

MODELLING THE COMMERCIAL PROPERTY MARKET: AN EMPIRICAL STUDY OF THE SINGAPORE OFFICE MARKET

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ABSTRACT

This paper disentangles the complexities of the commercial real estate market and provides a clear structure to understand the key determinants driving property market performance. There is a preference for using GDP, unemployment rate, and office (FIRE) employment as the main determinants of the space market (demand side); office floor stock, construction orders and vacancy rate (especially in the United States) as the property market (supply side) determinants in the office market. A regression model for Singapore's office property market for the period from June 1992 to December 2005 was constructed. The office rent equation was able to account for 72 per cent of variation in gross rent for the period June 1992 to December 2005. Changes in previous year vacancy rates, contemporaneous construction costs, prime lending rate (lagged 6 months) and contemporaneous office sector employment were identified as the key determinants in explaining the variation in office rents in the Central Region of Singapore.

INTRODUCTION

The opening up of world economies and the deregulation of financial markets have acted as the catalyst for the rapid growth of global capital flows. The free flow of trade coupled with the Singapore's government pro-active approach in attracting foreign investments have significantly contributed to the development of Singapore as a key financial hub for the Asia Pacific region. Singapore's political stability, skilled work force and efficient infrastructure provided an attractive proposition for multinational companies seeking to expand their operations in the Asia Pacific region.

As an international financial centre, commercial office properties are a prominent part of Singapore's landscape, serving the business and financial services sector. In addition, it is also an asset which is commonly found in the investment portfolios of global investors and the balance sheets of large corporations. The recovery from the 1997-1999 Asian Financial Crisis saw increased international capital flows into the South East Asia region. Thus, real estate professionals require a better understanding of the key determinants that influence Singapore's office market. Rental values are a key property benchmark, a major cost for tenants and a source of income for the landlord and it is often used as an indicator by other market participants such as developers to assess the feasibility of their projects.

For that reason, understanding the characteristics of rental fluctuations provides important insights to the behaviour of the office property market.

Many quantitative techniques have developed over time to model and forecast the long term pattern of rental variations. The use of econometric modelling procedures is quite common in Europe and the United States. However, the use of such procedures has received nominal attention in the South East Asia region. In part, limited research can relate to real estate information inefficiency due to its heterogeneity, diversity and a rapidly evolving property market place.

The purpose of this paper is to theoretically and empirically examine the rental determinants of Singapore's commercial property sector with the objective of disentangling the complexities of the dynamic interaction of such parameters on income performance. As suggested by Born and Phyr (1994), measuring rental patterns is of particular importance as it provides information to make a decision about investing and developing and can be used to predict the cyclical behaviour of commercial property development and explain its severity. In addition, rental growth forecast parameters are often incorporated into cash flow models for property appraisals.

Following this introduction, the next section reviews literature on the conceptual framework relating to the commercial property market. This will assist in identifying and distinguishing property market structures and the associated conceptual models. The third section details the data and selected model and empirical findings. The last section provides concluding comments.

LITERATURE REVIEW

The volatility in commercial property market performance can be shown by the market's internal and external forces within which property decisions are made. Decisions relating to locating or investing in commercial properties often involves large amount of funds, therefore it is essential to comprehend the fundamental concept and framework that defines the commercial real estate market. Archer and Ling (1997) suggested a three market conceptual framework illustrating the relationships between the space, capital and property markets. This is shown in Figure 1.

A feature of the Archer and Ling (1997) three market model is the distinction of the property, space and capital elements. This can be separated into individual characteristics:

Space market

The demand for space is generally dependent on rent and other exogenous economic factors. In addition, it could also be influenced by the location and accessibility to a defined site for a particular economic activity. The dynamic characteristics of demand of

space can be extremely complicated to grasp as it can possibly relate to a particular economic activity, locality and timeframe (Archer and Ling 1997).

Capital market

Over the past decades, real estate has become an increasingly attractive asset class. Potential benefits of property includes its reported inflation hedging properties, taxation benefits (depreciation benefits, tax allowances etc.) and its relative low correlation with equities in the case of direct property investment. Low correlation means greater diversification potential, which makes it an attractive asset class for investors who wish to optimise their multi-asset portfolio (Fisher *et al* 1993).

In the capital markets, real estate competes with other assets (such as bonds and shares) for a place in investor's portfolios. Functions of the capital markets include:

- Assessment of risk of investments
- Determine the required returns on investments (risk premium)
- Allocating scarce capital amongst competing uses.

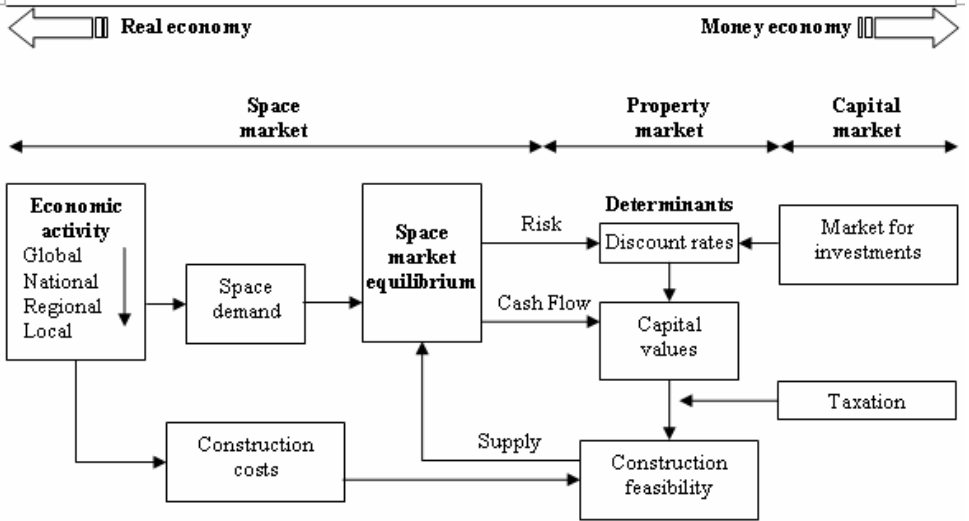
Modern portfolio theory suggests a selection of investments with minimum trade offs and deriving highest possible returns with relatively low risk. The required rate of return on a real estate investment consist of two principal components, namely the risk free rate and a risk premium that reflects the risk profile of the property's cash flow (Archer and Ling 1997). Required risk premium for investments relative to their risk is determined simultaneously in the property (specific systematic risk) and capital markets (risk free rate). Hendershott *et al* (1998) suggests that the capital market (risk free interest rate and the real estate risk premium) affects the space market by altering equilibrium rents.

Property market

According to Archer and Ling (1997), the determination of property specific discount rates, property values, capitalisation rates and construction feasibility occurs in the property market. In the initial stages, the property specific discount rate is determined through the interaction of the risk free rate, market risk premium and the risk profile of the specific property. After which, the market value and capitalisation rate of the property can be assessed through discounting the expected cash flow of the specific property, taking into consideration any government income tax effects.

On this knowledge, developers can assess the current property market condition using the information on property values and construction costs to determine the construction feasibility of a specific development. If property value exceeds construction costs, developers/investors would have more incentive to commence new construction to capture any potential profits (DiPasquale and Wheaton 1992).

Figure 1: The relationship of space, capital and commercial property markets



Source : Archer and Ling (1997)

OFFICE RENTAL AND INCOME MODELS – SPACE, PROPERTY AND CAPITAL MARKET DETERMINANTS

Global office markets have received a considerable amount of attention by academics and practitioners as compared to the rest of the commercial sectors. This is because, compared with alternative property sectors, the office market is considered to be well established with relatively more frequent transactions over the long term (other than residential) and have well defined geographical locations (Higgins 2000).

Literature reviewed in this section is categorised into three geographical regions: European, United States and the Pacific Rim. In addition, the literature will be arranged chronologically in descending time order. The aim of categorising is to identify the key rental determinants utilised in each region and time frame. This would assist in the justification for the inclusion of demand and supply side proxies in the property market model.

Table 1 presents a summary of the determinants utilised by studies conducted in Europe, United States and the Pacific Rim.

Table 1: Office rental income model

Author(s) (Year)	Equation (Period)	Geographical Coverage	Determinants		
			Space	Property	Capital
EUROPE					
Gardiner and Henneberry (1988)	Single Equation Regression Model (1977-1984)	8 regions across United Kingdom	Regional GDP Unemployment Rate Service Sector Employment Average Regional Income	Office Floor Stock	
Giussani, Hsia and Tsolacos (1993)	Single Equation Regression Model (1983-1991) Annual	10 European cities	Real GDP Unemployment Rate Service Sector Employment Economic Uncertainty		Long Term Interest Rate
Dobson and Goddard (1992)	Single Equation Regression Model (1972-1987) Annual	United Kingdom	Office Employment	House Price Index	Interest Rates
D'Arcy, McGough and Tsolacos (1997a)	Single Equation Regression Model (1982-1994) Annual	22 European cities	GDP		Interest Rates
Hendershott, Lizieri and Matysiak (1998)	Multi Equation Regression Model (1976-1996) Annual	City of London	Office Employment	Vacancy Rate Office Floor Stock	Real Interest Rates
McGough and Tsolacos (1999)	Multi Equation Regression Model (1980-1998) Quarterly	United Kingdom	Service Sector Employment Real GDP	Past Rents New Construction	
D'Arcy, McGough and Tsolacos (1999)	Single Equation Regression Model (1970-1997) Annual	Dublin, Europe	Real GDP Service Sector Employment	Office Floor Stock New Office Completion	
Matysiak and Tsolacos (2003)	Regression Model (1987-2001) Quarterly	United Kingdom	Volume of Retail Sales Job Vacancies Consumer Confidence	New Construction Orders	Interest Rates Narrow Money Supply Broad Money Supply Share Price Index
UNITED STATES					
Hekman (1985)	Multi Equation Regression Model (1979-1983) Annual	14 cities across the United States	GNP SMSA Employment Rate Unemployment Rate	Vacancy Rates	
Shilling, Sirmans and Corgel (1987)	Multi Equation Regression Model (1960-1975) Annual	17 cities across the United States	Non Manufacturing Employment Population	Vacancy Rates Operating Expenses Office Floor Stock Property Tax	
Glascok, Jahanian and Sirmans (1990)	Single Equation Regression Model (1984-1988) Annual	6 sub market in Baton Rouge, Louisiana	Employment Growth	Vacancy Rate Level of Amenities Physical Building Attribute	
Wurtzebach, Mueller and Machi (1991)	Regression Model (1978-1990) Quarterly	United States	Inflation Expected Inflation Unexpected Inflation	Vacancy Rate	
Sivitanides (1997)	Single Equation Regression Model (1980-1988) Bi-Annual	19 major office markets across United States	Service Sector Employment	Vacancy Rates Absorption Rate Office Completion Vacancy Changes	
PACIFIC RIM					
Hendershott (1995)	Single Equation Regression Model (1970-1992) Annual	Sydney		Vacancy Rate Replacement Costs Building Depreciation Rate	
Parker, MacFarlane, Peng and Murray (2003)	Multi-Equation Regression Model (Undisclosed) Annual	Sydney	Office Employment	Available Floor Stock	
Chin (2003)	Single Equation Regression Model (1988-2001) Annual	Bangkok, Hong Kong, Lumpur, Singapore and Taipei	GDP Unemployment Rate Consumer Price Index Service Sector Output	Available Floor Stock	Interest Rates Prime Lending Rate
De Wit and Van Dijk (2003)	Single Equation Regression Model (1986-1999) Quarterly	46 location in Asia Europe and United States	GDP Unemployment Rate Level of Inflation	Stock Vacancy Rate	

Table 1 summarises the rental determinants of direct office real estate for the European, United States and Pacific Rim regions. To be consistent with the three market framework, determinants of office rents have been categorised into space, capital and property (office) markets. In addition, the table shows a range of quantitative models that have been utilised to undertake modelling and forecasting work. Examples of quantitative models include:

- **Single Equation Model** (Chin 2003, Colwell and Jackson 2004, D'Arcy *et al* 1997a, 1999, De Wit and Van Dijk 2003, Dobson and Goddard 1992, Gardiner and Henneberry 1988, Giussani *et al* 1993, Glascock *et al* 1990, Silver and Goode 1990, Sirmans and Guidry 1992) – whereby property, economic and financial variables are used to capture the interaction within the demand and supply framework (Chin 2003). The single equation model is based on the assumption that rent is to be a linear function of a series of independent variables (Stevenson and McGarth 2003). Such a model could help explain the historical variation in rental values (dependent variable) and predict rental trends in the future.
- **Multi-Equation Model** (Hendershott *et al* 1998, Hekman 1985, McGough and Tsolacos 1999, Parker *et al* 2003, Rosen 1984, Shilling *et al* 1987) - typically consist of two more equations which incorporate endogenous and exogenous variables which are used to model rental change, development markets and space demand changes (Chin 2003). According to McGough and Tsolacos (1999), using multiple equations has the ability to capture dynamics of the property market more effectively than the simpler model because it integrates the influence of the exogenous variables and allows an interaction between them and the endogenous variables within the system. However, such theoretically based models can limit the flexibility in modelling, particularly when used for forecasting purposes (Stevenson and McGarth 2003). In addition, equations within the model require careful examination to prevent spurious results.

Different quantitative models have their advantages and disadvantages in terms of their application and explanatory power. It is imperative for analysts to identify leading indicators which are representative of the economy and the property market for successful application of any of the aforementioned models.

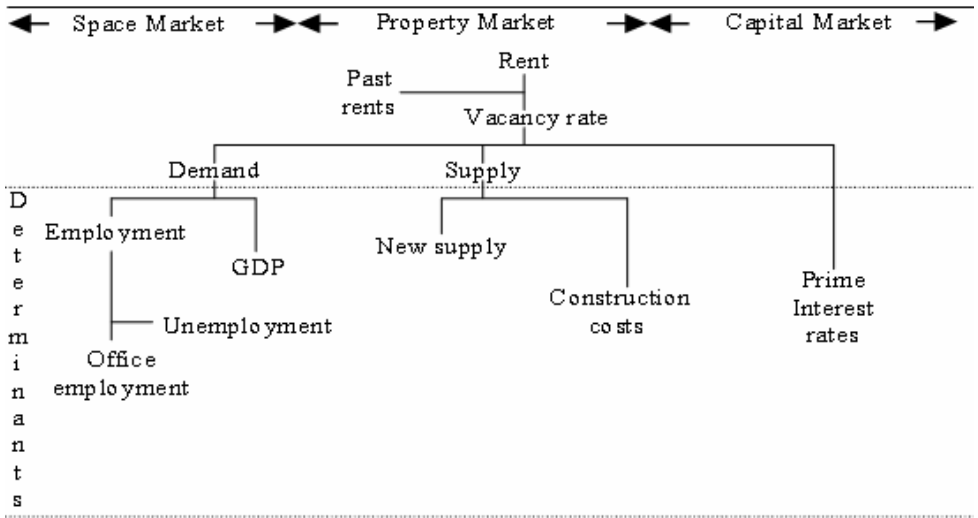
The literature review revealed that there is a strong preference by studies in the European and Pacific Rim region to utilise GDP, service sector employment and unemployment rate as the demand side proxy. Available office floorstock was identified as the key to proxy of supply side influences. This is dissimilar from studies conducted in the United States as they have a strong preference to use the vacancy variable to proxy supply side influences. In addition to the above findings, the single equation model was the most widespread modelling procedure used in existing work (see Table 1), representing about 70% of studies reviewed.

DEVELOPMENT OF THE SINGAPORE OFFICE RENT MODEL

To ensure a consistent approach is taken, the Archer and Ling (1997) conceptual framework was utilised, whereby selected rental determinants were grouped into the space, property and capital markets. These determinants were identified over the course of reviewing published literature of property professionals and academics from across the globe. It was established that different sets of rental determinants were applicable to estimate rental movements in different regions. In addition, explanatory variables of rents in national, regional and local markets also vary. Statistically significant rental determinants derived in the Pacific Rim differs from those employed in Europe and the United States.

Office rent models - have received substantially more attention by property researchers compared to the rest of the commercial sectors as data series in this area are more readily available. This is made apparent as there was more extensive published literature in comparison to the other commercial sectors. Selected property market determinants are representative of the demand (space market) and supply (property market) side influences. In addition, influences of the capital market are also considered and are presented in Figure 2.

Figure 2: Model of office rent determinants



DATA

The accuracy of the rental estimate is greatly dependent on the availability and quality of the data series employed in the analysis. Therefore, particular care was taken to examine the accuracy and adequacy of the acquired data series. The data required for this study have been obtained through manual extrapolation and electronic means from various government agencies. All quarterly and monthly data have been converted and presented on a semi-annual basis from June 1990 to December 2005. Below presents the sources from which the data series have been obtained.

Singapore Department of Statistics

- i **Gross Domestic Product (GDP)** - the inclusion of GDP as a measure of economic activity is well established in the office property market. As the economy strengthens, confidence would grow within the economy and this would stimulate the demand for goods and services.
- ii **Unemployment Rate** – the unemployment data have been compiled through the Labour Force Survey and General Household Survey, with the former conducted by Ministry of Manpower and the latter conducted by the department of statistics. The majority of the previous studies on the office sector have applied the unemployment rate as one of its explanatory variables of rent. It was found that the unemployment rate is inversely related to rents.
- iii **Employment Figures** – Finance, Insurance and Real Estate Services (FIRE) employment figures are used as a proxy for space market influences. Changes in the level of business and finance sector employment is a derived demand, reflecting the demand for the services produced by office based activities (Chin 2003). It is expected to have a positively correlation with office rents.

Urban Redevelopment Authority

- iv **Rental Index** - have been sourced through the Real Estate Information Systems (REALIS) administered by the URA. The index is for the private sector's offices in the central region consisting of 22 planning areas (covering approximately 13,050 hectares of land) as prescribed in the Development Guide Plan. Rent refers to gross rent per month inclusive of service charges (URA 2005).
- v **Supply of Space** - Several studies in the literature review excluded supply side variables due to data limitations. However, those studies that included supply side variables utilised building output (Tsolacos 1995); changes in existing floor stock (D'Arcy *et al* 1999, Gardiner and Henneberry 1988, Hendershott *et al* 1998, RICS 1994, Robertson and Jones 1999, Shilling *et al* 1997) in their analysis.
- vi **Vacancy Rate** - The use of the vacancy rate as an explanatory variable of rent is commonly found in studies conducted in the United States (see Frew and Jud 1988, Glascock *et al* 1990, Hekman 1985, Shilling *et al* 1987, Sivitanides 1997, Wurtz bach *et al* 1991). D'Arcy *et al* (1999) suggested that vacancy variables

can be considered as endogenous variables in a rent equation; that is they are simultaneously determined by other common variables (see also Wheaton and Torto 1988).

Building and Construction Authority

- vii **Building Materials Price Index** - Prices used are ex-factory prices of manufactured building materials and CIF (cost, insurance, freight) price of imported building materials. The building materials price index is used as a proxy for construction costs as a measure of space supply.

Monetary Authority of Singapore

- viii **Prime Interest Rates** - have been sourced through the MAS financial database. Commercial property investments and developments are extremely sensitive to fluctuations in interest rates as some form of financial leverage is typically used. As suggested by Dobson and Goddard (1992) and Matysiak and Tsolacos (2003), the relationship between interest rates and rent can be either positive or negative.

METHODOLOGY

A single equation model of office rent determination was utilised in this study. This method is chosen due to its versatility and has been used widely by property analysts and academia for modelling rental performances (see Table 1). Estimates from the model is dependent on the demand and supply factors operating in the market. Hence, variation in rents will reflect changes in market conditions caused by the interaction between these demand and supply variables (D'Arcy *et al* 1999). The hurdles (relating to the selection and measurement of variables to proxy demand and supply factors in the market and the availability and reliability of the data in question) as suggested by Giussani *et al* (1992) relating to the successful use of such a model were satisfied through the critical evaluation of the determinants in the literature review. The single equation model assumes that rent is to be a linear function of a series of independent variables. Such a model could help to explain the historical variation in rental values (dependent variable) and predict rental trends in the future (Stevenson and McGrath 2003).

The initial set of independent variables is selected based on existing literature. However, it has to be noted that certain determinants were excluded due to the lack of representative data or incomplete series. For the office rent determination model, three variables have been used to capture demand for office space (space market), gross domestic product (*GDP*); FIRE employment (*OEMP*) and unemployment rate (*UEMP*). Three other key variables have been used to proxy supply side influences (property market) of office rents and they are existing supply (*OSUPPLY*), vacancy rate (*VAC*) and construction costs (*COSTS*). The capital market determinant for the office market consists of the prime lending rate (*IRATE*). Therefore, the single model of rent determination can be expressed as:

$$ORENT_t = f(GDP_{t...t-4}, OEMP_{t...t-4}, UEMP_{t...t-4}, OSUPPLY_{t...t-4}, \\ VAC_{t...t-4}, COSTS_{t...t-4}, IRATE_{t...t-4})$$

The subscripts denote time and $t...t-4$ are the lags applied to the respective determinants. A maximum of four lags (2 years) were allowed for individual variables to capture the delayed response of the rental adjustment process. *ORENT* is the gross office rent of office space in the Central Region.

Statistical software has been used to conduct the multiple regression analysis. In total, 36 explanatory variables for the Singapore's office market (including lagged series) were tested. Prior to lagging the independent variables, there were 32 observations in each series, commencing from June 1990 to December 2005. All the independent variables were allowed to lag a period of up two years to capture lagged responses during the rental adjustment process. Therefore, four observations were omitted and the period of analysis will hence commence from June 1992 and conclude in December 2005.

Lagged explanatory variables are a reflection of the common assumption made in current property forecasting studies, that the changes in rent over numerous periods may be attributable to the effects of the past changes in the space (demand) and property (supply-side) variables. For the space market, these lags mainly reflect the time taken for the recognition of the direction, magnitude and persistence of changes in economic activity and translate them into expression of demand for space in the market and thus exert an influence on rents. On the supply-side, the lags show that completed buildings in one period can affect current or future rents depending on the speed at which the market absorbs new supply. The most significant lags and maximum lag length are expected to be different for each variable and will be determined by the data (D'Arcy *et al* 1999).

To construct the model, all variables were sequentially entered into the model using the stepwise regression approach. Variables were assessed based on a predefined criterion, and only variables with the highest level of significance were entered into the equation. This allows for the initial specification of an equation with the highest explanatory power.

Table 2: Expected direction of explanatory variable to dependent rents variable

	Expected Sign
Space Market	
GDP	+
OEMP	+
Property Market	
VAC	-
COSTS	+
OSUPPLY	-
Capital Market	
IRATE	+/-

Table 2 presents the expected relationship between the rental values and the explanatory variables. Additional adjustments were made, whereby contemporaneous and lagged values of the explanatory variables which did not take the correct priori sign and were not statistically significant, based on the t-statistic, were dropped from the estimates.

RESULTS

Prior to conducting the regression analysis, there are certain tests that were undertaken to assess the suitability of the data series. The Augmented Dickey-Fuller (ADF) unit root test was performed on individual series to determine the stationarity of the data series. ADF tests are carried out on the first differences of all data series for the period June 1990 to December 2005. The results are reported in Table 3.

Table 3: Tests for stationarity

	Variable	Computed ADF Statistic
Δ	COSTS	-5.25
Δ	UEMP	-3.99
Δ	GDP	-7.64
Δ	IRATE	-4.56
Δ	OEMP	-6.76
Δ	OSUPPLY	-3.42
Δ	VAC	-5.16
Δ	OFFICE RENT	-3.11

Critical values at 5%: -2.99 and at 10%: -2.64 for sample period Jun 1990 to Dec 2005 for all variables.

All differenced series appear to be stationary at the five percent level of significance.

Table 4: Single equation regression model for office rents

					Collinearity Statistics	
					Tolerance	VIF
Coefficient					t-test	Prob.
Office rents						
Δ	VAC_{t-2}	-0.11	-2.32	0.03	0.96	1.04
Δ	$COSTS_t$	1.69	2.85	0.01	0.94	1.06
Δ	$IRATE_{t-1}$	0.35	3.12	0.01	0.98	1.02
Δ	$OEMP_t$	2.49	4.24	0.00	0.95	1.06
R^2		0.72				
Observations		26				
DW statistic		1.92				

Table 4 provides the coefficient figures for the office rent model. The t-statistic test (criteria $t_{0.05, 26} = 1.706$) and the Durbin-Watson (DW) statistic exceeded the requirements with the former indicating that the variables are normally distributed and the latter revealing that residual serial correlation were insignificant in the equation. In addition, the collinearity statistics, tolerance and VIF, suggests that multi-collinearity were not observed.

An assessment of the residual correlations is depicted in Figure 3.

Figure 3: Autocorrelation function for residuals

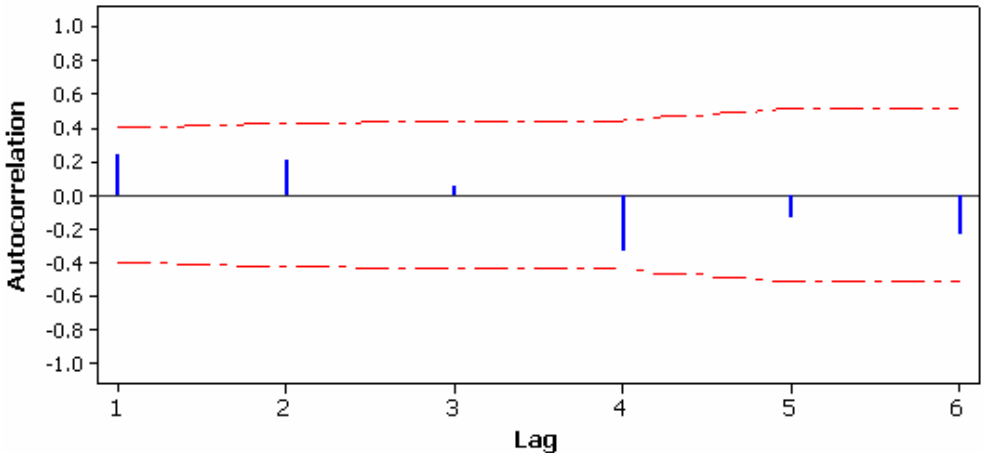


Figure 3 indicates that no patterns exist in the residuals as the correlation figures are within the two standard error limits (indicated by the dashed lines in Fig. 3). These diagnostic tests satisfy the assumptions for a single regression model.

Furthermore, a test on potential structural break within the office market was conducted using the Chow breakpoint test. To do so, it is required that significant events (event) that may contribute to a structural change be identified. The Asian crisis has been identified as the most significant event within the sample period as it significantly shocked the Asian real estate market in the years 1997 and 1998. Although dating the crisis period is extremely difficult, Bond *et al* (2004) in their study on the contagion effects of the Asian Crisis on the Asian real estate market, isolated the period from the third quarter of 1997 to early 1998 as the crisis period. As a result, this period was tested and the output from the diagnostic test did not indicate any structural breaks. The reported value of the Chow breakpoint test *F*-value probabilities (0.18 and 0.23) for the period Dec 1997 and June 1998 were not significant; thus indicating no structural change within the sample period.

The office rent equation suggests that 72 per cent of variation in current gross office rent in Singapore central region can be explained by changes in vacancy rate the previous year, changes in construction costs, changes in prime lending rate previous six months and changes in office sector employment. These results differ slightly with Chin's (2003) study for the period 1988-2001 on Singapore where the author found changes in floor space and prime lending rate as the key variables when determining office rents. However, it has to be noted that the period of analysis and sources of data differ between the two studies.

Contrary to some existing literature, GDP was not statistically significant in explaining variations in rent in the office property market, although office employment was a significant factor. Other variables that were dropped from the estimate (statistically not significant or deriving a wrong sign) include unemployment rate and office supply. The actual and predicted value of the Singapore's office market is shown in Fig. 4. Predicted values are generated by applying the estimated coefficients to the independent variables.

Figure 4: Comparison of office property rent model predicted to actual office rents

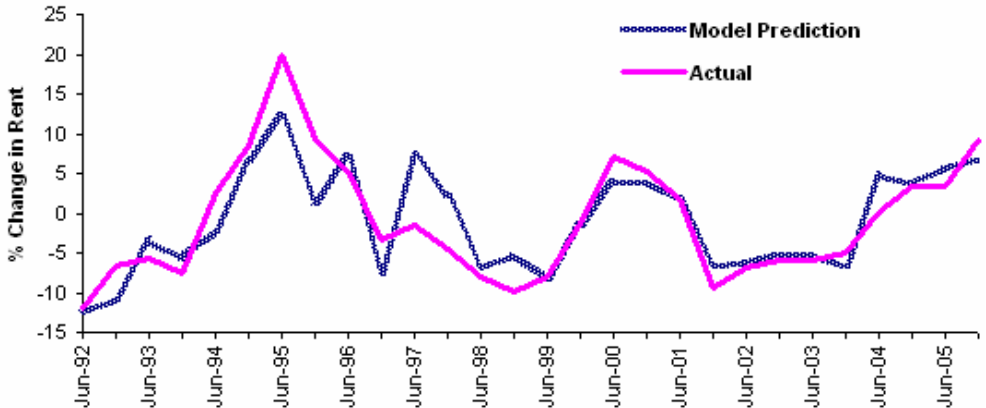


Figure 4 demonstrates that the office rent model was able to capture the long run pattern of changes in gross rents. In December 1995, there is a spike in the actual rent series and the model underestimated the rise. In the period from June 1997 to 1998, the model over predicted the rise in rent. From about June 1999 to Dec 2005, the model was able replicate the actual rent series accurately.

CONCLUSION

The aim of this paper is to construct a rent determination model for Singapore's office property market for the period from June 1992 to December 2005. Single equation regression model was utilised to explain the variations in the gross rent of the office market. Rental determinants were selected through reviewing similar previous studies around the globe. Time series data of the chosen determinants were sourced through a host of government agencies and property companies.

Diagnostic tests were conducted on the data series prior to the analysis to extract any possible bias in order to produce meaningful results. The initial specification of the office rent equation was obtained through the stepwise selection approach. Manual selection was subsequently carried out, whereby contemporaneous and lagged values of the explanatory variables which did not take the correct sign and were not statistically significant, were dropped from the estimates.

Once the final regression equation was produced, further tests were performed to ascertain the stability and robustness of the equation. No significant errors were detected. The office rent equation was able to account for 72 per cent of variation in gross rent for the period June 1992 to December 2005. Changes in previous year vacancy rates, construction

costs, the prime lending rate (lagged 6 months) and office sector employment were identified as the key determinants of variation in gross office rents in the Central Region of Singapore.

The predicted values of the regression models were compared to actual rent series through visual examination. The office rent model was able to capture the general trend of changes in gross rent with a reasonable accuracy.

Finally, the study was able to provide a good insight to the office rental adjustment process and was successful in explaining the rental fluctuations for the period from June 1992 to December 2005. The research provided the structure and process to model the performance of a property market. Future research can look at the forecast application with associated tests.

REFERENCES

Archer, W. R. & Ling, D. C. 1997, 'The Three Dimensions of Real Estate Markets: Linking Space, Capital, and Property Markets', *Journal of Real Estate Finance*, Fall, pp. 7-14.

Bond, S. A., Dungey, M. & Fry, R. 2004, '*A Web of Shocks: Crises across Asian Real Estate Markets*', Proceedings of the 2004 Hong Kong-Singapore International Real Estate Research Symposium, Hong Kong, pp. 326.

Born, W. L. & Phyr, S. A. 1994, 'Real Estate Valuation: The Effect of Market and Property Cycles', *Journal of Real Estate Research*, Vol. 9, No. 4, pp. 455-486.

Chin, H. W. 2003, '*Macro-economic Factors Affecting Office Rental Values in Southeast Asian Cities: The Case of Singapore. Hong Kong, Taipei. Kuala Lumpur and Bangkok*', Pacific Rims Real Estate Society Conference, Brisbane, Australia.

Colwell, P. F. & Jackson, C. 2004, 'Modelling rental changes across key retail investment market in Britain', *Journal of Property Investment and Finance*, Vol. 22, No. 5, pp. 354-385.

D'Arcy, E., McGough, T. & Tsolacos, S. 1997a, 'An empirical investigation of retail rents in five European cities', *Journal of Property Valuation & Investment*, Vol. 15, No. 4, pp. 308-314.

D'Arcy, E., McGough, T. & Tsolacos, S. 1997b, 'National economic trends, market size and city growth effects on European office rents', *Journal of Property Research*, Vol. 14, No. 4, pp. 297-308.

D'Arcy, E., McGough, T. & Tsolacos, S. 1999, 'An econometric analysis and forecasts of office rental cycle in the Dublin area', *Journal of Property Research*, Vol. 16, No. 4, pp. 309-321.

De Wit, I. & Van Dijk, R. 2003, 'The global determinants of direct office real estate returns', *Journal of Real Estate Finance and Economics*, Vol. 26, No. 1, pp. 27-45.

DiPasquale, D., & Wheaton W. C. 1992, 'The Markets for Real Estate Assets and Space: A Conceptual Framework', *Journal of the American Real Estate and Urban Economics Association*, Summer, No. 20, pp. 181-197.

Dobson, S. M. & Goddard, J. A. 1992, 'The Determinants of Commercial Property Prices and Rents', *Bulletin of Economic Research*, Vol. 44, No. 4, pp. 301.

Fisher, J. D., Wilson, S. H. & Wurtzebach., C. H. 1993, 'Equilibrium in Commercial Real Estate Market: Linking Space and Capital Markets', *Journal of Portfolio Management*, Summer, pp. 101-107.

Frew, J. & Jud, G. 1988, 'The vacancy rate and rent levels in the commercial office market', *Journal of Real Estate Research*, Vol. 3, No.1, pp.1-8.

Gardiner, C. & Henneberry, J. 1988, 'The development of a simple regional office rent prediction model', *Journal of Valuation*, Vol.7, No.1, pp.36-52.

Giliberto, M. 1998, 'Linking space, property and capital markets', *Property Council of Australia Investment Series*, Sydney.

Giussani, B., Hsia, M. & Tsolacos, S. 1993, 'A comparative analysis major determinants of office rental values in Europe', *Journal of Property Valuation & Investment*, Vol.11, pp.157-173.

Glascock, J., Jahanian, S. & Sirmans, C. 1990, 'An analysis of the office market rents: some empirical evidence', *AREUEA*, Vol.18, No.1, pp.105-119.

Hekman, J. 1985, 'Rental price adjustment and investment in the office market', *AREUEA*, Vol.13, No.1, pp.31-47.

Hendershott, P. 1995, 'Real effective rent determination: evidence from the Sydney office market', *Journal of Property Research*, Vol.12, pp.127-135.

Hendershott, P., Lizieri, C. & Matysiak, G. 1998, 'The working of the London office market: model estimation and simulation', *Real Estate Research Institute*, WP-63.

Higgins, D. 2000, *The Determinants of Commercial Property Market Performance*, Unpublished PHD, University of Technology, Sydney, Sydney.

Matysiak, G. & Tsolacos, S. 2003, 'Identifying short-term leading indicators for real estate rental performance', *Journal of Property Investment & Finance*, Vol. 21, No. 3, pp. 212-232.

McGough, T. & Tsolacos, S. 1999, 'Interactions within the office market cycle in Great Britain', *Journal of Real Estate Research*, Vol. 18, No. 1, pp. 219-231.

Parker, D., MacFarlane, J., Peng, V. & Murray, J. 2003, 'Forecasting Property Market Cycles: An Application of the RICS Model to the Sydney CBD Office Market', *Journal of Financial Management of Property and Construction*, Vol. 8, No. 3, pp. 179-191.

RICS 1994, *Understanding the Property Cycles*, RICS, London.

Robertson, M. & Jones, C. 1999, 'A cross-sectional model of rents in urban retail centres', *Journal of Property Research*, Vol. 16, No. 1, pp. 51-66.

Rosen, K. 1984, 'Toward a model of the office building sector', *AREUEA*, Vol.12, No.3, pp.261-269.

Shilling, J., Sirmans, C. & Corgel, J. 1987, 'Price adjustment process for rental office space', *Journal of Urban Economics*, Vol. 22, pp. 90-118.

Sirmans, C. & Guidry, K. A. 1992, 'The determinants of shopping centre rents', *Journal of Real Estate Research*, Vol. 8, No. 1, pp. 107-115.

Sivitanides, P. S. 1997, 'The rent adjustment process and the structural vacancy rate in the commercial real estate market', *Journal of Real Estate Research*, Vol. 13, No. 2, pp. 195.

Sliver, M. & Goode, M. 1990, 'Econometric forecasting model for rents in the British retail property market', *OMEGA International Journal of Management Science*, Vol. 18, No. 5, pp. 529-539.

Stevenson, S. & McGrath, O. 2003, 'A comparison of alternative rental forecasting models: empirical tests on the London office market', *Journal of Property Research*, Vol. 20, No. 3, pp. 235-260.

Urban Redevelopment Authority. 2004c, *Property Market Information: Technical Notes*, Urban Redevelopment Authority, viewed 10 May 2004, <http://www.ura.gov.sg/real_estate/technical.html>.

Urban Redevelopment Authority. 2004d, *Real Estate Information System*, URA, viewed December 2004.

Urban Redevelopment Authority. 2005a, *Development Guide Plans*, URA, viewed 5 June 2005, <http://www.ura.gov.sg/dgp_reports/lib-dgp_report.html#map>.

Wheaton, W. 1987, 'The cyclic behaviour of the national office market', *AREUEA*, Vol. 15, No. 4, pp. 281-299.

Wheaton, W. & Torto, R. 1988, 'Vacancy rates and the future of office rents', *AREUEA*, Vol.16, No.4, pp.430-436.

Wheaton, W. & Torto, R. 1995, 'Office rent indices and their behaviour over time', *Journal of Urban Economics*, Vol.8, pp. 281-299.

Wheaton, W., Torto, R. & Evans, P. 1997, 'The cyclical behaviour of the Greater London office market', *Journal of Real Estate Finance and Economics*, Vol.15, No.1, pp.77-92.

Wheaton, W. C. 1999, 'Real estate "cycles": Some fundamentals', *Real Estate Economics*, Vol. 27, No. 2, pp. 209.

Wurtzebach, C. H., Mueller, G. R. & Machi, D. 1991, 'The impact of inflation and vacancy of real estate returns', *Journal of Real Estate Research*, Vol. 6, No. 2, pp. 153-168.