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# Simulating Hong Kong's Office Leasing Market via System Dynamics Modeling

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This study introduces a combined method, on the basis of both system dynamics and econometric modeling, in forecasting the office rental values in Hong Kong. The findings suggest that the office rental values in Hong Kong appear to be more fluctuating when the price level of the office ownership market is comparatively volatile, likely due to the over-reaction of economic trends by the supply side of the property market. It is plausible to say development lags and adjustment cost, under the current land policies in Hong Kong, are the main attributes behind this phenomenon. In order to reduce the volatility on the office market, the government should relax the approval procedures concerning changing land use, and the subsequent rearrangement of premium payment. Further, the current policies on land sales need to be revised, especially concerning the application list system. Those measures could reduce the time required and the transaction cost incurred for the supply side to adjust to the ever-changing demand.

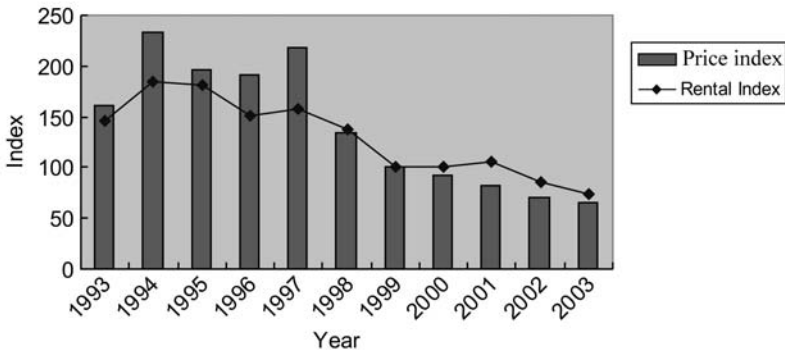
### Keywords

office rental values; system dynamics modeling; econometric modeling; Hong Kong; land policies

**Introduction**

To assess the competitiveness of a city as a business (or financial) centre, one of the major determinants is whether its rental values of office space can compete with that in other cities. Hong Kong, due to its advantageous location, has become a business centre for foreigners to have business relationships with Mainland China. Though Hong Kong is regarded as one of the major cities in Asia, currently its office rents are actually comparable to those in cities like Beijing, Shanghai, and Singapore (Jones Lang LaSalle, 2003). The narrower rental gap is partly the result of the onslaught of the severe acute respiratory syndrome (SARS) that started around March 2003. Also, Hong Kong suffered the most from the Asian Financial Crisis back in late 1997, alongside Singapore. In short, Hong Kong has encountered two waves of downward pressures in office rents, and the economy in general over the last decade. These two factors restrained the demand for office spaces, which caused the downfall in office rents. Figure 1 illustrates the price/rental movements of Class A offices over the last decade.

**Figure 1: Office price and rental indices (Source: Rating & Valuation Department)**



To see the impact that SARS brought into the office market, the rental level of office space has dropped by 15.73% from March to June 2003 and a remarkable 23.66% decline in Class A office rents in year 2003 in general (Chesterton Petty, 2004). Also, the vacancy rate remained double-digit in the same year. A report from Jones Lang LaSalle stated that the nominal rental level in Hong Kong currently is comparable to those in the early 1970s. In other words, Hong Kong has become one of the most competitive major cities in the world, in terms of total business cost per employee.

With SARS' ramifications minimized and the newly found competitiveness in office rents, in addition to the adoption of the Closer Economic

Partnership Arrangement (CEPA) between Hong Kong and Mainland China, it is expected that office demand would be recovered in the near future. Jones Lang LaSalle (2003) commented that integration with Pearl River Delta further catalyzed the development of a mature office market in Hong Kong. According to Hang Seng Property Market Trends, there would be an expected increase of 3.3% in office rent in the 1<sup>st</sup> quarter of 2004, and about 5%-10% rise in office rent in the next 12 months.

The theme of this paper is to simulate the rental movements, or dynamics, of office spaces in Hong Kong under certain scenarios regarding government's land policies. Hong Kong is selected because it has long been one of the most vibrant commercial/financial centers in Asia, probably in the world. It was especially the case with the occurrences of events in the last decade such as the handover to China, the Asian Financial Crisis, and the SARS epidemic. The association with Mainland China could bring a lot of new economic opportunities to Hong Kong, while the negative aspects that come along with the positives could induce a complicated, yet interesting, dynamic on Hong Kong office market.

Also, Hong Kong has one of the most extensive land policies in the world. Regarding land sale, Hong Kong uses an application list system which requires developers to offer a price for a piece of vacant land high enough before it could be put on sale via an auction. On the other hand, if developers decide to increase supply of properties through other forms such as redevelopment, a premium has to be paid to the government before it takes place, not to mention the various decrees regulating the density, heights, land use, etc. It has been shown in previous studies suggest that land use planning system is considered crucial in determining outcomes (Monk et al., 1996). The public agents involve themselves into, through various institutional and legal proceedings, procedures from land production to land disposal. However, the results are somehow mixed, when it comes to the effects of government planning policies on the housing market. Some other studies show that government planning on land supply had its impact on housing supply and house prices. Brueckner (1995) suggested that growth-control policy through planning tends to raise housing prices in the long run. Monk and Whitehead (1999) shared similar ideas that prices and output, along with density, were likely affected by planning. This viewpoint was further supported by Adams and Watkins' (2002) study, which concluded that planning constraints induced higher prices and densities, restrictions in quantity of homes supplied, and convergence in the design and type of new homes. Similarly, Cheshire and Sheppard's (1995) study in Darlington and Reading (United Kingdom) illustrated that the repercussions of the planning system on housing prices were significant but not enormous. White and Allmendinger (2003) added that planning restrictions tend to reduce choice

in the United Kingdom. Monk and Whitehead (1999) suggested that supply was unable to respond to price and income adjustments by altering the development density.

This paper intends to fill in the knowledge gap by simulating the future office rental trends, in response to different institutional settings regarding land supply and land use policies.

This paper is divided into four sections. Firstly, a literature review provides the work done by previous studies on forecasting the trends of commercial real estate values and returns, setting up the foundation and focus of this study. Then, the methodology and data section provides a general picture of the framework used for the study. In the third section, results from the model are presented and analyzed. The last section concludes the study.

## **Literature Review**

Forecasting future office rental trends is among the most researched topics in real estate studies. However, the methodologies involved in these researches and their respective effectiveness are generally questioned. For instance, it was argued that earlier approaches in estimating rental growth rates in discounted cash flow valuation exercises are often overly simplistic, which leads to unrealistic projections (Hendershott, 1996; Born and Pyhr, 1994). It was also found by Kummerow (1997) that Australian valuers commonly adopted a single, linear, and compounding rent growth rate in their assessments during the 1980s. A study conducted by Cowley (2003), on valuers in Brisbane, Australia, found that broad cyclical rent forecasts were used by most valuers in cash flow studies, but it appeared to lack a methodology and fortitude in recognizing the volatility of the property market, due to the conservative nature of forecasts in this city.

Regarding the factors used on previous office rental market researches, McGough and Tsolacos (1995) selected demand side factors such as GDP and employment growth, to examine commercial building activity in the UK and its procyclicality. Clayton (1996) found, in a Canadian study, that real estate returns were a function of general capital market conditions. The impact of economic fundamentals on building vacancy rates as a generator of property cycles was examined by Canter, et al. (1996). Grissom and DeLisle (1999) commented that the relationship between macroeconomic variables and the property market provide the ability to distinguish between the different stages of real cycles when looking at property returns. Another survey conducted by McDonald (2002) on office market econometric models focused on the models developed by Wheaton et al. (1997) and Hendershott

et al. (1999). The DiPasquale/Wheaton (1996) – Wheaton/Torto/Evans models incorporate the majority of the explanatory variables found to be dominant in the many models that have evolved over time.

In general, the dominant property/market determinants adopted for office rents include observed and natural vacancy rates and space supply, in addition to historical or observed rents. The prevalent economic/financial determinants adopted include economic activity, interest rates, and employment (Tonelli et al., 2004).

## **Methodology and Framework**

This paper presents a two-stage framework on the determination of the office rental movements in Hong Kong. First, a multiple regression model is depicted as the main feature of the framework in this study. Then, it will be put into a system dynamics structure in order to portray the dynamic conditions of Hong Kong's office rental market.

### *Stage 1—Static modeling*

In Stage 1, a multiple regression model will be introduced to capture the adjustments of office rent, based on historical data. Office rental movements are the results of the adjustments of the demand and supply of office space over time. Therefore, both demand side and supply side elements will be injected into the model, aiming for capturing the dynamics of the demand/supply situations of the office rental sector.

On the demand side, the change in the consumer price index (CPI) is selected for the study, which is considered the representation of the general price movements in Hong Kong. This is primarily the indicator of the price movements of consumer goods in general. The best lending rate (or the interest rate) is essentially the cost of capital for businesses, which can be utilized as a measuring stick to compare with the expected return of starting a business, thus shaping the demand for office spaces (see D'Arcy et al., 1997). GDP growth rate reflects the general economic performance at a particular period of time, compared to that of a preceding period. A positive rate indicates that the economy is performing well, which is a catalyst for further production of goods and services due to the sustainable demand (see Giussani et al., 1993; Tsolacos et al., 1998; D'Arcy et al., 1999).

It is worth noting that the Finance, Insurance and Real Estate (FIRE) sector unemployment rate, instead of the general unemployment rate, is selected for this study. Many studies (Armstrong, 1979; Wheaton, 1987; Pollakowski et

al., 1992; Clapp, 1993; Howland and Wessel, 1994; DiPasquale and Wheaton, 1995; Liow, 2000; Jayantha and Ganesan, 2002) have suggested that the services sector, especially the FIRE sector, has been the major source of demand for office space in the economy. For years, the FIRE sector has accounted for around 20%-27% of Hong Kong's GDP (C&SD, 2005). Due to the increasing importance of the FIRE sector to Hong Kong's economy, the real wage index of the FIRE sector, not the general wage index, has been included in the model as well. Since the development of the FIRE sector has been crucial to the office space demand and its rental movement, the real wage index of the FIRE sector provides a good reflection of the productivity of labour over the years. Further, since Hong Kong has gradually become a service-oriented economy, another indicator, called the export of service (EOS) index, is selected for the model, as this figure describes the income generated from the provision of service to foreign countries. It is assumed that a higher EOS index suggests a higher level of demand for Hong Kong's service, thus to a certain extent expanding the demand for office space from companies which offer such service.

On the supply side, four variables are used in the study. Office stock illustrates the general supply situations of office space in an area (see Gardiner and Hennebery, 1988 and D'Arcy et al., 1999 for discussions on the impact of office stock on office rent). As a higher level of office stock suggests a higher level of supply, a negative impact is expected to occur in the rental value of office space. Vacancy rate indicates the discrepancies of demand and supply conditions of office space (for discussions concerning the effect of vacancy on office rental market, see Rosen, 1984; Wheaton et al., 1997). The yield rate essentially shows the income-earning ability of office space in the rental market. A higher yield rate insinuates a higher rental level, given a constant office price level. It is expected a higher yield rate encourages more supply on the office rental market, while a higher relative price level on the office rental market could reduce the demand for office space. Lastly, the forecast supply is the estimated amount of new office space supplied in the year after, provided by official data, which in perspective can tell us about the anticipations of the provision of office floor space in the future.

The aforementioned data is gathered from the Census & Statistics Department in Hong Kong (general economic indicators such as GDP, FIRE sector unemployment rate, etc), the Rating & Valuation Department (office rents, yield rates, vacancy rates, and office stocks, forecast supply), and HSBC (best lending rate) during the period 1990:1-2004:4. The rental values, vacancy rates, yield rates, office stocks, and forecast supply are the figures of Class A offices in Central. The Central is selected because it is generally regarded as the central business district (CBD) in Hong Kong. The amount

of Class A office stocks in Central is about 40% of the total Class A office stocks available in Hong Kong Island, and more than 25% of the total Class A office stocks available in Hong Kong (Rating & Valuation Department, various issues). It is believed that price/rental movements in Central's offices are good indicators of such movements in Hong Kong. Lastly, it should be noted that due to data limitations, data on office stock, vacancy rate, and the forecast supply are assumed to be constant on a yearly basis.

Due to the issue with stationarity, the model used in this study will be primarily under "first differencing". Also, the lagged value of the change in office rental value is included in the equation to take into account the possible impact of past changes in office rental value to that in the current period. It should be noted that GDP growth is included without first differencing, as the original data of GDP growth is stationary, grounded on the results from the ADP tests (See Appendix 1 for details). Therefore, the resulting equation for the multiple regression model is depicted as follows:

$$\Delta OR_t = \beta_1 * \Delta OR_{t-1} + \beta_2 * \Delta FIREUR_t + \beta_3 * GDPG_t + \beta_4 * \Delta YR_t + \beta_5 * \Delta FS_t + \beta_6 * \Delta VR_t + \beta_7 * \Delta EOS_t + \beta_8 * \Delta LR_t + \beta_9 * \Delta OPI_t + \beta_{10} * \Delta OS_t + \beta_{11} * \Delta CPIC_t + \beta_{12} * AFC + \beta_{13} * SARS + \beta_{14} * D_2 + \beta_{15} * D_3 + \beta_{16} * D_4 + \varepsilon_t \quad (1)$$

In which,

- OR = office rent (per square meter a month);
- FIREUR = FIRE sector unemployment rate (%);
- GDPG = GDP growth;
- YR = yield rate (%);
- FS = forecast supply (in m<sup>2</sup>);
- VR = vacancy rate (%);
- EOS=export of service index;
- LR=lending rate;
- OPI= office price index;
- OS=office stock;
- CPIC=change in consumer price index;
- AFC= dummy variable (Asian Financial Crisis);
- SARS= dummy variable (Severe Acute Respiratory Syndrome);
- D<sub>2</sub>=2<sup>nd</sup> quarter seasonal dummy variable;
- D<sub>3</sub>=3<sup>rd</sup> quarter seasonal dummy variable;
- D<sub>4</sub>=4<sup>th</sup> quarter seasonal dummy variable.

A total of five dummy variables are used. The value of 1 in the AFC dummy variable represents the sudden shocking effect that the Asian Financial Crisis inflicted to many Asian countries, from the 3<sup>rd</sup> quarter of 1997 to the end of 1998. The SARS dummy variable, on the other hand, is used to reflect the economic shock that accompanied the onslaught of the Severe Acute Respiratory Syndrome which started around the 4<sup>th</sup> quarter of 2002 until

June (2<sup>nd</sup> quarter) of 2003. Furthermore, dummy variables  $D_2$ ,  $D_3$ , and  $D_4$  are included to represent the impact seasonal effects on office rental adjustments in the 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> quarter of each year, respectively.

The results in Table 1 suggest that, with the exceptions of  $\Delta OPI$ ,  $\Delta YR$ , and the seasonal dummy variable  $D_3$ , the remaining variables selected are not considered statistically significant, judging from their relatively small  $t$ -values. This is particular the case regarding the supply-side variables. This implies that the supply side factors, such as current office stock, vacancy rate and the forecast supply of office space, do not seem to make a significant impact on office rental adjustments. On the other hand, their insignificance could be the results to the relatively lack of data for the supply-side variables. Furthermore, the respective impact of the Asian Financial Crisis (AFC) and SARS are not statistically significant in the determination of the movements of office rents over time. A stepwise process will then be carried out, in order to eliminate irrelevant factors from the study. The revised equation of the multiple regression model will be as follows:

$$\Delta OR_t = \beta_1 * \Delta OR_{t-1} + \beta_2 * \Delta FIREUR_t + \beta_3 * \Delta CPIC_t + \beta_4 * \Delta LR_t + \beta_5 * \Delta YR_t + \beta_6 * \Delta OPI_t + \beta_7 * D_{3t} + \varepsilon_t \quad (2)$$

**Table 1: Results of the regression model** (\*\*suggests significance at 5% level, \* suggests significance at 10% level)

Variable	Coefficient ( $t$ -value)
$\Delta OR(t-1)$	0.159999 (1.267923)
$\Delta FIREUR$	-13.65512 (-1.324113)
$\Delta OPI^{**}$	1.523175 (3.558427)
$\Delta CPIC$	6.079991 (1.368918)
$\Delta LR$	13.33436 (1.673434)
$\Delta YR^{**}$	25.31588 (2.890469)
$\Delta EOS$	-0.405059 (-0.756696)
$\Delta OS$	-0.000211 (-1.258320)
$\Delta VR$	0.769011 (0.332773)
$\Delta FS$	-4.74E-05 (-0.378337)
GDPG	0.675516 (0.211045)
$D_2$	1.428405 (0.176004)
$D_3^*$	17.68633 (1.900060)
$D_4$	-0.949072 (-0.117066)
AFC	1.041655 (0.066157)
SARS	-9.220326 (-0.509871)
Adjusted $R$ -squared	0.444
Durbin-Watson statistic	2.452



The results in Table 2 show that most of the variables have a positive relationship with office rental adjustments ( $\Delta OR$ ). The positive relationship between  $\Delta OR_t$  and  $\Delta OR_{t-1}$  insinuates that past movements of office rent, to a certain extent (about 17% in this case), influence the mechanisms of current rental adjustments. The positive correlation between  $\Delta CPIC$  and  $\Delta OR$  suggests that as the general price level increases, the office rental level is likely to follow. An increase in general price level indicates a higher level of demand for goods and services in general. As mentioned before, due to the undeniable role of the service sector in deciding the demand for office space, higher service demand appears to induce higher office demand, thus pushing up the office rental level. A higher lending rate represents a higher cost incurred from financing, which is crucial when businesses have the intention to buy office space for use instead of renting. This shifts the potential office demand from the ownership market to the rental market. Yield rates inform us the income generating capacity of properties. A higher yield rate implies either a higher rental level, or a comparatively lower price level. It can trigger a higher demand in the ownership sector, due to a relatively lower cost in obtaining office space. In other words, the price of office space will increase, as reflected in the OPI. Meanwhile, due to the limited land resources in Hong Kong, the only ways to meet the increasing demand in the ownership sector are either through redevelopment or shifting the existing office space from the rental sector to the ownership sector. Either way, this induces a lower supply of office space in the rental sector, placing a positive impact on office rents in the process.

**Table 2: Results of the regression model**

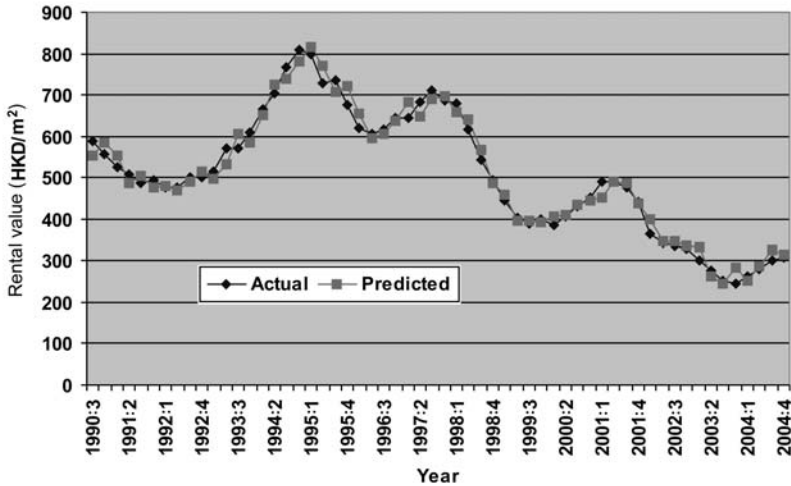
Variable	Coefficient ( <i>t</i> -value)
$\Delta OR_{t-1}$	0.170838 (1.514336)
$\Delta FIREUR^*$	-16.55031 (-1.959355)
$\Delta CPIC$	5.904593 (1.583958)
$\Delta LR$	11.04533 (1.601155)
$\Delta YR^{**}$	25.60995 (3.299671)
$\Delta OPI^{**}$	1.488758 (4.060690)
$D_3^{**}$	14.89766 (2.370414)
Adjusted <i>R</i> -square	0.514
Durbin-Watson statistic	2.368

(\*\*suggests significance at 5% level, \* suggests significance at 10% level)

The negative relationship between  $\Delta FIREUR$  and  $\Delta OR$  suggests that when the business environment is the FIRE sector starts to get worse, the demand for labour will drop (represented by a positive change in FIRE unemployment rate), so as the demand for office space for their daily operations. As a result, the office rents are likely to adjust negatively.

To see whether the proposed model is a good predictor of office rents in the future, the predicted rental values obtained from the model are compared to the rental values from the historical data. The results are shown in Figure 2. (Also refer to Appendix 2 for the results of the Theil’s inequality coefficient).

**Figure 2: Actual vs. predicted rental values**



*Stage 2—The dynamic modeling*

Having set up the foundation of the study in the first stage, we enter the second stage, which is the adoption of the system dynamics model for forecasting the office rental adjustments. Control theory is applied on system dynamics to analyze industrial systems along with economic, social, and environmental systems as well. The algorithm of system dynamics can be leveraged for the analysis of complex systems with multiple sources of uncertainties. The analytic capability that can provide an analytic solution for complex and non-linear systems is one of the most powerful features of the system dynamics (Kwak, 1995) (for details, please refer to Appendix 3). System dynamics is also designed as a practical tool that identifies a problem, focusing on feedback processes involved in the system, and makes it useful in devising as well as testing alternative policies that alleviate the pressing problems they may confront organization (Sterman, 2000).

However, simulation modeling is a relatively new concept in real estate industry (Tonelli et al., 2004). Meanwhile, there have been signs of approvals towards the use of such structural modeling, when it comes to situations where weaknesses are observed in regressions and trend

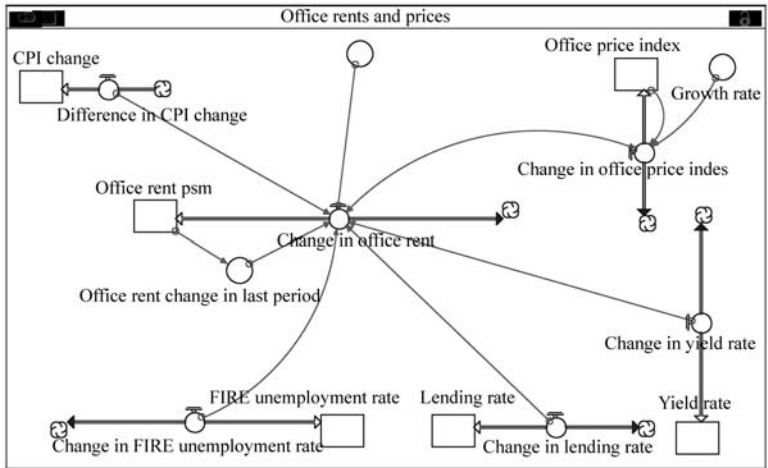
forecasting (Sterman, 1988; Sterman, 2000; Lyneis, 2000). Structural modeling for forecasting purposes have been used, from understanding America's urban crisis (Forrester, 1969) to dynamics of the housing market from the perspective of housing associations' (Vennix, 1996), in addition to studies regarding supply and demand cycles for Sydney and Perth, Australia (Kummorow, 1997; Kummorow, 1999). But in general, studies under such structure are relatively few.

According to Tonelli et al. (2004), there are a couple of advantages when statistical models are adapted to a system dynamics framework. Firstly, usual analyses are static in nature, which do not take the changing dynamics of the market environment into consideration. Meanwhile, a system dynamics model takes the interaction of different variables into account, which consequently induces changes overtime. The credibility of the model can then be enhanced, as it permits parameters such as employment growth and demolition rate to be varied exogenously. Lyneis (1999) shares similar viewpoints about the usefulness of system dynamics modeling, as more reliable forecasts of short- to mid-term trends can be provided by system dynamics models than statistical models, thus leading to better decisions. It provides a means of understanding the causes of industry behavior, and the determination of factors, to which forecast behavior are significantly sensitive, is allowed to be detected earlier. Further, system dynamics models allow the determination of reasonable scenarios as inputs to decisions and policies.

Lastly, pure regression analysis only allows a single relationship between dependent and independent variables at a time. Meanwhile, structural equation modeling (SEM) can estimate many interrelated equations at once, but it assumes the linearity of all relationships (Hair, 1998).

From Figure 3, the rectangles represent the stocks of the variables selected for analysis. Pipes represent the flows (the rate of change or essentially the first difference of variables) between the current value of a variable and that in the previous period. Arrows indicate casual influences, grounded on the results obtained in stage 1. Originally, one of the strength of system dynamics is that positive feedback (self-reinforcing) loops and negative feedback (self-correction) loops are included in the system. The interactions of positive and negative feedback loops help seek balance and equilibrium (Sterman, 2000), which avoids illogical situations such as unlimited growth of a certain stock variable. In this study, instead of describing the system in a complicated manner, the use of the multiple regression model in stage 1 contains the positive and negative feedbacks for the determination of office rental values.

**Figure 3: Concept map describing the interactions between the generators of the system dynamics model**



Two scenarios are constructed, in order to gauge the adjustments of office rent under different situations concerning land supply. In Hong Kong, the government is the sole owner of land and the sale of land is determined under an application list system. The main feature of this arrangement is that developers are required to offer a price high enough, from the government’s perspective, before a piece of land is being put on sale in an open auction. The problem with the existing system is that if the price is lower than the minimum amount set by the government, the land would not be extracted from the list, even though the demand for land for development exists. In other words, such arrangement could either increase the cost for development and/or postpone the supply of space. The reaction of the supply side could be even slower under this system due to the higher transaction cost that could lead to higher discrepancies between demand and supply, thus creating a more fluctuating office leasing market. The two scenarios in this study will be built around the above conditions.

*Scenario 1*

In this scenario, the office price index is set to increase by 1.5% on a quarterly basis. The rationale behind this setting is that the price adjustments of properties are induced by the respective adjustments of its supply and demand. A relatively higher rate of change in price level insinuates that the positive demand change for office space outweighs the positive supply change. It is assumed that if the government releases some of the measures regulating land supply, the supply side will then react to demand adjustments

in a timely and less costly manner. The result of such is likely a more stabilized office price level, as the new supply absorbs a part, if not all, of the demand shocks. On the other hand, the OPI is assumed to rise relatively faster under *status quo*, as it takes more time for the supply side to react to the demand changes, resulting in further price growth.

As far as the other variables in the system are concerned, they are set the same way in both scenarios, based on their respective adjustments shown in the official data. The interest rate has been rising constantly during the last 18 months or so, courtesy of the linked exchange rate system between the Hong Kong dollar and the U.S. dollar. And the cycle of positive interest rate changes does not seem to end yet. In this study, the best lending rate is assumed to increase by 0.25%/quarter for the first 10 quarters. Such rate will cease adjusting from then on, signaling the end of the cycle. The yield rate is assumed to be constant throughout the simulation period, as the yield rate of office space in Hong Kong is hovering around 3.5% during the past year or two (RVD, 2005).

Further, after several years of deflation recorded in Hong Kong, the general price level starts climbing back up in early 2005 (C&SD, 2005). As a result, a positive adjustment of CPI is assumed in the system, which a difference in CPI change will increase by 0.2% per quarter. The FIRE sector unemployment rate is assumed to drop by 0.1% a quarter, which is considered appropriate since such rate has been falling from 5.6% in mid 2003 to 3.4% in mid 2005 (C&SD, 2005). The seasonal dummy variable is set at the value 1 in the 3<sup>rd</sup> quarter of each year, a value of 0 when otherwise. The constants set for the aforementioned variables are extracted from the official data regarding such in the 4<sup>th</sup> quarter of 2004.

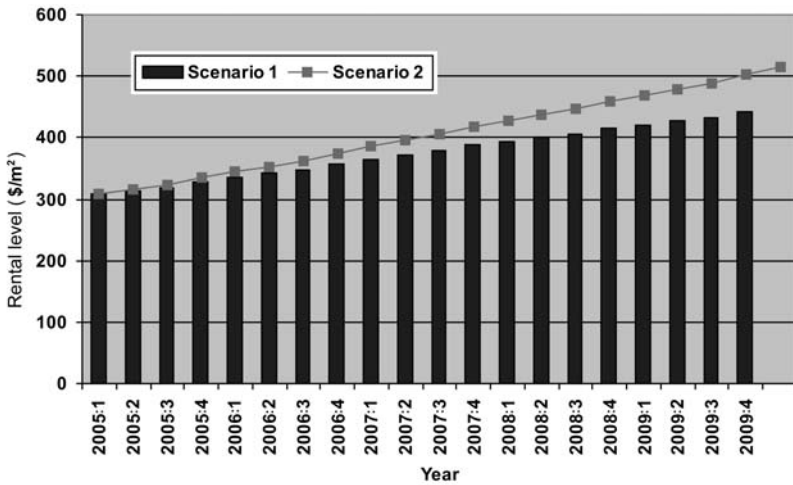
### *Scenario 2*

The conditions in Scenario 2 are more or less the same as that in Scenario 1, with the only difference being that the projected OPI growth is set at 2.5%/quarter, reflecting a more vigorous office price change due to the slower response from the supply side under the current land policy settings.

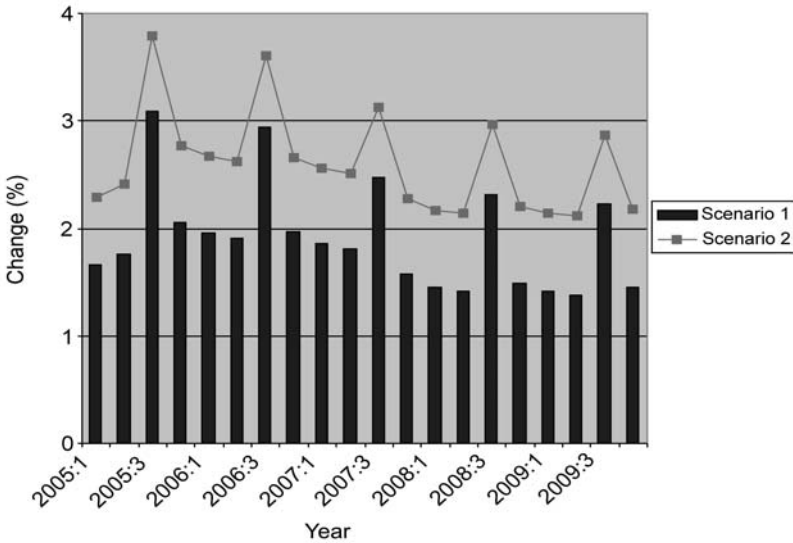
## **Test Results**

By comparing both scenarios with one another, it can be observed that a comparatively lower office rental levels are being simulated in Scenario 1 (Figure 4). Also, when the proposed OPI is surging, the percentage change in office rental value is higher in Scenario 2 than that in Scenario 1, suggesting a higher volatility (Figure 5).

**Figure 4: Simulated office rental levels**



**Figure 5: Percentage changes in office rent in the scenarios**



From a market perspective, the higher volatility on office rents (in terms of its percentage change) under a faster growing office ownership sector (similar to Scenario 2) insinuates the inefficiency of the property market. As mentioned before, a higher price level implies a relatively lower supply, given the same level of demand. Provided the limited land resources in Hong

Kong, new office supply could be generated through existing vacant lots, new constructions or redevelopments. In the meantime, the asymmetrical occurrences of demand and supply could lead to erroneous predictions that could create negative impact on the performance of the market. As demand and supply do not appear simultaneously, it takes time for the supply side to adjust to the everchanging demand. Before new constructions and redevelopments could even take place, the only source of office space supply, other than the current vacant lots, in response to the price rise is through a shift from the rental sector to the ownership sector. This leads to a fall in the supply of office space in the rental sector, causing an upward movement of rental values. In general, it creates a more fluctuating office market, thus a more risky environment for business operations.

As stated by Gallagher and Wood (1999), the causes of these occurrences were quoted as being the long-term investment nature of real estate; development lags; space demand uncertainty; high adjustment (acquisition/disposal) costs; and the “unbridled enthusiasm” of developers. However, it is believed that the government’s policies on land sales could exacerbate the existing problem of land market inefficiency. We suggest that such arrangement should be eliminated, in order to reduce the transaction cost incurred in developments and to restrain the volatilities on the office space market.

Aside from the revision of the existing land sales arrangements, there is something that the government could possibly do in order to keep the office leasing market from being too volatile. While demand side uncertainties are out of the government’s control, the government’s land use policies appear to play a role in affecting supply-side elements such as adjustment cost and development lags. There are two procedures that need to be completed before any redevelopment projects take place. Firstly, developers need to obtain the approval of the government (the Planning Department to be exact) in order to change the usage of an area. Secondly, a premium payment is required before the commencement of any redevelopment projects. It can be said that these two measures, associated with the high land price policy adopted by the government, are significant in determining the adjustment cost and the development lags of office space supply. The government could relax the first two institutional measures, such as speeding up the approval process for the applications for changing land use and probably re-arranging the payment of premiums to after the redevelopment process. This could help reduce the adjustment cost and development lags, thus decreasing the volatility (or the price risk) of the office user (leasing) market.

## Conclusions

Two scenario studies are conducted, via system dynamics model, in attempt to explore the dynamics of office rental levels in Hong Kong, with respect to the existing government land policies. The paper integrates system dynamics and econometric modeling as the basis of our study. This eliminates the problems associated with static regression models used in previous studies. Further, by incorporating econometric models, irrelevant factors would be screened out. This is a more rounded approach that is able to obtain more realistic results, which are the basis of better decisions.

The results suggest that comparatively lower office rental levels and a more volatile office leasing market are likely to exist when there is a larger discrepancy between supply and demand in the ownership sector (reflected in the higher volatility in the price level). It is believed that government policies on land sales/use play a role in postponing the reaction time of the supply side. Further, it is also expected that the land use policies exert some influence in determining the development lags and adjustment cost of development projects. Both institutional arrangements, which incur higher transaction cost in supplying new office space, in a sense exacerbate the discrepancies between demand and supply over time. A highly fluctuating office market is likely to cause problems in the long run, such as a more risky business environment in terms of operating cost, thus adversely affecting Hong Kong's competitiveness as a financial centre.

In order to reduce the high volatilities on the office market, the government should relax its land use policies, such as the modification of the existing decrees on land use and premium arrangements. Also, the existing land sales policies, in particular regarding the application list system, should be revised or at best eliminated, to bring more flexibility to the supply-side. This could reduce the time needed and the transaction cost involved for the supply side to adjust to the changing demand and diminish the volatility on the office rental market.

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**Appendix 1: The advanced Dickey-Fuller test results for stationarity**

Variable	Level	1 <sup>st</sup> difference
OR	-1.967	<i>-3.957*</i>
FIREUR	-2.689	<i>-7.220**</i>
OPI	-2.385	<i>-4.249**</i>
CPIC	-1.337	<i>-4.210**</i>
LR	-2.264	<i>-3.909*</i>
YR	-2.770	<i>-7.919**</i>
EOS	1.391	<i>-10.132**</i>
OS	-3.071	<i>-8.437**</i>
VR	-2.659	<i>-7.440**</i>
FS	-3.028	<i>-7.416**</i>
GDPG	<i>-6.259**</i>	<i>-12.817**</i>

Note: The critical values at 1%\*\*, 5%\*, and 10% significance levels are -4.13, -3.49, and -3.17, respectively. The terms in *Italic* represent the forms of variables used in the regression model. Also, deterministic trend is assumed to exist in the above variables.

**Appendix 2: Theil’s inequality coefficient for the evaluation of forecast from the results in Stage 1**

	Dynamic process	Static process
Theil’s inequality coefficient	0.055892	0.020737
Bias proportion	0.022435	0.010878
Variance proportion	0.688184	0.009824
Covariance proportion	0.289382	0.979299

**Appendix 3**

Kwak (1995) reiterates that system dynamics modeling is both a continuum and an iteration of activities that range from the structuring of the conceptual model to the technical requirements. In practice, this continuum can be broadly structured into five main steps as outlined in the following main steps below:

**Step one: System understanding** – It begin with the process of deepening the modeler’s understanding of the system with relevant information, on which the systems dynamics model would be conceptualized. The modeler would take a step back in space and time in order to appreciate the underlying web of ongoing, reciprocal relationships that are cycling to produce the patterns of behaviors that a system is exhibiting.

**Step Two: Conceptualization** – The translation of the systems perspectives into something more specific that would reflect the implementation viewpoint. At this stage, causal loop diagrams are drawn to show the relationships of the dynamics of the variables involved in the system. The objective is to depict the model to resemble the real world as closely as possible. Usually, more than one generation of causal loop diagrams are developed to arrive at one that is manageable and also to be within the constraints of finite data while ensuring that the model remain realistic.

**Step Three: Model formation and equation simulation** – A few variables are organized into a set of equations that characterize the nature of the relationships, as depicted in the casual loop diagrams. This step also includes assigning numerical values to define the direction and strength of these relationships.

**Step Four: Model validation** – Model testing and validation are to be in accordance with the model purpose. Completing this step enables the confirmation that the system loop is 'closed'.

**Step Five: Policy analysis** – The validated model is applied to solve the given problem or support scenario planning.