OFFICE MARKET CYCLES: A SYSTEM DYNAMICS APPROACH TO IMPROVE ALLOCATIVE EFFICIENCY

Max Kummerow[1] and Mohammed Quaddus[2]
[1] Department of Property Studies
[2] Graduate School of Business
Curtin University of Technology
GPO Box U 1987, Perth
Western Australia 6845
(April, 1998)

Abstract: This paper explores the dynamics of office market systems through a simple simulation model. The modelling objectives are to understand the system better and gain insight about how to change the system to improve allocative efficiency. A model structure which appears to be similar to real office markets generates explosive cycles under plausible lag and adjustment parameter assumptions. Unstable dynamics of the system result from inability to make correct decisions due to lag structures and feedbacks. Additional causes for office market cycles include random shocks, agency problems, prisoners' dilemma, faulty information (poor forecasting, market research, and valuation techniques), and differing equilibria in office space and financial markets. Simulation results suggest that deviations from equilibrium can be much reduced by changing the information structure of the system.

Keywords: Office cycles, system dynamics, office oversupply, office markets, institutional economics, Australia

Ubiquitous Cycles

Office market cycles are surprisingly widespread. Hendershott and Kane (1992) cite vacancy rates of 20% in 30 U.S. cities during the mid-1980s and estimate economic losses--chiefly present value of lost rents from excess vacant space--at U.S.$130 billion. In Australia at the beginning of 1993, CBD office vacancy rates were: Perth 32%, Melbourne 27%, Sydney 22% (BOMA, 1993). Sykes (1996) estimates aggregate write-offs and provisionings by Australian lenders during 1991-94 at AUS$28 billion, much of this due to non-performing real estate. Writing off $28 billion would require reducing loan portfolios or other assets by $280 billion if bank capital adequacy ratios were to be maintained around 10%. Comparing these figures to the Australian GDP of less than AUS$500 billion, real estate cycles must have been a major cause of the severe early 1990s Australian recession.[1] London, Stockholm, Singapore, Tokyo, Johannesburg, Toronto, and many other cities have suffered oversupply pulses as well. Property oversupply contributed to the worldwide Great Depression of the 1930s. Barras (1994) maintains that investment property oversupply occurs in every other macroeconomic cycle--about once every ten years.[2]

Markets may be even more volatile than in the past due to international capital flows and information technology. Hong Kong, Bangkok, Jakarta, Kuala Lumpur, Shanghai, Seoul, and other Asian centers currently face an oversupply of office space. The diversity of locations, times, economic systems, and political regimes where oversupply has occurred suggest a fundamental causal mechanism in the office market process.

[1] Minsky, 1992, espouses this asset value deflation/debt crisis theory of macroeconomic cycles.
[2] Wheaton, 1987, Leitner, 1994, and Barras, 1994, list additional examples of office market cycles.

Explanations for Office Oversupply Cycles

Qualitative interviews with industry informants[3] and literature research led to a list of office oversupply explanations summarised as:

1. *Greed or fee driven deals.* The finance literature refers to “asymmetric information” or “principal/agent conflict” (Cole and Robert, 1996). As one agent put it, “A lot of people don’t get paid unless a deal happens.” But more deals means less likelihood all projects can perform as projected.

2. *Flood of capital seeking investment opportunities, due, in part, to financial deregulation during the early 1980s*. Fisher (1992) recommended integration of research on property and financial markets. In both the U.S. and Australia, 1980’s financial deregulation led to sudden increases in capital supply, some controlled by inexpert or corrupt lenders. Asian markets experienced foreign capital inflows and plentiful local capital in recent years. Some informants spoke of a “herd instinct” among risk averse fund managers.

3. *Strategic behaviour--the prisoners dilemma game*. A developer’s strategic decision problem can be expressed as “If my project goes ahead and everybody else’s does not, rents will be high and my project profitable. If everyone else also builds, market rents will fall and we will all lose money.” This is a prisoners’ dilemma game where, absent cooperation or regulation, individually rational behaviour (commencing a project when demand warrants) leads to a collectively irrational outcome.

4. *Land use regulatory process delays, and other government policies*. Land use regulations, tax treatment of real estate or other policies may promote too much or too little development. By increasing the time from project inception to completion, regulatory delays make forecasting more difficult and mistakes more likely.

5. *Faulty data and poor forecasts of supply, demand, rents, and values.* Roulac, et al. (1990) argued for more intensive, project specific data gathering and analysis in real estate decisionmaking, pointing out that development budgets typically spend too little on such research, relative to investment capital at risk.

6. *System dynamics*. Many potential projects appear to be profitable if the market responds (incorrectly) to current prices, forgetting about lags and cycles. Once a demand backlog develops due to supply lags, deliveries (office completions) must at some point exceed current demand growth for supply to “catch up.” Overshooting of supply is likely, especially if demand growth subsequently falls as often happens due to macroeconomic cycles.[4]

Imbalances of supply and demand introduce allocative and production inefficiencies into office markets. Too much or too little office investment misallocates capital, increases risk, and reduces social returns to capital. Severe oversupply cycles damage financial intermediaries and macroeconomic outcomes.

A System Dynamics Model of an Office Market

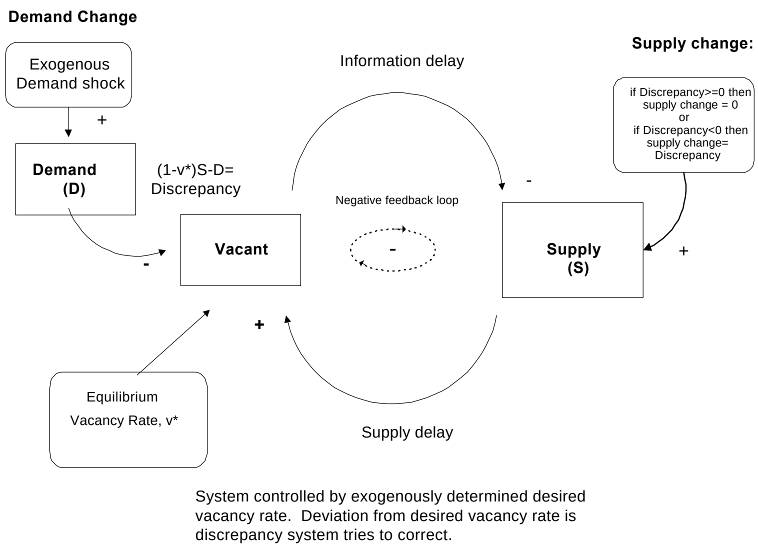
Constructing office buildings involves unavoidable time delays. Figure 1 represents an office market system with physical stocks and flows, that is, without prices. This physical (priceless) version of an office market model is driven by the discrepancy from an equilibrium state where supply, S, equals demand, D, plus an equilibrium vacancy, V* (ie. discrepancy XV =

[3] Kummerrow, 1997a qualitative research includes an Australian Institute of Valuers and Land Economists study group in Perth and property industry and academic sources in America, Perth, Sydney, and Singapore.

[4] Similar dynamics--demand shock, order increase, backlog, catch up, oversupply--occur in any inventory control problem. Senge (1990) presents a “beer game” inventory control model “archetype.”

S-(D+V*)). If there is excess supply, the supply change called for is zero. This implies that buildings are not demolished or converted to other uses.

Figure 1 Influence Diagram for Priceless Office Market Simulation



Once a space shortage occurs in the model (ie XV <0), the system adjusts by trying to eliminate the discrepancy, constrained by production capacity and supply lags. Clapp (1993), Hendershott (1992, 1997), and other authors use the equilibrium vacancy rate concept as the state towards which office markets adjust. In markets, rents (prices), transmit a signal of the discrepancy from equilibrium to suppliers. Rents respond inversely to vacancy rates, however, so the priceless model is consistent with the stylised facts of office market behaviour.[5]

Model supply adjustment is a function of four parameters which give rise to dynamical behaviour:

1. *Oversupply.* If oversupply, OS, is set to 1, developers seek to build exactly the amount of space needed. If OS is 2, they order twice the discrepancy. Agency and prisoners dilemma market failures justify inclusion of this parameter.[6]

2. *Adjustment time.* In time series data, one can observe that supply pulses do not appear all in one year, but spread across perhaps 2-4 years. "Adjustment time," A, measures speed of adjustment. When XV*OS amount of space is ordered, $\frac{XV}{A}$*OS will be commenced in that year. Spreading out of commencements is due to planning lags early in the office market development process. If there is a need for 90,000 m² of new space, and adjustment time is 3, the market will commence 30,000 m² this year. The remaining 60,000 m² becomes a backlog. Each year the discrepancy will be updated and a third of the new discrepancy (including backlog) commenced.

3. *Supply lag.* Supply lag, SL, is the time from order to delivery. Physically, construction may require 2 or 3 years for major projects. However, anticipating future discrepancies could move the supply lag to 0 or even to a negative value if projects are

---

[5] Rosen and Smith (1983) used vacancy rate as a proxy for rents.
[6] Kummerow (1997a) includes an account of a prisoner's dilemma game in the Perth, Australia office market.

commenced early in anticipation of future demand.[7] SL=0 implies forecasting demand at the physical construction lag horizon, ie 2-3 years, and commencing projects for "just in time" inventory to meet future demand.

4. *Equilibrium vacancy rate*. Desired holdings of vacant office space are expected to vary directly with activity in the market (more sales implies more inventory needed) and inversely with the costs of holding vacant space such as interest rates and property taxes. Shilling et al 1987, and Pollakowski, et al. 1992, found equilibrium vacancy rates vary between cities and over time. We simplify here by leaving v* exogenous and constant.

How well the system is functioning can be proxied by how close it stays to equilibrium. Taking the discrepancy XV = S-(D+V*) as the "error" in the system, we can use statistics such as root mean square error or mean absolute percentage error as summary measures of system allocative efficiency over a period of time. Error statistics could not go to zero except in a static market with no construction or demand changes. Large errors reflect undersupply/oversupply cycles.

Simulation Results

The "base run" or "reference mode" of the system is set at:

- Equilibrium vacancy 10%[8]
- Supply lag 0, meaning, assuming a 2 year construction time, that developers commence projects based on correct forecasts of demand 2 years ahead.
- Adjustment time 1, meaning the market responds fully to discrepancies in one period.
- Oversupply 1, meaning the market does not over-react. New supply orders equal new demand.

These parameter settings emphatically do not represent the current state of the system, but rather an ideal situation towards which to move through system redesign and policy changes. The choice of 1970-2010 as the x-axis values in the plots is arbitrary as are supply and demand starting levels.

Figure 2 shows the effects of increasing the construction lag time in an economy with steady 2% per annum office demand growth. When supply lag, SL, is zero, this leads to the market staying at equilibrium--supply growth exactly tracking demand--an efficient market which clears within one time period (Figure 2A). As noted, setting the supply lag to zero would require forecasting demand at a horizon equal to the time required for construction.

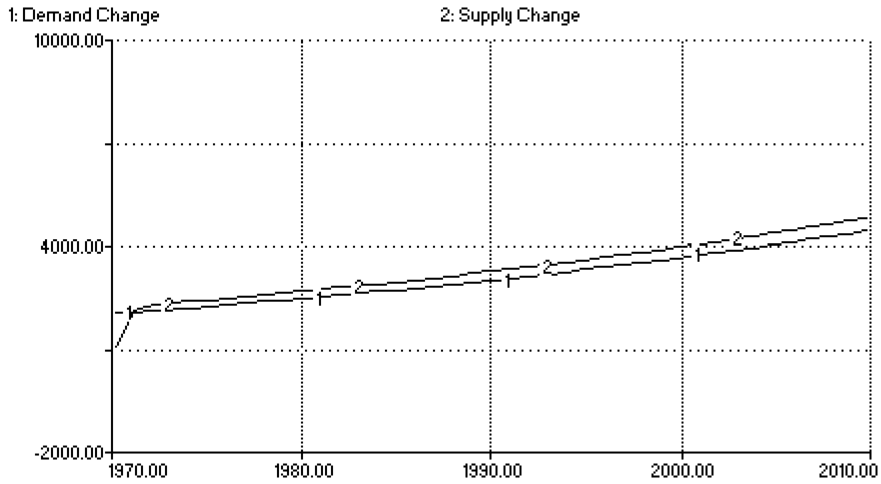
With the construction lag, SL, set to 1 year, steady growth in demand leads to a decaying cycle (Figure 2B). With the supply lag at 2 years, the cycle explodes--successive cycles amplitude increases (Figure 2C). Note that in this case OS, the oversupply parameter, is set to 1 meaning orders match discrepancy--oversupply cycles in figure 2C are not due to too many fee driven deals. The explosive cycles of figure 2C come solely from steady economic growth and a two year supply lag in a system where new supply orders depend upon current vacancy conditions. If we infer that rents reflect vacancy conditions, this means lenders are underwriting projects based on current rents. Thus a "conservative" approach of waiting until rents justify construction, in fact leads to an explosive cycle due to construction lags. A lender policy meant to avoid risk creates risk.

Figure 2 Model 1 Supply and demand change, supply lag effect

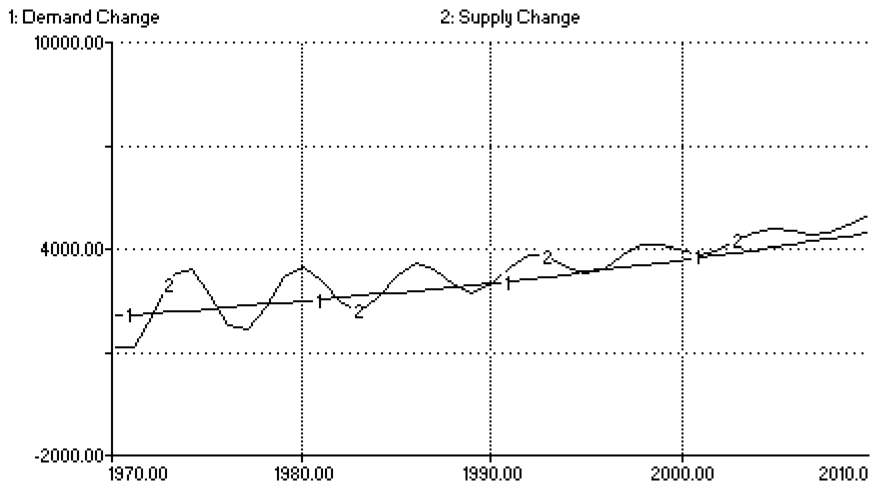
A) Base run with supply lag 0, oversupply, and 1adjustment time 1, equilibrium vacancy .10, growth

[7] Shilton, 1995, found a variety of supply lags in different American cities, ranging from 0 to 4 years.
[8] Sydney 1970-1996 average was 9.2%.

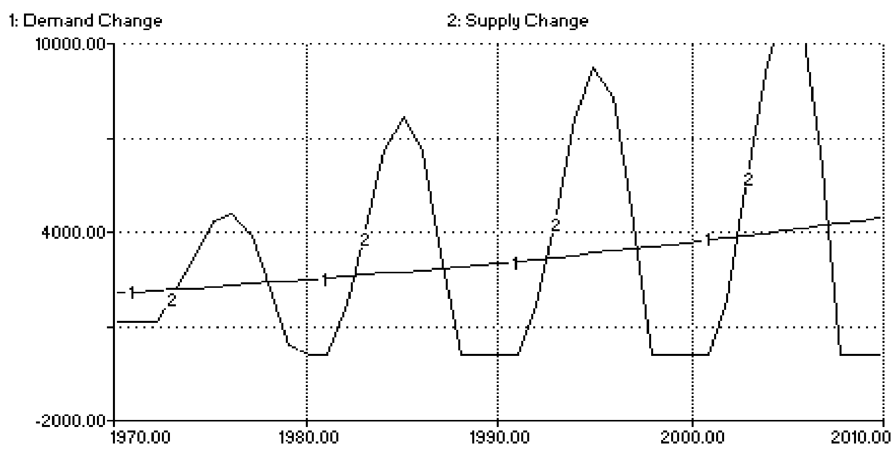
2% per year.



B) Supply lag 1, adjustment time 1, and oversupply 1 creates a decaying cycle.



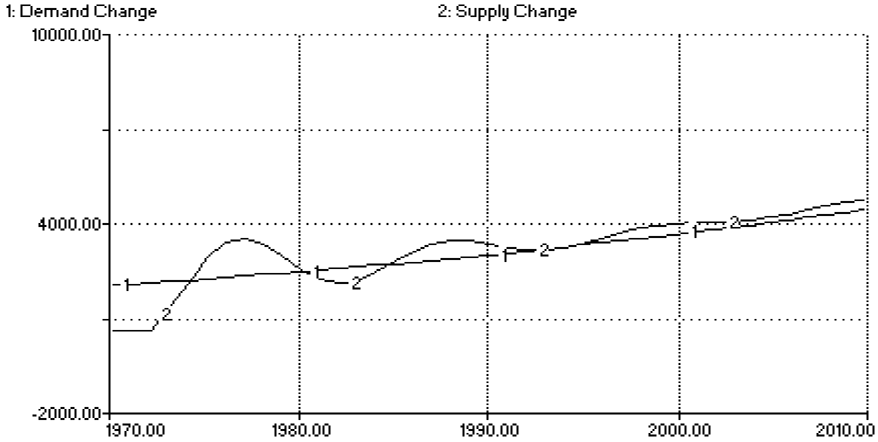
C) Supply lag 2, adjustment time 1, oversupply 1, 2% growth, cycle explodes.



Spreading out project commencements, that is, adjustment times, A, greater than 1, tends to decrease amplitude of cycles. The explosive cycle of the previous graph is smoothed and moderated if adjustment time is moved up to 2 (Figure 3). But, higher adjustment times also increase mean average percentage error (MAPE) because of slower catching up to demand. With supply lag SL=2 and oversupply, OS=1, the optimum setting for A (given V*=.10 and demand growth at 2%) is around 1.5 with system behaviour worsening on either side of this setting.[9] This quantifies the qualitatively obvious result that starting too many projects in a single year could lead to oversupply, and the equally obvious corollary that spreading commencements over time is wise policy.

Figure 3 Model 1 Supply and demand changes, adjustment time effect

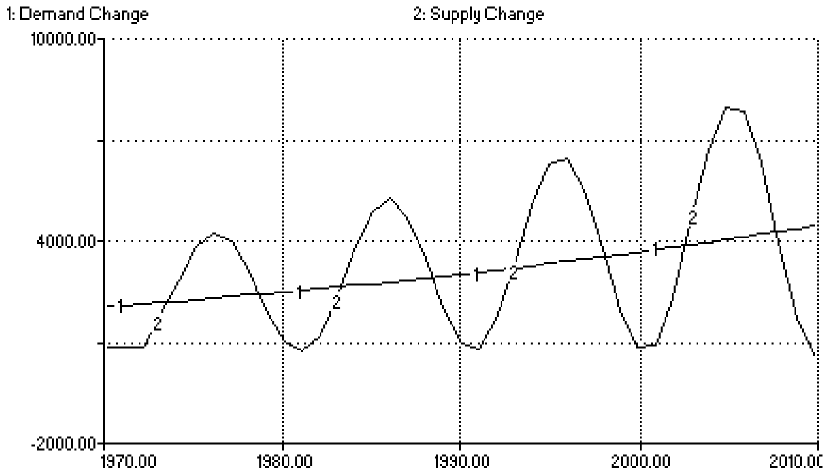
A. Supply lag 2, oversupply 1, adjustment time 2. The cycle is smoothed, up to an optimum level of the A parameter, by a longer adjustment time.



In certain regions, the system is quite sensitive to relatively small changes in parameter values. Figure 4 demonstrates a remarkable improvement in system behaviour due to reducing the SL parameter from 1.5 to 1.25. That is, reducing the SL delay only one quarter (from 18 months to 15 months), nearly eliminates the cycle. If the real system behaves anything like these models result, major increases in market efficiency can be had by a combination of: a) reducing planning and construction lags, b) forecasting demand and building for it, rather than waiting until demand is on hand, c) spreading out commencements over time (increasing A).

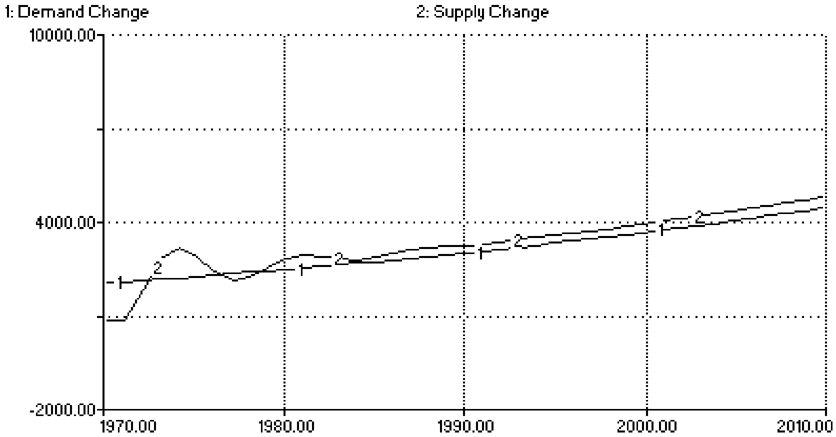
Figure 4 Model 1 Supply and demand changes, sensitive or offsetting cycles.

A. With supply lag 1.5, adjustment time 2, and oversupply 1.5, exploding cycle.



[9] Steve Keen, University of Western Sydney, derived this optimum figure from the difference equations.

B. Cutting the supply lag to 1.25 (only 3 months difference) while leaving adjustment time at 2 and oversupply at 1.5 as in the previous graph, leads to dramatic reduction in cycle amplitude.



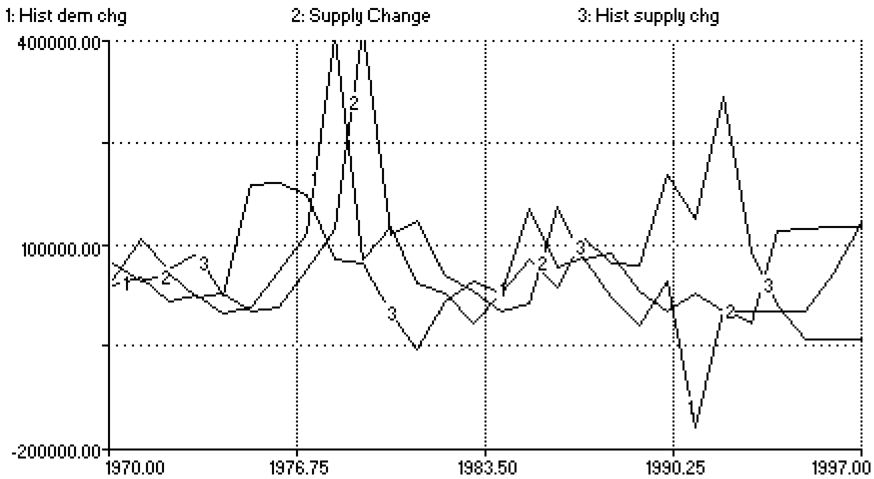
Other combinations of the four supply adjustment parameters result in varied outcomes--stable cycles, chaotic cycles, etc. Of course, other changes (housing cycles, investment cycles, inventory cycles, stock market cycles, agricultural cycles, random shocks, etc) take place in the economy at the same time, but with different frequencies. Cycles can reinforce each other or cancel out, depending upon frequencies.

Historical demand growth scenario

Historical Sydney CBD office demand change figures (office net takeup) show a very large spike in 1978 a smaller series of positive takeup years in the mid-1980s, negative demand in the early 1990s, and reasonably strong demand recovery beginning in 1992.[10] Figure 5 uses historical demand figures as the exogenous model input, and shows both the actual supply changes generated by the system during the period and the supply changes generated by the model at its "efficient market" settings in response to the historical demand figures.

Figure 5 Historical supply and demand change versus supply change generated by a model without lags

Efficient market settings (oversupply 1, adjustment time 1, supply lag 0)



Observe how poorly the real world market has done in matching supply and demand during this period. Actual Sydney historical supply change was not a rational response to demand patterns. This is where we started--supply and demand have not matched well in office

[10] These data undoubtedly include measurement errors. Early data may confuse gross and net demand.

markets. Many model settings will improve on market outcomes.[11] This negative finding--the lack of connection between supply and demand in the real world data--indicates major design faults in the office market system. These results direct our attention towards re-designing the system to create a closer connection between supply and demand.

When long enough lags are included, the model does as badly as the real system in matching supply and demand, generating pronounced cycles in response to the historical demand pattern. The model can therefore be set to mimic a real office market system by adjusting the parameters, thereby giving some indication of the parameter setting in a real market.

The system was also tested using random shocks plus a constant trend growth in demand. Not all patterns of random shocks generated cyclical behaviour, but most did. The system might show regular cycles absent shocks, but irregular cycles with shocks. System feedback and delay structures continue to play an important role, even with random shocks.

Model Validity

The strongest argument for whatever validity the simulation model may have is the plausibility of its simple mathematics in comparison to what we know about the real world system. The adjustment equations mimic observable processes and seem similar to what occurs in real world markets. We know that when demand appears, projects do not all begin immediately (justifying the adjustment parameter, A), there are undoubtedly physical construction lags and some attempts to forecast future conditions (leading to various supply lags, SL), and certainly oversupply tendencies(OS) are a reasonable hypothesis given recent experience and what we know about agency and prisoners' dilemma problems. All this, of course, does not guarantee that the complex real system behaves like the simple model.

Is it Feasible to Improve System Design and Policies?

Model outcomes imply that office market cycles might be smoothed by adjusting system supply response parameters. Markets are experimenting with adjustments and additional ideas can be suggested for further research and pilot studies:

Supply Lag, SL. Although "design and build"[12] accomplishes some decrease in construction time, building smaller projects is probably the most effective way to reduce physical process delays. Singapore may have reduced office cycle amplitude in recent years by cutting adjustment times through government sponsored land assembly and fast planning approvals. Singapore accomplishes office project planning reviews in 9 months that take at least 2 years in Australia.[13] Presenting projects for review earlier in the cycle could create an inventory of pre-approved projects, while still allowing time for public comment. It might be beneficial for governments to encourage timely early stages of office development.

Oversupply, OS. Improving contracts and reward structures could promote alignment of interests between investors and agents. A property industry paid fees proportional to number of projects constructed rather than long term investment outcomes faces incentives to build more projects regardless of demand. Agents may evolve into property advisory services seeking long term relationships with institutional investors rather than short term single transactions. Long term relationships imply concern about long run investment outcomes.

[11] This is consistent with Paich and Sterman's (1993) finding that a simple rule would do better than managers in a system with even relatively simple feedback delays.

[12] This refers to a construction management technique whereby construction begins before final detailed drawings are completed. This saves time, but may be more costly or risky.

[13] Singapore assembles land quickly through the powerful Urban Redevelopment Authority agency. Reviews are expedited because there is only one level of government (as opposed to significant state and municipal reviews in Australia), and a top down, more authoritarian planning philosophy.

Securitization of real estate finance is also a significant system change. Markets express concerns about the value of existing portfolios quickly when share prices adjust to market perceptions of impending oversupply.

Adjustment time, A. In a prisoner's dilemma game it is hard to see how decisions independent of other decisions can be correct or even evaluated. In oversupplied office markets, outcomes for all investors are linked through system-wide price adjustments. Mancur Olson (1971) argued that for better outcomes, cooperation is necessary, enforced by institutions, because otherwise each actor will want to be a free rider who benefits from the restraints imposed on others.

Perhaps coordination can be achieved through improved information--in effect, a change in the rules of the game whereby the players all know what the other "prisoners" will do in time to react rationally. A municipally enforced "limited entry" policy should seek to avoid both undersupply and oversupply. Details should be carefully designed to avoid unintended effects. A simple rule might link allowable commencements to demand/supply conditions with automatic feedback correction and limited planner discretion.

Conclusions

This paper shows how the cyclical dynamics of the office market can be modelled by using system dynamics methodology. A transparent yet rigorous priceless modeling approach has been taken to simulate the office market system. It has been shown that an office market system is a negative feedback system which tries to adjust itself towards the equilibrium vacancy rate. Four adjustment parameters have been proposed—oversupply, adjustment time, supply lag, and equilibrium vacancy rate. Results suggest that market efficiency gains might be obtained by the combination of: (i) reducing planning and construction lags, (ii) forecasting demand and building for it, rather than waiting until demand is on hand, and (iii) spreading out commencements over time.

The priceless model can be extended to model the reference mode (real vacancy rate and prices over the years) of the office market system. This can be achieved by combining the system dynamics model with econometric models relating vacancy rates to supply, demand, and price changes. The combined model can then be used for system behaviour study and forecasting purposes. We plan to pursue our research in this direction.

References

Barlas, Y. 1996, 'Formal aspects of model validity and validation in system dynamics', *System Dynamics Review,* Vol. 12, no. 3: 183-210.

Barras, Richard. 1983, 'A simple theoretical model of the office-development cycle.' *Environment and Planning A*, V. 15: 1381-1394.

Barras, Richard. 1994, 'Property and the economic cycle: building cycles revisited." *Journal of Property Research*, V. 11: 183-197

Born, Waldo L. and Stephen A. Pyhrr. 1994 'Real Estate Valuation: The Effect of Market and Property Cycles.' *Journal of Real Estate Research*. ,9(4), 455-485

Clapp, J. 1993, *The Dynamics of Office Markets,* Urban Institute Press, Washington.

Cole, R A & Robert, A E. 1996, 'The Role of Principal-Agent Conflicts in the 1980's Thrift Crisis', *Real Estate Economics*, 24(2), 195-218.

Coyle, R. G. 1996, *System dynamics modelling: A practical approach,* Chapman & Hall., London.

De Geus, A. P. 1992, 'Modelling to predict or to learn?', *European Journal of Operational Research,* Vol. 59: 1-5.

DiPasquale, D. & Wheaton, W. C. 1996, *Urban Economics and Real Estate Markets,* Prentice Hall, Englewood Cliffs.

Eppli, M. J. & Shilling, J. 1994, 'Speed of Adjustment in Commercial Real Estate Markets', *Southern*

Economics Journal.
Fisher, J. 1992, ‘Integrating Research on Markets for Space and Capital’, *Journal of the American Real Estate and Urban Economics Association*, 20(2), 161-180.
Forrester, J. W. 1991, ‘System dynamics and the lessons of 35 years’, in *The systemic basis of policy making in the 1990s*, ed. K. B. D. Greene, http://www.rtpnet.org/~gaotwals/stella/sdg/sdlesson.txt
Forrester, J. W. & Senge, P. M. 1980, ‘Tests for building confidence in system dynamics models’, *TIMS Studies in the Management Sciences,* V 14: 209-228.
Fudenberg, D. & Tirole, J. 1992, *Game Theory,* MIT Press, Cambridge, MA.
Hendershott, P. 1997, ‘Uses of Equilibrium Models in Real Estate Research’, *Journal of Property Research,* 14(1), 1-14.
Hendershott, P. & Kane, E. 1992, ‘Causes and Consequences of the 1980’s Commercial Construction Boom’, *Journal of Applied Corporate Finance,* Vol. May: 61-70.
Jaffe, Austin J. and Shiawee X. Yang. 1997, ‘Fun and Games in Real Estate Leasing.’ *Real Estate Finance*, Summer: 55-62
Janssen, J., Kruift, B. & Needham, B. 1994, ‘The Honeycomb Cycle in Real Estate’, *Journal of Real Estate Research,* Vol. 9, no. 2: 237-251.
Kummerow, M. 1997a, *A Paradigm of Inquiry for Applied Real Estate Research: Integrating Econometric and Simulation Methods in Time and Space Specific Forecasting Models--Australian Office Market Case Study*, PhD dissertation, Curtin University.
Kummerow, M. 1997b, ‘Commercial Property Valuations with Cyclical Cash Flow Forecasts” *The Valuer and Land Economist* V.34 no.5: 424-428
Leitner, H. 1994, ‘Capital markets, the development industry, and urban office marekt dynamics: rethinking building cycles.’ *Environment and Planning A*. V 26: 779-802
Minsky, Hymen. 1992, ‘On the Non-neutrality of Money’ *FRBNY Review* Spring:77-82
Mueller, Glenn R. 1997, ‘Torto Wheaton Select Review.’ *Real Estate Finance*, Spring: 75-87
Olson, M. 1971, ‘The Logic of Collective Action:Public Goods and the Theory of Groups’, *Harvard Economic Studies,* Vol. CXXIV.
Paich, M. & Sterman, J. D. 1993, ‘ Boom, bust, and failures to learn in experimental markets’, *Management Science,* Vol. 39, no. 12, : 1439-1458.
Pollakowski, H.Wachter, S. & Lynford, L. 1992, ‘Did Office Market Size Matter in the 1980’s?’, *Journal of the American Real Estate and Urban Economics Association,*Summer: 303-324.
Ragan, P. 1993, ‘CBD Office Markets: Analysing Supply Side Behaviour’, *Valuer and Land Economist,* May.
Renshaw, E. 1991, *Modelling Biological Populations in Space and Time,* Cambridge University Press, Cambridge.
Rosen, K T and Smith, L B. 1983, ‘The Price Adjustment Process for Rental Housing and the Natural Vacancy Rate’, *American Economic Review*, 73, 779-786.
Roulac, Stephen E. 1996, ‘Real Estate Market Cycles, Transformation Forces and Structural Change’ *The Journal of Real Estate Portfolio Management* Vol. 2, #1: 1-17.
Senge, P. M. 1990, *The Fifth Discipline,* Random House Australia, Sydney.
Shilling, J. D., Sirmans, C. F. & Corgel, J. B. 1987, ‘Price Adjustment Process for Rental Office Space’, *Journal of Urban Economics,* Vol. 22: 90-100.
Shilton, L. 1995, *Patterns of Office Space Demand Cycles*, Fordham University Real Estate Center.
Singapore, U.R.A. 1996, *Price and Rental Indices, quarter 3, 1996*, Urban Redevelopment Authority.
Sykes, T. 1996, *The Bold Riders,* 2 edn, Allen and Unwin, St. Leonards, NSW.
ULI 1993, ‘The Grass is no Greener: the Real Estate Troubles in Japan, the U.K., and Continental Europe’, in ULI 1993 Fall meeting, , Urban Land Institute.
Wheaton, W. C., Torto, R. G. & Evans, P. 1995, ‘The Cyclic Behavior of the Greater London Office Market’, *Working paper MIT Center for Real Estate*.