Modeling The Structure of CV Formation and Expectations: The Commercial Retail Real Estate Sector

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The commercial retail real estate sector

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Abstract

Purpose – The paper aims to form system dynamics modeling in conjunction with econometric analysis and planned scenario analysis which will uniquely structure the process whereby the \textit{ex ante} capital values of the prime retail real estate sector.

Design/methodology/approach – The integrated system dynamics model investigates the structural factors affecting a unique expectation-centered capital value (CV) formation of the prime retail real estate sector, through system dynamics modeling, econometric analysis, and the analysis of planned scenarios. This model extends beyond the usual lags and time line aspect of the price discovery process. The retail real estate sector is investigated within the Singapore context, as this sector changes dynamically and non-linearly in relation to rental, cost and general demand expectations and to exogenous shocks like the Severe Advanced Respiratory Syndrome (SARS) outbreak. These macroeconomic factors are introduced to investigate their impact on retail space CVs through sensitivity analysis, during the simulation period of 20 quarters from the zero reference quarter (2Q2002).

Findings – The paper finds that simulation runs of the expectations-centered system dynamics model are based on three scenarios. Sensitivity analysis is conducted for each scenario. Optimistic scenarios' CVs are lower than those of the likely scenario, owing to developers forming excessively high expectations that cannot be met by the actual rental levels. Pessimistic scenarios' CVs are highest. Based on bounded logic and the conditions for all scenarios, there are huge differences in expectations resulting in a large disparity in the endogenous CVs. Low actual rents are primarily due to poor informational efficiency, as the prime retail real estate sector is not transparent enough, and that many transactions are privately closed. Expectations cannot be met as the market information is not disseminated extensively through the agents and players. The scenarios clearly highlight the problem of informational non-availability in the sector. The main policy implication is a need for a more transparent system of sharing rental and pricing information for the retail real estate sector, which is meaningful for real estate developers, investors and urban planners to sustain the retail real estate sector’s viability.

Originality/value – This paper takes system dynamics modeling to the next level of incorporating econometric analysis, to estimate the sensitivity of retail rent to cost and the change in retail rent, for effectively structuring the dynamic process whereby the \textit{ex ante} CVs of the prime retail sector in Singapore are formed and assessed, through a unique and rigorous expectations-centered system dynamics model of rents, cost, retail stock, general demand and exogenous factors.

Keywords Capital, Value analysis, Retail trade, Real estate, Singapore

Paper type Conceptual paper

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Introduction
To investigate the retail real estate capital values (CVs), it is imperative to understand price discovery, in particular its aspect that is distinct from the typical lags and the time line conceptions. The retail real estate sector is traded infrequently in dispersed local markets, and the transaction price information is often confidential. This tends to slow the process of price discovery and aggravates the asymmetrical information problem. Therefore, information efficiency and other factors like the cost and retail demand expectations, retail stock factors, macroeconomic factors and exogenous demand shocks, significantly affect the endogenous formation of retail real estate CVs. Dynamic complexity emerges and these elements require an enhanced structural understanding of the retail real estate sector CV formation. Thus, this paper investigates the structural factors affecting a unique expectation-centered CV formation of the prime retail real estate sector, through system dynamics modeling, econometric analysis (for retail rental growth and the sensitivity of retail-rent-to-cost estimations), and the analysis of planned scenarios. This paper has the following objectives:

- To investigate the structural and expectational factors affecting the ex ante CV formation of Singapore’s prime retail real estate sector.
- To introduce a rigorous, dynamic and ex ante model that accounts for an unanticipated demand shock to Singapore’s prime retail real estate sector.
- To investigate the prime retail real estate CVs on an ex ante basis through the analysis of planned scenarios.

Depending on how transparent the retail real estate sector is, developers’ expectations are formed and adjusted to the actual retail rent through a time delay. A high fixed land cost further creates a cost barrier, and in conjunction with expectation adjustments, would form negative feedback loops that prevent the full corrective actions of closing the information gap between the desired and actual rents. The result is that the developers’ retail rent does not converge to the actual rent. The stock of retail space also affects CV formation. The effect of costs on rent and the effect of retail stock on rent are factors that determine the value of actual retail rent, through the sensitivity ratio of costs on rent and the sensitivity ratio of the retail stock on rent. Macroeconomic factors like the gross domestic product (GDP) growth in real terms and the Severe Advanced Respiratory Syndrome (SARS) outbreak are simulated to investigate their impact on retail space CVs through sensitivity analysis. Simulations are run for three different scenarios: likely scenario with GDP at a growth rate of 4 percent; pessimistic scenario with the SARS outbreak; and the optimistic scenario where there is robust GDP growth.

The optimistic scenario CVs are anticipated to be lower than those of the likely scenario, owing to developers forming excessively high expectations that cannot be met by the actual rental levels. The pessimistic scenario results in the highest CVs. Based on bounded logic and the conditions for the three scenarios, there are huge differences in expectations that result in significantly large disparity in the endogenous CVs. Low actual rents for all three scenarios may well be the result of poor informational efficiency, as the prime retail sector is not transparent enough, and that many transactions are privately closed. Thus, expectations cannot be met, as the market information is not disseminated extensively through the agents and players.
Under an expectations-centered system dynamics model, CVs formed under the three scenarios clearly highlight the problem of informational non-availability in the dynamic retail real estate system. The policy implication, meant for developers, investors and urban planners, is the growing need for a more transparent system of sharing rental and pricing information for retail real estate in Singapore. It is highly meaningful for real estate developers, investors and urban planners in order to sustain the viability of the retail real estate sector. This paper is therefore organized along several sections: the first section provides the introduction while the next (second) section is concerned with a review of the related literature. The third section briefly introduces the Singapore retail real estate sector. The fourth section is concerned with the system dynamics framework and its model building, followed by the fifth section that discusses the post-model findings. The sixth section concludes the paper.

**The related literature**

Price discovery is that process by which the opinions of market participants, concerning the value of a real estate asset, are combined in a single statistic – its market price. Price discovery is enhanced when there is information efficiency and the real estate market is liquid, with a high flow of price-relevant information. When the market is illiquid, owing to lack of trades or confidentiality, there is widespread use of appraisals to make an assessment of real estate value. The result is appraisal smoothing (appraisal lag). Price discovery studies focus on the efficiency of commercial real estate markets. In the real estate market context, Geltner and Miller (2000) denote price discovery to be that process by which asset market prices are formed, specifically through the discovery and incorporation by market participants of information relevant to the values of assets. Under such a theoretical conception, where two markets have a common component of value, the relevant price information is discovered first in one market and then transmitted to the second market (Geltner et al., 2003).

Furthermore, Schroeder and Mintert (1999) state that price discovery is also uncertain because the two parties in the transaction do not have precise information regarding demand and supply. The buyer’s and seller’s decisions are based on their interpretation of the market fundamentals in that the market supply and demand curves may well have “bands” around them, as reproduced in Figure 1. They highlight that the less certain the participants’ knowledge of market supply and demand, then the wider are the bands around the supply and demand curves. As the bands widen, the resulting transaction prices become more variable, and it is more likely that individual transactions (for the same quality) would yield prices that are different from each other and the market price level. These bands indicate that any individual transaction price may differ from the market price because market participants possess imperfect information, regarding market supply and demand. Fisher et al. (1999) suggests that, in the USA during the late 1990s, the “band width” around the premiums, represented by the positive ratios of the price-to-net-asset-value of the real estate investment trusts (REITs), is around 15 percent although there is evidence that valuation differentials have exceeded these bounds in the past. Thus, the magnitude of the price differences is a measure of the price discovery efficiency. Large price differences across transactions (for the same quality) reflect inefficient price discovery, whereas small price differences indicate efficient price discovery. Price discovery is not a costless activity because individual buyers and sellers must collect and carefully
analyze recent market fundamentals, to arrive at a discovered price that is reflective of uncertain current market conditions. To be more efficient in the real estate price discovery process, developers and investors must have knowledge of recent and expected market demand and supply.

Hence, Fama (1970) defines three forms of market efficiency: weak, semi-strong and strong. The degree of efficiency is a function of the speed that new information becomes impounded into prices. Efficiency also relates to the information set that can be expected to influence prices, and in this way the three forms of efficiency can be defined. For a market to be weak-form efficient, it is necessary that all information contained in past prices be contained in current prices. It should then not be possible to predict future prices on the basis of information contained in past prices. If a market is semi-strong efficient, then all publicly available information is immediately capitalized into prices. In strong-form efficient markets, prices reflect all privately available information. Barkham and Geltner (1996) reiterate that asset market informational efficiency is gauged by the speed at which new information is impounded into the value of assets. A market lacks informational efficiency if asset prices do not quickly and fully reflect extant information relevant to the value of the assets traded in that market. Geltner et al. (2003) highlight a market’s essential role of markets is to coordinate the flows of information to participants. If there are many participants and many trades, and so information flow is fast, then it is incorporated quickly into prices. Such information may be purely exogenous, as in fundamental variables like economic growth and inflation, or purely endogenous to the specific asset like trading volumes. In thin markets, in the absence of reliable information for an investment, then information from market aggregates like an index or from other markets, which have a common or overlapping set of pricing factors, would assume greater importance.

Of interest are price discovery within the private (direct) real estate market, and price discovery between the public (indirect) real estate market and the private market. The direct real estate market is unlike the securitized markets in that heterogeneous assets are traded frequently in dispersed local markets, and that the transaction price information is often confidential. Such conditions make price discovery slower and the scope for asymmetrical information becomes more problematic. Greater liquidity and
homogeneity in the traded assets enables faster price discovery in the share market’s public exchange, relative to the private real estate asset market. Price discovery between these two markets is likely to depend on both markets’ liquidity. Since the process involves information transfer from one market to the other, other things being equal, increased liquidity in the public market should increase the flow of relevant information, thereby enhancing the price discovery process between the two markets.

When liquidity in the private market is low, price discovery within the direct market is limited and appraisers lean more heavily on public market information with historical data. Thus, information availability is important in forming the expectations of investors that are vital to the price discovery of real estate accommodation, in particular the prime retail sector.

Nevertheless, some asset markets are more information efficient than others, leading to a different speed of price discovery and a resulting temporal lead and lag relationship in the market prices of related assets that trade in different types of market. There are therefore different types of real estate CV indices that may respond to news that arrived at time $t$. Geltner and Miller (2000) conceptualize five types of CV indices, as reproduced in Figure 2:

1. Index 1 is the “REIT Share Price Index” – the densest and most liquid market for trading real estate equity assets. It moves first and fastest, and has the most informational efficient price discovery.

![Figure 2. Lags and times line of five types of CV indices](image)

Source: Geltner and Miller (2000)
Index 2 is the “Constant-Liquidity Private Market Value Index” – an index of private real estate market values. Because investors tend to hold back and wait for new CVs, there is a reduction in liquidity, taking longer to sell properties. Although reflecting nearly “full information”, the search cost, transaction costs and the thinness of the real estate market are not assumed away.

Index 3 is the “Contemporaneous Transaction-Price-based Index” – an index reflecting the expected sales price within each period of time, i.e. the cross-sectional mean. The empirically observable transaction prices are not expected to overshoot the new, full-information value like Index 1 and Index 2 did, and so this Index 3 is a bit less volatile and slightly more lagged in time.

Index 4 is “Contemporaneous Appraised Value Index” – an index of micro-level appraised values, implying cross-sectional aggregation at a current point in time. The only difference between this Index 4 and Index 3 is the temporal lag error present in the optimal micro-level appraisal. Index 4 is a bit smoothed and lagged in time, as appraisers compile transaction prices before finalizing opinions of how the news, arriving at time t, has changed the real estate value.

Index 5 is the “Appraisal-Based Index with Staggered Appraisals” – an index based on micro-level valuation observations but not all properties are reappraised at the same point in time in this index. Index 5 suffers a stale appraisal problem, and it is a smoother and temporally lagged version, relative to Index 4.

On the whole, appraisers conduct an assessment of value, based on fundamental variables and asset market information, including transactions and a market-wide appraisal index as discussed above. However, transaction prices are a noisy signal and it is the appraiser’s role to extract the signal from the noise in an efficient manner for price discovery. For appraisal smoothing, the state of the art mainly comprises two alternative approaches at the aggregate-level indices of the private real estate market. First, the “reverse engineering” approach starts with an appraisal-based index and then proceeds to “unsmooth” this index. Second, purely transaction-based indices are estimated based only and directly on transaction price data, according to Geltner et al. (2003).

On price discovery between the public and private commercial real estate markets, Barkham and Geltner (1995a, b) investigate the securitized and unsecuritized commercial real estate markets in the USA and UK. Commercial properties are publicly traded indirectly in the stock market under the REIT or real estate company shares. Similar commercial properties are privately traded in the real estate market under direct real estate transactions. To the extent that there is a common element in the value of all these real estate assets, price discovery for such a common element may conceivably occur in the public market from which information is then transmitted to the private market. Price discovery findings accordingly show that the public securitized markets are more informational efficient than the private unsecuritized markets. However, Barkham and Geltner (1995a, b) conclude that the direct real estate markets show a potentially serious violation of the “semi-strong form” of informational efficiency under two key explanations. First, the apparent lead of the securitized market is an illusion caused by measurement error in data, owing to appraisal smoothing in the direct real estate returns. Second, the direct real estate markets may
merely reflect changes over time in investor perceptions and preferences. By inference, the price discovery of the common commercial real estate value element first occurs in the securities market but it appears that such information is not completely transmitted to the direct private commercial real estate markets for about a year or longer in the USA. Evidence suggests that the price information transmittal and influence from the securitized to the direct market is faster and more complete in England than in the USA, perhaps because of the greater homogeneity in England and of a larger share of the real estate assets having been securitized there. The fact that price discovery occurs in the securities market has some implications for capital market theory in that the trading density, liquidity and micro-structure advantages of the securities markets do outweigh the market breadth and the participant-sophistication advantages of the direct private markets in commercial real estate.

Nevertheless, Tuluca et al. (2000) argue that the price for real estate assets is not a public market discovery process, which is transmitted to the private market, but involves a feedback process between the two markets. This argument is appealing if one considers that the private direct real estate market is dominated by sophisticated investors, and that the public market is more strongly affected by small investors. Thus, a cointegration analysis should uncover two long-run equilibrium relationships, and when the long-term relationship is incorporated in models, investigating the dynamics of private and public real estate, then the resulting price is discovered in the two markets through a feedback process with the private market possibly leading the way. From the asset microstructure of transaction prices, Geltner et al. (2003) reiterate that prices are unlikely to be uniformly informative. The embedded information content depends on several factors: the number of informed and uninformed traders in the market; how risk-averse these traders are; complexity of the underlying asset; costs of the information production; and the organizational structure of the market. There are problems in applying microstructure models to the private direct real estate market. From the securities market microstructure theory, the “noise trader” may not be present at all in the private search markets. To enable “informativeness”, the mainstream microstructure literature holds more direct relevance for the indirect market of real estate assets, which are traded in public stock exchanges.

Schwann and Chau (2003) next investigate the extent to which abnormally large returns (positive or negative) to securitized real estate are transferred to the returns in the direct real estate market, and the extent to which the price discovery relationship is stable over time in Hong Kong (HK). Event-methodology regressions show that price discovery is muted in the period following a news event and that the estimate of the long run price discovery effect is reduced once the analysis controls for the news effect. The change in the strength of price discovery may well be linked to a change in the HK’s banking regulations in February 1994 that have limited the banks’ risk exposure to real estate loans, through capping their exposure at 40 percent of total lending, or to anti-speculative measures introduced by the government in mid-1994, to curb speculation in the residential sector. The findings suggest that the size of the price discovery effect depends on the amount of real estate information embedded in the history of securitized returns.

Nevertheless, the price-setting process in Europe for a land plot in Germany, for example, depends primarily on demand and supply factors that include the current...
econmic and social circumstances, the national and regional policy on urban development and the legal environment. The important factors denote the legal and planning circumstances, the land use type especially investment-oriented developments and the location (Dieterich et al., 1993). In France, Acosta and Renard (1993) highlights that there is no such thing as a “real price” of land, and it depends on the intensity of demand at specific allocation and development rights granted by local plans and related building regulations. Both the German and French land values are determined more by the demand factors. In Sweden, Kalbro and Mattsson (1995) interestingly states that real estate prices are governed by the market, and that changing expectation values owing to the changes in land use, are governed by market forces with the municipality being the price maker. The emphasis is on the supply side although Tay et al. (1999) find that rental rate of a retail unit is positively related to the size of shopping centers but negatively related to its own size. Retail space in shopping centers that are more accessible by transport and with shops having better locations and larger frontage within the centers, would command higher rental premiums. Retail rental value also depends on the types of tenants bidding, and that the age of the shopping center is found to be positively related to retail rents. However, supply factors like the lease provision, rent-free periods and turnover rent provisions have minimal impact on the average rent. Furthermore, Benjamin et al. (1998a, b) find that the share of retail sales depends on the local retail competition, household income and the travel distances to malls in competition. The mismatch in the amount and location of retail space demand affect retail sales, from which the rents are paid, and they challenge the financial worthiness of the retail investor as well as creditors.

As a result, consider that the demand and supply for retail space may be moving toward or away from equilibrium at any moment, owing to long lead times for retail space construction, in the following equations:

\[ Q_D = f(P_t, Sales) \] \hspace{1cm} (1)

\[ Q_s = f(P_{t-1}, Cost) \] \hspace{1cm} (2)

\[ P_t = f(P_{t-1}, VR) \] \hspace{1cm} (3)

Demand \((Q_D)\) is determined by the rental price \((P_t)\) of retail space and the retail sales level, which in turn is determined by relative prices, incomes and demographic factors. The supply of retail space \((Q_s)\) is influenced by the previous period’s rental price of space \((P_{t-1})\) and the relative cost of producing it. The rental price is related to the lagged rental price \((P_{t-1})\) and the vacancy rate \((VR)\). Demand is strongly influenced by retail spending while supply is negatively affected by land use regulation. In terms of the demand factors affecting retail real estate rents, Chun et al. (2001) find that anchor tenants like jewelry stores, home furnishings, fast food restaurants and other services, are among highest sales volume tenants in regional shopping centers. These anchor tenants generate positive externalities that reduce the true marginal cost of space allocated to a department store. Other reasons causing rent and sales to vary are the difference in the age of the shopping center, population and income growth. Their results also show that faster retail sales growth is associated with proportionately 
higher rental growth while a decline in retail sales causes a proportionate decline in rents.

Average rents do not respond immediately to a change in the income-generating capacity of a retail center but rather that the response is “smoothed”. Rental change is due to changes in sales over a period of time and not at a point in time. Hardin and Wolverton (2000) investigate the determinants of neighborhood shopping center rents and find that the primary trade area characteristics and the real estate specific characteristics are determinants of retail rents. For the primary trade area characteristics, income and population play a major part in determining the demand and household purchasing power. Center square footage, property age and anchor tenants are other primary factors affecting retail rents. There is a positive marginal effect of proximity to higher order retail centers, and a marginal effect of proximity to malls diminishes greatly within one-and-a-half miles from a mall. A neighborhood center located near a higher-ordered shopping center is likely to benefit from the effective extension of the maximum range of potential center patrons. As consumers become aware of additional shopping opportunities in close proximity to higher ordered retail centers, they incorporate these into their shopping patterns, thereby enhancing the demand for household retail consumption.

On the real estate micro-market factors, it is accessibility, visibility, the household count in the trade area, household income and car parking that have a positive impact on rents. The initial lease term, percentage rents and tenant status as a national chain also affect the base retail rent. Hardin and Wolverton argue that rent is a function of vacancy, market, draw, lease and location where rent is the annual per square foot rental rate for shop space. The market can be represented by a vector of retail space market-condition variables for a given center and primary trade area. The retail center’s appeal consists of the center specific characteristics and potential demand externalities like the center’s exterior, accessibility, center design, lease types and purchasing power from location models. However, Eppli and Shilling (1996) produce results that deviate from Reilly’s gravitation model. They find that there is a weak relationship between actual retail sales at a retail center and the distance between the center and its competition. It is the size of retail center (relative to its competition) that is a better determinant of the center’s overall success. A dominant shopping center in terms of its size in a market area is able to draw a larger disproportionate market share.

At the macro level, demand plays an important part, and Tsolacos (1999) reiterates that retail activities and retail real estate demand are determined by retail profit, retail sales, disposable income, GDP and consumer expenditure. The main macroeconomic variables like GDP, volume of retail sales and consumer expenditure, along with retail rents and CVs are pro-cyclical and they tend to lead the retail building cycles. Retail real estate developers do not react immediately to changes in expenditure and rents. Thus, the preferred structural dynamic specification that explains the development cycle has to incorporate changes in rents lagged three quarters, and changes in consumer expenditure lagged four quarters. Carter et al. (2002) observe the internalization of externalities on the demand side through deploying lease, tenant and location variables under a simplified choice and non-choice view of the developers’ decisions affecting total rents. Findings by Benjamin et al. (1998a, b) render equal weighting to both the demand and supply factors, as both demand and supply are price inelastic. Therefore, shifts in demand and supply would result in relatively large
changes in rent and relatively small changes in the quantity supplied and demanded. On retail development valuation, Rao and Rutenberg (1979) point out that retail price is determined by total revenue (TR) minus total cost (TC), where TR is determined by the demand side and TC by the supply side. Cost factors affecting the bid price of the retail firm would include operating costs like direct cost, availability of public utilities and social overhead capital, the firm size owing to economies of scale. Increasing size would reduce improvement costs while zoning regulation would control the type of land use permitted. With lesser restrictions on the potential development of a retail site, the development can become more valuable as the developer has more options to adjust his proposed design.

Another key factor is the vacancy rate, which is the amount of retail space that is vacant owing to inventories being held by investors or that some spaces are in the transition of changing tenants. Fair (1972), Smith (1974), Rosen and Smith (1983) highlight that the price-adjustment mechanism and the rental housing market can be viewed as operating in a typical stock-flow manner (Khor et al., 1998). There is always a stock of rental housing units providing housing services, and there is a demand for these services at any one point in time. Both demand and supply functions interact to fix the level of rents and stock of vacant rental units. Such is also true for the demand and supply of retail real estate assets. According to Voith and Crone (1998), the natural vacancy rate for office should depend on variables like the expected rental rates, operating costs and construction costs and expected absorption rates. It can be discerned that dynamic complexity exists in an economic system structure. Each variable is interactive and can be interlinked with other variables.

Grenadier (1995) reiterates that both local and macro- factors aid in determining the vacancy rate. Some common macroeconomic factors are interest rate, inflation and overall business climate while local factors comprise demographics, income level, zoning laws and properties of employment growth. Petros (1997) defines the structural vacancy rate to be the desired inventory of vacant units held by landlords, given current and expected market conditions. Thus, optimal vacancy rate should fluctuate through time depending on the investors’ perceptions of market strength. Chen (2003) observes that retail price movement is affected by rental movement. Price movement exhibits more volatility than rental movement, especially in recent years. This can be due to the dynamism of the retail real estate sector. Other factors affecting CVs include consumer confidence, formed by expectations of investors.

In general, the real estate literature argues that rental movements can be largely explained by vacancy but a dynamic interaction between retail space absorption, retail space completions and structural vacancy can be readily observed to evolve through time. Retail space absorption affects the investor’s perception of market strength because in a strong market with rising, investors may well be inclined to hold more vacant units, to capitalize on future rental increases and strong demand. In a weakening market with rising vacancies, investors tend to hold fewer vacant units, to minimize their losses from weak demand and declining rents. At the same time, investors’ perception of market strength is affected by supply-side variables like retail space completions. Under myopic expectations, rapid rises of the completions in the present may even generate expectations of high completion levels in the immediate future. In anticipation of an imminent softening market, landlords are inclined to adjust rents downward more drastically, to fill up vacancies quickly. Such behavior implies a
dynamic complexity that results in a lower level of desired vacant units and lower structural vacancy rate. A negative relationship between retail space completions and rental change is also inferred.

There is limited empirical research on control theory and retail real estate although there is a study on office system dynamics by Kummerow (1999), who states that system dynamics models offer two advantages – relative ease to incorporate qualitative mental and written information plus quantitative data; relative ease to conduct simulations with inadequate data to support statistical methods or when the changes in structural processes render historical data misleading. System dynamics models can be complex but system dynamics problems have two things in common. First, there is a motive to improve a situation by suggesting how people can act on the system. Second, there are feedback loops where insights from system dynamics models often have to do with the delayed and counterintuitive effects of feedbacks. Kummerow (1999) constructs a simple office supply response model where he shows that a single negative feedback loop is used to control supply responses, to resolve discrepancies from the equilibrium vacancy. When vacancy equals the determined equilibrium vacancy, then supply and demand are in balance and the discrepancy would be zero. No supply adjustment would occur. If there is excess supply, then the supply change called for is also zero, and this implies that buildings are not demolished or converted to other uses. Once a space shortage occurs in the model, the system adjusts to eliminate the discrepancy, constrained by supply adjustment parameters. For simplicity, his model enables the supply responses to be continuous and the supply adjustment is modeled as a function of four parameters, giving rise to system behavior. The parameters are oversupply, adjustment time, supply lag and the equilibrium vacancy rate.

Simulation results show that system behavior depends upon the responses to a discrepancy updated and responded to in each time period. The overall outcome depends on the growth rate, equilibrium vacancy rate and the supply responses. It can be concluded that the capital markets’ concerns about risk may well be the key to the implementation of system design innovations. More stable and efficient real estate markets, including the retail real estate sector, should improve risk-adjusted returns to investors and lower costs to tenants. Designing institutions that produce more efficient system outcomes should also give investors a competitive edge in attracting lower cost capital for retail real estate investments.

The Singapore retail real estate sector
The Singapore retail real estate sector started in the early 1960s where centrally located stores in the Raffles Place Central Business District mainly catered to local residents and tourists. Small sub-centers served the various local ethnic groups like the Malay community in the Geylang Serai area, the Chinese in Chinatown and the Indians in the Serangoon road area. By the late 1960s, the Urban Renewal Authority (URA) was set up and Singapore’s retail market experienced rapid development. URA launched urban renewal and the sales of sites program, and introduced the first phase of planned one-stop self-sufficient shopping centers and mixed-use center developments, to maximize land scarcity usage and attain the highest and best use of land. These centers were mainly located in the central area’s Orchard Road retail belt in the 1970s and 1980s. By the 1990s, the central area became too congested and in 1991, the URA

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formulated the Concept Plan with the objective of reducing the Central Area’s congestion through decentralization. Four new regional centers were earmarked for development, each having at least one suburban shopping center. These are the Seletar, Tampines, Woodlands and Jurong East regional centers. Tampines is the first suburban town to be built and proved to be self-sufficient while Jurong East has been successful for its large-scale industrial estates. Each regional center developed its own transportation infrastructure, with the mass rapid transit (MRT) resolving traffic congestion by moving people underground. In the 2001 Concept Plan, Seletar remains the last suburban new town to be built, as the first three regional centers towns proved to be self sufficient in holding the changing population. Current construction of the new Northeast MRT line resolves further traffic congestion for the three regional centers.

Although physical planning is highly regulated in Singapore, the government sustains a high degree of flexibility on the release of sites from the state land bank for commercial development. Sites are made available when the physical infrastructure is in place and in response to the economy’s internal demand. Physical planning guidelines control the number, size and location of new commercial developments, reinforcing the success of the suburban shopping center concept in Singapore. Singapore’s retail space can be classified under three categories:

1. primary shopping area;
2. secondary shopping area; and
3. suburban shopping area.

The “primary shopping area” is the Orchard Road retail belt that is an elongated corridor, stretching along a large part of the central area’s civic and cultural district. It has the highest density of retail space and is the prime location for the retail real estate sector in Singapore. It serves the domestic and tourist populations. The "secondary shopping area” is the area outside the ”primary shopping area” but within the central area. It is subdivided into seven main areas: Chinatown, High Street and City Hall, the Downtown Business District, Jalan Sultan and Serangoon, Marina and North Bridge Road, the Singapore River and Bugis. As there are several formats of retail developments in the area, rental values vary fairly widely. The "suburban shopping area” comprises all other areas. Most suburban retail centers are found near public housing new towns, near large private housing estates and in the vicinity of MRT stations.

**The system dynamics model**
System dynamics is a state-of-the-art model that enhances learning of complex systems and is interdisciplinary. Forrester (1961) reiterates that all business, investment and policy decisions are based on models, usually mental models. In system dynamics, the “mental model” denotes one’s beliefs concerning the network of causes and effects, which explains how a system operates, along with the model’s boundary and the time horizon we consider relevant. Our mental models tend to be limited, internally inconsistent and unreliable, constraining our ability to properly understand the unfolding impacts of our decisions. Since policy decisions often provoke unforeseen reactions, policy resistance becomes inevitable. Policy resistance refers to the tendency for intervention to be defeated by the response of the system to the intervention itself. To understand the sources of policy resistance, it is imperative to understand the
complexity of systems and the mental models that help to make decisions. The solution lies in system dynamics, which renders the ability to see and understand the retail space sector, and the CV process formation as a complex system, in this paper. There are some important symbolic elements of dynamic complexity that have to be understood before deploying system dynamics in Singapore’s prime retail sector. From control theory and engineering, such symbolic elements refer to the stocks and flows, feedback, time delay and nonlinearity.

As a result of the review in the earlier section on “The related literature”, this paper’s research hypothesis can be broadly represented by three expressions in equations (4) to (6), which are on the whole consistent with the previous generalized equations of equations (1) to (3) and their theoretical conceptions. The price discovery literature underscores the importance of the expectation of CVs by market participants in the retail real estate sector and the flow of price-relevant information, which is affected by differing informational efficiency and retail real estate liquidity. In addition, the market price of CVs are formed by buyers and sellers based upon their interpretation of the retail real estate market demand and supply factors. These market participants must collect and analyze demand and supply factors at a cost to arrive at a discovered price, reflective of prevailing market uncertainty and inclusive of exogenous demand factors like the SARS outbreak. The retail real estate micro-market factors pertaining to demand and supply are in turn discussed at length in formulating equations (1) to (3), while the macro-level demand factors are discussed in the later half of “The related literature” section:

\[ P = f(\text{expectation, vacancy rate, retail demand factors, retail supply factors, SARS outbreak}) \]  

(4)

where \( P \) = CV, of the retail real estate sector (market).

Retail Real Estate Demand Factors = \( f(\text{level of retail sales, tenant types, location, size, frontage size, age, parking, relative prices, consumer disposable income, demographic factors like population, interest rate, GDP, tourists arrival}) \)  

(5)

Retail Real Estate Supply Factors = \( f(\text{cost, planning provisions and regulations}) \)  

(6)

Consequently, it is readily observed that the various explanatory (causal) factors on the right-hand-side of the above equations (4) to (6) are appropriately extended from the extant related literature, in order to render the system dynamics model free from modeling error and the final model estimations clear of biased errors. There is, however, a joint feedback process involving retail real estate CVs, demand and supply factors. Hence, the dynamic and expectation-centered structure of CV formation of the prime retail real estate sector in Singapore can be conceptualized in Figure 3.
The data
The model estimation is primarily influenced by reliable data. The data are collated in the period between 1994 and 2002 at quarterly frequency. As such, this paper covers the performance of Singapore’s economy and its prime retail real estate sector in this period. The required data comprise GDP in real terms, effective rents, CVs, retail space stock and vacancy rates. On economic performance, the GDP, government expenditure, aggregate investment and aggregate consumption data are required. High quality, quarterly time series data are collected and collated from the following authoritative national and reliable private international sources: the Singapore Statistics database, comprising the domestic universe of economic indicators, maintained by the Department of Statistics in the Ministry of Trade and Industry; the Property Market Information – Commercial and Industrial Properties and its various quarterly real estate benchmark-universe price reports, maintained by the Urban Redevelopment
Authority of Singapore; the Data Stream online information system; the Jones Lang LaSalle (JLL) Real Estate Intelligence Service-Asia Research Data, a popular prime real estate asset class research index of ten key Asian cities; and the Jones Lang LaSalle Online Market Reports.

The model estimation

From Figure 3, the retail space CV is the current market value for retail space per year, and is obtained by dividing the actual retail rent by the initial yield. This is a dynamic value as it changes with time, depending on the yield and rent.

\[
\text{CV or Asset Price} = \frac{\text{Current Market Rent}}{\text{Initial Yield}}.
\]  

(7)

Initial yield, which is sometimes also known as the overall capitalization rate, is the rate of interest appropriate to the particular interest in the real estate asset (property) being valued. It is expressed as the interest accruing to capital in a year. Yield is thus a combination of rental growth rates and rates of rental return. It is the growth rate, which determines the CV of the property. This growth rate, implied in a particular transaction, is in line with market expectations. Utilizing JLL’s prime retail centers” initial yield of 7.8 percent, step functions are introduced to impute different initial yield values to account for the changing market situation.

The availability of information forms the expectations of developers that in turn forms the developers’ expected retail rent. The initial value or the developers’ expected retail rent is taken to be S$1,065 psm per quarter, the net effective rent on net leasable area in 2Q2002. Vacancy rate is interlinked with the retail real estate demand and supply factors, to show the effect of retail stock on rent that plays a part in the CV formulation of prime retail centers. The effect of cost on retail rents also plays a part in determining the rent and CV formation of prime retail space. System dynamics modeling can generate the CVs over the next five years. For this purpose, a causal loop diagram to depict system non-linearity is constructed in terms of stock and flow structures, control and feedback structures as shown in Figure 3.

Positive feedback loops are self-reinforcing loops that generate growth, amplify deviations and reinforce change. Negative loops seek balance, equilibrium and stasis. Negative feedback loops bring the state of the system in line with a goal or desired state. They counteract any disturbances that move the state of the system away from the goal. Stocks and flows highlight the underlying structure of the prime retail real estate sector in Singapore. Stocks and flows track accumulations of retail rent, information, expectations, the effects of cost, retail stock and CV as they move through the real estate market system itself. The stock symbol represents the developers’ expected rent psm after the accumulation of information from expectations of the developers, based on the retail rental market. The stock symbol also represents the CV of the retail shopping center, after accumulating information on the yield, GDP growth and the actual retail rent.

On the bases of past prices and the “semi-strong form” informational efficiency on the costs, vacancy rate and market outlook, developers form expectations for the rent. Developers’ retail rent is largely dependent on the change in expected rent. This change is based on three variables - expected rent (rental price), indicated rent and the time delay to adjustment:
Change in expected rental price = (Indicated retail rent psm – Developers’ expected rental price psm)/(Time to adjust developers’ expected rental price).

(8)

In a material delay, the stock is the quantity of material in transit and the output of the delay is a flow. Here, developers’ expected rent psm is a stock because expectation, perception or belief is a state of the system which in this case, a state of mind. Developers’ expectation about the value of the retail real estate asset (property) tends to remain at its current value until there is some reason to change it. In the adaptive expectation conception, when an error occurs due to changes in information content, then the indicated rent, which is the reported rent, would differ from the perceived rent, which is the expected rent. The larger the error, the greater the rate of adjustment in the developers’ expectation, in order to reach the equilibrium rent psm. This expectation adjustment is a negative feedback loop, B1 due to changes in perceptions of the developers as depicted in Figure 4.

Developers’ state of expectation adjusts in response to the gap between the current expectation (belief) and the reported actual rent of the variable, together with the time to adjust developers’ expected retail rent. This structure is known as a first-order information delay. Developers’ expected rent then adjusts to the indicated retail rent, not the actual rent. Indicated rent is the market clearing or equilibrium rent. It is the rent after taking into account the actual and minimum retail rent:

Indicated rent = MAX(Minimum retail rent, Actual retail rent),

(9)

where the MAX function gives the maximum value of the expression within parentheses.

Given the developers’ expected rent psm, the actual rent can be determined by short term pressures, arising from imbalances of retail supply and demand or changes in the expected cost, as depicted in Figure 5. Hence, prices are set by an anchoring and adjustment process, in which various factors such as expectations, cost, competition, vacancy rate and SARS occurrence can cause developers to adjust price accordingly. The anchor rent adjusts itself to past transaction data or past experience. Retail rents

Figure 4.
Negative feedback loop of developers’ expectation adjustment

Source: Author (2005)
are anchored to expected rents and this anchor rent gradually adjusts to the actual level of rents, closing a positive reinforcing feedback loop, R1. The higher the expectations of the developers, the higher the rent would go and similarly, the lower the expectations of the developers, the lower the rent would be. Actual rent is adjusted up or down from the expected rent in response to various pressure. If demand for retail space exceeds supply, rent increases, whereas when there is excess supply of retail property, rent falls. The actual rent is thus the contract rent that is posted for rental. It is the net effective rent, which the landlords get after deducting the outgoings. For all retail real estate assets, a considerable sum of money needs to be expended regularly to maintain, insure and let. This expense is known as outgoings and is a cost to the landlord, which is determined by the terms of lease in the agreement.

To encourage prospective tenants to lease vacant space, it has become common for landlords to offer incentive packages. The general form of these packages is to keep the contract rent high but at the same time offer rent-free periods and/or capital incentives so that the (net) effective rent paid by the tenant would be much lower. Expected costs, which are the outgoings, consist of the operating expenses that the landlord has to pay like utilities and water, security and preventive maintenance and property tax. Property tax, however, excludes the major taxes and debt servicing. Retail rent is the average effective rent after taking into account the expected costs. Thus, rents can increase but is slowed by the effect of costs on rent:

\[
\text{Effect of costs on rent} = 1 + \text{sensitivity of rent to costs} \times \frac{\text{Expected Outgoings}}{\text{Developers' expected rent psm}},
\]

where the sensitivity of rent to costs is the elasticity of effective rents and outgoings.

To find the sensitivity of retail rent to cost, the multiple regression analysis (MRA) is conducted to estimate the econometric relationship in equation (11):

\[
DOUTGG = -10.935 - 0.893 \text{DERENT} + 0.752 \text{DERENT}_{L1} \\
+ 0.894 \text{DOUTGGL}_{L1}
\]

\[\text{Adjusted } R^2 = 0.75, \text{ DW} = 1.64,\]

Adjusted $R^2 = 0.75$, $DW = 1.64$ where the dependent variable is $DOUTGG =$ change in outgoing at $t$ and the causal variables are:
DERENT = change in rent at \( t \);
DERENTL1 = change in rent at \( t - 1 \); and
DOUTGGL1 = change in outgoing at \( t - 1 \).

Lagging of time by a quarter (i.e. at \( t - 1 \)) is utilized as a corrective action for autocorrelation. Autocorrelation results in the error term correlating over time and the error term is not random. By lagging the period, the temporal lag error can be discovered and “detrended”. The sensitivity of retail rent to cost (from April 2000 to July 2002) is estimated from the JLL data and found to be \(-0.893\), showing a significance level of 0.067 with an associate \( t \) value = 2.499. \( R^2 = 0.75 \) is sufficiently high, as it shows a measure of good fit. The Durbin-Watson (DW) test statistic for serial correlated error (i.e. autocorrelated residuals) shows a DW in the range of > 1.35, indicating that positive serial autocorrelation is not problematic:

\[
\text{Expected outgoings} = \text{Average of expected outgoings over effective rents} = 12.9\%.
\]

This cost pressure of equation (11) forms another balancing loop, B2, which limits rental increases through the sensitivity of cost on retail rents as depicted in Figure 6. As depicted in Figure 7, a ghost image of “expected costs: outgoings” is created to serve as an input to “effects of costs on rent”. Making a “photocopy” of this variable avoids stretching a flow wire across other wires and makes the diagram easier to read. Retail rents are assumed to respond to the balance of demand and supply. As vacancy rate increases, retail rent is adjusted below the expected equilibrium level, relative to a reference level, and is negatively signed as the stock coverage leads to lower retail rents. Retail rents depend on perceived retail stock and not stock at a point in time because it takes time to gather and report the transactions and rentals of the retail space:

\[
\text{Effect of retail stock on rent} = (\text{Perceived retail stock/Reference retail stock})^{\text{Sensitivity of Retail Rent to Retail Stock}}
\]

\[(12)\]

**Figure 6.**
Negative feedback loop of cost pressure

**Source:** Author (2005)
Perceived Stock Coverage = SMOOTH(Stock Coverage, Coverage Perception Time),

\[ \frac{\text{Perceived Stock Coverage}}{\text{SMOOTH}} = \frac{\text{Stock Coverage}}{\text{Coverage Perception Time}}. \]  

where the SMOOTH function is a stock-adjustment process. This SMOOTH function estimates a first-order exponential smoothing of an input, commonly assumed in macroeconomic models. The function imputes an exponential averaging of time and an optional initial value in the algebraic form of \( S(t) = S(0)e^{+dt} \), where \( S \) is the stock level and \( dt \) is the interval-coverage time:

While the Reference Retail Stock = 543,322 sq.m (as of 2Q2002),

\[ \text{Stock Coverage} = \frac{\text{Retail Stock}}{\text{New completions}} = 226.81. \]

Econometric analysis is again conducted to estimate equation (15) under the MRA:
\[
DRent = 5.978 + 0.0001964DStock - 0.455DRentL1 - 0.166DRentL2 + 0.0007758DStockL1
\]

Adjusted \(R^2 = 0.77\), DW = 2.18,

where the dependent variable is \(DRent = \text{change in rent at } t\) and the causal variables are:

- \(DStock\) = change in stock at \(t\);
- \(DRentL1\) = change in rent at \(t-1\);
- \(DRentL2\) = change in rent at \(t-2\);
- \(DStockL1\) = change in stock at \(t-1\).

Even though the coefficient for the \(DStock\) is not significant as its significance level of 0.523 is > 0.005, the \(R^2 = 0.77\) is high, indicating a good fit. The DW value of 2.18 indicates slight negative serial autocorrelation error and minimal model specification error. As a result, the \(DStock\)'s coefficient can be utilized for further analysis as a sensitivity or elasticity ratio. Lagging it by two periods (i.e. \(t-2\)) helps to correct for autocorrelation that had not been "detrended" in a first lag. Thus, the sensitivity of retail rent to stock is taken to be 0.0001964.

Changing real estate market conditions can adversely affect the pricing of the retail real estate sector adversely. The recent SARS outbreak in Singapore resulted in falling rents for retail real estate assets although rental rates in the prime area had been relatively stable. To be able to know its impact on CV in the long run, it is necessary to run a computable analysis for the next twenty quarters. Actual rent is the instantaneous rent that is used to impute the converter CV, with an initial yield of 7.8 percent for the prime area in 2Q2002 after obtaining information for several key variables – expectations, cost, vacancy rate and SARS occurrence. Given the dynamic nature of the real estate market cycle, CVs of the retail real estate sector would be changing based on different market conditions. One important variable is GDP growth, which results in changing CVs affecting the total return for retail accommodation:

\[
\text{Actual Retail Rent} = \text{Developers' Expected Rent psm} \times \text{Effect of Costs on Rents} \times \text{Effect of Retail Stock on Rent} \times (1 + \text{SARS Outbreak}/100),
\]

where the SARS Outbreak variable is its percent probability:

\[
CV = (\text{Actual Retail Rent} \times 4)/(\text{Initial yield}) \times \text{GDP Growth Factor}.
\]

CV, which is the eventual retail real estate asset price that is to be forecasted for the next 20 quarters, is a result of the combination of the flow effect of the variables – expectation, cost, vacancy rate and SARS occurrence – on the actual retail rent. In addition, dynamic market conditions like the GDP growth would play a major part in formulating CV. A GDP growth factor of 4 percent is presumed to be the current growth rate for the economy.
Post-model findings
The resulting system dynamics model for the Singapore prime retail sector started with the conceptual causal loop diagram of Figure 3, and then proceeded to construct the “causal loop flow diagram” as depicted in Figure 7. Such a flow diagram codifies the required model equations in programmable format under the “iThink” program. The system dynamics model is initialized by the starting- and boundary-condition values before it is run for subsequent simulations, which utilize the JLL database. The ex ante CVs for the next 20 quarters from 2Q2002 are anticipated from the simulations, to be followed by the planned scenario analysis. The system dynamics model for Singapore’s prime retail sector can be deployed for generating three planned scenarios. These scenarios are analyzed in the following sub-sections to enable the expectational analysis and the CV policy implication.

The likely scenario
From the likely scenario of Figure 8, the initial yield of prime retail space at 2Q2002 is 7.8 percent p.a. It is used as the initial value for forecasting the CV in the first seven quarters. It is subsequently stepped down to 6.8 percent for the next four quarters, and then stepped up again to 8.8 percent and 9.8 percent respectively for the next eight quarters. Different initial yields are adopted to show the changing retail real estate market cycle, where a recovering economy on the whole would reflect a lower value of the initial yield and higher CV.

Source: Author; iThink program (2005)
Cost pressure creates a negative feedback loop that acts to adjust developers’ expected rent to the actual retail rent. The cost of outgoings forms a cost pressure, which declines with time as the effect of expected cost is taken into account in the actual rent. Thus a maturing exponential curve for actual retail rent is seen in the simulated graph.

Every negative loop includes a process to compare the desired and actual conditions and take corrective action. There is this information gap that needs to be closed in the closed feedback loop. In most cases, the rate at which the state of the system approaches its goal diminishes as the discrepancy falls. This goal-seeking behavior involves a gradual approach as a large gap of desired and actual states tend to generate large responses, while small gaps tend to elicit small responses. A large gap exists at first as new information is first reported.

The graph shows a first order smoothing of developers’ expected retail rent to actual retail rent. The response is a classical exponential goal-seeking behavior. The rate of information updating to add on to the developers’ expectations is greatest immediately after the change in the actual value of the variable, when the error in the belief is greatest. Once the feedback or updated belief is taken into account and adjustment is made to close the information gap, then the error falls and subsequent adjustments diminish. Gradual decline is shown for the change in developers’ expected retail rent in the graph as adjustment falls. Once the gap is closed, change is reduced to zero.

Developers’ expected retail rent and actual retail rent both show the S-shaped growth as we see that no real quantity can grow forever. Eventually, one or more constraints halt the growth. Both variables are exponential at first but gradually slow until the state of the system reaches an equilibrium level. The carrying capacity of both developers’ expected rent and actual retail rent is limited by the constraint of high land cost.

The high fixed land cost results in the actual retail rent not being able to converge with the developers’ expected retail rent. Rents are created more slowly than the change in cost due to informational inefficiency as costs are inclined to be fixed. Thus, initially actual retail rent increases steeply together with developers’ expected rent. However, owing to the cost barrier, developers’ expectations cannot be met and we see actual retail rent lagging by a large amount of S$3,343 psm p.a. by Q7, i.e. the 7th quarter, when both become constant. This implies that large expectation gaps cannot be adjusted accordingly.

The graph in Figure 8 shows that the rate of increase for both actual rent and the developers’ expected rent declines gradually from Q4 onwards and became constant at Q8. The increase in rent up to Q4 results in increasing CVs for the forecasted first four quarters. When actual rent becomes constant, we see the erratic movement of the capital values when initial yields changes accordingly. In fact, CV shoots higher than the developers’ expected retail rent between period 8 and 11 to S$24,700. CVs fluctuate between S$6,200 and S$24,700 psm p.a. and the CV starts to decline at Q19 to $17,200 with an increase in the initial yield.

The developers in the likely scenario, as compared to the optimistic scenario (next discussed) would represent a more realistic picture of the overall economy, and the developers would thus be able to realize higher CV as observed in Figure 8.
**The optimistic scenario**

To conduct a sensitivity analysis for the GDP growth scenario, growth factors of 0.5 percent to 7 percent are adopted. Results from Figure 9 produce the optimistic scenario’s forecasts that are similar in graphical shapes to the likely scenario of Figure 8. However, owing to developers being too positive on the overall economy, they form excessive rental expectations. These high expectations cannot be met, resulting in CVs that are worse than those in the likely scenario.

Compared to the likely scenario, CVs do not increase as uniformly as actual retail rent and the developers’ expected rent. Instead, the rate of rising CVs starts to decline as early as the Q4-quarter from the zero reference quarter (the start of the forecast period). CVs still manage to be higher than the actual retail rent as the cost barrier is too high.

The gap between actual rent and developers’ expected rent still lags by an amount of about $S3,337 psm p.a. CVs only rise to $S16,600 psm, which is much lower than the highest CV of $S24,700 psm for the likely scenario and the lowest being $S4,185 psm.

**The pessimistic scenario**

To conduct a sensitivity analysis for the SARS occurrence, where the probability ranges from 0 to 0.6, Figure 10 shows that the gap between the actual retail rent and the developers’ expected rent becomes narrower as the difference in amount is now $S3,240 psm, as compared to $S3,337 psm for the optimistic scenario.

![Graph 4 (Untitled)](image)

1: Yield (percentage per annum)
2: Actual retail rent ($S psm per quarter)
3: Capital value ($S per annum)
4: Developers’ expected retail rent ($S psm per quarter)

**Source:** Author; iThink program (2005)
CVs range from S$8,800 psm to S$35,000 psm. This highest CV level is even higher than that in the likely scenario in which the highest CV is S$24,700 psm. From Q19, the CV again shows a declining trend as it starts to fall to S$24,300 at the end of 20 quarters.

Figure 10 shows the adverse effect of the SARS Outbreak. With no SARS outbreak or by having it under control, CVs can be realized as high as S$35,000 psm *ceteris paribus*. But with a high probability of 0.6 for the SARS occurrence, CVs can be as low as S$8,800 psm. Thus, there can well be a wide disparity between the highest and lowest CV ranges. We see a higher increase in CV from the Q8 to Q11 quarters probably because during that period, the expectations of developers hold more optimism for a broad-based economy recovery and a lower probability of the SARS outbreak. Retail rent is therefore priced higher, even higher than the CVs in the likely scenario. However, with a higher SARS probability during Q19 (the 19th quarter) and expectations of developers beginning to fall off, CVs can then be seen to be tapering downwards.

**Conclusion**

This paper has taken system dynamics modeling to the next level of combining it with econometric analysis, to estimate the sensitivity of retail rent to cost in equation (11) and the change in retail rent of equation (15), for effectively structuring the process whereby the *ex ante* CVs of the prime retail sector in Singapore are formed, through a unique and rigorous expectations-centered system dynamics model of rents, cost, retail stock, general demand and exogenous factors. Such an expectations-centered system
dynamics model extends beyond the usual lags and time line aspect of the price discovery process, involving information efficiency to some degree, because the expectations of prevailing retail rental values are being formed through past transactions. Depending on how transparent the retail real estate market is, developers’ expectations are formed and adjusted to the actual retail rent through a time delay. In addition, a high fixed land cost creates a cost barrier, and this cost pressure in conjunction with expectation adjustments, would form negative feedback loops that prevent the full corrective actions of closing the information gap between the desired and actual rents. Such unanticipated side effects occur in a dynamic and complex closed system. The result is that the developers’ retail rent is not able to converge to the actual rent. The stock of retail space also determines the CV formation of the dynamic and complex retail real estate sector. The effect of costs on rent and the effect of retail stock on rent are factors that determine the value of actual retail rent, through the sensitivity ratio of costs on rent and the sensitivity ratio of the retail stock on rent.

Certain macroeconomic factors like Singapore’s GDP growth and SARS outbreak are introduced to investigate their impact on retail space CVs through sensitivity analysis, during the simulation forward-period of 20 quarters from the zero reference quarter (the current period, 2Q2002). Simulation runs of the expectations-centered system dynamics model are based on three different scenarios: likely current market scenario with GDP at a growth rate of 4 percent; pessimistic scenario with the SARS outbreak; and the optimistic scenario where there is robust GDP growth. Sensitivity analysis is conducted for the optimistic and pessimistic scenarios.

All three scenarios produce graphs of similar shapes. However, CVs of the optimistic scenario are anticipated to be lower than those of the likely scenario, owing to developers forming excessively high expectations that cannot be met by the actual rental levels. The pessimistic scenario results in the highest CVs. Based on bounded logic and the conditions for the three scenarios, there are huge differences in expectations that result in significantly large disparity in the endogenous CVs. Low actual rents for all three scenarios may well be the result of poor informational efficiency, as the prime retail sector is not transparent enough, and that many transactions are privately closed. Thus, expectations cannot be met as the market information is not disseminated extensively through the agents and players. Under an expectations-centered system dynamics model, CVs formed under the three scenarios for the next twenty quarters from 2Q2002 clearly highlight the problem of informational non-availability in the complex and dynamic retail (real estate) system. The main policy implication for Singapore’s retail real estate sector would be a more transparent system of sharing rental and pricing information of retail real estate. This is highly meaningful for real estate developers, investors and urban planners in order to sustain the viability of the retail real estate sector.

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**Further reading**


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