DYNAMIC RELATIONSHIP BETWEEN STOCK AND PROPERTY MARKETS

Dr Kim Hiang LIOW  
Associate Professor and Deputy Head (Academic) 
Department of Real Estate 
National University of Singapore 
4 Architecture Drive 
Singapore 117566 

Tel: (65) 8743420 / 8746504 
Fax: (65) 7748684 
E-mail: rstkh@nus.edu.sg.
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Abstract

This paper investigates the long-run and short-term relationships between stock and property markets. We focus on the combined and relative impacts of a real estate system that comprises residential and office property prices on all-stock and property stock prices. Using Autoregressive Distributed Lag (ARDL) cointegration procedure, the results suggest that there exists a long-run contemporaneous relationship between all-stock (and property stock) prices and real estate prices. Both the long-run and short-term influences of the combined residential and office property prices on all-stock and property stock prices weaken after controlling for changes in the macroeconomic factors. Additionally, all-stock and property stock prices are largely influenced by office real estate price in the long run. On the other hand, residential real estate price impacts stronger on all-stock and property stock prices in the short-term. Our combined perspective has implications for portfolio investment strategies and policy-making.

I. INTRODUCTION

This paper investigates the relationship between stock and property markets by focusing on the extent to which real estate prices affect stock market prices in the Singapore economy. Similar to other real estate markets in Asia, direct real estate is a significant asset of the Singapore economy. Real estate investment and development firms account for about 15% of the Republic's stock market capitalization. In addition, about 40 percent of the Singapore listed non-real estate firms own at least 20 percent real estate (Liow, 1999). The expectation is that changes in real estate prices impact changes in stock prices. One important question arising from this expectation is the nature and extent of the relationship between the real estate prices and stock prices both in the long- and short-run in the presence of macroeconomic factors (Ross, 1976). This study seeks to empirically address this question.

Both stock and property markets are parts of a larger economy. The performance of stock market in the economy reflects underlying corporate performance. The performance of real estate, on the other hand, reflects property market performance. For many firms in the economy, property is both a factor of production and an asset. In good times, corporate growth in profitability (with higher share prices) leads to corporate expansion which further leads to rising rental level given increased demand and short-run supply inelasticity. Rising rents lead to higher capital values in the property markets and hence raise net asset values anticipated in the stock prices. In a recession, the reverse process happens. However, in the longer term, rising rents and capital values of real estate might increase the cost of capital of the companies. Coupled with other possible speculative development activities and bank lending on real estate, one likely scenario is that higher returns to real estate are associated with low (negative) returns to the corporate sector and vice versa. Hence, real estate and stock markets can be related both in long-term and short-run in different manners.

This study takes the perspective that real estate market is a driver of stock market. This means that instead of examining the extent of return co-movements and causality in the two markets, we focus on the possible combined impact of residential and commercial real estate sectors on all-stock and property stock markets in the long-term and short-run in the Singapore economy. There are five key motivating factors for undertaking this study. First, Singapore is one of the strongest Asian economies and leading financial centre in
Asia. The inflow of foreign investment from Europe, North America and Asian countries has contributed significantly to the rate of economic development. In particular, the real estate sector has played an important role in enhancing the Republic’s status and attracting multi-national companies to establish their regional headquarters. Second, real estate accounts more than 50 percent of the nation’s wealth and productive capital. Published statistics further reveal that real estate contributes to between 10.7 and 19.5 percent of the Republic’s Gross Domestic Product over the last five years.¹ Third, the office space market has always been an important sector of the property market due to its traditional role as the preferred real estate class of institutional investors. On the other hand, the residential sector has been of great interest to investors as it is a source of wealth for many Singaporeans especially during the 1993-1995 property market boom periods. Consequently, residential and office property prices can be major driving forces of changes in stock market prices. The expectation is that at least part of the stock market return and volatility can be attributed to the two real estate markets. Fourth, compared with real estate markets in the US and the UK, real estate in Asian countries (including Singapore) commands a much lower initial yield. Hence real estate has become the most favored investment target within Asia and real estate markets may have a greater impact on stock markets. Finally, as considerable research has been undertaken in the US and UK, similar studies in other macroeconomy and investment markets, such as those of emerging economies in Asian countries, are expected to generate useful comparative evidence.

The approach taken in this study is that of long-run equilibrium via cointegration. Instead of relying on the more common Johansen multivariate cointegration procedure, autoregressive distributed lag (ARDL) cointegration modeling of Pesaran and Shin (1999) will be carried out to determine if there is a long-term equilibrium relationship between (property) stock prices, real estate prices and selected common macroeconomic factors in the Singapore economy. In this regard, the research tests two hypothesis: (a) that the inflation-adjusted (real) stock market prices show a long-term contemporaneous equilibrium relationship with the inflation-adjusted real estate market system that comprises residential and office real estate prices and common economic fundamentals reflected in the real gross domestic product and real interest rates, and (b) that the contemporaneous convergence of the variables in the system exhibits minimum systematic error due to the presence of an error correction mechanism (short-term relationship).

The results of this study reveal that there exists a long-run equilibrium relationship between (property) stock prices, residential and office real estate prices. Additionally, the combined impact of residential and office real estate sectors on (property) stock markets weakens after controlling for changes in the macroeconomic factors. This implies that at least part of the correlations between stock prices and real estate values arises because of the common economic fundamentals affecting both markets. Our evidence thus complements those of Ling and Naranjo (1999), Quan and Titman (1999) and Tse (2001) and adds to this emerging body of literature in international real estate.

The remainder of the study consists of four parts. Section II reviews the relevant empirical literature. The data and ARDL cointegration methodology are explained in Sections III and IV. The empirical results are presented in Section V. The last section concludes the paper.

II. LITERATURE REVIEW

¹ These statistics are derived from various issues of the Department of Statistics, Singapore.
In the context of this study, three related bodies of empirical literature are reviewed. The first group of research involves examining the relationship between real estate and stock markets. One of the earliest studies was conducted by Liu, Hartzell, Greig and Grissom (1990). They find that the US securitized real estate market is integrated with the stock market. However, they further find that the US commercial real estate market (direct) is segmented from the stock market. Okunev and Wilson (1997) detect a weak non-linear relationship between the US securitized real estate market and overall stock market using a non-linear mean reversion stock price model. In the UK, Lizieri and Satchell (1997) find a strong contemporaneous correlation exists between property stock returns and overall equity market returns. From an international perspective, in an empirical study that covers 17 countries, Quan and Titman (1999) report that, with the exception of Japan, the contemporaneous relationship between the yearly real estate prices changes and stock returns is not statistically significant. Finally, Tse (2001) finds that both unexpected changes in Hong Kong residential and office property prices are important determinants of the change in stock prices. The study uses impulse response function and an error-correction VAR model to examine the dynamic relationship between real estate and common stock prices.

The second group of research seeks to empirically investigate the relationships between direct and indirect real estate markets in the context of price discovery. The usual argument is that since the underlying assets of the two markets are real estate, they should be closely related to each other. In general, a number of studies (Giberto, 1990; Gyourko and Keim, 1992; Myer and Webb, 1993; Clayton and Mackinnon, 2001, Barkham and Geltner, 1995; Newell and Chau, 1996; Liow, 1998(a)) have detected strong positive contemporaneous correlation and lead-lag linkages in the US, UK, Australia and Singapore markets. However, there is also evidence of segmentation, with Singapore commercial real estate and property stock markets moving apart in recent years (Liow, 1998(b)). Additionally, a combination of cointegration and an error correction mechanism allows for long-run and short-term relationships between property stock and real estate markets to be simultaneously captured. A majority of the studies such as Ong (1994), Wilson and Okunev (1996), He (1998), Wilson et al (1998) and Chaudhry et al (1999) appear to support that the notion that the two markets are segmented (i.e. not cointegrated). More recently, however, Tuluca, Myer and Webb (2000) find that the price indices of capital and real estate markets (T-bills, bonds, stocks, public real estate and private real estate) are cointegrated. Specifically, their system of the five asset indices was governed by three common (non-stationary) factors since two cointegrating vectors were present. The existence of this long-term equilibrium relationship has a different effect on asset allocation, price discovery and predictability of returns.

Finally, the third group of research aims to uncover the relationships between asset markets and macroeconomy as implied under the APT. There is growing evidence that the expected variations in stock and bond returns are related to the state of the economy as reflected in key macroeconomic variables. Examples of the systematic factors include growth rate in real per capita consumption, real Treasury-bill rate, term structure of interest rates and unexpected inflation. Similarly, most studies that investigated the relationships between real estate returns and the macroeconomy include factors that are based on previous studies of stock market returns. Examples of such real estate studies include McCue and Kling (1994), Ling and Naranjo (1997), Karolyi and Sanders (1998), Brooks and Tsolacos (1999) and Liow (2000). These studies have documented linkages, of different degree, between commercial property market and key macroeconomic factors.

This study represents an attempt to integrate the three group of real estate empirical literature by assessing the combined and relative impacts of real estate markets on general stock and property stock markets,
from both the long-run and short term perspectives, after controlling for changes in the macroeconomic conditions. A recent study by Kallberg, Liu and Pasquariello (2002) (KLP) shows that Asian stock and real estate markets are related. They analyze how real estate and stock markets reacted during the time around the Asian financial crisis and investigate whether the crisis has fundamentally changed the relationship between real estate and stock markets. Using Granger Causality test and BLS technique, they identify regime shifts in time series of the monthly securitized real estate returns and equity index returns and volatilities in eight Asian countries. Our present study complements and differs from the KLP research in that we use direct residential and office real estate price indices (instead of securitized real estate price indices). Additionally, instead of raising the Granger Causality issue between real estate and stock markets, we take the perspective that real estate prices drive stock market prices and employ the ARDL cointegration methodology to examine their possible long-run relationship and short-term linkages in the economy.

III. DATA

The raw data required for this study are the published Urban Redevelopment Authority (URA)'s quarterly residential (PPIR) and office (PPIO) property price indexes, Singapore Stock Exchange (SGX)'s Straits Time Index (STI) and property-stock index (SESP) and three common macroeconomic variables. The main characteristics of the data are briefly described below:

(a) The quarterly PPIR and PPIO, published by the URA and available since 1975, have been considered as the residential and office property performance benchmark in Singapore. They are subsets of the Singapore private property index that is computed from information obtained in caveats lodged with the Land Registry. The price indices measure price changes of various types of property over time. The weights in the price index are computed based on the moving average of transactions over the last 12 quarters. For the commercial space, an overall index for the office (PPIO) and retail properties as well as sub-indices by locality are available. For the residential space, sub-indices for detached house, semi-detached house, terrace house, apartment and condominium are available. Generally, the index does not assume the problems inherent with an appraisal-based index as it is transaction-based.

(b) We use a locally value weighted market-based index – the Straits Times Index (STI) to represent the local stock market. Additionally, we include Singapore property stock index (SESP), the only market-based indicator that tracks the daily share price performance of all listed property investment and development firms, to proxy for the influence of property stock market. The SESP includes stocks of companies with substantial residential and office real estate exposure. For example, the four biggest property firms, City Development, CapitaLand, Keppel Land and Singapore Land have an average of 80% investment in offices and residential properties.

(c) The economic variables included in this study help explain asset pricing equilibrium. Following literature, the most popular ones are Gross Domestic Product (GDP), Interest Rate (INT) and inflation. Although it is very unlikely that the three variables are able to capture all relevant economic risks, they act as a joint proxy for a set of key latent variables that determines asset prices in an economy. First, the GDP is used as a proxy to measure the overall level of economic activities in an economy. During periods of high economic growth, there is great confidence within the economy and this would stimulate demand for investment assets and hence lead to increases in asset prices. Hence, changes in GDP are expected to have a positive influence on stock and real
estate prices. Interest rate variables have been used in a number of studies as a state variable to proxy for expectations about future economic conditions and capture the state of investment opportunities. For example, Merton (1973) proposes interest rate as a state variable to account for changes in the investment opportunity set. This is because the possibility of any shift in the set would influence the overall demand, supply and prices of assets. It has therefore been included in the studies of stock market returns (Chen, 1991) and equity REIT returns (Ling and Naranjo, 1997). In this paper, the prime lending rate is used to proxy for the influence of interest rate.

Finally, inflation rate influences are also considered important in the pricing of asset returns. In this study, the effect of inflation rate is indirectly examined by deflating the price indexes and economic variables by the consumer price index (a proxy for inflation). For practical purpose, this approach also helped reduce a multicollinearity problem that exists between the three macroeconomic factors.

(d) All the real price index data are transformed by taking the natural logarithm so that the difference in the log of the price variables (LNSTI, LNSESP, LNPIR and LNPIO) can be interpreted as the relative real price change or return (RSTI, RSESP, RPPIR and RPPIO). The availability of the STI data dictates the beginning date of the quarterly interval evaluated. Because the real GDP variable is found to be subject to significant seasonal fluctuations, it is further de-seasonalised. Finally the natural log transformation is taken for the seasonally-adjusted real GDP (LNGDP) for the usual statistical reasons and that the coefficients on the variables can be conveniently interpreted as constant elasticity. Table 1 provides the usual statistical description, normality tests and correlations of the variables from 1985:1 to 2002:4, the full period for which all the six variables have complete set of data. All the four index returns display a negative skewness (between -0.4840 and -0.2891) and a kurtosis value in excess of 3 (between 3.0863 and 4.8677). Additionally, only the all-stock market return distribution (RSTI) departs significantly from normality (JB statistic is 13.09). Figures 1 and 2 plot the quarterly real price indexes of the stock and property markets.

IV. METHODOLOGY

The principal task in this paper is to search for a long-run equilibrium relationship and short-term dynamics between all-stock price index / property stock price index (dependent variable), residential and office real estate indices and the selected macroeconomic factors. For this purpose, we first draw on the theory of cointegrated processes to disclose whether the specified variables are in long-run equilibrium. Briefly, the concept of cointegration is developed from the belief that certain economic variables should not diverge from each other by too far a distance or diverge without bound. Such variables may drift apart in the short-run but if they continue to be too far apart in the long-run, then economic forces will bring them together again (Granger, 1986). As such, an error correction model can be established to capture the short-run equilibrium.

The well-established approach to testing long-run relations between more than two variables is the Johansen (1988)'s Full Information Maximum Likelihood technique (FIML). Another recent and alternative

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2 In many countries a GDP price deflator is used since consumer prices are not necessarily a good proxy for inflation in national output. However, the GDP price deflator series for Singapore is only available on an annual basis. Hence we have to use quarterly consumer price index as a proxy for inflation.

3 In econometric modeling it is not common to take the log of an interest rate series. Therefore, we did not take the natural logarithm of the real prime interest rate.
approach is the ARDL procedure advanced in Pesaran and Shin (1999). The main advantage of the ARDL approach is that it can be applied regardless of whether the regressors are I(0) or I(1), and this avoids pre-testing problems associated with the standard cointegration analysis such as FIML which requires the classification of the variables into I(1) and I(0). The statistical procedures are covered in two stages and are briefly explained below.

**Testing of cointegration**

In this first stage, a “bound test” is conducted to search for the existence of a long-run relation between the variables in the system. Basically, the lagged level terms are added to an error correction form of the underlying ARDL model and the F-statistic is computed. Pesaran, Shin and Smith (2001) tabulate two sets of asymptotic critical values to provide critical value bounds for all classifications of the regressors into pure I(1), purely I(0) or mutually cointegrated. The null hypothesis of no cointegration will be rejected if the computed F-statistic from the ARDL model falls outside the critical value bounds, a conclusive inference can be drawn without needing to know the integration / cointegration status of the underlying regressors. However, if the F-statistic falls inside these bounds, inference is inconclusive and we need to know the order of the integration of the underlying variables before conclusive inferences can be made.

In the present context, the investigations involve testing the existence of a long-run relation between all-stock price (and property stock price), residential property price and office property price. In addition to the two unadjusted stock price indices (i.e. RSTI in Model 1 and RSESP in Model 3), as a robustness test we also examine another two adjusted stock market indices. First, since there is a redundancy in that the all-stock price index (RSTI in Model 1) includes the property component, an adjusted all-stock price index (RZSTI in Model 2) is derived by orthogonalising the RSTI to remove the component related to RSESP. Second, as property stocks are influenced by both stock market and underlying real estate market, another orthogonalization procedure is performed to “strip out” the stock market portion of property stock index to derive an adjusted property stock price index (RZSESP in Model 4).

As the data are quarterly, we first choose 4 for the maximum order of the lags in the ARDL regression. The computed F-statistics of the four three-variable error correction ARDL models (4, 4, 4) below are evaluated against the critical value bands. The F-statistic for testing the joint null hypothesis that there exists no long-run relationship between the three price indices \((H_0: z_1 = z_2 = z_3)\) has a non-standard distribution irrespective of whether the three variables are I(0) or I(1). The null hypothesis of no cointegration between the three price indices will be rejected if the computed F-statistics falls outside the 95% critical value bands of between 3.793 and 4.855.

**Model 1 (Unadjusted all-stock price):**
\[
RSTI_t = a_0 + \sum_{j=1}^{4} b_j RSTI_{t-j} + \sum_{j=1}^{4} c_j RPIIR_{t-j} + \sum_{j=1}^{4} d_j RPIO_{t-j} + Z_1 LNSTI_{t-1} + Z_2 LNPPIR_{t-1} + Z_3 LNPPIO_{t-1} + \text{error}_t
\]

**Model 2 (Adjusted all-stock price):**
\[
RZSTI_t = a_0 + \sum_{j=1}^{4} b_j RZSTI_{t-j} + \sum_{j=1}^{4} c_j RPIIR_{t-j} + \sum_{j=1}^{4} d_j RPIO_{t-j} + Z_1 LNZSTI_{t-1} + Z_2 LNPPIR_{t-1} + Z_3 LNPPIO_{t-1} + \text{error}_t
\]

**Model 3 (Unadjusted property stock price):**
\[
RSESP_t = a_0 + \sum_{j=1}^{4} b_j RSESP_{t-j} + \sum_{j=1}^{4} c_j RPIIR_{t-j} + \sum_{j=1}^{4} d_j RPIO_{t-j} + Z_1 LNSESP_{t-1} + Z_2 LNPPIR_{t-1} + Z_3 LNPPIO_{t-1} + \text{error}_t
\]
Model 4 (Adjusted property stock price): \( RZSESP_t = a_0 + \sum_{j=1}^{4} b_j RZSESP_{t-j} + \sum_{j=1}^{4} c_j RPPIR_{t-j} + \sum_{j=1}^{4} d_j RPIO_{t-j} + z_1 LNZSESP_{t-1} + z_2 LNPPIR_{t-1} + z_3 LNPPIO_{t-1} + \text{error}_t \)

We then expand the above ARDL models to include the two macroeconomic variables (real GDP and real prime interest rates). The 95% critical value bands for the four multivariate ARDL models (4, 4, 4, 4, 4) in models 5 to 8 below are between 2.850 and 4.049.

Model 5 (Unadjusted all-stock price): \( RSTI_t = a_0 + \sum_{j=1}^{4} b_j RSTI_{t-j} + \sum_{j=1}^{4} c_j RPPIR_{t-j} + \sum_{j=1}^{4} d_j RPIO_{t-j} + \sum_{j=1}^{4} e_j RGDP_{t-j} + \sum_{j=1}^{4} f_j RINT_{t-j} + z_1 LNSTI_{t-1} + z_2 LNPPIR_{t-1} + z_3 LNPPIO_{t-1} + z_4 LNGDP_{t-1} + z_5 INT_{t-1} + \text{error}_t \)

Model 6 (Adjusted all-stock price): \( RZSTI_t = a_0 + \sum_{j=1}^{4} b_j RZSTI_{t-j} + \sum_{j=1}^{4} c_j RPPIR_{t-j} + \sum_{j=1}^{4} d_j RPIO_{t-j} + \sum_{j=1}^{4} e_j RGDP_{t-j} + \sum_{j=1}^{4} f_j RINT_{t-j} + z_1 LNZSTI_{t-1} + z_2 LNPPIR_{t-1} + z_3 LNPPIO_{t-1} + z_4 LNGDP_{t-1} + z_5 INT_{t-1} + \text{error}_t \)

Model 7 (Unadjusted property stock price): \( RSESP_t = a_0 + \sum_{j=1}^{4} b_j RSESP_{t-j} + \sum_{j=1}^{4} c_j RPPIR_{t-j} + \sum_{j=1}^{4} d_j RPIO_{t-j} + \sum_{j=1}^{4} e_j RGDP_{t-j} + \sum_{j=1}^{4} f_j RINT_{t-j} + z_1 LNSESP_{t-1} + z_2 LNPPIR_{t-1} + z_3 LNPPIO_{t-1} + z_4 LNGDP_{t-1} + \text{error}_t \)

Model 8 (Adjusted property stock price): \( RZSESP_t = a_0 + \sum_{j=1}^{4} b_j RZSESP_{t-j} + \sum_{j=1}^{4} c_j RPPIR_{t-j} + \sum_{j=1}^{4} d_j RPIO_{t-j} + \sum_{j=1}^{4} e_j RGDP_{t-j} + \sum_{j=1}^{4} f_j RINT_{t-j} + z_1 LNZSESP_{t-1} + z_2 LNPPIR_{t-1} + z_3 LNPPIO_{t-1} + z_4 LNGDP_{t-1} + \text{error}_t \)

where STI_t, SESP_t, PPIR_t and PPIO_t are the real price indices for the stock market, property stock market, residential and office properties respectively; ZSTI_t and ZSESP_t are the adjusted all-stock and property stock price indices respectively; GDP_t is the de-seasonalized real gross domestic product and INT_t are the real prime lending rates respectively. The LN-prefix and R-prefix denotes the log-transformed series and the first-difference or returns respectively.

There are two other methodological issues with regard to the bound test. First, the selection of the lag length can be important in estimating the ARDL regressions. Specifically, there is a concern that the maximum lag length of 4 included in the ARDL models is unnecessarily large as it suggests that it may take up to a year (4 quarters) for information to be incorporated into stock prices. It is also large given the relative small sample size (i.e. only 72 quarterly observations). To address this concern, the tests are run over three other lag lengths of 1, 2 and 3 to determine the optimal lag length. Second, in the ARDL cointegration test, it is assumed that only one long
run relationship exists between the dependent variable and the exogenous variables (Pesaran, Shin and Smith, 2001, assumption 3). To test whether this is indeed appropriate in the current application, we change RSTI, RSESP, RZSTI and RZSESP (the dependent variable in each model) to RPPIO and RPPIR and repeat the steps to compute the F-statistic for the respective joint significance in the ARDL models.

**Estimating cointegrating and error correction models (ECM)**

The second stage of the ARDL approach is to estimate the coefficients of the long run cointegrating relationship and the corresponding ECM. For example, from model 8, the long-run cointegrating regression is

$$LNZSESP_t = x_0 + y_1*LNPPiR_t + y_2*LPPIO_t + y_3*LGDP_t + y_4*LINT_t + \varepsilon_t$$

The ECM model will be:

$$RZSESP_t = \alpha_0 + \sum_{j=1}^{k} \beta_j*RPPIR_{t-4} + \sum_{j=1}^{m} \delta_j*RPPIO_{t-4} + \sum_{j=1}^{n} \phi_j*RGDP_{t-4} + \sum_{j=1}^{p} \gamma_j*RINT_{t-4} + \alpha e_{t-1} + \text{(error)}$$

The lagged error correction term ($e_{t-1}$) derived from the ECM model is an important element in the dynamics of cointegrated systems in that it allows for adjustment back to the long-term equilibrium relationship given a deviation in the last quarter. The appropriate lag structure of the ECM is determined by three model selection criteria: Schwarz Bayesian criteria (SBC), Akaike Information criteria (AIC) and Hanna Quinn criteria (HQC).

V. **EMPIRICAL RESULTS**

**Existence of a long-run relationship**

Table 2 contains the respective F-statistics (computed over the alternative lag lengths of 1, 2, 3 and 4) for testing the existence of a long-run relationship between the variables included in Models 1 to 8. For Models 1 to 3, since the 12 computed F-statistics are between 5.9211 and 9.7354 and exceed the upper bound of the critical value bands at the five-percent level (3.793- 4.855) or at the one-percent level (5.288 - 6.309), we can firmly reject the null of no long-run relationship between the unadjusted all-stock price index (model 1) / adjusted all-stock price index (model 2) / unadjusted property stock price index (model 3) and office and residential property price indices in the three-variable system. Additionally, the F-statistics at lag length of 2 are the highest (8.0410, 9.7354 and 7.3470 for models 1, 2 and 3 respectively, all statistically significant at the 1 percent level). For model 4, only the F-statistic at the lag length of 2 (4.7123) exceed the upper bound of the 90 percent critical value band (i.e. 4.126). Thus given the relatively shorter sample period, it appears acceptable for us to retain the lag length of 2 for subsequent ARDL estimation.

(Table 2 here)

When the two macroeconomic variables (real GDP and real interest rates) are included, the ARDL models 5 and 6 derive the highest F-statistics of 7.7182 (dependent variable is RSTI) and 5.8056 (dependent variable is the RZSTI) respectively at the lag length of 2. As both values are all above the upper bound of the critical value bands of 2.850-4.049 (95%) and 3.817-5.122 (99%), they suggest that stock market is in long-run equilibrium with office and residential markets within the economic system. Further results reveal that, for models
7 and 8, only the computed F-statistics at the lagged length 2 (3.6873 and 3.7741) are just above the upper bound of the 90 percent critical value band (which is 2.425-3.574).

Finally, we consider the significance of the lagged level variables in the ECMs explaining RPPIO and RPPIR. Table 3 reports the F-statistics for the 8 models at the lag length of 2 (dependent variable: RPPIO or RPPIR). The range of the F-values is between 0.6596 and 3.4214 and all the values are statistically insignificant at the 95 per cent and 90% critical value bands. Hence the null hypothesis that the level variables do not enter significantly in the equations for RPPIO and RPPIR could not be rejected.

In all, the above test results suggest that there exists a long-run relationship between all-stock price index / property stock price index, office property price index, residential property price index and the selected macroeconomic variables, and that the combined influence of office and residential property price indices on the stock price indices can be assessed with the estimation of cointegrating models and ECMs that follow.

**Cointegrating models and ECMs**

*Models 1 to 4*

Table 4 provides the estimates of the ARDL long-run coefficients for Models 1 to 4. Table 5 contains the estimates of the corresponding ECMs.

All the four long-run cointegrating relationships are in line with a priori expectation. The respective signs for the two explanatory variables are all in the hypothesized direction. Since all the variables are tested in log forms, the coefficient of each explanatory variable denotes the percentage change in the dependent variable that results from a one percent change in an independent variable, other things being constant. Specifically, by summing up the coefficients of residential and office price indices, their combined impact on (property) stock markets can be estimated. For example, in the longer term, the combined impact of office and residential property prices on unadjusted all-stock and adjusted all-stock prices (models 1and 2) is about 0.671 and 0.447 respectively, implying that for a 1 percent increase per quarter in office and residential property prices, all-stock prices on average increase by between 0.447% and 0.671% per quarter (or between 1.81% and 2.68% per annum). Additionally, the impact of office property price on all-stock price is between 2.8 and 3.7 times the impact of residential property price on all-stock price. Hence stock market is significantly influenced by office property market in the long run. Further results indicate that the combined impact of office and residential property prices on property stock price is between 0.850 and 0.939 percent (Models 3 and 4). Again, office property price has a stronger influence on property stock price in the long run (the relative impact is between 1.3 and 1.6 times).

For the four models, a dynamic ECM each is estimated by incorporating the error correction term (ERRt−1) derived from the coefficient estimates from the respective long-term equilibrium models. Up to two lags are included as this has been concluded to be the appropriate lag length. In Table 5, the coefficients of the error correction term (ERRt−1) (i.e. speed of adjustment towards the long run equilibrium) for the four models are all statistically significant at the one percent level and are of correct sign. The estimated values are -0.537

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4 Additionally, all the four ARDL models passed all the diagnostic tests that were automatically computed by Microfit.
(unadjusted all-stock price), -0.617 (adjusted all-stock price), -0.540 (unadjusted property stock price) and -0.700 (adjusted property stock price). This implies that between 54% and 70% of the previous discrepancy between the actual and desired (long-run) stock prices is corrected in each quarter. Lastly, the relative impact of residential property return is much stronger than that of the impact of office return on all-stock return and property stock return. Specifically, the slope coefficients of residential property return for the four models are between 1.207 and 1.962, implying that both stock market and property stock market returns are elastic with the residential property return with an annual increase of between 4.93% and 8.07%. On the other hand, the elasticity coefficients for office property return indicate that stock market and property stock returns are expected to increase by between 0.27% and 0.77% per quarter should there be an increase of 1% per quarter in the office property return.

Models 5 to 8

Results of the estimated long-run relationship (with macroeconomic factors) in Models 5 to 8 are reported in Table 6. There is some evidence that real GDP drives all-stock and property stock prices. The impact of real interest rates on all-stock and property stock prices is negative and statistically significant in Models 7 and 8. Focusing our attention on the slope coefficients of residential and office property prices, it appears again that office market is a stronger mechanism affecting changes in stock prices. The four coefficients for office property price range between 0.288 and 0.683 and are all statistically significant at the conventional levels. On the other hand, none of the coefficients for residential property price (between 0.127 and 0.149) is statistical significant. Next, the combined impact of office and residential property prices on stock prices is between 0.437 and 0.848 (between 0.447 and 0.939 for Models 1-4). Hence it appears that the joint impact of real estate markets on stock markets has weakened in the long run after controlling for changes in the macroeconomic conditions. In line with prior literature, our evidence may indicate that at least part of the correlations between stock and real estate prices exist because of some common economic fundamentals affecting both stock and real estate markets.

Table 7 provides one ECM each for the four models. The coefficients of the ERR t-1 for the four models are between -0.552 and -0.654, of correct sign and are statistically significant at the one-percent level. In the short run, both residential and office property returns affect significantly all-stock and property stock returns. As compared to office property return, the slope coefficients for residential property return in the four models are all greater than 1 (1.050-1.371 for residential and 0.189-0.434 for office). Hence residential property return has a stronger and an elastic influence on stock market return. One possible explanation is that many listed real estate developers in Singapore focus on sales of residential projects in the short run. Hence the profitability of the projects has a direct short-term impact on their stock returns. On the other hand, many office properties are held under single ownership by institutional investors and listed property companies, and are therefore subject to less short-term market fluctuations.

VI. CONCLUSION

This study has provided an alternative perspective on the dynamic relationship between (property)stock prices and real estate prices in the Singapore economy. Specifically, a real estate system comprises of residential and office property is detected to be in long-run equilibrium with all-stock and property stock prices in the
macroeconomy using the ARDL cointegration methodology. By considering residential and office property markets in a real estate system, we are able to assess the combined and relative impacts of residential and office property prices on all-stock and property stock prices respectively.

Overall, the results provide three major conclusions. First, there exists a contemporaneous long-term relationship between all-stock price index / property stock price index, residential price index and office price index in a three-index cointegrated system. Hence there is systematic price co-movement among the general stock / property stock, residential and office real estate markets in the long term. Second, both the long-run and short-term impacts of the combined residential and office real estate on (property) stock markets weaken after controlling for changes in the macroeconomic conditions. The findings are broadly consistent with those of Ling and Naranjo (1999), Quan and Titman (1999) and Tze (2001). Finally, the relative impact of office and residential real estate prices on (property) stock market prices changes with respect to the investment horizon. In the long run, stock market (and property stock market) is largely influenced by office real estate market. On the other hand, residential property market exerts a stronger influence on (property) stock market in the short-term. Thus understanding and evaluating the joint and relative impacts of different real estate sectors on (property) stock markets according to investment horizon should be beneficial to portfolio investment strategies and policy-making. Specifically, our research has provided valuable evidence regarding the long-term and short-term relationships between stock and property markets and is useful to institutional investors in mixed asset allocation that covers all-stocks, property stocks and direct real estate.

REFERENCES


Department of Statistics, various publication issues, Singapore.


### Table 1  Descriptive Statistics of Stock and Property Returns: 1985Q1 to 2002Q4

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Jarque-Bara</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPPIO</td>
<td>0.0051</td>
<td>0.0703</td>
<td>0.1613</td>
<td>-0.2413</td>
<td>-0.4198</td>
<td>3.9699</td>
<td>4.8679</td>
</tr>
<tr>
<td>RPPIR</td>
<td>0.0137</td>
<td>0.0554</td>
<td>0.1306</td>
<td>-0.1408</td>
<td>-0.3931</td>
<td>3.0863</td>
<td>1.8508</td>
</tr>
<tr>
<td>RSTI</td>
<td>0.0110</td>
<td>0.1605</td>
<td>0.4419</td>
<td>-0.5702</td>
<td>-0.4840</td>
<td>4.8677</td>
<td>13.0913*</td>
</tr>
<tr>
<td>RSESP</td>
<td>0.0099</td>
<td>0.2146</td>
<td>0.6155</td>
<td>-0.6499</td>
<td>-0.2891</td>
<td>3.9207</td>
<td>3.4966</td>
</tr>
</tbody>
</table>

Correlation Coefficients

<table>
<thead>
<tr>
<th></th>
<th>RSTI</th>
<th>RSESP</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPPIO</td>
<td>0.232*</td>
<td>0.136</td>
</tr>
<tr>
<td>RPPIR</td>
<td>0.521*</td>
<td>0.254**</td>
</tr>
</tbody>
</table>

NB: RPPIO - Office property returns
RPPIR - Residential property returns
RSTI - All-stock returns
RSESP - Property stock returns
*, **, *** - Indicates two tailed significance at the 1%, 5% and 10% levels respectively

### Table 2  F-statistics for Testing the Existence of a long-run Relationship

<table>
<thead>
<tr>
<th>ARDL Model (dependent variable)</th>
<th>Panel A: Without Macroeconomic Factors</th>
<th>Panel B: With Macroeconomic Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum order of the Lags in the ARDL Model</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Model 1 (Unadjusted all-stock price index)</td>
<td>7.67311</td>
<td>8.04101</td>
</tr>
<tr>
<td>Model 2 (Adjusted all-stock price index)</td>
<td>9.30491</td>
<td>9.73541</td>
</tr>
<tr>
<td>Model 3 (Unadjusted property stock price index)</td>
<td>5.92152</td>
<td>7.34701</td>
</tr>
<tr>
<td>Model 4 (Adjusted property stock price index)</td>
<td>3.0997</td>
<td>4.71233</td>
</tr>
<tr>
<td>Model 5 (Unadjusted all-stock price index)</td>
<td>7.15211</td>
<td>7.17821</td>
</tr>
<tr>
<td>Model 6 (Adjusted all-stock price index)</td>
<td>3.3592</td>
<td>5.80561</td>
</tr>
<tr>
<td>Model 7 (Unadjusted property stock price index)</td>
<td>3.0042</td>
<td>3.68733</td>
</tr>
<tr>
<td>Model 8 (Adjusted property stock price index)</td>
<td>2.8461</td>
<td>3.77413</td>
</tr>
</tbody>
</table>

NB:
For Models 1-4 (K=2), the critical value bounds for the F-statistic are:
99%: 5.288 - 6.309
95%: 3.793 - 4.855
90%: 3.182 - 4.126
For Models 5-8 (k=4), the critical value bounds for the F-statistic are:
99%: 3.817 - 5.122
95%: 2.850 - 4.049
90%: 2.425 - 3.574

1, 2, and 3 : Indicates the existence of a long-run relationship at the 1%, 5% and 10% levels.
Table 3  Additional F-tests for the existence of a long term relationship a

<table>
<thead>
<tr>
<th>ARDL Model</th>
<th>F-statistics</th>
<th>Dependent variable: Office property price index</th>
<th>Dependent variable: Residential property price index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.6684</td>
<td>2.4569</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2.8904</td>
<td>2.7125</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2.5049</td>
<td>0.6600</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3.4166</td>
<td>0.6454</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3.4079</td>
<td>2.1719</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3.4214</td>
<td>2.0138</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3.3413</td>
<td>0.6596</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>3.0178</td>
<td>0.6775</td>
<td></td>
</tr>
</tbody>
</table>

NB:

- The tests are conducted using the maximum order of 2 lags in the ARDL Models (see Table 2)
- For Models 1-4 (K=2), the critical value bounds for the F-statistic are:
  - 99%: 5.288 - 6.309
  - 95%: 3.793 - 4.855
  - 90%: 3.182 - 4.126
- For Models 5-8 (K=4), the critical value bounds for the F-statistic are:
  - 99%: 3.817 - 5.122
  - 95%: 2.850 - 4.049
  - 90%: 2.425 - 3.574

Table 4  Estimated Long-Run Coefficients using ARDL Approach (without Macroeconomic Factors)

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Dependent variable: All-stock</th>
<th>Dependent variable: Property stock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1 Unadjusted price a</td>
<td>Model 2 Adjusted price a</td>
</tr>
<tr>
<td>LNPPIO</td>
<td>Coefficient</td>
<td>t-statistic</td>
</tr>
<tr>
<td>LNPPIR</td>
<td>0.1438</td>
<td>0.89</td>
</tr>
<tr>
<td>Constant</td>
<td>2.3544</td>
<td>39.77**</td>
</tr>
</tbody>
</table>

NB:

- a Model 1: Unadjusted All-stock price index
- Model 2: Adjusted All-stock price index
- Model 3: Unadjusted Property stock price index
- Model 4: Adjusted Property stock price index
- LNPPIO (LN) office property price index
- LNPPIR (LN) residential property price index
- *, ** Indicates two tailed significance at the 1 percent and 5 percent levels
### Table 5 Error Correction Models for All-stock and Property Stock Prices (without Macroeconomic Factors)

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Model 1a</th>
<th>Model 2a</th>
<th>Model 3a</th>
<th>Model 4a</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted all-stock price index</td>
<td>Adjusted all-stock price index</td>
<td>Unadjusted property stock price index</td>
<td>Adjusted property-stock price index</td>
</tr>
<tr>
<td>ARDL (1, 0, 2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSES A / RSEP s t -1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RPPI O t -1</td>
<td>0.0773 (0.86)</td>
<td>0.6467 (2.02**)</td>
<td>0.2861 (1.86**)</td>
<td>0.6501 (1.59)</td>
</tr>
<tr>
<td>RPPI R t -1</td>
<td>1.4299 (4.10*)</td>
<td>1.2074 (3.32')</td>
<td>1.9618 (3.60')</td>
<td>1.8147 (3.16')</td>
</tr>
<tr>
<td>Constant</td>
<td>1.2643 (5.21')</td>
<td>1.7346 (5.21**)</td>
<td>0.6156 (4.37')</td>
<td>0.4359 (4.30')</td>
</tr>
<tr>
<td>Ecm t -1</td>
<td>-0.5370 (-5.30*)</td>
<td>-0.6174 (-5.77**)</td>
<td>-0.5404 (-4.47*)</td>
<td>-0.7003 (-5.19*)</td>
</tr>
</tbody>
</table>

NB:  
- **Model 1:** Unadjusted All-stock price index  
- **Model 2:** Adjusted All-stock price index  
- **Model 3:** Unadjusted Property stock price index  
- **Model 4:** Adjusted Property stock price index  
- **Independent variables:**  
  - RSES A: returns on all-stocks  
  - RSEP S: returns on property stocks  
  - RpPIO: returns on office properties  
  - RpPIO t -1: one-quarter lagged returns on office properties  
  - RpPIR: returns on residential properties  
  - RpPIR t -1: one-quarter lagged returns on residential properties  
  - ECM t -1: Coefficient for error correction mechanism  
  - *, **, ***: Indicates two tailed significance at the 1 percent, 5 percent and 10 percent levels

### Table 6 Estimated Long-Run Coefficients using ARDL Approach (with Macroeconomic Factors)

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Dependent variable: All-stock</th>
<th>Dependent variable: Property stock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 5 - Unadjusted price a</td>
<td>Model 6 - Adjusted price a</td>
</tr>
<tr>
<td></td>
<td>Coefficient t-statistic</td>
<td>Coefficient t-statistic</td>
</tr>
<tr>
<td>LNPPIO</td>
<td>0.2882 2.12 **</td>
<td>0.3685 1.89 **</td>
</tr>
<tr>
<td>LNPPIR</td>
<td>0.1489 0.92</td>
<td>-0.3382 -1.31</td>
</tr>
<tr>
<td>LNGDP</td>
<td>0.4709 2.52 **</td>
<td>-0.8206 -0.19</td>
</tr>
<tr>
<td>INTEREST</td>
<td>-2.8212 -0.89</td>
<td>2.1918 1.51</td>
</tr>
<tr>
<td>Constant</td>
<td>0.0612 0.06</td>
<td>2.1918 1.51</td>
</tr>
</tbody>
</table>

NB:  
- **Model 1:** Unadjusted All-stock price index  
- **Model 2:** Adjusted All-stock price index  
- **Model 3:** Unadjusted Property stock price index  
- **Model 4:** Adjusted Property stock price index  
- **Independent variables:**  
  - LNPPIO: (LN) office property price index  
  - LNPPIR: (LN) residential property price index  
  - LNGDP: (LN) gross domestic product  
  - INTEREST: Prime interest rates  
  - *, **: Indicates two tailed significance at the 1 percent and 5 percent levels
Table 7 Error Correction Models for All-stock and Property Stock Prices (with Macroeconomic Factors)

<table>
<thead>
<tr>
<th>Independent variables b</th>
<th>Model 5 a</th>
<th>Model 6 a</th>
<th>Model 7 a</th>
<th>Model 8 a</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted all-stock price index</td>
<td>Adjusted all-stock price index</td>
<td>Unadjusted property stock price index</td>
<td>Adjusted property stock price index</td>
</tr>
<tr>
<td>ARDL (1, 0, 2, 0, 0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficient (t-statistic)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RPIPO t</td>
<td>0.1885 (1.97*** )</td>
<td>0.2072 (1.76** )</td>
<td>0.4341 (2.71* )</td>
<td>0.3752 (2.01*** )</td>
</tr>
<tr>
<td>RPIIR t</td>
<td>1.1237 (3.04* )</td>
<td>1.0504 (2.69** )</td>
<td>1.3714 (2.40** )</td>
<td>1.3006 (2.26** )</td>
</tr>
<tr>
<td>RPIIR t – 1</td>
<td>0.9499 (2.37** )</td>
<td>0.8629 (2.08** )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RGDP t</td>
<td>3.3080 (2.42** )</td>
<td>2.1752 (1.98**)</td>
<td>3.1193 (1.94*** )</td>
<td>2.8824 (1.76*** )</td>
</tr>
<tr>
<td>RINTEREST t – 1</td>
<td>-1.8452 (-0.87)</td>
<td>-0.4614 (-0.19)</td>
<td>-6.4911 (-1.96*** )</td>
<td>-6.006 (-1.71*** )</td>
</tr>
<tr>
<td>Constant</td>
<td>0.0400 (0.06)</td>
<td>1.2325 (1.38)</td>
<td>0.1111 (0.10)</td>
<td>2.4448 (2.01** )</td>
</tr>
<tr>
<td>Ecm t – 1</td>
<td>-0.6541 (-6.21**)</td>
<td>-0.5624 (-5.24**)</td>
<td>-0.6356 (-5.31**)</td>
<td>-0.5517 (-4.82)</td>
</tr>
</tbody>
</table>

NB: a Model 1: Unadjusted All-stock price index
Model 2: Adjusted All-stock price index
Model 3: Unadjusted Property stock price index
Model 4: Adjusted Property stock price index

b Independent variables
- RPIPO - returns on office properties
- RPIIR - returns on residential properties
- RPIIR t – 1 - one-quarter lagged returns on residential properties
- RGDP - first difference in (LN) gross domestic product
- RINTEREST - Change in the prime interest rates
- ECM t – 1 - Coefficient for error correction mechanism

*, **, *** Indicates two tailed significance at the 1 percent, 5 percent and 10 percent levels