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Industrial Real Estate Market Dynamics in Singapore: A VAR Approach

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The behavioural structure of large and strategic industrial real estate accommodation does not exist in a vacuum. Instead, its fundamental investment values and yields are uniquely affected through the dynamic interaction among exogenous and endogenous forces related to the industrial real estate demand-supply conditions, macroeconomic and institutional polices as well as urban industrial plans. This study aims to understand the dynamic behaviour of the industrial real estate market in Singapore that is slowly transitioning from a capital intensive to knowledge intensive economy. Using data obtained from various sources between 2001Q4-2010Q2 which essentially capture three property cycles, we incorporate a vector autoregressive (VAR) approach to holistically model the industrial real estate market in Singapore with respect to its demand-supply conditions, market capitalization rates which encompass information about rental yields, capital values along with future expectations.

This study will help policy makers and developers to understand the structure of the industrial real estate market in Singapore along with respect to its macroeconomic conditions. The results are insightful as the data capture both the public and private markets along with a new hi-tech industrial accommodation (science parks), which is slowly gaining prominence as of the turn at the 21st century as Singapore strives to steer towards a knowledge based industrial economy.

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Keywords

Industrial Real Estate, Vector Auto-Regression, Capital Values, Rental Yields, Property Cycle, Singapore

1. Introduction

From large scale factories used for manufacturing, warehouses that act as distribution centres to the most recently high technology industrial research production centres that churn out new designs and products, industrial accommodation has always been the important backbone of any thriving economy. However, it is also the least studied in the academic literature (Rabianski and Black, 1997) among the other sub sectors of the real estate market (housing and office).

There are several reasons for this lacklustre in the literature, which range from sheer difficulty in predicting demand to high diversity and locational differences which make this sub sector more diverse than other sectors in terms of their functional characteristics. Thus when compared to the housing, office and retail markets, the relationship between demand created by employment and demographics is rather intuitive.

Industrial real estate has traditionally been owner occupied or occupied by a single (long term) tenant, which suggests the industrial space is directly for its occupants or built by them, and thereby, part of firm investment decisions (Wheaton and Torto, 1990). Due to this reason, the speculative portion of this sub-market is (or has been) quite small compared to either the retail or housing market. However, recent trends in industrialized countries suggest that this structure is changing as firms prefer more rental type facilities (Yuen et al., 2003) due to the heavy fixed costs involved in providing hi-spec facilities.

Singapore, a land constrained nation, has gradually transformed its economy from labour intensive and heavily reliant on manufacturing industries towards a more service oriented and more recently knowledge intensive economy over the past four decades. Manufacturing has been the traditional engine for growth which accounts for about 20.9% in 2011 down from an average of 25.17% from 1985 to 2000[1]. The service industry currently makes up about 69% of the share of the nominal gross domestic product (GDP)[2]. Industrial land comprises 12.2% as of 2000[3] of the 710 km^2 city state island. Also, much like other categories of land uses in Singapore, industrial land is predominantly owned by the state; as

[1] Sing (2003)
[2] See MTI http://www.mti.gov.sg/Pages/home.aspx
[3] http://www.ura.gov.sg/interim/report1.pdf

of 1985, the state owns approximately 76.2%[4] which is supplied to the market through government land sales programs or other government agencies, like the Urban Redevelopment Authority (URA), Housing Development Board (HDB), Port Authority of Singapore (PSA), Land Transport Authority (LTA) and Jurong Town Corporation (JTC), which is the public sector industrial landlord in Singapore responsible for providing serviced industrial spaces[5].

In land constrained Singapore, most of the industrial supply is master planned by the JTC. The government plays an important role in maintaining rents and capital values at affordable levels to keep industrial tenants (manufacturers, services, research and development (R&D)) onshore, which leads to increases in economic activity.

Another important feature of the industrial real estate market is its physical and functional obsolescence. Since Singapore has grown from a labour intensive industrial society into a hi-tech capital and more recently, involved in knowledge intensive industrial activities over a period of less than four decades, the rate at which purpose built factories and specific manufacturing plants are becoming obsolete is higher here than recorded in other countries[6].

Gradual shifts in the industrial landscape in Singapore are marked by a slow transfer from warehouses, single purpose factories that cater to the manufacturing of information communication technologies (ICT), food, other material industries to multi-purpose business parks, and hi-spec facilities that accommodate knowledge intensive sectors such as R&D, infocommunications, software consultancies, the media and the arts. The government, who recognized the importance of innovation driven growth the first year that the national technology plan was put together in 1991, allocated S$2 billion for R&D infrastructure and human capital development in fields such as microelectronics and semiconductors, electronic systems, manufacturing technology, food and agro technology, and biotechnology and the medical sciences. A second (1996-2000) and a third (2001-2005) five year plan of science and technology gave a boost for industries to focus on industrial R&D to develop new products that would expand markets, thus taking advantage of growing developing neighbours, like China, India, Indonesia and Thailand. The R&D expenditure as of 2005 stood at 2.4%, which is still low compared to South Korea (2.9%) Japan (3.1%), and the US (2.7%). However, in the 2007 budget, the Singapore government committed to increasing this amount by 3%. Human resources followed suit with this expansion, and the number of full time equivalent researchers in Singapore increased by over 11% in 2005 which is more than 90 researchers per 10,000 workers compared to less than 30 in 1990 (Abeysinghe,2007).

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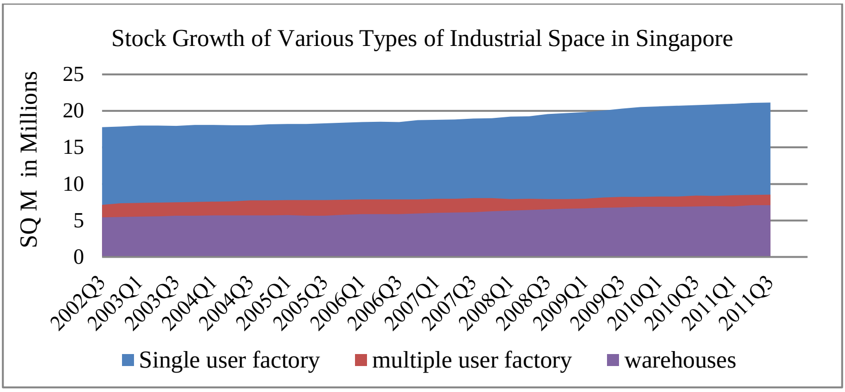
[4] Achieved by the state by the Land Acquisition Act (1966) see Zhu (2000)

[5] For more information on the role of JTC in the industrial real estate market in Singapore, see Sing (2003,p303)

[6] The reported depreciation rates for the U.S are around 2-3%.

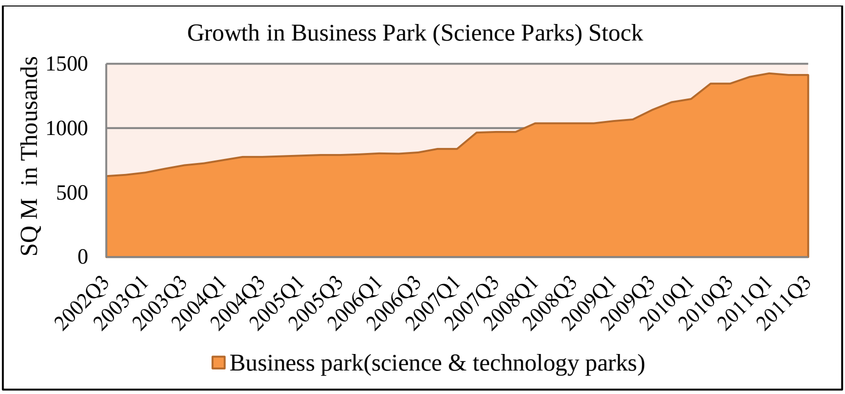
As the economy gears for this shift, demand for this new type of space would grow in importance; Figure 1 above depicts the rise in the stock of space for single and multi user factories and warehouses. From Figure 2 below, one can see the slow albeit steady emergence of this new industrial space in Singapore. To take this new entrant of industrial space into account, we will therefore incorporate characteristics of business parks (or science parks) into our overall analysis of the industrial real estate market in Singapore.

Figure 1 Industrial Space Distribution in Singapore (2002Q3-2011Q3)



Source: Realis, 2012

Figure 2 Chart that illustrates stock growth of business park space in Singapore (2002Q3-2011Q3)



Source: Realis,2012

In this paper, we hypothesize that the behavioural structure of all industrial real estate accommodations do not exist in vacuum. They are uniquely shaped through the dynamic interactions of industrial real estate demand-supply conditions, and macroeconomic and institutional polices. Together, these elements distinctively influence the demand-supply balance, capital values and rental yields of industrial real estate.

Owing to the unique industrial real estate market in Singapore, there is a lack of understanding on a holistic investment model that can track changes in the asset and space markets of the industrial real estate market. Also, since industrial real estate markets are more in tune with the economy and less with other real estate sub-markets, a pertinent research question could be 'Are there unique incubating environments for real estate value to be established (Space, Asset, Investment, Development, Market value) for the industrial real estate market ?' If so, how are they shaped in the case of Singapore? This could help us to describe a unique real estate value determination framework that can recommend real estate value enhancement solutions to stakeholders for wealth expansion activities. It is therefore useful to have an investment model of the supply and demand characteristics for the public and private industrial markets in Singapore. This would not only help us to understand the behavioural structure of the industrial real estate market in Singapore but also compare differences in choosing proxies to predict market cycles in other countries.

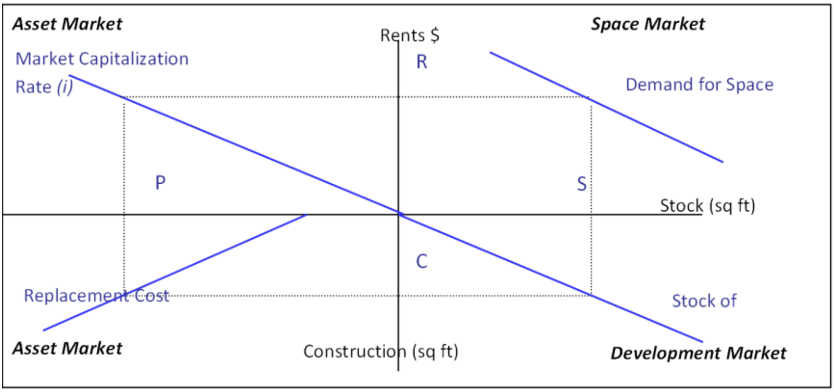
Rigorous econometric model estimations are conducted by using a vector autoregressive approach related to *industrial net space absorption, stock growth, vacancy rate,* and *capitalization rates that capture capital and rental values*. The required data set covers the relevant factors that affect the behavioural structure of industrial real estate from 2000:4 to 2010:1. The data set is obtained via local (URA & JTC) and international data sources as well as secondary private (Datastream & Realis, 2012) and institutional sources (JTC, 2012), thus giving us a clear understanding of the dynamical behaviour exhibited by the industrial real estate market in Singapore.

This paper is organized into several sections; the introduction section provided the purpose, objectives of the study along with the scope and methodology. The second section is concerned with the theoretical framework followed by a short review of the related literature. The third section discusses the selection of variables under VAR model specification. The fourth section describes the data and reviews the estimation results that describe how the island wide industrial property market behaves with respect to differences in macroeconomic demand and supply conditions. In the sixth section, we perform impulse response and variance decomposition analyses to evaluate our VAR model and conclude with the key results, and how the empirical results match our theoretical framework.

2. Theoretical Framework

This section provides a critical review of the related institutional and macroeconomic frameworks that enable a conceptualization of the factors which influence the behavioural structure of industrial real estate markets. The concept of the four-quadrant model by DiPasquale and Wheaton (1996) is introduced while the research hypothesis is framed from the literature review.

Figure 3 Stock-Flow Model of Real Estate Market



Source: DiPasquale and Wheaton (1996)

The stock-flow model by DiPasquale and Wheaton (1996) provides a simultaneous intuitive analysis of the (dis)equilibrium dynamics among the real estate space, asset, and development markets in an economy (Fig 3). In the context of this paper, spatial demand is derived from the usage of space by firms for production purposes, thus forming the basis for the real estate space market. Determinants of spatial demand by firms hinge upon their output levels and the relative cost of space. Central to occupancy cost is rent (R) (Fig 3), the annual outlay necessary to obtain the use of real estate which reflects the fundamentals of space markets in the northeast quadrant determines how much cash flow that a property can generate, thus forming its underlying physical asset value that is linked to the real estate asset market. The asset market is derived from the ownership of real estate and depicted under the northwest quadrant (see Fig 3). Ceteris paribus, when firms expand production with short-term inelastic supply, real rents (R) would rise. The reverse also holds true.

Asset pricing is also influenced by the market capitalization rate of real estate, which is reflected as *(i)* in Fig 3, and measures the direct positive ratio asset rent-to-price. It encapsulates the opportunity cost of capital, future expectations and risk perceptions of investors. It also measures the current yield that investors demand in order to hold real estate assets and is represented below.

$$\boldsymbol{P = R / i} \tag{1}$$

where P = Real estate asset price

R = Rent level
i = Market capitalization rate

The line in the southwest quadrant depicts the replacement cost of real estate assets. The curve does not originate from the asset price origin, which represents the minimum rate or return that developers seek for a feasible development to be embarked upon. Hence, new construction (C) which is the point of intersection between the southwest asset market and the southeast development market occurs at the replacement cost of real estate. This reflects yet another important aspect of the asset market: its governance of the flow of capital into the real estate property market. The flow of (C) is converted into a long-run stock of real estate space in the southeast quadrant as represented by the curved line that emanates from the origin. This curve constitutes the annual level of construction needed to replace the existing stock of space which deteriorates and depreciates over time and is represented below.

Thus, starting with an existing stock level (S) from the southeast quadrant, the property or development market determines (R) as it interacts with spatial demand in the space market. Subsequently, interactions between (R) with asset pricing capitalization rates (i) determine the asset price (P). This interaction further develops towards a comparison between replacement cost and (P) in the southwest quadrant, which would influence the development decision to add new construction (C) to (S) in the southeast quadrant.

$$\boldsymbol{\Delta S = C - \delta S} \qquad (2)$$

and supply of real estate space is captured as:

$$\boldsymbol{S = C / \delta} \qquad (3)$$

where S = Stock of real estate
C = New construction
δ = Depreciation

Overall, this stock-flow model explains that real estate markets are in equilibrium when the starting and ending stock levels equate. However, with short term adjustments in the rent, price and construction, disequilibrium occurs in which long term stock adjustments follow. In all, the stock-flow model serves as a framework of the fundamental dynamics and interactions of space, asset and development of the real estate market in this paper, where the stock-flow model of both the space and asset markets is a long-run model, given that construction exists.

However, the limitations of the model are that it does not trace the intermediate steps as the market moves to its new equilibrium, because the task of depicting intermediate market adjustments would require a dynamic system of equations that would complicate the analysis. To mitigate the inherent limitations of the model, an enhanced understanding of the space and capital markets, and appropriate structural behaviour that affects the pattern and movements of rents and prices can be further investigated by way of an autoregressive error approach. We employ this method to understand the behaviour of the industrial real estate market for the Singapore market.

The review on the demand and supply determinants of the industrial real estate in the next section further conceptualizes the potential underlying influences of industrial demand and supply conditions in influencing the structure and behaviour of the industrial real estate market.

3. Review of The Literature

The stock-flow model of DiPasquale and Wheaton (1996) offers a theoretical framework to explain the fundamental equilibrium adjusting dynamics and interactions of real estate space, asset and development market through short term adjustments in rent, price and construction.

Quantitative studies have proven to very useful in empirically estimating the cyclical movements of the industrial real estate market by using a set of information with regard to the forces that affect the demand and supply of space. These studies aim to identify key relationships in the industrial market which are essentially useful for developers, investors and even public officials (Thomson and Tscolacos, 2000; Sing, 2003; Wheaton and Torto, 1990; Kling and McCue, 1991).

One of the key variables that depict the behaviour widely identified in the literature is rents and prices (capital value), and industrial rents in turn have been reported to be affected by variables such as GDP, manufacturing output, industrial production and monetary variables (RICS,1994; Thomson and Tscolacos,1999; Atteberry and Rutherford,1993), and some studies have also related location specific factors that affect industrial rents (Ambrose,1990; Fehribach et al.,1993).

Despite the limitations of most of the earlier econometric empirical studies that revolved around North American and European markets, Koh (1987) is able to employ a two-stage least-square model by using the industrial market data of Singapore to study the relationship between industrial real estate demand and economic variables. Furthering which, through an autoregressive error approach, Ho (2005) empirically discovers the dynamics and structure between the office sector and capital value behaviour, in which the capitalization rate and the net space absorption behaviours are encapsulated within the real estate space, asset and property markets. Sing (2003) enhances econometric empirical studies on the industrial landscape by formulating a VECM to explain the dynamic relationship between private industrial space demand and other determinants by using industrial property market data from Singapore. Our paper will extend the previous analyses to the island wide industrial market.

Previous studies have used a simultaneous system of equations approach with a standard single equation ordinary least squares (OLS) to discover the dynamic interactions of various economic variables concerned with the industrial property market. Sims (1980), however, commends the use of VAR models in econometric modelling, due to previous criticisms of constraints imposed by the economic theory on more traditional economic models based on ordinary OLS or simultaneous equation systems (Thomson and Tsolacos, 2000). When used wisely, VAR based on economic reasoning can both fit the data and provide sensible estimates of causal relationships between variables (Stock and Watson, 2001).

4. VAR Model Specifications

There seems to be a predictable cyclical pattern that has emerged from the literature on the relationship between the macroeconomic conditions and property market aggregates (Mcgough and Tsolacos, 1997). Thus, theoretical intuition and previous empirical findings about different variables that affect the industrial real estate asset and space markets are used to guide us to our VAR model specifications. A discussion of the key variables and how we construct the equations with respect to our theoretical framework is given below.

4.1 Space Market Demand Drivers

With reference to the preceding stock-flow model, the identification and modelling of industrial real estate demand drivers in the space market should first be established. Subsequently, this allows the determination of rentals, capitalization rates and capital values in the industrial real estate asset market. The first equation that addresses the space market is the amount of new industrial space supplied in the market, as noted by DiPasquale and Wheaton (1996), is a function of higher levels of profitability. The level of profitability of industrial properties is given by construction costs and rents (or expected) and also the business climate of the quarter, where the first two exhibit negative and positive effects on the supply and the third a positive outlook respectively (Thomson and Tsolacos, 2000). However, for the industrial real estate market of Singapore, construction costs might be less significant due to fewer physical structures and compositions compared to its residential and office counterparts. Also JTC, the industrial master planner of the nation, may have some economies of scale by hoarding materials for construction activities, thereby avoiding high fluctuations in prices to deter the supply of space.

Industrial wholesale employment was empirically tested by DiPasquale and Wheaton (1996) as proxies to model industrial net absorption, and was found to be statistically significant. Yet the investment model in Wheaton and Torto (1990) for the demand and supply of real estate refutes the preceding empirical test, hence the precedent proxy has limited significance in determining industrial space demand. Consequently, to mitigate the problem, *manufacturing output* on its own is used as a proxy. The representation of the manufacturing sector has been found to be statistically significant and less problematic. DiPasquale and Wheaton (1996) have also analyzed the relationship between overall industrial productions against the *net space absorption* in the Philadelphia metropolitan areas, and found this to be significant. This is reinforced by the empirical model in Wheaton and Torto (1990).

DiPasquale and Wheaton (1996) have empirically tested through a vector error correction model that the change in real GDP is a strong determinant of industrial real estate demand. In Singapore, demand for industrial space is mainly for manufacturing (factory and purpose built models), warehousing and most recently, knowledge intensive sectors, such as biomedical, IT services, the media, the arts, etc., and thus a specific proxy would be the combined GDP of manufacturing and total (public and private) R&D spending. Both variables can cause an increase in demand for industrial space in Singapore. Another demand driver, the *Composite Leading Indicators* (CLIs), reflects business confidence and prospects, as well as the rational expectations of decision makers (Lucas, 1976).

Kling and McCue (1991) investigate the relationship between industrial property construction and the economy through VAR models, and implicitly highlight that supply lags demand. Changes in the *existing stock* could have resulted from a combination of changes in the completion of pipeline stock, vacancy and net absorption. Apart from reinforcing the relevance of the existing supply as an important value determining vector, Sing (2003) also addresses the short-run importance of *interest rates* in influencing supply.

4.2 Asset Market Demand Drivers

Past rental yields in the U.K. industrial market have been reported to strongly influence present values, thus making them important for the determination of current rents. Rents often travel inverse to occupancy levels in the space market, where a high *vacancy level* that indicates less demand will drive rents down in subsequent quarters. A well exhibited phenomenon would be the rent adjustment model which uses the search theory by Wheaton and Torto (1994). More often, the effect of demand pressures in the market that translates into changes in rents would depend on the degree of availability of industrial space for occupation. Overall, a negative relationship between floor space availability and rents is evident from historical data in Singapore.

Capital value that encapsulates the opportunity cost of capital, future expectations, risk perceptions and preferences of investors empirically tested by DiPasquale and Wheaton (1996) explains that capital value captures both existing rents *and* expectations of future rental growth. As a result, these factors serve as proxies to forecast capital value through incorporation into *cap rate determinants*. The asset market is determined by existing capital values. In Singapore with the introduction of the strata industrial title, industrial properties, especially business parks, are becoming increasingly attractive as an investment vehicle. We use cap rates[7] to take into account changes in *capital values* and their associated *rental yield* because the market cap rate tells us two things: more demand for property as an investment means lower cap rates, and overheating of the market by higher rental yields compared to the purchase price might bring in more supply. In simple terms, an increase (decrease) in market capital rates indicates a decrease (increase) in capital values[8].

4.3 Space and Asset Market Supply Drivers

Wheaton and Torto (1990) have also highlighted the importance of the cost of capital in influencing industrial real estate demand, and incorporated long-term corporate AAA rated bonds with expected inflation based on a four-period average lag of current and past inflation.

In Singapore, the supply of industrial land is determined by the government land sales program; hence, inelastic supply of space will have major repercussions on the dynamics of the real estate market. Therefore, we will proxy ‘new industrial completed stock’ to account for the supply side of the equation. In accordance with our literature review, our structural VAR model which captures the space, asset and development markets for the industrial real estate market is as follows:

$$\begin{aligned} Y_i &= \sum \beta_0\, \Delta GDP_{t-1} + \sum \beta_1\, \Delta PLR_{t-1} + \sum \beta_2\, \Delta VC_{t-1} \\ &\quad + \sum \beta_3\, \Delta NSTOCK_{t-1} + \sum \beta_4\, \Delta NABIS_{t-1} + \sum \beta_5\, \Delta Cap_{t-1} \\ &\quad + \sum \beta_6\, \Delta CLI_t + \sum \beta_7\, \Delta TB_t + \sum \beta_8\, \Delta CC_t + \varepsilon_t \qquad (4) \end{aligned}$$

NABIS = Net absorption of industrial space, GDP_t = Absolute contributions to gross domestic product from the manufacturing sector , PPI_{t-1} = Overall industrial property price index lagged by one period, NSTOCK = growth of real estate stock in each period(in sqm), PLR_{t-1} = Prime lending rate (lagged by one period),CLI = Composite Leading Indicator, VC_t=vacancy rate, CPI = Consumer Price Index of the Singapore economy* , TB_t = Government T-Bond yield* , *exogenous*

[7] see Appendix 1 for description and construction of cap rate variable

[8]For ease of interpretation, the ratio of capital value to rents is assumed to be constant. This is not too strong since historical trends in Singapore confirm this relationship. Thus increases in cap rates are mostly caused by rising rents and decreases by rapidly increasing capital values.

where i in Y_i represents all six endogenous variables as the dependent variable, thus giving us a set of six specifications which holistically models the entire industrial real estate market in Singapore.

In theory, if the industrial real estate market is efficient and in equilibrium, all macroeconomic conditions that affect demand and supply would be fully reflected in the prices which would determine the volume of new supply in the future (DiPasquale and Wheaton, 1996). However, real estate markets tend to be inefficient, thus other factors such as interest rates (t-bonds), economic outlook (given by CLIs), and material costs (CC) are incorporated as exogenous variables since they are determined by activities in the global market which lie outside our endogenous VAR specifications.

The CLIs anticipate turning points in economic growth cycles[9] and can be important for explaining the decisions taken by developers on whether to build at every time t. We treat all of the above variables as *endogenous,* thus leaving CLI, T-bond yield and cost of construction as e*xogenous* supply variables which represent the development market in our model. This is because we feel that they are not inherently involved in the dynamics of space and asset markets in Singapore[10] but act as an external factor which determines decisions about timing of supply in the development sector.

5. Data Description

We utilize a ten year quarterly time series data provided by the URA for information that pertains to stock levels and rental yields for industrial real estate in Singapore. Although the time period is not too long (36 quarters), there has been three cycles as indicated by the industrial property price index in Singapore (base=2005). As shown in Figure 4, we believe, however, that this captures the sufficient dynamics of the industrial real estate market in Singapore.

Economic variables like combined GDP (includes manufacturing and R&D), CLIs, prime lending rate and government treasury 10 year bond yields were obtained from DATASTREAM. Some variables were converted into their log forms for ease of interpretation, apart from which, all the variables were

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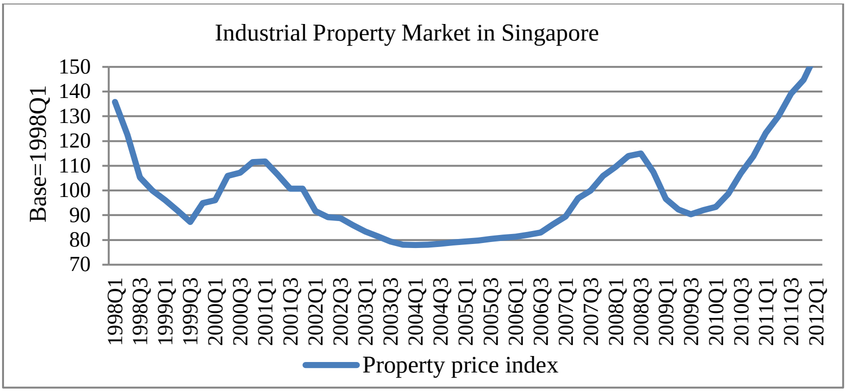
[9] For Singapore, the CLIs include the following time series, total new companies formed, money supply, stock exchange of Singapore indices, business expectations for stock of finished goods (manufacturing sector), business expectations for wholesale trade, US purchasing managers' index manufacturing),total non-oil seaborne cargo handled, domestic liquidity indicator (DLI) and total non-oil retained imports (NORI).

[10] In Singapore, construction cost matters more for private developers. Since the JTC owns most of the industrial space, they are almost always able to keep stock of material supply to ride price fluctuations.

integrated of order one I(1), which were subsequently differenced before employing the VAR model.

Figure 4 Quarterly Time Series of Industrial Property Price Index of Singapore



Source: Realis, 2012

We however do not find the set of chosen variables to co integrate over time, thus rejecting the use of an error correction mechanism. For modelling the entire industrial real estate market in Singapore, we choose to use an unrestricted VAR approach instead of a vector error correction mechanism, which was found to be more appropriate to the private industrial real estate market in Singapore as shown by Sing (2003). Descriptive statistics of the concerned variables are given below in Table 1.

6. VAR Model Estimation

From the above selected variables, we construct our empirical model to predict the dynamics of the industrial property market in Singapore. The estimation is carried out by using an unrestricted VAR model which consists of five endogenous and three exogenous variables.

The structural form of the VAR equations to be estimated with the respective endogenous variables is as follows, and for ease of understanding, we have split them into space and asset market equations in accordance with our theoretical framework.

Table 1 Descriptive Statistics

	NET_ABSORPTION	CAP_RATE	NSTOCK	VACCANCY_RATE	GDP	PLR	CLI	T_BOND	CC
Mean	4.932855	0.049776	4.942574	10.915790	9.495099	5.374737	99.63421	3.068684	0.665789
Median	5.158992	0.053050	5.422684	11.10000	9.512764	5.330000	99.70000	3.105000	0.550000
Maximum	6.692065	0.070200	6.238325	14.25000	9.785115	5.800000	119.3000	4.090000	10.70000
Minimum	0.000000	0.021900	0.000000	6.900000	9.165829	5.300000	83.30000	2.030000	-10.00000
Std.Dev	1.108813	0.015707	1.378164	2.258321	0.194855	0.132027	9.937134	0.575740	3.751704
Skewness	-2.426520	-0.732796	-2.581620	-0.246424	-0.172553	2.686059	0.049409	-0.116435	-0.782187
Kurtosis	11.54792	2.249756	9.526227	1.937658	1.633291	9.015034	1.959639	2.025762	5.973732
Jarque-Bera	152.9801	4.292137	109.6469	2.171491	3.146070	102.9805	1.729183	1.588665	17.87639
Probability	0.000000	0.116943	0.000000	0.337650	0.207415	0.000000	0.421224	0.451883	0.000131
Sum	187.4485	1.891500	187.8178	414.8000	360.8138	204.2400	3786.100	116.6100	25.30000
Sum Sq. Dev	45.49027	0.009128	70.27539	188.7005	1.404829	0.644947	3653.626	12.26463	520.7855
Observations	38	38	38	38	38	38	38	38	38

Space market

$$\Delta NABIS_t = \mu + \sum \alpha_0 \, \Delta GDP_{t-1} + \sum \alpha_1 \, \Delta PLR_{t-1} + \sum \alpha_2 \, \Delta VC_{t-1} + \sum \alpha_3 \, \Delta NSTOCK_{t-1} + \sum \alpha_4 \, \Delta NABIS_{t-1} + \sum \alpha_5 \, \Delta Cap_{t-1} + \sum \alpha_6 \, \Delta CLI_t + \sum \alpha_7 \, \Delta TB_t + \sum \alpha_8 \, \Delta CC_t + \varepsilon_{0t} \quad (5)$$

$$\Delta VC_t = \mu + \sum \beta_0 \, \Delta GDP_{t-1} + \sum \beta_1 \, \Delta PLR_{t-1} + \sum \beta_2 \, \Delta VC_{t-1} + \sum \beta_3 \, \Delta NSTOCK_{t-1} + \sum \beta_4 \, \Delta NABIS_{t-1} + \sum \beta_5 \, \Delta Cap_{t-1} + \sum \beta_6 \, \Delta CLI_t + \sum \beta_7 \, \Delta TB_t + \sum \beta_8 \, \Delta CC_t + \varepsilon_{0t} \quad (6)$$

$$\Delta PLR_t = \mu + \sum \gamma_0 \, \Delta GDP_{t-1} + \sum \gamma_1 \, \Delta PLR_{t-1} + \sum \gamma_2 \, \Delta VC_{t-1} + \sum \gamma_3 \, \Delta NSTOCK_{t-1} + \sum \gamma_4 \, \Delta NABIS_{t-1} + \sum \gamma_5 \, \Delta Cap_{t-1} + \sum \gamma_6 \, \Delta CLI_t + \sum \gamma_7 \, \Delta TB_t + \sum \gamma_8 \, \Delta CC_t + \varepsilon_{0t} \quad (7)$$

The six equations together form a complete system of dynamic equations where α, β, γ , ζ , ξ and κ are the structural parameters of each endogenous variable which when estimated, will depict the complete behavioural structure of the industrial real estate market in Singapore.

Asset market

$$\Delta CAP_t = \mu + \sum \zeta_0 \, \Delta GDP_{t-1} + \sum \zeta_1 \, \Delta PLR_{t-1} + \sum \zeta_2 \, \Delta VC_{t-1} + \sum \zeta_3 \, \Delta NSTOCK_{t-1} + \sum \zeta_4 \, \Delta NABIS_{t-1} + \sum \zeta_5 \, \Delta Cap_{t-1} + \sum \zeta_6 \, \Delta CLI_t + \sum \zeta_7 \, \Delta TB_t + \sum \zeta_8 \, \Delta CC_t + \varepsilon_{0t} \quad (8)$$

$$\Delta \, NSTOCK_t = \mu + \sum \xi_0 \, \Delta GDP_{t-1} + \sum \xi_1 \, \Delta PLR_{t-1} + \sum \xi_2 \, \Delta VC_{t-1} + \sum \xi_3 \, \Delta NSTOCK_{t-1} + \sum \xi_4 \, \Delta NABIS_{t-1} + \sum \xi_5 \, \Delta Cap_{t-1} + \sum \xi_6 \, \Delta CLI_t + \sum \xi_7 \, \Delta TB_t + \sum \xi_8 \, \Delta CC_t + \varepsilon_{0t} \quad (9)$$

$$\Delta GDP_t = \mu + \sum \kappa_0 \, \Delta GDP_{t-1} + \sum \kappa_1 \, \Delta PLR_{t-1} + \sum \kappa_2 \, \Delta VC_{t-1} + \sum \kappa \, \Delta NSTOCK_{t-1} + \sum \kappa_4 \, \Delta NABIS_{t-1} + \sum \kappa_5 \, \Delta Cap_{t-1} + \sum \kappa_6 \, \Delta CLI_t + \sum \kappa_7 \, \Delta TB_t + \sum \kappa_8 \, \Delta CC_t + \varepsilon_{0t} \quad (10)$$

The reduced form p-th order VAR represented in Eq (4) can be denoted by VAR (p) and represented as follows:

$$y_t = \mu + A_1 y_{t-1} + A_2 y_{t-1} \dots . + A_n y_{t-1} + \varepsilon_t \quad (11)$$

where μ is a $K \times 1$ vector of constants that represent the intercepts, A_i is a $K \times K$ matrix for every $i=1$ to p, p being the lag specified. The error term ε_t, $k \times 1$ vector of error terms satisfy all three assumptions of a VAR equation (zero means, no serial correlation and contemporaneous covariance matrix).

The above VAR specifications were subjected to four lags after running an Eviews function, the lag order selection criteria, based on various independent statistics[12]. As mentioned previously, the Johansen co-integration tests results showed no signs of co- integrating vectors, thus leading to the conclusion that the variables selected do not exhibit long run equilibrium at least within our chosen time span.

7. Estimation Results

Although VAR models are generally evaluated by using impulse response and variance decomposition methods (next section), the estimated coefficients do give us some expected results in accordance with our theory and are reported in Table 2.

The augmented Dickey-Fuller test results for unit roots confirm that all the variables attained stationarity after first differencing. The VAR estimated equations exhibited non-constant variance, hence, they were subjected to weighted least square estimations. The Akaike and Schwarz information criteria indicated lags up to four as the most appropriate structure for Eqs (5-10).

First, we look at the weighted least square regression (WLS) coefficients for the estimated equations, Eqs (5)-(10), as given in Table 2. The net absorption is highly volatile and hence a one percentage positive change in the previous period leads to a revision of 1.2 percentage points downwards in the current period. This effect gradually slows down. Similarly, a one percentage change in the cap rate two quarters in the past will reduce demand for net absorption by 31%. As we know, a positive change in the cap rate should entail an increase in rentals to capital value which in turn reduces demand for space in the near future. A simple Granger causality test at two lags confirms this result[13].

Adding more supply in previous quarters does not have a significant effect on the present take up of space for industrial activity, however, an increase in vacancy ($\Delta 1\%$) in the previous quarter leads to increases in the take up of space ($\Delta +0.30\%$) due to perhaps less competition for space, which translates to lower rents. Vacancy increases ($\Delta 1\%$) two quarters back does however reduce net absorption ($\Delta -0.297\%$) in the present, which taken together with the first result,

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[12] Lags were selected by using Akaike and Schwarz information criteria and final prediction error (FPE).

[13] Granger causality tests results can be obtained upon request.

would mean net absorption peaks right when new supply comes into the market and reverses as competition brings back rents to their equilibrium level.

An increase in the GDP which includes manufacturing output and R&D expenditure in any of the previous four quarters always increase the present net absorption. It is the highest of course during the first quarter. A one percentage positive change of the GDP in the previous quarter increases net absorption by 5.75%, and this is statistically significant at the one percent level. The Granger causality tests indicate that the causality is the strongest in the first two quarters following a change in the GDP levels.

An increase in the prime lending rate in general leads to less expansionary activities, thus reducing demand for space, but its effect lags by three to four quarters. However, a one percentage positive change in the lending rate in the previous two quarters leads to a 16% change in net absorption in the same direction, which might suggest a lag in the decision of a firm to take up space. Also, a positive economic outlook reflected by the CLIs exhibits a positive effect on net absorption in general.

Moving to what drives the capitalization rates for industrial real estate, although the coefficients look small, the actual numbers that represent the cap rates are larger; for example, a one percentage positive change in the net absorption three quarters back will cause a 0.006%[14] change in the present cap rate. Since cap rates in our specifications are differences, this change actually works up to a 25-27% increase in the actual cap rates. Since the ratio of the capital value to rentals in Singapore is almost at a constant level, increases in the cap rates can be attributed to rapidly rising rental yields.

The new supply in Singapore is governed by the land sales program that seems to behave independently from profit driven free land markets. In theory, as the capital values rise, keeping other things constant, developers would start construction activity which leads to an increase in new supply of industrial space. Although the inverse relationship and a large coefficient between cap rates (t-i,i=1,2) and new stock (t) seem to back this, it is not significant. An increase in the change of supply in previous periods almost always leads to a reduction in the supply in the current period; this is evident from a simple plot of the changes in the total industrial supply in Singapore.

[14] Increases in the cap rate may indicate market wide strong rental yields with respect to constant capital values.

Table 2 Weighted Least Square Regression Coefficients of The Unconstrained Vector Autogressive Models Eqs (5)-(10)

Dependent Variable	**Δ *NABIS*$_t$ Eq.5**	**Δ *CAP*$_t$ Eq.6**	**Δ *NSTOCK*$_t$ Eq.7**	**Δ *VC*$_t$ Eq.7**	**Δ *GDP*$_t$ Eq.9**	**Δ *PLR*$_t$ Eq.10**
Constant	-0.016	-0.001	-0.242	0.006	-0.042***	-0.044***
Δ NABIS $_{t-1}$	-1.280***	0.000	0.157	0.044	-0.033**	-0.001
Δ NABIS $_{t-2}$	-0.677***	0.004	0.805	0.007	-0.045*	-0.053***
Δ NABIS $_{t-3}$	-0.515***	0.006***	0.944	-0.040	-0.007	0.028**
Δ NABIS $_{t-4}$	-0.365***	0.000***	0.584	-0.096	-0.048**	-0.012
Δ Cap$_{t-1}$	11.351	-0.267	-74.043	37.187	3.330	-3.423
Δ Cap$_{t-2}$	-31.516**	0.351**	-5.214	-10.691	5.357**	6.492***
Δ Cap$_{t-3}$	8.406	0.230*	46.449	-29.579**	-2.564	-2.883
Δ Cap$_{t-4}$	-11.683	0.126	-47.552	-1.593	1.053	3.756
Δ NSTOCK$_{t-1}$	0.057	0.001**	-0.712***	-0.023	-0.005	-0.009
Δ NSTOCK$_{t-2}$	0.018	0.002***	-0.517**	-0.153**	-0.023**	-0.007
Δ NSTOCK$_{t-3}$	0.029	0.001**	-0.574**	-0.137***	0.001	0.017***
Δ NSTOCK$_{t-4}$	-0.097**	0.000	-0.469**	-0.005	0.003	0.035***
Δ VC $_{t-1}$	0.373**	0.001	-0.299	0.310*	0.032	0.115***
Δ VC$_{t-2}$	-0.297**	-0.005***	-0.966*	0.385***	-0.014	0.008
Δ VC $_{t-3}$	0.029	-0.001	-0.593	-0.238	0.025	-0.129***
Δ VC $_{t-4}$	-0.097	0.001	-0.032	0.017	-0.074***	0.024**

(Continued…)

(Table 2 Continued)

Dependent variable	Δ ***NABIS***$_t$ **Eq.5**	Δ ***CAP***$_t$ **Eq.6**	Δ ***NSTOCK***$_t$ **Eq.7**	Δ ***VC***$_t$ **Eq.7**	Δ ***GDP***$_t$ **Eq.9**	Δ ***PLR***$_t$ **Eq.10**
ΔGDP_{t-1}	5.759***	0.002	4.767	-0.776	-0.028	0.181**
ΔGDP_{t-2}	2.416**	-0.010	-4.621	-0.568	-.400**	1.169***
ΔGDP_{t-3}	3.101**	-0.033**	-8.204	-2.175	0.401**	0.171
ΔGDP_{t-4}	2.476**	0.015	-3.866	-4.096**	0.623**	0.414***
ΔPLR_{t-1}	1.232	-0.003	9.702*	-2.403*	-0.023	0.324***
ΔPLR_{t-2}	16.412***	0.005	-5.137	2.403	-0.075	-0.311*
ΔPLR_{t-3}	-2.880	-0013	-0.395	-0.973	0.576	1.156***
ΔPLR_{t-4}	-6.927**	-0.070*	-15.899*	-0.133	-0.452	-0.581**
ΔCLI	0.079**	-	0.204	-0.042	0.027***	0.015***
ΔT-Bond yield	-0.122	-	-0.511	-0.037	-0.07***	-0.073***
ΔCC	-0.048*	-	0.015	-0.070**	-0.009**	-0.016***
Adj. R-squared	0.892781	0.538929	0.139309	0.456878	0.320581	0.743427
F-Statistic	12.41062	2.601773	0.832438	2.152766	1.646602	4.970678

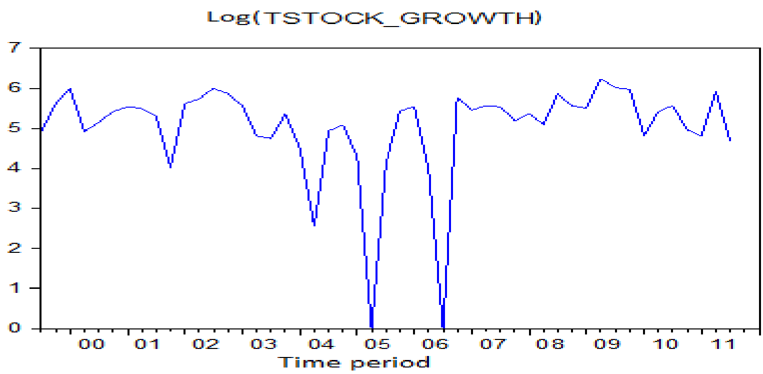
Notes: *.** and *** denote that coefficient is significant at 10%, 5% and 1% levels respectively.

A positive change in the prime lending rate (Δ+1%) four quarters prior curtails a new supply of industrial space (Δ-15%) for industrial activity at present, possibly due to less competition among buyers, and thus less value attained from auctions at higher lending rates. Finally, an increase in the vacancy in previous periods reduces supply in the current period, a result that is consistent with our theory.

The model seems robust in explaining these trends; the specifications were selected based on the lowest Akaike and Schwarz criteria. Our model also exhibited no autocorrelations at and above four lags, and normality tests concluded that the residuals are normally distributed. The Breusch Godfrey serial correlation LM test, which can be used for up to 4 lags, showed no positive serial correlation which makes the coefficients consistent and robust.

However good the structural coefficients are in a VAR model, we always need to be careful about their casual interpretation as time aggregation, omission of variables and random shocks may distort direct policy conclusions. For this reason, we will look at impulse response functions and perform a variance decomposition analysis for better interpretability of the results.

Figure 5 Graph That Illustrates Industrial Stock Growth in Singapore (2000-2011)



Source: Realis, 2012

8. Impulse Response and Variance Decomposition Analyses

VAR methods have a unique advantage over other econometric analysis in that the analysis does not need to conform to the economic theory (Sims, 1980). However, a structural VAR can use the economic theory to sort out the links between variables through time, albeit with the help of institutional knowledge about the system of study (Sims, 1986; Bernanke, 1986; Blanchard and Watson, 1986).

Our structural VAR in the previous section was used to make causal interpretations by using the four quadrant theoretical framework that describes the real estate dynamics with the variables involved. Although the above causality model is insightful for policy makers to understand the relationships, there might be other hidden variables in the macroeconomic structure that might change, thus making it difficult to draw concrete inferences on the behaviour of interdependent time series variables. Therefore, structural inferences and policy analysis are difficult since they require differentiating correlation with causality. This would be the classical identification problem in econometrics, a problem which is hard to solve by using statistics but usually mitigated with institutional knowledge about the subject of study (Stock and Watson, 2001).

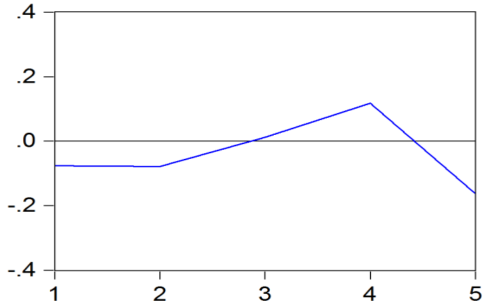
The most powerful function of VAR modelling lies in its ability to forecast and observe multivariate relationships between contemporaneously correlated time series. VAR modelling, such as that performed in this study, offers an alternative to structural causal modelling where the inter temporal optimizing behaviours of individuals and firms are not captured (Lucas and Sargent,1979, Sims, 1980).

The two tools which illustrate such dynamics are the *impulse response* and *variance decomposition analyses.* The former traces the response of endogenous variables to change in one of the innovations (error term). As noted by previous authors, the ordering of variables is important, so we used the conventional Cholesky-dof adjusted decomposition method provided by E-views to convert the structural VAR model into a recursive system which was subjected to evaluation.

We only report four specific impulse response functions for brevity, and illustrate the behavior of the industrial real estate market in Singapore. In Figure 3 below, we see that one standard deviation positive shock to the net absorption, thus signaling that expansionary activity leads to a negative effect on vacancy rates for the next two periods and then slightly rising (possibly due to sub-letting activities in the wake of competitive rents) in the third period only to fall back into the negative band again.

To speculate on the sudden increase in the third quarter, this may be attributed to existing industrial tenants who are freeing up space to gain in on short term rental increases due to a phenomenon widely noted through the subletting activities of large scale tenants in Singapore.

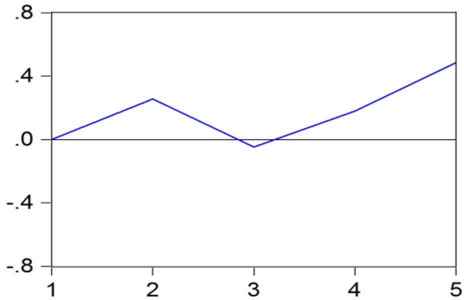
Figure 6 Response of Vacancy Rates to Cholesky one S.D. to Net Absorption innovation



Similarly, an increase in the GDP increases production, shown as a one standard deviation positive shock that increases the net absorption of space on the island over the next few quarters, as shown in Figure 4 below.

An unexpected one standard deviation positive shock to the GDP (S$ 2580 million) in the current quarter will cause an increase in the net absorption by 0.25 (10,230 sq m) in the next quarter. The expansionary process leads to increases in space absorption in the space market, thus leading to increases in rents and capital values in the short term. Keeping the cap rates stable, as soon as the existing stock has been leased, we can see a sudden upward change in the cap rate, thus reflecting competitive rents, since the stock of new supply takes time. These healthy rental figures proceed for a short business cycle and trigger new development of space in the asset market (Figure 1).

Figure 7 Response of Net Absorption to Cholesky One S.D. to GDP[15] Innovation

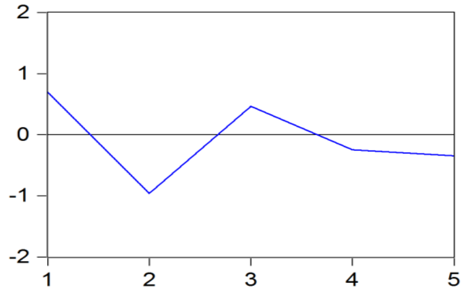


As the theory predicts, the effect of this increase in the cap rates should bring in new supply. In considering that industrial premises take a short while to

[15] Accounts for manufacturing and R&D

service, we should see new space coming into the market in the first couple of quarters. However, as Singapore constricts supply through a land sales program which has near complete autonomy, the supply of new industrial space is out of sync, and shows an intermittent supply in the short and long terms as shown below.

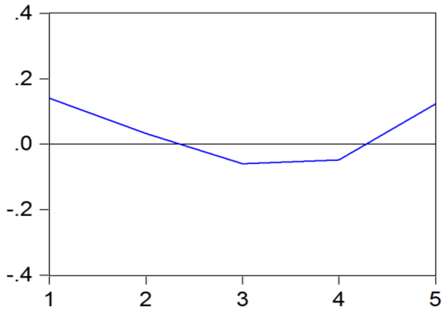
Figure 8 Response of Stock Growth to Cholesky One S.D. to Capitalization Rate



This point is evident when we look at the shocks to the new supply variable and its effect on the vacancy rates in Singapore. In the figure below, it is hard not to notice that the new supply of stock does not raise the vacancy levels much. It increases in the first quarter to fall back, leaving almost an unaffected inflow of new stock.

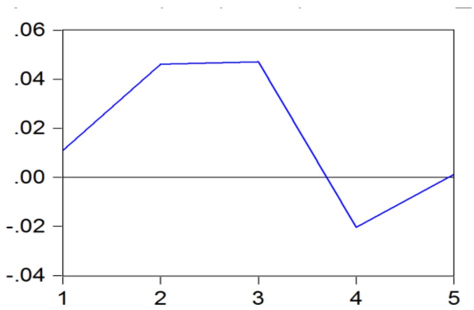
This can imply that making new space available may be timed according to industrial needs. The government might ensure that there is less overbuilding in order to keep the rentals in a steady state, and avoid wide fluctuations, which would lead to ease of doing business in Singapore.

Figure 9 Response of Vacancy Rate to Cholesky One S.D. to Stock Growth



Although rental fluctuations do appear in Singapore, one inference is that they might not be due to the supply but rather, the fluctuations in local and global economic demand. For example, in our sample, the CLI which predicts future economic activity is highly negatively correlated (-0.70) to vacancy rates. On the supply side, an increase in vacancy rates in Singapore seems to be followed by higher interest rates as seen in Figure 10.

Figure 10 Response of Prime Lending Rate to Cholesky one S.D to Vacancy Rates



A one standard deviation positive shock to vacancy rates (~2.2%) is followed by an increase in interest rates by 11 basis points in the first quarter to 40 basis points in the second and third quarters.

9. Variance Decomposition Analysis

Variance decomposition analysis marks the importance of the impact of each variable relative to each other with respect to random innovation shocks to the entire system. We will be able to determine how much of a change in a variable is due to its own shock and how much is due to shocks in other variables in the system. We report three important variables: net space absorption, and changes in cap and vacancy rates, to capture the essential dynamics of the market. Table 3 shows the variance decomposition of other variables due to a one standard deviation (0.46) shock given to the net absorption of space which comes up to 146.40 sq m. We observe all of the shock is absorbed by itself in the first period followed by variables such as cap rates (11%), GDP (10%) and most importantly, vacancy rates (25%) by the fifth period as shown in Table 4.

A shock to the cap rate (Table 4), which when increased, indicated that favourable rental yields could in theory influence absorption, stock growth and vacancy rates, all features of the asset market more than any other variable. Results are expected as the table below shows shocks to cap rate influence net absorption, stock growth and vacancy rates in order of importance. Similarly, changes in the prime lending rate are captured almost immediately by net absorption and vacancy rate. This coupled with regression modelling predicts an substantial increasing effect on vacancy rates as the lending rate goes up.

Granger causality tests of up to four lags also show this unidirectional relationship .

10. Summary of Key Results

In looking at some of the results that we obtained, we can compare our findings with respect to the four quadrant theoretical model proposed by DiPasquale and Wheaton (1996) to see how different the industrial market in Singapore performs. Starting from the asset market, the demand for space is mainly driven by increases in manufacturing output as well as R&D expenditure in previous quarters; this is consistent with previous studies. A decrease in the prime lending rate does spur some growth in demand, although with a lag of more than two. The CLI is a good predictor of industrial demand in Singapore, as it shows positive correlation with future demand. A Granger causality up to three lags does support this observation.

One of the key variables that predicts the behaviour of industrial real estate widely identified in the literature is rents and prices (capital value). Industrial rents have been reported to be affected by variables such as GDP, manufacturing output, industrial production and other monetary variables (RICS,1994; Thomson and Tscolacos,1999; Atteberry and Rutherford,1993). Some studies have also related location specific factors that affect industrial rents (Ambrose,1990; Rutherford and Eakin,1993).

The study finds positive effects of lagged manufacturing output on industrial space absorption. This is significant and consistent for all four lags that we incorporated. This result complements findings from studies in the U.S (Wheaton and Torto,1990) and U.K (Giussani & Tsolacos,1994; Nicholson and Tebbutt,1979); however, it contradicts with Sing (2003) who finds a negative relationship by employing a vector error correction mechanism for the private industrial market in Singapore from 1985 to 1999.

We also find that island wide rents are strongly influenced by vacancy and absorption rates, and rents in previous quarters, which give evidence of serial correlation (up to 10-12 periods), similar to ones found in the housing markets (Gyourko and Glaeser,2006). In fact, in a separate exercise, we split one of our endogenous variable 'capitalization rate' into its separate components of 'average rental yields' and 'capital values' and put them as two separate variables into the VAR modelling to observe the impact of rents on itself. The average rents in the first period exhibits strong persistence even after four quarters (as shown in Figure 5). An unexpected one standard deviation shock to average rents ($4.26) in the current period leads to increase of $2.75 in average rents in the following two quarters.

Table 4 Variance Decomposition of Net Absorption

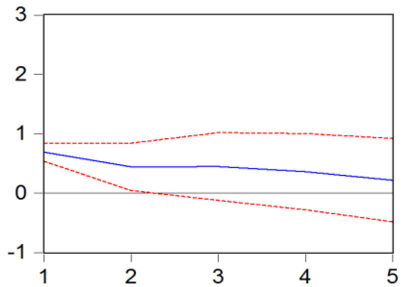
Period	S.E.	D(NET_ABSORPTION)	D(CAP_RATE)	D(NSTOCK)	D(VACCANCY_RATE)	D(GDP)	D(PLR)
1	0.4622	100.000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.8481	79.951	0.1777	1.0333	9.6568	9.0604	0.1196
3	1.1210	70.239	2.1012	7.9862	5.8073	5.3656	8.5002
4	1.5578	46.689	6.8961	4.1531	27.554	4.0986	10.608
5	1.8246	41.434	11.082	3.5831	24.934	10.046	8.9186

Table 5 Variance Decomposition of Cap Rate

Period	S.E.	D(NET_ABSORPTION)	D(CAP_RATE)	D(NSTOCK)	D(VACCANCY_RATE)	D(GDP)	D(PLR)
1	0.0038	12.970	87.029	0.0000	0.0000	0.0000	0.0000
2	0.0046	18.401	64.738	16.476	0.0762	0.1640	0.1432
3	0.0066	44.625	37.068	8.7602	7.5859	1.4951	0.4649
4	0.0067	43.528	36.359	8.8807	8.4898	2.1814	0.5602
5	0.0069	42.330	34.605	8.4085	8.7699	5.2782	0.6070

However, our supply side variable, stock growth, does not have a good fit; none of our macroeconomic variables seem to explain its behaviour, possibly due to heavy government intervention and autonomy over supply of land for industrial purposes in Singapore.

Figure 11 Response of Av_rent to Cholesky one S.D to Av_rent



In general, we find that a one standard deviation shock given to stock growth (~1334 sq ft) in the current period causes average rents to spiral downward by $6 and $1.87 in the second and third quarters respectively only to recover back into positive bands from the fourth quarter onwards. This shows the sensitivity of stock supply on average rentals in Singapore. Public authorities need to take caution as its supply side policies might have a deep impact on industrial occupancy through adjustments in rental yields.

Although the land supply is in the hands of the state, the timing of new supply follows those noticed in completely free markets, Factors such as lending rates and vacancy have a negative impact on new supply, however, construction cost fluctuations have no impact, as possibly JTC rides these unexpected waves by storing materials for construction activities.

11. Conclusion

The objective is to study the fundamental structure and behaviour of industrial real estate in Singapore, and broadly indicate the relative impacts of macroeconomic variables at different time-lags. The structure and function of industrial real estate in developed economies are fundamentally changing, moving away from a traditional factory type model to a more adaptable spaces that accommodate creative and knowledge intensive industrial activities. Thus we need dynamic models to understand how space and asset markets are shaped through endogenous and exogenous factors.

The academic literature on the dynamics of industrial real estate is scarce with a few exceptions (Thomson and Tscolacos, 2000; Sing, 2003; Wheaton and

Torto, 1990; Kling and McCue, 1991) compared to its counterparts in the housing and office markets (Mankiw and Weil, 1989; Case and Shiller, 1989; Quigley; 2002; Glaeser and Gyourko, 2006; Case and Mayer, 1996; Sivitanides et al., 2003). This study therefore makes some contribution in this direction by taking the case of the industrial real estate market in Singapore. We find that this sub market does follow most of the theoretical predictions of the four quadrant model proposed by DiPasquale and Wheaton (1999), however, we find supply bottlenecks in our case by government intervention can lead to disruption of the equilibrium process. The VAR model that we propose performs well to past data and can be used to predict near future dynamics when one or more endogenous macroeconomic variables change. In conclusion, we find that GDP, CLI and low interest rates are good predictors of the net absorption of space in Singapore. Quarterly stock growth seems less predictable, possibly due to government restrictions, rental yields are sticky and are positively affected most by expansionary activities signalled through increases in the GDP, growth of industrial stock and negatively by vacancy rates.

This study presents a useful model based on a previously well studied theoretical model that explain the dynamics of real estate markets (four-quadrant model). By using this approach, we are also able to successfully forecast near term capitalization rates, net absorption and vacancy rates[16] with some accuracy and it is a recommended tool to track the dynamics of the entire industrial real estate market in Singapore.

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[16] Refer to Appendix 1A for fitted model performance.

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Appendix A

Figure 3 Ordinary Least Square Model Fit of Three Key VAR Estimate Equations