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Title:

System dynamics of optimal commencement timing for office building construction

Summary

Through office market forecasting consultancy jobs, a PhD dissertation and several papers, I developed a system dynamics model to simulate office market oversupply cycles as a function of trend economic growth, an equilibrium vacancy rate and three supply response parameters. (_______, 1997, 1999, 2002). This paper proposes extensions of the previous work. Supply will be made endogenous and "lumpy" by explicitly using "building sized" supply changes, rather than assuming continuous supply responses. Prices will be explicitly included—previous versions used vacancy rates to signal market conditions. Most importantly, forecast errors will be added to replace the deterministic simulations of previous papers. These innovations in the model should make it more useful to decision makers for exploring optimal timing of major office towers.

Market timing makes the difference between projects that make money (NPV>0) versus those that lose money (NPV<0) over the economic life of the building. The decision problem is framed as a trade-off between two kinds of errors resulting from two different project commencement policies.

Many financial institutions adopt a "conservative" policy of waiting until current market conditions (rent levels, occupancy rates, space absorption, leasing pre-commitments) justify construction. This creates a **supply lag error** due to possible changes in market conditions over the 2-3 year period required for construction. At the aggregate market level, the backlogs created by this policy greatly increase risks by generating costly endogenous cycles (See "the problem", below).

A rational expectations commencement policy based on forecasting should eliminate cycles, replacing them with random walk errors. However, if the decision maker shifts to a just-in-time inventory decision policy based on forecasting market conditions at a 2-3 year forecast horizon when the project will be ready for occupancy, there is a possibility of large **forecast errors**. Choosing the optimum time for commencing a project depends on the relative size of these two kinds of errors.

Decision makers need to understand the trade offs between possible forecast errors and market conditions changes (supply lag errors) in order to choose a

commencement timing policy that minimises the expected sum of the two different types of error.

Table 1: Comparing two decision policies under two states of nature

	Forecast correct	**Forecast wrong**
Stable market	*Both ok*	*Current conditions better*
Market change	*Forecasting better*	*Depends*

Table 1 shows that the best decision policy depends on what happens in the market during the period between project commencement and completion of the building as well as on the quality of forecasts.

The problem

Office market cycles are ubiquitous under a wide variety of political and economic regimes, suggesting a more fundamental cause than local government policies or market conditions. These cycles cause major damage to investor and financial intermediary cash flows and balance sheets and contribute to macroeconomic problems.

Economists refer to the losses that result from allocating too much capital to a particular asset class as "allocative inefficiency." Such inefficiency reduces aggregate returns on investments and condemns the economy to a slower growth path. Large inefficiencies or misallocations can lead to economic instability, especially where debt financing is used, as is often the case in real estate (Minsky, 1974, Fisher, 1933). Major cycles are damaging enough to banks' balance sheets that they can contribute to financial crises and macroeconomic recessions as in the U.S. (1975, late l980s), Australia (early 1990s), Japan (early 1990s-present) and Thailand, Indonesia and Korea (1997-present). The lessons have not yet been learned with the next property bubble likely to burst in China (Australian Financial Review, 1/28/03).

The 1997 collapse of the Thai financial markets, followed by contagion to Indonesia, Malaysia, Korea, Hong Kong and Taiwan, was triggered by a Thai property developer's three million dollar default on a payment due on a foreign currency (Euro) loan. The default signalled the extent of non-performing assets throughout an overbuilt real estate sector. "When the Thai property market began to unravel in 1996 and 1997, the property developers could no longer pay back the cash that they had borrowed from financial institutions. This led to a snowballing effect of non-performing loans…" (Hanipah, 2003). By 1999, about half of all firms in Thailand, Indonesia, Malaysia and Korea were unable to meet current debt repayments. (World Bank, quoted by Hanipah, 2003).

Property cycles have recurred at intervals for more than a century and in many countries. Sterman's system dynamics textbook includes a graph of 100 years of real estate cycles and a description of the supply lags that generate endogenous cycles (Sterman, 2000). A Melbourne property crash during the 1880s led to one of the worst economic collapses in Australian history, lasting a decade. The Empire State building commenced construction in September 1929, weeks before the October stock market crash. It was referred to as the "Empty State building" and did not achieve full occupancy until after World War II.

These cycles have not necessarily gotten less severe over time. The 1986 property oversupply in over 200 U.S. markets caused some of the biggest losses in history and were intertwined with the savings and loan problems that cost U.S. taxpayers about $150 billion. Hendershott and Kane (1994) estimated losses (chiefly the present value of uncollected rents on excess vacant space) at U.S. $130 billion during the 1980s U.S. office oversupply cycle that led to vacancy rates over 20% in hundreds of U.S. cities.

Australia suffered a serious office oversupply cycle in the early 1990s that contributed to the length and severity of a recession. Vacancy rates in the Perth, Australia CBD reached 32% of the office stock, an astonishing figure considering that demand growth had averaged less than 4% per year over the previous decade. A single project in Perth destroyed one fifth of the capital of the state employees' pension fund. Rents collapsed from about $350/m² in 1989 to a low of $65 in 1994, and building values throughout the market dropped to less than half of cost. Australian banks wrote off $28 billion in bad loans in 1993-94 and an educated guess would be that at least a third would have been due to empty office buildings.

A lot of money rides on decision makers understanding their "windows of opportunity" in timing the commencement of major office towers. These windows tend to be brief because market conditions look similar to all of the actors who are planning projects. In a typical market, favourable market conditions lead to a "race" between a number of competing projects (Grenadier, 1994).

A slightly tongue in cheek article by two California office market consultants presented a two by two matrix showing developers reactions to good and bad markets studies of favorable and unfavorable markets. In all four quadrants of this table, even where a poor quality market study said not to build, the developers' conclusion was "build, build, build, build." Developers, they concluded, will build as many projects as they can finance. (Detoy and Rabin, 1974)

The herd mentality of fund managers and financial institution staff therefore, becomes a serious problem where all of the money sources decide in a short time that "now office projects will make money." Of course, if they all go ahead with projects the result will be that they all will lose money due to oversupply pushing down rents and increasing vacancy rates. In Perth in 1994-5 all of the new projects were either put to lenders, sold for less than half of cost or held with impaired cash flows that lasted for a decade before the market recovered. The

State Employees pension fund currently has their tower for sale for 45% of its original real cost. However, projects leased in the mid-1980s showed very attractive returns and projects bought at the trough of the cycle in 1993-96 gave their owners outstanding capital gains. A Perth project bought for $16 million sold for $35 million just 4 years later.

Obviously the timing of project commencement decisions is a key issue for office markets, financial institutions and even in extreme cases for national economies. Long term leases "lock in" market conditions at the time of initial lease-up, so even if the market recovers a building may still have weak cash flows for 5-10 years or more. Discounting gives these early cash flows considerable weight in determining the overall results of the investment. As rule of thumb, if a project is completed in a favourable leasing environment it will make money (NPV>0) while if it is completed in an unfavourable market the building will lose money (NPV<0).

Identifying windows of opportunity

Office market cycles can be modeled as an inventory control strategic uncertainty problem analogous to the beer game. Through interviews with leasing agents, developers, project managers and researchers in the property industry, I collected a list of over a dozen causes of cycles (________1997) including prominently:

- Asymmetric information. Some people make money even on projects that fail, so there are incentives for them to advocate projects that are not justified by market demand.
- "Prisoner's dilemma." Strategic uncertainty where developers and investors don't know how many competitive projects will proceed means individual rationality (this project will make money) becomes collective irrationality (too many projects means the market collapses).
- Serially correlated shocks in the macroeconomy. Economists still cannot call "turns" from boom to recession very well—leading to big mistakes in planning projects with long time lags.
- System dynamics. Perhaps the most fundamental cause of endogenous office market cycles, as demonstrated by a simple system dynamics model, is supply lags that lead to backlogs and overshooting of office supply. This is, essentially, the same inventory control problem as "the beer game," in a supply chain where major office projects may take nearly a decade to plan and complete (_________, 1998, 1999, 2000).

The problem can be looked at as an "information structure" or system "policies" problem. Banks and other investors, remembering how badly they were burned in the last cycle, tend to attempt to adopt "conservative" policies to avoid losses on what are perceived (correctly) as highly risky major investments. Believing office investments to be risky, investors and lenders tend to want to see them justified by current market conditions—rents, pre-leasing commitments, overall market space absorption and vacancy rates—before approving finance for construction of new projects. But tenants are seldom willing to commit to long-term leases at above market rents. Therefore, by the time rents and leasing pre-commitments from tenants rise to levels justifying new construction it is too late. Rents continue their upwards spike (demand is relatively price inelastic during times of robust economic growth) which then, based again on the "look at current market conditions" mentality, in combination with strategic uncertainty and the asymmetric information incentives arising from the profit centers in large projects, tends to call forth excess supply.

I am assuming, of course, a purely speculative building, that is, one that is completed before it is rented. It is possible to pre-lease buildings, but that strategy merely shifts risks to the tenants, without improving efficiency. Tenants vary in their ability to undertake such risks. Major tenants (a national telecom or major corporation) could easily pre-commit to lock in a favourable rent. But then *they* face the question of when to do so. The project commencement decision has been delegated to the tenant, but similar issues arise as to market efficiency and project timing.

It should be pointed out that even if lenders were always prudent and insisted on leasing commitments before starting projects, the result could be inefficient if lack of office space were a significant bottleneck restricting economic activity. High rents and space shortages have negative effects throughout a local economy. The efficient solution is always for supply and demand to be in balance and for that to happen, supply lags have to be taken into account. Otherwise just-in-time inventory is impossible in a growing economy simply because it takes time to build major buildings. From the local economy's point of view, economic activity and job growth are probably enhanced by availability of plenty of office space and lower rents.

Staff in financial institutions find it very hard to bet large sums of money against the current market reality. To "get it right" they would have to first say during the cycle's recovery stage, "Here is $300 million, go ahead and build a building that would be worth $200 million at current market rents although there is not enough demand to fill it." Only by making that kind of decision will projects be completed early enough for just-in-time inventory, given the two-three years required for construction. This "conservative" policy leads to a space shortage in a growing market during the time buildings are under construction. As rents (and demand from tenants trying to get space quickly in a rising market) spike upwards, it is undoubtedly perceived as an equally career threatening move to say "No, you can't have $300 million to build a building, even though current rents say it will be worth $400 million, rents are continuing to rise sharply and a lot of tenants want space." This would be the situation during a boom, before supply has caught up to demand. In these circumstances, lenders tend to ignore the implications of cranes on the city skyline or "new supply in the pipeline."

Conservative lending policies designed to *reduce* risk can therefore actually *create* risk by calling forth oversupply cycles in response to price volatility in the presence of supply lags. Too little supply, too late, sets the scene for oversupply a few years in the future.

From a system dynamics point of view, the problem can be solved by investors and lenders adopting just-in-time inventory policies and changing the information structure of the system. Instead of relying on current information on market conditions, the decision should be based on forecasts of market conditions at time of project completion. This implies a 2-3 year forecast horizon, the time required from ground breaking to completion of major office construction projects and taking account of the price elasticities due to impending new supply from projects under construction.

Trading off market change versus forecasting risks

Under the "current conditions justify project commencement" policy, investors are exposed to the error arising from changes in market conditions (other projects commencing, onset of recession, collapse of a telecom and dot.com boom, etc.) during the 2-3 year construction period. On the other hand, if they justify supply decisions on the basis of forecasts of conditions at a 2-3 years horizon, they are subject to forecast errors. In that period of time, the economy could "turn" from boom to recession, a major risk exposure. Forecasting an increase in demand over a period when demand actually contracts could lead to very serious errors.

From an individual project perspective, the conservative "wait for current conditions" policy is probably rational. But collectively, because it generates cycles, it is probably irrational.

My model demonstrates that the "current conditions" policy generates cycles. Cycles are exacerbated by higher trend economic growth, quicker responses to demand (bunching project commencements), a tendency for the industry to build more than is justified by demand and the length of the supply lag. Longer lags lead to longer cycles with higher amplitude and these are explosive cycles even when economic growth is a steady, moderate linear trend. The model showed that cycles moderated dramatically as the lag decreased from 18 months to one year. This implies that office markets could mitigate cycles and move towards a random walk by using rational expectations and forecasts—just-in-time policies.

A simple rule that commenced a few projects every year would be more efficient than the current bunching of project commencements. This is a classic counterintuitive system dynamics result.

But, all of this assumes perfect foresight. My previous papers have explored the dynamics of systems without incorporating the forecast errors problem. Adding forecasting errors to the model will make the simulation more realistic. These simulations will provide important insights on efficient policies for timing of project commencements under uncertainty about future market conditions. If there are serially correlated and large changes in supply and demand conditions during construction and the forecast gets these wrong, then it is possible that the "use forecasting for just-in-time inventory" policy would give worse results (larger financial losses, more of a mismatch of supply and demand) than the "wait until justified by current conditions" project commencement policy. The random walk of rational expectations could have larger errors than the cyclical oversupply errors generated by current conditions policies. However, this seems unlikely, given the size of the cycles generated by the current conditions policy at the aggregate market level. Rational expectations might expose individual projects to large errors. Similar forecasting errors by a number of firms could throw the market out of equilibrium and lead to inefficiency, but it is doubtful that it would generate cycles.

Depending on assumptions about forecast errors and changes in market conditions, one could imagine a range of policies being correct under differing circumstances. Because forecast errors get much larger at a three year horizon than they would be at a six month horizon, investors might optimise by forecasting at some shorter horizon than the full 2-3 year construction horizon, in effect compromising between "current conditions" and "rely on forecasts" policies by choosing an intermediate forecast horizon. The contribution of system dynamics models can be to quantify this trade-off and help identify optimal intermediate project timing policies.

The macroeconomy, a fundamental driver of office demand, can be forecast fairly accurately one quarter ahead, but much less accurately eight quarters (two years) out. Probably by 5 years, the best office demand forecast could not do much better than to use the mean of the past time series, so the forecast error becomes the variance of the series.

Forecast errors can be estimated from past time series and from literature on errors in forecasting the macroeconomy. Since errors would undoubtedly be highly variable across markets and time periods, it is perhaps more important to understand how the errors operate to create changes in optimal project timing than to worry about whether forecast errors are estimated accurately. This would best be addressed on a case by case basis. The focus in this paper is on system dynamics, given particular patterns of forecast errors.

It seems likely that if forecast errors increase as a function of the forecast horizon, and are relatively small for the first few quarters, the most efficient estimates could be based on a forecast horizon somewhere between the construction horizon and zero. That is, it might be sensible to build the project based on "current conditions" expected at an intermediate forecast horizon, say six months or one year in the future. That would allow a project to "get a jump" on competitors that are cautiously waiting for rising rents to justify construction based on current conditions, without taking undue risks that demand forecasts would be very far wrong.

The modelling exercise therefore, is to explore market efficiency (size of “errors” in matching supply and demand) under various assumptions about market changes and forecast errors. The result will be decision policies for optimal project timing, based on expected market changes and forecast errors.

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