A Web of Shocks: Crises Across Asian Real Estate Markets[1]

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Abstract

The behaviour of real estate markets during the 1997-98 financial crisis in Asian economies has received little attention despite the extensive research on other asset markets over this time. This paper examines the transmission of shocks across national real estate markets prior to and during the Asian crisis using a multivariate latent factor framework. The results reveal that diversification opportunities prior to the crisis are much reduced during the crisis. A comparison with regional equity markets shows that the transmission of shocks differs across the real estate and equity markets, providing evidence that investment in multiple asset classes provides some protection from large market downturns.

Key words: Latent factor, contagion, indirect estimation, real estate.
JEL Classification: G14,F36,C30

1 Introduction

During the 1997-98 East Asian financial crisis currencies collapsed and stock market losses were large. While these aspects of the crisis have been well analysed, the behaviour of the regions' real estate markets has remained relatively unexplored. That new territory remains is surprising as the over-extension and subsequent collapse of bank credit to the property sector was a feature common to many of the economies in the region (Herring and Wachter 1999, Mera and Renaud 2000). This paper explores the transmission of the East Asian crisis shocks in real estate markets across national borders. In doing so, this paper has broader implications for asset market diversification, adding to the evidence that diversification across asset classes, as well as geographical borders, assists in risk management. In addition the paper further develops the empirical literature on contagion modelling.

A strong correlation in the behaviour of asset markets in response to large shocks is known in the finance literature as contagion (Forbes and Rigobon 2002, Pericoli and Sbracia 2003). Its presence seriously limits the potential for portfolio diversification. However, if some asset classes transmit shocks differently, diversification opportunities remain. We consider the transmission of shocks across real estate markets during the East Asian crisis, and benchmark this against behaviour in the equity markets. In the pre-crisis period there is substantial potential for geographic diversification across real estate markets, but during times of crisis this is greatly reduced. A similar conclusion holds for equity markets. However, crisis transmissions in real estate markets differ from those evident in the equity markets - implying that even during crisis periods some diversification gains remain across these asset classes.

Specifically, this paper asks how much of the volatility observed in the public real estate markets of Hong Kong, Singapore, Japan, Australia and the US was due to contagion effects, or the transmission of unanticipated shocks across the region. This definition of contagion is consistent with those given in the existing empirical finance literature, including that of increased correlation, see Dungey, Fry, González-Hermosillo and Martin (2003).[1] While the promulgation of shocks in the East Asian crisis for other asset markets has been investigated - for an overview see Dornbusch, Park and Claessens (2000) and more recently Pericoli and Sbracia (2003) - this is less so for real estate markets. This is partly because accurate, high frequency information on real estate returns in East Asian countries is difficult to obtain. To overcome this problem, data on real estate securities, recently compiled by the European Public Real Estate Association, are used to represent country real estate returns.

Until the East Asian crisis real estate returns in Asia far outstripped those available in the US and Europe for most of the 1990s (see de Wit and van Dijk 2003 for a comparison). Although commercial real estate markets are inherently local there were a number of regional influences prior to the crisis which signalled the future value of real estate assets in individual markets. For example, rising interest rates, falling rental income (due to reduced demand and oversupply of new commercial buildings), failure of multinational tenants and reductions in bank lending to the sector. Each of these events impact the valuation of commercial real estate, and could contribute to spreading doubt about the sector across the region.

The novelty of this paper is in quantifying the relative contribution of transmissions between geographically diverse real estate markets to their observed volatility. Three main points result. First, during the pre-crisis period there appear to be substantial opportunities for diversification across geographic borders in real estate markets, potentially more so than in eq-

[1] Specifically, Dungey, Fry, Gonzalez-Hermosillo and Martin (2003) show that the contagion tests of Forbes and Rigobon (2002), Bae, Karolyi and Stulz (2003), Favero and Giavazzi (2002), Eichengreen, Rose and Wyplosz (1995,1996) can be written in the same framework as the latent factor model proposed in this paper, and that the tests of contagion are tests on the same parameter in each case.

uity markets. Second, during periods of crisis real estate markets do tend to move together, reducing the protection geographic diversification offers during these periods. A similar result holds for equities. However, and finally, the transmission effects generally differ between real estate and equity markets, implying opportunities for diversification protection by investing across asset classes as well as geographical borders. A further point that results from the analysis is expressing returns in local currency or USD makes little qualitative difference to these outcomes.

The paper proceeds as follows. Section 2 reviews the existing literature on modelling international real estate returns, discussing in particular the conflicting evidence on the integration of real estate markets with other asset classes. Section 3 describes the data set and section 4 explains the modelling methodology. The empirical evidence for promulgation of shocks in real estate markets are reported in section 5. As a benchmark these results are compared with evidence on promulgation of shocks in equity markets in the same region and period. The evidence for contagious transmissions in real estate markets is then reassessed while controlling for the volatility in equity markets. Section 6 concludes the paper.

2 The transmission of shocks in real estate markets

Physical real estate investment can be an important diversification strategy in a mixed portfolio, particularly in providing an inflation hedge. However, it has the disadvantage of being lumpy and relatively illiquid. An alternative method of investing in real estate while minimising these drawbacks is real estate securities. The advantages of using this type of data are considerable. Real estate securities are traded on public markets and as such have low transaction costs and a high level of transparency in trading. Transaction can also be conducted quickly and allow fund managers and investors to alter their real estate exposure with the minimum of waiting. This compares to the direct real estate market where transactions of investment grade property can take in excess of six months and in some cases longer than one year[2]. From a methodological viewpoint real estate securities are preferred for the current study as contagious events often occur over short time horizons with near instantaneous transmission of shocks between markets. Detecting this contagion using data on the direct property market would be empirically more challenging due to the lower frequency nature of the data collection.

The extent to which real estate securities provide diversification opportunities through differences to other asset classes - particularly equities, is the subject of debate. Glascock, Lu and So (2000) provide a useful summary of the literature and additional results for the US REIT market. They find that for much of the 1990s the REIT market was cointegrated with the overall stock market though there was no evidence of cointegration with the bond market. However, these results are sample sensitive. It appears that REITS offer diversification benefits during some time periods but not in all cases. Given this uncertainty in the literature, additional research on the times when real estate securities provide diversification opportunities becomes important.

If the real estate securities market is segmented from the equities market, then these markets should behave differently in promulgating shocks during times of financial stress, providing portfolio protection. The evidence for this during the East Asian financial crisis is somewhat mixed. Kallberg, Liu and Pasquariello (2002) find limited evidence of Granger causality from Asian equity indices to real estate based equity indices for the five years to 1999, which encompasses the crisis period. However, they also find support for a structural break in the relationship between the two markets, with the timing of the break centred on the 1997-98 crisis. In an alternative

[2]For a more detailed discussion on transactions and liquidity in the direct property market see Bond and Hwang (2004).

approach related to the model of this paper, Mei and Hu (2000) conclude that Asian real estate stock portfolios were integrated during the Asian crisis as the result of a strong empirical common factor. More general evidence, however, suggests that country-specific shocks are dominant in driving real estate backed securities returns for Asia-Pacific economies, as documented in Bond, Karolyi and Sanders (2003). These contradictory findings raise the related question of whether crisis periods differ from non-crisis periods. If correlation across real estate market returns increases during a crisis period this reduces the protection available to investors from diversification.

The current paper builds on this research in a number of ways. We focus on the real estate securities of developed markets in Asia, specifically Hong Kong, Japan, Singapore and including Australia and the United States, in comparison with Kallberg, Liu and Pasquariello who focus primarily on developing countries. Public real estate markets in many developing countries are not well established, with securities often tightly held by a small number of shareholders and with infrequent trading of the remaining shares. Total capitalisation is very small. In contrast, the more developed markets considered here are characterised by higher capitalisation and relatively more liquidity.

The next section provides a thorough description of the data and sample period before proceeding to document the preliminary evidence for contagion.

3 Data Description

The data used in this study was obtained from the European Public Real Estate Association. Total country real estate returns are available on a daily basis. The indices are constructed on a consistent basis across countries from the share prices of companies with greater than \$US200 million listed capitalisation, who derive at least 60 percent of their income from property investment related activities. They must also be listed on the local stock exchange.[3] The aim of these new indices is to reflect property investment which is primarily for the purposes of obtaining income, thus companies engaged in construction and similar activities are excluded. However, in the Asian indices companies which build residential housing are included. The data are capitalisation weighted, and then reweighted to account for the proportion which is freely traded on the exchange. The indices are available both in local currency terms and in US dollars. Initially our analysis concentrates on local currency returns, which we then compare with US dollar denominated results.

Table 1 shows the number of companies included in the index for each country along with the market capitalisation as at January 1, 1998[4]. The markets considered clearly differ greatly in size and market capitalization. The US market is notably the largest, and the Singaporean market the smallest, at less than 100th the size. The Australian and Hong Kong markets are of a comparable market capitalisation, but the Hong Kong market is more concentrated, with half the number of companies included. The Japanese market is slightly smaller but even more concentrated, involving only 8 companies in the index[5].

The sample period ranges from January 1, 1997 to March 31, 1998. The sample is further separated into a pre-crisis period, and two crisis sub-periods as discussed in the next section.

[3]This is the definition for the Asian component of the indices. See the 'Rules for the EPRA/NARIET Global Real Estate Indices' documentation for full details on indices for other regions. Contact the first author for details.

[4]More details on the characteristics of the data in monthly form are available in Bond, Karolyi and Sanders (2003).

[5]It also needs to be noted that there are differences in the tax treatment of the securities in the sample. For the US and Australia, the real estate securities (real estate investment trusts and listed property trusts, respectively) are able to distribute earnings to shareholders without tax at the entity level. These trusts are formed to hold investment grade real estate. Whereas in Hong Kong, Singapore and Japan, at the time of the financial crisis, the underlying security is a property company. These company may have extensive holdings of real estate on their balance sheet. They may also engage in other real estate related activites, such as development, to a greater extent than an investment trust.

Table 1:
Securitised Real Estate Markets Characteristics As At 1 January 1998

market	number of companies	market capitalisation ($US mil)
Australia	26	27,367
Hong Kong	13	28,607
Japan	8	17,718
Singapore	4	1,682
US	106	149,771

3.1 Selection of the Crisis Period

One of the most difficult aspects of empirical work on financial crises is dating the crisis period; see Pesaran and Pick (2003) and Dungey, Fry, González-Hermosillo and Martin (2003). There is no clear method of identifying when a crisis begins or ends. Many studies use an event such as the devaluation of the Thai baht on July 2, 1997, or the Russian bond default on August 17 1998, although even then argument often arises as to when 'pressures' began to arise in the market.[6] Even less clear is the date that a crisis is considered to have concluded. In existing models of contagion, the sample period is often chosen exogenously, which is also the approach taken in this paper. Endogenous dating of crises is a useful area for future research.

The defining shock for the Asian real estate securities markets during the East Asian crisis period was the decline in the Hong Kong equity markets beginning October 20-23, 1997, associated with the successfully defended speculative attack on the Hong Kong dollar. This episode followed the break of the peg of the Taiwanese dollar to the US dollar by speculators the previous week (The Economist 1997b). During this period of speculative attack, Hong Kong's Hang Seng Index plummeted by almost a quarter, and led declines in

[6] For example, Lowenstein (2001) details the pressures leading up to the Russian default and subsequent LTCM collapse, and McKibbin and Martin (1998) implicate pressure in Thai equity markets prior to to the baht collapse.

other major stock markets around the world, including Japan, Singapore, and even Wall Street. Five days after the major Hong Kong crash, on October 27, Wall Street suffered the largest fall in terms of points (554) of any one day to that date (Forbes and Rigobon 2002 study this period). In successfully defending the speculative attack the Hong Kong currency board operations automatically led to large increases in interest rates, which quickly impacted on the real estate industry in Hong Kong (The Economist 1997a). Increased volatility was also felt in other real estate securities markets around the region. Figure 1 presents data for the real estate securities returns along with a comparison with equity market returns for the period January 1, 1997 to March 31, 1998.

Hong Kong experienced further episodes of turmoil in 1998. Three further clear speculative attacks were made on the Hong Kong currency, in January, June and August 13th. The August attack was the most severe, with the stock market reacting in such an adverse way that the Hong Kong Monetary Authority (HKMA) broke it's noninterventionist stance and bought stocks to counter the stock market decline (HKMA 1998:p125). In the period just preceding this attack, on July 28th the Monetary Authority also removed regulations on property exposure for the banking sector, in a move interpreted as support for the property market (HKMA 1998:p125, The Economist 1998a). Here we explore the promulgation of the shocks in international real estate markets during 1997-1998 with regard to the first two shocks, the October 1997 speculative attack and the January 1998 attack, the shaded areas on Figure 1 represent the two periods of crises considered. The figure clearly highlights the magnitude of the shocks in the various markets/countries.

The two criteria used to determine the crisis period dates are the presence of a speculative attack and stock market turmoil. Each crisis period is conveniently deemed to cover three months of daily observations. This is in part to ensure sufficient observations, and in part because the complexity of the shocks hitting financial markets in this period makes it very difficult to isolate any one event. Crisis period 1 begins on October 1, 1997 and ends on December 31, 1997, a total of 65 observations. This period contains the first speculative attack in October 1997 and the subsequent decline in real estate and stock market indices in Hong Kong. Crisis period 2 begins on January 1, 1998 and ends on March 31, 1998, a total of 63 observations and contains the second speculative attack. The pre-crisis period extends from January 1, 1997 to September 30, 1997 (195 observations).

Although there were further speculative attacks in 1998, as documented above, these were not included in the estimation for two reasons. First, increasing the number of crisis periods quickly increases the number of parameters to be estimated in the model described below. Second, the attack on Hong Kong in August 1998, was just days before the onset of the Russian crisis triggered by Russian default in bond markets. An analysis of the turmoil in August 1998 would require the inclusion of at least Russian markets to avoid model misspecification, and these data are currently not available.

The number of adverse shocks during each crisis period makes it difficult to *a priori* attribute contagion in crisis period 1 specifically to a Hong Kong shock for example. Many other extreme events occurred during this period, including the falls in the US stock market. The approach here is to examine the transmission of shocks across the quarter in order to understand how the periods are different. It is then possible to make some association with particular events given history.

3.2 Sample Characteristics

Table 2 shows that over the entire sample, the average daily return for the local currency real estate markets under consideration ranged from -0.17 percent in Singapore to 0.09 percent in Australia. The largest daily fall in the markets was experienced in Singapore, on the 8th of January, closely associated with a similar size fall in the Hong Kong returns. Singapore

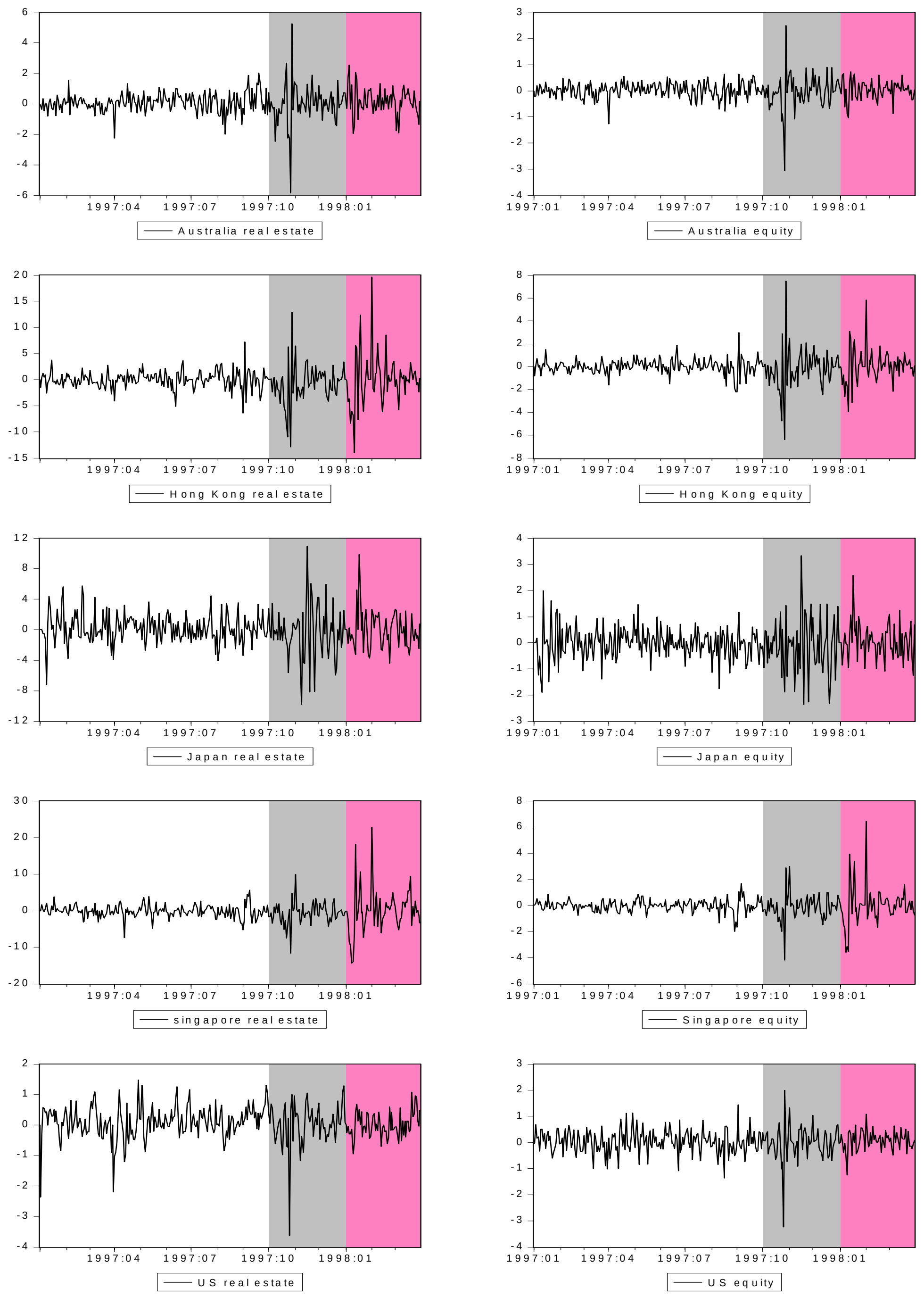

Figure 1: Real estate returns and equity returns in local currency over the period 1/1/97-31/3/98. Shaded areas indicate crises periods. Crisis 1: 1/10/97 - 31/12/97. Crisis 2: 1/1/98-31/3/98.

and Hong Kong also experienced the greatest rises in their returns, and the highest variance. The non-Asian markets of the US and Australia, by contrast, experienced relatively low rates of volatility, with commensurately smaller maxima and minima. Table 2 also shows descriptive statistics for returns in the pre-crisis, crisis period 1 and crisis period 2 subperiods. In general the volatility for each return is higher in the crisis periods than the pre-crisis period. An exception to this is the US which has lower volatility in the second crisis period. All markets experience the largest negative daily return during a crisis period; for Australia, the US and Japan this occurs in the last quarter of 1997, for Hong Kong and Singapore in the first quarter of 1998. By contrast, the largest positive daily return for the US occurs in the pre-crisis period, although for all other countries this occurs during a crisis. The average return falls during the crises, with the exception of Australia and Singapore where the average daily return rises in the first quarter of 1998.

As with the majority of reported real estate returns data, each series exhibits skewness, kurtosis and non-normality. Consistent with other asset markets, the returns also demonstrate statistically significant univariate GARCH(1,1) effects. These results are well established in the finance literature and hence not reported here.[7]

3.3 Pre-testing for contagion:

To gain some insights into an appropriate structure to impose on a multivariate model examining transmission of shocks in real estate markets, we pre-test for contagion using bivariate correlation tests. Tests of the significance of the change in bivariate correlation coefficients are commonly used in the finance literature as evidence of the existence of contagion; see particularly Forbes and Rigobon (2002), but also Ellis and Lewis (2000) and Baig

[7] The test statistics are available from the authors on request. The finding of skewness is consistent with the previous findings of Bond and Patel (2003).

Table 2:
Descriptive statistics of real estate index daily percentage returns in local currency terms over the total sample period, the pre-crisis period, crisis period 1 and crisis period 2.

	mean	max	min	std.dev.
total sample period (1/1/97 to 31/3/98)				
Australia	0.09	5.28	-5.85	0.87
Hong Kong	-0.16	19.68	-13.99	2.99
Japan	0.01	10.93	-9.80	2.38
Singapore	-0.17	22.75	-14.41	3.17
US	0.07	1.48	-3.63	0.55
pre-crisis period (1/1/97 to 30/9/97)				
Australia	0.10	2.03	-2.25	0.61
Hong Kong	0.01	7.23	-6.43	1.63
Japan	0.14	5.78	-7.19	1.84
Singapore	-0.13	5.65	-7.44	1.68
US	0.10	1.48	-2.36	0.53
crisis period 1 (1/10/97 to 31/12/97)				
Australia	-0.05	5.28	-5.85	1.37
Hong Kong	-0.81	12.95	-12.87	3.73
Japan	-0.34	10.93	-9.80	3.48
Singapore	-0.60	9.88	-11.61	2.91
US	0.03	1.29	-3.63	0.71
crisis period 2 (1/1/98 to 31/1/98)				
Australia	0.18	2.53	-1.944	0.89
Hong Kong	-0.03	19.68	-13.99	4.79
Japan	-0.02	9.88	-4.44	2.42
Singapore	0.14	22.75	-14.41	5.82
US	0.00	1.08	-0.95	0.41

and Goldfajn (1999) for applications.

For the purposes of these preliminary tests, the two crisis periods discussed above are aggregated into one crisis period from October 1, 1997 to March 31, 1998. Table 3 contains the correlation coefficients between the real estate security returns in the pre-crisis period and the longer crisis period, and in the final panel the results of testing for an increase in correlation between the given pairs of real estate returns between the non-crisis and combined crisis periods.[8] Statistically significant increases in correlation consistent with contagion are indicated between Hong Kong and each of Australia, Japan, Singapore and the US. In addition, there appears to be significant contagion between the US and Japan. No directional causality is indicated at this stage. However, the results broadly support the analysis of Section 1 which places Hong Kong at the centre of the real estate market turmoil. Building on these preliminary bivariate tests, the next section develops a model which measures the extent of contagion in a multivariate portfolio of real estate assets.

4 Model Specification

This section formally specifies a multivariate latent factor model of contagion in real estate returns for Australia (AU), Hong Kong (HK), Japan (JP), Singapore (SG) and the US (US). The framework is that developed in Dungey and Martin (2001) and is closely related to those used by other authors in testing for contagion. The general idea is that financial market assets, in this case real estate security returns, are deemed to respond to a common shock and a country-specific shock (also known as a systemic

[8] Forbes and Rigobon (2002) provide a form of the correlation test for contagion which controls for the increase in the variance of returns associated with the move from non-crisis to crisis periods when the crisis period is too short to provide an efficient estimate of the crisis covariance matrix. In the current application this is not necessary, as the total crisis period contains sufficient observations. Instead a simple test for the increase in correlation from the separate sample periods is sufficient, similar to that of Butler and Joaquin (2002).

Table 3:

Bivariate correlation t-test statistics for contagion. Pre-crisis period 1/1/97-30/9/97. Crisis period 1/10/97-31/3/97. Local currency estimation.

	Australia	Hong Kong	Japan	Singapore	US
Correlation coefficient in pre-crisis period (1/1/97 to 30/9/97)					
Australia	–				
Hong Kong	0.13	–			
Japan	0.10	0.13	–		
Singapore	0.15	0.28	0.03	–	
US	0.18	0.13	0.08	0.18	–
Correlation coefficient in combined crisis period (1/10/97 to 31/3/98)					
Australia	–				
Hong Kong	0.41	–			
Japan	0.19	0.31	–		
Singapore	0.26	0.70	0.14	–	
US	0.29	0.32	0.27	0.12	–
t-test statistic for increase in correlation					
Australia	–				
Hong Kong	2.69*	–			
Japan	0.85	1.65**	–		
Singapore	1.03	5.02*	1.02	–	
US	1.05	1.68**	1.80**	-0.54	–

*(**)denotes 5(10)% level of significance.

and idiosyncratic shocks in the finance literature). Contagion is thought of as interdependencies between markets which arise during crisis periods over and above the interdependencies evident during tranquil times. That is, country specific idiosyncratic shocks impact on other markets during a crisis period. The relationship between the factor model of contagion and alternative tests such as those of Bae, Karolyi and Stulz (2003), Eichengreen, Rose and Wyplosz (1995,1996), Favero and Giavazzi (2002) and Forbes and Rigobon (2002) are outlined in detail in Dungey, Fry, González-Hermosillo and Martin (2003). As the explanatory factors in the model are latent, the approach has the advantage of only requiring data on the dependent variable as there are no observed explanatory variables. This is a particular advantage when considering contagion in high frequency financial markets data where it is difficult to find relevant data to capture market fundamentals of the same frequency.

Let $s_{\mathsf{i,t}}$ be the demeaned continuously compounded percentage return of the i^{th} real estate index at time t, which is calculated by taking the daily difference of the natural logarithm of the real estate price index, that is

$$s_{\mathsf{i,t}} = \log(S_{\mathsf{i,t}}) - \ln(S_{\mathsf{i,t}})$$

where $S_{\mathsf{i,t}}$ is the real estate index for country i. Defining $\overline{s}_{\mathsf{i}}$ as the corresponding sample mean, the demeaned real estate return (referred to hereafter as the real estate return) is given by

$$y_{\mathsf{i,t}} = s_{\mathsf{i,t}} - \overline{s}_{\mathsf{i}}. \tag{1}$$

In a tranquil period where no significant contagion exists, a simple model of interdependence between real estate returns $y_{\mathsf{i,t}}$ can be specified as a linear function of a set of independent latent factors. The factor model is similar to models common in the finance literature for equity returns, fixed interest markets and currencies, such as Diebold and Nerlove (1989), Mahieu and Schotman (1994), King and Wadhwani (1990), Fama and French (1996), Bekaert, Harvey and Ng (2005) and Flood and Rose (2004). Theoretical foundations for the model can also be found in Masson (1999) in his description of contagion in currency markets.

$$y_{i,t} = \lambda_i V_t + \phi_i C_{i,t} \qquad i = AU, HK, JP, SG, US. \tag{2}$$

The first factor V_t is common to all returns but has varying impacts on each return given by the loadings λ_i. This factor captures interdependencies evident across countries and can be thought of as a common factor. The second factor $C_{i,t}$ captures country-specific shocks which impact on real estate returns through the country-specific parameter ϕ_i. It is through the country specific factor that benefits from diversification arise.

In a crisis period, normal interdependencies between financial markets are governed by the common factor V_t and the country loadings λ_i are maintained. However, additional 'contagious' linkages may arise during a crisis period, k, as an unanticipated shock in market j spills over to another market i.[9]

$$y_{i,t} = \lambda_{iK} V_t + \phi_i C_{i,t} + \sum_{1} \sum_{1} \delta_{i,j,k} I_{k,t} C_{j,t}, \quad i, j = AU, HK, JP, SG, AU \quad \forall i \neq j \tag{3}$$

Formally, these linkages are modelled by the inclusion of country j specific shocks ($C_{j,t}$) in the returns of country i during crisis period k. The importance of contagion for each return is given by $\delta_{i,j,k}$ $\forall i \neq j$. The indicator variable $I_{k,t}$ in equation (3) is a dummy variable to identify each crisis period. Hence to test the hypothesis of no contagion in a particular crisis, $k = 1$, involves a test of $\delta_{i,j,1} = 0$ $\forall i, j, i \neq j$. Similarly a test of no contagion over all crisis periods

[9] This is the identifying assumption of this paper. An alternative would be to assume that the country-specific shocks continue to be promulgated in the crisis period as in the tranquil period and that the coefficent λ_i changes between the non-crisis and crisis periods. The latter is dubbed 'shift contagion' by Forbes and Rigobon (2001). Unfortunately it is not possible to separately identify the two in the same specification. The choice made here is consistent with the majority of the literature on testing contagion - see Dungey, Fry, González-Hermosillo and Martin (2003).

considered involves a test of $\delta_{i,j,k} = 0 \; \forall i, j, k, i \neq j$. It is the additional impact of one country's shocks on another during a crisis that may offset benefits from diversification.

The current empirical application focusses on a tranquil or pre-crisis period, and two crisis periods, that is $k = 2$ in (3). To identify the model with the 5 countries examined in this application we also impose some restrictions on the direction of the contagious linkages. These are that Australia does not transmit contagion into any of the other countries - Australia is only a receiver of contagion effects in this model. This restriction seems well founded in that the Australian market was not considered to be exhibiting its own crisis characteristics during the period and hence did not transmit them to other countries, for example all the Asian countries exhibited much greater increases in volatility than Australia and the US. The US linkages are maintained because of its role as the major world financial market, the potential for it to act as a conduit for crises between markets (see Kaminsky and Reinhart 2002), as well as to examine whether the US stock market turmoil of 1997 was a source of contagion. The second restriction is that Singapore does not transmit contagion to the US in either crisis period - this receives support from the bivariate correlation tests reported in Table 3 where the correlation between US and Singaporean returns *fall* between the non-crisis and crisis periods.

The two crisis periods are defined by the dummy variables $I_{1,t}$ and $I_{2,t}$ as follows

$$I_{1,t} = \begin{cases} 1 & 1/10/97 \text{ to } 31/12/97 \\ 0 & \text{otherwise} \end{cases},$$

$$I_{2,t} = \begin{cases} 1 & 1/1/98 \text{ to } 31/3/98 \\ 0 & \text{otherwise} \end{cases}.$$

The selection of these crisis period dates was discussed in Section 3.1.

The common factor is further augmented to allow for potential autoregressive features and volatility clustering noted in the univariate data. This is achieved by letting the common factor evolve with an AR(1) process, ρ_V, and the errors from that process to demonstrate GARCH(1,1) characteristics. Placing these dynamics on the common factor implies that both of these characteristics are common across the different real estate returns, which seems appropriate from examining the univariate test results. The common factor is specified as follows to capture potential AR(1) and GARCH(1,1) characteristics whereby

$$V_t = \rho_V V_{t-1} + e_{V,t}, \tag{4}$$

$$h_t = 1 - \alpha - \beta + \alpha e^2_{V,t-1} + \beta h_{t-1}, \tag{5}$$

$$e_{k,t} = \sqrt{h_t} u_{V,t}, \tag{6}$$

$$u_{V,t} \sim N(0,1). \tag{7}$$

The structure of the coefficients α and β in equation (5) is an identifying assumption to normalise the variance of the common factor; see Diebold and Nerlove (1989).

The country-specific factors are specified to be normal random variables with constant variances whereby

$$C_{i,t} \sim N(0,1). \tag{8}$$

Estimation of the model proceeds using an indirect estimation method (Gourieroux, Monfort and Renault 1993). A full discussion of the estimation method is contained in the Appendix.

4.1 Volatility Decompositions

The assumption of independent factors in the model of equations (3) to (8) facilitates a variance decomposition of the volatility of returns. This has the advantage of quantifying the relative importance of contagion, world factors and country-specific factors over the sample period, and provides a meaningful representation of the results. The pre-crisis period decomposition is

$$var\left(y_{i,t}\right) = \frac{\lambda_i^2}{1-\rho_V^2} + \phi_i^2. \tag{9}$$

The volatility decompositions for each of the crisis periods depends on the specification of the contagious linkages for each case. For Australia, Hong Kong, Japan and Singapore the volatility decomposition in crisis period k is

$$var\left(y_{i,t,k}\right) = \frac{\lambda_i^2}{1-\rho_V^2} + \phi_i^2 + \sum_{1,j\neq i} \delta_{i,j,k}^2 \quad i = AU, HK, JP, SG, \quad j = HK, JP, SG, US, \quad \forall i \neq j. \tag{10}$$

Note, that $j \neq AU$, indicating that Australia is only a receiver of contagion effects and does not transmit them to other countries. For the US, which receives contagion only from Japan and Hong Kong, the volatility decomposition in crisis period k is

$$var\left(y_{US,t,k}\right) = \frac{\lambda_i^2}{1-\rho_V^2} + \phi_i^2 + \sum_{1} \delta_{US,j,k}^2 \qquad j = HK, JP \tag{11}$$

These decompositions will form the basis of the analysis in Section 5.

5 Evidence of contagion in a multivariate framework

The evidence from the bivariate tests in Section 3.3 suggests the presence of contagion between the sample countries during the combined crisis period. This section considers the evidence from a multivariate model presented in section 4, across two distinct crisis periods as defined in section 3.1. Table 4 presents the volatility decompositions for local currency real estate returns for the pre-, first and second crisis periods as described in equations (9) to (11).

During the pre-crisis period the relatively large contributions of the country-specific factors to volatility shown in the first rows of Table 4 indicate substantial scope for diversification across the regional real estate markets. Excluding Australia, each index has over 70 percent of total volatility associated with a country-specific factor, and the contribution of the common factor to this group of countries is as low as 4-10 percent in the case of Japan and the US. The importance of country-specific factors is consistent with the international asset pricing for real estate securities discussed in Bond, Karolyi and Sanders (2003). Hong Kong and Singapore exhibit relatively more commonality in their volatility with between 18 and 28 percent due to the common factor. Australia is anomalous during the pre-crisis period, with 84 percent of volatility common factor driven.

The results above may be misleading if not considered in conjunction with the contributions of each factor in terms of levels effects. Although the analysis suggests that Australia is more affected by the common factor than Hong Kong and Singapore, from Table 2 the level of volatility in the Hong Kong and Singaporean markets is far in excess of that of the Australian market. To take into account the relative volatility of the real estate markets, the decompositions in levels can be calculated by multiplying the results in Table 4 by the variances of market returns in the various periods shown in Table 2.[10] In levels, the effect of the common factor in Hong Kong and Singapore exceeds that observed for Australia (0.74 and 0.54 versus 0.49 percentage points squared respectively). Similar inferences can be drawn for the US and Japan, as the US market is far less volatile than that of Japan.

The contribution of total contagion to volatility is relatively high for Australia, at 93 percent of volatility and for the US at 82 percent of volatility, as shown in the middle panel of Table 4. The East Asian markets experienced

[10] This is calculated for Australia for example as the proportion of Australian volatility accounted for by the common factor multiplied by the variance of the Australian returns; that is $0.8432 \times 0.76^2 = 0.49$.

proportionately less, at around 58 percent for Hong Kong and Singapore and 33 percent for Japan. The main sources of contagion in the first crisis period are from Hong Kong into Australia, Japan into Hong Kong and Singapore into both Hong Kong and Japan.

Contagion from Japan contributed between 14 and 57 percent to the other real estate markets in the sample - consistent with Kaminsky and Reinhart's (2002) argument that developed markets act as a centre through which developing market crises travel to other seemingly unrelated developing countries. It may be that this argument can be extended to include the spread of crises to relatively developed financial markets as well as seems to be the case with Singapore here.

In the second crisis period the overall level of volatility rose in Japan and Singapore, but fell in Australia, Hong Kong and the US compared with the first crisis period (see Table 2). Although overall volatility rose in Japan, the proportionate increase in volatility appears to be as a result of strong contagion effects from Hong Kong. Almost 70 percent of the volatility in the Japanese real estate securities market is sourced from Hong Kong in the second crisis period. The breakdown of volatility for Singapore is similar to the first crisis period in that total contagion contributes about 51 percent to total volatility. However, contagion from Hong Kong plays a more important role for Singapore's volatility compared to the first crisis period which is characterised by contagion primarily from Japan. However, there remains substantial feedback from Japan to Singapore in the second crisis period and vice versa. Singapore plays an important role in the second crisis period, and acts as a conduit for contagion, with the largest proportionate effects into Hong Kong (88 percent of the total volatility in Hong Kong), as well as substantial effects into Australia (38 percent to the total volatility in Australia).

The picture painted by the two crises period results is consistent with the bivariate contagion results presented in Section 3.3, in that Hong Kong has discernible contagion effects on all the other markets, and there are links between the US and Japan. However, the multivariate model also picks up some additional channels - disentangling the effects from Singapore to Hong Kong in addition to Hong Kong to Japan, and the effect of Singapore on Australia.

Potential benefits from portfolio diversification may depend on the currency composition of the portfolio. However, Forbes and Rigobon (2002) and Bae, Karolyi and Stulz (2003) both find that contagion effects are little changed by currency of denomination. To examine this issue further the models were re-estimated in a constant currency of US dollars[11]. Broadly, the results were quite similar to the those estimated in local currency terms. The key differences are that the country-specific factor is generally less important in the US dollar terms, with Australia being the exception. Further, contagion from Hong Kong to the US is much larger in US dollar terms in the first crisis period, and smaller in the second crisis period. This may indicate that Hong Kong was in fact important in contributing to the real estate market turmoil in the US in the last quarter of 1997.

5.1 Comparison: Equity market contagion

To provide an benchmark for the transmission of shocks in real estate markets during this tumultuous period we estimate the transmissions between local currency denominated equity market indices using the model of equations (3) to (8) for the same group of countries. The indices chosen were the ASX200/All Ordinaries for Australia, the Hang Seng Index for Hong Kong, the Dow Index for Japan, the Straits Times index for Singapore and the Dow Jones Industrial for the US.[12] The results from estimation of the model are shown in Table 5.

[11] These results are available from the authors on request.

[12] The equity market indices were extracted from Thomson Financial Datastream, with the following source codes: Australia ASXAORD(PI), Hong Kong HNGKNGI(PI), Japan JAPDOWA(PI), Singapore SNGPORI(PI), US DJINDUS(PI).

Table 4:

Real estate market: Unconditional volatility decompositions expressed as a percentage of total in local currency terms over the pre-crisis period (1/1/1997 to 30/09/97), crisis period 1 (1/10/97 to 31/12/97) and crisis period 2 (1/1/98 to 31/03/98).

factor	Australia	Hong Kong	Japan	Singapore	US
		pre-crisis period results			
common	84.32	27.51	4.26	18.53	9.48
country	15.68	72.49	95.74	81.47	90.52
Total	100.00	100.00	100.00	100.00	100.00
		crisis period 1 results			
common	6.20	11.34	2.84	7.93	1.67
country	1.15	29.89	63.74	34.85	15.97
contagion from					
Australia	–	–	–	–	–
Hong Kong	67.46	–	11.86	0.66	44.22
Japan	20.81	14.06	–	56.56	38.13
Singapore	4.04	44.53	17.95	–	–
US	0.33	0.17	3.62	0.01	–
Total	100.00	100.00	100.00	100.00	100.00
		crisis period 2 results			
common	12.93	3.02	0.63	8.96	4.44
country	2.40	7.97	14.23	39.40	42.38
contagion from					
Australia	–	–	–	–	–
Hong Kong	39.56	–	68.67	23.45	45.99
Japan	6.89	0.53	–	28.18	7.19
Singapore	38.20	88.45	16.46	–	–
US	0.02	0.03	0.01	0.01	–
Total	100.00	100.00	100.00	100.00	100.00

Like the real estate assets, in the pre-crisis period the equity market indices also provide substantial opportunities for diversification, with relatively large country-specific factors. The breakdown is not the same as that reported in Table 4 which suggests further scope for diversification across equity and real estate markets.

The crisis period results suggest that the equity markets experienced generally less contagion in the crises than the real estate markets as a proportion of total volatility. The key differences appear in the impacts from and to the US. Given the large movements in US equity markets in the first crisis period outlined in Section 3.1, this is not unexpected. Contagion from the US equity market contributes around 19 percent to the volatility of Hong Kong and Japanese equity markets in the first crisis period compared to negligible levels for the real estate returns in the same period. Contagion to the US from Hong Kong and Japan was also less important in equity markets than in real estate in both periods. While Singapore was largely affected by shocks from Japan in the real estate market, Singapore was mostly impacted by shocks from Hong Kong in the equity market (75 percent of Singapore's volatility emanated from Hong Kong in the second crisis period). The upshot of this is that the transmission of shocks between the different asset classes can be quite different, with the implication that successful portfolio management should consider diversification both by asset class and geographical location.

5.2 An integrated approach: Real estate and equities combined

To better understand the commonalities between the real estate and equity markets during this period we consider both markets simultaneously. There are three possible approaches to examine this issue. First, and ideally, the model specified in equations (3) to (7) could be augmented to include the two sets of asset markets (equity and real estate markets) while controlling for common shocks to all markets, and common shocks for markets in each

Table 5:

Equity Market Contagion: unconditional volatility decompositions expressed as a percentage of total in local currency terms over the pre-crisis period (1/1/1997 to 30/9/97), crisis period 1 (1/10/97 to 31/12/97) and crisis period 2 (1/1/98 to 31/3/98).

factor	Australia	Hong Kong	Japan	Singapore	US
			pre-crisis period results		
common	6.56	55.60	11.00	46.27	2.23
country	93.44	44.40	89.00	53.73	97.77
Total	100.00	100.00	100.00	100.00	100.00
			crisis period 1 results		
common	0.41	32.38	5.67	24.01	2.06
country	5.83	25.85	45.91	27.88	90.61
contagion from					
Australia	–	–	–	–	–
Hong Kong	65.12	–	23.26	10.81	5.84
Japan	11.63	20.06	–	37.08	1.49
Singapore	16.75	2.36	6.99	–	–
US	0.26	19.35	18.17	0.22	–
Total	100.00	100.00	100.00	100.00	100.00
			crisis period 2 results		
common	2.27	14.44	2.50	10.69	1.94
country	32.35	11.53	20.25	12.41	85.06
contagion from					
Australia	–	–	–	–	–
Hong Kong	33.37	–	40.50	74.29	12.69
Japan	1.08	3.40	–	2.38	0.31
Singapore	30.48	69.62	36.13	–	–
US	0.45	1.01	0.62	0.23	–
Total	100.00	100.00	100.00	100.00	100.00

country. A similar framework is proposed in Dungey and Martin (2001). The disadvantage of this approach is that the parameterisation of such a model expands quickly. Second, is to include an observed common factor, such as a global index return, similar to a CAPM model. In the current application the assumption of independence between the observed and latent factors is difficult to maintain. Hence we proceed in a third way, which overcomes these difficulties at the expense of some loss of efficiency in the estimates. Our procedure is to control for common shocks across the two markets by estimating the model in equations (3) to (7) on the residuals from regressing real estate returns on equity returns. For simplicity we refer to these returns as the excess real estate returns.

Table 6 reports the results of estimating the latent factor model on the excess real estate returns. In the pre-crisis period substantial benefits from cross country diversification are evident in the large country specific contributions to excess real estate returns. Country specific factors make a substantially smaller contribution in the two crisis periods. The pattern of contagion observed in the first crisis period highlights the role of Japan and Singapore. With the exception of Australian excess real estate returns, which are mostly affected by contagion from Hong Kong, the dominant components of contagion in the other countries lie with these two countries. In the second crisis Hong Kong features more strongly, while Singapore retains an important role.

Overall the difference between the decompositions for the excess returns and the raw real estate returns is not marked (compare the central panels of Tables 4 and 6). The key difference between the two models is in the role for Hong Kong in the first crisis period. Compared with the model which does not control for the effect of the equity market, the excess returns model does not appear to have a strong role for contagious shocks from Hong Kong to the other countries in the sample, except to Australia. The key point from this analysis is that although there seem to be some systematic relationships

Table 6:

Contagion in the real estate market having controlled for equity market effects: unconditional volatility decompositions expressed as a percentage of total in local currency terms over the pre-crisis period (1/1/1997 to 30/09/97), crisis period 1 (1/10/97 to 31/12/97) and crisis period 2 (1/1/98 to 31/3/98).

factor	Australia	Hong Kong	Japan	Singapore	US
			pre-crisis period results		
common	79.67	18.32	3.01	12.20	3.80
country	20.33	81.68	96.99	87.80	96.20
Total	100.00	100.00	100.00	100.00	100.00
			crisis period 1 results		
common	4.69	7.61	1.99	5.56	0.78
country	1.20	33.94	64.13	40.02	19.84
contagion from					
Australia	–	–	–	–	–
Hong Kong	61.89	–	0.02	7.66	1.02
Japan	18.21	25.98	–	46.52	78.36
Singapore	13.16	31.60	33.02	–	–
US	0.85	0.87	0.84	0.24	–
Total	100.00	100.00	100.00	100.00	100.00
			crisis period 2 results		
common	11.54	2.08	0.45	5.41	2.18
country	2.94	9.28	14.63	38.92	55.14
contagion from					
Australia	–	–	–	–	–
Hong Kong	46.93	–	68.70	23.87	30.41
Japan	3.31	0.57	–	31.79	12.27
Singapore	35.28	88.05	16.19	–	–
US	0.00	0.02	0.02	0.01	–
Total	100.00	100.00	100.00	100.00	100.00

between the countries in the sample in terms of contagious transmissions, there are also some real benefits to diversification across asset classes and countries in a crisis period. The benefits from diversification arise as the nature and severity of the shock across the two crisis periods examined reveal different transmission mechanisms. That is, a portfolio diversified across asset classes will provide greater protection from the effects of a crisis than a single asset class based portfolio.

6 Conclusions

Although the Asian financial crisis is receding from recent memory as economic growth returns to the region there remain important conclusions to be drawn about the nature of financial market transmissions and the behaviour of major asset classes during crisis periods. In this paper we have examined how unanticipated shocks were propagated through the real estate backed securities and equity markets of the major developed economies of the Asia Pacific region over the period from late 1997 to early 1998. In particular the paper examined the transmission of unanticipated shocks, or contagion in the real estate backed securities markets of the region. Given the depth of research on the Asian crisis it is surprising that little knowledge exists of the behaviour of real estate securities markets over this time. Simple bivariate correlation tests indicate that the Hong Kong real estate markets were at the centre of contagion during this period. Using a multivariate latent factor model the unconditional volatility of country level asset returns can be decomposed to reveal the sources and magnitude of transmission from other markets. These tests confirmed the central role played by Hong Kong in the crisis. In addition Singapore and Japan are shown to have an important secondary role in transmitting the crises through contagion. The Pacific Rim countries of Australia and the US were receivers of contagion over this period although the magnitude of the shocks received by the US were small.

A number of implications for portfolio management arise from the empirical results of this study. Firstly in non-crisis periods there appear to be large gains to be achieved from geographic diversification strategies in real estate markets. For almost all of the countries included in the study the gains from geographic diversification from real estate are in excess of that available to equity investors. The exception to this is the Australian real estate market which may reflect the fact that some listed Australian real estate securities hold properties located in other countries. In common with other asset classes the benefits of geographic diversification for real estate are reduced during periods of crisis. In the Asian crisis two phases are evident. In the last quarter of 1997 the geographic diversification benefits for real estate investors in Asian markets did not fall as far as it did for equity market investors. During the first quarter 1998 the evidence of benefit from geographic diversification for real estate investors is more difficult to determine. Contagion in equity markets followed broadly similar patterns to real estate markets, although the real estate markets of Hong Kong, Singapore and Australia were more influenced by localised contagion than the corresponding equity markets.

A final finding of the study was that the choice of local currency or US dollar denominated returns did not appear to affect the main conclusions regarding the transmission paths for contagion. The implications of this evidence for portfolio management are that it seems although the benefits of diversification do decrease during periods of financial stress, when markets tend to move together, the extent of common movement differs by asset class as well as by geographical location. Hence, although increased correlation reduces diversification benefits during crises, a portfolio across asset classes will experience less common movement than a single asset class based portfolio.

7 Appendix A

7.1 Estimation Methodology

The contagion model developed in Section 4 contains autoregressive and conditional hetroskedasticitic characteristics, and hence maximum likelihood techniques will produce inconsistent estimates. The alternative estimation approach adopted here is to use simulation based methods, in particular, indirect estimation (Gourieroux, Monfort and Renault 1993), also known as the efficient method of moments estimator (Gallant and Tauchen 1996) or simulated GMM (Duffie and Singleton 1993).

Indirect estimation involves simulating the model in (3) to (8) $H = 100$ times to generate simulated real estate returns. Moments of this simulated data are then compared with those from the actual data. The collection of moments is labelled the auxiliary model, which is designed to capture the salient empirical moments of the distribution of the data. Parameter estimates are obtained by minimising the weighted difference between the average auxiliary model from the simulated data and the observed data. Formally, let $\hat{\Psi}$ represent the vector of (33×1) unknown parameters given in the model developed in Section 4. The estimator is given as the solution to

$$\hat{\Psi} = \arg\min G'\Omega^{-1}G$$

where G is a vector of $(M \times 1)$ moment conditions, and Ω is a $(M \times M)$ weighting matrix. In the current application the weighting matrix is set as an identity matrix. The weighting matrix may be calculated based on the outer product of the gradients of the actual data adjusted for autocorrelation with Newey-West weights; see Gourieroux, Monfort and Renault (1993) for further details.

The auxiliary model is designed to capture the salient characteristics of the data set and consists of five parts. The first component is the lower diagonal of the variance-covariance matrix of the real estate returns (actual and simulated) calculated during a pre-crisis period. This yields $N\left(N \times 1\right)/2 =$ 15 unique elements. The purpose of this component of the auxiliary model is to identify the λ_{i} and ϕ_{i} parameters which represent the interdependencies of the real estate markets during 'normal' times. The second and third components of the auxiliary model are the two lower diagonal of the variance-covariance matrix sourced from the two crisis periods. In each crisis period, this yields an additional 15 moment conditions, or 30 moment conditions over the two crisis periods. From these variances and covariances, the loadings on the contagion parameters $\delta_{\mathsf{i,j,k}}$ can be identified.

To identify the autoregressive parameter on the common factor, the first principal component, PC_{t}, of the real estate indices is extracted using an Eigen decomposition, and regressed on the lag of itself to obtain one further unique element. Although extracting the principal component provides a good approximation of the common factor, it does not take account of the conditional variance structure of this factor. It is used as the fourth component of the auxiliary model.

The fifth and final part of the auxiliary model is designed to identify the GARCH characteristics of the common factor. Taking first the mean of the standardized and demeaned squared change in the principal component extracted for the fourth element of the auxiliary model, (Z_{t}), the fifth component is the product of Z_{t} with its own first and second order lags. Then the fifth component of the auxiliary model, $(G5)$, is given by:

$$G5 = \overline{(Z_{\mathsf{t}} \times Z_{\mathsf{t}-1})}\tilde{}\,\overline{(Z_{\mathsf{t}} \times Z_{\mathsf{t}-2})},$$

where

$$Z_{\mathsf{t}} = \frac{\Delta PC_{\mathsf{t}}^2 - \overline{\Delta PC_{\mathsf{t}}}^2}{\sigma_{\Delta PC_{\mathsf{t}}^2}}.$$

The auxiliary model contains $(15 + (15 \times 2) + 1 + 2 = 48)$ unique elements with which to identify the 43 unknown parameter estimates. Thus, the model has five over identifying restrictions.[13]

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