Creativity and control dynamics in prime office-space markets

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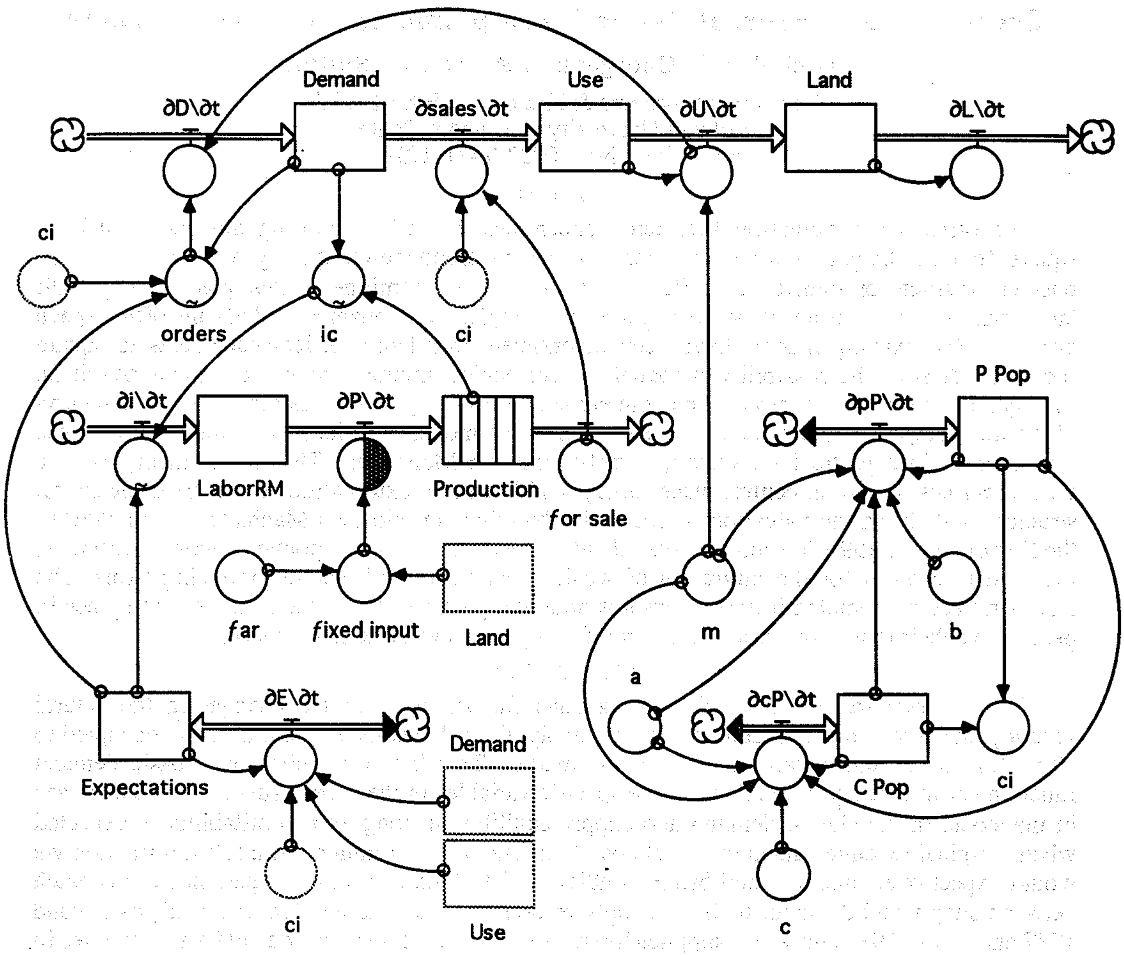
ABSTRACT

The office-space valuation literature concentrates on office-building attributes, such as square footage, height, number of floors, perceived architectural quality and distance from business districts or transit stops. Real estate researchers combine central place theory with landmark proximity in an effort to explain the complex relationships underlying office-space pricing. Yet, existing models have been inconsistent in relating office-space rents to square footage, indicating the possibility of spatial autocorrelation among corporate economic activities. The dynamic behavior pattern of the commercial real-estate cycle signals the creative interaction of business firms in their locale. A system dynamics model describes the interaction of these relationships in a particular location, namely midtown Manhattan. The model incorporates a third-order cost function, central place theory, and landmark externalities to describe the causal structure underlying the valuation of 103 office buildings in midtown Manhattan, from 1980 to the first quarter of 1990. To embody spatial autocorrelation among corporate economic activities, the model accounts for the migration of wealth controlling and wealth producing firms. The results reflect the complex interrelationships underlying prime office-space markets and place in perspective their long-term cycles as exemplified by the New York office market.

INTRODUCTION

Office-market researchers seek, among other factors, to trace the changes in the natural vacancy rate, a rate in which demand equals supply given that some space must be unoccupied to allow for moves and expansions within the market. This literature relies on a basic demand function because rarely, if at all, are there specific variables in the supply function for a decrease in the stock. In the classic demand and supply equilibrium, long-term profitability is expected when marginal revenue equals marginal cost. In a rational environment with full information we would expect over time an equilibrium condition. Yet, American cities experience a mismatch between supply and demand, with the supply response overshoots the demand Analysis beyond 1987 and before 1980 show oversupplies likewise in New York that caused 16% vacancy rates in 1976 and 1990. The degree of mismatch in years of excess supply measured in the number of years to have the space absorbed varies from five to over ten years. The excess supply is usually attributed to stupidity, greed and, during the 1980s, volatile tax changes. Without a historical perspective, one can believe that the 1980s was a unique environment for real-estate gluttony or it can ponder that in established cities such as New York the boom-bust cycle is now 100 years old. Excess capacity, as measured by vacancy rates in the office market in the United States exceeds 20%.

Meanwhile, the hedonic regression pricing of single family homes (Gloudemans & Miller, 1976) and apartment buildings (Sirmans, Sirmans, & Benjamin, 1990) is an established valuation estimation approach. Office building valuation research attempts to describe the dynamics of office markets by focusing on office building attributes that affect rents. In an analysis of the buildings in Chicago, for example, Brennan Cannaday & Colwell (1984) find that the total square footage, the height and the location of the building within the central business district affect rent. Frew & Jud (1988) conclude that a building's age, number of floors and distance from the interstate affect office rents in Greensboro, North Carolina but, unlike Vandell & Lane (1989), distance to the central business district is unimportant. Glasock, Jahanian & Sirmans (1990) confirm that the size of the building, sub-market and the designation of class A, B or C



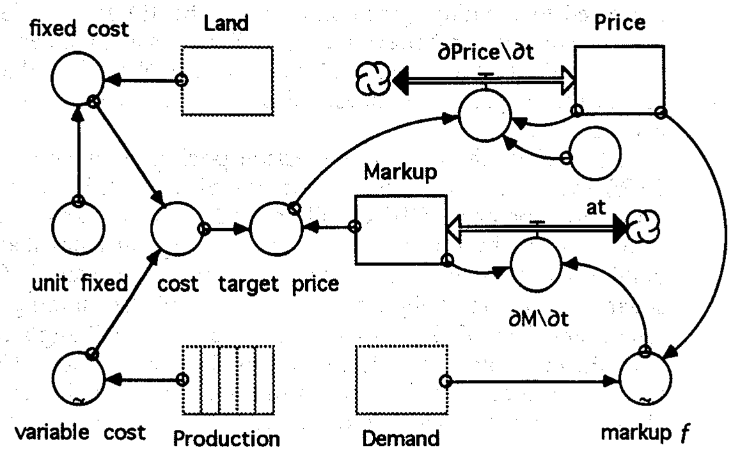


Fig. 1.
Office real estate system
& price infrastructure
midtown Manhattan.
a, b & c = migration parameters,
at = adjustment time,
C Pop = control population,
ci = creative interaction ratio,
*f*ar = floor area ratio,
ic = investment capability function
m = migration fraction,
orders = order function &
P Pop = production population.

relates to the rents collected in their sample of leases from 197 buildings in Baton Rouge for a four year period. Vandell & Lane (1989) agree with the importance of the physical characteristics and location, including distance to transit stops and to the center of the central business district in their Boston study. Vandell & Lane further argue that the architectural-quality perceptions of architects also can affect a building's rent. Asabere and Huffman (1991) find that historic designation of a district in Philadelphia did not influence the price of the non-residential lots in that district.

All these studies rely on ordinary least squares (OLS) and two-stage regression, either linear or with Box-Cox transformations. Their results are inconsistent in relating rent to square footage. In some cases, for example, the use of a log transformation increases model robustness. In other cases, however, the same transformation for square footage decreases it. None of these models were tested for autocorrelation. When autocorrelation exists, there is a possible mis-specification of the model or the presence of spatial autocorrelation among economic activities (Kennedy, 1989; Theil, 1971).

The data of Lynch (1960) and Pennartz (1990) indicate that the character of the neighborhood in the urban environment may cause a meaningful reaction to local residents and workers. One surrogate for the character of the neighborhood is the presence of unique buildings and parks. New York has institutionalized landmarks in its urban fabric through preservation designation. Yet, the non-residential land sale analysis of Philadelphia, PA, concludes that the proximity of landmarks may not contribute to the value of office buildings (Asabere & Huffman, 1991).[1] Muth (1968) raised the question of the relative substitution of transportation costs versus the desire for the amenity of open space. In midtown Manhattan, Central Park is the amenity center, while Grand Central Station is the center that minimizes transportation cost.

A system dynamics model describes the interaction of these relationships in a particular location, namely midtown Manhattan. To describe the real-estate cycle, the model incorporates a third-order cost function, central place theory, and landmark externalities to describe the causal structure underlying the valuation of 103 office buildings in midtown Manhattan, from 1980 to the first quarter of 1990. To embody spatial autocorrelation among corporate economic activities, the model accounts for the migration of wealth controlling and wealth producing firms. The results reflect the complex interrelationships underlying prime office-space markets and place in perspective their long-term cycles as exemplified by the New York office market.

MODEL STRUCTURE

The real-estate industry consists of a host of participants. Developers and the web of developer agents have a short term horizon and they behave as though each new building is an option. If delivered expeditiously and with a minimum of delay, this option allows them to cash in on the delivery. In contrast, long-term institutional holders combine both a short-term call and a long-term Walrasian equilibrium mentality. Figure 1 shows the structure underlying the long-term cyclical patterns of demand and supply in midtown Manhattan. The model consists of three sectors. The left half of Figure 1 shows the office-space market, an extension of the one-sector Kondratieff model (Rasmussen, Mosekilde, & Sterman, 1985), where demand and supply are driven by the shared expectations of office-space developers and users. Although shared, these expectations about the future are weighted differently by office-space users and developers when they place their orders and invest in new office building projects, respectively.

In the valuation process, office-space users comb through information about comparable properties in size and attributes. Influenced by the comparable previous transactions, users also evaluate the uniqueness of the property in question. Kennedy (1989) and Theil (, 1971) note that

1 The rivers minimally affect the office concentration in midtown Manhattan, with a few office buildings located close to either the East or the Hudson River because of the historical development and transportation routes.

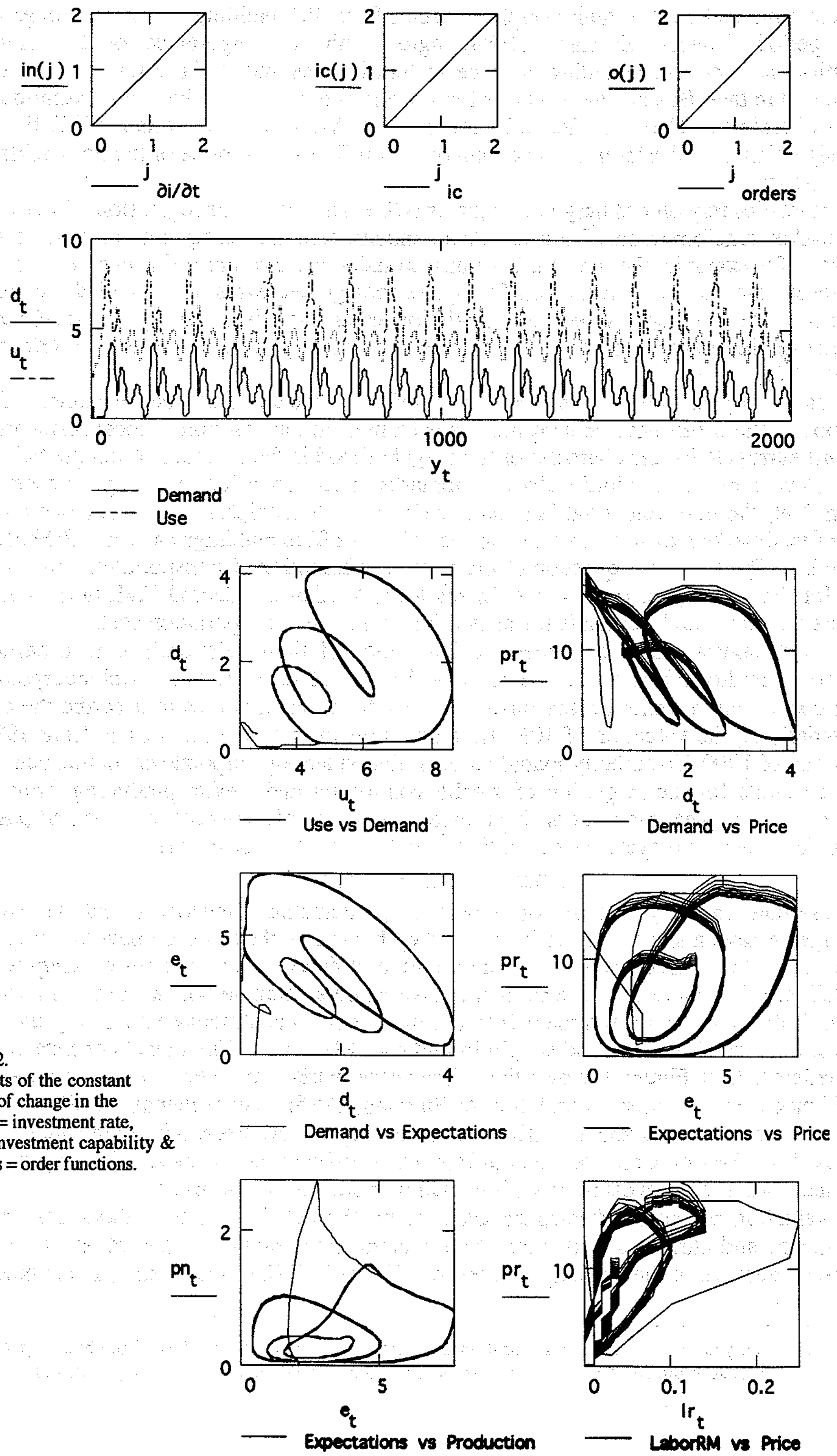


Fig. 2.
Results of the constant rates of change in the ∂i/∂t = investment rate, ic = investment capability & orders = order functions.

in a series of economic data inertia, the impact of the previous transaction, positively effects the next transaction. Kennedy uses the term spatial autocorrelation to note that in cross sectional data a random effect on one activity i.e., a sales transaction, will cause an effect on an adjoining activity. Odlund (1988) reviews the economic geographer's use of the concept of spatial autocorrelation. The right half of Figure 1 shows the office-space users or customers, business firms consisting of two distinct populations PPop and CPop.

In the early stages of their development, most firms concentrate on producing wealth through the development of new products and services. This is the production oriented population (PPop). Subsequently, however, some firms concentrate on controlling existing wealth rather than on producing new wealth and markets. This is the control oriented population (CPop). Together, the stage of their life-cycle, and the mix of their products and services determine the production and control orientation of each population. In turn, this mix determines each firm's location needs, causing the dynamic long-term cyclical behavior patterns of demand and supply for commercial real estate as exemplified by the New York office market. PPop seeks to locate in an area that maximizes contacts with other business persons (Archer, 1981; Clapp, 1980), while CPop in a prestigious area with amenities (Armstrong, 1972; Hutton & Ley, 1987). Conversely, PPop seeks to locate closest to the primary transportation center to minimize both cost and travel time. The CPop functions are not labor intensive, but of high-level executive decision making and control. CPop executives tend to maximize the value of the setting than to minimize cost. Their creative interaction leads to some technological or other advantage that causes one group to migrate to, convert to or assimilate another. Detailed analyses have been made of equations of the form

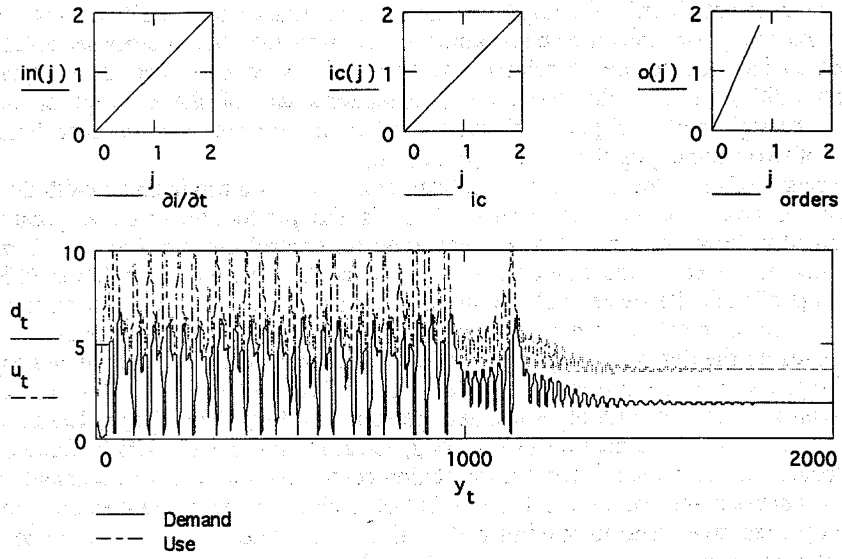
$$\begin{aligned} P\dot{P}op &= P\,Pop \cdot f_1(P\,Pop, C\,Pop) \\ C\dot{P}op &= C\,Pop \cdot f_2(P\,Pop, C\,Pop) \end{aligned} \tag{1}$$

postulated to describe the interaction of two species, but they may also be used as models of interaction between two human groups (Renfrew & Cooke, 1979). Then creative interaction leads to migration from one group to the other, (1) can take the form

$$\begin{aligned} P\,Pop &= P\,Pop \cdot (a - b \cdot P\,Pop) - m \cdot \frac{P\,Pop}{C\,Pop} \\ C\,Pop &= C\,Pop \cdot (0.05 \cdot a - c \cdot C\,Pop) + m \cdot \frac{P\,Pop}{C\,Pop} \end{aligned} \tag{2}$$

where a,b & c are migration parameters and m denotes the migration fraction. The creative interaction (ci) between PPop and CPop in Figure 1 affects the shared expectations of developers and users of office space as well as the orders and the rate of sales.

The lower part of Figure 1 is the valuation or price infrastructure, with the price of a building being a cubic function of its square footage. Short-term developers invests some funds in a new project. They estimate the time it will take until they can call the option, i.e., the option becomes exercised, and the short-term developer turns the building over, i.e., sells it to a long-term investor. The short-term developers also estimate the value or market clearing price of this option. A key determinant in estimating the market clearing price is the expected rent and vacancy rate. Short-term developers price projects according to cost, weighted by a markup fraction. Developers build to satisfy an expected demand. Each project requires land as well as labor and raw material. Land is the fixed and the labor and raw material the variable input for each development site. Developers can construct buildings up to the maximum allowed by zoning. In New York, the primary constraint is the floor area ratio (*f*ar). The *f*ar multiplies the square footage of the land lot to determine the total $ft.^2$ The land remains fixed for all possible building sizes on that site, much like an original capital contribution. The transaction price for the land is a function of the expected size of the building. The cost per $ft.^2$ for each building depends on its size. The building cost per $ft.^2$ is a function of a fixed cost for the foundations, heating plant and electrical frames, and the variable cost for the interior structural frame, fenestration and wall finishes. The fixed and variable cost for a building depend on its height and



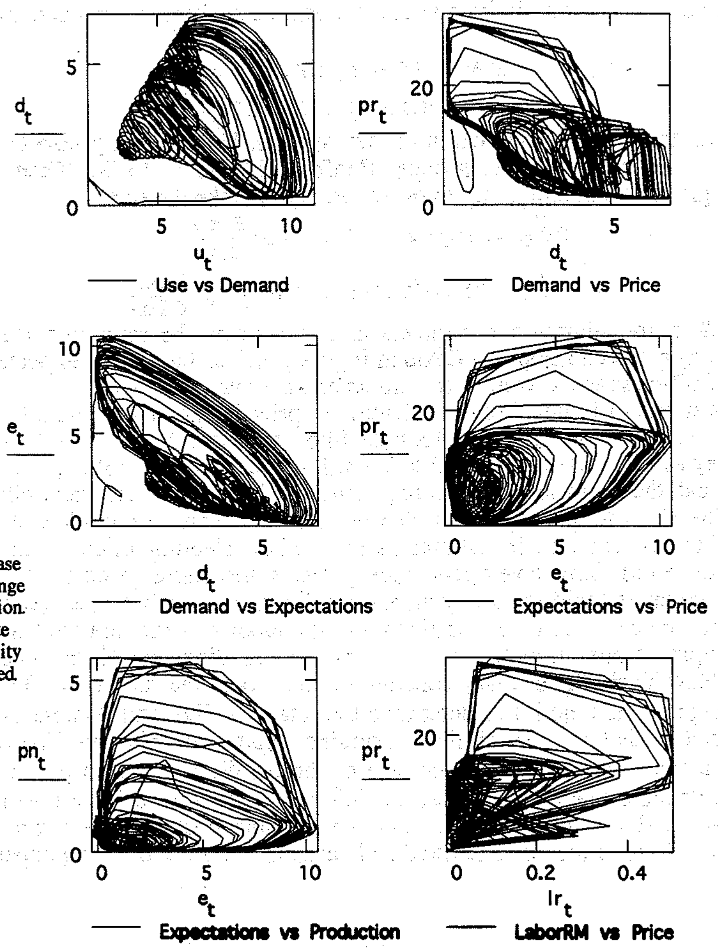


Fig. 3.
A Walrasian equilibrium results from a 100% increase in the constant rate of change in the orders = order function. The ∂i/∂t = investment rate & ic = investment capability functions remain unchanged.

mass. Load bearing wall systems suffice for a 10-story high building, interior steel girder systems sustain 10 to 40-story buildings, and tubular steel frame systems are necessary for higher buildings. Nicholson (1978) illustrates the relationship between the fixed and variable cost functions for a project. The curve has the form of a third order function, commonly observed in production cost functions. Since there is no relative minimum or maximum, developers build up to the point of inflection because after that point the marginal cost increases significantly.[2]

MODEL BEHAVIOR

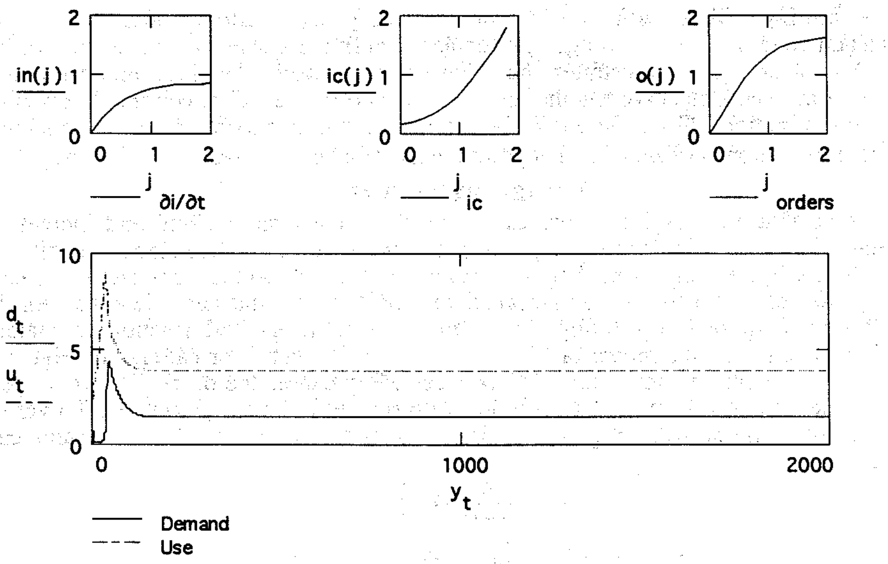
We observe that there is a business cycle during which firms expand and increase their employment. The increase in their employment puts pressure on the office market supply. At the beginning of the cycle, employers begin to signal of their expected demand for space and builders of space react. It would be serendipitous to expect that for this new cycle the demand for space would be unlimited. By fixing the migration parameters and fraction to match the midtown Manhattan data, the model of Figure 1 produces the behavior patterns of Figure 2. If, for some reason, the creative interaction (ci) between PPop causes the orders for office space to double, then the system can reach a long-term Walrasian equilibrium (Figure 3). To verify the existence of equilibrium, with migration parameters and fraction fixed, the system can be described as

$$
\begin{aligned}
\dot{d} &= u \cdot m \cdot \frac{e}{d + ci} - ci \cdot \frac{p}{tt} \\
\dot{e} &= ci \cdot (u - e - d) \\
\dot{\ell} &= u \cdot m - \ell \\
\dot{\ell r} &= \frac{p}{d \cdot e} - far \cdot \ell \\
\dot{p} &= far \cdot \ell - \frac{p}{tt} \\
\dot{u} &= ci \cdot \frac{p}{tt} - u \cdot m
\end{aligned}
\tag{3}
$$

where, d=demand, e=expectations, ℓ=land, ℓr=labor & raw material, p=production and u=use of office space. To locate and to classify the equilibrium point, (3) is linearized and evaluated as

$$
\begin{bmatrix}
\frac{0.001 \cdot d}{(2.13 + d)^2} & \frac{0.001}{2.13 + d} & 0 & 0 & -0.71 & -\frac{0.05 \cdot d}{2.13 + d} \\
-2.13 & -2.13 & 0 & 0 & 0 & 2.13 \\
0 & 0 & -1 & 0 & 0 & 0.05 \\
\frac{0.001}{d^3} & \frac{0.001}{d^3} & -11.36 & 0 & \frac{1}{d^2} & 0 \\
0 & 0 & 11.36 & 0 & -\frac{1}{3} & 0 \\
0 & 0 & 0 & 0 & 0.71 & -0.05
\end{bmatrix}
\tag{4}
$$

2 In an analysis of Green Bay residential property, the use of a cubic transformation reduced auto-correlation and improved the specification of the model, increasing the R^2 of the regression (Shilton & Zaccaria, 1991).



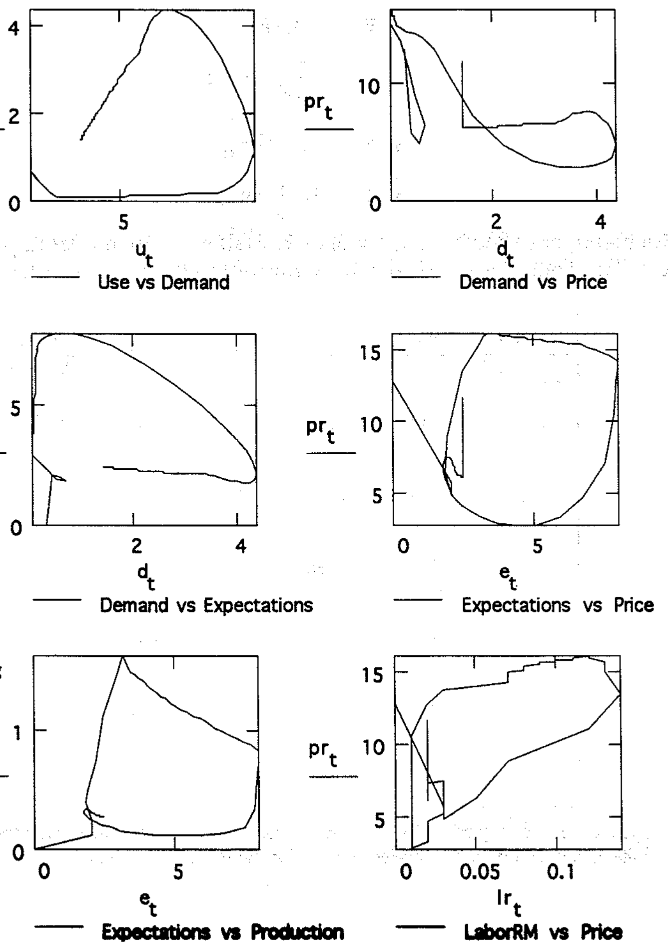


Fig. 4.
Using a Gompertz Type I curve instead of constant orders and a Gompertz Type II curve instead of the constant investment rate function can help the system reach equilibrium much faster. Also helpful is the quadratic investment capability (ic) function, intesecting above zero both the ∂i/∂t and the order Gompertz curves, twice.

with the real parts of its complex eigenvalues in (5) being non positive. This indicates that the phase plots in a neighborhood of the equilibrium point should be unstable spirals (Beltrami, 1987), like the ones of Figure 3.

$$\left[-3.13, -0.876-0.528\cdot i, -0.876-0.528\cdot i, 0, 0, 0.369\right] \tag{5}$$

Yet, if the demand and supply resemble Gompertz curves, as they do in midtown Manhattan, then the investment rate ($\partial i / \partial t$) takes the form shown on top of Figure 4. To match the non linearity, orders are no-longer a linear function of expectations, but assume some form of a savings function. This is viable, since savings also depend on expectations. The investment capability (ic) assumes a quadratic form, again typical for midtown Manhattan. The system reaches equilibrium even faster than it did with the linearity assumptions (Figure 4). Yet, a mere 7.83% decrease in ic can bring the office real-estate system back into an unstable spiral in the neighborhood of its equilibrium point (Figure 5).

REFERENCES

Archer, W. 1981. Determinants of Location for General Purpose Office Firms within Medium Size Cities. *AREUE Journal, 9* : 283-297.

Armstrong, R. 1972. *The Office Industry: Patterns of Growth and Location.* Cambridge, MA: MIT Press.

Asabere, P. & Huffman, F. 1991. Historic Districts and Land Values. *Journal of Real Estate Research, 6* (1): 1-8.

Beltrami, E. 1987. *Mathematics for Dynamic Modeling.* Boston, MA: Academic Press.

Brennan, T.P., Cannaday, R.E., & Colwell, P.F. 1984. Office Rent in the Chicago CBD. *AREUEA Journal, 12* (3): 243.

Clapp, J. 1980. The Intrametropolitan Location of Office Activities. *Journal of Regional Science, 10* : 387-399.

Frew, J. & Jud, G.D. 1988. Vacancy Rates in the Commercial Office Market. *Journal of Real Estate Research, 3* (1): 1-8.

Glasock, J.L., Jahanian, S., & Sirmans, C.F. 1990. An Analysis of Office Market: Some Empirical Evidence. *AREUEA Journal, 18* (2): 105-119.

Gloudemans, R.J. & Miller, D.W. 1976. Multiple Regression Analysis Applied to Residential Properties: A Study of Structural Relationships Over Time. *Decision Sciences, 17* : 294-304.

Hutton, T. & Ley, D. 1987. Location, Linkages and Labor: The Downtown Complex of Corporate Activities in a Medium Sized City: Vancouver, British Columbia. *Economic Geography, 63* : 126-141.

Kennedy, P. 1989. *A Guide to Econometrics.* Cambridge, MA: MIT Press.

Lynch, K. 1960. *Image of the City.* Cambridge, MA: Technology Press.

Muth, R. 1968. Urban Residential Land and Housing Markets. In *Issues in Urban Economics* , Baltimore, MD: John Hopkins University Press.

Nicholson, W. 1978. *Microeconomic Theory.* Hinsale, IL: Dryden Press.

Odlund, J. 1988. Spatial Autocorrelation. In *Scientific Geography Series* , Newbury Park, CA: Sage.

Pennartz, P.J.J. & Elsinga, M.G. 1990. Adults, Adolescent and Architecture. *Environment and Behavior, 22* (5): 675-714.

Rasmussen, S., Mosekilde, E., & Sterman, J.D. 1985. Bifurcations and Chaotic Behavior in a Simple Model of the Economic Long Wave. *System Dynamics Review, 1* (1): 92-110.

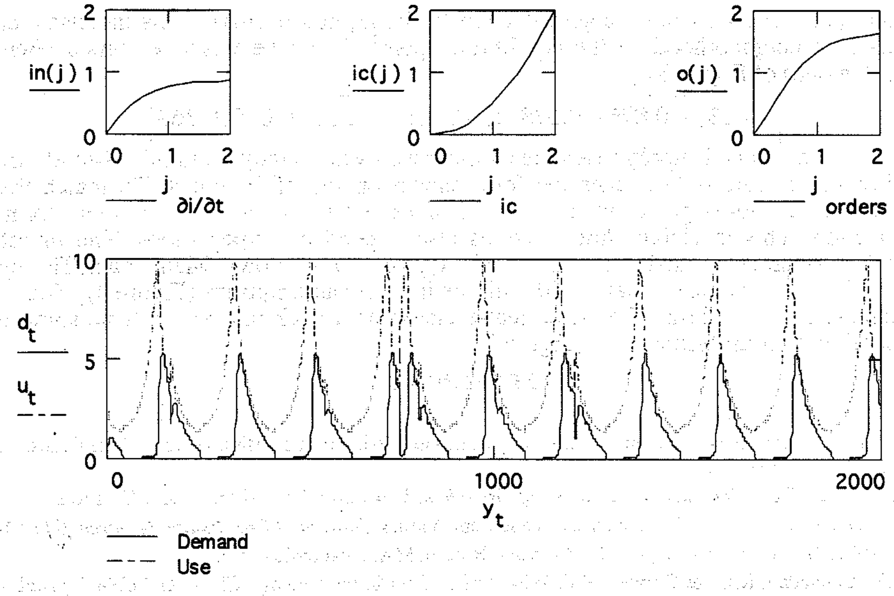
Renfrew, C. & Cooke, K.L. 1979. *Transformations: Mathematical Approaches to Culture Change.* New York, NY: Academic Press.

Shilton, L.G. & Zaccaria, A. 1991. *Location, Location and Cubic Transformation: Manhattan Office Valuation.* Working paper, New York, NY: Fordham University.

Sirmans, G.S., Sirmans, C.F., & Benjamin, J.D. 1990. Rental Concessions and Property Values. *Journal of Real Estate Research, 5* (1): 141-152.

Theil, H. 1971. *Principles of Econometrics.* New York, NY: Wiley.

Vandell, K.D. & Lane, J.S. 1989. The Economics of Architecture and Urban Design: Some Preliminary Findings. *AREUEA Journal, 17* (2): 235-260.



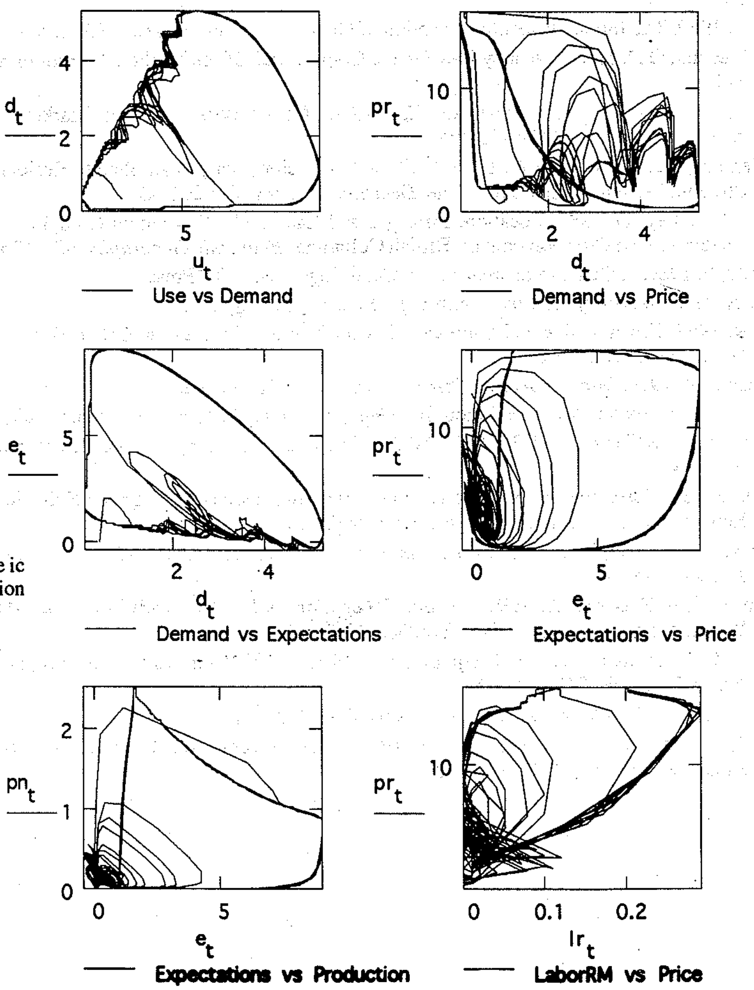


Fig. 5.
A mere 7.83% decrease in the ic (investment capability) function brings the office real estate system back into an unstable spiral in the neighborhood of its equilibrium point.