Ann Reg Sci (1992) 26:257–267

The Annals of
Regional Science

Alternative uses of spatial microeconomics

John G. Greenhut[1] **and Melvin L. Greenhut**[2*]

[1] Arizona State University West, Phoenix, AZ 85069-7100, USA
[2] Texas A & M University, College Station, TX 77843-4228, USA

Abstract. This paper contends that classical spaceless price theory is excessively limited. In contrast, the spatial model provides a robustly general framework such that it even sheds light on the beta statistic in portfolio theory and the capital asset pricing model (CAPM), which led to 1990 Nobels for Markowitz and Sharpe. The paper further demonstrates that the spatial dimension advances other facets of economics, including product differentiation theory, waiting time and advertising impacts on prices, etc. Indeed, the subject of international dumping of goods is shown to have ties to spatial microeconomics besides imperfect competition theory. This paper's objective is therefore to demonstrate some of the inclusiveness of spatial microeconomics.

This paper is to some extent a reorientation of a paper (Greenhut and Greenhut 1991) presented at the WEA International 1991 Conference. Rather surprisingly, it may seem, is the fact that the convention paper was part of the Finance Section meetings of the conference; that is, it was a paper strictly on finance. But what does finance theory (or practice) have to do with regional science? Even more significantly, what does it have to do with this journal's issue *in honor of (and to the memory of) Claude Ponsard?*

Our answer to the above questions is simply that the subjects are interwoven, as the present reorientation of the WEA paper will demonstrate in part. To be sure, the paper that follows discards most of the materials included in the convention paper, where emphasis was on the effects of different *types* of inflation on stock prices. In their place, this paper establishes the regional scientist's interest in the way firms price over an economic landscape. The main purpose of this

* Respectively, Associate Professor of Finance and Business Economics, Arizona State University West; Abell Professor of Liberal Arts and Distinguished Professor of Economics, Texas A&M University and Adjunct Distinguished Professor, University of Oklahoma.
Correspondence to: J. G. Greenhut

paper is therefore to go off in a different direction, and well beyond the convention paper by demonstrating here that the concept of beta in portfolio theory and the capital asset pricing model (CAPM) model, which led to 1990 Nobels for Markowitz and Sharpe, is in fact a theoretical bedfellow of the world of spatial price theory. Beyond this, the present paper will further demonstrate that not only does CAPM have ties to, let us now say, plant location theory, or the impacts of costly distances, but so too do many other subjects, as will shortly be noted. We are accordingly proposing that this paper's objective is to demonstrate some of the inclusiveness of spatial microeconomics, as we in effect are also contending that classical spaceless price theory is extremely limited. It is in this context that this paper adds in our opinion to the memory of the multiple writings of Claude Ponsard.

Section I of the paper proposes that the capital asset pricing model (CAPM) of finance theory can be advanced by an industrial organization (structures) framework. Section II then converts our industrial structures model to a spatial price theory model, in effect enhancing CAPM by the information that can be gained from spatial microeconomics. These initial discussions establish the foundation for Sect. III's demonstration that the landscape (or say the economic distance parameter) can also serve as proxy for the advertising and storage of goods (e.g. Phlips 1983 a, b; Smith 1989), as proxy for product differentiation by a firm and firms, including the interdependence of product types and spatial pricing alternatives (e.g., de Palma et al. 1986), as proxy for address models (e.g., Lowell 1970), as proxy for waiting time impacts on prices (e.g., DeVany 1976; Saving 1982), and also as proxy for international trade (e.g., Vernon 1979). Most importantly, this paper proposes that the economic landscape is fundamental to advanced microeconomic theory (as in Phlips and Thisse 1982). But first a few introductory remarks about CAPM are relevant for the specialists in regional science who may not be familiar with this facet of finance theory.

Finance theory's CAPM

This paper focuses initial attention on the beta statistic, a parameter which relates the volatility of a company's stock return against that of all stocks in the market. Considerable research has attempted to uncover empirically the accounting factors which determine individual company beta values, but the statistical results have been conflicting and generally inconclusive. Correspondingly in a sense, theoretical derivations of the determinants of beta have been limited largely to the income volatility that stems from the firm's leverage of fixed assets and debt.[1] No economic theory concerning the determinants of volatility at the gross profits level has been proposed nor has any been advanced which adequately identifies beta differences *among industries*; for instance, some industries such as gold mining and petroleum have extremely volatile earnings and stock prices, yet possess

[1] For interested readers, a survey of research on the association between accounting variables and beta can be found in Foster (1986) and Beaver (1989).

some of the lowest betas that can be found.[2] This paper will contend that the spatial price theory which is so often used by regional scientists and economists implicitly explains the impact of industrial characteristics on betas.[3]

I. CAPM and industrial structures[4]

Consider the profit maximizing requirement of marginal revenue $p(1-1/e_i)$ equal to the ith firm's marginal cost (MC_i) in an $i = 1, \ldots, n$ firm homogeneous good industry. This relation can be easily converted to an industrial structures perspective. Specifically, if we define g_i as the relative change in the quantity produced in the industry ($\mathrm{d}Q/Q$) to that of the individual firm $\mathrm{d}(q_i/q_i)$ *and* multiply g_i by e_i, we obtain the industry's elasticity E; i.e., $e_i g_i = E$. Substituting E/g_i for e_i in the firm's $MR = MC$ equation, and then aggregating over the i firms in the industry, with $\sum g_i/n = G$ and $\sum MC_i/n = MC$, yields $P[1-G/E] = MC$.

We designate G as the industry's competitive Gravity index. It follows then from the inverse of $[1-G/E]$ that $P = MF \cdot MC$, where the markup factor, MF, equals $[E/(E-G)]$. The rate of change in price P is approximated by the sum of the percentage increases (decreases) in MF and MC. Increases in the percentage change in price therefore do not depend on concentration ratios, but rather on changes in the G index and/or elasticity. With respect to elasticity E, we obtain the critical relation:

$$\frac{\mathrm{d}(MF)/MF}{\mathrm{d}E} = \frac{-G}{E \cdot (E-G)} < 0 \ . \tag{1}$$

A decline in elasticity produces an inflationary impact on price through the markup factor; and, significantly, this impact is most pronounced in markets with low E and/or high G values. *Ceteris paribus*, high beta values stemming from large earnings volatility would obtain in low elasticity, high competitive-gravity industries.

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2 Rosenberg and Guy (1976a) provided an overall framework for understanding the differences among industry betas by formulating beta as a function of relative responses of a business to major factors that affect the overall economy. Perhaps due to difficulty in operationalizing this framework, Rosenberg and Guy (1976b) only offered an empirical estimate of the degree to which different industry betas were not explained by accounting fundamentals. For example, the beta for gold stocks was found to be only 0.36 on average compared to an estimated 1.187 based on accounting variables such as debt leverage. The authors did not offer theoretical explanation as to why industry betas differ, but could only state the importance of including these measured differences in industry betas in projecting the beta of an individual company. The arbitrage pricing theory, originating with Ross (1976), provides an alternative empirical methodology for linking stock returns to economic factors. The more specific research presented in Greenhut and Greenhut (1991), which we are outlining here only briefly given the purposes of this paper, is oriented towards enhancing the operationality of these finance theory frameworks. This is done in the backlight of the spatial pricing practices of industries which are of central interests to economists and regional scientists.

3 An appendix to this paper provides further background on portfolio theory, the capital asset pricing model, and beta for interested readers.

4 As mentioned previously, this section only sketches some of the material presented in the convention paper. For full details, contact either author.

The industry's G index can be seen to vary naturally from 0 to 1, according to three classifications. (a) The zero value applies, for example, when the representative firm is so small that a change in its quantity has no observable impact on the total quantity produced in the industry. Let us refer to this "perfectly competitive" industry as Industry 1. (b) If the other firm(s) ignored a given firm's change in quantity, with the effect of some discernible change taking place in the industry's total output, the gravity index would range between zero and one. Let us refer to the product in question as the output of Industry 2. (c) The limit value for G is unity. This obtains when all firms in an industry seek to maintain their relative shares. Phrased otherwise, if the relative change in the industry's total output is in proportion to that of the individual representative firm, G equals 1. Of course, not only may all firms endeavor to maintain their individual market shares in conformance to either a cartel structure or the practice of conscious parallelism of action, but this industry, call it Industry 3, may also depict a simple monopolist.

II. From industrial structures to delivered prices

Directly identifying quantity-price conjectural variations is virtually impossible in the real business world. In effect, the conjectural variations approach is just an abstract analytical device for use in the ivory tower. However, ascertaining the way that firms price over their market spaces is not a difficult empirical study at all.[5] Observations along this line would reveal the relevant industrial structure for a firm, and in turn enable a much more penetrating application of the CAPM approach to stock prices. The spatial price policies of firms are, we now propose, intrinsic to the earnings volatilities of firms, and hence the beta values of finance theory. Accordingly, we shall examine price patterns instead of quantity conjectures, doing this by reversing our references to the industries described earlier, beginning initially now with Industry 3.

Industry 3 depicts firms whose $\mathrm{d}q_i/q_i$ remains in constant proportion to $\mathrm{d}Q/Q$. These firms would pursue a delivered price system, *DPS*, over an economic landscape which is of such form that if one firm raises (lowers) its delivered price schedule (DPS), the other(s) in conformable reaction would match that change. Industry 2, on the other hand, then consists of establishments whose managers ignore a DPS change by the representative firm. Finally, Industry 1 relates to the situation where the rival firm(s) reacts oppositely to a change in the representative firm's DPS, lowering its price if the rival raises its price and vice versa.[6] The respective spatial price systems described here are referred to in spatial microeconomics as Löschian (Industry 3) pricing, Hotelling (Industry 2) pricing, and Greenhut-Ohta (Industry 1) pricing.[7] Note further that Industry 3 can be

5 See Greenhut et al. (1980).

6 See Hamilton et al. (1989), where in effect Cournot is our Industry 2. This Cournot case approaches a Bertrand Industry 1 instance when spatial transport costs are very low for the Bertrand firms *and* the firms in the Cournot model approach a very large number.

7 See Phlips and Thisse (1982), Part I Hotelling and Lösch Approach, pp 11–130, and Part II The Greenhut-Ohta Approach, pp 131–194.

characterized as having a homogeneous market structure (i.e., its member firms act identically to each other); Industry 2 can be called a Cournot Industry (i.e., its firms ignore each other); while Industry 1 depicts a heterogeneous structure (i.e., its member firms act oppositely to each other).

Under Industry 3 (Löschian spatial pricing), any decrease (increase) in price by the firm(s) at one production center is matched by the firm(s) at a distant-but rival production center. Under Industry 2's approach, often also referred to as the Hotelling-Smithies approach, a change at one center in the basic mill price, and thus in the delivered prices therefrom, fails to elicit a response from the rival center. Under Industry 1 pricing, a reduction (increase) in mill price at one point promotes an increase (reduction) in mill price at the distant center.[8]

Profits are basically greatest under Industry 3 pricing, then comes Industry 2, with Industry 1 yielding the lowest profits. Volatility of earnings stem, in turn, from industry type and the factors evaluated previously in this paper, e.g., basic demand elasticities. The overall result is that theories of finance and portfolio management, as in CAPM (or the arbitrage pricing theory, APT) tie up directly with industrial organization theory and the microeconomics of space. In fact, going beyond this paradigm, we would suggest that evaluations of CAPM, and in particular the macroeconomic impacts of inflation, indicate minimal earnings volatility in the case of a market structure characterized by Industry 1 pricing. This is so because demand elasticity is greatest in that case with G approaching zero.

More inclusively than stated above, any increase in elasticity because of entry reduces the rate of change of the markup $\{[\mathrm{d}(MF)/MF]/\mathrm{d}E<0\}$, while the opposite of course results when firms exit the industry. In the initial event, the increase in price in Industry 1 does not keep pace with the rate of increase in cost, whereas in the latter event it is exaggerated. We recognize further that a decrease in elasticity due to inflation triggers a higher multiple. And given the last mentioned instance, a homogeneous structure, or say Industry 3 competition, would generate the greatest multiple of all.

III. Product differentiation, waiting time and other extensions

A critically important facet of models of stock market prices is that the major stock exchanges center on oligopoly firms and regulated monopolies; ipso facto, theories concerning prices over an economic landscape are theories of oligopolistic enterprises, some in collusion with others, some under substantial regulation and control by government, and some in a form of spatial competition with each other, such as the types of competition described above in this paper. The economic landscape generates a world of oligopolistic industries. These, to repeat, are also the industries whose stocks are bought and sold in the market. More than that they are the industries on which microeconomic theory must be constructed.

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8 See Greenhut et al. (1987), particularly Chapts. 2 and 3.

"Space" and "distance" and the world of oligopolies provide results which are not only important to such fields as finance theory (or vice versa if you prefer), but in effect are also intrinsic to a variety of economic phenomena. As noted in our introduction, a vital tie-up is that which relates to product differentiation. Indeed, the individual product variants of firms can be viewed as if each is located along a spectrum of consumer desires, where each variant has a well-defined "market area". The spatial framework of thought naturally uncovers the effects of new product variants as well as enabling comparisons of product varieties under a number of different market structures (Lowell 1970; Lancaster 1979; Salop 1979; Scherer 1979; Vernon 1979; Novsheck 1980; Salant 1980; Phlips and Thisse 1982; Anderson 1986; Neven 1986; de Palma et al. 1988).

As another example, it is well recognized that demands for many products and services are limited not only by the price of the good or the fee that is charged but also by other costs of acquisition, such as waiting time or storage costs (DeVany 1976; DeVany and Saving 1977; Phlips and Thisse 1981; Saving 1982; Smith 1989). This is particularly true in evaluating service activities, including privat medical-care alternatives; simply put, the spatial analogy sheds new light on the positive relation between fees and the number of medical practitioners (M.L. Greenhut et al. 1985a).

Spatial analysis of market entry (Benson 1985) can lead to consideration of the regulation of airlines (Greenhut et al. 1991), and in turn the address models (Archibald et al. 1986). These lead back to the impacts of mergers and antitrust regulation, all made more tractable and realistic once the imperfectly competitive environment of firms is taken into account (Benson and Greenhut 1989). Similarly, the efficiency and welfare implications of such economic practices as the bundling of goods (so-called tying contracts), bank charges on checking accounts, wage discrimination by sex and education, quantity discounts, and the nonlinear price schedules charged by telephone companies, are amenable to spatial analysis (Phlips 1983a, b).

We also contend that the spatial framework sheds light on a number of important international trade issues. A tariff barrier, for one example, has many of the properties of a transport cost, from which it can be shown that an ad valorem tax has different impacts than a specific tax (Greenhut and Norman 1986). International-trade theorists are in fact becoming particularly concerned with two phenomena that do not fit easily into "traditional" spaceless economic theory: the emergence of the multi-national enterprise and the increasing proportion of trade flows that is accounted for by intra-industry trade (Vernon 1979; Buckley and Casson 1987; Dunning 1987). In addition, many trade theorists are concerned with the dumping issue (Brander and Krugman 1983; Greenhut et al. 1985b). Spatial microeconomic analysis provides insights into why companies and industries change their orientation from a chiefly export-based operation to one which strictly emphasizes local markets, and most generally one that deals in both markets, with intra-industry trade going each way (Norman and Dunning 1984).

Beyond the above noted particular subject applications, it was previously suggested that the spatial dimension should underlie all of microeconomic theory besides that of time. In particular, it is well established in spatial price theory that the mere facts of costs of distance and a limited number of sites available at any point in space signify the prevalence of a comparatively small number of firms in any market. Thus an action-reaction interdependence prevails between the firms of an industry, and between production centers (Greenhut and Greenhut 1975). A Löschian landscape, for example, can be imagined, with oligopolistic firms occupying central stage. It has long been a joke that every economist has his or her own theory of oligopoly. The inference exists that there is no deterministic oligopoly outcome, and hence as is argued so often by members of the Chicago School, microeconomics should, and must be rooted in the purely competitive framework. The present authors believe otherwise.

Consider in this regard the Greenhut et al. (1987, Chapter 19) solution. They recognized the existence of behavioral uncertainty in oligopolistic industries as a unique uncertainty, one that is intrinsic to a market characterized by sellers who identify their rivals and who act as well as react according to their conjectures about the rivals' behavior. They argued that this uncertainty is a cost, just as is risk. Unlike risk, however, and in accordance with standard literature in operations research and economics, they regarded it as a subjective cost, not as the objective (statistical) cost which underlies the different returns one can expect to receive under risk. It follows that the variance of net receipts, positive and/or negative, to which oligopolists are subject demands a residual payment which – in the long run – must cover the degree of behavioral uncertainty that underlies a given industry. It is a small, yet formidable step to recognize that this residual income adds on to the standard average cost that viable firms must and will recover in the long run.

In their theory, the behavioral uncertainty cost generates a new average total cost curve, call it ATC_u. Most dramatically, the subject authors demonstrated that in a competitive free entry/exit oligopoly market a tangency between the oligopolist's negatively sloping average revenue curve and the ATC_u eventuates, doing this at a point directly above the minimum long-run technological average cost point of classical economic theory. The conclusion is that the oligopoly firms which dot an economic landscape must cover their explicit and all implicit costs (including the cost of behavioral uncertainty) in the long run; then, if competition prevails between these firms, they will cover these costs exactly via the free entry and exit of firms which eliminates the short-run surpluses and losses that exist. It should be manifest that this theory, which in turn can be shown to stem from present day location theory, not only identifies the firms whose ownership shares can be bought and sold in the market, but whose short-run income variances establish unique firm risks which portfolio managers (and the CAPM model) seek to diversify away.

Pursuant to the above, the paper further contends that emphasis on oligopoly market relations, i.e., in effect emphasis on the costs of space (distance), is fundamental to the very core of economic theory. And we deliberately did stipulate economic theory, not just microeconomics; this was done in belief that, to the extent that macroeconomic policy prescriptions are plotted against the backdrop of the *perfectly flexible* price-output, entry-exit world of pure competition, economic policy practitioners must (and will continue) to err quite substantively.

It suffices under this paper's objective and page limitations that we have merely sketched the generality of the spatial framework. (Additional and more detailed discussion of this issue can be found in Greenhut et al. 1987.) We lament that its generality has yet to be recognized throughout the profession. Most importantly, however, let us note again in this last regard that given the cost of distance, the world of industry is one of oligopoly. Failure to evaluate and understand the oligopoly market implies theoretical emphasis on pure competition and/or on monopolistic competition and/or on simple monopoly, each of which will often be an unproductive exercise, especially if applied directly to the world of business. Such misplaced emphasis completely ignores the sequential world of location and price equilibrium under cooperative and noncooperative games between decision makers who readily identify their rivals (as in Thisse and Vives 1988). The world of economic space can alone provide empirical evidence. It must also be used in the theoretical work of economists.

IV. Final remarks

"Quantity conjectures" are often derogated as being derived from extreme abstraction. In contrast, the way that firms in an industry *price* over space can be determined directly. That focus therefore provides a precise view of industrial structures without need for extreme abstraction. Indeed, the firm's pricing not only provides a gravity index but along with demand elasticity, product type, and the state of the macroeconomy, also point to beta relationships. These several relationships can, in turn, provide a rich perspective of past and future stock prices.

Given improved predictability of future betas compared with that possible on the strict basis of historical values *or* on the basis of historical values adjusted by special subjectively included considerations, it would follow that portfolios can be evaluated more precisely. Then the set of portfolios designed for different risk aversion levels could be made increasingly continuous and hence appropriate for more investors. Standing behind applications of betas would be an oligopoly theory which per se deals only with empirically observable events. One would hope that as this correlation is considered, the other many extensions of spatial price theory, which include analytical analogues and insights into product differentiation theory, advertising policies, inventory storage etc., will also be recognized. The composite would be a microeconomic theory based not just on time but on space and, accordingly, a theory which can furthermore provide a realistic-substantial foundation for evaluating the economic policies of governments.

Appendix

The basis for the capital asset pricing model (CAPM) was formed by the portfolio theory developed by Harry Markowitz, whose work along with others mentioned below can be reviewed more completely in texts on financial management or investments, such as Hirt and Block (1990, Chapter 20). For present purposes it suffices to say that Markowitz demonstrated how an investor can reduce the variance of the returns on his investments through portfolio diversification. As a consequence, the investment decision for a particular asset hinges not only on its contribution to the overall return, but also on the asset's impact on total portfolio variance. Markowitz derived the variance of the portfolio to consist of the variances of the individual investments and the covariances between all of the assets in the portfolio, according to:

$$\mathrm{VAR}\,(R_p) = \frac{1}{N^2}\cdot\left[\sum_i \mathrm{VAR}\,(R_i) + \sum_i \sum_{j\neq i} \mathrm{COV}\,(R_i, R_j)\right] , \tag{A 1}$$

where R_p and R_i respectively represent the expected return for the investment portfolio and the individual assets $i = 1, \ldots, N$. Practical application of the theory, therefore, unfortunately involves the determination of $N\cdot(N+1)/2$ variances and covariances for an N asset portfolio. For a portfolio comprising 100 stocks, 5,050 variances and covariances would have to be determined.

To remedy this computational problem, Markowitz proposed relating the future returns of an asset to the *average* expected return on all assets combined, rather than each separately. That relationship is provided by beta, which is the slope coefficient calculated as $\mathrm{COV}\,(R_i, R_m)/\mathrm{VAR}\,(R_m)$ in the simple linear regression between the asset's return and that of the overall market:

$$R_i = \alpha_i + \beta_i \cdot R_m + \varepsilon_i \tag{A 2}$$

where R_m is the expected return for the total market. The portfolio variance then can be shown to derive as:

$$\mathrm{VAR}\,(R_p) = \mathrm{VAR}\,(R_m)\cdot\frac{1}{N}\sum_i \beta_i + \frac{1}{N^2}\sum_i \mathrm{VAR}\,(\varepsilon_i) \tag{A 3}$$

which requires a relatively low $2\cdot N+1$ values: N individual betas plus N individual residuals (volatility not related to the market) plus 1 total market variance. The task of calculating portfolio variance of 100 stocks thus reduces to 201 unknowns.

The refinement using beta meant significant savings in implementing portfolio theory. More importantly, perhaps, it opened up a new point of view for financial theorists. William Sharpe, John Litner, Jan Mossin, and Jack Treynor are regarded as the chief architects of CAPM, which sets forth the price of an asset in terms of its expected, or required, return as:

$$R_i = R_f + \beta_i \cdot [R_m - R_f] , \tag{A 4}$$

where R_f is the expected return on a risk-free security, commonly considered to be US Treasury Bills. This equilibrium is formed by arbitrage opportunities that would exist between investing in the individual asset or a portfolio that consists of $(1-\beta_i)$ percentage of funds invested in Treasury Bills and the remaining β_i percentage of funds in a market basket such as the S&P 500. Associated with this equation are the Markowitz portfolio concepts that: (1) investors will not require a return based upon the full range of uncertainty (i.e., total variance) of returns on an asset, but only on the component that stems from the overall market volatility (which accordingly cannot be diversified away), and (2) CAPM achieves minimal portfolio risk/variance for a given expected return, or alternatively maximum return for a given level of risk. Quite clearly, what led to 1990 Nobels for Markowitz and Sharpe relates directly to a subject which spatial price and regional science theorists have been investigating since World War II; namely, the different residual returns for different behavioral uncertainties that each competitive oligopoly firm must cover.

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