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**TOWARDS A REAL ESTATE
LAND USE MODELING PARADIGM**

By

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Towards A Real Estate Land Use Modeling Paradigm*

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abstract

This paper develops a conceptual research-oriented framework for understanding how land uses are allocated in the marketplace. The analyses highlight the crucial roles that market information and transaction costs play in determining the outcomes of transactions between real estate users and suppliers and the dynamics of real estate land uses and prices.

key words: Land use modeling; Allocative efficiency; Informational efficiency.

Our paper develops a schematic, analytic framework for understanding how land uses are determined in the marketplace. In this model, potential real estate users compete with each other; as do the suppliers of real estate. Our analysis highlights the crucial roles that market information and transaction costs play in determining the outcomes of transactions between real estate users and suppliers and the dynamics of real estate market land uses and prices.

The paper emphasizes, and is directed towards examining commercial land uses, but the analysis is quite general. One intention of our paper is to provide a framework for understanding both the merits and limitations of various existing research models in the commercial real estate arena. Therefore, our analysis will illustrate how selected earlier research has simplified or assumed elements of our more general land use model.

We commence our presentation by outlining our analytic model for allocating real estate users to real estate parcels. The model paradigm is one of economic allocative efficiency, whereby users and suppliers compete for resources. We discuss how real estate market information and transaction costs affect the physical allocation of parcels. Hence, in our second section, we show how informational market efficiency relates to the notion of physical real estate market allocative efficiency.

TOWARDS A LAND USE PARADIGM

Model building is a simplifying process, by which theoretical structure is converted into useable hypotheses that can be tested empirically. In the context of the commercial real estate market, commercial spatial organization is the outcome of the process which allocates land-using economic activities to sites. Transactions between owners of real estate (i.e., those who control the supply) and those who wish to rent or purchase space are freely entered contracts with legal-institutional constraints. We usually use the phrase “arms length transactions” to connote the competitive, market nature of these transactions. The constraints on market transactions consist of institutional and regulatory behavior, such as real estate taxes, zoning regulations, and at the end of the spectrum, eminent domain.¹ In this simple world, all parcels compete for real estate space users. Competition among potential occupants determines the market rent for a parcel (i.e., land and improvements), with the highest bidder in principle receiving the use of the parcel.

A. Demand for Real Estate

The market clearing solution for real estate parcels will be the highest bidder for each site. However, in the real world, the real estate market is an offer-counter offer negotiation process with asymmetric information.²

¹Even eminent domain provides verbal obeisance to the fair market price as the appropriate amount to be paid for public sector taking of private real estate.

²Some real estate transactions are the result of auction markets such as sheriff foreclosure sales and tax lien sales. Many of these auctions are thin and do not represent competitive market outcomes. During the last several years, public sector real estate auctions are reputed to be relatively competitive market driven (e.g., Resolution Trust Cor-

The *reservation price* (i.e., the highest price a potential user would pay for a specific parcel) is a closely guarded secret. Information of seller and buyers are often proprietary, and not exchanged freely, if at all. The outcome of allocating real estate users to parcels is unlikely to be independent of relative information held, bargaining positions, and bargaining-negotiation dexterity. We define the reservation price for a real estate space user as a function of three vectors of variables, as shown in equation (1):

$$R_t^{ij} = F(X_t^i, Y_t^j, Z_t^{ik}) \quad (1)$$

where R_t^{ij} is the reservation price for parcel i by user (entity) j at time t , X_t^i denotes a vector of characteristics variables for parcel i at time t , Y_t^j denotes a vector of variables about entity j at time t , and Z_t^{ik} denotes a vector of variables about the interrelationship between parcel i and parcel k at time t . For X , Y , and Z , hereafter, we suppress the time subscript.

The first two variables for the reservation price function, X and Y , describe virtually any market. For example, the demand for bottled soft drinks is a function of various characteristics of the drink (e.g., does it contain caffeine or not), and features of the consuming entity, such as the household's income and socio-demographics (e.g., how many children in the family).

The Z variable transforms the general reservation price function into a real estate market reservation price. The interrelationship between land uses and users, externalities and agglomerations economics of real estate, is

poration (RTC) auctions). Asymmetric information may lead to non-competitive market solutions. It is difficult to characterize the nature of *observed* transactions without specifying a model. Implicitly, asymmetric information acts as a transaction cost, which tends to generate a persistent bid-ask spread.

extraordinarily important to many users of real estate. For the residential market, the perception of neighborhood, or the access to shopping, work, or schools is important for determining what people are willing to pay for housing at a particular locale. For commercial office space, such items as a prestige address or a specific location may be key for determining what a potential real estate user would be willing to pay.

B. Supply by Real Estate Owners

The suppliers of real estate are profit maximizers, who from time to time may alter and modify their parcels in order to maximize the present value of net revenues. An owner can take several investment actions to improve or alter his site with the objective of increasing revenue through these new investment outlays. We define equation (2) as the investor's decision function:

$$D_{hk}^i = I(C_{hk}^i, R_{ht-1}) \quad (2)$$

where D is a measure of benefit to the owner of parcel i by altering it from use h to use k . Subscripts h, k for C denote the investment cost for altering parcel i from condition h to a new condition k , and R_{ht-1} denotes the demand price that persisted in the market last time period for parcels with the condition k . Presumably, last periods market rents are important data inputs used for forecasting future expected benefits (revenues) for the parcel.

The decision function may be based upon a present value or rate of return computation. The owner must choose investment programs, which maximize his decision criteria, including consideration of investment risks.

In theory, the investment decision is predicated upon expectations about future rents based upon current investment outlays.

C. Determining Market Equilibrium

In order to examine the process by which users are “allocated to parcels,” we present Figure 1, a matrix where the columns represent the parcels $(1, \dots, M)$ and the rows represent users of space $(1, \dots, N)$. In theory, each space user will have a reservation price for each parcel dependent upon available information, perceived risks, the characteristics of the parcel, the nature of the user, and the relationship between the specific parcel and all other parcels. It is, of course, possible that the reservation price will be zero for some users for some (even many) sites. The allocation of users to sites occurs, whereby each parcel owner looks down his column to find the entity wishing to pay the highest price for using his parcel. Abstracting from the assignment problem associated with programming models, one would allocate users to parcels in order to maximize the total rents and/or values of *all* parcels. This is the real estate principle of *highest and best use*.³

³Real estate highest and best use is equivalent to and consistent with the economist’s optimal resource allocation. The economic efficiency criterion is Pareto optimality. In the absence of rankings about the relative desirability of wealth distributions, Pareto optimality requires that we consider any reallocation of real estate users and/or changes in land uses if we can make one market participant better off without making anyone worse off. (This would include providing information to market participants.) If it is not possible to reallocate resources without making at least one market participant worse off, then the existing resource allocation is Pareto optimal. Abstracting from second-order conditions, a perfectly competitive real estate market will fulfill the first-order conditions for Pareto optimality.

In theory, the conditions for Pareto optimality market efficiency must be modified in the presence of external effects among real estate users and producers. Perfect competition will

While this process may not seem stable, certain stabilizing forces do exist in the market, at least in the short-run. In time, existing location for users will be preferred to alternatives for the following reasons:

1. Users typically invest (tenant improvements) in currently occupied parcels in order to conduct their business activities. These tenant improvements are seldom fully recoverable in the marketplace.
2. Users, leaving current locations to new parcels, typically will incur expensive moving costs.
3. Entering and exiting market activities by changing parcels usually require significant transaction costs in the form of lease arrangements and/or space purchase, negotiations, and time.
4. Finally, search and information costs for finding alternative parcels and market prices are usually expensive in terms of both time and money.

In brief, information costs and transactions costs (broadly defined to include losses caused by changing locations) are paramount determinants in user location choices.⁴

not engender, in the presence of external effects in real estate use and real estate supply, Pareto optimality market efficiency. In such cases, real estate users and producers take into account private (rather than social) costs generated by externality effects. In principle, systems of taxes, subsidies and regulations can be created to restore the economy toward efficient allocations. Surely, externalities in real estate matter. Hence, in our analysis, we assume implicitly that optimal taxes, subsidies and regulations permit allocative market efficiency to obtain.

⁴Our paradigm simplifies the real demand by suppressing both the labor and capital markets.

Most commercial office space market models can be classified or analyzed in terms of how they aggregate the matrix in Figure 1. For example, if a model maintains a large number of columns, perhaps aggregating the parcels by sub-markets within an MSA, one would have an intra-urban office location market analysis.⁵ Similarly, if a model compresses all of the columns into one, while maintaining desegregated users, the resulting model would be an aggregate demand for office space by user type.⁶

Most existing models of the office space represent aggregations of various forms of our schematic model. Aggregation is frequently done to reduce resource requirements as well as simplify the problem by reducing the number of relationships for which a model must be solved. These are legitimate concerns, as long as they do not simultaneously suppress underlying analytic realities.

D. Adjustments to Equilibrium

Virtually, every model we have examined for office markets proclaims to explore either equilibrium or adjustments to equilibrium.⁷ These studies are subdivided into two camps. One camp examines the relationship between rents (or values) and equilibrium (or optimal) vacancy rates.⁸ The models are either at the city, sub-national or national level. The adjustments to equilibrium rental rates are achieved through new production and

⁵See, for example, Voith and Crone (1988).

⁶See, for example, Wheaton (1987).

⁷See Rosen (1984), Voith and Crone (1988), and the references therein.

⁸The analysis is best typified by Voith and Crone (1988) and Wheaton and Torto (1988). Also, for the residential real estate market, Rosen and Smith (1983) provide a theoretical framework for explaining how adjustments the trade-off between rent changes and vacancy rates, similar to the Phillips curve in macroeconomics.

conversions with some lag. The key issue is the adjustment lag, and a special emphasis is placed upon whether the market responds efficiently. The other camp focuses upon equilibrium rates of return and variability.⁹ These latter models come out of the finance tradition and examine the risk-return trade-offs.¹⁰ They explore how risks and returns are affected by changing local regional and macro economics conditions.

INFORMATIONAL EFFICIENCY IN REAL ESTATE MARKETS

The outcome of many real estate transactions is affected by the type and amount of available real estate information. Surprisingly, few studies have been devoted to testing how information affects real estate market outcomes and whether informational efficiency prevails. Fama's (1976) basic description of informational efficiency has been accepted in the real estate literature: in an efficient market, the probability distribution used by the market for setting prices at time t is the true conditional distribution implied by all the information available to the market.

⁹See Miles, Cole, and Guilkey (1990) and the references therein.

¹⁰These analyses examine whether one can alter the overall portfolio risk by investing in office space at various geographic location, other types of land uses and/or other types of non-real estate asset classes; see, for example, Hartzell, Heckman, and Miles (1986), and Firstenberg, Ross, and Zisler (1988). This literature has evolved from the portfolio diversification literature and hinges upon accurately predicting the co-variation of returns across real estate and other assets. In terms of our paradigm in Figure 1, diversification implies aggregation over all land users and parcels (across all MSAs) to produce geographic diversification across land uses.

For empirical testing of the efficient market hypothesis, researchers must assume an asset pricing model to specify the probability distribution used by the market. When the price behavior is inconsistent with the *joint* assumption of informational efficiency and “an” asset pricing model, one cannot determine whether the asset pricing model or market efficiency fails. More seriously, when individuals have different beliefs and information, Fama’s definition for the efficient market may not be adequate to describe the relationship between the beliefs of individuals and the market. In other words, Fama’s definition does not provide precise meanings for the terms “the market,” “the true density function,” “information available,” and so on. The lack of precise definition of informational efficiency has led to an “ideal” price behavior benchmark, which characterizes the efficient market as (i) perfect competition, (ii) frictionless transactions, (iii) homogeneous beliefs and information, and (iv) rational investors.¹¹

An improved notion of informational efficiency is developed by Beaver (1981, p. 28), who distinguishes between information system and signal efficiency. A securities market is efficient with respect to a signal if and only if the configuration of prices is the same as it would be in an otherwise identical economy (i.e., with identical preferences and endowments) except that every individual receives signal y_t as well as his/her private signal. A securities market is efficient with respect to an information system if and only if signal efficiency holds for every signal from the information system. With Beaver’s definitions, we can consider informational efficiency with

¹¹Samuelson (1965) appears to be the first who combined the ideal market conditions with the constant discount rate present value model. Samuelson showed that stock prices have the martingale property; that is, the current price is the sufficient statistic for the next period’s price.

respect to alternative information functions; for example, one may suggest, as in Fama (1970), weak form efficiency, semi-strong form efficiency and strong form efficiency.¹²

We have implicitly considered informational efficiency at a fixed point in time. Another important issue is whether the market is efficient with respect to information to be released in the future. Markets exist both before and after traders receive information. Rubinstein (1975) and Milgrom and Stokey (1982) show that for the market to achieve *dynamic* informational efficiency, traders must agree about how the information revealed in the future should be interpreted. This is unlikely to be true for many real estate markets.

Historically, empirical tests of market efficiency have preceded the development of theory. Financial research has put a considerable emphasis upon the opportunity to earn abnormal returns as a test of market efficiency. Existing market efficiency tests in the real estate literature appear to follow the finance tradition.

The earliest tests of real estate market efficiency were performed by Gau (1984 & 1985) and Linneman (1986). Gau concludes that prices in the Vancouver commercial real estate market appear to follow a random walk. Linneman suggests that housing prices in the Philadelphia area are not consistent with the efficient market, but arbitrage opportunities virtually do not exist because of high transaction costs. Case and Shiller (1989) suggest that the single family housing market is inefficient in that returns

¹²Fama's taxonomy provides a crude partitioning of information sets. One may consider information efficiency with respect to a specific information function.

on housing are positively autocorrelated.^{13,14}

While we have reservations about the hedonic index approach in each of these earlier studies, the mere improving or correcting of the estimation of hedonic indices would not resolve our concerns. A theory of market efficiency specifies the process by which information is reflected in prices. Future analyses of market efficiency must contain explicit models of micro real estate valuation. The analyses need to create a framework of equilibrium or market adjustment dynamics toward the equilibrium, including an explicit mechanism by which information is translated into transactions.

This is not an easy task; but it may not be impossible. For example, Dokko, Edelstein, Pomer, and Urdang (1991) allow and test for the possibility that commercial real estate markets are in disequilibrium and that adjustments to equilibrium occur over time in terms of changes in real returns. When they take into account locational and property use differences in the real required returns, commercial real estate markets appear to adjust to equilibrium quickly.

An important extension of the efficient real estate market tests, attributed to the pioneering works of LeRoy and Porter (1981) and Shiller (1981), is the empirical validity of the present value operator. Meese and Wallace (1992) apply the present value model test to housing markets, and Scott (1990) and Dokko and Edelstein (1992) to agricultural farm land markets. In future studies for commercial real estate, we should recognize

¹³The *positive* autocorrelation finding contradicts Shiller's general contention that investors overreact; for example, see Shiller (1984).

¹⁴The autocorrelation test assumes a constant expected rate of return. This is unlikely to be true for the real estate market with changing state variables. Case and Shiller assume that the hedonic index is independent of time; it is unlikely in a real estate market that the relative value of locations do not change over time.

a number of difficulties with the implementation of the present value model test. Similar to the traditional market efficiency tests, the present value model is tested in conjunction with a set of models related to the discount rate and rental behavior, among others. Given information asymmetry and transaction-moving costs, rental rates are not likely to adjust immediately to changes in market equilibrium. Therefore, the present value model test requires an explicit consideration of the market adjustment process in rents. In particular, if there were a partial adjustment process, volatility of in-sample rents may not be used as a yardstick to measure the rationality of in-sample price fluctuations.¹⁵

¹⁵Market prices are likely to look forward beyond the end of the researcher's finite sample period.

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Figure 1: Parcel-User Reservation Price Matrix

		parcels			
		1	2	...	N
users	1	R^{11}	R^{12}	...	R^{1N}
	2	R^{21}	R^{22}	...	R^{2N}
	\vdots	\vdots	\vdots	...	\vdots
	M	R^{M1}	R^{M2}	...	R^{MN}