Macroeconomic risk influences on the property stock market

Kim Hiang Liow, Muhammad Faishal Ibrahim and Qiong Huang
Department of Real Estate, National University of Singapore, Singapore

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Abstract

Purpose – The purpose of this paper is to provide an analysis of the relationship between expected risk premia on property stocks and some major macroeconomic risk factors as reflected in the general business and financial conditions

Design/methodology/approach – Employs a three-step estimation strategy (principal component analysis, GARCH (1,1) and GMM) to model the macroeconomic risk variables (GDP growth, INDP growth, unexpected inflation, money supply, interest rate and exchange rate) and relate them to the first and second moments on property stock excess returns of four major markets, namely, Singapore, Hong Kong, Japan and the UK. Macroeconomic risk is measured by the conditional volatility of macroeconomic variables.

Findings – The expected risk premia and the conditional volatilities of the risk premia on property stocks are time-varying and dynamically linked to the conditional volatilities of the macroeconomic risk factors. However there are some disparities in the significance, as well as direction of impact in the macroeconomic risk factors across the property stock markets. Consequently there are opportunities for risk diversification in international property stock markets.

Originality/value – Results help international investors and portfolio managers deepen their understanding of the risk-return relationship, pricing of macroeconomic risk as well as diversification implications in major Asia-Pacific and UK property stock markets. Additionally, policy makers may play a role in influencing the expected risk premia and volatility on property stock markets through the use of macroeconomic policy.

Keywords Macroeconomics, Property, Stock markets, Financial risk

Paper type Research paper

1. Introduction

Real estate is the world's biggest business accounting for 15 percent of global gross domestic product (GDP) with assets of US$50 trillion compared with US$30 trillion in equities (Bloomberg, 2004). Moreover more than 50 percent of the world's total assets are invested in direct real estate and securitized real estate investment vehicles such as real estate investment trusts (REITs) or real estate stocks (Brown and Matysiak, 2000). In the literature on real estate returns, a number of studies have examined the risk-return performance and pricing of real estate in the macroeconomic context. The importance attached to this line of research originates from the substantive work on the systematic effects of economic variables on stock and bond returns. Since real estate is an integral part of the economy, its returns are linked to the macroeconomy and business conditions (Liu and Mei, 1992). Additionally, some studies such as Ling and Naranjo (1997) and Mei and Hu (2000) have considered time variations in returns and risk premia in economic factors. Undoubtedly, this area of research has greatly enhanced investors' understanding regarding the macroeconomic impact of real estate investment performance. This is especially meaningful when real estate is a significant

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asset of a nation's economy such as in the USA, UK and many developing economies in Asian-Pacific region.

While much works have been done on stock markets and USA REITs, this research provides an alternative perspective on the dynamic relationship between listed real estate market and the macroeconomy. Specifically, we examine whether the expected risk premia on property stocks of Hong Kong, Singapore, Japan and UK could be linked to the conditional volatilities of a set of principal components derived from six chosen observable macroeconomic variables. Coupled with providing insights from the Asia real estate market perspective, the inclusion of the UK market in this study provides an opportunity to make comparison between the results from Asia and the UK real estate markets.

Another contribution of the paper stems from the use of a three-step methodological framework in addressing the objectives of the paper. First, for each market, the method of principal component analysis is employed to group relevant economic factors that determine excess returns on property stocks. Second, a Generalized Autoregressive Conditional Heteroscedasticity (GARCH) specification is applied to a set of derived principal components to measure their time-varying conditional variances and covariances. Third, the possible influence of the major economic risks on the expected risk premia of property stocks is determined using Generalized Method of Moments (GMM). Following the implementation of these approaches, we compare the significance and direction of major economic risks on the expected risk premia across all real estate markets.

Since property stock combines the investment characteristics of direct real estate and general stock, property stock market return and volatility profiles are likely to be different from those of stock markets (especially) in the long term. Moreover, property stocks are also different from REITs in their organization form, tax status, institutional framework and risk-return performance. Thus, we propose to extend the inquiries of this study to cover major property stock markets and examine the potential impact that macroeconomic risk may have on property stock excess returns.

In a preview of our results, we are able to find that the expected risk premia on property stocks of the four markets are time-varying and dynamically linked to the conditional volatilities of the macroeconomic factors. Significant results are obtained from the macroeconomic volatilities as useful predictors for the expected risk premia and their conditional variances. But these significant results depend upon the individual markets involved.

To establish a background for the study, the next section provides a review of relevant literature. This is followed by presentations of research data and methodology. The empirical results are then reported and their implications are discussed. The final section concludes the study.

2. Related literature

The significance of economic fundamentals using the arbitrage pricing theory (APT) of Ross (1976) has been well documented. Studies by Fama (1981), Chen *et al.* (1986), Chen (1991) and Ferson and Harvey (1991) have documented a significant relationship between the US stock returns and real economic variables such as industrial production, real GNP, interest rates, inflation and money supply. Beenstock and Chan (1988) also identify a set of economic factors to explain variations in the UK stock returns – interest rate, money supply and two inflation measures. Harvey (1995) investigates the influence of oil prices, world industrial production, world inflation rate, world market equity return and the return on a foreign-currency index on emerging market returns. Sill (1995) documents that the industrial production output, T-bill rate and inflation are statistically significant in explaining the US stock market excess returns. In addition, the conditional variance-covariances of the three macroeconomic factors are important drivers of the conditional stock return volatility. Other recent studies include Liljeblom and Stenius (1997), Errunza and Hogan (1998), Kearney and Daly (1998),Cheung and Ng (1998), Aylward and Glen (2000), Hondroyiannis and Papapetrou (2001), Bislon *et al.* (2001), Patro *et al.* (2002) and Fifield *et al.* (2002).

In the real estate literature, Kling and McCue (1987) consider the influences that macroeconomic factors have on the USA office construction using vector autoregressive (VAR) models that include monthly office construction, money supply, nominal interest rates and output (GNP). Chan *et al.* (1990) suggest that the bond market risk premium and stock market capitalization are the most important macroeconomic variables in explaining the average variation in REIT returns whilst Liu and Mei (1992) find that capitalization rate, dividend yield and Treasury Bill yield explain a significant portion of US REIT excess returns. Using the VAR methodology, McCue and Kling (1994) show that prices, nominal rates, output and investment directly influence real estate returns. In addition, the state of economy explains almost 60 percent of the variations in REIT return series. Ling and Naranjo (1997) employ nonlinear multivariate regression techniques to find that the growth rate in real per capita consumption, real Treasury Bill rate, term structure of interest rates and unexpected inflation have influence on time-varying commercial real estate returns. Karolyi and Sanders (1998) find that there are varying degrees of predictability among stocks, bonds, and REITs and that most of the predictability of returns is associated with the economic variables employed in the asset pricing model. In addition, there is an important economic risk premium for REITs that is not represented in conventional multiple-beta asset pricing models. More recently, Johnson (2000) examines the association between Federal Reserve monetary policy and real estate returns using REIT indices as well as an index that removes the stock market influence to isolate the returns that are unique to real estate. Their results indicate a significant association between monetary condition and the performance of real estate market. In the UK, the Granger causality test results reported by Lizieri and Satchell (1997) indicate that the wider economy leads the real estate market in the short term but that, with a longer lag structure, positive real estate returns may point to negative future returns in the economy. Brooks and Tsolacos (1999) develop a VAR model that includes the rate of unemployment, nominal interest rates, spread between the long- and short-term interest rates, unanticipated inflation and dividend yield. Although their results are not strongly suggestive of any significant influences of the variables on variations of the filtered property returns series, there is some evidence that the interest rate term structure and unexpected inflation have contemporaneous effects on property returns.

The relationship between real estate market and the macroeconomy has also been investigated for some Asia markets. However, the number of study is relatively limited compared to the USA and UK. Liow (2000) assesses the cointegration properties of commercial real estate prices, real estate stock prices and three macroeconomic variables in the Singapore economy over the period 1980-1997.His results indicate that the commercial real estate market is linked to the property stock market and macroeconomic conditions in the long-run, and that about 10 percent of the deviation between the actual and equilibrium value of the commercial real estate price is corrected in each quarter. Chau *et al.* (2001) indicate that both capital market variables and local economic variables are statistically significant in explaining the appraisal-based returns for Hong Kong real estate. The two sets of variables account for 58 percent to 87 percent of the total variation in returns, with the capital market factors contributing between 32 percent and 75 percent to the explanatory power. Liow *et al.* (2003) find that interest rate risk of Singapore real estate stocks is systematic and priced in the APT framework. Liow (2004) investigates the behavior over time of excess returns on commercial real estate in Singapore. He finds that the expected risk premia on office and retail real estate are both time varying and relate to time-varying conditional volatilities of five macroeconomic factors. Similarly, West and Worthington (2003) employ a GARCH-M model to consider the effect of macroeconomic factors on Australian commercial real estate, listed property trust and property stock returns over the period 1985 to 2002. Finally, Mei and Hu (2000) use a multi-factor latent variable model to examine the time variation of expected returns on Asian (Hong Kong, Singapore, Indonesia, Malaysia, the Philippines, Thailand and Japan) and the USA real estate stocks. The macroeconomic variables included in their study are short-term interest rates, the spread between long- and short-term interest rates, changes in the dollar exchange rates and the dividend yield on the market portfolio. They find that risk premia of Asian property stocks vary substantially and are significantly influenced by macroeconomic risk factors.

3. Sample and data characteristics

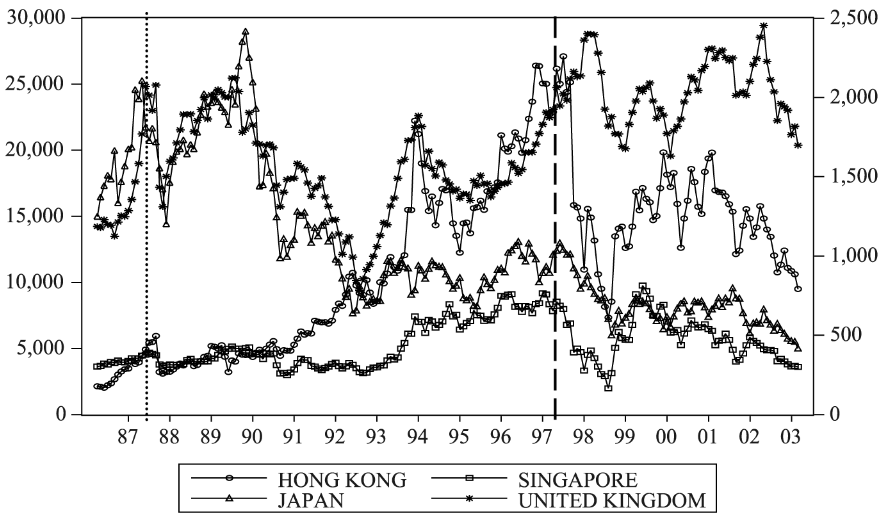
Our monthly price index dataset comes from the Datastream International. The markets (indexes) studied are: Hong Kong (Hang Seng Property Index), Singapore (Singapore All-Equity Property), Japan (Tokyo SE Real Estate Index) and the United Kingdom (Financial Times Real Estate Index). These four economies and their listed property markets are important to deserve a study. Japan is a significantly developed economy in Asia and also a world industrialized economy. Hong Kong and Singapore are major tiger economies in Asia. The fourth market, the UK is a world major economy and also a member of G7. Compared with other countries in Asia, Japan, Hong Kong and Singapore have track record of listed property companies that play a relative important role in the general stock indexes. Moreover, these three property stock markets are the only three Asian markets listed by Pierzak (2001) (reported in Worzala and Sirmans, 2003, p.1117). Specifically, the total number of property companies included from these four economies is 90 and is approximately 28.5 percent of the number of property companies around the world. The USA has the highest number of real estate companies (133) and is followed by UK (36), Australia (25), Hong Kong (22), Japan (20), The Netherlands (13), Singapore (12) and France (10). Additionally, 17 real estate companies (26.2 percent) of these four markets are in the USD one-billion club (UK: 6, Hong Kong: 6, Japan: 3 and Singapore: 2). Together these statistics suggest that these four economies have the world's relatively significant listed property markets in the respective regions: i.e. Asia and Europe. With bullish sentiment about property investment opportunities in Asia, this study reinforces the increased potential importance of Asia listed property in investment portfolios for both local and international investors. Finally, a study on Asia listed property particularly of Singapore and Hong Kong provides a good opportunity to examine the time-varying risk-return performance real estate investment and their macroeconomic effects in a market structure that is different from the major industrialized economies like Japan and the UK – land scarcity, high population density, lower initial yield and relatively high real estate values. The inclusion of the UK market in our study can provide comparative evidence and generate significant investor interest in international real estate.

Table I describes the property stock indexes adopted for this study. Figure 1 displays the index movements over the sample period from May 1986 to March 2003, the longest period for which the index data are available.

Hong Kong	Hang Seng Property Index is a capitalization-weighted index of all the stocks designed to measure the performance of the property sector at the Hong Kong Stock Exchange. The index consists of 6 members and its total market capitalization was HK$ 315.8 billion as at 11/07/03
Japan	Topix Real Estate Index is a capitalization-weighted index designed to measure the performance of the real estate sector of the Topix Index. The index was developed with a base value of 100 as of 04/02/68. It consists of 34 members with a total market capitalization of $ 2.98 trillion yen as at 11/07/03
Singapore	Singapore Property Equities Index is a capitalization-weighted index of all the stocks traded on the Stock Exchange of Singapore's property sector. The index was developed with base value of 1000 as of 03/01/97. It consists of 21 members with a total market capitalization of S$ 16.65 billion as at 11/07/03
UK	FTSE Real Estate Index is a capitalization-weighted index of stocks designed to measure the performance of the real estate sector of the FTSE all share Index. The index was developed with a base value of 1000 as of 31/12/85. It consists of 61 members and its total market capitalization was 16.96 billion pounds as at 11/07/03

Source: Datastream

Table I. Property stock index description



Source: Datastream

Figure 1. Property stock price indices

Monthly stock return is computed as the natural logarithm of the price index relative. Excess returns on real estate stocks are defined as returns minus yields to risk-free interest rate. The three month Treasury bill yield is utilized as the risk free rate for Singapore and the UK. Since it is not available for Hong Kong and Japan, the three-month Euro-yen deposit is used for the risk free rate for Japan. For Hong Kong, as the HK dollar is pegged with US dollar, we use the three-month Euro-Hong Kong Dollar deposit average rate. All the data are extracted from the Datastream.

Table II presents the descriptive statistics of monthly excess returns of the four property stock portfolios over the study period. They include the mean, standard deviation, maximum and minimum of excess returns, the measures for skewness and kurtosis, the Jarque-Bera (JB) normality test and the Ljung-Box statistics for 6, 12, 18 and 24 lags applied on the excess return series. Over the full period, the respective average monthly excess returns are −0.8 percent (Japan), −0.4 percent (the UK), −0.2 percent (Singapore) and 0.3 percent (Hong Kong). The monthly volatility of excess returns is the highest for Hong Kong (11.7 percent), followed by Singapore (10.4 percent), Japan (8.8 percent) and the UK (6.1 percent). Except for Singapore, the distributions of excess returns are negatively skewed for the remaining three markets although the skewness values are small. With the exception of Japan, excess kurtosis of greater than 3 is found in other three series. Consequently the hypothesis of a normal distribution is rejected for Hong Kong, Singapore and the UK. Finally, the Ljung-Box Q statistics indicate that the null hypothesis of uncorrelated excess returns could not be rejected for Japan and the UK. On the other hand, the excess return series of Hong Kong and Singapore displays conditional heteroskedasticity as Q (12), Q (18) and Q (24) are all statistically significant at the conventional probability levels.

As in other real estate studies, the macroeconomic variables included in this study are hypothesized to act as joint proxy for a set of latent variables that determine excess returns on property stocks. An important point to take note is that this set of variables does not capture all economic risk, but it does include macroeconomic variables that are generally regarded as the more important variables that affect excess return on property stocks. Based on "simple and intuitive financial theory", supported by relevant oversea and local literature and dictated by availability of data, property stock

	Hong Kong	Japan	Singapore	UK
Mean	0.003	−0.008	−0.002	−0.004
Std. Deviation	0.117	0.088	0.104	0.061
Maximum	0.452	0.207	0.477	0.150
Minimum	−0.620	−0.299	−0.389	−0.378
Skewness	−0.700	−0.211	0.286	−1.345
Kurtosis	8.449	3.254	8.281	8.904
Jarque-Bera	269.089***	2.064	239.856***	355.966***
Lejung-Box Q statistics				
Q (6)	5.68	1.25	7.72	6.76
Q (12)	22.02**	4.65	27.30***	14.98
Q (18)	28.45*	13.70	30.43**	19.15
Q (24)	33.38*	16.17	33.56*	22.74

Notes: ***, **, * Indicates two tailed significance at the 1%, 5% and 10% levels respectively

Table II.
Descriptive statistics of monthly excess returns on property stocks – 1986:5 to 2003:3

market excess returns are expected to relate to changing trends in the economic and business conditions as reflected in the variation of the following variables: growth in gross domestic product (GDPG), industrial production output growth (INDPG), unexpected inflation (UINFL), interest rate (INTR), money supply growth (MSG), and changes in exchange rate (XCHG). These variables have the additional appeal that they are all somewhat "exogenous" in the sense that they come from outside the property stock markets. In addition, these variables have been adopted in past research of similar nature. The main economic justifications for the inclusion of the macroeconomic variables are briefly provided below.

Growth rate in GDP (GDPG)

Equity returns are a function of the future cash flow stream that is highly dependent upon future economic conditions. There is evidence that current stock return levels are positively related to future levels of real activity as measured by GDP. The variable GDPG is computed as the geometric mean difference between successive months' seasonally-adjusted gross domestic product (GDP). GDP is a measure of all currently produced final goods and services valued at market prices and is thus an aggregated value of all the industries in an economy. Since real estate is a significant asset of a nation's economy, the economic growth should reflect the property market conditions. Consequently, the GDP growth could have predicative power to property stock returns. During periods of high economic growth, there is confidence within the economy and this would stimulate demand for products and services. Firms seeking expansion would then require more commercial space. Accordingly growth in GDP is expected to have a positive influence on the excess returns for property stocks. On the contrary, in periods of economic downturn accompanied by high economic volatilities, investors' confidence on the prospect of the economy may be dampened and as a consequence, associated with a lower expected excess returns on investment assets and capital (including property stocks). Hence, we would expect the direction and significance of the relationship between the conditional variance of GDPG and excess returns to be determined empirically.

Growth rate in Industrial production output (INDPG)

The variable INDPG is taken to be the geometric mean difference between successive months' industrial output index (INDP). The INDP is a measure of the production sector of an economy and also indicates the national economic growth. This measure reflects the activities of all the industries in an economy. Fama (1981) documents a relationship between concurrent measures of US stock returns and industrial production that is positive and significant. Therefore, a priori, the INDPG is expected to be related to excess returns. Moreover, we expect the direction and significance of the relationship between the conditional variance of INDPG and excess returns to be determined empirically.

Unexpected inflation (UINFL)

Inflation rate influences are also considered important in financial and real asset pricing. It is generally measured by changes in Consumer Price Index (CPI) which measures the retail prices of a fixed "market basket" of several thousand goods and services purchased by households. Inflation is usually separated into two parts: the expected inflation rate and the unexpected inflation. The latter is usually defined as the difference between the actual and the expected rate. Ferson and Harvey (1991) argue that unexpected inflation could be a source of economic risk and, as a result, a risk premium would be added if the stock of firms has different exposure to unexpected inflation. So far, the extant literature provides no clear answer on the impact of unexpected inflation on asset returns. A group of research has confirmed the inflation hedge ability of assets especially real estate (Fama and Schwert, 1977). However, other studies find that real estate fail to hedge against unexpected inflation (Brueggeman *et al.*, 1984). Also, securitized real estate has been found to provide no effective inflation hedge (Glascock and Davidson, 1995). In light of the lack of agreement between the theory and evidence, it is difficult to predict the direction of the relationship between property stock excess returns and unexpected inflation. Nevertheless, a positive relationship is more likely with respect to the UINFL risk on securitized real estate in Asian markets that enjoy higher capital appreciation. Following Brown and Matysiak (2000), we regress current values of inflation onto one-month lagged values. The residuals from the regression are used as estimates for the unexpected inflation (UNINF).

Interest rate (INTR)

This economic indicator is selected here because it would have effects on both the future cash flow of property firms and discount rate. Generally, higher interest rate would increase debt service of property companies and reduce future net income. Higher interest rate can also affect investment activities of property companies in financing real estate investment and development. In a high interest rate environment, interest rate is thus expected to negatively affect excess returns on property stocks. On the contrary, higher interest rates will increase the income to investors in money market funds and then in turn stimulate the economy and stock market. So far, empirical evidence regarding the direction and significance of interest rate impacts on stock market returns, real estate markets, and securitized real estate has been mixed (Ling and Naranjo, 1997; Lizieri and Satchell, 1997; Devaney, 2001 and Swanson *et al.*, 2002). In a recent study, Liow and Huang (2006) find that real estate stocks are generally sensitive to changes in the long-term and short-term interest rates and to a lesser extent, their conditional volatilities. However, there are disparities in the magnitude as well as direction of sensitivities in interest rate level and volatility across different listed real estate markets and under different market conditions. As in most study, the respective prime lending rates are used as a proxy of interest rate movement in the four economies in this research.

Growth in money supply (M2G)

There exists economic rationale to include money supply as a relevant macroeconomic factor. First, changes in money supply will alter the equilibrium position of money, thereby altering the composition and price of assets in an investors' portfolio. Second changes in money supply may impact on real economic variables and having a lagged influence on stock and property stock returns. Both of these mechanisms suggest a positive relationship between changes in money supply and excess returns on property stocks. However, increases in money supply may also give rise to greater inflation uncertainty and thus can have an adverse impact on real estate markets. In particular, excessive growth in money supply may lead to an inflationary environment and in turn lower property stock prices because of higher expected discount rates required. The excess returns would therefore be negatively affected. In this study, growth rate in money supply is taken to be the geometric mean difference between successive months' money supply, represented by M2, which is broad measure of money in an economy.

Changes in exchange rate (EXCHG)

According to the purchasing power parity (PPP) theory, exchange rates will adjust to reflect relative inflation levels and hence exchange rate risk will not be separately priced. However, in the short-to-medium term, deviations from PPP imply that exchange rate risk must be borne by investors. For example, an appreciation of local currency relative to the US$ is expected to decrease exports and profits and lead to lower economic growth. The appreciation of local currency would therefore be negatively associated with the excess returns on (property) stocks. On the contrary, a decrease in the cost of imported goods may be beneficial for a country that has substantial trade relations with the USA and can in turn generate long-term benefits for the economy and stock market. Exchange rate is measured as local currency to US$ for the four countries in this study.

The selection of the six local macroeconomic variables is not perfect and cases can be made for the inclusion of other factors. Furthermore, the proxies almost surely contain measurement error. Table III provides the descriptive statistics of the six macroeconomic variables. As can be seen, the macroeconomic variables display different degree of skewness and leptokurtosis. The combination of skewness and kurtosis for the macroeconomic variables contributes to different volatilities across all economies. Except for two time series (GDPG for Hong Kong and INDPG for Japan), all other time series' JB statistics are statistically significant from zero. Consequently the hypothesis that the macroeconomic returns are normally distributed is rejected. While the Ljung-Box Q tests cannot reject the null hypothesis of uncorrelated returns for the EXCHG series for UK at any of the pre-specified lags, they reject the null hypothesis of uncorrelated returns for other time series. This finding implies that the macroeconomic time series exhibit conditional heteroskedasticity and that a GARCH specification is appropriate for capturing the presence of time-varying volatility. Moreover, Spearman correlation results reported in Table IV indicates that the economic variables are significantly related. The correlations between the macroeconomic variables could produce a collinearity problem. To overcome this problem, principal component analysis (PCA) is used to construct independent economic factors from the six economic variables. The factors extracted from the macroeconomic variables are orthogonal to each other and hence eliminate multicollinearity among the original macroeconomic variables. The estimated economic factors (principal components) thus convey the relevant information of the economy in a reduced form of macro-model.

4. Research methodology

4.1 Theoretical framework

The theoretical framework used for examining the link between economic risk and expected excess returns on property stocks is the APT, which is an equilibrium theory of financial asset pricing. The structural framework is governed conceptually by a multiple-factor model (1) implied under the APT:

Table III.
Descriptive statistics of macroeconomic variables

		Panel A							Panel B Lejung-Box Q Statistics			
		Mean	SD	Max.	Min.	Skewness	Kurtosis	Jarque-Bera	Q (6)	Q (12)	Q (18)	Q (24)
Hong Kong	GDPG	0.0070	0.0083	0.0392	−0.0196	-0.1108	3.6599	4.09	471.56***	752.11***	879.67***	983.59***
	INDPG	−0.0009	0.0087	0.0350	−0.0396	-0.0789	6.3628	95.86***	162.92***	180.02***	199.26***	201.84***
	UINFL	−5.55E-20	0.0071	0.0272	−0.0556	-2.2120	20.7702	2836.54***	65.79***	140.16***	198.15***	244.36***
	INTR	0.0065	0.0013	0.0091	0.0041	-0.3057	2.1444	9.35***	907.31***	1282.80***	1342.00***	1357.70***
	M2G	0.0103	0.0329	0.1782	−0.1906	-1.4036	21.2337	2878.77***	20.93***	28.11***	56.56***	59.22***
	EXCHG	5.50E-06	0.0013	0.0058	−0.0070	-0.1065	10.7982	514.75***	29.87***	38.13***	42.48***	51.08***
Japan	GDPG	0.0018	0.0042	0.0156	−0.0177	-0.3309	5.9461	77.12***	161.92***	318.30***	394.09***	498.10***
	INDPG	0.0008	0.0146	0.0428	−0.0438	-0.1003	3.3835	1.58	36.96***	40.88***	48.80***	68.24***
	UINFL	5.98E-20	0.0027	0.0157	−0.0072	1.4023	8.8999	360.96***	11.07*	27.52**	43.16***	51.13***
	INTR	0.0026	0.0016	0.0066	0.0011	1.0123	3.0297	34.68***	1174.00***	2155.90***	2877.10***	3351.30***
	M2G	0.0038	0.0037	0.0167	−0.0047	0.8589	3.7803	30.11***	424.47***	673.05***	859.41***	958.44***
	EXCHG	−1.73E-03	0.0355	0.0963	−0.1626	-0.5940	4.7116	36.72***	9.00	21.66**	25.28	31.35
Singapore	GDPG	0.0072	0.0103	0.0349	−0.0338	-0.5028	4.6124	30.54***	144.69***	157.34***	168.43***	181.05***
	INDPG	0.0065	0.0599	0.2545	−0.2329	-0.2025	6.6246	112.51***	77.72***	94.57***	102.92***	109.19***
	UINFL	−1.13E-19	0.0025	0.0075	−0.0075	0.1862	3.6594	4.85*	17.22***	28.49***	34.06**	42.29**
	INTR	0.0050	0.0006	0.0064	0.0043	1.0369	3.2565	36.93***	818.86***	1038.40***	1058.80***	1096.60***
	M2G	0.0091	0.0174	0.1551	−0.0620	3.8466	33.6207	8431.39***	16.10**	22.03**	25.12	28.48
	EXCHG	−1.07E-03	0.0149	0.0571	−0.0567	0.2044	5.6105	59.06***	10.08	19.57*	21.89	24.27
UK	GDPG	0.0052	0.0028	0.0147	−0.0040	0.4182	4.3205	20.67***	177.17***	275.23***	357.82***	400.05***
	INDPG	0.0007	0.0093	0.0324	−0.0421	-0.2487	5.7957	68.20***	34.39***	43.95***	51.61***	56.33***
	UINFL	−6.94E-20	0.0023	0.0126	−0.0068	0.9474	7.2900	186.03***	26.33***	43.58***	53.98***	64.10***
	INTR	0.0064	0.0025	0.0117	0.0031	0.7837	2.4433	23.40***	1114.00***	1959.00***	2543.40***	2930.40***
	M2G	0.0067	0.0062	0.0652	−0.0217	3.5664	43.1210	14045.69***	10.71*	14.73	19.25	31.00
	EXCHG	−1.10E-04	0.0300	0.1325	−0.0761	0.7098	5.4091	66.14***	5.94	10.71	21.67	26.37

Notes: GDPG = Growth in Gross Domestic Product; INDPG = Growth in Industrial Production Output; UINFL = Unexpected Inflation; INTR = Prime Lending Rates; M2G = Change in Money Supply; EXCHG = Change in Exchange Rate; ***, **, * Indicates two tailed significance at the 1%, 5% and 10% levels respectively

Country		INDPG	UINFL	INTR	M2G	XCHG
Hong Kong	GDPG	0.436***	0.346***	−0.074	0.355***	−0.111
	INDPG		0.268***	−0.030	0.207***	0.097*
	UINFL			0.150**	0.122*	−0.042
	INTR				0.078	0.022
	M2G					−0.115
	XCHG					1.000
Japan	GDPG	0.179***	0.214***	0.494***	0.269***	0.080
	INDPG		−0.062	0.010	0.159**	−0.091*
	UINFL			0.302***	0.084	−0.065
	INTR				0.198***	−0.066
	M2G					−0.016
	XCHG					1.000
Singapore	GDPG	0.218***	0.220***	−0.248***	−0.003	−0.022
	INDPG		−0.086	−0.038	−0.003	0.047
	UINFL			−0.023	0.202***	−0.070
	INTR				0.268***	−0.033
	M2G					−0.045
	XCHG					1.000
UK	GDPG	0.160**	0.161**	0.258***	0.233***	0.062
	INDPG		0.108	−0.012	0.019	0.018
	UINFL			0.274***	0.248***	0.039
	INTR				0.260***	−0.005
	M2G					0.007
	XCHG					1.000

Notes: ***, **, * Indicates two tailed significance at the 1%, 5% and 10% levels respectively

Table IV. Spearman correlation matrix of macroeconomic variables

$$R_{it} = E_{t-1}(R_{it}) + \sum_{j=1}^{k} b_{ij}F_{jt} + \varepsilon_{it} \tag{1}$$

where $R_{it}$is the excess return on the ith asset in period t,$E_{t-1}(R_{it})$ is the expected excess return, conditional on an information set from the period (t-1). F_{jt} is the unanticipated factor. ε_{it} is the error term, which is orthogonal to F_{jt}.

The following properties characterize the multifactor model (1):

$$E_{t-1}(F_{j,t}) = E_{t-1}(\varepsilon_{i,t}) = E_{t-1}(F_{j,t}\varepsilon_{i,t}) = 0 \tag{2}$$

$$E_{t-1}(\varepsilon_{i,t}\varepsilon_{s,t}) = \alpha_{i,s} \tag{3}$$

$$E_{t-1}(F_{j,t}F_{w,t}) = h_{jw(t-1)} \tag{4}$$

Condition (2) indicates that the risk factors $F_{j,t}$and the error term $\varepsilon_{i,t}$are unexpected components based on the time t-1 information set, and the factors are orthogonal to the error term. Condition (3) allows that the factors cannot capture all of the systematic risk. Thus, the error term could be correlated across assets, but the covariance is assumed to be constant over time. Condition (4) assumes the conditional variances and covariances of the factors could change over time.

The multifactor asset pricing model is consistent with the conditional capital asset pricing model (CCAPM). Similar to the standard CAPM, CCAPM is formed relating to a benchmark portfolio. However, CCAPM expectations are taken conditionally on some information set. Following Sill (1995), the conditional expected excess return on an asset at time *t*-1 is proportional to the conditional covariance of the asset with the benchmark portfolio (equation 5). The benchmark portfolio is assumed to be perfectly correlated with the economy-wide intertemporal marginal rate of substitution. The factor of the proportionality (δ) is the ratio of the conditional expectation of the excess return on the benchmark portfolio to the conditional variance of the benchmark portfolio.

$$E_{t-1}(R_{it}) = \frac{E_{t-1}(R_{mt})}{VAR_{t-1}(R_{mt})}[COV_{t-1}(R_{mt}, R_{it})] \tag{5}$$

With a constant δ, the CCAPM can then be expressed as:

$$E_{t-1}(R_{it}) = \delta COV_{t-1}(R_{mt}, R_{it}) \tag{6}$$

Assume that the excess return on the benchmark portfolio also has a multi-factor format, then:

$$R_{mt} = E_{t-1}(R_{mt}) + \sum_{j=1}^{k} b_{mj}F_{jt} + \varepsilon_{mt} \tag{7}$$

Substitute (1) and (7) into the CCAPM (6), we have:

$$E_{t-1}(R_{it}) = \delta[\alpha_{mi} + \sum_{j=1}^{k}\sum_{w=1}^{k} b_{ij}b_{mw}h_{jwt-1}] \tag{8}$$

The conditional variance of the asset excess return can be written as:

$$VAR_{t-1}(R_{it}) = \alpha_{ii} + \sum_{j=1}^{k}\sum_{w=1}^{k} b_{ij}b_{iw}h_{jwt-1} \tag{9}$$

Hence equations (8) and (9) indicate that the expected excess returns and the conditional variance of excess returns are a function of the conditional variances and covariances of the economic factors. This system of (9) and (10) is a multiple-equation framework that can be estimated using the Generalized Method of Moments (GMM) of Hansen (1982). With a set of economic factors identified, equations (8) and (9) are rewritten as:

$$E_{t-1}(R_{it}) = \alpha^{*}_{mi} + \sum_{j=1}^{k}\sum_{w=1}^{k} b_{ij}b^{*}_{mw}h_{jwt-1} \tag{10}$$

$$VAR_{t-1}(R_{it}) = \alpha_{ii} + \sum_{j=1}^{k}\sum_{w=1}^{k} b_{ij}b_{iw}h_{jwt-1} \tag{11}$$

The GMM estimation of equations (10) and (11) requires observable macroeconomic risk variables and a set of instruments. The observable macroeconomic risk will be represented by the conditional variances of the retained principal components from PCA. The estimation involves three major steps; for each market, PCA is first applied on the original six chosen macroeconomic variables and the dominant principal components that are equivalent to those original variables are extracted. Then a GARCH (1, 1) model is employed to estimate the conditional variances of the dominant principal components. The conditional covariances of the dominant principal components are the products of square roots of the estimated conditional variances. The matrix of the conditional variances and covariances together with a constant will be used as instruments in GMM estimation. Overall, the estimation procedures cover three steps: PCA, GARCH (1, 1) and GMM. They are briefly described below.

4.2 Principal components analysis (PCA)

We employ PCA to identify relevant factors from the six chosen macroeconomic data under consideration for each market. PCA is a method which significantly reduces the number of variables from p to a much smaller set of k derived orthogonal variables that retain most of the information in the original p variables. The first principal component is the combination that accounts for the largest amount of variance in the sample. The second principal component accounts for the next largest amount of variance and is uncorrelated with the first. Successive components explain progressively smaller portions of the total sample variance. After applying this analysis to the original macroeconomic data of each market, the dominant principal components are then extracted and used as inputs into a GARCH (1, 1) to estimate the relevant economic risk. In the present context, PCA is particularly appealing because the k derived variables are orthogonal to each other. Consequently the problems of multicollinearity among the original economic variables are resolved.

4.3 Estimation of conditional volatility – GARCH (1, 1) model

Financial models such as ARCH (Engle, 1982) and generalized ARCH (Bollerslev, 1986) are able to capture volatility clustering and predict the volatility. Specifically, the ARCH model allows the conditional variance of a time series to change over time as a function of past squared errors by imposing an autoregressive structure on conditional variance and allowing volatility shocks to persist over time, and hence expected equilibrium returns (excess returns) also vary over time. Bollerslev (1986) extends the ARCH process to GARCH that allows for more flexibility in lag structure.

According to Bollerslev *et al.* (1992), GARCH (1, 1) as opposed to higher order models, is parsimonious and allow for long memory in the volatility process and fits most economic time series. In the present context, the conditional variances of real estate stock excess returns and the dominant principal components extracted from the PCA are estimated using a standard GARCH (1, 1) specification described by the following system of equations:

$$Y_{j,t} = \mu + \beta_i \sum_{i=1}^{n} Y_{j,t-i} + \delta D_1 + \lambda D_2 + \varepsilon_{j,t}$$

$$h_{j,t} = \alpha_0 + \alpha_1 \varepsilon_{j,t-1}^2 + \alpha_2 h_{j,t-1}$$

$$\varepsilon_{j,t} | \Omega_{t-1} \sim N(0, h_{j,t})$$

where $Y_{j,t}$ is the real estate stock return series or dominant principal components. $Y_{j,t-i}$ are the optimal autoregressive lags of the excess returns or dominant principal components. To capture the impact of 1997 Asian financial crisis and 1987 stock market crash, we add two dummy variables (D1 and D2) to the mean equation. The first dummy variable, D1 takes a value of one for the period October 1997 – September 1998 and zero otherwise; and the second dummy variable, D2 takes a value of one for the period of October-December 1987 and zero otherwise. Our main intention is to control for regime shifts in the four markets following the stock market crash in 1987 and financial meltdown in 1997. Specifically, there is some evidence of a reduction in real estate returns and an increase in real estate volatility and correlations with other assets following the Asian financial crisis (Kallberg *et al.* 2002). $\varepsilon_{j,t}$ is the disturbances, $h_{j,t}$ is the conditional variance, and Ω_{t-1} is the information set at the time period (t-1). The conditional variance equation ($h_{j,t}$) is a function of three terms: (a) the mean, (b) news about volatility from the previous period, measured as the lag of the squared residuals from the mean equation: ε^2(the ARCH term), and (c) last period's forecast variance: $h_{j,t}$ (the GARCH term). Hence if innovations have been large, they are likely to be large in the next period. This is described as volatility clustering. Furthermore, the sum of coefficients in the conditional variance equation ($\alpha_1 + \alpha_2$) measures the degree of persistence in shocks to volatility, and must be less than or equal to unity for stability to hold. To ensure the process is well defined, the parameters α_1, α_1 and α_2 must be non-negative.

4.4 GMM estimation

GMM was proposed by Hansen (1982). Hansen and West (2002) consider the contribution to the analysis of economic time series of the GMM estimator. Unlike maximum likelihood estimation, the GMM is a robust estimator because it does not require information of the exact distribution of the disturbances. It only requires some specification of certain moment conditions. Moreover, APT models that are subject to nonlinear restrictions on the parameters can be readily estimated using the GMM. A main requirement of the GMM estimation is to write the moment condition as an orthogonality condition between an expression including the parameters and a set of instrumental variables. The GMM estimator selects parameter estimates so that the sample correlations between the instruments and disturbances are as close to zero as possible. The estimated parameters are consistent and asymptotical normal.

In the present context, the GMM is used to estimate two-equation system (10 and 11) for each market. The estimated residuals from the GARCH (1, 1) models are used as the retained principal components to proxy for macroeconomic risk factors. The estimates of the conditional variances and conditional covariances of the retained principal components are used to construct a set of instruments. The conditional covariance between any two dominant principal components is computed by taking products of square roots of the estimated variances. Hence, the final instrument set for the GMM specification includes a constant, the conditional variances of dominant principal components and the respective conditional covariance terms.

5. Results and discussion

5.1 PCA results

Table V summarizes the results from applying PCA to the six macroeconomic variables considered in the paper. In particular, Panel A details eigenvalues and proportions of variance explained by the principal components for all markets, while Panel B summarizes the variables with large factor loadings for the retained principal components.

The Kaiser criterion (Kaiser, 1960) recommends that only those principal components with eigenvalues greater than 1 should be retained. As can be seen, the first three (Hong Kong), 3 (Japan), 3 (Singapore) and 2 (UK) principal components have latent roots greater than one and they are able to explain approximately 64.01 percent, 65.98 percent, 61.33 percent and 45.99 percent of factor variance in Hong Kong, Japan, Singapore and UK respectively. Further, the first principal component for the respective markets is the most important since it is able to explain between 22.36 percent (Singapore) and 29.01 percent (Japan) of the total sample variance. In the case of the UK market, the Kaiser criterion is relaxed slightly to include the third principal components with a latent root slightly below one (0.972). This relaxation allows at least 60 percent of the variance in the data for each market to be accounted for. Hence, the first three principal components for all markets are retained.

In Panel B of Table V, we report only those macroeconomic variables that have high loading coefficients of either sign in each retained principal component vector. The most salient point emerging from the results relates to the consistency of the high loading variables across the markets examined. All the six macroeconomic factors are significant for Hong Kong and Japan. With the exception of the money supply variable, the remaining five macroeconomic factors are significant for Singapore and the UK. In all cases, the first principal component has positive high correlations with GDP (between 0.696 and 0.818). Another related variable, the industrial production output (INDP) is also important for Hong Kong (first principal component), Japan and UK (second principal component) and to a lesser extent, Singapore (third principal component). The importance of the GDP and INDP in the principal component is not surprising particularly for Hong Kong and Singapore that have generally demonstrated higher economic growth rates over extended time periods relative to the industrialized economies. Except for Japan, the first principal component is also moderately and positively correlated with unexpected inflation (factor loading is between 0.562 and 0.683). For Japan, unexpected inflation is negatively related to the second principal component (factor loading is -0.662). The appearance of the unexpected inflation as a high loading variable in the first principal component (except for Japan) is readily understandable. This variable, along with the interest rates, which are represented in the first principal component (Japan and the UK) and second principal component (Hong Kong and Singapore) respectively and the money supply, to a lesser degree, are the key indicators of the financial sector of an economy. Finally, in all markets except Hong Kong, the exchange rate appears as a high loading variable in the third principal component. For Hong Kong, the exchange rate factor is

Table V.
Eigenvalues and proportions of variance explained by derived principal components (Panel A) and factor loadings for the retained principal components (Panel B)

Country		Panel A: derived principal components 1	2	3	4	5	6	Country	Panel B: Factor loadings for the retained principal components 1	2	3
Hong Kong	Eigenvalue	1.650	1.139	1.051	0.931	0.705	0.523	Hong Kong	GDPG (0.816)	INTR (0.739)	
	% of Variance	27.504	18.987	17.516	15.520	11.756	8.717		INDPG (0.764)	XCHG (−0.572)	M2G (0.610)
	Cumulative %	27.504	46.491	64.007	79.527	91.283	100.000		UINFL (0.562)		
Japan	Eigenvalue	1.740	1.167	1.051	0.804	0.758	0.479	Japan	GDPG (0.759)	INDPG (0.724)	XCHG (0.924)
	% of Variance	29.008	19.456	17.514	13.394	12.641	7.988		INTR (0.741)	UINFL (−0.662)	
	Cumulative %	29.008	48.464	65.977	79.372	92.012	100.000		M2G (0.615)		
Singapore	Eigenvalue	1.343	1.256	1.081	0.930	0.776	0.614	Singapore	GDPG (0.794)	INTR (0.585)	INDPG (0.609)
	% of Variance	22.381	20.931	18.017	15.507	12.927	10.236		UINFL (0.654)		XCHG (−0.637)
	Cumulative %	22.381	43.312	61.329	76.836	89.764	100.000	UK	GDPG (0.696)	INDPG (0.717)	XCHG (0.719)
UK	Eigenvalue	1.691	1.069	0.972	0.919	0.718	0.633		UINFL (0.683)		
	% of Variance	28.177	17.810	16.192	15.309	11.967	10.545		INTR (0.689)		
	Cumulative %	28.177	45.987	62.179	77.488	89.455	100.000				

Notes: GDPG (Growth in Gross Domestic Product), INDPG (Industrial Production growth), UINFL (Unexpected Inflation), INTR (Prime lending rates), M2G (Money supply growth), EXCHG (Growth in Exchange rate); figures in the parentheses are correlations (factor loadings) of macroeconomic variables and principal components negatively correlated with the second principal component. In all cases therefore, the dimensionality of the economic dataset is reduced from six to three.

5.2 GARCH (1, 1) estimates

Table VI indicates the number of lags included in the GARCH (1, 1) mean equation for excess returns and the three retained principal components for each market. As the figures show, one-month lag is determined to be optimal for property stock excess returns of Japan and the UK. For Hong Kong and Singapore, however, there are stronger autocorrelations in the excess return series and the optimal lags are determined to be 11 months. The optimal number of lags for the retained principal components ranges from 2 to 10.

The estimated results from the GARCH (1, 1) models are provided in Table VII. They include the coefficient estimates for the variance equation and the *p*-value for the GARCH (1, 1) parameters. With some exceptions, the majority of parameter estimates from the GARCH process are statistically significantly different from zero. These results imply that the conditional volatilities of the retained principal components are time varying. Figures 2-5 plot their conditional variances. In addition, results for the GARCH process reveal that the conditional excess returns on property stocks vary over time. The Lijung-Box statistics for the 24th order serial correlation in the level and squared standardized residuals and the ARCH LM tests indicate that the estimated GARCH (1, 1) models, with minor exceptions, fits the data reasonably well.

As the figures in Table VII show, the intercept term α_0(time-dependent component of volatility) is significantly positive for all except the excess returns and 2nd principal component for Japan. The ARCH parameter $\alpha_1$is also insignificantly positive for the excess returns and 2nd principal component of Japan. Of the 12 GARCH parametersα_2

	Principal component 1	Principal component 2	Principal component 3	Excess returns
Hong Kong	6	6	9	11
Japan	6	2	9	1
Singapore	9	3	6	11
UK	7	10	2	1

Notes: Mean equation in the GARCH (1, 1) model consists of a constant and auto lags of principal component or excess return. Dummy variables of 1987 stock market crash and 1997 financial crisis are also included in the mean equations.
The GARCH (1,1) model for each market is defined as:

$$Y_{j,t} = \mu + \beta_i \sum_{i=1}^{n} Y_{j,t-i} + \delta D_1 + \lambda D_2 + \varepsilon_{j,t}$$
$$h_{j,t} = \alpha_0 + \alpha_1 \varepsilon_{j,t-1}^2 + \alpha_2 h_{j,t-1}$$
$$\varepsilon_{j,t} | \Omega_{t-1} \sim N(0, h_{j,t})$$

where $Y_{j,t}$is jth principal component that is retained from PCA or excess return on property stocks. $Y_{j,t-i}$ are the optimal autoregressive lags of the principal component or excess returns. D_1 is the dummy variable for 1997 financial crisis; D_2 is the dummy variable for 1987 market crash. $\varepsilon_{j,t}$ is the disturbances, $h_{j,t}$ is the conditional variance, and Ω_{t-1} is the information set of period (*t*-1)

Table VI. Lags in the mean equations of GARCH (1,1) for the retained principal components and real estate stock excess returns

Table VII.
GARCH (1, 1) estimates for the principal components and excess returns on real estate stocks

	Model	α_0	α_1	α_2	$\alpha_1 + \alpha_2$	$Q^1(24)$	$Q^2(24)$	ARCH LM (12)	ARCH LM (24)
Hong Kong	P1	0.1046(0.009***)	0.1575 (0.000***)	0.5445 (0.000***)	0.7020	41.637(0.014**)	23.998 (0.462)	0.995 (0.456)	1.076 (0.377)
	P2	0.0156 (0.072*)	0.1931 (0.000***)	0.8012 (0.000***)	0.9943	12.731 (0.970)	16.464 (0.871)	0.869 (0.580)	0.681 (0.864)
	P3	0.0337 (0.098*)	0.3641 (0.002***)	0.6166 (0.000***)	0.9807	28.530 (0.238)	11.176 (0.988)	0.496 (0.915)	0.406 (0.994)
	R	0.0023 (0.045**)	0.1754 (0.029**)	0.6345 (0.000***)	0.8099	6.563 (1.000)	10.587 (0.992)	0.218 (0.997)	0.396 (0.995)
Japan	P1	0.1498 (0.098*)	0.1867 (0.040**)	0.1980 (0.607)	0.3847	27.752 (0.271)	23.995 (0.462)	1.292 (0.227)	0.876 (0.633)
	P2	0.7467 (0.975)	0.0077 (0.999)	0.1078 (0.000***)	0.1155	45.249 (0.005***)	7.038 (1.000)	0.241 (0.996)	0.217 (0.999)
	P3	0.7030 (0.000***)	0.1111 (0.022**)	0.1377 (0.026**)	0.2488	9.876 (0.995)	29.302 (0.209)	0.238 (0.996)	0.959 (0.524)
	R	0.0022 (0.213)	0.0670 (0.332)	0.6445 (0.000***)	0.7115	13.301 (0.961)	13.476 (0.958)	0.880 (0.568)	0.479 (0.981)
Singapore	P1	0.4812 (0.000***)	0.0630 (0.000***)	0.1563 (0.000***)	0.2193	22.600 (0.544)	32.224 (0.122)	0.435 (0.948)	1.122 (0.327)
	P2	0.2989 (0.001***)	0.5267 (0.003***)	0.1335 (0.414)	0.6602	25.110 (0.400)	20.742 (0.654)	0.854 (0.594)	0.708 (0.837)
	P3	0.1340 (0.077*)	0.1997 (0.042**)	0.6431 (0.000***)	0.8428	15.134 (0.917)	16.769 (0.858)	0.987 (0.464)	0.792 (0.742)
	R	0.0003 (0.084*)	0.1962 (0.032**)	0.7807 (0.000***)	0.9769	9.038 (0.998)	24.718 (0.421)	1.760 (0.059*)	1.150 (0.299)
UK	P1	0.1164 (0.009***)	0.4641 (0.006***)	0.2911 (0.067*)	0.7552	25.307 (0.389)	15.110 (0.917)	0.373 (0.971)	0.521 (0.968)
	P2	0.3304 (0.003***)	0.4062 (0.009***)	0.2314 (0.159)	0.6376	10.856 (0.990)	15.028 (0.920)	0.434 (0.948)	0.804 (0.728)
	P3	0.1752 (0.000***)	0.0009 (0.000***)	0.8240 (0.000***)	0.8249	18.208 (0.793)	0.961 (1.000)	0.035 (1.000)	0.032 (1.000)
	R	0.0023 (0.062*)	0.2179 (0.051*)	0.0524 (0.898)	0.2703	19.232 (0.740)	22.969 (0.522)	0.576 (0.859)	0.893 (0.611)

Notes: Q^1 is Q statistics for standardized residuals from GARCH (1, 1); Q^2 is Q statistics for squared standardized residuals from GARCH (1, 1); ARCH LM test is used to test existence of ARCH effects in the residuals; numbers reported are F-test statistics from ARCH LM test; figures in parentheses are *p* values; *, **, and *** indicates two-tailed significance level at 10%, 5% and 1% respectively

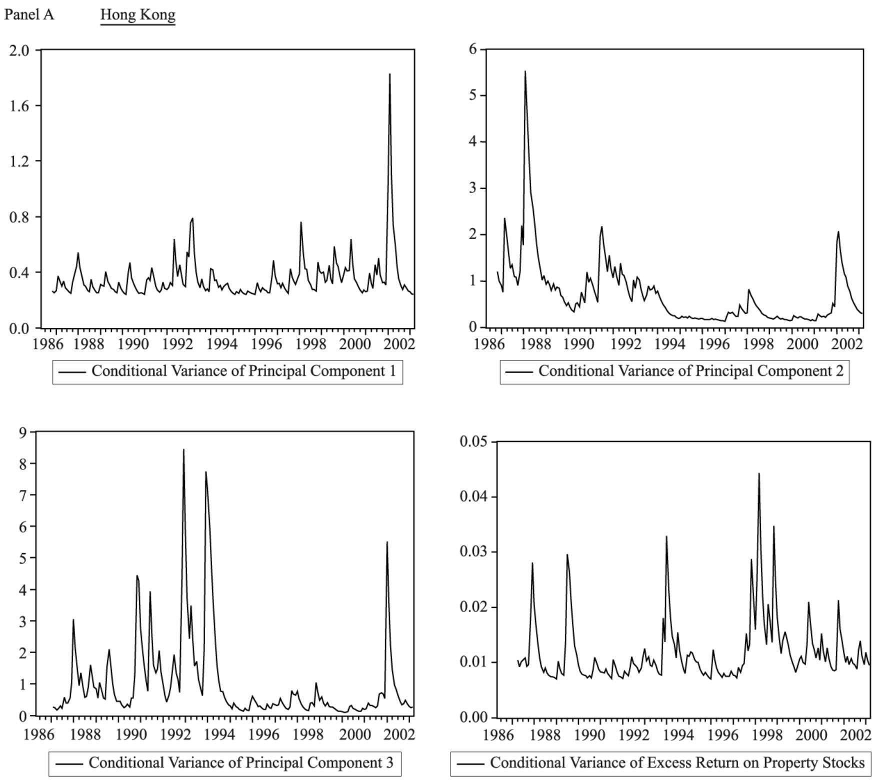


Figure 2. Conditional Variance Graphs of the Retained Principal Components and Real Estate Stock Excess Returns (Panel A, Hong Kong)

for the retained principal components, three (P1 for Japan, P2 for Singapore and the UK) are not important. Furthermore the magnitude of $\alpha_2$is reasonably larger than $\alpha_1$in the volatility equations for the property stock excess return series and most of the retained principal components. The implication is that volatility in the four real estate stock markets and the macroeconomic variables are more responsive to its owned lagged values than they are to new surprises in the market place. The sum $(\alpha_1 + \alpha_2)$ measures the change in the response function of shocks to volatility per month, is less than unity implying shock decay with time. As noted, Singapore and Hong Kong real estate stock markets have considerably higher volatility persistence (0.9769 for Singapore and 0.8099 for Hong Kong) than their Japanese (volatility persistence is 0.7115) and the UK counterparts (volatility persistence is 0.2703). For the retained principal components, the highest and lowest volatility persistence values are 0.9943 (HK: P2) and 0.1155 (Japan: P2) respectively.

5.3 GMM results

Table VIII provides the GMM estimates for the expected excess return determination of equations 10 and 11. b_{ij} is the coefficient of the jth principal component impacting on property stock excess returns $(j = 1, 2, 3)$. b^{*}_{mj} is the coefficient of the jth principal component on the benchmark portfolio excess returns multiplied by the constant δ. With the exception of the third principal component for Japan and second principal

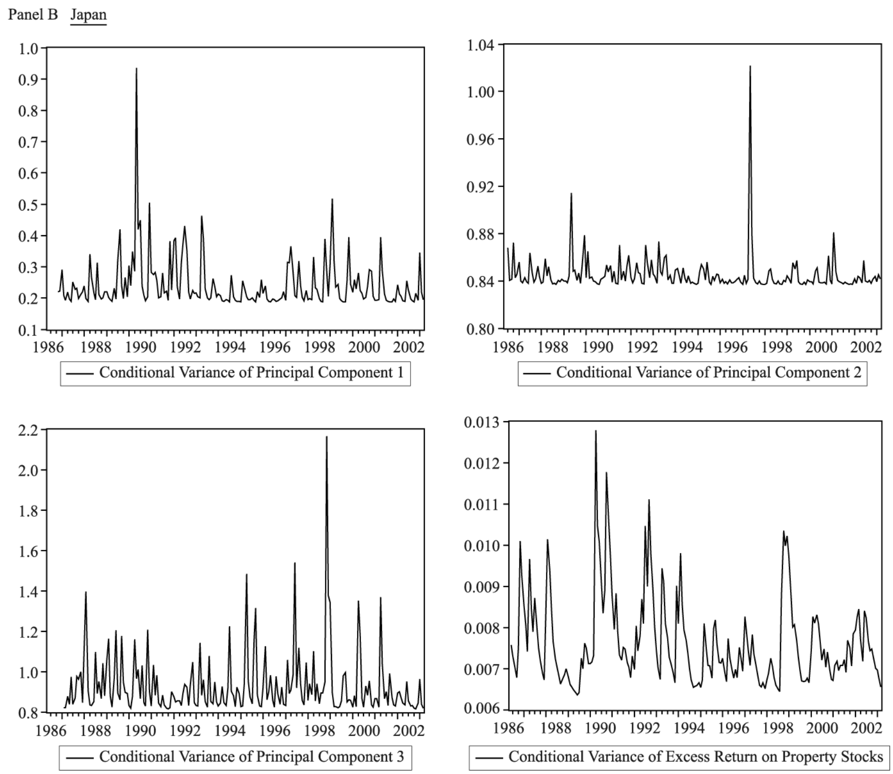


Figure 3.
Conditional Variance Graphs of the Retained Principal Components and Real Estate Stock Excess Returns (Panel B, Japan)

component for Singapore, the remaining component coefficients (b_{ij}) for the four markets are statistically significant different from zero. For all markets, the first principal component predicts strong positive excess returns. Similarly, the second principal component also predicts higher positive excess returns for Hong Kong, Japan and the UK. On the other hand, the impact of the third principal component on excess returns is significantly negative for Hong Kong and the UK, significantly positive for Singapore and has little effect for Japan.

Table IX presents the overall picture regarding the direction and significance of the six original macroeconomic risk factors on the expected excess returns for all markets. It appears that the GDPG and INDPG are able to predict positive excess returns for all four markets. Hence the role of the GDP and INDP risk in explaining the excess return generating process of stock market is supported, of which listed real estate is part of it. However, there are disparities in the significance as well as direction of sensitivities of other macroeconomic risk factors across the different real estate stock markets. For Hong Kong, the results confirm the ability of unexpected inflation (+), interest rate (+), money supply (−) and exchange rate (−) to explain fluctuations in excess returns. For Singapore, while real estate stock excess returns response positively to the unexpected inflation and exchange rate risk, the insignificantly negative interest rate risk impact on the excess returns somewhat contradicts the results of Liow and Huang (2006). For the two industrialized economies Japan and the UK; GDP, INDP and interest

Panel C Singapore

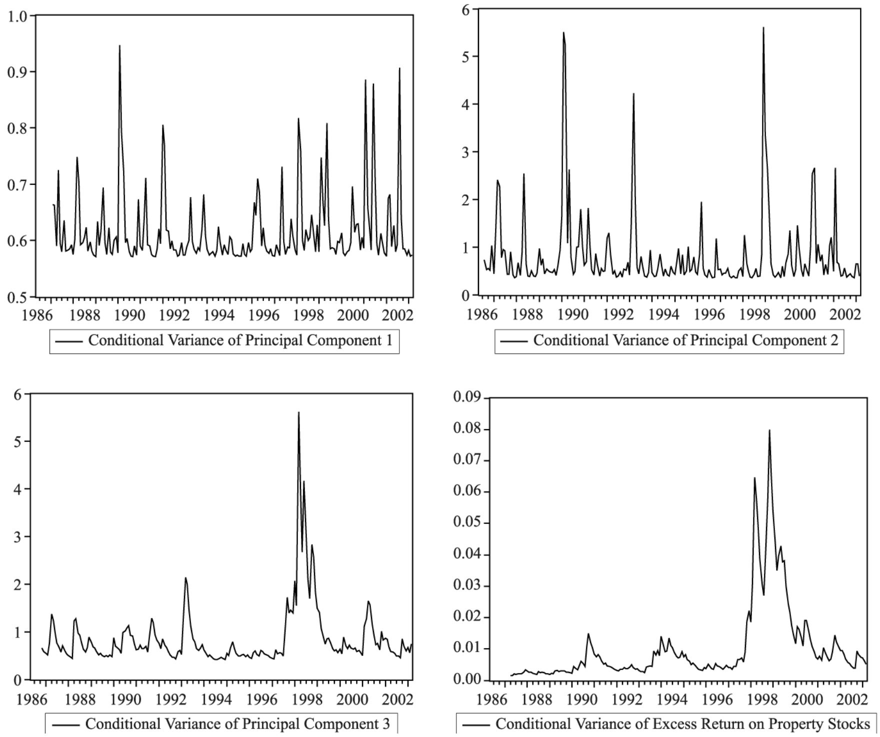


Figure 4. Conditional Variance Graphs of the Retained Principal Components and Real Estate Stock Excess Returns (Panel C, Singapore)

rate are important and impact positively on excess returns of their property stocks. On the contrary, the direction of unexpected inflation is opposite for Japan (negative) and the UK (positive). Another observation is that while money supply is important in predicting excess returns for Japan, exchange rate is an important factor in the excess return generating process of the UK property stocks. Finally, the finding that exchange rate is not significant in Japan is somewhat harder to interpret. Future research could help to indicate whether these differences are related factors such as the maturity of the listed property sector and state of economic development in the respective economies.

The GMM coefficients on the conditional variance and covariance terms in equations 10 and 11 are displayed in Table X. To aid interpretation, Table XI provides a summary of the relations between the macroeconomic risk factors and conditional first and second moments of excess returns for all markets. Note that the variance and covariance terms associated with the third (Japan) and second (Singapore) principal components are excluded as the respective principal components are statistically insignificant. As in Fama and French (1989), Backus and Gregory (1993) and Sill (1995) who investigate stock markets, we find that the expected excess returns on real estate stocks are time-varying and are linked to business and financial conditions which are measured in terms of the conditional volatilities of the principal components (and hence the macroeconomic factors).

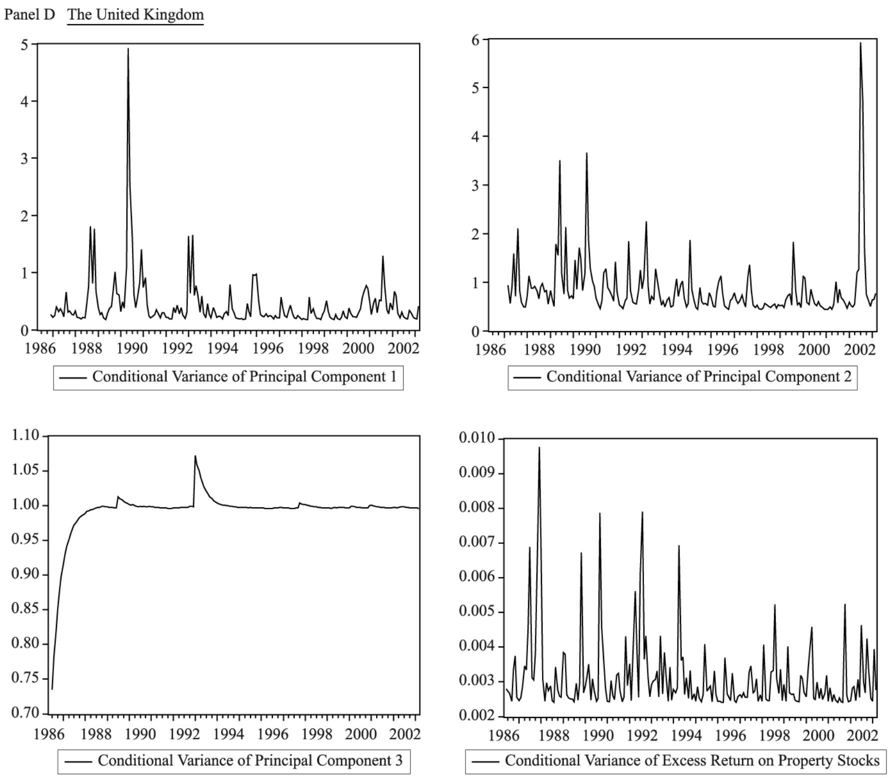


Figure 5.
Conditional Variance Graphs of the Retained Principal Components and Real Estate Stock Excess Returns (Panel D, UK)

Table VIII.
GMM estimates from the system of two equations

	Market			
Parameter	Hong Kong	Japan	Singapore	UK
α^*_{mi}	0.0052 (0.283)	0.0120 (0.150)	0.0320 (0.278)	−0.0058 (0.000***)
b_{i1}	0.0405 (0.000***)	0.0329 (0.000***)	0.1413 (0.006***)	0.0326 (0.073*)
b_{i2}	0.0620 (0.000***)	0.0600 (0.023**)	−0.0043 (0.522)	0.0430 (0.013**)
b_{i3}	−0.0210 (0.000***)	0.0039 (0.579)	0.0644 (0.000***)	−0.0754 (0.015**)
b^*_{m1}	0.0785 (0.665)	0.1014 (0.139)	−0.3743 (0.156)	−0.0045 (0.925)
b^*_{m2}	−0.3902 (0.011**)	−0.2782 (0.070*)	−0.0208 (0.431)	−0.1513 (0.072*)
b^*_{m3}	0.1114 (0.253)	−0.0652 (0.000***)	0.1642 (0.003***)	0.0808 (0.519)
α_{ii}	0.0099 (0.000***)	0.0020 (0.483)	−0.0220 (0.049**)	0.0029 (0.000***)

Notes: The GMM two-equation system is: $E_{t-1}(R_{it}) = \alpha^*_{mi} + \sum_{j=1}^{3}\sum_{w=1}^{3} b_{ij} b^*_{mw} h_{jwt-1}$; $VAR_{t-1}(R_{it}) = \alpha_{ii} + \sum_{j=1}^{3}\sum_{w=1}^{3} b_{ij} b_{iw} h_{jwt-1}$; $b_{ij:}$ Property stocks – macroeconomic variables (represented by principal components); b_{i1}– P1 b_{i2}– P2 b_{i3}– P3; $b^*_{mw:}$ Market portfolio–macroeconomic variables (represented by principal components); b^*_{m1}– P1 b^*_{m2}– P2 b^*_{m3}– P3; numbers in the parentheses are p values; *** at 1% significance level; **at 5% significance level; * at 10% significance level

	Macroeconomic factors	Related Principal Components	Relationship of the Macroeconomic Factors with Excess Returns on Real Estate Stocks	
			Sign	Significance
Hong Kong	GDPG	P1 (***)	+	✓
	INDPG	P1 (***)	+	✓
	UINFL	P1 (***)	+	✓
	INTR	P2 (***)	+	✓
	M2G	P3 (***)	−	✓
	XCHG	P2 (***)	−	✓
Japan	GDPG	P1 (***)	+	✓
	INDPG	P2 (**)	+	✓
	UINFL	P2 (**)	−	✓
	INTR	P1 (***)	+	✓
	M2G	P1 (***)	+	✓
	XCHG	P3	+	X
Singapore	GDPG	P1 (***)	+	✓
	INDPG	P3 (**)	+	✓
	UINFL	P1 (***)	+	✓
	INTR	P2	−	X
	XCHG	P3 (**)	+	✓
UK	GDPG	P1 (*)	+	✓
	INDPG	P2 (**)	+	✓
	UINFL	P1 (*)	+	✓
	INTR	P1 (*)	+	✓
	XCHG	P3 (**)	−	✓

Notes: GDPG (Growth in Gross Domestic Product); INDPG (Industrial Production Growth); UINFL (Unexpected Inflation); INTR (Prime Lending Rate); M_2G (Money Supply Growth); EXCHG (Change in Exchange Rate); P1, P2 and P3 are retained principal components; * in the parentheses represents the significance level of the estimated coefficients on the principal components (*** at 1% significance level, ** at 5% significance level, * at 10% significance level); +/− indicates the sign of macroeconomic factors, and ✓ (X) indicates whether the relationship of a macroeconomic factor with excess returns is statistically significant (insignificant) at the conventional probability levels

Table IX. Macroeconomic factor relations with real estate stock excess returns

Overall findings and implications

Several findings and implications are derived from the results. For Hong Kong, expected property stock excess returns are positively correlated with the conditional variances of GDP growth, INDP growth, unexpected inflation and exchange rate; and negatively correlated with the conditional variances of interest rate and money supply. However for Singapore, higher expected excess returns are associated with a higher conditional variance of INDP growth; and a lower conditional variance of GDP growth, unexpected inflation and exchange rate. The results indicate that while all five conditional variance coefficients are negative for the UK market, the expected excess returns in Japan are positively correlated with the conditional volatilities of GDP growth, interest rate, money supply and unexpected inflation. Additional effects on the expected excess returns are seen coming from the conditional covariances of the

			Conditional variance and covariance term	$E_{t\text{-}1}$ (R_{it})	$\text{Var}_{t\text{-}1}$ (R_{it})
Hong Kong	P1cv	Conditional variance (P1)	Conditional variance (GDPG, INDPG, INFL)	0.0032	0.0016
	P2cv	Conditional variance (P2)	Conditional variance (INTR, XCHG)	−0.0242	0.0038
	P3cv	Conditional variance (P3)	Conditional variance (M2G)	−0.0023	0.0004
	P1P2cv	Conditional covariance (P1,P2)	Conditional covariance (GDPG, INDPG, UINFL, INTR, XCHG)	−0.0109	0.0050
	P1P3cv	Conditional covariance (P1,P3)	Conditional covariance (GDPG, INDPG, UINFL, M2G)	0.0029	−0.0017
	P2P3cv	Conditional covariance (P2,P3)	Conditional covariance (INTR, XCHG, M2G)	0.0151	−0.0026
Japan	P1cv	Conditional variance (P1)	Conditional variance (GDPG, INTR, M2G)	0.0033	0.0011
	P2cv	Conditional variance (P2)	Conditional variance (INDPG, UINFL)	−0.0167	0.0036
	P1P2cv	Conditional covariance (P1,P2)	Conditional covariance (GDPG, INTR, M2G, INDPG, UINFL)	−0.0031	0.0039
Singapore	P1cv	Conditional variance (P1)	Conditional variance (GDPG, UINFL)	−0.0529	0.0200
	P3cv	Conditional variance (P3)	Conditional variance (INDPG, XCHG)	0.0106	0.0041
	P1P3cv	Conditional covariance (P1,P3)	Conditional Covariance (GDPG, UINFL, INDPG, XCHG)	−0.0009	0.0182
UK	P1cv	Conditional variance (P1)	Conditional variance (GDPG, UINFL, INTR)	−0.0001	0.0011
	P2cv	Conditional variance (P2)	Conditional variance (INDPG)	−0.0065	0.0018
	P3cv	Conditional variance (P3)	Conditional variance (XCHG)	−0.0061	0.0057
	P1P2cv	Conditional covariance (P1,P2)	Conditional covariance (GDPG, UINFL, INTR, INDPG)	−0.0051	0.0028
	P1P3cv	Conditional covariance (P1,P3)	Conditional covariance (GDPG, UINFL, INTR, XCHG)	0.0030	−0.0049
	P2P3cv	Conditional covariance (P2,P3)	Conditional covariance (INDPG, XCHG)	0.0149	−0.0065

Table X.
Estimated coefficients on significant conditional variance and covariance terms of the principal components

	Macroeconomic risks	Relationship of macroeconomic variables with principal components	Relationship of macroeconomic risk with expected excess returns and conditional variances of excess returns $E_{t\text{-}1}(R_t)$	$\mathrm{Var}_{t\text{-}1}(R_{it})$
Hong Kong	Conditional variance of GDPG	P1 (+)	+	+
	Conditional variance of INDPG	P1 (+)	+	+
	Conditional variance of UINFL	P1 (+)	+	+
	Conditional variance of INTR	P2 (+)	−	+
	Conditional variance of M2G	P3 (+)	−	+
	Conditional variance of XCHG	P2 (−)	+	−
Japan	Conditional variance of GDPG	P1 (+)	+	+
	Conditional variance of INDPG	P2 (+)	−	+
	Conditional variance of UINFL	P2 (−)	+	−
	Conditional variance of INTR	P1 (+)	+	+
	Conditional variance of M2G	P1 (+)	+	+
Singapore	Conditional variance of GDPG	P1 (+)	−	+
	Conditional variance of INDPG	P3 (+)	+	+
	Conditional variance of UINFL	P1 (+)	−	+
	Conditional variance of XCHG	P3 (-)	−	−
UK	Conditional variance of GDPG	P1 (+)	−	+
	Conditional variance of INDPG	P2 (+)	−	+
	Conditional variance of UINFL	P1 (+)	−	+
	Conditional variance of INTR	P1 (+)	−	+
	Conditional variance of XCHG	P3 (+)	−	+

Notes: GDPG (Growth in Gross Domestic Product); INDPG (Industrial Production Growth; UINFL (Unexpected Inflation); INTR (Prime Interest rate); M_2G (Money Supply Growth); EXCHG (Change in Exchange Rates); P1, P2 and P3 are retained principal components; +/− represents the sign of relations of macroeconomic risks and expected excess returns and conditional variances of excess returns

Table XI. Relationship between macroeconomic risk and expected property stock excess returns and conditional variances of excess returns

retained principal components (and hence the macroeconomic factors). Specifically, the relationship between the property stock risk premia and conditional covariances of economic factors can be increasing, decreasing or flat, depending on model parameters and the probability structure across the different the economies.

The estimated results also suggest that the conditional volatility of property stock market excess return is dynamically related to the conditional variances and covariances of the retained principal components (and hence the macroeconomic factors). For Hong Kong and Singapore, when the volatilities of GDP growth, INDP growth and unexpected inflation are high, the volatilities of their real estate stock market risk premia are high. On the other hand, higher volatilities of the risk premia are associated with lower exchange rate volatilities in the two markets. For the UK, the conditional volatility of its risk premium is positively related to the conditional volatilities of all five important macroeconomic factors (GDP growth, INDP growth, unexpected inflation, interest rate and exchange rate). On the other hand, an inverse relationship between the conditional volatility of risk premium and unexpected inflation risk is found for Japan.

In summary, for all four markets, our estimation results are able to reveal a significant relationship between the first and second conditional moments on property stock excess returns and the conditional variances and covariance of a set of six pre-specified macroeconomic risk factors (represented by three retained principal components). However, the influences of the macroeconomic risk factors on the expected risk premia in terms of direction and significance do vary across the four markets studied. Consequently, the results imply that there are opportunities for risk diversification in International property stock markets and have some practical implications. For example, portfolio managers interested in global real estate asset allocation may want to understand how the world market real estate risks differ across countries and what explain these differences. The relationship between property stock market risk and the macroeconomy may also provide useful information for government policy makers in regulating the relevant economic and financial variables.

Conclusion

The main thrust of this paper is an empirical investigation of the relationship between the expected risk premia on property stocks and some major macroeconomic risk factors as reflected in the general business and financial conditions in an international context. A novel feature of the analysis is the three-step estimation strategy employed to model the macroeconomic risk and relate them to the first and second moments on property stock excess returns of four major markets, namely, Singapore, Hong Kong, Japan and the UK. Macroeconomic risk is measured by the conditional volatility of macroeconomic variables.

An important aspect of this study relates to the relationships between the expected risk premia and conditional variance, as well as covariances of macroeconomic factors which can be increasing, decreasing or flat depending on model parameters and the distribution characteristics of the excess returns across the different economies. Although it is now well recognized that property returns react to fluctuations in macroeconomic variables, any definite prediction of the relationships between the expected risk premium on property and major macroeconomic risk factors is difficult if not impossible. However, our results will help international investors and portfolio managers deepen their understanding of the risk-return relationship, pricing of macroeconomic risk as well as diversification implications in major Asia-Pacific and UK property stock markets. Additionally, policy makers may play a role in influencing the expected risk premia and volatility on property stock markets through the use of macroeconomic policy.

Collectively, the evidence from this study indicates that for all the four markets studied, the six macroeconomic variables, GDP growth, INDP growth, unexpected inflation, money supply, interest rate and exchange rate can be represented by three principal components which are time-varying. In addition, between five and six macroeconomic risk factors are highly correlated with the retained principal components. Furthermore, GARCH and GMM evidence suggests that the expected risk premia and conditional volatilities of the risk premia for the four markets are time-varying and dynamically linked to the conditional volatilities of the three retained principal components (and hence the macroeconomic factors). However the impact of the macroeconomic risk factors on the expected risk premia in terms of direction and significance do vary across the four markets studied. Hence there are opportunities for risk diversification in international property stock markets.

Finally, while this is among the very first few international real estate studies in the time-varying macroeconomic risk perspective of excess returns on major property stock markets, the scope and variety of the models we examine is still limited. For example, this study has not exhausted the effect of other documented macroeconomic variables (e.g. the term structure of interest rate, consumption, unemployment etc) on property stock pricing due mainly to lack of sufficiently long historical data series for some markets. Further work can also embark on developing alternative estimable relationship between macroeconomic risk and property stock excess returns with other econometric models such as a multi-factor latent variable model or a time-varying co-spectral specification. Other promising avenues that can be pursued are the international or global implications of the findings and relate them to cross-country differences such as institutional factors, market structure and pricing efficiency.

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Corresponding author
Kim Hiang Liow can be contacted at: rstlkh@nus.edu.sg