	0.100	0.210
Taiwan			1.000	0.092	0.154	0.150	0.045	0.106
Australia				1.000	0.191	0.210	0.078	0.186
Japan					1.000	0.238	0.029	0.125
Singapore						1.000	0.116	0.194
US							1.000	0.343
UK								1.000

The research periods cover two important crisis periods: June 2, 1997 to December 31, 1997 (Asian Crisis)5 and June 25, 2007 to March 31, 2009 (Sub-prime Crisis)6. The crisis sample includes 615 trading days. The unconditional correlation for full period, crisis period and tranquil period is reported in table 4 (Correlation Matrix of Daily Returns on Securitized Real Estate Indices). The correlation results show that the

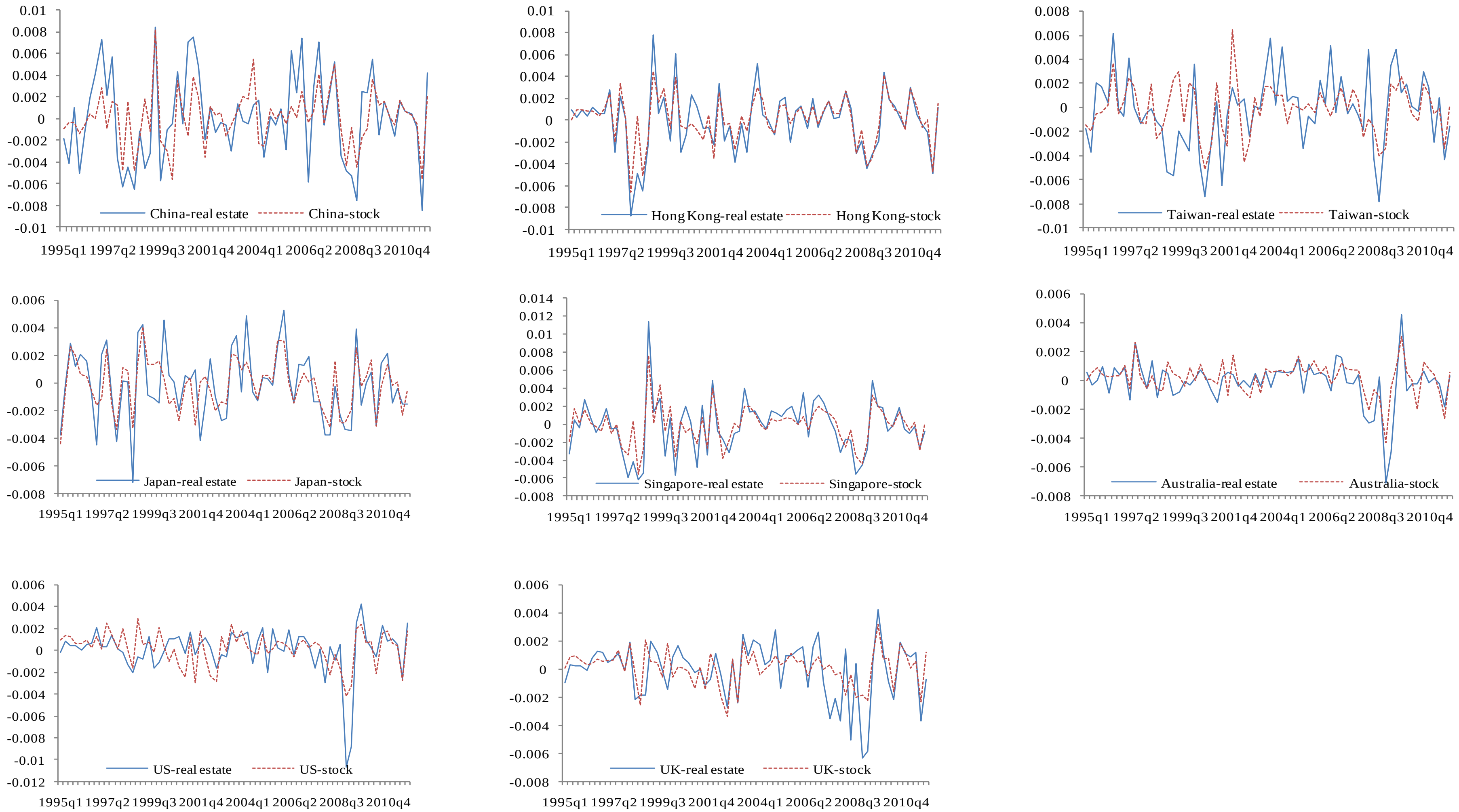
5 From definitions of Forbes and Rigobon (2002)

6 Sub-prime crisis begin with the fail of two sub-prime hedge funds of Bear Stearns, the two subprime hedge funds had lost nearly all of their value amid a rapid decline in the market for subprime mortgages.

unconditional correlation of the sample markets for the full sample period ranges from 0.098 (Taiwan and US) to 0.597 (Hong Kong and Singapore). In addition, the changes from panel B (crisis days) to panel C (tranquil days) is striking, the unconditional correlation increases greatly from on average 0.37 of crisis periods to on average 0.19 of tranquil time. Based on the results of unconditional correlation test, contagion effect among these securitized real estate markets exists.

To have a more straightforward understanding of the research samples, the stock and real estate returns are plotted for all eight markets in Figure 4 (Real Estate Securities and Stock Market Total Returns, Local Dollars). As can be seen, the trend for the two markets is similar. However, real estate markets are more volatile than stock markets. Besides, the returns drop significantly for Asian markets during 1997 Asian financial crisis and all markets decrease a lot during subprime crisis.

Figure 4 Real Estate Securities and Stock Market Total Returns, Local Dollars



Chapter 3: Long-Term and Short-Term Relationship in Securitized Real Estate Markets: A Co-Movement Perspective

3.1 Introduction

Recently, the majority equity markets in the world have linked together closely, their responses to shocks are similar because of the globalization. Consequently, global listed property markets also tend to move together and this trend would be more obvious during financial crisis. Similar to stock markets, the international co-movement of real estate securities returns is of key importance for global investors who seek to invest in a well-diversified real estate investment portfolio, particularly when international real estate securities diversification might be more effective than international stock diversification (Hartzell et al. 1996). Besides, increasing interdependence relationship would greatly encourage the risk of cross-section contagion effect.

For those above reasons, this chapter asks two research questions. Firstly, what are the codependence relationship of securitized real estate markets among the GC (Greater China) area and their relationship with other developed real estate markets in the world? Secondly, whether the contagion effect of securitized real estate markets can also be examined by comparing the comovement relationship during the crisis and tranquil period? This codependence relationship is examined using both a regression quantile-based co-movement box method (Cappiello, Gérard and Manganelli, 2005) and asymmetric dynamic conditional correlation (ADCC) GARCH model (Cappiello, Engle and Sheppard, 2006). The two methods are complementary for each other and both of them are robust to heteroskedasticity problem: The quantile based co-movement box examines the codependence over a long-term time period, while univariate ADCC-GARCH model is used to examine a short-term co-movement relationship. A lot of literature investigates codependence among financial asset returns using a variety of methods. A straight forward way is studying the correlation structure of asset indices (Panton, Lessig and Joy, 1976), however, the conventional conditional correlation test will be biased upward during a crisis when stock market volatility increases due to heteroscedasticity in asset returns (Forbes and Rigobon, 2002). A dynamic co-movement relationship can be examined by CAPM model and improved CAPM model. Furthermore, concerning with the heteroskedasticity feature of finance data, based on ARCH or GARCH framework, GARCH derivative models can be used to estimate dynamic conditional correlation series (e.g. DCC-GARCH model). Dynamic model is preferred here since the interrelationship of the financial series isn't constant all the time. However, one common feature of these methods is that their estimations are all based on the preconfigured assumption of data distribution. The co-movement box doesn't need to rely on any assumptions of data distribution and can also provide a long term dynamic result of codependence relationship of these securitized real estate markets. In practice, it's possible that no long term relationship can be detected by traditional static cointegration test, while we can still adopt co-movement box method to observe different level of tail dependence among these securitized real estate markets and different changes of tail dependence aroused by financial crisis. It is hoped that quantile based co-movement box can detect some cointegration relationship for certain quantile of sample, which static Johansen test is unable to.

By focusing on GC markets, this study is hoped to provide a new perspective of empirical methods for testing the level of codependence of emerging securitized real estate markets with developed real estate markets and contagion effect during crisis time. The empirical result of this paper indicates a closer interdependence relationship between the GC markets when compared with their co-movements with the other main securitized real estate countries both in the long run and short run. All the markets show a significance increase in left tail dependence during crisis periods, especially for China Mainland and Hong Kong markets, implying a closer linkage of both the two markets with other important markets compared with Taiwan market.

This chapter proceeds as follows. Analytical framework is introduced in Section 2. Section 2 also illustrates how to empirically apply those methods to study codependence level and financial contagion. Section 3 describes the data and discusses empirical results of the analysis.Section4 concludes.

3.2 Research Design

Chapter 3 proceeds with the analytical framework being introduced. Chapter 3.2 discusses and illustrates how to empirically apply the models that study the codependence level and the financial contagion. Chapter 3.3 discusses the data and the empirical results of the study while Chapter 3.4 concludes the study.

3.2.1 The Co-movement BoxModel

The long-term bivariate co-movement relationship is examined via adopting the co-movement box, developed by Cappiello, Gérard and Manganelli (2005). The following analytical framework measures the bilateral co-movements. The merits of the co-movement box model are that it is robust to time varying volatility and to its departure from normality. In addition, it offers a simple and intuitive visual measure of integration.

Let r_{it} and r_{jt} be the time series returns of two different asset markets. $q_{\theta_t}^{r_i}$ is the time t θ-quantile[7] of the conditional distribution of r_{it}. Define $F_t(r_i, r_j)$ as the conditional cumulative joint distribution of the two asset returns. $F_t^{-}(r_i|r_j) \equiv P_r(r_{it} \leq r_i|r_{jt} \leq r_j)$ and $F_t^{+}(r_i|r_j) \equiv P_r(r_{it} \geq r_i|r_{jt} \geq r_j)$, then the conditional probability would be like

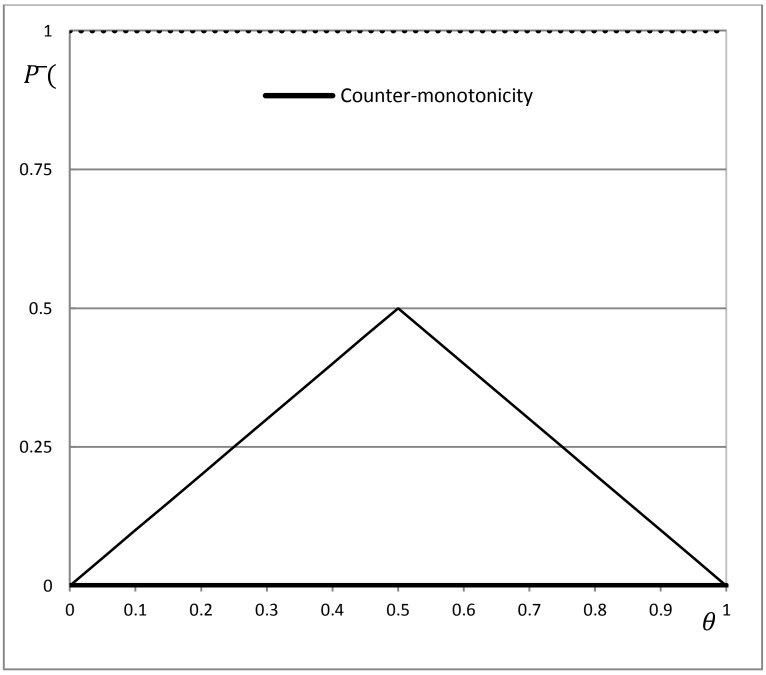
$$P_t(\theta) \equiv \begin{cases} F_t^{-}\left(q_{\theta_t}^{r_i}\middle|q_{\theta_t}^{r_j}\right) & \text{if } \theta \leq 0.5 \\ F_t^{+}\left(q_{\theta_t}^{r_i}\middle|q_{\theta_t}^{r_j}\right) & \text{if } \theta \geq 0.5 \end{cases} \quad (3.1)$$

7 Quantiles are points taken at regular intervals from the cumulative distribution function (CDF) of a random variable. Dividing ordered data into q essentially equal-sized data subsets is the motivation for q-quantiles; the quantiles are the data values marking the boundaries between consecutive subsets. Put another way, the kth q-quantile for a random variable is the value x such that the probability that the random variable will be less than x is at most k / q and the probability that the random variable will be more than x is at most (q − k) / q. There are q − 1 of the q-quantiles, one for each integer k satisfying 0 < k < q.

For each quantile θ, $P_t(\theta)$ measures the probability of the returns of markets i are below (or above) its θ quantile at time t, conditional on the same event occurring in market j. The $P_t(\theta)$ can be analyzed in co-movement box easily. The shape of $P_t(\theta)$ will depend on the joint distribution of series r_{it} and r_{jt}. Three extreme cases do not need simulations: 1. Independence. Here $\rho_{ijt} = 0$, $P_t(\theta)$ will be piece-wise linear, with slope equal to one, for $\theta \in (0,0.5)$, and slope equal to minus one, for $\theta \in (0.5,1)$. 2. Perfect positive correlation, here $\rho_{ijt} = 1$, $P_t(\theta)$ is a flat line that takes on unit value. 3. Perfect negative correlation. Here $\rho_{ijt} = -1$, $P_t(\theta)$ is always equal to zero.

Figure 5 theComovement Box

This figure plots the probability that a random variable r_{it} falls below (above) its θth-quantile conditional on another random variable r_{jt} being below (above) its θth-quantile, for θ< 0.5 ($\theta \geq$ 0.5). The case of perfect positive correlation (co-monotonicity), independence, and perfect negative correlation (counter-monotonicity) are presented.



The shape of $P_t(\theta)$ provides key insights about the dependence between two asset returns and the higher $P_t(\theta)$, the higher the codependence between the two time series returns. The shape of $P_t(\theta)$ can also be used to detect the whether this dependence has changed over time. So when a shock comes, the correlation of the two series would possibly change. It can be directly detected if the $P_t(\theta)$ of the two periods are plotted in one graph. Therefore, an upward (downward) shift of these curves would be consistent with an increase (decrease) of integration.

3.2.2 Empirical Measure of Co-Movement Box

To estimate the co-movement box empirically, the following model would be computed to access the dynamic pattern of the co-movement of two data series. In order to test for differences in the probability of co-movement based on the co-movement box, first the univariate time varying quantiles associated with the returns series of interest should be estimated, using the conditional Autoregressive Value at Risk model (CAViaR) , developed by Engle and Manganelli (2004). The CAViaR model is a method to interpret VAR as a quantile of future portfolio values conditional on current information. It does not require any of the extreme assumptions, for instances, the normality or i.i.d (identical independent distribution) returns. In addition, this method is robust to heteroscedasticity as well as to the GARCH model by considering an empirical fact that the distribution of the financial time series is correlated (autoregressive specification).

This study estimates the time-varying quantiles of the returns r_t, using the same CAViaR specification with Cappiello, Gérard and Manganelli, 2005:

$$q_t(\beta_\theta) = \beta_{\theta 0} + \beta_{\theta 1} D_t + \beta_{\theta 2} r_{t-1} + \beta_{\theta 3} q_{t-1}(\beta_\theta) - \beta_{\theta 2}\beta_{\theta 3} r_{t-2} + \beta_{\theta 4}|r_{t-1}|. \quad (3.2)$$

, where$q_t(\beta_\theta)$ denotes the time t, with θth quantile being the distribution of portfolio returns formed at time t-1 while $q_{t-1}(\beta_\theta)$is its lagged value (autoregressive factor). Here, $q_t(\beta_\theta)$ is expressed as a function of parameter β and series return, r_t. The r_{t-1} is the actual returns of the financial asset at time t-1. This CAViaR model would be correctly specified if the true DGP were as follows:

$$r_t = \alpha_0 + \alpha_1 r_{t-1} + \varepsilon_t \varepsilon_t \sim \text{i.i.d.}(0, \sigma_t^2), \quad (3.3)$$

$$\sigma_t = \gamma_0 + \gamma_1 D_t + \gamma_2 |r_{t-1}| + \gamma_3 \sigma_{t-1}.$$

The time dummy D_t is added to the CAViaR specification to ensure that we have exactly the same proportion of quantile exceedances in both the tranquil and crisis periods. For each of the securitized real estate markets, the dynamic quantile is estimated using model (2) for 19 quantile probabilities from 0.05 to 0.95.

Secondly, construct the indicator functions I(·) for each series and quantile, which are equal to one if the observed return is lower than this quantile and zero otherwise and at the last, then regress the θ-quantile indicator variable of returns on market j on the θ-quantile indicator variable of returns on market i, that interact with the time dummies that identify the periods of greater integration. Then these regression coefficients would be a direct measure of conditional probabilities of co-movements and of their changes across regimes.

Using the following regression the average conditional probability $P_t(\theta)$ can be estimated:

$$I_t^{r_i r_j}(\beta_\theta) = \alpha_{\theta,1} + \alpha_{\theta,2} D_t^T + \eta_t \tag{3.4}$$

, where $I_t^{r_i r_j}(\beta_\theta) \equiv I\left(r_{it} \leq q_t^{r_i}\left(\beta_{\theta r_i}\right)\right). I\left(r_{it} \leq q_t^{r_i}\left(\beta_{\theta r_i}\right)\right)$ for each θ-quantile, and for $\theta \in (0,1)$, $q_t^{r_i}\left(\beta_{\theta r_i}\right)$ and $q_t^{r_j}\left(\beta_{\theta r_j}\right)$ denote the estimated quantiles while D_t^T is the dummy for the test period.

And the estimators of the variables are shown to be asymptotically consistent with the estimators of the average conditional probability $P(\theta)$ in the two periods:

$$\alpha_{\theta,1} \xrightarrow{p} E[P_t(\theta)|\text{period B}] \equiv P^B(\theta), \tag{3.5}$$

$$\alpha_{\theta,1} + \alpha_{\theta,2} \xrightarrow{p} E[P_t(\theta)|\text{period A}] \equiv P^A(\theta), \tag{3.6}$$

So testing for the shift in cointegration from period B to period A is equal to estimating whether or not $\alpha_{\theta,2}$ is significant from zero. If $\alpha_{\theta,2}$ equal to zero, then the two conditional probabilities coincide. If $\alpha_{\theta,2}$ is greater than zero, then the conditional probability during the test period would be higher than the conditional probability during the benchmark period.

Therefore, integration would increase when a shock or crisis comes, and then the following condition must be satisfied:

$$\varepsilon(0,1) = \int_0^1 \left[P^A(\theta) - P^B(\theta)\right] d\theta > 0 \qquad (3.7)$$

3.2.3 The ADCC-GARCH Model

First, the bivariate short term evolution of the co-movement between the eight securitized real estate markets would be examined by the ADCC-GARCH model. In the DCC-GARCH (full name please) model, the covariance matrix Ht can be decomposed as Ht=DtPtDt. Dt is estimated from the univariate GARCH model, which is a diagonal matrix containing the conditional standard deviations relative to the asset returns. Pt is the time-varying correlation matrix with ones on the main diagonal and on every other off-diagonal elements less than or equal to one in absolute value.

Following Liow et al. (2009), this ADCC-GJR(Glosten-Jagannathan-Runkle)-GARCH model is estimated in a three-step procedure. In the first step, the univariate GJR(1)-GARCH(1,1) model is estimated for each return series. The residual ε_t generated from first step is transformed to estimate the conditional correlation structure in step two. In the second step, the bilateral conditional correlation matrix would be calculated as: $P_t = E(\varepsilon_t \varepsilon_t' | \tilde{\mathcal{S}}_{t-1})$. Correlation structure is given as $p_t = diag\{Q_t\}^{-\frac{1}{2}} Q_t\, diag\{Q_t\}^{-\frac{1}{2}}$ in the DCC model of Engle (2002), where$diag\{Q_t\}$is a diagonal matrix and $Q_t$is positive definite, which guarantees that P_t be a correlation matrix with ones on the main diagonal and on every other off-diagonal elements less than or equal to one in absolute value. The dynamic correlation structure evolves as a scalar process and is specified by a GARCH process:

$$Q_t = \overline{Q}(1 - a - b) + a\varepsilon_{t-1}\varepsilon_{t-1}' + bQ_{t-1} \qquad (3.8)$$

, where $\overline{Q}$ is the unconditional correlation matrix of the standardized error terms, $\overline{Q} = E(\varepsilon_t \varepsilon_t')$. a and b are scalar parameters to capture the shocks from previous residuals and effect of lagged dynamic conditional correlations on current level. The sum of the parameters equals to one, constraining the unconditional correlation to range between [-1, 1].

In the final step, the conditional correlation equation would be extended by adding one asymmetric effect. The asymmetric effect aims to capture the possible situation where the return's volatility changes more when negative shocks come, than when positive shocks come. It's also documented that the conditional correlation would be influenced by the asymmetric effect. Therefore and following Cappiello *et al,* (2006), then equation (1) is enriched by allowing for the asymmetry effect in the conditional correlation structure:

$$Q_t = \bar{Q}(1 - a - b) - g\bar{E} + a\varepsilon_{t-1}\varepsilon_{t-1}^{'} + bQ_{t-1} + g\eta_{t-1}\eta_{t-1}^{'} \qquad (3.9)$$

, where g is a vector parameter for the asymmetric effect; $\eta_{t-1}\eta_{t-1}^{'}$, η_t is defined as $I(\varepsilon_t<0)\varepsilon_t$, where $I(\cdot)$ is an indicator function that is one when $\varepsilon_t<0$ and zero otherwise. $\bar{E}$ $=E[\eta_t\eta_t^{'}]$, is the sample covariance matrix.

3.3 Empirical Results

There are two possibilities for the long term codependence relationship: firstly, possible cointegration could exist in certain quantile of returns, it's impossible that every distribution of return series has exactly the same comovement level. Secondly, high cointegration relationship could appear in certain period of time, and it's unreasonable to believe that cointegration level remains constant throughout the whole research period. For the above two reasons, quantile-based comovement box is introduced to examine long-term cointegration relationship between the Greater China securitized real estate markets as well as these developed real estate markets as a more comprehensive research tool.

The co-movement values using the quantiles cauculated from the CAViaR model for the whole research period are reported in Table 5 (Co-Movement Values of 20 Quantiles from 1995-2011), with 20 quantiles being included in the empirical work in total. The independent value is θ (when $q_\theta \leq 0.5$) and $(1-\theta)$ (when $q_\theta > 0.5$). The more the co-movement value of two securitized real estate series departs from the independent value, then the more cointegrated that the two securitized real estate markets would be. In general, none of the research samples are strictly independent although the China markets and the Taiwan markets have nearly independent values with the US and the UK markets, as compared with the other Asian markets. Among the Greater China members, the China and the Hong Kong securitized real estate markets have a much closer relationship each and that they even have the second closest relationship among all research pairs. Hong Kong and Singapore has the highest co-movement value for each quantile, indicating a deeper linkage between these two markets in almost all conditions. On average, Hong Kong has much higher co-dependence relationships with the other Asian countries, the US and the UK than with the China mainland and the Taiwan securitized real estate markets. In addition, the Taiwan markets have the lowest co-dependence with the other markets, which could be attributed to its relatively smaller market capitalization of real estate industry.

To get a direct visual impression of the co-movement possibility, the co-movement values for each quantile among the GC market, and among the GC market with the other countries, are plotted in the co-movement box of Figure 6 (Weighted Average Co-Movement Values between Real Estate Securities Returns for Five Groups (Among GC, GC-US, GC-UK, GC-AU, GC-JP and GC-SG) Over the Full Study Period: Jan 1995 – Dec 2011)) over the whole research period. The average co-movement possibility value of the GC market with the other country is the weighted average value, and with the GDP of the three GC members as the weight. The more the departure of the co-movement value from the independent line, then the higher the degree of the co-movement relationship between the sample pairs would be. Consistent with the results of Table 5, Figure 6 shows that the China and the Hong Kong securitized real estate has each the highest degree of co-movement among the GC markets. Among all the trade partners of the GC market, the GC market has a closer relationship with the Singapore securitized real estate market and that the overall is more related with the Asian countries rather than with the US and

UK markets. As can be seen in Figure 6, the co-movement box can easily help to visualize the complicated co-dependence relationship and to offer a better understanding of it.

Although certain co-movement relationships are observed in Table 5 and Figure 6, the highest co-movement value of 0.6741 (for Hong Kong and Singapore) is still far from the value of 1 (i.e. being fully integrated). Therefore, it is necessary to examine the co-movement relationship during different time periods. The average probability of long-term co-dependence among the GC markets during the crisis period and the tranquil period is reported in Table 6 (Average Co-Movement Values between Securitized Real Estate Returns over the Tranquil (Upper Triangular Portion) and The Crisis Periods (Lower Triangular Part) Across All Quantile Ranges). The upper triangular part is the average value of the tranquil time and is lower in average value for the crisis time for all quintiles. Without any exception, the average co-movement possibility value in crisis time is significantly higher than that in the tranquil period.

Table 5Co-Movement Values of 20 Quantiles from 1995- 2011

The table presents the estimated probability that the second securitized real estate market returns falls below(above) its θth-quantile conditional on the first securitized real estate market returns being below (above) its θth-quantile, for $\theta < 0.5$ ($\theta \geq 0.5$) for the whole research period(Jan 2, 1995 – Dec 31, 2011). The quantile of each return series are estimated using conditional quantile regressions. 20 quantiles are covered in this empirical work.

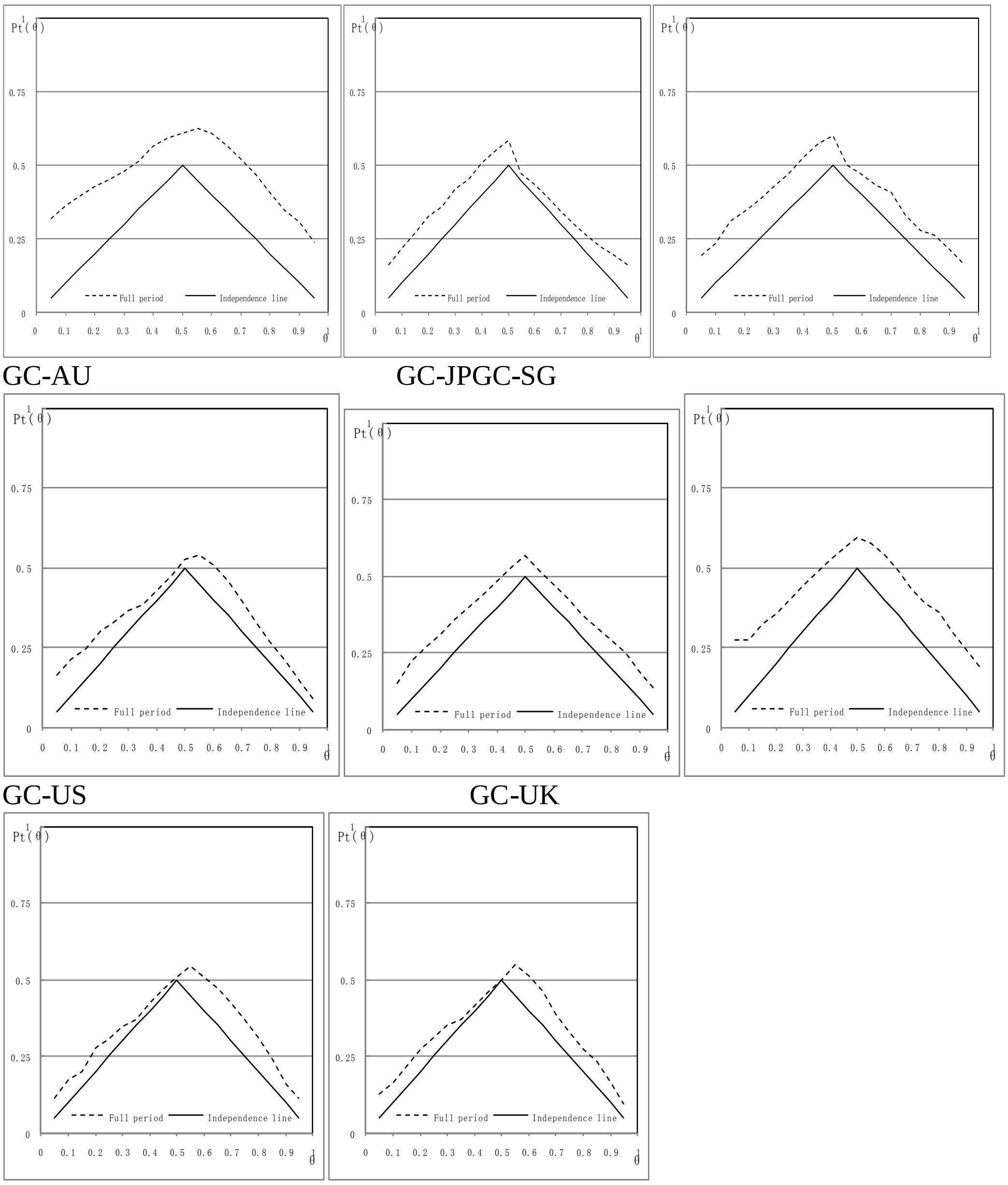
	Q1(0.05)	Q2(0.1)	Q3(0.15)	Q4(0.2)	Q5(0.25)	Q6(0.3)	Q7(0.35)	Q8(0.4)	Q9(0.45)	Q10(0.5)	Q11(0.55)	Q12(0.6)	Q13(0.65)	Q14(0.7)	Q15(0.75)	Q16(0.8)	Q17(0.85)	Q18(0.9)	Q19(0.95)
CH-HK	0.3182	0.3617	0.3966	0.4271	0.4524	0.4809	0.5124	0.5660	0.5927	0.6080	0.6257	0.6085	0.5697	0.5208	0.4698	0.4075	0.3472	0.3073	0.2397
CH-TW	0.1613	0.2179	0.2717	0.3269	0.3582	0.4198	0.4539	0.5105	0.5472	0.5862	0.4726	0.4380	0.3929	0.3428	0.2972	0.2582	0.2237	0.1961	0.1613
HK-TW	0.1961	0.2332	0.3123	0.3421	0.3844	0.4286	0.4732	0.5306	0.5738	0.6032	0.4988	0.4685	0.4340	0.4060	0.3295	0.2800	0.2629	0.2157	0.1613
Average	0.2252	0.2709	0.3269	0.3654	0.3983	0.4431	0.4798	0.5357	0.5713	0.5991	0.5324	0.5050	0.4655	0.4232	0.3655	0.3152	0.2780	0.2397	0.1874
CH-AU	0.1613	0.2114	0.2470	0.3007	0.3295	0.3646	0.3823	0.4282	0.4717	0.5243	0.5443	0.5094	0.4601	0.3988	0.3295	0.2659	0.2106	0.1438	0.0915
HK-AU	0.2528	0.2964	0.3225	0.3345	0.3696	0.3988	0.4321	0.4745	0.5114	0.5483	0.5976	0.5589	0.5261	0.4809	0.4140	0.3290	0.2746	0.2092	0.1220
TW-AU	0.1438	0.1918	0.2310	0.2724	0.3051	0.3567	0.3997	0.4511	0.5065	0.5544	0.4639	0.4326	0.3991	0.3697	0.2920	0.2375	0.1990	0.1373	0.0741
Average	0.1860	0.2332	0.2668	0.3025	0.3347	0.3734	0.4047	0.4513	0.4965	0.5423	0.5353	0.5003	0.4618	0.4165	0.3452	0.2775	0.2281	0.1634	0.0959
CH-JP	0.1438	0.2179	0.2644	0.3094	0.3521	0.3944	0.4352	0.4821	0.5278	0.5631	0.5172	0.4712	0.4252	0.3719	0.3304	0.2920	0.2499	0.1830	0.1351
HK-JP	0.2484	0.3290	0.3777	0.3803	0.4166	0.4395	0.4831	0.5219	0.5646	0.5993	0.5530	0.5126	0.4850	0.4460	0.4105	0.3574	0.3065	0.2659	0.1961
TW-JP	0.1569	0.2245	0.2847	0.3182	0.3617	0.4249	0.4825	0.5388	0.5947	0.6341	0.4654	0.4407	0.3997	0.3632	0.3138	0.2615	0.2266	0.1852	0.1482
Average	0.1830	0.2571	0.3090	0.3359	0.3768	0.4196	0.4670	0.5143	0.5624	0.5988	0.5119	0.4749	0.4367	0.3937	0.3516	0.3036	0.2610	0.2114	0.1598
CH-SG	0.2702	0.2702	0.3211	0.3563	0.3957	0.4380	0.4825	0.5252	0.5622	0.5932	0.5826	0.5426	0.4931	0.4329	0.3896	0.3596	0.2978	0.2397	0.1874
HK-SG	0.4533	0.4511	0.4983	0.4827	0.5300	0.5448	0.5927	0.6167	0.6421	0.6577	0.6741	0.6499	0.6195	0.5876	0.5648	0.5219	0.4634	0.3813	0.3182
TW-SG	0.2092	0.2245	0.2833	0.3171	0.3774	0.4424	0.4912	0.5230	0.5637	0.5940	0.4746	0.4467	0.4059	0.3755	0.3251	0.2876	0.2339	0.1787	0.1656
Average	0.3109	0.3152	0.3675	0.3853	0.4344	0.4750	0.5222	0.5550	0.5893	0.6149	0.5771	0.5464	0.5062	0.4654	0.4265	0.3897	0.3317	0.2666	0.2237
CH-US	0.1133	0.1744	0.2005	0.2833	0.3069	0.3480	0.3712	0.4267	0.4693	0.5035	0.5512	0.5106	0.4764	0.4301	0.3758	0.3150	0.2441	0.1569	0.1090
HK-US	0.1787	0.2528	0.2819	0.3030	0.3365	0.3502	0.3905	0.4446	0.4887	0.5275	0.5933	0.5509	0.5268	0.4824	0.4220	0.3585	0.3051	0.2528	0.2005
TW-US	0.0654	0.1242	0.1715	0.2103	0.2493	0.3066	0.3662	0.4321	0.4795	0.5279	0.4630	0.4267	0.3954	0.3596	0.2929	0.2430	0.1991	0.1635	0.1046
Average	0.1192	0.1838	0.2180	0.2655	0.2976	0.3349	0.3759	0.4345	0.4792	0.5196	0.5359	0.4960	0.4662	0.4241	0.3636	0.3055	0.2494	0.1911	0.1380
CH-UK	0.1220	0.1591	0.2179	0.2757	0.3112	0.3516	0.3673	0.4140	0.4557	0.4934	0.5506	0.5170	0.4626	0.3864	0.3295	0.2724	0.2324	0.1634	0.0915
HK-UK	0.2353	0.2680	0.3211	0.3345	0.3757	0.3951	0.4296	0.4685	0.5056	0.5269	0.5918	0.5540	0.5049	0.4692	0.4053	0.3432	0.2847	0.2245	0.1569
TW-UK	0.1133	0.1460	0.1976	0.2517	0.3042	0.3683	0.4059	0.4484	0.4988	0.5352	0.4780	0.4543	0.4109	0.3625	0.2911	0.2441	0.2063	0.1438	0.1002
Average	0.1569	0.1910	0.2455	0.2873	0.3304	0.3717	0.4010	0.4436	0.4867	0.5185	0.5401	0.5085	0.4595	0.4060	0.3420	0.2866	0.2412	0.1772	0.1162

Notes: CH, HK,TW stands for Mainland China, Hong Kong and Taiwan securitized real estate markets; AU, JP, SG, US and UK stands for Australia, Japan, Singapore, United States and United Kingdom securitized real estate markets.

Figure 1Weighted Average Co-Movement Values between Real Estate Securities Returns for Five Groups (Among GC, GC-US, GC-UK, GC-AU, GC-JP and GC-SG) Over the Full Study Period: Jan 1995 – Dec 2011)

The figure plot the estimated probability that the second securitized real estate market returns falls below(above) its θth-quantile conditional on the first securitized real estate market returns being below (above) its θth-quantile, for $\theta < 0.5$ ($\theta \geq 0.5$). Weighted average is the average probability value using country GDP as weight.

CH-HKCH-TW HK-TW



Notes: CH, HK, TW stands for Mainland China, Hong Kong and Taiwan securitized real estate markets; AU, JP, SG, US and UK Stands for Australia, Japan, Singapore, United States and United Kingdom securitized real estate markets.

Table 6Average Co-Movement Values between Securitized Real Estate Returns over the Tranquil (Upper Triangular Portion) and The Crisis Periods (Lower Triangular Part) Across All Quantile Ranges

	CH	HK	TW	AU	JP	SG	US	UK
CH	—	0.4403	0.3380	0.3202	0.3317	0.3838	0.3267	0.3197
HK	0.6156	—	0.3676	0.3781	0.4029	0.5264	0.3749	0.3864
TW	0.4226	0.4261	—	0.3066	0.3531	0.3523	0.2890	0.3090
AU	0.4345	0.4836	0.4032	—				
JP	0.4747	0.4963	0.3989		—			
SG	0.5598	0.6241	0.4413			—		
US	0.3892	0.4235	0.3246				—	
UK	0.3589	0.4074	0.3442					—

Note: CH, HK, TW stands for Mainland China, Hong Kong and Taiwan securitized real estate markets; AU, JP, SG, US and UK Stands for Australia, Japan, Singapore, United States and United Kingdom securitized real estate markets

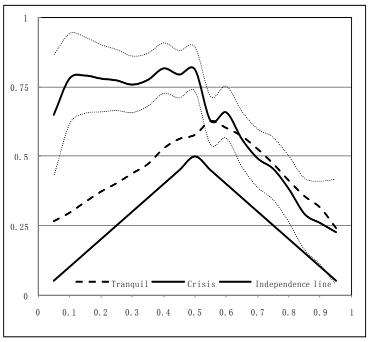
Then the codependence possibilities for each quantile during the crisis period and the tranquil period are directly plotted in Figures 7(Estimated Co-Movement in Crisis vs. Tranquil Periods among Greater China Area) and 8 (Estimated Co-Movement in Crisis Vs. Tranquil Periods Of Greater China Area With Other Countries) by the co-movement box method. The quantile is from 0.05 to 0.95 and the results are presented in the co-movement box together with an independent line.

First, comparing the co-dependence level during the tranquil period among the three real estate markets, it can be seen that China and Hong Kong each has an overall further distance departure from the independence line, indicating the highest level of co-dependence compared with the other two pairs, while the co-dependence relationship of China and Taiwan has the lowest value but with still no complete independence. Secondly, the results of the crisis days for all the pairs show a striking evidence of contagion and especially for the left tail. That is, the negative returns of the three markets from the left tail can quickly become contagion to each other, and causing a decrease return in the other securitized real estate markets of GC area, while the positive returns have no such influence. For example, the probability in the 10%-quantile of co-movement, between China and Hong Kong during crisis days is 0.78 as compared with that of 0.29 during tranquil days, has increased by 163%. This result is consistent with the large body of literature of the Left tail and is often heavier than the right tail. Coles *et al.* (1999) find that extreme dependence was much stronger in bear markets than in the bull market. Studying the European countries and the global markets, both Poon *et al.* (2004) and Knight *et al.* (2005) find that the left tail dependence is much stronger than the right tail dependence. One reason behind this phenomenon could be that the returns are moved by news, which create volatility and cluster to be followed by additional news. It is also stated that the increase in common stock prices caused by good news, increases or gets dampened by the increase in risk premium to at least compensate for higher volatility; while the drop in common stock prices caused by a portion of bad news gets further enlarged by the increase in the risk premium (Campbell and Hentschel, 1992; Jondeau and Rockinger, 2003).

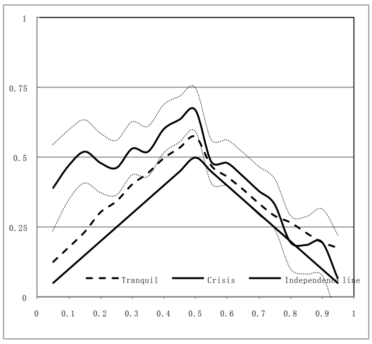
Figure 7Estimated Co-Movement In Crisis Vs. Tranquil Periods Among Greater China Area

The figure plot the estimated probability that the second securitized real estate market returns falls below(above) its θth-quantile conditional on the first securitized real estate market returns being below (above) its θth-quantile, for $\theta < 0.5$ ($\theta \geq 0.5$), in crisis and in tranquil periods. The quantile of each return series are estimated using conditional quantile regressions. The dashed lines are the two standard error bounds for the estimated co-exceedance likelihood in crisis periods.

Mainland China – Hong Kong



Mainland China – Taiwan



Hong Kong – Taiwan

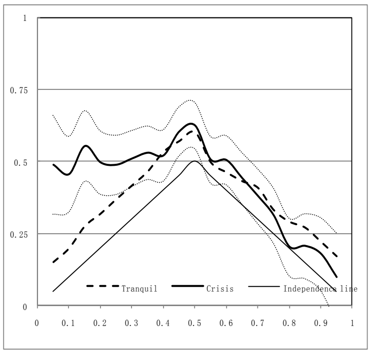
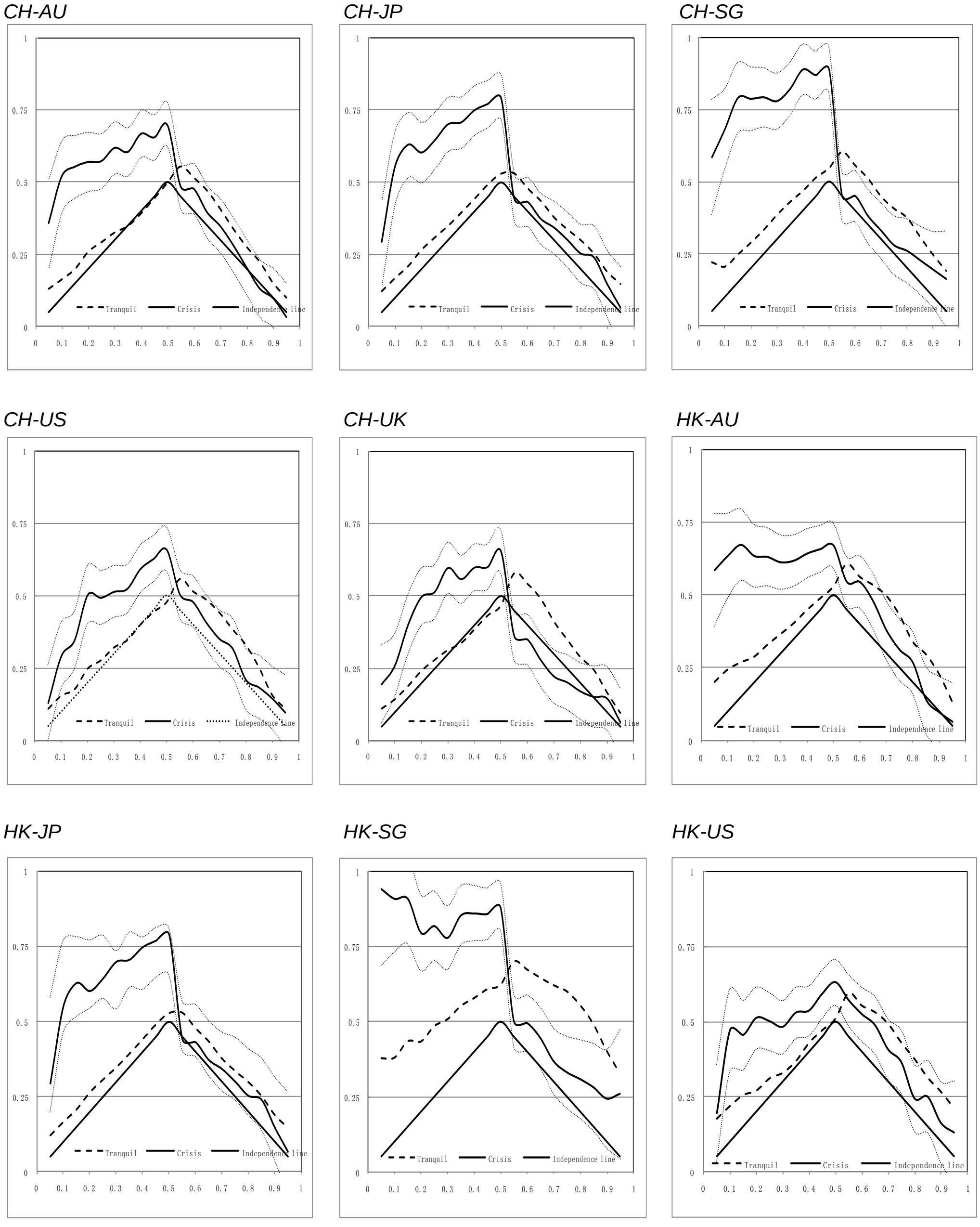
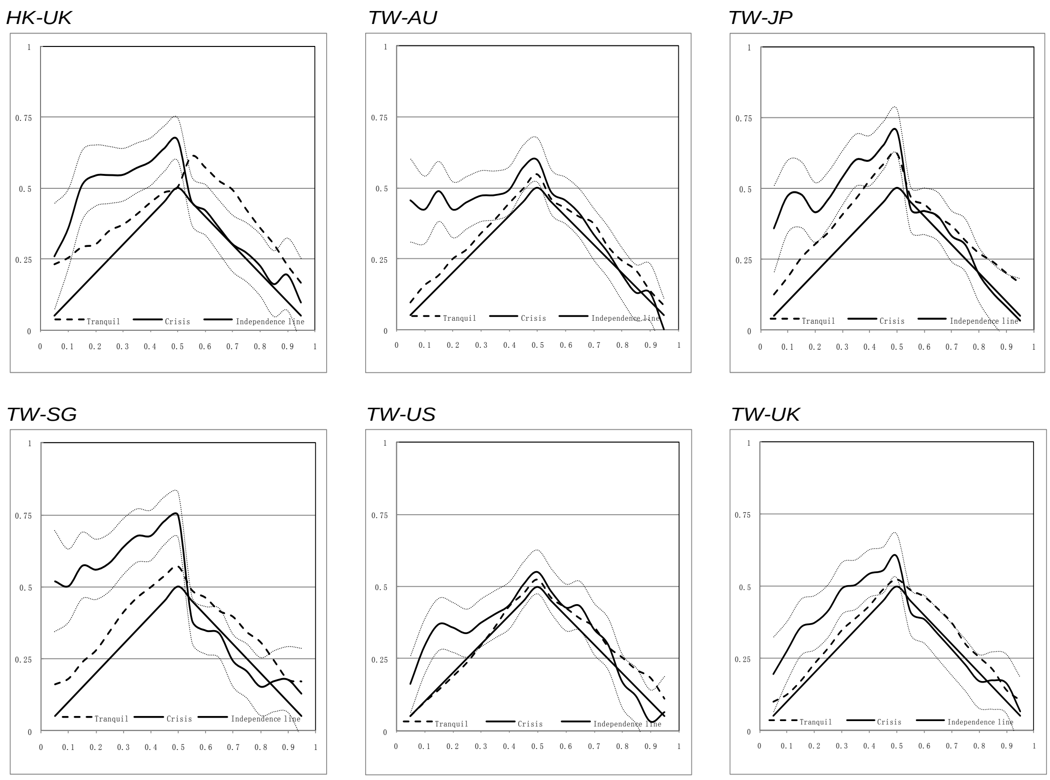


Figure 8 plots the co-dependence probability results between the GC markets with the other securitized real estate markets. The first five graphs show the result of the China real estate markets with the other Asian markets (i.e. Australia, Japan and Singapore), the United States and the United Kingdom real estate markets. Overall, the probability value in the tranquil period is very close to the independent line while the China and Singapore pair has a closer relationship than the other research pairs during tranquil time. The lines from the tranquil days show a slightly higher dependence level on the right tail. In general, the China markets have a closer relationship with the Asian countries than with the US and UK markets, implying more possibility of a regional integration rather than a global integration. However, all pairs show the significant left tail contagion during crisis time and that the contagion effect is the largest between the China and the Singapore market. The probability of co-movement for the smallest quantile in crisis time is not so statistically significant from the probability of co-movement in tranquil times for the last two pairs. This is because the standard errors for the extreme lower parts of the distribution become wider owing to the limited number, which could exceed the extreme value (i.e. the smallest quantile).

Figure 8Estimated Co-Movement in Crisis Vs. Tranquil Periods Of Greater China Area With Other Countries

The figure plot the estimated probability that the second securitized real estate market returns falls below(above) its θth-quantile conditional on the first securitized real estate market returns being below (above) its θth-quantile, for $\theta < 0.5$ ($\theta \geq 0.5$), in crisis and in tranquil periods. The quantile of each return series are estimated using conditional quantile regressions. The dashed lines are the two standard error bounds for the estimated co-exceedance likelihood in crisis periods.





Notes: CH, HK, TW stands for Mainland China, Hong Kong and Taiwan securitized real estate markets; AU, JP, SG, US and UK Stands for Australia, Japan, Singapore, United States and United Kingdom securitized real estate markets.

The Hong Kong real estate markets show a higher probability in comparison to the five markets and the China real estate markets. This may be due to Hong Kong's more open economy and much less restrictions on foreign capital flows to the Hong Kong market. Similarly, the contagion effect is striking on the left tail for all three Asian pairs than with the US and UK markets. The contagion effect is the largest between the Hong Kong and Singapore markets, indicating a much stronger connection within the Asian area than with the Global markets. At the last and while the probability of co-movement relationships for the Taiwan real estate markets with those of Australia, Japan and Singapore are significantly different from the independent line in tranquil times, the co-dependence relationship with the US and UK markets is much less obvious. Compared with the striking contagion effect for the China and Hong Kong real estate markets, the Taiwan markets seem to have a much lesser influence from the crisis. The connection between the Taiwan real estate markets and the Asian region is much stronger than that with the US and UK real estate markets.

In Table 7, a formal significance joint T test is proposed to further affirm the observation that we get from Figures 7 and 8. The significance of the co-dependence differences between crisis time and tranquil time is examined separately for the lower tail (i.e. the quantile below 0.5) and the upper tail (i.e. the quantile above 0.5). The statistical value that is computed as the sum of $\alpha_{\theta,2}$ (in equation 8) over quantile θ and that the standard errors are reported with the significant results being presented in bold print. Consistent with the observations from Figures 7 and 8, the left tail shows significant differences of co-dependece possibilities between the crisis period and tranquil period for all real estate pairs, indicating a clear sign of contagion. Moreover, only two statistics are significantly different in the upper tail, showing an inconvincible indication of contagion for these quantiles. The results are consistent with the previous findings and reasons as discussed in the last paragraph.

Table 7 Significance Tests for Five Groups (Among GC, GC-US, GC-UK, GC-AU, GC-JP and GC-SG) between the Market Tranquil and the Crisis Periods

country pairs	**lower tail($\theta \leq$ 0.5)**		**upper tail (θ >0.5)**	
Panel A - GC markets	Stat.	s.e.	Stat.	s.e.
China-Hong Kong	**0.3488**	0.0597	-0.0174	0.0600
China-Taiwan	**0.1645**	0.0518	-0.0043	0.0500
Hong Kong - Taiwan	**0.1368**	0.0538	-0.0284	0.0520
Panel B - GC markets with US				
China - US	**0.1724**	0.0470	-0.0595	0.0506
Hong Kong - US	**0.1562**	0.0513	-0.0709	0.0567
Taiwan - US	**0.0988**	0.0430	-0.0346	0.0473
Panel C - GC markets with UK				
China - UK	**0.1967**	0.0470	**-0.1358**	0.0489
Hong Kong - UK	**0.1593**	0.0541	-0.1327	0.0545
Taiwan - UK	**0.1219**	0.0468	-0.0612	0.0471
Panel D - GC markets with AU				
China - AU	**0.2760**	0.0497	-0.0653	0.0483
Hong Kong - AU	**0.2790**	0.0548	-0.0873	0.0533
Taiwan - AU	**0.1653**	0.0488	-0.0247	0.0458
Panel E - GC markets with JP				
China - JP	**0.3167**	0.0506	-0.0500	0.0506
Hong Kong - JP	**0.2477**	0.0570	-0.0782	0.0561
Taiwan - JP	**0.1437**	0.0523	-0.0630	0.0498
Panel F - GC markets with SG				
China - SG	**0.4252**	0.0557	-0.1008	0.0554
Hong Kong - SG	**0.3637**	0.0650	**-0.1978**	0.0654
Taiwan - SG	**0.2534**	0.0534	-0.0936	0.0507

Note: T statistics indicated in bold are significant at 5% level. CH, HK, TW stands for Mainland China, Hong Kong and Taiwan securitized real estate markets; AU, JP, SG, US and UK Stands for Australia, Japan, Singapore, United States and United Kingdom securitized real estate markets

The short term co-movement relationship is examined by the ADCC-GARCH model. Table 8 presents the coefficients of the conditional correlation equation for the ADCC-GJR(1)-GARCH(1,1) model. Almost all the coefficients in DCC process (i.e. a and b) are significant for 18 real estate correlation pairs, indicating that the assumption of a constant correlation does not hold for this data set. The empirical results show that the correlations are time-varying and clustering, which means that their current correlation is correlated to past correlation values. The asymmetric effect measures (g) and are significant for almost half pairs of the research sample at the 10% confidence level. The significant pairs are those three pairs within the Greater China area and the four Asian pairs (i.e. Hong Kong-Australia, Hong Kong-Singapore, Taiwan-Japan and Taiwan-Singapore). The implication is that the ADCC-GARCH model specification could well fit well the data set.

Table 8ADCC Estimates: Jan 1995 – Dec 2011

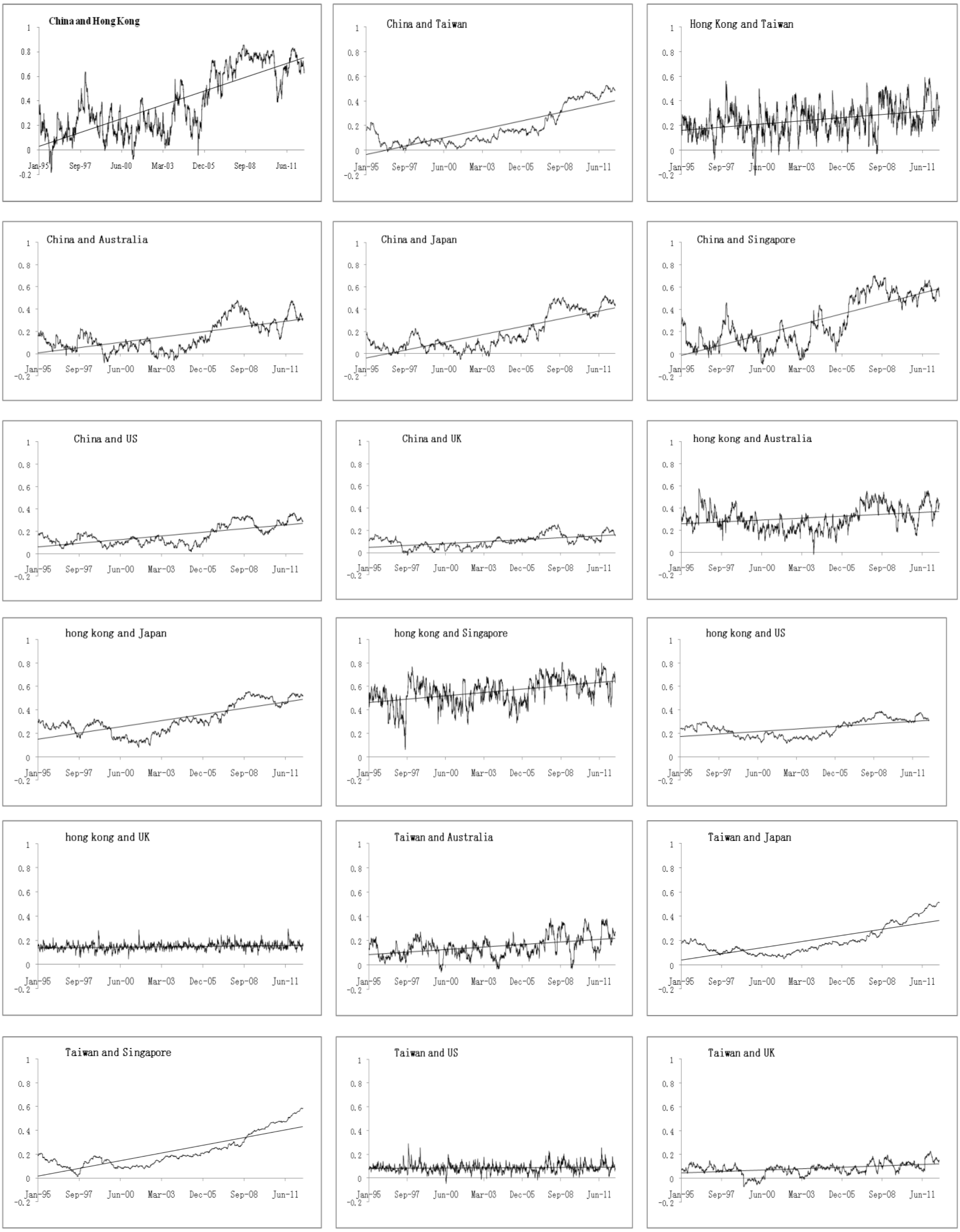
This table reports the parameters (*a*,*b*,*g*) of the conditional correlation equation for each securitized real estate market returns pair via adopting the ADCC-GARCH model. The descriptive summaries of each dynamic conditional correlation series are reported, including the mean, standard deviation, maximum and minimum correlation value. ***,** and * respectively denote significance at the 1%, 5% and 10% levels.

	a	*b*	*g*	*mean*	*SD*	*Maximum*	*Minimum*
CH-HK	0.0227 ***	0.9750 ***	0.0093 **	0.3909	0.2594	0.8584	-0.1845
CH-TW	0.0037 ***	0.9969 ***	0.0011 **	0.1826	0.1517	0.5262	-0.0127
HK-TW	0.0275 ***	0.9456 ***	0.0198 **	0.2435	0.1190	0.5899	-0.2364
Average	-	-	-	0.2723	0.1767	0.6582	-0.1445
CH-AU	0.0079 ***	0.9901 ***	0.0001	0.1574	0.1339	0.4813	-0.0802
CH-JP	0.0065 ***	0.9932 ***	0.0014	0.1863	0.1603	0.5221	-0.0505
CH-SG	0.0131 ***	0.9861 ***	0.0014	0.2862	0.2190	0.7021	-0.0912
CH-US	0.0030	0.9600 ***	0.0002	0.1664	0.0864	0.3636	0.0173
CH-UK	0.0025 **	0.9976 ***	0.0005	0.1040	0.0564	0.2573	-0.0242
Average	-	-	-	0.1801	0.1312	0.4653	-0.0458
HK-AU	0.0143 ***	0.9738 ***	0.0090 *	0.3125	0.1054	0.5783	-0.0202
HK-JP	0.0045 ***	0.9956 ***	0.0011	0.3188	0.1277	0.5579	0.0790
HK-SG	0.0233 ***	0.9604 ***	0.0240 ***	0.5560	0.1139	0.8094	0.0602
HK-US	0.0278 *	0.1161	0.0364	0.2417	0.0707	0.3895	0.1131
HK-UK	0.0121 **	0.9400 ***	0.0103	0.1479	0.0256	0.2927	0.0453
Average	-	-	-	0.3154	0.0886	0.5256	0.0555
TW-AU	0.0116 ***	0.9771 ***	0.0054	0.1515	0.0852	0.3829	-0.0615
TW-JP	0.0025 ***	0.9988 ***	0.0011 ***	0.2009	0.1198	0.5158	0.0490
TW-SG	0.0024 ***	0.9990 ***	0.0014 **	0.2227	0.1397	0.5860	0.0104
TW-US	0.0168	0.8188 ***	0.0077	0.0872	0.0349	0.2897	-0.0467
TW-UK	0.0137 **	0.9290	0.0126	0.0819	0.0492	0.2297	-0.0701
Average	-	-	-	0.1488	0.0858	0.4008	-0.0238

Notes: CH, HK,TW stands for Mainland China, Hong Kong and Taiwan securitized real estate markets; AU, JP, SG, US and UK Stands for Australia, Japan, Singapore, United States and United Kingdom securitized real estate markets

To visualize the dynamic conditional correlation, Figure 9(Conditional Correlation for Securitized Real Estate Markets: Jan1995–Dec2011) plots the 18 conditional correlation relationships for the three GC markets within the GC region and with other securitized real estate markets. In general, the overall trend for these correlation relationships is upwards, meaning that the co-movement increases during the research period. For example, the conditional correlation between the China mainland and Hong Kong ranges from the lowest -0.18 to highest of 0.86. To compare horizontally, a higher level of correlation could be observed for the three markets with each other, and a relatively lower level of correlation exists between the GC markets with the other securitized real estate markets. Among the other securitized real estate markets, the three GC members have a stronger conditional correlation with the Asian markets than with the US and UK markets. That is, the movements of the Greater China securitized real estate markets are more synchronized within the Asian region than with the other out-of-region markets. Moreover, the three GC markets have a stronger relationship with the Singapore market than with the other Asian markets, which is consistent with the long-term, co-movement box results. From the observation of the longitudinal comparison, the Taiwan securitized real estate market is less integrated with either the GC market members or the other developed securitized real estate markets, as compared with the China mainland and Hong Kong markets. This result may imply a possible higher diversification benefit from investing in the Taiwan real estate markets.

Figure 9Conditional Correlation for Securitized Real Estate Markets: Jan1995–Dec2011



From Figure 9, some structural breaks could be observed during the crisis period and even peaks could appear during some of the time. However, it is still not clear whether or not the co-movement relationship has any significant change during the crisis period versus the tranquil period. The paired T-test is conducted to compare the mean value during these two periods. As observed from Table 9 (Paired T Test Analysis for Conditional Correlation During Tranquil Period and Crisis Period), all mean values of the conditional correlations are much higher during the crisis time than during the tranquil time. All differences of the correlation value are statistically significant at the 1% significance level. This result implies that the short term co-movement level has been largely raised during crisis periods, which could mean that the contagion effect exists in the global securitized real estate.

Table 9Paired T Test Analysis for Conditional Correlation During Tranquil Period and Crisis Period

This table illustrates the average correlation value for 18 conditional correlation pairs both during the tranquil period and crisis periods (June 2, 1997 to December 31, 1997 (the Asian Crisis)[8] and June 25, 2007 to March 31, 2009 (the Sub-prime Crisis)). Paired T test is conducted to compare the difference of dynamic conditional correlation values during the two time periods. ***,** and * respectively denote the significance at the 1%, 5% and 10% levels.

Unconditional Correlation Pair	*Mean Tranquil period*	*Mean Crisis period*	*T-statistics*	
CH-HK	0.353698	0.631199	-26.5113	***
CH-TW	0.17635	0.222856	-7.1143	***
HK-TW	0.237285	0.283291	-8.9989	***
CH-AU	0.131961	0.321896	-37.3765	***
CH-JP	0.163226	0.335122	-26.5861	***
CH-SG	0.253587	0.497296	-27.7471	***
CH-US	0.038737	0.033556	11.1317	***
CH-UK	0.081627	0.113161	-7.855	***
HK-AU	0.297522	0.409139	-26.2076	***
HK-JP	0.30453	0.411004	-20.0745	***
HK-SG	0.547078	0.613771	-13.7945	***
HK-US	0.103448	0.103562	-0.0726	
HK-UK	0.238783	0.243426	-2.0258	**
TW-AU	0.141865	0.214002	-20.4052	***
TW-JP	0.196938	0.226579	-5.7308	***
TW-SG	0.220243	0.238399	-3.0012	***
TW-US	0.026187	0.022607	2.5321	**
TW-UK	0.106455	0.116353	-4.5245	***

[8] From definitions of Forbes and Rigobon (2002)

3.4 Comparison with Real Estate Returns

One concern about securitized real estate data series is that it will contain information from both security market and underlying property industry. However, the frequency of direct real estate data is usually monthly or quarterly which is too low for empirical estimation, an alternative way is to contain the stock market effect from securitized real estate data by controlling for the covariance with the market.

Applying single index return generating model to eight securitized real estate market returns, I regress the securitized real estate returns against the individual stock market returns and save the residuals. Following Mccue and Kling (1994), the residuals are series that mimics a real estate return series. Then the long term comovement box and short term ADCC-GARCH model are applied to the new real estate returns data.

Table 10 (co-movement values of 20 quantiles for real estate returns from 1995-2011) summarizes the overall co-movement values using the real estate returns for the whole research period, consistent with securitized real estate returns, values of GC market and average values of GC market with other countries for 20 quantiles are reported. The larger value of possibilities, the more integrated two markets would be. In general, the value of co-movement are very close to independent value for all the market pairs, indicating that eight real estate markets are nearly independent of each other markets. Compared with possibility values of securitized real estate market data, without effect from stock market, the relationship between international real estate market is much lesser but a little more than completely independent of each other. For the relationship of GC market with other countries, GC market have slightly closer relationship with Asian markets rather than US and UK market, especially with Singapore market, which is consistent with the results of securitized real estate returns.

Table 10 co-movement values of 20 quantiles for real estate returns from 1995-2011

The table presents the estimated probability that the second securitized real estate market returns falls below(above) its θth-quantile conditional on the first securitized real estate market returns being below (above) its θth-quantile, for $\theta < 0.5$ ($\theta \geq 0.5$) for the whole research period(Jan 2, 1995 – Dec 31, 2011). The quantile of each return series are estimated using conditional quantile regressions. 20 quantiles are covered in this empirical work.

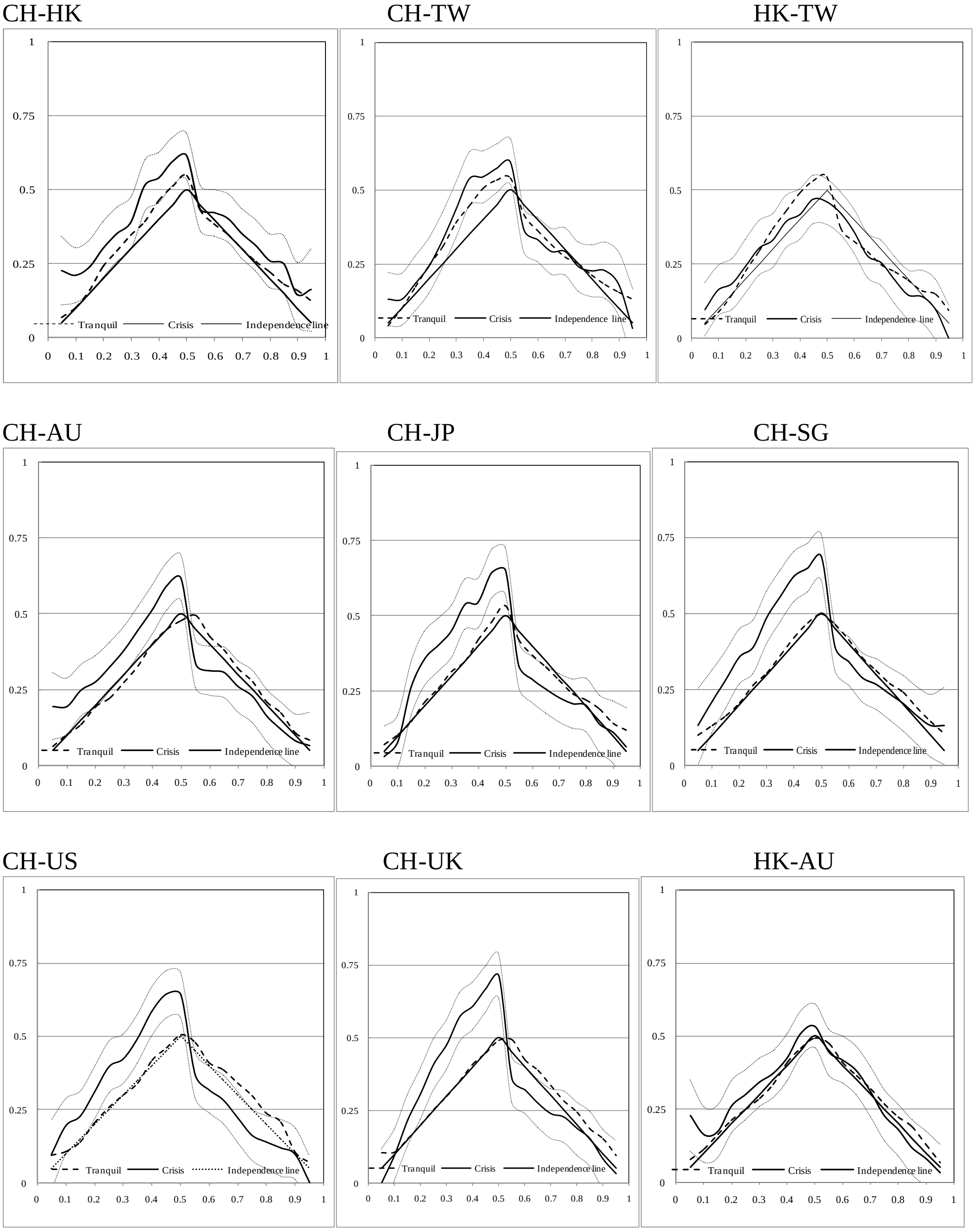
	Q1(0.05)	Q2(0.1)	Q3(0.15)	Q4(0.2)	Q5(0.25)	Q6(0.3)	Q7(0.35)	Q8(0.4)	Q9(0.45)	Q10(0.5)	Q11(0.55)	Q12(0.6)	Q13(0.65)	Q14(0.7)	Q15(0.75)	Q16(0.8)	Q17(0.85)	Q18(0.9)
CH-HK	0.0902	0.1173	0.1714	0.2481	0.3005	0.3534	0.4099	0.4743	0.5244	0.5576	0.4331	0.3914	0.3571	0.3075	0.2644	0.2278	0.1910	0.1579
CH-TW	0.0541	0.1038	0.1744	0.2448	0.3113	0.3955	0.4589	0.5115	0.5389	0.5477	0.4091	0.3581	0.3119	0.2760	0.2481	0.2143	0.1865	0.1579
HK-TW	0.0541	0.0970	0.1519	0.2290	0.2969	0.3624	0.4260	0.4805	0.5228	0.5333	0.3800	0.3327	0.2907	0.2489	0.2202	0.1884	0.1579	0.1421
Average	0.0662	0.1060	0.1659	0.2406	0.3029	0.3705	0.4316	0.4888	0.5287	0.5462	0.4074	0.3607	0.3199	0.2775	0.2442	0.2102	0.1785	0.1526
CH-AU	0.0812	0.1150	0.1504	0.2053	0.2373	0.2887	0.3442	0.4173	0.4677	0.4967	0.4732	0.4106	0.3725	0.3128	0.2689	0.2030	0.1654	0.1038
HK-AU	0.0993	0.1196	0.1654	0.2188	0.2554	0.2948	0.3390	0.4111	0.4657	0.4972	0.4697	0.4111	0.3654	0.3181	0.2617	0.2166	0.1805	0.1218
TW-AU	0.0496	0.1015	0.1519	0.2143	0.2617	0.3218	0.3738	0.4224	0.4642	0.4773	0.4251	0.3553	0.3126	0.2812	0.2545	0.2211	0.1880	0.1331
Average	0.0767	0.1120	0.1559	0.2128	0.2514	0.3018	0.3523	0.4169	0.4659	0.4904	0.4560	0.3923	0.3502	0.3040	0.2617	0.2136	0.1780	0.1196
CH-JP	0.0677	0.1015	0.1624	0.2323	0.2788	0.3324	0.3758	0.4371	0.5038	0.5486	0.4101	0.3592	0.3197	0.2790	0.2373	0.2177	0.1835	0.1399
HK-JP	0.0857	0.1105	0.1579	0.2493	0.3122	0.3624	0.4189	0.4822	0.5519	0.5928	0.4456	0.3925	0.3654	0.3090	0.2572	0.2222	0.1940	0.1760
TW-JP	0.0677	0.0970	0.1699	0.2335	0.2969	0.3730	0.4312	0.4726	0.5259	0.5477	0.3915	0.3434	0.2984	0.2609	0.2355	0.1985	0.1654	0.1444
Average	0.0737	0.1030	0.1634	0.2384	0.2960	0.3559	0.4086	0.4639	0.5272	0.5631	0.4157	0.3651	0.3278	0.2830	0.2433	0.2128	0.1810	0.1534
CH-SG	0.1038	0.1421	0.1805	0.2256	0.2806	0.3293	0.3886	0.4478	0.4948	0.5238	0.4527	0.4027	0.3442	0.3060	0.2653	0.2346	0.1850	0.1421
HK-SG	0.1218	0.1579	0.2015	0.2493	0.3095	0.3512	0.4086	0.4506	0.4998	0.5292	0.4512	0.4145	0.3706	0.3309	0.2887	0.2459	0.2136	0.1940
TW-SG	0.0587	0.1038	0.1669	0.2233	0.3041	0.3451	0.4015	0.4500	0.4938	0.4972	0.4101	0.3598	0.3087	0.2745	0.2292	0.1929	0.1579	0.1015
Average	0.0947	0.1346	0.1830	0.2327	0.2981	0.3419	0.3996	0.4495	0.4961	0.5167	0.4380	0.3923	0.3412	0.3038	0.2611	0.2245	0.1855	0.1459
CH-US	0.0947	0.1196	0.1519	0.2199	0.2770	0.3166	0.3622	0.4416	0.4863	0.5233	0.4642	0.3976	0.3719	0.3241	0.2779	0.2233	0.1940	0.1038
HK-US	0.0812	0.1196	0.1534	0.2323	0.2996	0.3309	0.3783	0.4371	0.4908	0.5170	0.4441	0.3953	0.3577	0.3015	0.2698	0.2166	0.1895	0.1534
TW-US	0.0587	0.0993	0.1504	0.2087	0.2734	0.3436	0.3996	0.4534	0.4837	0.4940	0.4206	0.3463	0.3087	0.2692	0.2463	0.2019	0.1729	0.1421
Average	0.0782	0.1128	0.1519	0.2203	0.2833	0.3304	0.3800	0.4440	0.4869	0.5115	0.4430	0.3797	0.3461	0.2983	0.2647	0.2139	0.1855	0.1331
CH-UK	0.0902	0.1060	0.1609	0.2154	0.2743	0.3233	0.3828	0.4365	0.4792	0.5215	0.4742	0.4100	0.3712	0.3211	0.2752	0.2357	0.1820	0.1421
HK-UK	0.1002	0.1177	0.1424	0.2168	0.2685	0.3123	0.3530	0.4053	0.4474	0.4868	0.4373	0.3993	0.3536	0.3065	0.2510	0.2234	0.1889	0.1656
TW-UK	0.0451	0.0880	0.1399	0.1906	0.2698	0.3248	0.3990	0.4410	0.4722	0.4967	0.4266	0.3705	0.3332	0.2940	0.2689	0.2369	0.1880	0.1602
Average	0.0785	0.1039	0.1477	0.2076	0.2709	0.3202	0.3783	0.4276	0.4663	0.5017	0.4460	0.3933	0.3527	0.3072	0.2650	0.2320	0.1863	0.1560

The existence of contagion effect during crisis is also examined for real estate returns in Figure 10 (Estimated Co-Movement for real estate returns in Crisis vs. Tranquil Periods of Greater China Area and GC Area with Other Countries). Though the overall contagion effect is weaker than that of securitized real estate markets, the upward shifts for quantiles less than 0.5 during crisis are still can be seen from the eighteen graphs. Compared with Hong Kong and Taiwan market, mainland China real estate market has a relatively stronger contagion effect with five other markets, this may due to increasing foreign direct investment on China real estate markets, which increase the co-movement of mainland china real estate industry with rest of the world. Within GC market, China and Hong Kong market has a stronger contagion effect than the other two market pairs, this result is consistent with that of securitized real estate market, indicating a closer long-term relationship between mainland China and Hong Kong in both real estate market as well as securitized real estate market. In last chapter, Hong Kong and Singapore has a strong contagion effect with each other during crisis, but this effect is much weaker for real estate returns, this may imply the very close relationship between Hong Kong and Singapore is mainly at security market level rather than industry level.

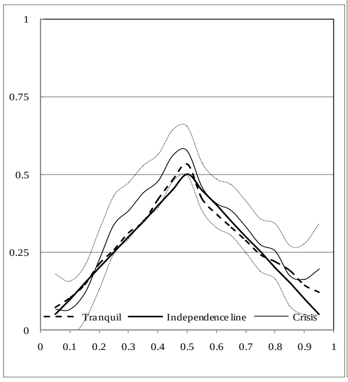
Then short-term ADCC-GARCH model is also applied to real estate returns and the results are reported in Figure 11(Conditional Correlation for Securitized Real Estate Markets: Jan1995–Dec2011). Compared to the conditional correlations of securitized real estate markets, there are no clear trends of increasing correlation relationship between the market pairs and most of the conditional correlations are close to zero. This result is consistent with previous long-term study, indicating that the international real estate markets that under studied are integrated at a very low level near to independence of each other. Especially, among all the research pairs, Hong Kong and Singapore has the highest correlation on average and a slightly upward trend, which is consistent with results from securitized real estate market returns. Since all the conditional correlations are near zero, it is unnecessary to test for contagion effect because with GARCH model, only overall results for all quantiles are shown.

Figure 10 Estimated Co-Movement for real estate returns in Crisis vs. Tranquil Periods of Greater China Area and GC Area With Other Countries

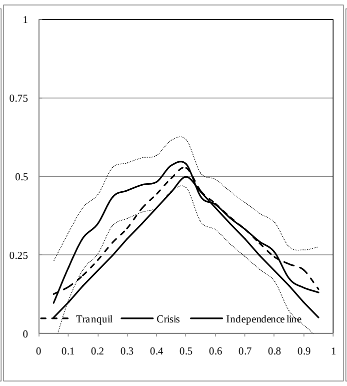
The figure plot the estimated probability that the second securitized real estate market returns falls below(above) its θth-quantile conditional on the first securitized real estate market returns being below (above) its θth-quantile, for $\theta< 0.5$ ($\theta\geq$ 0.5), in crisis and in tranquil periods. The quantile of each return series are estimated using conditional quantile regressions. The dashed lines are the two standard error bounds for the estimated co-exceedance likelihood in crisis periods.



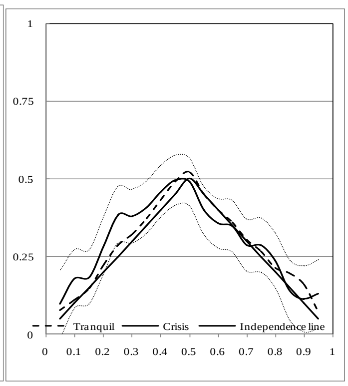
HK-JP



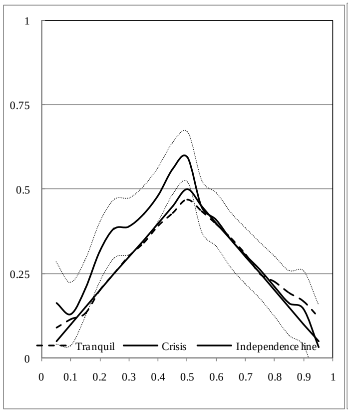
HK-SG



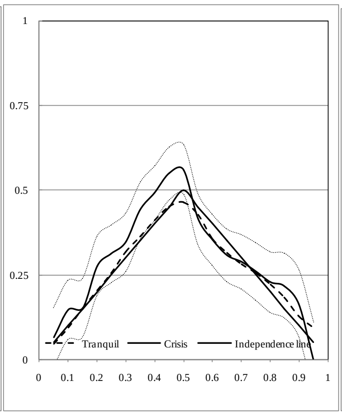
HK-US



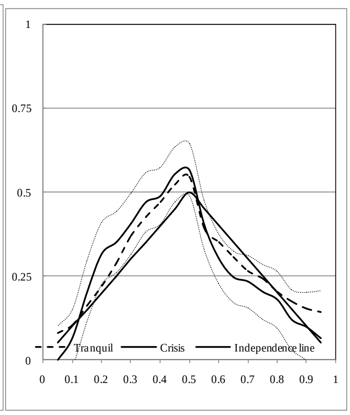
HK-UK



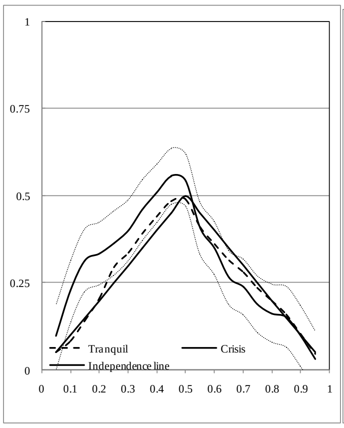
TW-AU



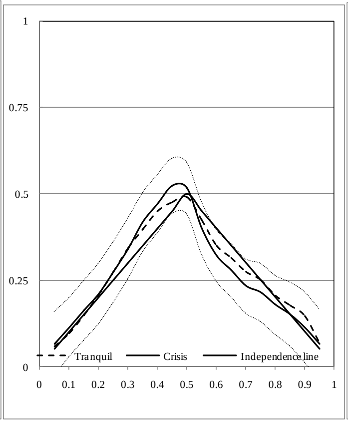
TW-JP



TW-SG



TW-US



TW-UK

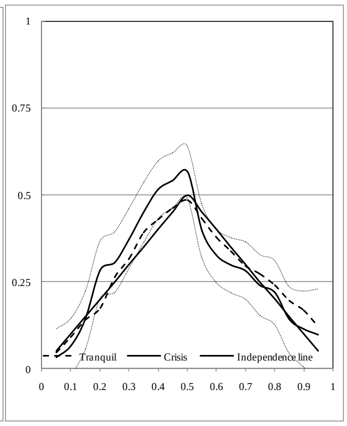
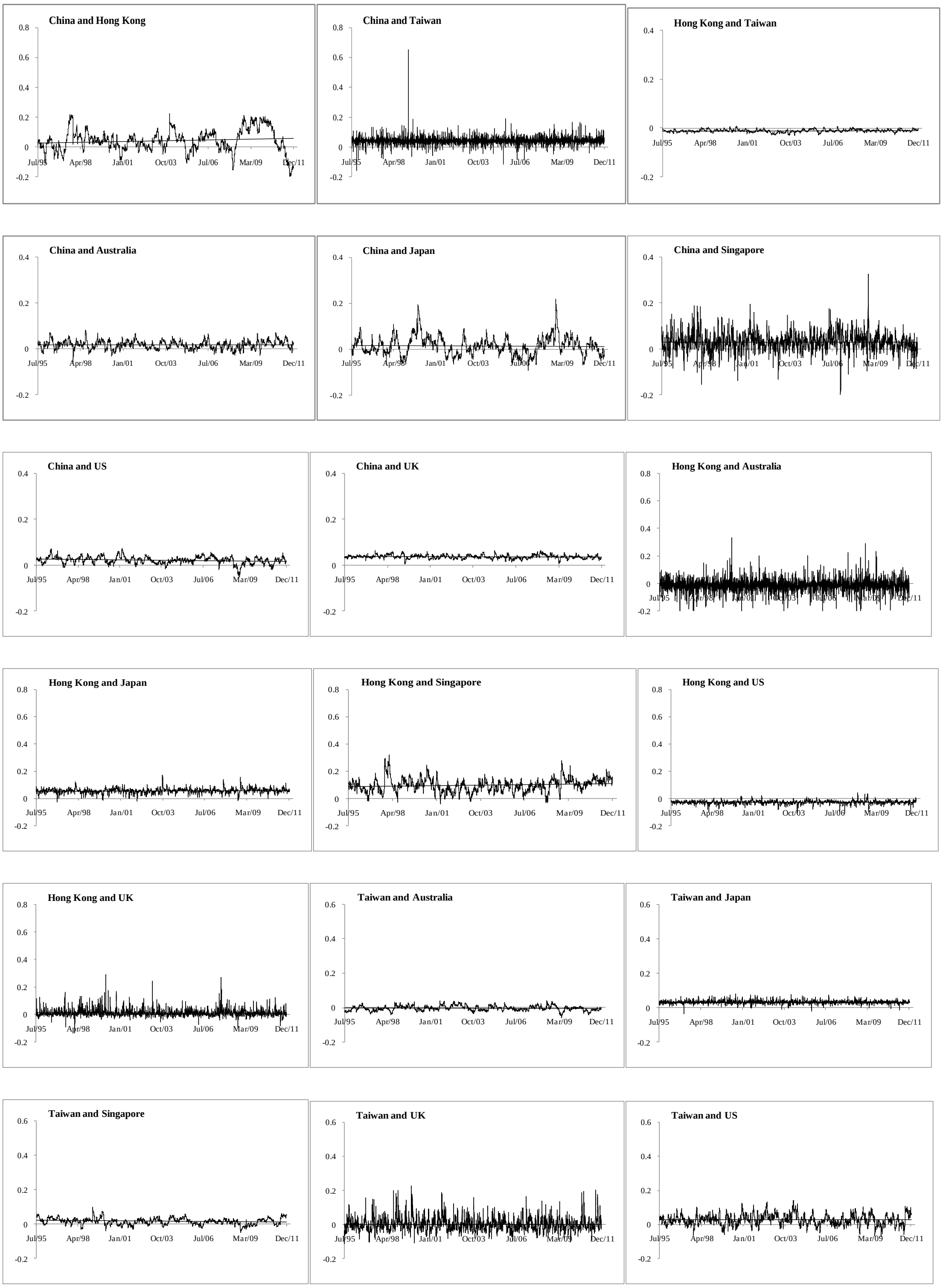


Figure 11Conditional Correlation for Securitized Real Estate Markets: Jan1995–Dec2011



3.5 Summary of the Chapter

This study examines the long term and short term integration relationships within the GC markets and with the other five developed securitized real estate markets (i.e. Australia, Japan, Singapore, US and UK). The long term relationship is examined by the co-movement box model, which is adopted in the real estate literature for the first time while the short term effect is examined by the ADCC-GARCH model. The co-movement box is based on the conditional autocorrelation quantile regressions (CAViaR) and on the conditional probability that is estimated by OLS regression. Contrary to the standard correlation measures, this model is robust to time varying volatility and to the departure from normality. Besides, it offers a simple and intuitive visual measure of integration. By adopting these two empirical models and together with the Johansen cointegration test, the co-dependence probability is also estimated during both the crisis and tranquil times to examine the existence of the contagion effect among these markets.

This study provides some interesting empirical findings: both the long-term and short-term co-dependence relationships are relatively stronger within the GC real estate markets than with the other securitized real estate markets, and that the obvious contagion effect during crisis time could be observed within this region.

In the long term, the co-movement box is adopted for both the whole research period and for two separate time periods (i.e. the tranquil and crisis times). The empirical results indicate that there is a much stronger interdependence linkage between the GC markets with the Asian region than with the US and UK markets; implying a regional integration rather than the global integration. The highest co-integration happens between the China mainland and the Hong Kong securitized real estate markets. However, the long-term co-integration level for all the rest research pairs is still low, which is far less than being fully integrated. Therefore, investors could still benefit from diversification benefits and from investing in the GC markets and in the rest securitized real estate markets.

Moreover, all the co-movement pairs show the significant contagion effect on the left tail during the crisis, which is consistent with the findings of Campbell and Hentschel (1992), Coles *et al.* (1999), Poon *et al.* (2004) and Knight et al. (2005). The Taiwan market has the lowest probability of co-movement with the other securitized real estate markets while Hong Kong has the highest probability, which could be owing to its more open economy and to a much lesser restriction on foreign investments in Hong Kong.

In the short term, the overall dynamic correlation level increases for the 18 securitized real estate return pairs during the research period. The co-movement level is higher within the GC markets, as compared with the correlations between them and the other securitized real estate markets. A higher correlation could also be found between the GC markets with other the Asian securitized real estate markets. Among the research pairs other than the GC markets themselves, a consistently high co-integration level could always be seen between the GC members with the Singapore markets. Compared with the China mainland and Hong Kong markets, the Taiwan market is still less integrated with the other securitized real estate markets. To test possible structural changes, the paired T-test results show that the conditional correlation level for all the securitized real estate market pairs significantly increases during the crisis period. Therefore, the contagion effect does exist between the securitized real estate markets during the research period.

The real estate returns are also added after taking off the effect from stock market, as a comparison to securitized real estate markets. Both in the long-term and short-term, the co-movement level of real estate returns is much lower near to completely independent than that of securitized real estate returns. However, for GC market, consistent with results from securitized real estate market, Mainland China and Hong Kong has a closer band for both direct and indirect real estate markets than the other two pairs. Besides, GC market has a closer relationship with Asian market rather than other countries, especially for Hong Kong and Singapore pair. The contagion effect of real estate returns is still clear for lower quantiles during crisis, indicating the increasing co-movement between the negative returns from eight real estate markets.

Further studies could be undertaken to improve via adding on the common macro-economic conditions to the estimation of probability, or via using some macro-economic variable as the indicator of crisis times. For instance, real estate markets are very vulnerable to the changes of the interest rate and the inflation rate.

Chapter 4: Correlation Dynamics and Determinants in International Securitized Real Estate Markets

4.1 Introduction

Chapter 3 examines the dynamic interdependence relationship among listed property markets both in the long term and short term. The dynamic of conditional correlation in the short term shows an increasing trend among all the sample pairs. However, the explanation for the dynamic changes or correlation structure in the co-movement relationship is still unknown. Because this correlation structure reflects the nature and extent of global real estate securities market integration and diversification performance of international real estate securities portfolios, a better understanding of dynamic movements in the real estate securities markets' correlation structure and the forces behind market integration is important for international investors to evaluate the potential risks and rewards of global real estate diversification. This is why my study is motivated.

In this Chapter, I systematically analyze conditional correlation dynamics and ask one research question. What are the major driving forces across eight major listed securitized real estate markets in GC market (Mainland China, Hong Kong and Taiwan), two developed real estate market (US and UK) as well as in Asia-Pacific (Australia, Japan, Singapore) for the period 1995Q1 through 2011Q4 (17 years, the longest period in which all relevant data are available)?The empirical indicator of the degree of integration is the quarterly estimates of conditional correlation of returns derived from ADCC-GARCH in last chapter across the eight securitized real estate markets.[9] Results from this study helped investors and policy makers to understand better some important "real estate" factors that could influence the co-movements of global real estate securities markets over time. My research strategy is the following:

[9] As a robustness check, I also provide the unconditional correlation to model the correlation determinants across the eight real estate securities markets.

- I estimate quarterly conditional correlations to understand how the pattern of international correlations of real estate securities returns have changed over time.

- Then I undertake a pooled cross-section time series regression analysis to assess, quantitatively, whether and how each of the five selected real estate variables: direct real estate market return performance differential, size differential of the real estate securities market, real estate securities market volatility differential, co-existence of REIT influence in the stock market and global securitized real estate market volatility, affects the correlations of real estate securities market returns. We also employ, for each economy pair, a set of control factors that includes selected macroeconomic, stock market, institutional quality and crisis dummy variables. Whilst previous stock market studies have also attempted to investigate the significance of these control factors (predominantly macro-economic variables) in explaining the stock return correlations, I focus on the role of the five real estate variables, without and then with the set of controls. The detailed variable choice and methodology will be elaborated later. Results are robust against the pooled cross-section time series regression models with random effects, feasible generalized least squares (FGLS) and a dynamic generalized method of moment (GMM) techniques, as well as one-step ahead forecasting.

- I employ principal component analysis (PCA) to identify dominant "real estate" and "control" principal components from the pool of real estate and control variables. The extracted dominant principal components are then included into a stepwise regression model to estimate the relative importance of "real estate" and "control" factors which are retained in the regression. The PCA allows a large number of theoretically important correlation variables to be considered and can be used effectively in multiple regression analysis to address the problems of multicollinearity because the derived dominant components are orthogonal to each other. Results indicate that the real estate factors are able to explain up to 77.7% of real estate securities return correlations. However, the importance of "real estate" factors in explaining correlations varies across the economies studied and is thus country-specific.

A number of differences from the earlier literature follow from our studies. First, GARCH based conditional correlation estimates can accounts for heteroskedasticity in finance data, while unconditional correlation could be biased during crisis period. This chapter will report the correlation determinant results using the two different correlation estimates (i.e. conditional and unconditional) in both the US and local dollar denominations. The results are largely similar using the two different types of correlation measurements.

Second, the model this chapter proposed casts a wider net in term of state variables in the study of correlation determinants since the use of lower frequency; i.e. quarterly frequency data allowed us to do so. In addition to some usual macroeconomic and stock market state variables which are considered "control" variables in this study, I include five "real estate" state variables to assess whether they are significant and the extent of their importance in explaining across-market real estate securities return correlations. As pointed out above, the examination of these five "real estate" variables distinguishes my work from the previous stock market literature. For the stock market variables, I include stock market correlation, a global stock return factor, an institutional quality variable and a crisis factor. In total, I consider 19 state variables in the chapter[10]. They will be explained later in the study.

Third, the set of 18 pairwise conditional correlation equations (from the eight economies) is estimated as a pooled cross-sectional time series model, controlled for unobserved heterogeneity and cross-sectional dependence using panel random effects and feasible GLS estimators. We also use Arellano-Bond dynamic GMM as a robustness check. This econometric analysis is conducted on a quarterly dataset dominated both in the US dollars and in the home currency. Additional robustness check on the pooled sample involves the use

[10] In comparison, Bracker and Koch (1999) considered 14 variables (excluding three seasonality factors; instead we have made seasonable adjustment to all quarterly data using Census 12 method prior to formal investigation), Pretorius (2002) considered 15 factors (excluding seasonality variables), Beine and Candelon (2010) considered 13 variables, and Wati (2011) considered 10 factors, in their studies respectively.

of unconditional returns to estimate the pairwise correlations. Finally, the correlation model is employed to generate out-of-sample forecasts of the conditional correlation structure. The outcomes from these empirical implementations should strengthen support to the validity of the model in explaining and forecasting the correlation structure for sample dataset and is an evidence of a modest methodological contribution in international real estate research.

Fifth, PCA permits an objective evaluation of the impact of the "real estate" variables on the correlation structure, thus identifying appropriately the incremental change in explanatory power of the correlation model through the addition of the "control" principal components to the information variable set. In this way, results from the combined use of panel regression and PCA in establishing the role of the selected "real estate" variables are robust and more convincing.

This chapter proceeds at follows. Section 2 presents an economic theory of real estate securities return co-movement. This is followed by Section 3 where the eight developed real estate securities markets and a discussion of an empirical model that includes various determinants of real estate securities correlation structure are introduced. Section 4 reports the empirical results on correlation dynamics and significant driving forces. Section 5 concludes the chapter.

4.2 Research Design

4.2.1 Data

The securitized real estate markets in the GC market, five other developed markets (US, UK, Australia, Japan and Singapore) are investigated in this study. As many of the selected macroeconomic variables are only available quarterly, we employ daily returns to construct and match a quarterly conditional and unconditional time series of the correlation matrices and conduct the analysis quarterly in home currency, as well as in the US dollar term (explained in the next section).

4.2.3 Methodology

Two steps includes in the methodology part. Firstly, using ADCC-GARCH model, the dynamic conditional correlation pairs are estimated for eight real estate securities in both local currency and US dollars. The detail of the method is stated in last chapter. Then in the second step, we explore why the correlational interdependence varies intensity over time by focusing on the role of five real estate factors. The relevant methodologies are briefly explained below.

Modeling of correlation structure

Given the stock market results of Bracker and Koch (1999), Pretorius (2002) and others, it is clear a set of macroeconomic and stock market variables is related to the level of integration of the stock markets of the developed/developing countries. Moreover, based on the exposition of the theoretical reasons why cross-market correlations between real estate securities markets could exist in theoretical framework, I include four key considerations governing the selection of the correlation factors and their proxies; (a) major real estate factors (i.e. industry-specific factors) that are potentially important for the development of global real estate securities markets and could thus possibly influence the extent of market interdependence over time; (b) that changes over time in the economic factors that determine stock market returns are also the potential determinants of changes in real estate securities market correlations over time. These variables have been used by relevant stock market studies and they will be considered as control factors in our securitized real estate research; (c) availability of relevant and complete time series proxies and data from 1995Q1 to 2011 Q4 (68 quarters), and (d) development of parsimonious models in order to reduce potential multicollinearity among the various selected factors. Finally, I am guided by economic theory that provides *a priori* information about some relevant variables and their signs of the coefficients. For the purpose of this study, all variables are categorized into “real estate”, “macroeconomic”, “stock market”, “Institutional development” and others. Table 10 provides the list of selected 19 factors, their measurement proxy and expected signs of coefficients. They are:

(a) **Real estate factors**: size differential of real estate securities market (LNRESIZE), real estate securities market volatility differential (REVOL), underlying direct real estate return performance differential (DIRECT), co-existence of real estate investment trusts (DREIT) and global real estate securities market volatility (GREV)

(b) **Control factors** (macroeconomic/stock market/institutional development/others): growth differential in gross domestic product (GDPG), actual inflation differential (INF), real interest rate differential (INT), term structure premium differential (TS), bilateral exchange rate return (EX), bilateral exchange rate volatility (VEX), bilateral trade intensity (TRADE), growth in money supply differential (MSG), global stock market return (GST), stock market correlation (STCOR), institutional quality differential v(IS)[11], crisis dummy (DCRISIS)[12], region effect (DREG)[13] and correlation time trend (LNTREND)[14]

---

[11] We consider the different stages of market development, variations in market transparency and institutional differences among the sample markets, although they are broadly classified as developed markets. Towards this end, we use the World Bank Governance indicators which cover six aspects of institutional quality (IS) - voice and accountability; political instability and violence; government effectiveness; regulatory quality; rule of law and control of corruption. We compute a simple average of these six indices as a proxy for aggregate institutional quality. The absolute value of the average (IS) differential between two economies could have a negative relationship with the correlation of their real estate securities markets. The underlying argument is that two real estate securities markets could be potentially correlated if minimal institutional obstacles to cross-border real estate capital flows are present.

[12] Based on the theory of contagion, we include a crisis dummy (DCRISIS) to denote the Asian financial crisis periods (1997Q3-1999Q4) and global financial crisis periods (2007Q3-2009Q4). This dummy variable is used to test the (structural) effect of the 1997 AFC and 2008 GFC on the correlations; i.e. whether the average level of correlation was higher during the two crisis periods.

[13] Stock markets within a region can be interdependent due to geographical proximity, policy coordination or contagion effect. Therefore, the correlation between two economies that are in the same region (North Americas, Europe and Asia-Pacific) might be higher than that of two economies in different regions. I include a region dummy (DREG) to recognize this possibility.

[14] Similar to stock markets, real estate securities market correlations are expected to be higher over time due to increasing globalization and securitization, increasing stock market correlation and ongoing

Combiningall 19 variables, the final empirical regression model (4.1) is specified below:

$$\rho_{ijt} = \lambda_0 + \lambda_1 \left|LNRESIZE_i - LNRESIZE_j\right|_t + \lambda_2 \left|REVOL_i - REVOL_j\right|_t + \lambda_3 \left|DIRECT_i - DIRECT_j\right|_t$$
$$+ \lambda_4 DREIT_{ijt} + \lambda_5 GREV_t + \lambda_6 \left|GDP_i - GDP_j\right|_t + \lambda_7 \left|INF_i - INF_j\right|_t + \lambda_8 \left|INT_i - INT_j\right|_t$$
$$+ \lambda_9 \left|TS_i - TS_j\right|_t + \lambda_{10} \left|MSG_i - MSG_j\right|_t + \lambda_{11} EX_{ijt} + \lambda_{12} VAREX_{ijt} + \lambda_{13} TRADE_{ijt} + \lambda_{14} GST_t$$
$$+ \lambda_{15} STCOR_{ijt} + \lambda_{16} \left|IS_i - IS_j\right|_t + \lambda_{17} DCRISIS_t + \lambda_{18} LNTREND_i + \lambda_{19} DREG_{ijt} . + \varepsilon_{ijt} \text{..........(1)}$$

where ρ_{ijt} is the estimated (conditional/unconditional) correlation between two real estate securities markets i and j at quarter t and ε_{ijt} is the error term, assumed to be iid.

Table 10 Explanatory Variables employed in the Study

Group	Variable	Represented by	Measured by	Expected sign of association with correlation
Real estate	Size differential of real estate securities markets	*LNRESIZE* $_{ijt}$	Absolute LNRESIZE differential between the two economies' real estate securities markets during quarter t. LNRESIZE is calculated as: LN{$(MCAP)_{\text{real estate}}/(MCAP)_{\text{gdp}}$}	Negative
	Real estate securities market volatility differential	*REVOL* $_{ij}$	Absolute REVOL differential between the two securitized real estate markets during quarter t; REVOL is the quarterly return variance	Negative
	Direct real estate market performance return differential	*DIRECT* $_{ijt}$	Absolute DIRECT differential between the two economies' orthogonalized real estate securities markets during quarter t. For each economy, DIRECT is calculated as the residuals (ε_t) from the regression: $(\text{Re}turn)_{re,t} = \alpha + \beta(return)_{stock,t} + \varepsilon_t$	Negative
	Co-existence of REIT influence	*DREIT* $_{ijt}$	Dummy equals 1 if both stock markets have a REIT structure during quarter t; 0 otherwise.	Positive
	Global real estate securities market volatility	*GREV* $_t$	Variance of daily global real estate securities market index (extracted from S&P Global Property) return during quarter t	Positive

relaxation of foreign exchange control policies. The coefficient of a linear time trend (LNTREND) should hence have a positive sign.

Macro-economic	Growth differential in gross domestic product	*GDP* $_{ijt}$	Absolute GDP growth differential between the two economies during quarter t.	Negative
	Inflation differential	*INF* $_{ijt}$	Absolute INF differential between the two economies during quarter t; INF is estimated from consumer price index during quarter t	Negative
	Real interest rate differential	*INT* $_{ijt}$	Absolute INT differential between the two economies during quarter t; INT is represented by the 3-month interbank rate in each economy during quarter t.	Negative
	Term structure premium differential	*TS* $_{ijt}$	Absolute TS differential between the two economies during quarter t. The TS is defined as the difference between long-term and short-term government bond rates in a country during quarter t	Negative
	%Change in the monetary aggregate differential	*MS* $_{ijt}$	Change in absolute MS growth differential be the two economies during quarter t……..	Negatrive
	% change in the bilateral exchange rate	*EX* $_{ijt}$	Change in bilateral exchange rate during quarter t	Negative
	Variability in exchange rate	*VAREX* $_{ijt}$	Variance in daily exchange rate during quarter t	Negative
	Bilateral trade openness	*TRADE* $_{ijt}$		Positive
Stock market	Global stock market returns	*GST* $_{t}$	Percent change in global stock market (proxied by S&P BMI) index during quarter t	Negative
	Stock market integration	*STCOR* $_{ijt}$	Correlations between the two corresponding stock markets during quarter t	Positive
	Regional effect	*DREG*$_{ij}$	Dummy equals 1 if both stock markets are in the same region (North America/Europe/Asia); 0 otherwise.	Positive
Institutional development	Institutional quality differential	*IS* $_{ijt}$	Absolute IS differential between the two economies during quarter t. IS covers six aspects: voice and accountability; political instability and governance; government effectiveness; regulatory quality; rule of law and control of corruption (World Bank Governance Indicators – WBGI). Represented by a simple average of the six indices as proxy for aggregate institutional quality	Negative
Others **Crisis dummy**	Financial crisis periods	*DCRISIS* $_{t}$	Dummy equal to 1 for Asian financial crisis periods (1997Q3-1999Q4) and global financial crisis periods (2007Q3-2009Q4), 0 otherwise	Positive
Others **Time dummy**	Non-linear trend	*LNTREND*	Quarterly non-linear time trend	Positive

Empirical estimation

(a) For the 18 pairs of real estate securities markets, I have computed the conditional correlations over each quarter (ρ_{ijt}) between 1995Q1 and 2011Q4 from the time series of daily returns.

(b) The variables are first tested for their stationary property using three panel unit root tests; the Harris-Tzavalis (1999), Breitung (2000) and Im-Pesaran-Shin (2003) tests. These three tests have as the null hypothesis that all 18 cross-sections contain a unit root. Furthermore, all the variables have been accounted for potential quarterly seasonality using Census 12 prior to formal analysis.

(c) I test for the sign and significance of λ_1 to λ_5 by entering the five real estate indicators without control variables first then with all other control variables. The regression series are estimated in three different ways, for both local dollar and US dollar returns. First, all 18 equations is estimated as a pooled cross-sectional time series model to minimize unobserved panel-level effects, thus constraining all regression coefficients, except the intercepts, to be identical across all 18 equations. As the Hausman test indicates the GLS random effect estimator is better than a within estimator for fixed effect models, the coefficients with a GLS estimator is first estimated for random effects model.[15] A feasible generalized least square (FGLS) is also used to account for cross-sectional correlation dependence and possible heteroskedasticity across panels (i.e. the variance for each of the panels differs), as well as a consistent generalized method of moment (GMM) estimator (Arellano and Bond, 1991) to

[15] The pooled OLS solution is not practical since it might be overly restrictive and can have a complicated error process (such as heteroskedasticity across panel units and serial correlation within panel units). In contrast the fixed-effects (FE) and random-effects (RE) models allow for heterogeneity across units but confine the heterogeneity to the intercept terms of the relationship. Please consult the standard econometric texts for the differences between FE and RE models. Further, a Hausman test is conducted to confirm whether the regressors are uncorrelated with the individual level effect (then the RE estimator is consistent and efficient) or if the regressors are correlated with the individual-level effect (then the FE estimator is preferred).

provide alternative coefficient estimates. The dynamic panel GMM model is implemented to render the unobserved panel effects orthogonal to the one-quarter lagged correlation variable, as well serves a robustness check on the pooled sample specification. Finally, whether using unconditional correlation measures produce different results is tested.

(d) Following Bracker and Koch (1999), I compare the out-of sample forecasting ability of the realized correlation models (for both local dollar and US dollar returns) with four other alternative forecasting models (no change model; historical average model, ARIMA model and Bayes model).[16] The performance of these five models is evaluated on the basis of achieving minimum root mean square error (RMSE) and a Theil decomposition of the MSE into bias, variance and covariance proportions (Pindyck and Rubinfield, 1998).

(e) The above pooled regression analysis is unable to address the problems of multicollinearity completely as some explanatory variables are highly correlated. Hence I appeal to PCA to estimate the relative importance of the five real estate factors in jointly explaining the real estate securities market correlation structure[17]. Briefly, the real estate and control variables are subject to the PCA in sequence to derive the “real estate” and “control” components, which are then used as explanatory factors into a stepwise regression analysis in order to identify those significant principal components that are the eventual “driving forces” of real estate correlation structure over time.

---

[16] Following Bracker and Koch (1999), the “no change” model employs the one-step forecast correlation from the previous quarter. The “historical average” specification uses the average one-step forecast correlation over the previous eight quarters. The third model develops an individual ARIMA specification to forecast one-step ahead. The Bayes approach regresses each bilateral correlation toward the overall mean across all correlations of the previous quarter. Finally, the fitted values from the correlation model (equation 1) (our model) are used to forecast one-step ahead correlation..

[17] Principal components analysis is a method which significantly reduces the number of explanatory variables from k to a much smaller set of p derived orthogonal variables that retain most of the information in the original k variables. The p derived components (factors) maximize the variance accounted in the original variables.

4.3 Empirical Result

Correlation determinants

All-time series variables are first tested for their stationary property using panel unit root tests in table 11(Panel Unit Root Test Results). With minor exceptions, all two panel unit root processes (both the common unit root process (Levin, Lin and Chu t-stat) and individual unit root process (Im, Pesaran and Shin W-stat) have consistently rejected the null of a unit root in the respective variables. Since all variables in the regression are stationary, the assumptions of classic regression analysis are fulfilled. Consequently, I proceed to the regression analysis.

Table 11Panel Unit Root Test Results: 1995Q1 – 2011Q4

Variable	Levin, Lin & Chu t-stat (common unit toot process)	Im, Pesaran and Shin W-stat (individual unit root process)
LNRESIZE	-2.13574 *	-1.44377*
REVOL	-1.72200*	2.05505
DIRECT	-7.26171*	-10.0278 *
GREV	-5.25354*	-5.39551*
GDP	-7.37778*	-18.4038*
INF	-5.61274*	-12.0855*
INT	-7.43452*	-8.60830*
TS	-5.12065 *	-4.47836*
EX	-1.57083*	-10.0200*
VAREX	-7.19940*	-13.2704*
TRADE	-18.3010 *	-14.9704*
MS	-4.45641*	-12.2968*
STCOR	-10.0223*	-12.7023*
GST	-8.89905*	-19.1522 *
IS	-13.8318 *	-8.33217 *

Notes: *The null is a unit root process. * - indicates the null is rejected at least at the 5% level*

Table 13 (Results of Pooled Time Series and Cross-Sectional Regression Analysis: 1995Q1-2011Q4) reports the results (in both local currency and US dollar returns) of estimating

Equation 1 using a generalized least squares (GLS) estimator for random effect model, FGLS model and dynamic GMM model. The dependent variable is the conditional correlation coefficient. For each estimation method, two different models are estimated. The first column is pure real estate model and the second one is real estate factors with control variables model. The first models for both local currency and US dollar returns are estimated by GLS with a random effect using five real estate factors without control variables. The results show that all five selected real estate indicators are statistically significant in explaining the correlations of real estate securities market returns. Moreover, the sign of the estimates are as expected: an increase in the global real estate securities volatility (GREV) and the co-existence of REIT influence (DREIT) increases the correlation of real estate securities returns, while the relative real estate securities market size differential (LNRESIZE), real estate securities market volatility differential (REVOL) and underlying direct real estate return performance differential (DIRECT) decrease the correlation of real estate securities returns. These five real estate variables jointly explain between 7.6% (local dollars) and 7.5% (US dollars) of the variation in the correlation coefficients of real estate securities market returns. After adding the control variables (macroeconomic, stock and other factors), the significance of real estate variables has been reduced. REVOL, GREV and DREIT become insignificant, while the significance level of DIRECT effect reduced to 10% (US dollar model). LNRESIZE becomes insignificant in US dollars model. Significant control variables for both US dollar and Local currency return correlations are bilateral trade (TRADE), cross-stock market correlation (STCOR) and the financial crisis dummy (DCRISIS). The influence of all these significant control variables is consistent to the requirements of the economic theory. Overall, the chosen independent variables (real estate and control factors) offer substantial explanatory power on the time series movement in the realized correlation structure (Adjusted R2 is 0.681 and 0.748, respectively for home currency and US dollar returns).Finally, the estimation results suggests that macroeconomic variables such as GDP, inflation and interest rate differentials are not significant in explaining real estate securities return correlation, an outcome which appears to be inconsistent with the requirements of economic theory. One possible reason is that these macroeconomic variables could be highly correlated with each other or with other explanatory variables, thus causing some regression results to be counter-intuitive.

Since dependent variable is a measure of real estate securities market correlation, the degree of cross-sectional dependence can be expected to be high. Therefore I employ the FGLS estimation which controls for cross-sectional dependence and heteroscedasticity. I also estimate the dynamic panel model with the GMM estimator developed by Arellano and Bond (1991) as a robustness check. Most of the five real estate factors are significant in FGLS model and the entire coefficient fits the previous hypothesis. For both FGLS and GMM models, TRADE, STCOR, DCRISIS and DREG[18] are significant, which is consistent with results of GLS with random effect. Term spread differentials (TS) are significant for three models out of four. Overall, the similar results obtained from the random effect model, FGLS and GMM estimations allow me to claim that our findings are robust to some specific econometric issues.

In summary, the estimated panel regression models have provided some preliminary evidence that real estate securities market correlation across the GC areas and their international partners could be influenced by the following factors:

(a) Among the five real estate factors, size differential of public real estate market (LNRESIZE), direct real estate market return difference (DIRECT) and coexistence of REIT influence (DREIT) are significant real estate factors across all six pure real estate models. Real estate securities market volatility (REVOL) is significant for 4 out of 6 models and global public real estate market volatility (GREV) is only significant for 1 out of 6 models.

(b) For the control variables, bilateral trade openness (TRADE), stock market integration (STCOR) and financial crisis period (DCRISIS) are all positively related with correlation structure for all six models.

[18] Dreg is omitted in GMM model for collinearity problem.

(c) Institutional quality differential (IS) and term spread differential (TS) are negatively related with correlation structure for 4 out of 6 and 3 out of 6 panel models

In addition, there is also some indication from the results that:

(e) Size differential of public real estate market (LNRESIZE) is negatively associated with the correlation structure, indicating that if real estate size of two markets are close, then the correlation between the two markets would be large. Direct real estate market return difference (DIRECT) is negatively related with correlation structure. This results mean if returns from underlying property market between two markets are closer, the more correlated two securitized real estate markets would be. The REIT factor (DREIT) is positively associated with the correlation structure. This result implies that the correlation between two real estate securities markets that have a REIT market structure during quarter t could be higher than that of two markets that behave otherwise. Further research could be conducted to test for the significance of this REIT factor across other international real estate securities markets.

A final robustness check involves using an alternative measure of real estate securities market correlation. Table 14 (Results of Pooled Time Series and Cross-Sectional Regression Analysis: 1995Q1-2011Q4) repeats the estimation by using the unconditional quarterly correlation coefficient (unconditional correlation). From the results of real estate factor models without control variables, all the estimation methodologies confirm that REVOL, GREV and DREIT are significant in explaining dynamic securitized real estate correlations. On the whole, the results obtained with the unconditional correlation measures are similar to those with the conditional correlation, although the conditional correlation results appear stronger. Among all control variables, TS, STCOR and DCRISIS are significant for all three estimations in both local currency and US dollars. Real GDP differential (RGDP), Global stock returns (GST), Institutional differential (IS) and linear trend (Trend) show strong explanation power for correlation changes for all the six models, the coefficient is also consistent with economic theory. To a lesser extent, Volatility of bilateral exchange rate changes (VAREX) explains certain correlation changes in 18 securitized real estate pairs for three models out of six. Two models confirm that TRADE and Money supply differential (MS) can significantly explain dependent variable.

Table 15 (Evaluation of Forecasting Results) compares the one-step-ahead forecasting ability of the correlation model (equation 1) with that of other four specifications.[19] As the numbers in Table 15 indicates, the strongest forecast performance in terms of RMSE is given by the correlation model (equation 1) for the years 2009, 2010, 2011 (both home currency and US dollar returns).

Following standard econometric procedures, the Theil decomposition (U) of the RMSE is partitioned into three components: bias (U_b), variance (U_v) and covariance (U_c)[20]. In terms of theil decomposition, the economic model (equation 1) doesn't outperform other classic models for all the components.

---

[19] Following Bracker and Koch (1999), the "no change" model uses the correlation from the previous quarter as forecast; the "historical" model uses the average correlation over the previous eight quarters; the "ARIMA" model is used to forecast one-quarter ahead; the "Bayes" approach regresses each bilateral correlation toward the global mean across all correlations of the previous quarter; and our model uses the fitted values from equation 1 to forecast one-quarter ahead,

[20] According to Pindyck and Rubinfield (1998), the three components should sum to 1. Moreover, the optimal foresting model should ideally yield values of U_b and U_v should be small so that most of the bias is concentrated on the covariance proportions.

Table 12 Results of Pooled Time Series and Cross-Sectional Regression Analysis: 1995Q1-2011Q4 (Dependent Variable: Conditional Correlation)

	Local Currency						US dollar					
	Random GLS		FGLS		dynamic GMM		Random GLS		FGLS		dynamic GMM	
LNRESIZE	-0.0324*	-0.0202*	-0.00503***	-0.0109***	-0.0186***	-0.0109***	-0.0331*	-0.0202	-0.00483***	-0.0222***	-0.0205***	-0.0132***
REVOL	-15.40***	5.215	-8.313***	0.496	-2.878	6.973	-23.17***	1.535	-6.982**	-3.293	-10.02	2.381
DIRECT	-12.72***	-5.578***	-2.317***	-2.222***	-7.631***	-3.435***	-6.191***	-2.722*	-0.772	-4.378***	-5.405***	-2.684***
GREV	0.164	0.0936	0.815	0.384	-0.311	0.225	0.533*	0.0327	0.701	-0.0277	0.0633	0.498
DREIT	0.111***	0.0206	0.0490***	0.00784	0.0696***	0.0116*	0.129***	0.0326	0.0689***	0.0203**	0.0789***	0.0193***
GDP	-	0.00160	-	0.0106	-	-0.0305	-	-0.00739	-	0.0509	-	-0.0305
INF	-	-0.0422	-	-0.0137	-	-0.0460	-	-0.0999	-	0.00446	-	-0.0714
INT	-	0.104	-	0.0402	-	-0.0419	-	0.226*	-	0.178*	-	0.0807
TS	-	-0.422	-	-0.388***	-	-0.445**	-	-0.625	-	0.0922	-	-0.522**
EX	-	-0.0199	-	0.0308	-	-0.0365	-	0.00227	-	0.0793	-	-0.00379
VAREX	-	-0.245	-	0.122	-	0.759	-	0.108	-	-0.113	-	0.729
TRADE	-	0.348***	-	0.218***	-	0.327***	-	0.443***	-	0.0983***	-	0.400***
MS	-	-0.00537	-	-0.00453	-	-0.00523	-	-0.00576	-	-0.00992	-	-0.00567
STCOR	-	0.538***	-	0.470***	-	0.455***	-	0.558***	-	0.659***	-	0.498***
GST	-	-0.929	-	-2.017*	-	-1.046	-	0.0856	-	0.183	-	0.925
IS	-	-0.0137	-	-0.0186***	-	-0.0255**	-	-0.0271	-	-0.0154***	-	-0.0426***
DCRISIS	-	0.0344***	-	0.0159***	-	0.0394***	-	0.0315***	-	0.0261***	-	0.0388***
DREG	-	0.00618	-	0.0259***	-	0	-	0.0141	-	0.0248***	-	0
TREND	-	0.000126	-	-8.45e-06	-	1.95e-05	-	0.000142	-	0.000168	-	-4.73e-05
R-SQ	0.0766	0.6814	-	-	-	-	0.0748	0.6497	-	-	-	-

Notes: Five real estate factors LNRESIZE(size differential of public real estate market), REVOL(Real estate securities market volatility), direct(direct real estate market return difference),GREV(global public real estate market volatility) and DREIT(coexistence of REIT influence). Thirteen control variables, they are GDP (Growth differential in real gross domestic product), INF(inflation differential), INT(real estate rate differential), TS(term structure premium differential), EX(change in bilateral exchange rate),VAREX(variability in exchange rate), TRADE(bilateral trade openness), MS(change in the monetary aggregate differential), STCOR(stock market integration), GST(global stock market returns), IS(institutional quality differential), DCRISIS(financial crisis periods) and DREG(regional effect).

Table 13 Results of Pooled Time Series and Cross-Sectional Regression Analysis: 1995Q1-2011Q4 (Dependent Variable: Unconditional Correlation)

	Local Currency						US dollar					
	Random GLS		FGLS		dynamic GMM		Random GLS		FGLS		dynamic GMM	
LNRESIZE	-7.57e-06	0.00129	0.00340	0.00371	0.00318	0.00887	-0.00107	-0.000972	0.00226	0.00268	0.000220	0.00431
REVOL	-62.90***	7.129	-98.21***	2.402	-31.03***	17.66**	-63.01***	3.776	-94.64***	-3.744	-32.60***	18.71**
DIRECT	-5.901***	-1.333	-7.165**	-1.020	-2.753	-0.139	-3.173*	0.639	-2.407	-0.522	-1.612	0.912
GREV	20.03***	6.916***	20.99***	6.303***	13.00***	4.449***	21.16***	6.582***	21.99***	6.370***	14.06***	4.216***
DREIT	0.0702***	-0.00791	0.0487***	0.00563	0.0595***	-0.00198	0.0644***	-0.0140	0.0456***	-0.00809	0.0550***	-0.00575
RGDP	-	-0.0660**	-	-0.0739*	-	-0.0727	-	-0.0782***	-	-0.0968**	-	-0.0995**
INF	-	-0.313**	-	-0.170	-	-0.240	-	-0.144	-	0.0156	-	-0.0272
INT	-	0.204	-	0.155	-	0.217	-	-0.0180	-	-0.0564	-	-0.0329
TS	-	-1.325***	-	-1.065***	-	-1.255***	-	-0.903*	-	-0.774***	-	-1.049***
EX	-	0.125	-	0.0494	-	0.0743	-	0.0970	-	0.0303	-	0.0421
VAREX	-	-1.342***	-	-1.635*	-	-1.052	-	0.273	-	-1.353*	-	0.106
TRADE	-	0.0618	-	0.0927***	-	0.0467	-	0.0670	-	0.0709***	-	0.0484
RMS	-	-0.0124**	-	-0.00814	-	-0.00377	-	-0.0114**	-	-0.00471	-	-0.00794
STCOR	-	0.595***	-	0.586***	-	0.538***	-	0.617***	-	0.617***	-	0.544***
GST	-	-2.801	-	-6.990**	-	-5.427*	-	-4.178*	-	-5.132*	-	-5.457**
IS	-	-0.0309**	-	-0.0260***	-	-0.0328*	-	-0.0282**	-	-0.0220***	-	-0.0237
DCRISIS	-	0.0292***	-	0.0349***	-	0.0295***	-	0.0183*	-	0.0261**	-	0.0175**
DREG	-	0.0202	-	0.0107	-	0	-	0.0258	-	0.0325***	-	0
TREND	-	0.000516	-	0.000627*	-	0.000552**	-	0.000715	-	0.000701**	-	0.000977***
R-SQ	0.2278	0.6271	-	-	-	-	0.259	0.6598	-	-	-	-

Notes: Five real estate factors LNRESIZE(size differential of public real estate market), REVOL(Real estate securities market volatility), direct(direct real estate market return difference),GREV(global public real estate market volatility) and DREIT(coexistence of REIT influence). Thirteen control variables, they are GDP (Growth differential in real gross domestic product), INF(inflation differential), INT(real estate rate differential), TS(term structure premium differential), EX(change in bilateral exchange rate),VAREX(variability in exchange rate), TRADE(bilateral trade openness), MS(change in the monetary aggregate differential), STCOR(stock market integration), GST(global stock market returns), IS(institutional quality differential), DCRISIS(financial crisis periods) and DREG(regional effect).

Table 14Evaluation of Forecasting Results

		local currency returns					US dollar returns				
	period	No change	Historical	ARMA	Bayes	Our model	No change	Historical	ARMA	Bayes	Our model
RMSE	2011q1	0.11953	0.13415	0.21531	0.13863	**0.08595**	0.12029	0.13463	0.22932	0.13673	**0.08517**
	2011q2	0.11981	0.13314	0.21022	0.13948	**0.08718**	0.12059	0.13359	0.22351	0.13721	**0.08489**
	2011q3	0.11995	0.13203	0.20936	0.14021	**0.08740**	0.12099	0.13248	0.18352	0.13783	**0.08556**
	2011q4	0.12108	0.13222	0.21158	0.14112	**0.08771**	0.12141	0.13257	0.18323	0.13856	**0.08567**
	2009	0.11025	0.12900	0.20833	0.13394	**0.08261**	0.11331	0.12995	0.21821	0.13338	**0.08247**
	2010	0.11590	0.12874	0.20888	0.13744	**0.08448**	0.11731	0.12951	0.22420	0.13605	**0.08369**
	2011	0.12009	0.13289	0.21162	0.13986	**0.08706**	0.12082	0.13332	0.20490	0.13758	**0.08532**
U	2011q1	0.24031	**0.14646**	0.25720	0.28157	0.16644	0.23394	**0.14664**	0.27250	0.26778	0.15865
	2011q2	0.23846	**0.14468**	0.24450	0.28084	0.16749	0.23268	**0.14476**	0.25698	0.26673	0.15773
	2011q3	0.23494	**0.14210**	0.23744	0.27876	0.16560	0.23016	**0.14213**	0.19220	0.26472	0.15739
	2011q4	0.23192	**0.14021**	0.23311	0.27540	0.16350	0.22614	**0.14011**	0.18973	0.26147	0.15509
	2009	0.23354	**0.15369**	0.25376	0.29080	0.17086	0.23322	**0.15469**	0.26479	0.27952	0.16511
	2010	0.23589	**0.14236**	0.23819	0.28480	0.16685	0.23096	**0.14301**	0.25586	0.27150	0.15969
	2011	0.23640	**0.14336**	0.24306	0.27914	0.16576	0.23073	**0.14341**	0.22785	0.26518	0.15722
Ub	2011q1	0.00160	0.00058	0.00029	0.00000	**0.00005**	0.00065	0.00054	0.00036	**0.00000**	0.00016
	2011q2	0.00172	0.00008	0.00577	**0.00001**	0.00012	0.00054	0.00007	0.00361	0.00001	**0.00000**
	2011q3	0.00252	**0.00001**	0.01520	0.00004	0.00005	0.00083	**0.00001**	0.16631	0.00005	0.00010
	2011q4	0.00478	0.00033	0.02799	0.00002	**0.00006**	0.00206	0.00030	0.14728	**0.00002**	0.00007
	2009	0.00917	0.00023	0.06642	0.00001	**0.00004**	0.00447	0.00023	0.05503	**0.00001**	0.00006
	2010	0.00477	0.00071	0.06257	0.00001	**0.00006**	0.00264	0.00069	0.03819	**0.00001**	0.00010
	2011	0.00265	0.00025	0.01231	0.00002	**0.00007**	0.00102	0.00023	0.07939	**0.00002**	0.00008
Uv	2011q1	0.45260	**0.06705**	0.47602	0.32057	0.08685	0.40623	**0.06717**	0.63676	0.29182	0.08286
	2011q2	0.45179	**0.08045**	0.43205	0.32200	0.08973	0.40922	0.08027	0.57445	0.29400	**0.07836**
	2011q3	0.44488	**0.08781**	0.40283	0.32124	0.08947	0.40582	0.08727	0.35597	0.29401	**0.08523**
	2011q4	0.41798	0.09668	0.38243	0.30778	**0.08970**	0.38429	0.09541	0.38093	0.28277	**0.08511**
	2009	0.44383	**0.07063**	0.29721	0.33286	0.09690	0.40868	**0.07108**	0.48757	0.30806	0.08687
	2010	0.44422	**0.05569**	0.30700	0.32205	0.08963	0.40195	**0.05638**	0.50208	0.29288	0.08351
	2011	0.44181	**0.08300**	0.42333	0.31790	0.08894	0.40139	**0.08253**	0.48703	0.29065	0.08289
Uc	2011q1	**0.54580**	0.93238	0.52369	0.67943	0.91311	0.59312	0.93229	**0.36287**	0.70818	0.91698
	2011q2	**0.54649**	0.91947	0.56218	0.67799	0.91015	0.59024	0.91967	**0.42194**	0.70599	0.92165
	2011q3	**0.55260**	0.91219	0.58197	0.67872	0.91048	0.59336	0.91272	**0.47771**	0.70594	0.91468
	2011q4	**0.57724**	0.90299	0.58957	0.69220	0.91024	0.61365	0.90429	**0.47180**	0.71721	0.91482
	2009	**0.54700**	0.92914	0.63636	0.66713	0.90306	0.58685	0.92869	**0.45740**	0.69194	0.91307
	2010	**0.55101**	0.94360	0.63043	0.67795	0.91030	0.59542	0.94293	**0.45973**	0.70711	0.91640
	2011	**0.55553**	0.91676	0.56435	0.68209	0.91099	0.59759	0.91724	**0.43358**	0.70933	0.91703

Notes: the “no change” model employs the one-step forecast correlation from the previous quarter. The “historical average” specification uses the average one-step forecast correlation over the previous eight quarters. The third model develops an individual ARIMA specification to forecast one-step ahead. The Bayes approach regresses each bilateral correlation toward the overall mean across all correlations of the previous quarter.

Importance of real estate factors

As highlighted above, I appeal to PCA to extract the dominant “real estate” and “control” components which are orthogonal to each other in order to minimize the mulcollinearity problems encountered in the pooled regressions reported above. Table 16 (Principle Component of Real Estate Variables and Control Variables) summarizes the PCA results of the two groups of variables considered in the paper. Specifically, the eigenvalues and proportion of variance explained by the principal components for the “real estate” and “control” group for all eighteen market-pair series are reported. Using the Kaiser criterion which recommends only those principal components with latent root (eigenvalue) greater than one should be retained, the results in Table 17(Principle Component of Real Estate Variables and Control Variables) clearly shows that in all markets examined, the bulk of the variability (between 62.5% and 81.6%) in the original five real estate variables can be explained by two principal components. In the case of “control” variables, the dimensionality of the dataset can be reduced from 14 to 4, 5 or 6 principle components. These dominant principal components jointly accounted between 62.6% and 82.4% of the variability in the original 14 control variables. Results using the US dollar returns are qualitatively similar; in particular, 2 “real estate” principal components and between 4 and 6 “control” principal components were extracted from the dataset.

The extracted dominants principal components, which are highlighted in Tables 16 and 17below, are used as inputs to a stepwise regression analysis to explain the real estate securities return correlation structure of the eighteen pairs studied. Specifically, the use of the stepwise regression procedure enables me to identify the incremental change in the explanatory power of the model through the addition of the real estate or control principal components to the information variable set, thus determining the significant principal components (whether “real estate” or “control” groups) that will be retained in the regression and the relative importance of real estate factors in explaining their return correlation could thus be evaluated.

Table 15Principle Component of Real Estate Variables and Control Variables (Macroeconomic/Stock Market/Others): 1995Q1-2011Q4 (Local Dollars)

		Principle components							
		Real Estate		Control					
country	measure	1	2	1	2	3	4	5	6
CH-HK	Eigenvalue	1.696	1.272	4.444	2.082	1.268	1.111		
	Variance proportion	42.405	31.793	34.188	16.013	9.756	8.543		
	Cumulative variance proportion	42.405	74.198	34.188	50.201	59.957	68.500		
CH-TW	Eigenvalue	1.567	1.247	3.103	2.407	1.440	1.183		
	Variance proportion	39.164	31.179	23.867	18.517	11.075	9.102		
	Cumulative variance proportion	39.164	70.343	23.867	42.385	53.460	62.562		
HK-TW	Eigenvalue	1.951	1.171	3.737	2.929	1.343	1.130		
	Variance proportion	39.019	23.418	28.745	22.529	10.328	8.694		
	Cumulative variance proportion	39.019	62.438	28.745	51.274	61.602	70.296		
CH-JP	Eigenvalue	1.893	1.349	4.004	2.047	1.389	1.149	1.042	
	Variance proportion	47.323	33.715	30.797	15.748	10.684	8.841	8.019	
	Cumulative variance proportion	47.323	81.038	30.797	46.545	57.229	66.071	74.089	
CH-SG	Eigenvalue	1.772	1.427	3.311	2.053	1.420	1.278	1.121	1.006
	Variance proportion	44.306	35.674	25.465	15.789	10.924	9.832	8.621	7.735
	Cumulative variance proportion	44.306	79.980	25.465	41.254	52.178	62.009	70.631	78.365
CH-AU	Eigenvalue	1.636	1.462	3.594	2.987	1.738	1.198		
	Variance proportion	40.912	36.545	27.645	22.974	13.373	9.216		
	Cumulative variance proportion	40.912	77.458	27.645	50.619	63.992	73.208		
CH-US	Eigenvalue	1.997	1.008	3.911	2.597	1.664	1.366	1.008	
	Variance proportion	49.935	25.191	27.935	18.551	11.888	9.755	7.197	
	Cumulative variance proportion	49.935	75.126	27.935	46.486	58.373	68.128	75.326	
CH-UK	Eigenvalue	1.757	1.507	3.378	2.484	1.439	1.144	1.032	
	Variance proportion	43.915	37.676	25.987	19.105	11.072	8.800	7.938	
	Cumulative variance proportion	43.915	81.591	25.987	45.091	56.163	64.963	72.902	
HK-JP	Eigenvalue	2.218	1.288	3.856	2.099	1.409	1.098	1.055	
	Variance proportion	44.368	25.754	29.659	16.148	10.838	8.444	8.116	
	Cumulative variance proportion	44.368	70.122	29.659	45.807	56.645	65.090	73.205	
HK-SG	Eigenvalue	1.800	1.318	3.165	2.963	1.440	1.150	1.058	
	Variance proportion	35.992	26.366	24.348	22.794	11.078	8.847	8.136	
	Cumulative variance proportion	35.992	62.358	24.348	47.143	58.221	67.068	75.204	
HK-AU	Eigenvalue	1.734	1.568	3.968	2.581	1.750	1.311	1.102	
	Variance proportion	34.682	31.352	30.525	19.857	13.458	10.084	8.474	
	Cumulative variance proportion	34.682	66.034	30.525	50.383	63.840	73.925	82.399	
HK-US	Eigenvalue	2.439	1.594	3.528	1.739	1.413	1.324	1.068	
	Variance proportion	48.787	31.880	27.142	13.376	10.869	10.183	8.213	
	Cumulative variance proportion	48.787	80.667	27.142	40.518	51.387	61.570	69.783	
HK-UK	Eigenvalue	2.117	1.325	4.222	2.348	1.640	1.075		
	Variance proportion	42.341	26.493	32.478	18.063	12.613	8.267		
	Cumulative variance proportion	42.341	68.834	32.478	50.541	63.153	71.420		
TW-JP	Eigenvalue	1.849	1.528	3.327	2.549	1.671	1.329		
	Variance proportion	36.985	30.562	25.589	19.604	12.856	10.220		
	Cumulative variance proportion	36.985	67.547	25.589	45.193	58.049	68.270		
TW-SG	Eigenvalue	2.006	1.241	3.494	2.161	1.900	1.158		
	Variance proportion	40.123	24.826	26.876	16.626	14.613	8.907		
	Cumulative variance proportion	40.123	64.949	26.876	43.503	58.116	67.023		
TW-AU	Eigenvalue	1.968	1.334	3.806	2.684	1.658	1.223		
	Variance proportion	39.367	26.688	29.275	20.650	12.755	9.408		
	Cumulative variance proportion	39.367	66.055	29.275	49.925	62.680	72.088		
TW-US	Eigenvalue	2.300	1.379	3.792	2.077	1.435	1.246		
	Variance proportion	46.003	27.580	29.170	15.979	11.038	9.583		
	Cumulative variance proportion	46.003	73.584	29.170	45.149	56.186	65.769		
TW-UK	Eigenvalue	1.888	1.287	3.742	2.593	1.326	1.067		
	Variance proportion	37.765	25.749	28.786	19.943	10.200	8.207		
	Cumulative variance proportion	37.765	63.514	28.786	48.728	58.928	67.136		

Notes: real estate factors are extracted from five real estate factors (LNRESIZE, REVOL, DIRECT,GREV AND DREIT). Control factors are extracted from 14 independent variables (RGDP, INF, INT, TS, EX, VAREX,TRADE,TMS,STCOR,GST,IS,DCRISIS,DREG,TREND).

Table 16Principle Component of Real Estate Variables and Control Variables (Macroeconomic/Stock Market/Others): 1995Q1-2011Q4 (US Dollars)

		Principle components						
		Real Estate		Control				
country	measure	1	2	1	2	3	4	5
CH-HK	Eigenvalue	1.639	1.323	4.305	2.316	1.309	1.052	
	Variance proportion	40.973	33.069	33.116	17.819	10.071	8.091	
	Cumulative variance proportion	40.973	74.042	33.116	50.935	61.006	69.097	
CH-TW	Eigenvalue	1.593	1.127	3.049	2.498	1.420	1.405	1.001
	Variance proportion	39.832	28.176	23.457	19.218	10.923	10.805	7.703
	Cumulative variance proportion	39.832	68.008	23.457	42.676	53.598	64.403	72.106
HK-TW	Eigenvalue	1.942	1.226	3.768	3.036	1.243	1.078	
	Variance proportion	38.832	24.515	28.985	23.355	9.562	8.294	
	Cumulative variance proportion	38.832	63.347	28.985	52.340	61.903	70.197	
CH-JP	Eigenvalue	1.698	1.360	4.047	2.130	1.369	1.290	
	Variance proportion	42.451	34.000	31.128	16.382	10.531	9.920	
	Cumulative variance proportion	42.451	76.452	31.128	47.510	58.041	67.961	
CH-SG	Eigenvalue	1.652	1.375	3.368	2.258	1.355	1.257	1.163
	Variance proportion	41.293	34.368	25.908	17.366	10.423	9.670	8.949
	Cumulative variance proportion	41.293	75.661	25.908	43.274	53.697	63.367	72.315
CH-AU	Eigenvalue	1.694	1.349	3.567	2.939	1.784	1.433	
	Variance proportion	42.338	33.715	27.441	22.606	13.723	11.027	
	Cumulative variance proportion	42.338	76.052	27.441	50.048	63.770	74.797	
CH-US	Eigenvalue	1.978	1.020	3.292	2.477	1.852	1.307	
	Variance proportion	49.438	25.493	25.323	19.052	14.245	10.053	
	Cumulative variance proportion	49.438	74.932	25.323	44.374	58.619	68.672	
CH-UK	Eigenvalue	1.729	1.485	3.345	2.504	1.488	1.283	
	Variance proportion	43.234	37.114	25.733	19.264	11.447	9.872	
	Cumulative variance proportion	43.234	80.349	25.733	44.996	56.443	66.315	
HK-JP	Eigenvalue	2.127	1.178	3.827	2.014	1.568	1.129	1.028
	Variance proportion	42.544	23.570	29.442	15.494	12.059	8.685	7.910
	Cumulative variance proportion	42.544	66.114	29.442	44.937	56.996	65.680	73.591
HK-SG	Eigenvalue	1.590	1.516	3.213	3.078	1.478	1.059	1.037
	Variance proportion	31.806	30.314	24.718	23.676	11.373	8.143	7.980
	Cumulative variance proportion	31.806	62.121	24.718	48.395	59.768	67.911	75.891
HK-AU	Eigenvalue	2.060	1.478	4.207	2.666	2.142	1.294	1.135
	Variance proportion	41.203	29.564	30.052	19.044	15.300	9.241	8.109
	Cumulative variance proportion	41.203	70.767	30.052	49.095	64.396	73.637	81.747
HK-US	Eigenvalue	2.588	1.593	3.533	1.984	1.419	1.307	
	Variance proportion	51.752	31.851	27.174	15.261	10.913	10.051	
	Cumulative variance proportion	51.752	83.602	27.174	42.435	53.347	63.398	
HK-UK	Eigenvalue	2.179	1.264	4.221	2.504	1.635	1.050	
	Variance proportion	43.579	25.275	32.472	19.264	12.575	8.078	
	Cumulative variance proportion	43.579	68.854	32.472	51.736	64.311	72.388	
TW-JP	Eigenvalue	1.889	1.363	3.473	2.553	1.705	1.339	
	Variance proportion	37.773	27.256	26.713	19.635	13.113	10.302	
	Cumulative variance proportion	37.773	65.030	26.713	46.349	59.461	69.763	
TW-SG	Eigenvalue	2.217	1.236	3.507	2.192	2.040	1.119	
	Variance proportion	44.331	24.714	26.976	16.859	15.692	8.608	
	Cumulative variance proportion	44.331	69.045	26.976	43.835	59.527	68.135	
TW-AU	Eigenvalue	2.001	1.536	3.841	2.694	1.824	1.129	
	Variance proportion	40.019	30.726	29.547	20.722	14.035	8.685	
	Cumulative variance proportion	40.019	70.745	29.547	50.269	64.304	72.988	
TW-US	Eigenvalue	2.211	1.455	3.817	2.302	1.435	1.236	
	Variance proportion	44.224	29.099	29.360	17.704	11.042	9.510	
	Cumulative variance proportion	44.224	73.323	29.360	47.064	58.106	67.616	
TW-UK	Eigenvalue	1.783	1.376	3.484	2.747	1.629	1.074	
	Variance proportion	35.653	27.525	26.803	21.133	12.528	8.259	
	Cumulative variance proportion	35.653	63.178	26.803	47.936	60.465	68.724	

Notes: real estate factors are extracted from five real estate factors (LNRESIZE, REVOL, DIRECT,GREV AND DREIT). Control factors are extracted from 14 independent variables (RGDP, INF, INT, TS, EX, VAREX,TRADE,TMS,STCOR,GST,IS,DCRISIS,DREG,TREND).

Table 18 (Results of Multiple Regression Analysis (Stepwise) For 18 Conditional Correlation Pairs in Local Currency) and 19(Results of Multiple Regression Analysis (Stepwise) for 18 Conditional Correlation Pairs in US Dollars) reports the stepwise regression results. In particular, the table details the coefficients and significance level of final principal components (or factors) that are retained by the stepwise regression. The adjusted R2 for the real estate and control, as well as the combined components is also shown. Overall, the proportion of total variance explained by the information set examined in this study was acceptable, ranging between 24.2% and 89.3% for local dollar return regressions; and between 26.5% and 92.5% for the US dollar return regressions. The results also indicates the importance of "real estate" and "control" factors to explain real estate securities return correlation structure varies across the sample economies examined; i.e. they are country-specific. For the local dollar returns, two real estate factors are statistically significant for China-Hong Kong, China-United States and Hong Kong-Japan, with the respective real estate factors able to explain up to 15.8%, 0.021% and 60.9% and of the variation in return correlations. For the rest 15 sample pairs, only 1 real estate factor is important in 8 out of 15 correlation pairs. Whilst the second real estate factor in China with Japan accounts for 77.7% of the variance in real estate securities return correlation. In the remaining seven pairs, the real estate factors are not significant at all in explaining correlations. Finally, the explanatory power of the control components ranges from a low point of 0.0% in 6 pairs to a high of 75.8% in China and Hong Kong Pair. Results for the US dollar returns indicate that whilst the real estate factors are able to explain from 0.028% to 74.7% of real estate securities return correlation, the control components are able to account between 0% (Hong Kong- Japan, and Taiwan-Japan) and 80.7% (China-Singapore) of real estate securities return correlation in all 18 economies studied.

Table 17Results of Multiple Regression Analysis (Stepwise) For 18 Conditional Correlation Pairs in Local Currency: 1995Q1-2011Q4

Country	Real estate variables		Control Variable					Adj. R-sq		
	RPC1	RPC2	CPC1	CPC2	CPC3	CPC4	CPC5	Real Estate	Control	total
CH-HK	-0.124***	0.080***	0.104***	-0.033***				0.158	0.658	0.816
CH-TW			0.125***					0.000	0.648	0.648
HK-TW			0.054***			-0.018***		0.000	0.396	0.396
CH-JP		-0.105***	0.054***	-0.021***				0.777	0.074	0.852
CH-SG	-0.085***		0.124***			-0.027***		0.038	0.821	0.859
CH-AU	0.034***		0.083***		0.039***	0.027***		0.642	0.183	0.824
CH-US	0.010***	-0.012***	0.074***				0.023***	0.021	0.872	0.893
CH-UK	-0.014***		0.015***	0.036***		0.016***		0.032	0.567	0.599
HK-JP	-0.096***	0.030***						0.609	0.000	0.609
HK-SG		0.021**	0.062***	0.027***			0.028***	0.028	0.587	0.615
HK-AU				0.049***	0.062***	0.017**	0.017**	0.000	0.650	0.650
HK-US		-0.032***	-0.072***		0.050***	0.021***		0.035	0.707	0.742
HK-UK				-0.006***	0.004***			0.000	0.242	0.242
TW-JP	0.087***					-0.021**		0.481	0.024	0.505
TW-SG	0.049***		0.073***			-0.026***		0.023	0.701	0.724
TW-AU				0.054***		0.017***		0.000	0.594	0.594
TW-US				0.007***	0.009***			0.000	0.334	0.334
TW-UK			-0.022***		0.014***			0.000	0.366	0.366

Notes: real estate factors are extracted using PCA from five real estate factors (LNRESIZE, REVOL, DIRECT,GREV AND DREIT). Control factors are extracted using PCA from 14 independent variables (RGDP, INF, INT, TS, EX, VAREX,TRADE,TMS,STCOR,GST,IS,DCRISIS,DREG,TREND). CH, HK,TW stands for Mainland China, Hong Kong and Taiwan securitized real estate markets; AU, JP, SG, US and UK Stands for Australia, Japan, Singapore, United States and United Kingdom securitized real estate markets

Table 18 Results of Multiple Regression Analysis (Stepwise) for 18 Conditional Correlation Pairs in US Dollars: 1995Q1-2011Q4

Country	Real estate variables		Control Variable					Adj. R-sq		
	RPC1	RPC2	CPC1	CPC2	CPC3	CPC4	CPC5	Real Estate	Control	total
CH-HK	0.161***		0.091***	-0.032***				0.758	0.073	0.831
CH-TW		0.053***	0.115***			-0.035***		0.028	0.715	0.743
HK-TW			0.070***			-0.021***		0.000	0.467	0.467
CH-JP	0.081***		0.048***	-0.019***	0.018***			0.747	0.084	0.831
CH-SG	0.082***		0.125***					0.045	0.807	0.852
CH-AU	0.041***		0.099***		0.025***	-0.022***		0.080	0.730	0.810
CH-US	0.024***	-0.024***	0.065***					0.136	0.637	0.773
CH-UK			0.029***	-0.029***		-0.014***		0.000	0.403	0.403
HK-JP	0.082***							0.636	0.000	0.636
HK-SG			0.061***	0.035***		0.016**	-0.023***	0.000	0.636	0.636
HK-AU				0.065***	0.063***	0.027***	0.016***	0.000	0.795	0.795
HK-US		-0.033***	0.081***	0.034***	-0.017***	0.023***		0.034	0.725	0.759
HK-UK	0.020***		0.008***	-0.034***	0.025***			0.681	0.243	0.925
TW-JP	0.083***							0.573	0.000	0.573
TW-SG		0.059***	0.072***			0.037***		0.109	0.650	0.759
TW-AU				0.088***	0.028***			0.000	0.702	0.702
TW-US		0.006**			0.009***			0.061	0.204	0.265
TW-UK			-0.039***		0.013***			0.000	0.649	0.649

Notes: real estate factors are extracted using PCA from five real estate factors (LNRESIZE, REVOL, DIRECT,GREV AND DREIT). Control factors are extracted using PCA from 14 independent variables (RGDP, INF, INT, TS, EX, VAREX,TRADE,TMS,STCOR,GST,IS,DCRISIS,DREG,TREND). CH, HK,TW stands for Mainland China, Hong Kong and Taiwan securitized real estate markets; AU, JP, SG, US and UK Stands for Australia, Japan, Singapore, United States and United Kingdom securitized real estate markets

Based on the PCA results reported in this study, I am inclined to conclude that in addition to macroeconomic and stock market factors (collected labelled as "control" variables in this study), real estate factors were found significant in explaining developed real estate securities market return correlation. The results therefore provide support for an economic globalization perspective of public real estate market integration in developed countries. The importance of the control and real estate factors in explaining correlation varies across various economies. For example, real estate factors are more important in influencing real estate securities return correlation for China-Japan and China-Hong Kong, even in the presence of major macroeconomic and stock market variables. These are to be broadly expected as real estate is a significant asset component in the three markets. Our finding regarding the greater importance of real estate factors in explaining return correlation of some economies thus provides greater support to the contribution of this study.

4.4 Summary of the Chapter

With a sample of 8 developed publicly listed real estate securities over the 1995-2011 time period, this study has examined their correlation dynamics and has evaluated the importance of the "real estate" factors in contributing to the degree of integration across the global real estate securities markets. This study is particularly meaningful in the context of increasing economic globalization and real estate asset securitization. However, a less formal research is undertaken for the real estate securities market correlation that is similar in scope and in the issues covered in this chapter.

The study has highlighted the significance of five included real estate factors in influencing the cross-market real estate securities return correlations to different degrees. In particular, the global real estate market volatility differential, the co-existence of REIT influence, the underlying direct real estate market return performance differential, the real estate securities market volatility differential and the real estate securities market size differential are significant correlation determinants. Moreover, we have established that the importance of the selected control and real estate factors in explaining the correlation that varies across the economies studied. Finally, given the plentitude of the variables available to international investors, it has becomes important for them to consider only those “real estate” and “control” factors that are particularly useful for modeling the changes in the international co-movement of the real estate securities markets. The contributions of this study are positive in this direction.

Chapter 5: Business Cycle Synchronization and Real Estate Market Cycle Coherence

5.1 Introduction

Since investors always seek to make profit by selling high (a bull market) and buying low (a bear market), studying the synchronization of the real estate market cycles would lead to greater understanding and clarity through studying the daily or monthly correlations for those investors who make their investment decisions based on a cyclical pattern. Therefore, the Chapter 5 aims to examine the coherent relationship of the GC (Greater china) public real estate market cycles with the other mature public real estate market cycles (i.e. of Japan, Singapore, Australia, UK and US) from a new angle by addressing following two questions: (a) what is the extent of public real estate market cycle coherence and how does it evolve through research period? (b)What is the possible impact of the business cycle synchronization of these markets on it?

Different definitions of the synchronization would come with the different methodologies of estimation. Within the frequency domain framework, Croux *et al*. (2011) define the cycle synchronization as the 'coherence' within a particular frequency domain. Another stream of literature that adopt a state space framework would define the synchronization as the phase shift between the stochastic cycles. More recently, Harding and Pagan (2006) adopt traditional dating rules to estimate the binary variable to represent the boom and bust phases of a cycle. Then the amount of the bivariate cycle synchronization is represented by a Pearson-type correlation based on the binary variable. Tested by a GMM based test model, a perfect synchronization condition is satisfied when all the correlations equal to 1 and that the perfect non-synchronization happens when all the correlations equal to 0. Following the pioneer work of Candelon *et al.* (2008), Chapter 5's study would define the synchronization when all the Pearson-type correlations of the cycles equal to a certain value (of less than 1), since neither the perfect synchronization nor the perfect non-synchronization would be a realistic hypothesis.

This research enhances the understanding of the dynamic linkage within and across the GC public real estate market from the cycle synchronization perspective. Specifically, I contributed to the literature in these area: (a) the study covers an emerging real estate market – the GC (Greater China) market and its main Asian trade partners and the US as well as the UK markets from 1994 till the end of 2011. We focus on this emerging real estate market because the market is under extensive study in the academic literature and because the market itself is more volatile for detecting changes in the cycle synchronization. Especially, during the study period, the relationship in this market has changed greatly both in a political way and in trade scope. Therefore, whether or not the three real estate markets or the aggregate economy are synchronized and to what degree that they are synchronized would be of particular interest to investors, after the China government took over Hong Kong's sovereignty since 1997 and after the China mainland and Taiwan had signed a series of agreement to encourage mutual economic cooperation. (b) This study even adopts the "common" synchronization index and the test for strong multivariate non-synchronization (SMNS) to estimate and examine the degree of bilateral and multivariate synchronization. This method is based on the generalized method of moments (GMM) model and is an extension of the Harding and Pagan(2006)'s measurement according to a study by Candelon *et al*. (2008). (c)The degree of synchronization of the business cycle for these markets has to be examined using the same technical tool and enables the study to detect the possible linkage between the business cycle and the pubic real estate cycle. It is hoped that the results of the study would shed more light on the explanation power of the business cycle synchronization on the public real estate cycle coherence.

Hence, chapter 5 proceeds with its chapter5.2 introducing the data used and the details of the research methodologies and the model. The next chapter5.3 discusses the results from the empirical estimation whilechapter5.4 summarizes the results.

5.2 Research design

5.2.1 Database

The data used in this chapter is the quarterly price level data of public real estate markets and stock markets from the fourth quarter of 1994 to the fourth quarter of 2011, which include the main expansion and contraction phases of the recent real estate crisis in these markets. The securitized real estate and the common stock market index are obtained from the Standard & Poor Global Index dataset and that the GDP data is obtained from the International Monetary Fund (IMF). We also use the INDP (industrial production index) data from the IMF as an alternative indicator to the GDP business cycle data. Both GDP and INDP data is deflated by price index in each country, thus real GDP and INDP are used in this chapter. This chapter not only includes real property stock returns but also real pure real estate series. The pure real estate series are obtained by regressing the securitized real estate returns against the individual stock market returns and saving the residuals.Therefore, pure real estate returns are included as comparison to securitized real estate returns. All the indices are in logarithm form, are seasonally adjusted and that their data sources are reliable and authoritative.

5.2.2 Cycle Identification

To analyse the synchronization of the different cycles, it is imperative to identify the different phases of the cycle first. There are two main stream of locating the expansion/recession phases of a cycle. The first one is to apply a parametric specification of the data generating process. After de-trending the price level data using Hodrick-Prescott filter or Beveridge-Nelson decomposition, the cycle has been decomposed to a smoothed series with cyclical part left. The stationary data then can be used in a regression, because I(1) process before would cause biased to the estimation results. One oldest and traditional way of identifying the cycle phases is to decide on the turning points in the random time series Y_t, which can be traced back to Burns and Mitchell (1946) and that such a traditional way of identifying the cycle phases is also been used by the NBER (The National Bureau of Economic Research). Other methods to recognize a cycle would be to study the transitory part Z_t of Y_t, after removing a permanent component of Y_t. Then the cycle would be indicated by indentifying the turning points in Z_t or the evidence of serial correlation in Z_t. The results could be quite distinct from the underlying series, whether it is Y_t or Z_t. In order to produce the well-defined real estate, finance and business cycles, the study would not use the de-trended series, Z_t, because this is not the cycle itself and because it only decides on some characteristics of a cycle.

The dating rules for this study follow the same algorithm by Harding and Pagan(2003) and by Claessens *et al*. (2011). This method searches for the maximum and minimum points through a certain period in the log-level quarterly time series. Consequently, the up and down phases denote those periods between the turning points. The censoring rules are applied to all these maximum and minimum points, i.e. the duration of a complete cycle and of each phase is to be at least five quarters and two quarters respectively. Specifically, a peak at time t in a series Y_t happens when:

$$Y_t > Y_{t-2} \dots Y_{t-1}, \text{and } Y_t > Y_{t+1} \dots Y_{t+2}$$

Likewise, there would be a trough at time t when:

$$Y_t < Y_{t-2} \dots Y_{t-1}, \text{and } Y_t < Y_{t+1} \dots Y_{t+2}$$

A complete business cycle contains two phases: the recession phase (from peak to trough) and the expansion phase (from trough to peak). This algorithm can also be applied to identify the finance cycle (Kaminsky and Schmukler, 2003; Candelon *et al*., 2008). For the finance and securitized real estate cycle, the contraction phase is called the "downturn" and the recovery phase is called the "upturn". After identifying the phases of the cycles, a binary random variable S_t is used to describe the expansion and recession phases in mathematical language. S_t

equals to one during the expansion phase or the upturn while S_t equals to zero during the recession phase or the downturn.

5.2.3 Synchronization Measurement of Binary Cycles

To measure the degree of synchronization of the cycles, the concordance index is introduced by Harding and Pagan (2002). The intuition of the concordance index is meant to measure what faction of time that the cycles are in the same phase. The index, CI_{xy} for the variables x and y is defined as:

$$CI_{xy} = \frac{1}{T}\sum_{t=1}^{T}[S_t^x \cdot S_t^y + (1 - S_t^x) \cdot (1 - S_t^y)] \tag{5.1}$$

, where

$$S_t^x = \begin{cases} 0, & \text{if x is in recession phase at time t} \\ 1, & \text{if x is in expansion phase at time t} \end{cases},$$

$$S_t^y = \begin{cases} 0, & \text{if y is in recession phase at time t} \\ 1, & \text{if y is in expansion phase at time t} \end{cases}$$

T denotes the number of time periods in the sample. The series are perfectly pro-cyclical (or counter cyclical) if the concordance index is equal to unity (or zero).he rolling concordance index is taken for comparison purposes and the rolling window is 5 years (20 quarters).

5.2.4 Multivariate Synchronization Measurement

Harding and Pagan (2006) proposed a GMM based estimation method to measure the multivariate cycle synchronization under the two extreme conditions of being perfectly synchronized or of being not synchronized at all. Candelon *et al*. (2009) have argued that these two conditions are not common in reality and they have proposed a more general framework known as SMS (ρ_0) – for a strong (but imperfect) Multivariate Synchronization of degree ρ_0. Their procedure starts from the following set of the $n(n+1)/2$ moment conditions to test for the SMS:

$$E([h_t(\theta, S_t)] = 0 \tag{5.2}$$

With

$$h_t(\theta, S_t) = \begin{bmatrix} S_{1t} - \mu_{s_1} \\ \vdots \\ S_{nt} - \mu_{s_n} \\ \frac{(S_{1t}-\mu_{s_1})(S_{2t}-\mu_{s_2})}{\sqrt{\mu_{s_1}(1-\mu_{s_1})\mu_{s_2}(1-\mu_{s_2})}} - \rho_0 \\ \vdots \\ \frac{(S_{(n-1)t}-\mu_{s_{n-1}})(S_{nt}-\mu_{s_n})}{\sqrt{\mu_{s_1}(1-\mu_{s_1})\mu_{s_2}(1-\mu_{s_2})}} - \rho_0 \end{bmatrix} \tag{5.3}$$

Let $\theta' = [\mu_{s_1}, \cdots, \mu_{s_n}, \rho_0]$ be a vector of parameters and S_t be the $1 \times n$ matrix with typical element S_{jt}. The first n subset in eq (5.2) defines the sample means of the cycle dummies whereas the second subset n(n-1)/2 moment conditions characterizes the estimates of all the bivariate cycle correlations.

And

$$g(\theta, \{S\}_{t=1}^{T}) = \frac{1}{T}\sum_{t=1}^{T} h_t(\theta, S_t)$$

, then calculate the time series average of eq (5.3). Harding and Pagan (2006) have proposed a test statistic for the moment condition via the Hansen(1982) wald test statistic:

$$W(\rho_0) = \sqrt{T}g(\theta, \{S\}_{t=1}^{T})' \hat{V}^{-1} \sqrt{T}g(\theta, \{S\}_{t=1}^{T}) \xrightarrow{d} \mathcal{X}^2_{(n-1)n/2} \tag{5.4}$$

Then

$$\hat{V} = \hat{\Omega}_0 + \sum_{k=1}^{m} \left[1 - \frac{k}{m+1}\right] [\hat{\Omega}_k + \hat{\Omega}_k']$$

, where

$$\hat{\Omega}_k = \frac{1}{T}\sum_{t=k+j}^{T} h_t(\hat{\theta}, S_t)h_{t-v}(\hat{\theta}, S_{t-v})'$$

is a consistent estimate of the covariance matrix for $\sqrt{T}g(\theta, \{S\}_{t=1}^{T})$ and m is equal to the integer part of $(T - \frac{n(n-1)}{2})^{\frac{1}{3}}$. See e.g. Newey and West (1987). The Wald test still depends on an unknown value, ρ_0 $(-1 \le \rho_0 \le 1)$. According to Candelon *et al.* (2009), an estimator of ρ_0 is selected by minimizing the test statistic $W(\rho_0)$, or in the form:

$$\hat{\rho}_0 = \text{argmin}_{\rho\in[\rho_-,\rho_+]}\sqrt{T}g(\theta, \{S\}_{t=1}^{T})^{'}\hat{V}^{-1}\sqrt{T}g(\theta, \{S\}_{t=1}^{T}) \tag{5.5}$$

The closed interval $[\rho_-, \rho_+]$ is determined and by which the SMS(ρ_0) cannot be rejected at a prespecified nominal size.

At the last and to test the relationship between real estate market coherence and the business cycle synchronization in the sample markets, a panel regression with fixed effect is adopted. First, to examine the possible dynamic changes of the real estate markets cycle synchronization, the study uses a rolling window of five years to access a time series of synchronization index $\hat{\rho}_{re,t}$. The same method also applies to the GDP and INDP data for the business cycle synchronization test. Secondly, the common stock market synchronization index is also used as a control variable because the securitized real estate market is a part of the financial market. The Lagged synchronization $\hat{\rho}_{re,t-1}$ is included in the regression because in the finance market, the best forecast for price today is the price of yesterday. Besides, a crisis dummy (CRISIS) is to be included to denote the Asian financial crisis period (1997Q3-1999Q4) and the global financial crisis period (2007Q3-2009Q4). Therefore, the empirical regression model is specified below:

$$\hat{\rho}_{re,t} = \alpha_0 + \beta_0\hat{\rho}_{gdp/indp,t} + \beta_1\hat{\rho}_{st,t} + \beta_2\hat{\rho}_{re,t-1} + \beta_3\text{CRISIS} + \beta_4\text{TREND} + \varepsilon_t \tag{5.6}$$

The panel regression method is adopted, and results are robust against the pooled cross-sectional time series regression models with random effect, feasible generalized least squares

(FGLS) and a dynamic generalized method of moment (GMM) techniques. At last, sub-period analysis is conducted for GC market with Australia, Japan, Singapore, US and UK respectively.

5.3 Empirical Results

5.3.1 Cycle Identification

The description results in table 20 (Descriptive Statistics of Real Estate Price Index and GDP Index) indicated both the nominal and real GDP and INDP price index. Since the base year of the eight public real estate price indices are different, the mean comparison is unnecessary.

Table 20Descriptive Statistics of Real Estate Price Index and GDP Index

Table A and Table B report the summary statistics of nominal and real quarterly GDP and INDP (industrial production index) value. All data is taken logarithm form and has been seasonally adjusted. J-B test is ignored because all data is leveled price data.

Table A1-GDP	CH	HK	TW	AU	JP	SG	US	UK
Mean	2.6669	1.6270	1.9236	2.1821	3.0520	1.4802	4.0427	2.7103
Median	2.5356	1.5913	1.8966	2.1142	3.0412	1.4061	4.0417	2.7059
Maximum	3.2893	1.7690	2.1089	2.5850	3.2165	1.7925	4.1845	2.8725
Minimum	2.1813	1.5178	1.8012	1.9594	2.9048	1.3047	3.8600	2.5764
Std. Dev.	0.3207	0.0835	0.0825	0.2000	0.0654	0.1427	0.1005	0.0829
Skewness	0.4722	0.3022	0.6308	0.5060	0.6212	0.7139	-0.2710	0.2394
Kurtosis	1.8489	1.5777	2.3050	1.8245	3.2850	2.1595	1.7702	1.9476
Observations	69	69	69	69	69	69	69	69
Table B1-INDP	**CH**	**HK**	**TW**	**AU**	**JP**	**SG**	**US**	**UK**
Mean	1.9150	1.1765	0.4324	1.8082	-0.0513	1.8380	1.9457	2.2178
Median	1.8957	1.1479	0.3973	1.7902	-0.0499	1.7743	1.9551	2.2159
Maximum	2.3064	1.3175	0.6571	2.0319	0.0793	2.1920	2.0023	2.3217
Minimum	1.5256	1.0688	0.3031	1.6519	-0.1946	1.6347	1.8459	2.1270
Std. Dev.	0.2265	0.0781	0.0969	0.1042	0.0572	0.1574	0.0403	0.0492
Skewness	0.1181	0.4680	0.7391	0.4647	-0.0408	0.7292	-0.9751	0.4014
Kurtosis	1.7867	1.8483	2.5307	2.1990	2.9739	2.3412	3.2446	2.1725
Observations	69	69	69	69	69	69	69	69
Table A2-Real GDP	**CH**	**HK**	**TW**	**AU**	**JP**	**SG**	**US**	**UK**
Mean	3.5844	1.2697	3.2493	0.3957	7.0194	-0.6651	4.7857	1.2726
Median	3.3374	1.2067	3.2865	0.3684	7.0851	-0.7163	4.7661	1.2412
Maximum	6.3003	3.8685	3.5552	0.7139	7.1851	-0.3294	6.8114	3.8438
Minimum	2.3215	0.9085	0.3615	0.0836	2.2115	-1.0268	4.5482	1.1372
Std. Dev.	0.7331	0.3697	0.3849	0.1941	0.5899	0.2032	0.2699	0.3204
Skewness	0.7969	5.0514	-6.2034	0.0462	-8.0163	0.0172	6.1757	7.6405
Kurtosis	3.9771	36.5648	47.3169	1.7628	65.8569	1.7263	47.4360	61.9015
Observations	69	69	69	69	69	69	69	69

Table B2-Real INDP	CH	HK	TW	AU	JP	SG	US	UK
Mean	1.8533	0.2323	-0.1843	-0.4652	-0.1261	0.1587	-0.0429	0.1385
Median	1.8640	0.1874	-0.1977	-0.4489	-0.0587	0.1484	-0.0497	0.1459
Maximum	4.0370	2.3192	0.2200	-0.3851	0.0931	0.6457	1.7313	2.4917
Minimum	0.8118	-0.1070	-3.0263	-0.5826	-5.0269	-0.2455	-0.2626	-0.1966
Std. Dev.	0.5308	0.3140	0.3919	0.0536	0.6027	0.2401	0.2318	0.3123
Skewness	0.6908	4.3096	-5.5498	-0.4601	-7.9573	0.1173	6.5575	6.2192
Kurtosis	5.5021	29.4323	41.4023	2.1349	65.2256	1.8536	51.2717	48.2263
Observations	69	69	69	69	69	69	69	69

For the nominal GDP of the 8 markets, and during the 17 years of the study period, the US market has on average highest GDP value followed by the UK market. Among the Asian markets, Japan has the highest GDP value to be followed by the China mainland while Singapore has the lowest GDP value for its relatively smaller market. The volatility of the China economy in aggregate is significantly higher than any of the other sample market because of its economy's continuously high growth rate ever since China's modern reform and open policy. The Japan market has a relatively lower volatility, being consistent with its relatively stable domestic markets during the study period. The INDP data is also an index data among all sample markets, The China mainland market is typically representative of the emerging countries and has the highest volatility during the study period, being consistent with its rapid growth recently. The US market has the lowest volatility that is reasonable for a mature mark. After taking price index into consideration, China market still shows the highest volatile real macroeconomic changes. For real INDP data, both China and Japan show high volatility of 0.53 and 0.60.

The dating rule as stated in the last chapter is applied to identify the cycles in both the securitized real estate markets and the aggregate economy for all samples. To be precise, a complete cycle must contain at least 5 quarters and each phase may contain at least two quarters. Figures 12 (Real Estate Cycle and Deflated Price Index of Real Estate Securities), 13 (Business cycle of GDP and GDP index) and 14(Business cycle of INDP and INDP index) show the evolution of the securitized real estate market price index, the GDP value and the INDP value for each of the countries, with the shaded area being drawn to visualize the upturn or boom phases. The securitized real estate price data is much more volatile than the GDP data and has more upturns and down turns than those of the GDP. The INDP data is more volatile than the GDP data and would be used as an alternative indicator for the business cycle. For the public real estate market and as can be observed, even the subprime crisis, the Asian financial crisis and the “dotcom” bubble are detectable by the dating rule. The GDP data is much less volatile while the Asian financial crisis is only obvious for the Asian countries. The China economy in aggregate maintains a high growth rate throughout the study period while very few downturns have been detected. The Asian financial crisis and its subprime crisis are detected by the study’s dating rules for the other Asian countries. The INDP data is more volatile than the GDP data while the contraction phases cover most of the major crisis for all samples. Like the GDP cycles, the Asian crisis is still not obvious for the INDP data of the non-Asian countries. However, the degree of synchronization and the differences between the countries cannot be observed by the naked eye, and so a further and a more advanced research tool is to be adopted in the next sub chapter.

Figure 12Real Estate Cycle and Deflated Price Index of Real Estate Securities: 1994Q4- 2011Q4

This figure plots the quarterly public real estate price index and the shaded areas correspond to the upturn phases. Spaces between the shaded areas correspond to downturn phases. All data has been deflated, taken in the logarithm form and has been seasonally adjusted.

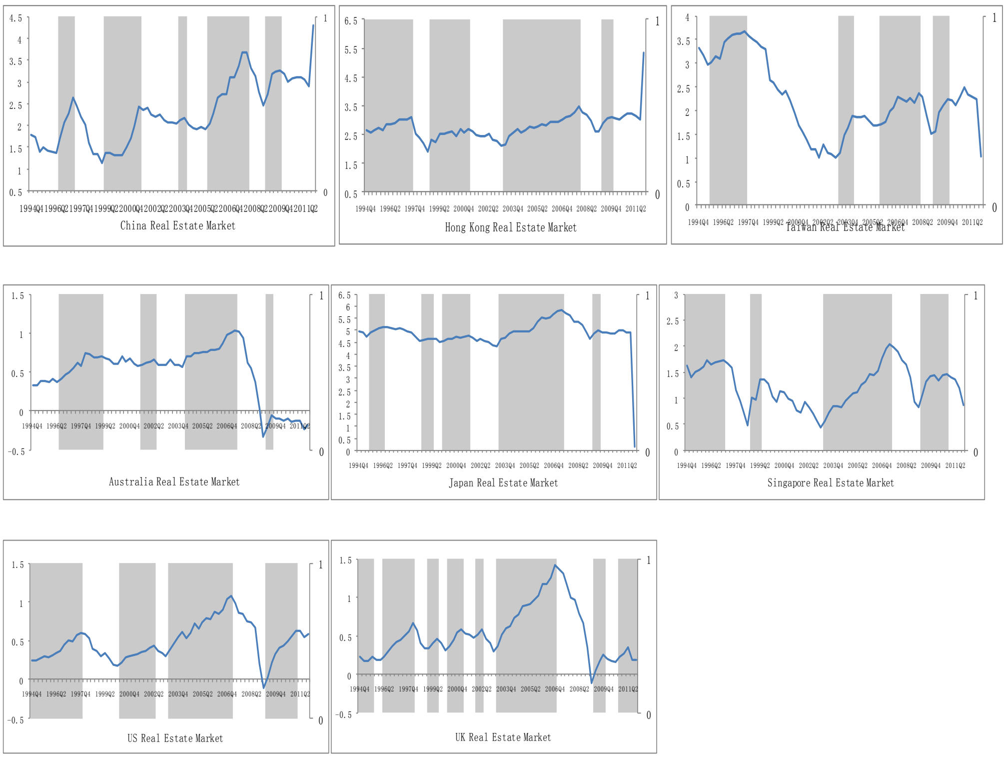


Figure 2Business cycle of GDP and GDP index: 1994Q4 - 2011Q4
This figure plots the quarterly GDP value and shaded areas correspond to the expansionary phases. Spaces between the shaded areas correspond to the recession phases. All data is taken in the logarithm form and has been seasonally adjusted.

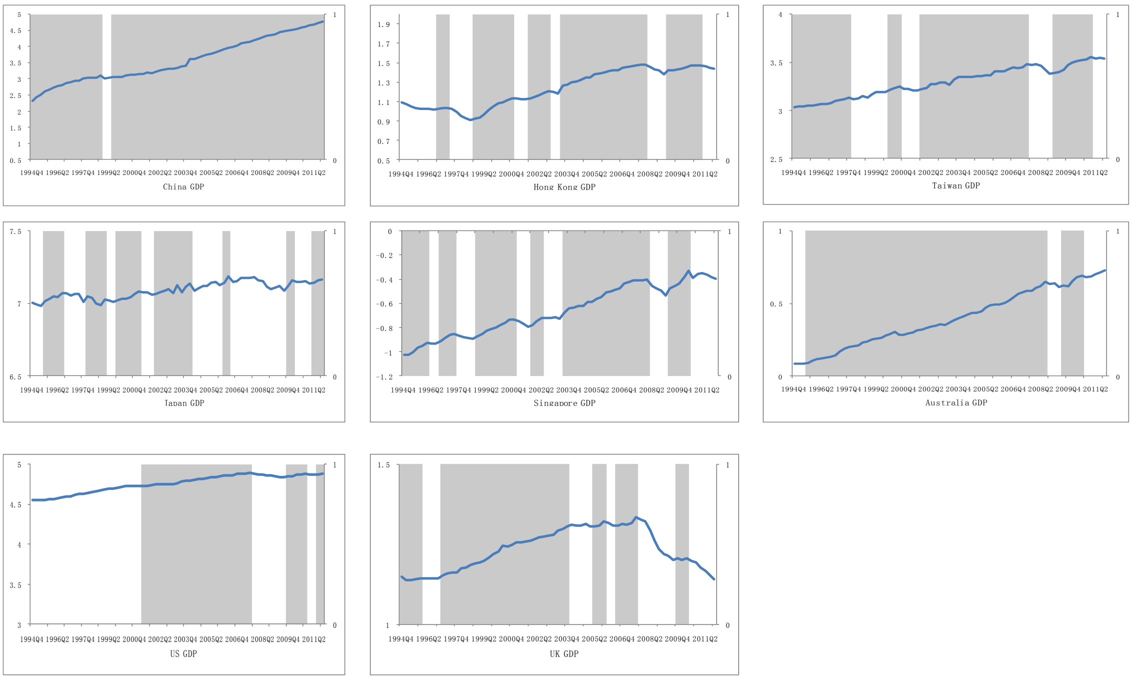
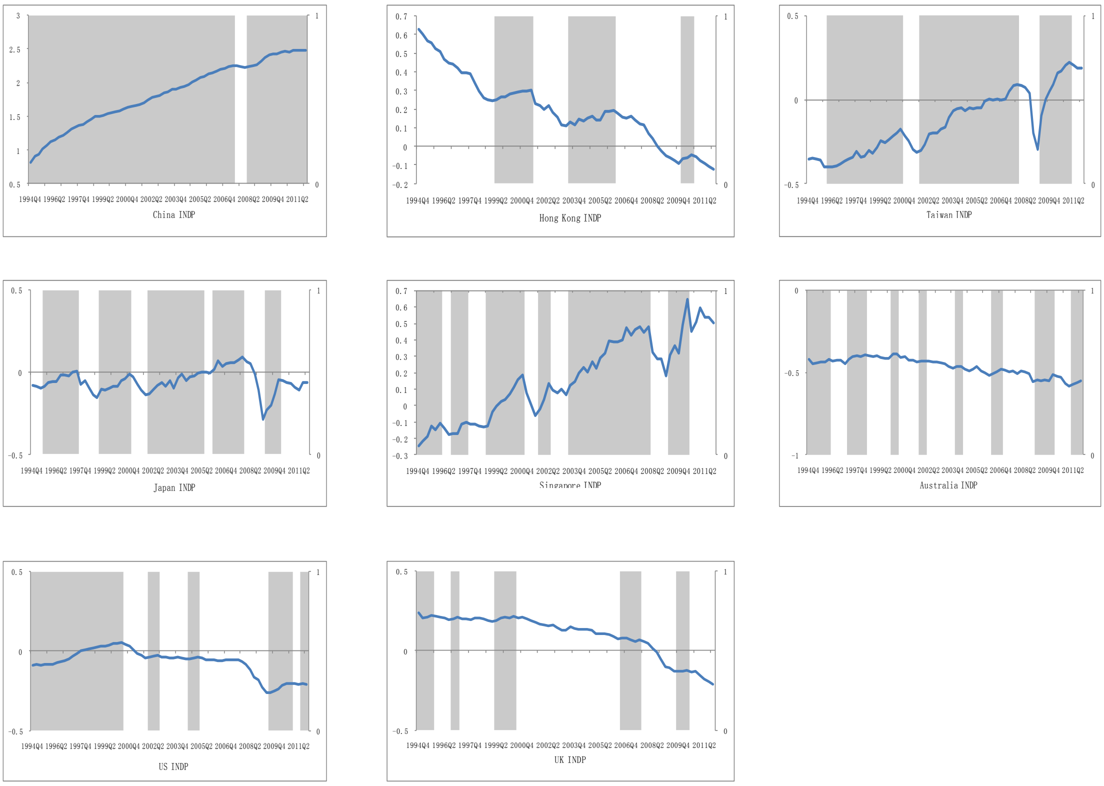


Figure 3Business cycle of INDP and INDP index: 1994Q4 - 2011Q4
This figure plots the quarterly INDP value and the shaded areas correspond to the expansionary phases. Spaces between the shaded areas correspond to the recession phases. All data is taken in the logarithm form and has been seasonally adjusted.



5.3.2 Concordance Analysis

Table 21 (Bivariate Concordance Index of Indirect and Direct Real Estate Cycle and Business Cycle) presents the bivariate concordance index for the securitized real estate markets cycle and the business cycle. The concordance index is calculated on the basis of the cycle dummy index S_t that we have identified by the dating rules. A higher value of the concordance index indicates a higher degree of synchronization. This study focuses on the GC markets and their relationships with the other countries and so only the GC market related results are reported. The indirect real estate concordance index is reported first and as observed, the Hong Kong and Singapore securitized real estate markets appear to be most highly synchronized and with the concordance index of 0.7826. The synchronization between China and US, Taiwan and UK is the lowest at the concordance index of 0.5217. Among the GC markets, Hong Kong is on average more synchronized with the other public real estate markets while the Taiwan concordance index is the lowest, which is consistent with the literature and with the economic facts that Hong Kong has the most liberal financial market.

As comparison, the results from direct real estate concordance index are slightly different from that from indirect index. On average, mainland China and UK are more synchronized with a concordance value of 0.7826 than other sample pairs, while Taiwan and Australia has the lowest average concordance index value of 0.2319. For the three GC markets, China and Hong Kong direct real estate market are more synchronized with other markets than Taiwan market with average values around 0.7. Compared with real estate securities, the concordance index of pure real estate data is less synchronized with each other, which is consistent with the fact that property market has less liquidity than securitized real estate market.

The business synchronization (GDP) is also the highest between Hong Kong and Singapore with a concordance index of 0.8261, which is consistent with real estate markets. China and Japan seems to have the lowest synchronization relationship in business. On average, Hong Kong is still more synchronized with other countries than mainland China and Taiwan. The overall concordance index is significantly higher than that of real estate market, which is consistent with literature that real estate is less integrated worldwide. The concordance index of INDP data is the highest between Taiwan and Japan markets of 0.7826 and the lowest for China and UK pair of 0.2899. On average, mainland China market is more synchronized with other countries than Hong Kong and Taiwan market. The results for INDP seem less related with GDP and real estate data. The concordance index is the lowest between mainland China and UK, while Taiwan and Japan has the highest synchronization degree. Hong Kong has the lowest average concordance index with all the other markets, probably because Hong Kong's manufacturing industry has been shrinking in recent years.

Table 19Bivariate Concordance Index of Indirect and Direct Real Estate Cycle and Business Cycle

RE	CH	HK	TW	AU	JP	SG	US	UK
CH	——							
HK	0.7246	——						
TW	0.7391	0.6957	——					
AU	0.5507	0.5652	0.5797	——				
JP	0.6667	0.7681	0.6087		——			
SG	0.5362	0.7826	0.6812			——		
US	0.5217	0.7101	0.5797				——	
UK	0.5507	0.7391	0.5217					——

DRE	CH	HK	TW	AU	JP	SG	US	UK
CH	——							
HK	0.6812	——						
TW	0.5072	0.4493	——					
AU	0.6667	0.6667	0.2319	——				
JP	0.7536	0.6522	0.2609		——			
SG	0.7246	0.5942	0.3188			——		
US	0.7246	0.6232	0.3188				——	
UK	0.7826	0.6087	0.3043					——

GDP	CH	HK	TW	AU	JP	SG	US	UK
CH	——							
HK	0.6087	——						
TW	0.7391	0.6957	——					
AU	0.8116	0.7101	0.6667	——				
JP	0.4638	0.4203	0.4348		——			
SG	0.6377	0.8261	0.7246			——		
US	0.5072	0.6667	0.6522				——	
UK	0.6087	0.5652	0.5797					——

INDP	CH	HK	TW	AU	JP	SG	US	UK
CH	——							
HK	0.3768	——						
TW	0.7391	0.4928	——					
AU	0.4493	0.4058	0.3913	——				
JP	0.6087	0.5362	0.7826		——			
SG	0.6232	0.5797	0.7101			——		
US	0.6232	0.4493	0.5797				——	
UK	0.2899	0.5942	0.4058					——

Notes: CH, HK, TW stands for Mainland China, Hong Kong and Taiwan securitized real estate markets; AU, JP, SG, US and UK stands for Australia, Japan, Singapore, United States and United Kingdom securitized real estate markets.RE stands for public real estate index while DRE stands for pure real estate index. Concordance index is calculated by $CI_{xy} = \frac{1}{T}\sum_{t=1}^{T}[S_t^x \cdot S_t^y + (1 - S_t^x) \cdot (1 - S_t^y)]$.

5.3.3 Synchronization Indices Estimation

Both the bivariate and multivariate synchronization indices $\hat{\rho}$ and their results over the entire sample period are reported in Table 22 (Estimation of Real Estate Market Synchronization and Business Cycle Synchronization). In the bivariate case, the null hypothesis for SMS($\hat{\rho}_0$) implies that there exists 'one common cycle' and would be rejected if $W(\rho_0)$ exceeds the critical value $CV_w(95\%)$. In the multivariate case, the critical value CV_w is determined by the bootstrap method to avoid the small sample distortion (see footnote). Non-rejection of the null hypothesis for the multivariate case would mean that there is one common cycle for all the estimated markets. $\hat{\rho}$ is the value that minimizes the test statistic $W(\rho_0)$. The closed interval $[\rho_-, \rho_+]$ would mean that the null hypothesis SMS($\hat{\rho}_0$) is not rejected over this interval.

For the public real estate market pair, the estimated synchronization indices $\hat{\rho}$ show no rejection of the hypothesis of SMS($\hat{\rho}_0$), indicating that there is a common cycle for all these sample pairs. The magnitude of synchronization for Hong Kong and Japan is the highest with value of 0.58, while that for the Hong Kong and Singapore securitized real estate markets is the second highest with a value of 0.57 among all sample pairs. The synchronization magnitudes for China and US securitized real estate markets are the lowest. From the synchronization indices interval, some pairs have the possibility of having a negative synchronization relationship. For the GC market, the mainland China and the Hong Kong securitized real estate markets, their degree of synchronization is higher than for the other two pairs, which is consistent with their closer economic and geography connections. In the multivariate case of the GC markets alone, the synchronization index is 0.5 for the GC markets. The null hypothesis of $\rho[\mathrm{CH}, \mathrm{TW}] = \rho[\mathrm{CH}, \mathrm{HK}] = \rho[\mathrm{HK}, \mathrm{TW}]$ cannot be rejected in the interval [0.18, 0.81], indicating that there is a common synchronization index for a wide synchronization magnitude range for the three real estate markets. The multivariate SMS test also applies to the GC market with respect to the other mature real estate market. The empirical results show that there exists one common cycle for the GC market with every mature securitized real estate market. The synchronization index ranges from the lowest of 0.45 (for the GC-UK pair) to the highest of 0.5 (for the GC-US pair), indicating that the extent of the synchronization of the co-cyclical behaviour is relatively weak for the GC market with respect to the other mature securitized real estate market than within GC market.

The hypothesis that a common synchronization index exists in all bivariate direct real estate sample pairs also cannot be rejected. Bivariate synchronization index ranges from -0.3 (Hong Kang and UK) to 0.36 (China and US). Within GC market, China and Hong Kang direct real estate market has the highest synchronization index value of 0.27, while Hong Kong and Taiwan has the lowest of -0.08. In multivariate case for direct real estate market, there is one common cycle exists in GC market with a synchronization index of 0.14, ranging from -0.54 to 0.75. According to the bootstrap critical values in cases including four markets, all the five GC market with other mature market pairs have a common cycle, ranging from 0.05 (GC and Australia direct real estate market) to 0.16 (GC and UK direct real estate market). Contrast to this value for indirect real estate market, GC market is more synchronized with US and UK market than within GC market itself. On general, the synchronization levels of direct real estate markets are much lower than that of indirect real estate markets, which is consistent with the results from concordance index.

The hypothesis of having a common synchronization index also cannot be rejected for all bivariate GDP sample pairs. The range of bivariate synchronization indices is wider than that of public real estate index from -0.11 (Taiwan and Japan) to 0.62 (Hong Kong and Singapore). The multivariate test for the three GC members indicates there is a common cycle among the three markets within the synchronization indices range of -0.43 to 0.66. The synchronization index $\hat{\rho}$ of the three GDP series is 0.12, lower than that of securitized real estate market, indicating a higher magnitude of real estate cycle coherence than business cycle synchronization. Similarly, multivariate SMS test also apply to binary variables correlation of business cycles for GC market with other five markets. The test results indicate that a common cycle exists in all the GDP samples, ranging from 0 (i.e. the GC with Japan) to 0.24 (i.e. the GC with Singapore and United States). The synchronization level is much lower than that of securitized real estate indexes.

The hypothesis of having a common synchronization index also cannot be rejected for all bivariate INDP sample pairs. The range of INDP synchronization is from -0.27 (Hong Kong and Australia) to 0.53 (Taiwan and Japan). The synchronization index $\hat{\rho}$ with lowest $W(\hat{\rho})$ of the three GDP series is 0.11, slightly lower than that of GDP. The synchronization index for GC market with other five markets ranges from 0.07 (GC with Australia) to 0.25 (GC with Japan). The results from INDP synchronization test are quite different from that of GDP. A time series of the synchronization indices is computed via rolling estimation with rolling window of five years.

Table 20Estimation of Real Estate Market Synchronization and Business Cycle Synchronization:1994Q4-2011Q4

market	Indirect Real Estate				Direct Real Estate				RGDP				RINDP			
	$\hat{\rho}$	$[\hat{\rho}_-,\hat{\rho}_+]$	$W(\hat{\rho})$	CV_w	$\hat{\rho}$	$[\hat{\rho}_-,\hat{\rho}_+]$	$W(\hat{\rho})$	CV_w	$\hat{\rho}$	$[\hat{\rho}_-,\hat{\rho}_+]$	$W(\hat{\rho})$	CV_w	$\hat{\rho}$	$[\hat{\rho}_-,\hat{\rho}_+]$	$W(\hat{\rho})$	CV_w
CH-HK	0.52	[0.35,0.67]	0.00003	N.A	0.27	[-0.05,0.56]	0.00009	N.A	0.07	[-0.34,0.46]	0.00004	N.A	0.08	[-0.15,0.29]	0.00010	N.A
CH-TW	0.46	[0.11,0.80]	0.00001	N.A	0.04	[-0.34,0.40]	0.00065	N.A	0.11	[-0.25,0.46]	0.00102	N.A	-0.03	[-0.23,0.14]	0.00000	N.A
HK-TW	0.48	[0.29,0.66]	0.00010	N.A	-0.08	[-0.44,0.26]	0.00097	N.A	0.32	[-0.06,0.68]	0.00064	N.A	0.19	[-0.16,0.53]	0.00000	N.A
CH-AU	0.08	[-0.41,0.56]	0.00013	N.A	-0.08	[-0.44,0.25]	0.00001	N.A	0.01	[-0.40,0.39]	0.00017	N.A	0.17	[-0.04,0.38]	0.00077	N.A
CH-JP	0.33	[-0.03,0.67]	0.00043	N.A	0.32	[-0.07,0.66]	0.00002	N.A	0.02	[-0.26,0.29]	0.00098	N.A	-0.12	[-0.35,0.08]	0.00144	N.A
CH-SG	0.09	[-0.31,0.46]	0.00077	N.A	0.4	[0.21,0.57]	0.00106	N.A	-0.03	[-0.42,0.32]	0.00060	N.A	0.00	[-0.37,0.35]	0.00000	N.A
CH-US	0.1	[-0.22,0.41]	0.00077	N.A	0.36	[0.08,0.62]	0.00066	N.A	0.03	[-0.26,0.30]	0.00080	N.A	0.07	[-0.21,0.35]	0.00011	N.A
CH-UK	0.15	[-0.15,0.42]	0.00065	N.A	0.25	[0.15,0.65]	0.00005	N.A	-0.05	[-0.34,0.21]	0.00087	N.A	-0.05	[-0.27,0.15]	0.00001	N.A
HK-AU	0.17	[-0.25,0.58]	0.00063	N.A	0.18	[-0.23,0.57]	0.00042	N.A	0.31	[-0.05,0.67]	0.00026	N.A	-0.27	[-0.52,0.05]	0.00016	N.A
HK-JP	0.58	[0.36,0.78]	0.00000	N.A	0.16	[-0.15,0.45]	0.00000	N.A	0.47	[0.17,0.77]	0.00015	N.A	0.17	[-0.15,0.48]	0.00004	N.A
HK-SG	0.57	[0.22,0.9]	0.00008	N.A	0.15	[-0.17,0.44]	0.00085	N.A	0.62	[0.29,0.92]	0.00016	N.A	0.30	[0.04,0.55]	0.00155	N.A
HK-US	0.36	[-0.03,0.75]	0.00021	N.A	0.23	[-0.10,0.54]	0.00000	N.A	0.36	[0.02,0.66]	0.00001	N.A	-0.08	[-0.47,0.28]	0.00018	N.A
HK-UK	0.44	[0.09,0.75]	0.00100	N.A	-0.3	[-0.66,0.04]	0.00018	N.A	0.06	[-0.26,0.36]	0.00005	N.A	0.05	[-0.42,0.48]	0.00044	N.A
TW-AU	0.14	[-0.26,0.52]	0.00071	N.A	-0.13	[-0.44,0.15]	0.00000	N.A	0.06	[-0.29,0.39]	0.00043	N.A	-0.14	[-0.59,0.26]	0.00045	N.A
TW-JP	0.21	[-0.16,0.56]	0.00034	N.A	-0.04	[-0.43,0.32]	0.00082	N.A	-0.11	[-0.52,0.26]	0.00001	N.A	0.53	[0.28,0.77]	0.00076	N.A
TW-SG	0.39	[0.08,0.68]	0.00016	N.A	0.03	[-0.29,0.33]	0.00032	N.A	0.36	[0.04,0.68]	0.00010	N.A	0.31	[-0.12,0.71]	0.00002	N.A
TW-US	0.25	[-0.11,0.60]	0.00016	N.A	0.06	[-0.32,0.43]	0.00052	N.A	0.36	[0.02,0.65]	0.00092	N.A	0.14	[-0.32,0.56]	0.00020	N.A
TW-UK	0.11	[-0.25,0.43]	0.00000	N.A	0.29	[-0.10,0.65]	0.00014	N.A	0.05	[-0.35,0.45]	0.00000	N.A	0.05	[-0.40,0.47]	0.00005	N.A
GC	0.5	[0.18,0.81]	0.23949	9.26	0.14	[-0.54,0.75]	4.09454	10.112	0.12	[-0.43,0.66]	3.65378	9.4476	0.11	[-0.19,0.40]	0.37389	0.7103
GC-AU	0.49	[0.21,0.76]	5.23256	9.3059	0.05	[-0.57,0.58]	4.83615	10.8142	0.07	[-1.00,1.00]	4.80414	14.1737	0.07	[0.01,0.1]	1.38022	1.6947
GC-JP	0.49	[0.20,0.76]	3.88184	9.238	0.07	[-0.61,0.70]	4.82327	10.7484	0	[-0.76,0.70]	5.67555	14.1722	0.25	[0.09,0.40]	7.10337	8.3058
GC-SG	0.49	[0.17,0.79]	0.76084	9.5626	0.12	[-0.53.0.71]	4.12874	10.6514	0.24	[-0.06,0.56]	3.10165	7.8552	0.15	[0.00,0.28]	1.59656	4.0537
GC-US	0.5	[0.14,0.83]	2.61035	10.0212	0.15	[-0.54,0.79]	4.74782	10.5758	0.24	[-0.02,0.45]	4.83902	8.5542	0.12	[0.00,0.22]	0.63065	3.2836
GC-UK	0.45	[0.16,0.71]	5.14031	10.1001	0.16	[-0.57,0.82]	4.28121	11.4117	0.04	[-0.75,0.90]	5.49845	14.1779	0.11	[0.00,0.19]	0.40287	1.9667

Notes: The estimated common synchronization index is demoted by $\hat{\rho}$. The closed interval $[\rho_-,\rho_+]$ is corresponding 95% confidence interval for $\hat{\rho}$. $W(\hat{\rho})$ tests for the SMS hypothesis (test of "multivariate synchronization' or 'homogeneity"). CV_w stands for 95% critical value of the bootstrap version of the test. In Bivariate case, CV_w is not reported because there is only one bivariate correlation .GC market includes CH, HK and TW. CH, HK, TW stands for Mainland China, Hong Kong and Taiwan securitized real estate markets; AU, JP, SG, US and UK stands for Australia, Japan, Singapore, United States and United Kingdom.

5.3.4 Rolling Estimation for the Concordance Index and the Synchronization Indices

Table 23 (Summary of Rolling Estimation for Securitized Real Estate Market Synchronization Index and Business Cycle Synchronization Index) presents the description statistics for the rolling estimation results and with the rolling period of 5 years. The same empirical methods are applied to the equity indices as the control variables. The rolling estimation is only applied to the bivariate synchronization indices because the multivariate indices have a quite high rejection rate via the bootstrap critical value in the rolling estimation process. On average, GC indirect market has a highest synchronization relationship with Singapore from the fourth quarter of 2000 to fourth quarter of 2011 for both public real estate cycles and business cycles. For direct real estate market, GC market in more synchronized with Japan market in this rolling period.

To better observe the time-varying trend of synchronization relationship among public real estate markets, the rolling concordance index for indirect real estate market is also estimated and the rolling window is also five years. The results for direct real estate market are not plotted for the similarity and simplicity purpose. The rolling concordance index and rolling synchronization indices are plotted together in figure15 (Rolling Concordance Index and Synchronization Indices for Public Real Estate Price). As can be seen from Figure 15, the trend of rolling concordance index and rolling synchronization indices for public real estate price value is quite similar. However, the magnitude of rolling synchronization indices is larger than rolling concordance index, this may because the process of taking average in rolling concordance estimation has smoothed the trend of synchronization.

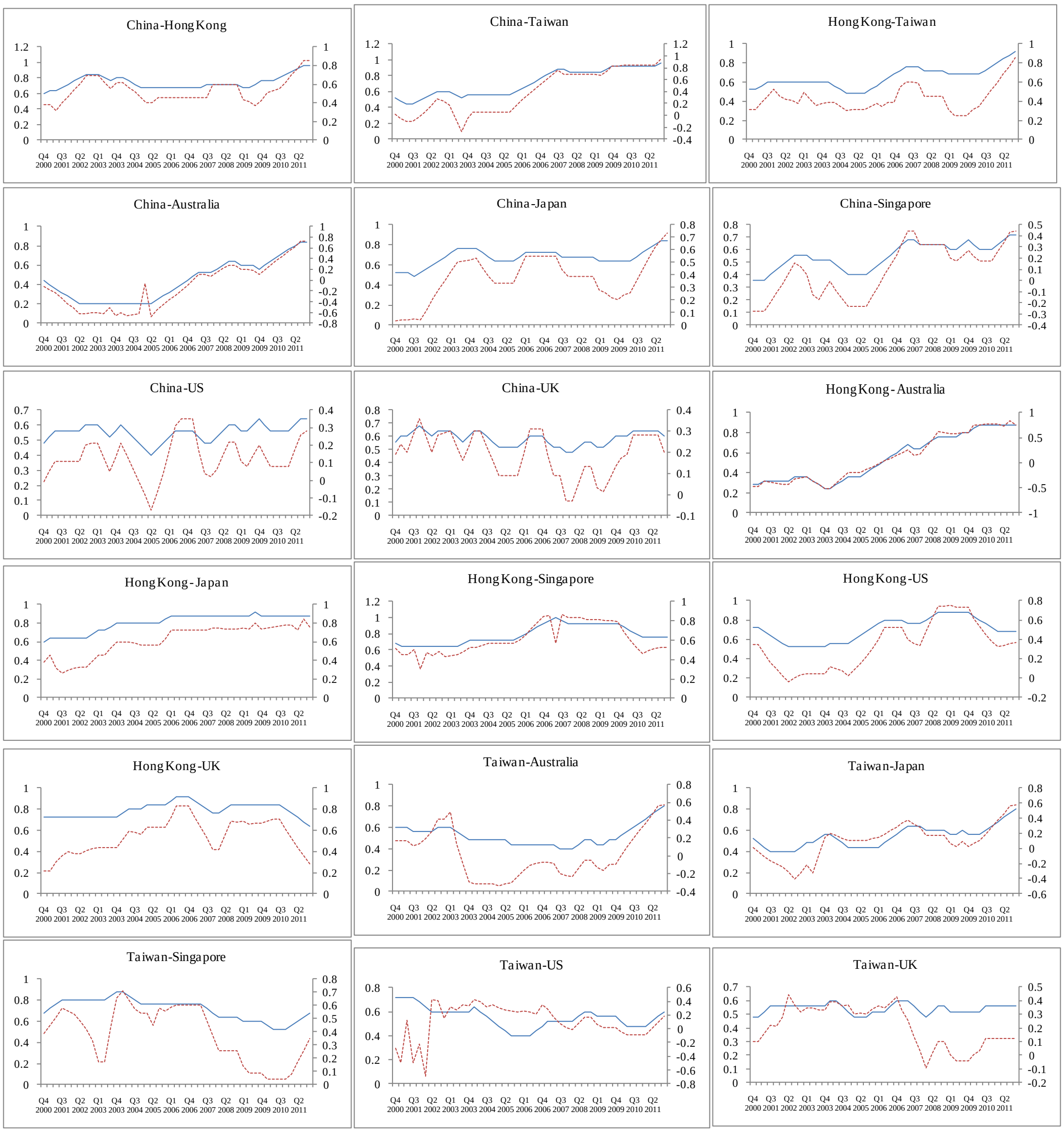
Overall, the trend of synchronization measured either by concordance index and synchronization indices is increasing over the research period except for Taiwan-Singapore, Taiwan-US and Taiwan-UK. The synchronization level has been raised during subprime crisis period in most cases. However, it is not very obvious by observing the graphs, thus this phenomenon will be further examined in panel regression analysis.

Table 21 Summary of Rolling Estimation for Securitized Real Estate Market Synchronization Index and Business Cycle Synchronization Index

$\hat{\rho}$	Indirect Real Estate				direct Real Estate				GDP				INDP			
	mean	s.d.	max.	min.	mean	s.d.	max.	min.	mean	s.d.	max.	min.	mean	s.d.	max.	min.
CH-HK	0.31	0.19	0.65	-0.08	0.28	0.26	0.72	-0.05	0.24	0.26	0.67	-0.14	0.21	0.23	0.76	-0.52
CH-TW	0.08	0.16	0.34	-0.35	0.08	0.29	0.49	-0.39	0.30	0.16	0.73	0.02	0.10	0.19	0.62	-0.18
HK-TW	0.36	0.19	0.68	-0.18	0.00	0.29	0.47	-0.47	0.47	0.27	0.87	-0.28	0.00	0.22	0.35	-0.25
CH-AU	0.30	0.40	0.85	-0.28	-0.20	0.26	0.29	-0.60	0.16	0.18	0.71	-0.05	0.22	0.17	0.44	-0.82
CH-JP	0.50	0.28	0.76	-0.12	0.45	0.27	0.73	-0.74	0.10	0.13	0.28	-0.17	-0.01	0.16	0.33	-0.31
CH-SG	0.13	0.20	0.51	-0.20	0.42	0.09	0.62	0.26	0.16	0.18	0.47	-0.17	0.09	0.22	0.47	-0.22
CH-US	0.14	0.12	0.41	-0.17	0.34	0.22	0.69	-0.03	0.24	0.15	0.66	0.09	0.10	0.16	0.31	-0.20
CH-UK	0.19	0.14	0.55	-0.03	0.24	0.19	0.52	-0.04	0.02	0.19	0.48	-0.24	0.02	0.08	0.17	-0.14
HK-AU	0.05	0.32	0.58	-0.47	0.00	0.23	0.40	-0.49	0.17	0.29	0.67	-0.21	-0.17	0.13	0.12	-0.44
HK-JP	0.26	0.16	0.55	-0.11	0.27	0.27	0.69	-0.24	0.05	0.12	0.27	-0.17	0.12	0.19	0.47	-0.24
HK-SG	0.70	0.13	0.87	0.46	0.02	0.30	0.57	-0.62	0.79	0.09	0.99	0.54	0.26	0.17	0.53	-0.07
HK-US	0.49	0.18	0.75	0.22	0.12	0.32	0.76	-0.40	0.12	0.22	0.46	-0.20	0.00	0.32	0.51	-0.58
HK-UK	0.59	0.12	0.83	0.34	-0.35	0.48	0.46	-0.98	0.05	0.16	0.34	-0.18	0.07	0.36	0.62	-0.31
TW-AU	-0.15	0.21	0.26	-0.48	0.00	0.19	0.50	-0.29	0.18	0.40	0.80	-0.39	0.16	0.16	0.35	-0.42
TW-JP	-0.17	0.19	0.21	-0.50	0.05	0.30	0.44	-0.53	0.19	0.22	0.47	-0.27	0.48	0.16	0.80	-0.09
TW-SG	0.45	0.20	0.86	0.07	0.05	0.30	0.37	-0.47	0.25	0.14	0.49	-0.01	0.40	0.25	0.97	-0.14
TW-US	-0.01	0.36	0.43	-0.57	0.11	0.34	0.60	-0.43	0.44	0.34	0.99	-0.39	0.36	0.13	0.58	0.04
TW-UK	0.24	0.19	0.60	-0.27	0.38	0.17	0.76	0.13	0.25	0.31	0.66	-0.45	0.22	0.21	0.40	-0.98
GC average	0.25	0.18	0.56	-0.20	0.12	0.28	0.56	-0.30	0.34	0.23	0.76	-0.13	0.10	0.21	0.58	-0.32
GC-AU	0.07	0.31	0.56	-0.41	-0.07	0.23	0.40	-0.46	0.17	0.29	0.73	-0.22	0.07	0.15	0.30	-0.56
GC-JP	0.20	0.21	0.51	-0.24	0.26	0.28	0.62	-0.50	0.11	0.16	0.34	-0.20	0.20	0.17	0.53	-0.21
GC-SG	0.43	0.17	0.75	0.11	0.16	0.23	0.52	-0.28	0.40	0.14	0.65	0.12	0.25	0.22	0.66	-0.14
GC-US	0.21	0.22	0.53	-0.17	0.19	0.29	0.68	-0.29	0.27	0.24	0.70	-0.17	0.15	0.20	0.47	-0.25
GC-UK	0.34	0.15	0.66	0.01	0.09	0.28	0.58	-0.30	0.11	0.22	0.49	-0.29	0.10	0.22	0.40	-0.48

Notes: The estimated rolling common synchronization index is demoted by $\hat{\rho}$, the rolling window is five years. S.D. measures standard deviation. CH, HK, TW stands for Mainland China, Hong Kong and Taiwan securitized real estate markets; AU, JP, SG, US and UK stands for Australia, Japan, Singapore, United States and United Kingdom

Figure 4Rolling Concordance Index and Synchronization Indices for Public Real Estate Price: 2000-2011



Notes: Comparison of rolling concordance index (solid line) and bivariate synchronization indices (dashed line). Rolling window is five year.

5.3.5 Relationships of Securitized Real Estate Cycles with Business Cycles

Using the time series of rolling synchronization indices in table 23, Table 24 (Results of Panel Regression Analysis) reports the results of estimating Equation (5.6) using a generalized least squares (GLS) estimator for random effect model and FGLS estimation which controls for cross-sectional dependence and heteroscedasticity. The dynamic panel model with the GMM estimator developed by Arellano and Bond (1991) is also used as a robustness check. The dependent variablesare the rolling bilateral synchronization index of indirect and direct real estate indices. The regression results with/without stock market as a control variable are both presented. Using independent variable of business cycle estimated with GDP value, only one out of three research models confirm that business cycle synchronization has significant influence on public real estate cycle coherence. The effect is still the same after taking stock market into consideration. As expected, stock market synchronization also increases the connection among sample real estate markets which is confirmed by two out of three models. When using industrial production index (INDP) as measure of business cycle, none of the research models confirm that business cycle synchronization encourage the coherence of international securitized real estate market, although the effect seems to be positive for all the models. The crisis variable is insignificant for most of time, indicating the possibility that crisis have no effect on international securitized real estate market coherence. Linear trend variable is significant for most of the models, implying the possibility that the trend of synchronization among sample real estate markets are increasing over the research period.

Using pure real estate index as dependent variables, the synchronization of GDP have positive explanation power for four out of six models with or without control of stock market synchronizations. Consistent with results from indirect real estate markets, stock market synchronization also can encourage the synchronization of indirect real estate markets. It is worthy to take notice that business cycle expressed by INDP synchronization has significant negative effect on direct real estate market synchronization, this is a weak evidence of that direct real estate market is sometimes used as a good hedge against economic recessions. More obvious evidence is that, for all the 12 models, crisis dummies actually have significant negative effect on direct real estate market synchronizations, indicating the opportunity that a portfolio based on international direct property market may be beneficial during financial crisis period. The coefficients for trend variables are negative, implying an opposite direction of synchronization as compared with that of indirect real estate market. However, the R-sqaure is quite low for this economic model, only around 0.18. Thus more information is contained in direct real estate markets aside from general macro-economic and stock markets.

The sub-sectional results of estimating Equation (5.6) using random effect, a generalized least squares (GLS) estimator for random effect model and FGLS estimation for both indirect and direct real estate market are reported in table 25 (Results of Sub-sectional Panel Regression Analysis) and 26. Along with the previous empirical results, five sub sections are included in this study, they are the GC market with Australia, Japan, Singapore, US and UK. With the special focus on business cycle synchronization factors, the business cycle synchronization factors measured either by GDP or INDP are significant for at least one research model in GC-Australia, GC-Japan, GC-Singapore, GC-US and GC-UK public real estate pairs. One models of GC-Australia have at least two models, confirming the possibility that the extent of business cycles may have impact on public real estate cycle synchronizations. However, the signs of coefficient have both negative and positive, so the effect would be harmful or beneficial would still be unknown. The control variables of stock market synchronization are included in all the five subsections and it is positively correlated with public real estate market synchronization for most of the research model. Table 26 reports the sub-sample estimation results for direct real estate index. Similarly, with a smaller R-sqaure, for all five models, at least one panel regression model confirm the significant effect from business cycle synchronization on direct real estate market synchronization. And for GC-Singapore, GC-US and GC UK pairs, crisis dummy has a significant negative effect on real estate synchronization relationship for most of the panel regression models. This is a distinguish feature of pure real estate data from indirect real estate data that pure international real estate data may offer a effective diversification benefits to investors during crisis period or economic recessions.

Table 22Results of Panel Regression Analysis: 1994Q4-2011Q4 (Dependent variable: $\hat{\rho}_{re,t}$)

Based on equation (5.6), the dependent variable is rolling indirect (RE) and direct (DRE) securitized real estate synchronization index $\hat{\rho}_{re,t}$, the coefficients are estimated by a generalized least square (GLS) estimator for random effect, feasible least squares (FGLS) and Arellano-Bond dynamic panel GMM estimation. ***,**,* indicates statistical significance at least at the 1%, 5% and 10% level respectively.

RE	with stock market						without stock market					
	GDP model			INDP model			GDP model			INDP model		
	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM
$\hat{\rho}_{gdp/indp}$	0.0113	0.0136*	-0.0108	0.00429	0.00948	0.0226	0.00899	0.0155**	-0.0167	0.0015	0.0084	0.0325
$\hat{\rho}_{st}$	0.036	0.0336***	0.119***	0.0354	0.0334***	0.117***						
$\hat{\rho}_{re,t-1}$	0.855***	0.884***	0.421***	0.856***	0.886***	0.425***	0.862***	0.897***	0.440***	0.863***	0.898***	0.444***
Crisis	0.00314	0.0293**	-0.0309	0.00377	0.0298**	-0.0312	0.00432	0.0285**	-0.029	0.00477	0.0284**	-0.0294
Trend	0.0115	0.0101*	0.0891***	0.0125	0.0103**	0.0870***	0.0156**	0.0127**	0.106***	0.0164**	0.0131**	0.102***
Constant	-0.00459	-0.00695	-0.146***	-0.00554	-0.006	-0.145***	-0.000801	-0.00171	-0.142***	-0.00154	-0.000449	-0.141***
R-sq	0.7645	-	-	0.7644	-	-	0.7639	-	-	0.7638	-	-

DRE	with stock market						without stock market					
	GDP model			INDP model			GDP model			INDP model		
	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM
$\hat{\rho}_{gdp/indp}$	0.179***	0.00266	0.151***	0.0603	-0.0171**	0.0141	0.174***	0.00462	0.138***	0.0629	-0.0169**	0.0258
$\hat{\rho}_{st}$	0.0611	-0.0213**	0.159***	0.0393	-0.0234**	0.144***						
$\hat{\rho}_{re,t-1}$	0.140***	0.0511***	0.512***	0.147***	0.0498***	0.521***	0.149***	0.0497***	0.511***	0.153***	0.0485***	0.520***
Crisis	-0.111***	-0.0140*	-0.0802***	-0.101***	-0.0148*	-0.0732***	-0.109***	-0.0150*	-0.0755***	-0.0998***	-0.0160**	-0.0692***
Trend	-0.200***	-0.120***	-0.179***	-0.180***	-0.119***	-0.159***	-0.192***	-0.123***	-0.155***	-0.176***	-0.122***	-0.140***
Constant	0.591***	0.443***	0.471***	0.577***	0.446***	0.453***	0.597***	0.440***	0.480***	0.581***	0.443***	0.462***
R-sq	0.1708	-	-	0.1822	-	-	0.1735	-	-	0.1833	-	-

Table 23 Results of Sub-sectional Panel Regression Analysis: 1994Q4-2011Q4 (Dependent variable: $\hat{\rho}_{re,t}$)

Five sub sections are covered in this table, they are: GC market-Australia, GC market-Japan, GC market-Singapore, GC market-US, GC market-UK. Based on equation (5.6), the dependent variable is rolling securitized real estate synchronization index $\hat{\rho}_{re,t}$, the coefficients are estimated by a generalized least square (GLS) estimator for random effect, feasible least squares (FGLS) and Arellano-Bond dynamic panel GMM estimation. ***,**,* indicates statistical significance at least at the 1%, 5% and 10% level respectively.

GC-AU	GDP model			INDP model		
	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM
$\hat{\rho}_{gdp/indp}$	-0.0727	-0.0493	-0.256***	0.0195	0.00698	0.00495
$\hat{\rho}_{st}$	0.346***	0.205*	0.706***	0.315***	0.179	0.711***
$\hat{\rho}_{re,t-1}$	0.695***	0.823***	0.355***	0.696***	0.824***	0.359***
Crisis	0.0109	0.0152	-0.0369	0.00467	0.00996	-0.0781
Trend	0.0602**	0.0334	0.224***	0.0488**	0.0289	0.161***
Constant	-0.314***	-0.165**	-0.938***	-0.275***	-0.143**	-0.803***
R-sq	0.7505	-	-	0.7499	-	-

GC-JP	GDP model			INDP model		
	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM
$\hat{\rho}_{gdp/indp}$	-0.062	0.00873	0.0488	-0.177***	-0.108**	-0.112
$\hat{\rho}_{st}$	0.182**	0.0909	0.121	0.200***	0.0717	0.138
$\hat{\rho}_{re,t-1}$	0.630***	0.811***	0.102	0.551***	0.770***	0.091
Crisis	-0.0086	-0.00954	0.00158	-0.0054	-0.0134	-0.00219
Trend	0.0569***	0.0374**	0.154***	0.0662***	0.0465***	0.160***
Constant	-0.0895	-0.0668*	-0.180**	-0.0683	-0.0545	-0.171**
R-sq	0.7499	-	-	0.6628	-	-

GC-SG	GDP model			INDP model		
	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM
$\hat{\rho}_{gdp/indp}$	0.166**	0.0411	-0.223	0.0304	-0.00602	-0.176*
$\hat{\rho}_{st}$	-0.122	0.0351	-0.0335	-0.0209	0.0598	-0.0179
$\hat{\rho}_{re,t-1}$	0.693***	0.866***	0.181**	0.760***	0.904***	0.165*
Crisis	0.00272	-0.0324	0.0843	-0.00349	-0.0458	0.0855
Trend	0.0301	-0.00247	0.0458	0.0126	-0.0101	0.0378
Constant	0.0228	0.0229	0.255**	0.0553	0.041	0.231***
R-sq	0.6183	-	-	0.6005	-	-

GC-US	GDP model			INDP model		
	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM
$\hat{\rho}_{gdp/indp}$	-0.0632	-0.0807**	-0.0452	0.0509	0.0689	0.325***
$\hat{\rho}_{st}$	0.031	-0.0171	0.0538	0.0543	-0.023	0.0362
$\hat{\rho}_{re,t-1}$	0.753***	0.917***	0.375***	0.751***	0.895***	0.301***
Crisis	0.047	0.0712**	-0.0331	0.0364	0.0590*	-0.0177
Trend	0.0196	0.0116	0.0542*	0.000418	-0.00668	0.00762
Constant	-0.00649	0.00682	-0.0436	0.0125	0.0426	0.0468
R-sq	0.6428	-	-	0.6407	-	-

GC-UK	GDP model			INDP model		
	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM
$\hat{\rho}_{gdp/indp}$	0.0217	0.00727	-0.124*	0.0299	0.022	-0.0592
$\hat{\rho}_{st}$	0.0935**	0.0880***	0.108	0.0718**	0.0754***	0.251***
$\hat{\rho}_{re,t-1}$	0.931***	0.949***	0.468***	0.943***	0.962***	0.449***
Crisis	0.00549	0.00126	-0.180***	0.0112	0.0107	-0.191***
Trend	-0.0300***	-0.0266***	-0.02	-0.0232***	-0.0220***	-0.0578***
Constant	0.0592***	0.0500**	0.206***	0.0455**	0.036	0.243***
R-sq	0.9258	-	-	0.9266	-	-

Table 26 Results of Sub-sectional Panel Regression Analysis: 1994Q4-2011Q4 (Dependent variable: $\hat{\rho}_{re,t}$)

Five sub sections are covered in this table, they are: GC market-Australia, GC market-Japan, GC market-Singapore, GC market-US, GC market-UK. Based on equation (5.6), the dependent variable is rolling direct real estate synchronization index $\hat{\rho}_{re,t}$, the coefficients are estimated by a generalized least square (GLS) estimator for random effect, feasible least squares (FGLS) and Arellano-Bond dynamic panel GMM estimation. ***,**,* indicates statistical significance at least at the 1%, 5% and 10% level respectively.

GC-AU	GDP model			INDP model		
	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM
$\hat{\rho}_{gdp/indp}$	0.382***	0.293***	0.0158	-0.061	-0.0869	0.225**
$\hat{\rho}_{st}$	-0.141	0.104	0.120*	-0.0703	0.0368	0.186**
$\hat{\rho}_{re,t-1}$	0.352***	0.123***	0.663***	0.294***	0.123***	0.671***
Crisis	-0.0119	0.0418	-0.0308	0.0427	0.0554*	-0.0434
Trend	-0.0768***	-0.0380**	0.0746***	0.00739	0.00875	0.0698***
Constant	0.160*	-0.0191	-0.297***	-0.048	-0.0678	-0.326***
R-sq	0.3328	-	-	0.2151	-	-

GC-JP	GDP model			INDP model		
	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM
$\hat{\rho}_{gdp/indp}$	0.337**	0.112	0.342***	-0.417***	-0.363***	-0.00861
$\hat{\rho}_{st}$	0.650***	0.568***	0.481***	0.581***	0.549***	0.396***
$\hat{\rho}_{re,t-1}$	-0.0236	-0.0866	0.230***	-0.234**	-0.0944	0.286***
Crisis	0.0662	0.00109	0.055	0.0388	-0.0346	0.0262
Trend	-0.216***	-0.162***	-0.245***	-0.157***	-0.150***	-0.219***
Constant	0.567***	0.438***	0.660***	0.623***	0.580***	0.650***
R-sq	0.458	-	-	0.5274	-	-

GC-SG	GDP model			INDP model		
	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM
$\hat{\rho}_{gdp/indp}$	-0.547***	-0.279***	-0.0883	-0.386***	-0.203***	-0.140***
$\hat{\rho}_{st}$	0.580***	0.0181	0.340***	0.211*	-0.108	0.363***
$\hat{\rho}_{re,t-1}$	-0.0168	0.119**	0.478***	-0.225***	0.0799	0.477***
Crisis	-0.0758	-0.0975***	-0.0348	-0.0964	-0.0946**	-0.0403
Trend	-0.217***	-0.0913***	-0.203***	-0.145***	-0.0450*	-0.209***
Constant	0.694***	0.496***	0.527***	0.641***	0.353***	0.534***
R-sq	0.4176	-	-	0.3153	-	-

GC-US	GDP model			INDP model		
	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM
$\hat{\rho}_{gdp/indp}$	-0.0366	0.0483	0.0375	-0.096	-0.029	0.180***
$\hat{\rho}_{st}$	-0.152*	-0.0766	0.00187	-0.174*	-0.0828	0.00736
$\hat{\rho}_{re,t-1}$	0.0361	0.0574	0.343***	0.0387	0.0486	0.363***
Crisis	-0.096	-0.0539	-0.0921**	-0.101*	-0.0544	-0.0790**
Trend	-0.239***	-0.209***	-0.249***	-0.227***	-0.202***	-0.268***
Constant	0.948***	0.778***	0.831***	0.931***	0.776***	0.857***
R-sq	0.623	-	-	0.627	-	-

GC-UK	GDP model			INDP model		
	Random GLS	FGLS	Dynamic GMM	Random GLS	FGLS	Dynamic GMM
$\hat{\rho}_{gdp/indp}$	-0.0101	0.256***	0.362***	0.521***	0.408***	0.375***
$\hat{\rho}_{st}$	-0.547***	-0.0165	0.2	-0.555***	-0.246***	-0.242***
$\hat{\rho}_{re,t-1}$	-1.128***	-0.497***	0.491***	-0.961***	-0.860***	0.312***
Crisis	-0.381***	-0.212***	-0.152***	-0.307***	-0.296***	-0.125***
Trend	-0.0946**	-0.124***	-0.216***	-0.0567*	-0.0783**	-0.111***
Constant	1.016***	0.658***	0.537***	0.798***	0.686***	0.470***
R-sq	0.6638	-	-	0.7413	-	-

5.4 Summaries of This Chapter

In Chapter 5, the synchronizations of the international securitized real estate market as well as pure real estate index are examined for the 8 real estate markets from a new angle. Meanwhile, the relationship between the business cycle synchronization and the real estate cycle coherence is studied in this chapter.

First, a traditional dating rule is used to identify the cycles for both the real estate data and the macroeconomic indicator (GDP/INDP). Using binary variables that represent the different phases of a cycle, preliminary empirical results for the synchronization from a bilateral concordance estimation known as the concordance index shows that the 8 securitized real estate markets are synchronized to an extent from 0.52 to 0.78. Wider than that of real estate securities, the concordance index for pure real estate markets ranges from 0.23 to 0.78. Compared with securitized real estate market, business cycle results indicate a slightly lower level of synchronization.

Secondly, both the bilateral and multilateral strong synchronization hypothesis is tested by a GMM based model test. The test confirms that a common cycle exists in every bilateral real estate and macroeconomic correlation pairs. Among all the market pairs, Hong Kong and Singapore are relatively more synchronized for both the indirect real estate cycle and the business cycle measured by GDP data. Within GC market, China and Hong Kong have a more synchronized relationship for both direct and indirect real estate cycles. Using bootstrap critical value in multilateral case, there is one common cycle exists in both securitized and direct real estate cycles and business cycles of GC market as a whole. Besides, GC market with five other markets (Australia, Japan, Singapore, US and UK) is tested to be synchronized for both real estate and business cycles. Similarly with results of concordance index, the synchronization level of eight business cycles and direct real estate cycles is slightly lower than that of securitized real estate cycles. Measured both by concordance index and synchronization indices, the rolling estimation finds an increasing trend of synchronization for most public real estate market cycles. Thus, as the diminishing of diversification benefits from international real estate securities, investors can still benefits from investing international pure real estate assets.

At last, using the time-varying synchronization indices, the relationship of business cycle synchronization and real estate cycle coherence is examined by a GLS model with random effect, feasible GLS and a dynamic GMM model. The regression results show that business cycle synchronization (measured either by real GDP or real INDP data) in the eight markets do have explanation power for both direct and indirect real estate market cycle coherence. Besides, equity cycle synchronization, and linear trend also explain the indirect real estate cycle coherence, implying an increasing trend in this coherence relationship. Especially, the significant opposite relationship between direct real estate cycle and crisis dummy indicates that investors can benefit from a pure international real estate portfolio during crisis period.

Chapter 6: Conclusion

6.1 Summaries of Main Findings

This PhD study focuses on the international securitized real estate investment issue and on the relationship of the securitized real estate market co-movement with key macroeconomic indicators and the common stock market. Besides, pure real estate index extracts from securitized real estate data is also used in this research as a comparison. The study's scope covers the GC (Greater China) market and 5 other real estate markets. For the international securitized real estate investment issue, this study not only examines the long run and short run co-movement relationship of the8 real estate markets but it also studies their co-cyclical behaviour via adopting new technical tools in the real estate literature for the benefit of investors. To thoroughly understand the co-movement relationship of the securitized real estate markets, this study empirically examines the macroeconomic indicators, the common stock market and especially the real estate industry determinants for the co-movement trend. Finally, the co-cyclical patterns of the securitized real estate markets, their relationship with the business cycle and the common stock market cycle are examined.

In chapter 2, literature on international real estate investment, techniques of measurement, and the linkage with macroeconomics and Greater China studies have been reviewed. To date, the literature on Greater China study and co-cyclical of public real estate market studies is quite thin. Besides, there are even lesser academic studies on fundamental factors that influence the correlation variations in public real estate market. Thus this thesis is trying to fill the gap in the literature by the following three chapters.

Using the co-movement box model that is based on the conditional auto-correlation quantile regressions (CAViaR) and the ADCC-GARCH (full name in brackets please) model, the empirical results of Chapter 3 shows that both the long-term and short-term co-movement level for the 8 securitized real estate markets each is still low. As comparison, the co-movements among pure real estate returns show weaker but similar trend of co dependence relationship.

These results indicate the feasibility of a long-term diversification strategy. The co-movement relationship is relatively stronger within the GC market than with the other securitized real estate markets. Besides, the possibility of regional market integration within Asian is higher than that of global market integration. Similarly, Chapter 5 deploys the newly developed GMM based synchronization test. All the 8 securitized real estate cycles are coherent and to a higher extent than the business cycle synchronization, will 8 indirect real estate cycles show relatively lower coherence relationships. Therefore, all the correlation studies affirm that investors could still gain diversification benefits from investing in the real estate markets, at least in direct real estate market. However, both the short-term studies and the synchronization studies have found the increasing trend in the correlation relationship, implying that the benefits from diversification in this market are decreasing over the study period.

Chapter 4 examines the explanation for the co-movement relationship among the 8securitized real estate markets. Using three GLS models with the random effect, the empirical results indicate that real estate factors for a feasible GLS and for a dynamic GMM are important to an effective understanding of the correlation structure. The importance of the selected control variables from the macroeconomic indicators and the common stock market are established. Though the GDP impact in real terms is not significant in explaining the conditional correlation, the business cycle synchronization that is estimated via the GDP index does have a strong impact on the coherence of the securitized real estate cycles in Chapter 5.

In Chapter 4, a financial crisis has a significant positive impact on the co-movement relationship of the 8 securitized real estate markets. Consistent with the findings of Chapter 3, the interdependence relationship is found to be much higher during a crisis period. The findings on the whole support the obvious evidence of the contagion effect during a crisis period for the 8 securitized real estate markets.

6.2 Research Contribution and Further Work

The co-movement change affirms the efficiency of the diversification investment strategy for investors. The long run studies of the co-movement offer suggestions on the choice of the long-term investment portfolio. The short run studies serve to enable a better understanding of the short-term investment strategy. To enable better investor decision making, their decisions should be based on price changes and on studies of the securitized real estate cycle synchronization, which offer informative references. The empirical results from this study suggest that the investors could still invest in the international securitized real estate as an effective investment asset class for enhancing risk diversification.

Besides and given a plenitude of variables that are available to international investors, it becomes important for such investors to consider only the “real estate” and “control” factors. These factors are particularly useful for modelling the changes of the international co-movement of the real estate securities markets. The contagion effect in the securitized real estate market should be given due attention by policy makers and by investors at large, because contagion inevitably leads to a global financial crisis, and because the correlations among the international real estate securities would be substantially raised via the contagion effect.

Since the real estate based correlation model of Chapter 4 is confined to the short and long-term forecasts, we are not sure whether or not the model could be successfully implemented to generate the “optimal” and *ex-ante* international securities portfolio for investing purposes. Further deliberation in this area may well be a challenging yet fruitful experience.

Further studies could be undertaken via incorporating the common macro-economic indicators of Chapter 3 into the probability estimations or via using the appropriate macro-economic indicators in crisis times. For instance, the real estate markets are vulnerable to changes in the interest rate and in the net inflation rate. Chapter 4 therefore enables more of the related cycle variables to be added to the model, which in turn analyses the relationship between the real estate and the business cycles (also known in general as the control variables). The other form of the business cycles or the financial cycles could be duly considered like the movement in a bank's line of credit to its creditor customers. Further study can be done especially on pure real estate cycle synchronization structures in Chapter 5, for it contains more information other than general macroeconomic and equity market.

References

Aggarwal, R., Lucey, B., and Muckley,C. (2003). Dynamics of Equity Market Integration in Europe, Evidence of Changes Over Time and With Events. Working paper, Institute for International Integration Studies,Trinity College Dublin.

Anderson, T.G., Bollerslev, T., Diebold, F. and Eberns, H. (2001). The distribution of realized stock return volatility. *Journal of Financial Economics*,61(1), 43-76

Anders,C,J and Christer,L.(2009). Spillover effects among the great China stock markets. *world development*, 37(4),839-851.

Arellano, M. and Bond, S.R. (1991). Some tests of specification in panel data, Monte Carlo evidence and an application to employment equations. *Review of Economic Studies*, 58, 277-297

Ash, R. F., & Kueh, Y. Y. (1993). Economic integration within Greater China, trade and investment flows between China, Hong Kong and Taiwan. *The China Quarterly*, 136(1), 711-745.

Bai, J. and Perron, P. (2003). Computation and analysis of multiple structural change models. *Journal of Applied Econometrics*,18,1-22

Ball, C. and Torus, W. (2004). Contagion in the presence of stochastic interdependence. research paper, Vanderbilt University and UCLA.

Bardhan, A. Edelstein, R. and Tsang, D. (2008).Global financial integration and real estate security returns" *Real Estate Economics*,36(2), 285-311

Beine, M and Candelon, B. (2011). Liberalization and stock market co-movement between emerging economies. *Quantitative Finance*,11(2), 299-312

Beine, M., Cosma, A., & Vermeulen, R. (2010). The dark side of global integration: Increasing tail dependence. *Journal of Banking & Finance*, 34(1), 184-192.

Bekaert, G. and Harvey, C.R. (1997). Emerging equity market volatility. *Journal of Financial Economics*,43, 29-77

Bond, S. A., Karolyi, G. A., & Sanders, A. B. (2003). International real estate returns, a multifactor, multicountry approach. *Real Estate Economics*, 31(3), 481-500.

Bodurtha, J.N., Cho, D.C. and Senbet, L.W. (1989).Economic forces and stock market, an international perspective. *Global Finance Journal,* 1, 221-46

Bracker, K. and Koch, P.D. (1999). Economic determinants of the correlation structure across international equity markets. *Journal of Economic and Business,* 51, 443-471

Bracker, K., Docking, D.S. and Koch, P.D. (1999). Economic determinants of evolution in international stock market integration. *Journal of Empirical Finance,* 6, 1-7

Brooks, C. and Tscolacos, S. (1999).The impact of economic and financial factors on UK property performance. *Journal of Property Research*,16(2), 139-152

Bwo-N,H and Chin-W.Y. and John, W-S. (2000). Causality and cointegration of stock markets among the united states, Japan and the south China triangle. *International Review of financial analysis,* 9(3), 281-297.

Campbell, J. Y., & Hentschel, L. (1992). No news is good news, An asymmetric model of changing volatility in stock returns. *Journal of financial Economics,* 31(3), 281-318.

Candelon, B., Piplack, J., & Straetmans, S. (2008). On measuring synchronization of bulls and bears, The case of East Asia. *Journal of banking & finance*, *32*(6), 1022-1035.

Candelon, B., Piplack, J., & Straetmans, S. (2009). Multivariate Business Cycle Synchronization in Small Samples. *Oxford Bulletin of Economics and Statistics*, *71*(5), 715-737.

Cappiello, L.,B. Gérard, and Manganelli S. (2005). Measuring comovements by regression quantiles.*ECB WP Series* #501.

Cappiello, L., Engle, R. F., & Sheppard, K. (2006). Asymmetric dynamics in the correlations of global equity and bond returns.*Journal of Financial econometrics*, 4(4), 537-572.

Case, B. Yang, Y. and Yildirim, Y. (2011).Dynamic correlations among assert classes, REIT and stock returns. *Journal of Real Estate and Finance* (forthcoming)

Chen, N., Roll, R. and Ross, S. (1986).Economic forces and the stock market. *Journal of Business*, July, 383-403

Chen, N. and Zhang, F. (1997).Correlations, trade and stock returns of the Pacific-Basin markets. *Pacific-Basin Finance J.* 5, 559-577

Cheng, H., & Glascock, J. L. (2005). Dynamic linkages between the greater China economic area stock markets—Mainland China, Hong Kong, and Taiwan. *Review of Quantitative Finance and Accounting*, 24(4), 343-357

Claessens, S., Kose, M. A., & Terrones, M. E. (2012). How do business and financial cycles interact? *Journal of International economics*, *87*(1), 178-190.

Coles, S., Heffernan, J., & Tawn, J. (1999). Dependence measures for extreme value analyses. Extremes, 2(4), 339-365.

Cotter, J., & Stevenson, S. (2006). Multivariate modeling of daily REIT volatility. *The Journal of Real Estate Finance and Economics*, *32*(3), 305-325.

Deardorff, A. (1998) .Determinants of bilateral trade, does gravity work in a neoclassical world. in Frankel, J, (ed), The regionalization of the world economy. The University of Chicago Press, Chicago

Dhar, R. and Goetzmann, W.N. (2006).Institutional perspectives on real estate investing. *Journal of Real Estate Portfolio Management*, 32, 110-116

Diebold, F. and Yilmaz, K. (2012).Better to give than to receive, predictive directional measurement of volatility spillovers. *International Journal of Forecasting*, 28, 57-66.

Edwards, S. (1998). Interest rate volatility, capital controls, and contagion (No. w6756). National bureau of economic research.

Eichholtz, P.M.A. (1996).Does international diversification work better for real estate than for stocks and bonds. *Financial Analysts Journal*, 52(1), 56-62

Eichholtz, P.M.A. (1996). The stability of the covariances of international property share returns. *Journal of Real Estate Research*, 11(2), 149-158.

Eichholtz, P., Huisman, R., Koedijk, K., & Schuin, L. (1998). Continental factors in international real estate returns. *Real Estate Economics*, 26(3), 493-509.

Engle, Robert F. and Manganelli, Simone. (2004) . CAViaR, Conditioanl autoregressive Value at Risk by regression quantiles., *Journal of Business&Economic Statistics* (22), 367-381

Fischer, K. P., & Palasvirta, A. P. (1990).High road to a global marketplace, The international transmission of stock market fluctuations. *The Financial Review*, 25, 371– 394.

Forbes, K.J. and R.Rigobon. (2002). No Contagion, only interdependence, measuring stock market comovements. *Journal of finance*, 57（5）,2223-2261.

Gilmore, C. G., & McManus, G. M., (2002) .International portfolio diversification, US and Central European equity markets. *Emerging Markets Review*, 3(1), 69– 83.

Guerts, T.G. and Jaffe, A.J. (1996).Risk and real estate investment, an international perspective. *Journal of Real Estate Research,* 11(2), 117-130

Harding, D., & Pagan, A. (2006). Synchronization of cycles. *Journal of Econometrics*, *132*(1), 59-79.

Hartzell, D., Hekman, J. and Miles, M. (1996). Diversification categories in investment real estate.*AREUEA Journal* 14, 230-254

Hashmi, A., and X. Liu. (2001). Interlink ages Among South East Asian Stock Markets (A Comparison Between Pre- And Post-1997-Crisis Periods). Working Paper presented at the 10th international Roe Vergara Financial Conference.

Hirata, H., Kose, M. A., Otrok, C., & Terrones, M. E. (2012). Global house price fluctuations, Synchronization and determinants (No. w18362). National Bureau of Economic Research.

Hoesli, M., Lekander, J. and Witkiewiez, W. (2004) .international evidence on real estate as a portfolio diversifier . *Journal of Real Estate Research,* 26(2), 161-206

Johansson, Anders C. and Lijunwall, Christer, (2009). Spillover effects among the Greater China stock markets. World Development, 37(4), 839-851

Kallberg, J. G., Liu, C. H., & Pasquariello, P, (2002). Regime shifts in Asian equity and real estate markets. *Real Estate Economics, 30*(2), 263-291.

Kim, S. and S.H. Kim, (2009). International Capital Mobility, Global vs Regional Perspective. Working Paper. Seoul National University.

Knight, J., Lizieri, C., & Satchell, S. (2005). Diversification when It Hurts? The Joint Distributions of Real Estate and Equity Markets 1. *Journal of Property Research*, 22(04), 309-323.

Ling, D. C., & Naranjo, A., (2002). Commercial real estate return performance, a cross-country analysis. *The Journal of Real Estate Finance and Economics*, 24(1-2), 119-142.

Liow, K. H., (2007). Cycles and common cycles in real estate markets. *International Journal of Managerial Finance*, *3*(3), 287-305.

Liow K.H., (2008). Financial Crisis and Asian Real Estate Securities Market Interdependence, Some Additional Evidence. *Journal of Property Research*, 25(2),127-155

Liow, K. H., & Webb, J. R., (2009). Common factors in international securitized real estate markets. *Review of Financial Economics*, 18(2), 80-89.

Liow, K. H., Ho, K. H. D., Ibrahim, M. F., & Chen, Z., (2009). Correlation and volatility dynamics in international real estate securities markets. *The Journal of Real Estate Finance and Economics*, 39(2), 202-223.

Liow, K.H., Chen, Z. and Liu, J. (2011).Multiple regimes and volatility transmission in securitized real estate markets. *Journal of Real Estate Finance and Economics*, 42, 295-328

Liow, K.H. and Newell, G, (2012). Investment dynamics of the Greater China real estate securities markets. *Journal of Real Estate Research*, 34(3), 399-428

Liow, K.H., (2012).Co-movements and correlations across Asian Securitized Real Estate and Stock Markets. *Real Estate Economics*, 40(1), 97-129

Liu, C. H., & Mei, J. (1998). The predictability of international real estate markets, exchange rate risks and diversification consequences. *Real Estate Economics*, 26(1), 3-39.

Longin, F. and Solnik, B, (1995).Is the correlation in international equity returns constant, 1960-1990.*Journal of International Money and Finance*, 14(1), 3-26

McCue, T.E. and Kling, J.L (1994).Real estate return and the macroeconomy, some empirical evidence from real estate investment trust data, 1972-1991. *Journal of Real Estate Research*, 9(3). 277-287

Michayluk, D., Wilson, P. J., & Zurbruegg, R. (2006). Asymmetric volatility, correlation and returns dynamics between the US and UK securitized real estate markets. *Real Estate Economics*, 34(1), 109-131.

Panton, D. B., Lessig, V. P., & Joy, O. M. ,(1976). Comovement of international equity markets, A taxonomic approach. *Journal of Financial and Quantitative Analysis*, (11),415– 32.

Peng, M. W., Lu, Y., Shenkar, O., & Wang, D. Y. (2001). Treasures in the China house: A review of management and organizational research on Greater China. *Journal of Business Research*, 52(2), 95-110.

Poncet, Sandra, (2003). Measuring Chinese Domestic and International Integration. *China Economic Review*, (14),1-21.

Poon, S.H., Rockinger, M. and Twan, J. (2004). Extreme value dependence in financial markets, diagnostics, models and financial applications. *Review of Financial Studies,* (17), 581-610.

Pindyck, R. and Rubinfield, (1998).*Econometric models and economic forecast*. McGraw-Hill Book Co

Pretorius, E. (2002). Economic determinants of emerging market interdependence. *Emerging Markets Review,*3, 64-105

Pyhrr, S. A., Roulac, S. E., & Born, W. L. (1999). Real estate cycles and their strategic implications for investors and portfolio managers in the global economy. *Journal of Real Estate Research*, *18*(1), 7-68.

Quigley.J.M. (1999). Real estate prices and economic cycles. *International Real Estate Review*, 2(1), 1-20.

Rantanapakon, O., and S. Sharma. (2002). Interrelationships among Regional Stock Indexes. *Review of Financial Economics*, 11, 91-108

Sagalyn, L. B. (1990). Real estate risk and the business cycle, evidence from security markets. *Journal of Real Estate Research*, *5*(2), 203-219.

Sirmans, C. F., & Worzala, E. (2003). International direct real estate investment, a review of the literature. *Urban Studies*, 40(5-6), 1081-1114.

Walti, S. (2011).Stock market synchronization and monetary integration. *Journal of International Money and Finance*,30, 96-110

Wang, Z., & Schuh, E. G. (2002). The emergence of a greater China and its impact on world trade, A computable general equilibrium analysis. *Journal of Comparative Economics*, 30(3), 531-566.

Wilson, P., & Okunev, J. (1999a). Spectral analysis of real estate and financial assets markets. *Journal of Property Investment & Finance*, *17*(1), 61-74.

Wilson, P. J., & Okunev, J. (1999b). Long-term dependencies and long run non-periodic co-cycles, Real estate and stock markets. *Journal of Real Estate Research*, 18(2), 257-278.

Yang, J., J. Kolari, and I. Min. (2003). Stock Market Integration and Financial Crisis, The Case of Aisa. *Applied financial economics*, 13(7), 477-86

Yin-Wong Cheung, Menzie Chinn and Eiji Fujii.(2003). China, Hong Kong, and Taiwan, A Quantitative Assessment of Real and Financial Integration, Santa Cruz Center for International economics, Dept of Economics, UCSC, US Santa Cruz.

Yunus, N., & Swanson, P. E. (2007). Modelling linkages between US and Asia-Pacific securitized property markets. *Journal of Property Research*, 24(2), 95-122.

Yunus. N. (2009). Increasing Convergence Between U.S. and International Securitized Property Markets, Evidence Based on Cointegration Tests.*Real Estate Economics*, 37(3), 383-41

Appendix 1 Data Sources

Variables	Data sources
Securitized real estate returns	S&P property index
Stock market returns	S&P broad market index
Interest rate	International monetary fund, International financial statistics
Inflation rate	
Growth in industrial production	
Term spread	
GDP	
Bilateral Trade	International monetary fund, Direction of Trade
Institutional Quality	The World Bank Governance Indicators
Exchange Rate	OECD economic outlook
FDI on real estate	National Bureau of each countries