Price Discovery Between Residential Land & Housing Markets

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Abstract

This paper focuses on the relationship between residential land and house prices. It examines whether high land prices in urban areas caused high property prices or whether high property prices leads to high land prices. The former hypothesis is based on the neoclassical theory of land rent, whilst the latter is based on the Ricardian rent theory. We first construct a constant quality price index for urban land using the hedonic methodology. A cointegration analysis is then carried out between the urban land price index and the residential property price index and the evidence indicates that the two series are integrated in the long run. The empirical results modeled in an error-correction framework indicate that Granger causality runs from the housing market to the land market, which is consistent with the Ricardian rent theory. However, we did not find any granger causality in the direction of the land market to the housing market. Although this suggests that price movements in the land market do not filter to the housing market, it does not imply that land policies are irrelevant. Due to cross-market interactions, an integrated approach to the land and house markets is required to tackle price volatility in the housing market.

Key words: price discovery, urban land price, residential market.

Price Discovery Between Land & Housing Markets

"It is frequently suggested that high land prices cause high house prices. A common argument for such causality confirms an 'implicit adding up' theory of price determination. In it house prices are the sum of adding up land costs, construction costs and builder's profit. Ricardian rent theory and its modern variants would dispute that conclusion by arguing for a residual view of land prices. Residential land prices, it argues, depend on the profitability of housing development – Ball, 1983" (Evans, 2004; p.17).

1. Introduction

House prices have escalated dramatically over the past decades, across different metropolitan areas, such as in South Korea (Hannah et al., 1993; Cho and Ma, 2006), Hong Kong (Tse, 1998; Cheung, Tsang and Mak, 1995), Sydney (Abelson, 1997), Taiwan (Lin, 1993; Chen and Patel, 1998), United Kingdom (Eve, 1992) and the US (Potepan, 1996). The boom in house prices is a big concern to policy makers due to its impact on the local and business communities. Aspiring home owners worry that the price escalation may price them out of the market, whilst businessmen worry that it would increase business cost and reduce their ability to compete. It is therefore not surprising that policies have been implemented in an attempt to control the price escalation and make housing more affordable.

On the demand side, a convenient group of culprit constantly blamed for the volatile and escalating prices in the housing market is the speculators. Hence, anti-speculation measures are commonly implemented to curb excessive speculation in the local housing market. On the supply side, a common accusation is that restrictive planning policies limit land supply and thereby, push up house prices. It is often contended that an expansion in the land supply would enlarge the housing stock, which in turn would reduce the pressure on house prices to increase. In most developed cities, urban land supply is often limited and characterized by fragmented land ownership. To a limited extent, planners can still increase land supply in these areas by permitting higher density residential developments on existing land and by allowing change of zoning and land use in the city fringe. However, even in areas where land supply is dominated by the state, for example in Hong Kong and Singapore, the release of land for development purpose is still a contentious issue.

Since the quantity, timing and pricing of land supply are regulated by the state, it is not surprising that government policies have been blamed for the booms and busts experienced in the housing markets. In particular, high land prices (due to planning restrictions and revenue maximization objective of the state when allocating scarce land resources) are often cited as the main cause for escalating housing prices in these metropolitans.[1] This flows from a neo-classical land rent theory

(see Needham, 1981) that the prices of housing are high because land prices are high. The logic is that the price of a product is determined by its production costs, of which land cost forms part of it. Evans (2004) contends that when land has alternative uses, it must receive its due remuneration like any factor of production. Hence, an increase in the price of land would cause a corresponding hike in the price of the product (housing). Others, however, countered that land prices are determined by demand, not supply on the basis that the residual valuation is employed by most developers to formulate their land bids. Grigson (1986), for example, argues that *"house prices determine land prices not the reverse, because the builder's estimate of the selling price of the building will largely determine his bid for the piece of land.* This view, which he claimed is shared by a number of economists and practitioners, is consistent with the Ricardo (1913) land-price theory that high land prices are a result (not cause) of high property prices.

There are therefore two different views on the relationship between land and housing prices. Do high land prices contribute to high property prices? Or is it the other way around, high property prices result in high land prices? So far, no studies have examined this issue empirically, primarily because of the lack of data since urban land are traded infrequently. This paper contributes to the literature by examining empirically the dynamic relations between the housing and land prices. Singapore offered a unique setting to study this issue because of its active land sales market. Between 1990 and 2000t, close to 500 development sites were sold for large private residential projects, or approximately 31 sites sold a year. We take advantage of the database to construct a constant quality land price index to capture quarterly price movements in the urban land market over the 16-year period. Once the land price index is constructed, cointegration and Granger causality tests are employed to examine its long-term and short-term relationship with the readily available housing price index. Results of the Johansen cointegration test indicate that land prices and housing prices are integrated, meaning that a long-term relationship exists between two time series. Modeling the Granger causality test within an error-correction framework, we observe a causality effect flowing from the housing market to the land market. Indicating that the prices in the housing market react quicker to new information or exogenous shocks, the results suggest that price movements in housing market serve as a reliable lead indicator of future price movements in the land market.

The remaining of this paper is organized as follows: Section 2 reviews related studies on this topic. Section 3 presents the data and research methodology to examine the long-term relationship between land and house prices. Section 4 discusses the results of our empirical investigation. Section 5 concludes and offers the policy implications as well as identifies areas for further research.

2. The Relationship Between Land Prices and House Prices

A number of studies have examined the causes for the rapid increase in house prices. Focusing on the demand side, house prices are modeled as a function of demographic factors, income, mortgage interest rate and housing stock (Chen and Patel, 1998). For example, Cho and Ma (2006) observe that there is a long-term negative relationship between housing values and interest rates in the Korean housing market.

A few studies have also examined the issue from the supply side, focusing on the effect of land supply on construction starts and house prices. Eve (1992), examining house prices in England between 1970 and 1990, noted that up to 35-40% of house price increases in certain areas could be attributed to land supply constraints. He posits that supply of land, which is constrained by the broader planning system, affects housing production start and consequently, house prices. Hannah, Kim and Mills (1993) similarly contend that a substantial part of the rapid price escalation experienced in the Korean housing in the 1980s has resulted from an under-allocation of land for residential use. Peng and Wheaton (1994) also observe that house prices and land supply are inversely related in Hong Kong between 1965 and 1990. Instead of the common explanation that land scarcity leads to a suppressed housing production and hence, house price escalation, they suggest that escalation in house prices associated with a sudden scarcity of land is actually caused by higher investment demand (due to expected land scarcity and higher rents). In particular, the observe that land supply restrictions in Hong Kong have not lowered housing output due to the capital-land substitution in the housing production. They further argued that in a rational market, any anticipated higher future rents (arising from information on future supply constraints) are capitalized into higher current housing prices. Generating higher residual land prices, this in turn lead to capital-land substitution in housing production.

In a subsequent study also on the Hong Kong market, Tse (1998) suggests that the true effects of land supply on house prices are not so straightforward because the influence of land supply on house prices through the housing production chain is partially diminished because the new land supply may be absorbed into the developers' land bank. He also proposes that high house prices will drive up land prices because property developers employ a residual method of appraisal and bargaining in the land market. Furthermore, since the Hong Kong government adopts a revenue maximization strategy in the land sales, he posits that the supply of land should be responsive to land prices, which in turn is determined by house prices. Employing the Granger causality test, his empirical tests, however, did not reveal any causality between land supply and housing prices in Hong Kong.

The above studies have focused primarily on the relationship between land supply and house prices. Only indirect inferences are made on the actual relationship between land prices and house prices. Many authors, such as Ball (1983), Grigson (1986), Eve (1992), Somerville (1996) and Tse (1998) have highlighted that the residual valuation method, which is commonly used for estimating land bids, treats land price as residual of output (housing) prices, the construction cost and the developer's required profit margin. This means that land prices are high (low) because house prices are high (low), all else being equal. This view is consistent with the Ricardian rent theory that the price of in-elastically supplied land is derived from the demand for the product. Unlike other factors of production, namely labor and capital, land is different because its price has no effect on the final product price. The Neo-classical land rent theory, on the other hand, proposed that the rent for land is not solely determined by the demand for the product (Needham, 1981; Evans, 2004). On the contrary, the supply-based approach subscribes to the argument that an increase in land price can cause an increase in the price of a good. In this context, it can be argued that price of house is high because the price of land is high. In a study on builders' profitability, Somerville (1996), however, concludes that whilst builders can readily pass short-run variations in construction costs on to new home buyers, they cannot do the same for land costs. Consequently, builder behavior would be expected to be much more sensitive to land costs because it directly affects the builder's bottom-line.

Another stream of literature has examined price determinants in the housing market and urban land market either separately or simultaneously (Ozanne and Thibodeau, 1983; Manning, 1988; Potepan, 1996). In their cross-sectional regression models, land prices are included as an explanatory variable for house prices and similarly, house prices as an explanatory variable for land prices. Potepan (1996), for example, estimates the determinants of rents, housing prices and urban land prices in a simultaneous system by employing a two-stage least square model on 159 observations in 56 metropolitan statistical areas (MSA's) in the US. In the housing price equation, the coefficient estimate for land price is positive and statistically significant, which he interprets to be consistent with the notion that a higher cost for acquiring land will reduce housing supply and therefore, push up the equilibrium housing price. In the land price equation, the coefficient estimate for housing price is also positive and statistically significant. He explains that higher house prices would increase the developers' demand for land, which in turn would push up land prices. Hence, in the simultaneous equation setting, house prices and land prices appeared to have significant effect on each other. Whilst these cross-sectional regressions are useful to identify any contemporaneous relationships, they ignore the inter-temporal and dynamic nature of the relationship between land and house prices. In particular, they do not provide a clear link on the price discovery process in the urban land and housing markets.

Figure 1 presents a conceptual framework to appreciate the complex relationships in a system comprising land supply, housing stock and new supply, land prices and house prices. New sites for residential development come from two sources, namely the government and private owners. Given the price of land, the land owners decide on the quantity of land to sell to the developers. Part of the new supply will be injected into the housing production process immediately, whilst the remaining portion will be held by the developers as stocks in their land bank. Upon completion, the newly constructed units expand the existing housing stock. This may have spill-over effects on the rental and capital values of the new and old housing, which in turn influence the movement of land prices.[2] Grigson (1986), nevertheless, argues that new-build supply is only a tiny part of the total supply and cannot adapt quickly to the major demand fluctuations induced by financial and other factors. Zhou (1997), examining the relationship between sales and price of existing single-family homes, finds that there exists a bidirectional causality relationship between the two variables. In particular, price affects sales significantly, whilst sales affects price weakly.

[Figure 1]

In this system, house prices have a direct influence on land prices, whilst the influence of land prices on housing prices is more indirect. As noted by Evans (2004), any increase in the supply of land for housing may take years to affect prices since planning permission has to be obtained first. Then the houses have to be built and only when they are being sold will prices be affected. In addition, a portion of the new land supply may be taken out of the system temporarily through the developers' land banking initiatives. Hence, we would expect the price effect to be weaker from land to housing markets as compared to price movements flowing from the housing market to the land market.

3. Data & Research Methodology

This paper focuses on the price discovery between residential land and housing markets. The literature on price discovery in real estate markets has focused primarily on the relationship between securitized and direct real estate prices. The general theme of such studies is to detect in which market the price formation occurs first; in other words, which is the leading market. Typically, the cointegration test is employed to detect if a long-run relation exists between the two markets. One weakness of such studies, however, is that the short-term relation between the two markets is usually ignored. In our paper, we employ the Granger causality test in an error-correction framework to detect the price discovery process by simultaneously capturing long-term and short-term relations.

3.1 House Price Movements in Singapore

The Residential Property Price Index is the most widely used index to track house price movements of private residential houses in Singapore. Published quarterly by the Urban Redevelopment Authority (URA), the price index is computed from information obtained in caveats lodged with the Singapore Land Registry.[3] Figure 2 shows that private house prices in Singapore have increased by more than 664% between 1975 and 2005. After adjusting for inflation, this represents an annual growth rate of 8.1%. It is noticeable that the house price index, led by economic expansion and government policies that made it easier to purchase private housing,[4] started to rise dramatically from the late 1980s to reach a peak of 1112.5 in 1996:2.

The market dropped significantly between late 1996 and end 1998 following the introduction of anti-speculation measures on 15 May 1996 and the financial crisis which hit Asia from 1997:4.[5] The housing market started to pick up in 1999-2000 but its recovery was abated by several external factors: the terrorist attack (September 2001), the bombing in Bali (2002:2) and the Severe Acute Respiratory Syndrome (SARS) epidemic that hit the region in first half of 2003.

[Figure 2]

3.2 Land Price Index Construction

Before the relationship between land prices and house prices can be examined, we first construct a constant quality price index for residential land in Singapore. As data on land sales prior to 1990 was not readily available, the constructed land price index covers a 16-year period from 1990:1 to 2005:4. It spans over two up- and down-cycles of the real estate market. Our data set comprises 492 residential sites transacted in Singapore. It covers both private and public supply of development sites. Compiled from published information maintained by the relevant government agencies as well as market reports by property consultants and local press reports, the information includes the transaction price as well as the size, plot ratio and tenure of the individual plots sold. We supplement the data with the distance of the individual plots to the central business district (CBD) and to the nearest metro station (metro).

The most active period of the land sales was between 1993 and 1997 with 254 sites sold during the five-year period. This period coincided with the rapid growth in the housing market. Besides the government land sales program, the supply pipeline was also boosted by private owners who

came together to sell their houses collectively for redevelopment into higher density residential projects. Corresponding to the slump in the Singapore property market after the Asian financial crisis, the number of residential sites sold also dropped dramatically to 5 in 1998:1-1999:2. Since 2000, sale activities in the urban land market have started to pick up again. Responding to criticisms that its land sales policies accentuated the boom and bust cycles of the real estate market, the Singapore government started selling land under the Reserve List system in June 2001. By allowing land supply to be triggered by demand from the developers, the system is supposed to be more responsive to changing market conditions.[6]

Following Yu, Khor and Lim (2000) who developed a land price index in Singapore covering the period 1990 to 1997, we adopted the hedonic-based methodology to track price movements in the residential land market over the study period. A number of authors have also adopted the same approach to construct land price indexes in the US. Milgram (1969) proposes the usage of the multiple regression analysis to construct a land price index. Greenlees (1980) employed hedonic regressions to construct a land price index for the San Francisco-Oakland area. The hedonic technique, which controls for the quality of sites and yields a more stable index series than simple averaging of land values, involves regressing sales prices of development sites on a set of variables representing site attributes and locational characteristics, and a time trend. The land price index is derived by taking the anti-log of the time binary variables. An implication of choosing the hedonic formulation is that the estimated index is conditional on the functional form of the hedonic equation and the regressors available to control for quality differences in the housing units. Schwann (1998), nevertheless, observes that price index constructed using the standard hedonic regression is quite robust to small samples. In our study, we regressed the natural logarithm of land prices against plot size, plot ratio, site tenure, distance to CBD, distance to the nearest metro and a set of binary variables to represent the time series. The goodness of fit for our hedonic model is 70.9%, which is comparable to that achieved by Bible and Hsieh (1999).

Figure 3 charts the housing price index (*HPI*) and the land price index (*LPI*) over the study period. The potential built-up areas (in square meters) are also tabulated to show the supply of development sites in each quarter. Between 1990 and 2005, house prices have more than doubled, whilst land prices have tripled over the same period. Although both indexes appeared to move in tandem with each other, the land price index exhibited more volatility than the house price index. This result is similar to Eve's evidence in the UK market. It is consistent with the notion that house prices are sticky, of which several theories have been expounded in the mainstream economics literature (see Blinder, 1991). Rather than cut (increase) prices when demand is low (high), developers may elect to provide more (less) auxiliary incentives. Even if the firms like to raise or lower prices, they might hesitate to do so unless and until other sellers move

first. Also, the sellers are prepared to hold on to their units (if they can afford to) rather than sell them at a lower price in the event of a negative shock introduced in the housing market.

[Figure 3]

3.3 Cointegration & Granger Causality Tests

Focusing on the price discovery between residential land and housing markets, we employ Granger causality tests to examine whether house prices (*HPI*) lead land prices (*LPI*). Before proceeding with the causality tests, it is important to examine if the house price index and land price index are stationary and cointegrated. Hence, the first stage of our empirical exercise involves testing that each of the two time series demonstrate the same order on stationarity. A standard unit root test is applied to both time series as follows:

$$\Delta HPI_t = \alpha + \delta HPI_{t\text{-}1} + \beta_i \sum_{i=1}^{m} \Delta HPI_{t-i} + \varepsilon_t \qquad (1)$$

$$\Delta LPI_t = \alpha + \delta LPI_{t\text{-}1} + \beta_i \sum_{i=1}^{m} \Delta LPI_{t\text{-}i} + \varepsilon_t \qquad (2)$$

where $\Delta HPI_t = (HPI_t - HPI_{t-1})$, $\Delta LPI_t = (LPI_t - LPI_{t-1})$ and ε_t is a pure white noise error term. The Augmented Dickey-Fuller (ADF) is employed to verify the null hypothesis $H_0 : \delta = 0$ (against the alternative hypothesis $H_1 : \delta \neq 0$). Once the unit roots of the two series are determined, the second stage of our empirical investigation involves evaluating whether there is a long run relationship between them using the Johansen (1998) cointegration test. Engle and Granger (1987) pointed out that a linear combination of two non-stationary series may be stationary and if such a stationary linear combination exists, the two non-stationary series are said to be cointegrated. The stationary linear combination, which is called the cointegrating equation, may be interpreted as a long-run equilibrium relationship between the two series.

If the two series are cointegrated, the Granger causality test needs to be specified in an error correction framework to prevent model misspecification and loss of information about the long term contemporaneous relationship between the two variables (Fung and Isberg, 1992; Ong, 1994). The error correction models with *HPI* and *LPI* as the dependent variable are as follows:

$$\Delta HPI_t = \sum_{i=1}^{n} \varphi_i \Delta HPI_{t\text{-}i} + \sum_{j=1}^{m} \lambda_j \Delta LPI_{t\text{-}j} + \gamma \hat{e}_{t\text{-}1} + u_t \qquad (3)$$

$$\Delta LPI_i = \sum_{i=1}^{n} \varphi_i \Delta LPI_{t-i} + \sum_{j=1}^{m} \lambda_j \Delta HPI_{t-j} + \gamma \hat{e}_{t-1} + \nu_t \quad (4)$$

where the Δ prefix denotes the price indexes' first difference (or returns). $\hat{e}_{t-1}$ is the lagged error correction term, which allows for adjustment back to the long-term equilibrium relationship given a deviation in the past period. The optimal number of lags to be used in the models is decided based on the Akaike information criteria (AIC), which minimizes the values of

$$\boldsymbol{AIC = [\,(T + g + 1) \,/\, T - g - 1)\,]\,(SSE \,/\, T)} \quad (5)$$

where *T* is the number of observations, and *g* is the number of lags in the autoregression. To apply the test, the optimal order of φ_i s is first determined by constraining all λ_j s to zero. Autoregressions containing from one to eight lags (two years) are estimated and the AICc compared. Second, using the optimal order of φ_i determined in the first step, regressions are estimated and AICs calculated for m = 1 up to m = 8.

The null hypothesis for Equation (3) and Equation (4) is $\lambda_1 = \lambda_2 = ...\lambda_j = 0$, which would indicate no causality relationship between the two markets. If the null hypothesis is rejected for Equation (3) and accepted in the second equation, we can conclude that *LPI* Granger-cause *HPI*, meaning that price formation occurs in the land market first and that it leads the housing market. This would be consistent with the consistent with the neo-classical argument that land costs are factored in house prices. Conversely, if the null hypothesis is accepted in Equation (3) and rejected in Equation (4), we can conclude that *HPI* Granger-cause *LPI*, which is consistent with the Ricardian rent theory. In other words, price formation occurs in the housing market first, which is then filtered down to the land market. However, if the null hypothesis is rejected in both equations, we can conclude that feedback exists between the two markets. This means that the interaction between house prices and land prices are bi-directional. To test for causality across the two markets, each error correction model (Equation 3 and Equation 4) is first estimated in its restricted form, that is $\lambda_1 = \lambda_2 = ...\lambda_j = 0$. The model is then estimated in its unrestricted form by removing the constraints. The Wald test statistic, which is applied to test the significance of the unconstrained cross-market terms, is computed as:

$$\boldsymbol{Wald\ test\ statistic = [\,(SSE_R - SSE_U) / SSE_R\,]\,[\,d_U / (d_R - d_U)]} \quad (6)$$

where *SSE* is the sum of squared errors, d_i are the degrees of freedom and the subscript $_R$ and $_U$ representing the restricted (*R*) and unrestricted model (*U*) (see Fung and Isberg, 1992).

4.0 Empirical Results

Our time series data on land prices and house prices consists of quarterly observations from 1990:1 to 2005:4. All the data are transformed to natural logarithms. The empirical tests are carried out in three stages: (1) The Augmented Dickey-Fuller (ADF) test to examine stationarity of the two time series. (2) Johansen cointegration test to determine if there is a long run relationship between the two series. (3) An error correction model to study the Granger causality effects and price adjustments between the two markets.

4.1 Unit Root Test

Results of the ADF test on the unit root for the level and the first difference of our time series data are reported in Table 1. Compared with the critical value for the ADF statistic of -2.61 at the 1% level, the reported statistics in the first column indicate that the null hypothesis (i.e. there is a unit root for the particular time series) cannot be rejected for both series. We can therefore conclude that the housing price and land price indices are not stationary in level terms. However, when the ADF test is run on first differences of the two variables, the null hypothesis is, rejected Since the computed absolute ADF test-statistics (-4.07 and -2.74) are greater than the absolute critical value (-2.61), we can conclude that both series are I(1) stationary. This means that stationarity can be induced by first differencing the time series.

[Table 1]

4.2 Johansen Cointegration Test

The Johansen cointegration test results together with two associated test statistics, namely the trace and maximum eigenvalue statistics, are presented in Table 2. Both the trace and maximum-eigenvalue tests reject the null hypothesis of no cointegrating relationship between the two variables at the 1% level. The results indicate one cointegrating equation between the two markets, which suggests the existence of a stable long-run relationship between house prices and land prices. The reported results, which are based on the assumption of no deterministic trend in the cointegrating equations, are robust to alternative trend assumptions.

[Table 2]

4.3 Granger Causality Test

Since the two price indexes are cointegrated, it is essential to include the error correction term in the Granger causality model. Based on the Akaike information criterion (AIC), the optimal lag structure for the house price model (Equation 3) contains five lagged *HPI* and one lagged *LPI*. Likewise, the optimal structure for the land price model (Equation 4) is seven lagged for *LPI* and one lagged *HPI*. The estimated results of the optimal error correction model over the entire sample period are presented in Table 3. The adjusted R^2 is 0.641 for Equation 3 and 0.353 for Equation 4. The goodness of fit for both models can also be seen in Figure 4, which plots the actual, fitted and residual values of *HPI* and *LPI*, respectively. The Durbin-Watson statistics indicate that the residuals are well behaved.

[Table 3]

γ, the coefficients for the error correction term, is statistically significant at the 5% level in both equations. This indicates that the error-correcting adjustments account for a significant proportion of price variations in the housing and land markets. The results, which also confirm our earlier observation that the two time series are cointegrated in the long run, is consistent with the Granger's Representation Theorem that whenever cointegration exists between two non-stationary series, there must be an error correction mechanism maintaining it (Engle and Granger, 1987). The results also indicate that the error correction model provides a superior method of measuring the relationship between land prices and house prices as compared to the vector autoregressive (VAR) model. Comparing the magnitude of their coefficients on the error terms, it is noted that, once there is a shock in the market, the rate of convergence to long-run equilibrium relation is much quicker in the land market: A deviation from the equilibrium level of land price during the current period will be corrected by 65.3% in the next period. In comparison, a deviation from the equilibrium house price during the current period will be corrected to a smaller degree (9.0%) in the next period.

[Figure 4]

The last row in Table 3 shows that the house price model (Equation 3) yields a Wald test statistic of 1.81, which is not statistically significant even at the 10% level. This shows that the addition of the lagged land market (*LPI*) does not make significant contribution to the model. This finding is further supported by the observation that none of the lagged LPI coefficients are significant at the 10% level in the HPI model. Overall, the results imply that causality leading from the land market to the housing market is extremely weak, if present at all, which is inconsistent with the

common belief that high housing costs are caused by high land costs. In the case of the land price model (Equation 4), the Wald test statistic of 3.75 is weakly significant at the 10% level. This is consistent with the Ricardian rent theory that high house prices lead high land prices. Given that Granger causality is moving from the housing market to the land market, we can conclude that price formation in the housing market lead the land market. The data shows that lead-lag relationship is one quarter. In addition, the housing market is less insulated from cross-market changes as compared to the land market.

4.4 Robustness Tests

Several tests are carried out to check the robustness of our results. Firstly, we achieve the same conclusions as reported previously when the error-correction model is augmented with three exogenous variables, namely interest rate, unemployment rate and gross domestic product. Secondly, we tried out alternative specifications for the hedonic model used in our construction of the land price index. The results of the reported cointegration and Granger causality tests are not sensitive to the way the land price index is constructed.

Thirdly, we also checked the stability of the estimated parameter in the error correction models over time by splitting the sample into two different sub-periods (1990:1-2001:2) and (2001:3-2005:4). The Chow test is then conducted to determine whether or not any structural changes have occurred over the test period (see Fung and Isberg, 1992). The derived Chow test statistics of 0.522 (*HPI* model) and 0.716 (*LPI* model) are not statistically significant, indicating that there is no structural change over the two sub-periods. Hence, we can conclude that the introduction of land sales through the Reserve List scheme in June 2001 has not affected the long-run and short-run relationships between the land market and housing market.

Fourthly, we supplement the dynamic relationship between land prices and house prices with information on the amount of land supplied in each quarter over the study period. This would facilitate the dynamic process regarding the relation between land supply and land prices as well as the relation between supply of land and housing prices. However, like Tse (1998), our exploratory investigation reveals that land supply does not Granger-cause house prices.

5. Conclusions

This paper has employed an error correction model to examine the price discovery process between the land and housing markets. Based on the quarterly price indexes of private housing and residential land in Singapore between 1990:1 and 2005:4, the empirical results suggest that: (1) House and land prices are cointegrated, meaning that are related to each other in the long-term. (2) The rate of convergence to long-run equilibrium relation is more rapid in the land market than in the housing market. (3) There is a Granger causality effect moving from the housing market to the land market, which is consistent with the Ricardian rent theory. (4) There is no reverse causality, i.e. land prices do not Granger cause house prices. In summary, whilst it is not wrong to say that high property prices cause residential land prices to rise, it is incorrect to attribute rising house prices to high land prices. As noted by Evans (2004; 11), restrictive planning systems can lead to situations where the Ricardian theory becomes more relevant.

The general implication of the current research is that price movements in the land market are not independent of what happened in the private housing market. Although land prices do not granger cause house prices, this does not mean that land policies are irrelevant. For example, if the government deliberately releases a lot of development sites for residential projects, the market will be flooded with new supply; thus leading to cheaper housing. However, the wealth effects will not be positive if majority of the house occupiers are home-owners, which is the case in Singapore. In such a scenario, a house represents an accumulation wealth of a household that rises (fall) with the appreciation (depreciation) of the house prices (Chen and Patel, 1998). Furthermore, not all the new land supply will be translated into building stocks because developers may decide to land bank part of the new supply and as a result, the spillover effect on the housing market will be insignificant. Hence, any government policies designed to tackle price volatility in the housing market will be incomplete if the supply and pricing of development sites are ignored. Because of the cross-market interactions, an integrated approach to understanding the systems of land and house markets (as presented in Figure 1) should be adopted. Having a good knowledge of cross-market causality will also help prospective investors to take advantage of future price movements in the land market by looking at how prices are behaving now in the housing market.

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Figure 1: Direct & indirect relationship between house and land prices

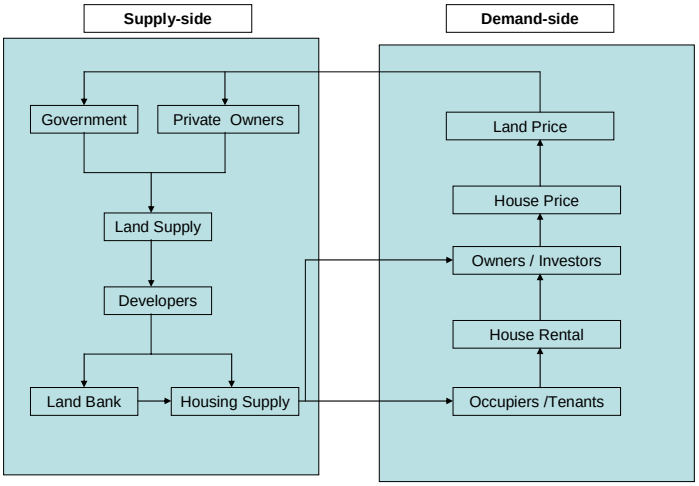
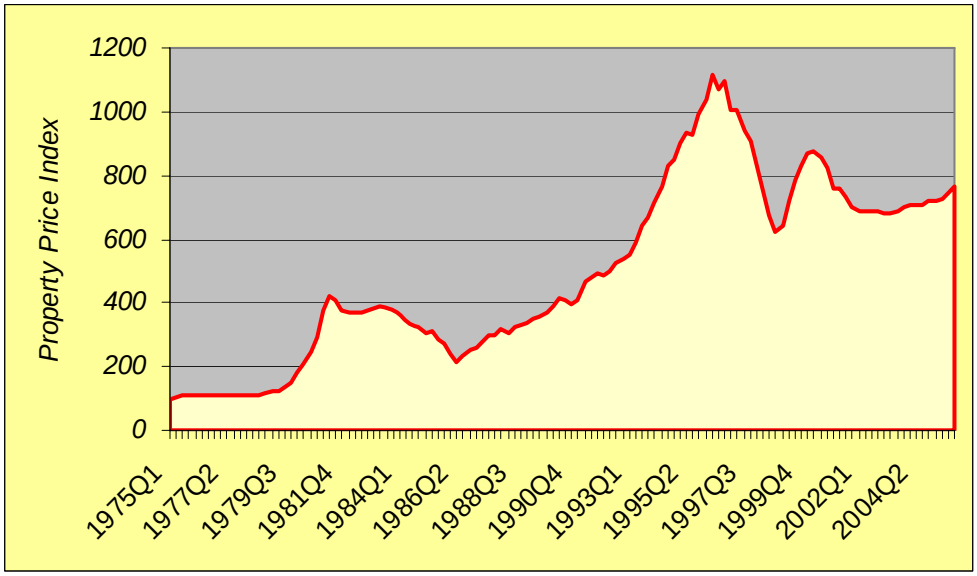
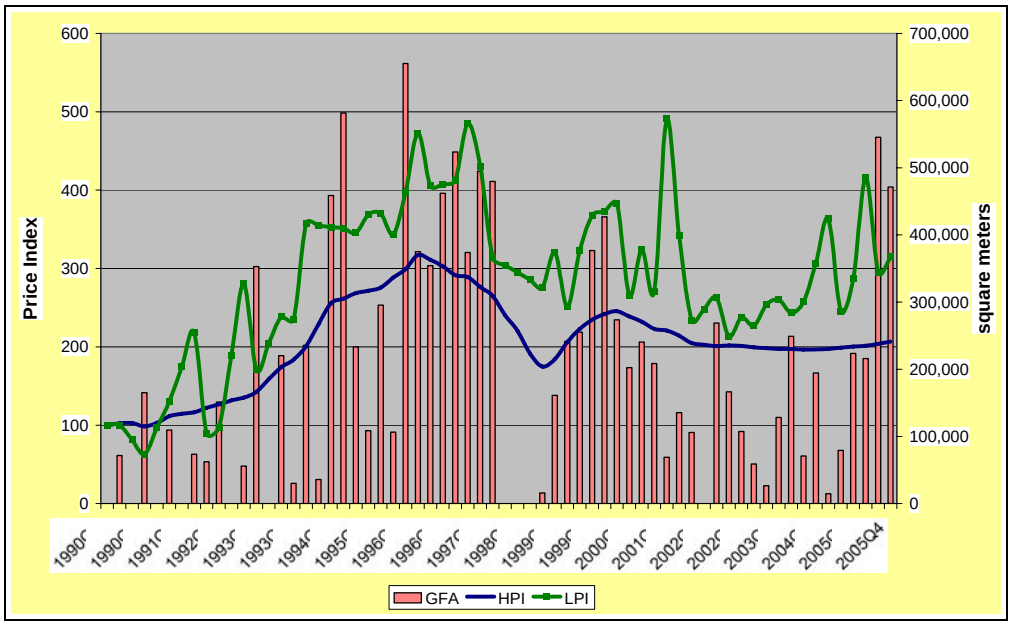


Figure 2: Housing price movements (1975-2005)



Data Source: URA

Figure 3: Land and housing price movements (1990-2005)



Source: URA & authors' compilation

Table 1: Augmented Dickey-Fuller unit root (ADF) tests

Time Series	On the Level	First Differenced
LPI	1.19	-4.07***
HPI	0.41	-2.74***

Note: *** denotes significant at the 1% level with a critical value of -2.61.

Table 2: Johansen cointegration test

Hypothesized no. of CE (s)	Eigenvalue	Trace statistic	Probability	Max-Eigen statistic	Probability
None	0.2550	24.396***	0.0127	17.369***	0.0291
At most 1	0.1123	7.0274	0.1250	7.0274	0.1250

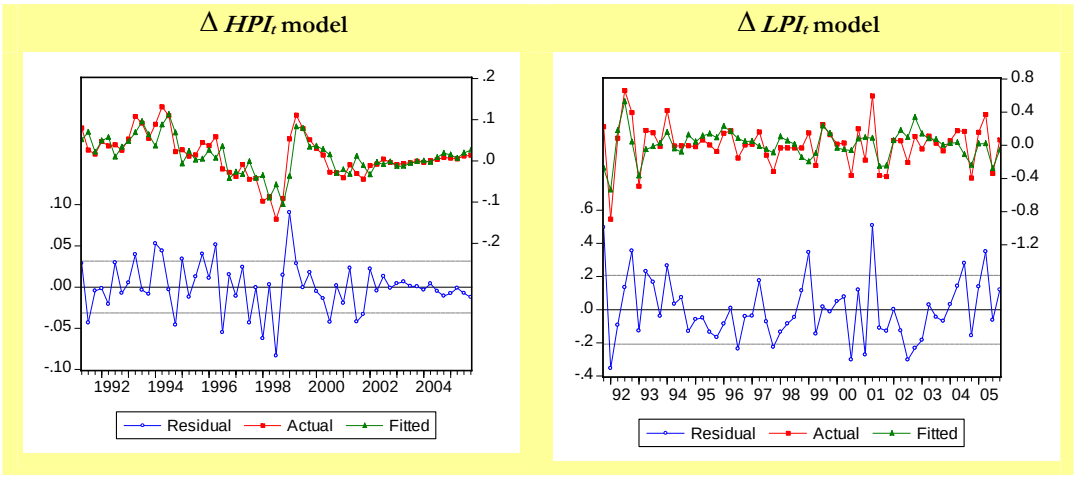
CE refers to cointegrating equation. *** denotes rejection of the hypothesis at the 1% level. The reported probability denotes MacKinnon-Haug-Michelis (1999) p-values.

Table 3: Estimation results of error correction models (1990-2005)

Dependent Variable	Δ *HPI*$_t$ *(Equation 3)*		Δ *LPI*$_t$ *(Equation 4)*	
	Without Δ *LPI*$_{t-j}$	With Δ *LPI*$_{t-j}$	Without Δ *HPI*$_{t-i}$	With Δ *HPI*$_{t-i}$
γ coefficients	-0.06	-0.090	-0.88	-0.653
T-statistic of γ	-2.17**	-2.563**	-3.28***	-2.262**
Adjusted R^2	0.64	0.641	0.32	0.353
Durbin-Watson statistic	2.14	2.121	1.93	2.066
Sum squared residual	0.053	0.052	2.224	2.063
Number of observations	59	59	57	57
F-statistic	21.21	18.24	4.70	4.81
Wald Test	-	1.81	-	3.75*

** and * denote statistically significant at 5% and 10% levels, respectively.

Figure 4: Comparison of the actual with the fitted values



Footnotes

[1] The state, like any private land owners would, seeks to maximize revenue from its land sales program. During the Singapore parliament debate on May 18, 2002, the Minister for National Development underlined the motivation for land sales and why a reserve price is set, *"It again goes back to the fundamental principle that State land is an asset that belongs to the people. As a custodian of the people's assets, the Government has the responsibility to ensure that land is disposed of at its true market value and this means setting a reserve price to ensure that our land is not sold off for a song".*

[2] The causal relationships between residential property prices and rentals have been examined by Cheung, Tsang and Mak (1995). Based on Hong Kong data from 1982 to 1991, they only found causal relationships in 11 cases (out of 40) and in these cases, price changes lead rental changes by one quarter.

[3] The transaction-based price index, which is computed based on the Moving Average method with the weights computed based on the moving average of transactions over the last 12 quarters, do not suffer from the smoothing biases associated with appraisal price series.

[4] Since 1993, Singapore residents are allowed to use their savings in the centrally-administered pension fund to meet mortgage payments for private property purchases.

[5] The anti-speculation measures announced on May 15, 1996 included imposing tax of 100%, 66% and 33% of the gains from disposal if the property is sold within the first, second and third year of purchase, respectively. In addition, buyers of residential properties are required to pay 20% of the purchase price in cash. They are also not allowed to use savings in their central provident fund to cover stamp duties related to property transactions.

[6] The government list a number of development sites that are available for sale under the Reserve List. If a developer is interested to purchase any sites placed on the reserve list, he can make a formal application. The applicant has to indicate the minimum price he is willing to pay for that site and if this is figure is accepted by the authority, a public auction will be conducted for the site with disclosure of the reserve price being equivalent to the minimum sum committed by the applicant.