"ANALYSIS AND IMPLICATIONS OF SPATIAL COMPETITION"

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER

THESIS DIRECTOR'S SIGNATURE

Houston, Texas
(May 1970)
Analysis and Implications of
Spatial Competition
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ABSTRACT

For many years, economists abstracted from considerations of space in building models of competition. This deficiency was in part made up by Harold Hotelling's contribution in 1929 to the economics of space. The theory developed by Hotelling was later elaborated on by Arthur Smithies.

This thesis examines the assumptions and conclusions of Hotelling and Smithies. As is the case in many theoretical articles in economics, the models constructed by these authors are not applicable in their present forms to actual problems in the real world. The major contribution, then, of the thesis is its concluding section, which shows how the assumptions of Hotelling and Smithies should be modified to make them models applicable to actual decisions.
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I. Introduction

Many of the most formidable difficulties of economic analysis are connected with time and space. The former is handled through the study of economic dynamics. The latter has been considered implicitly in theory by abstracting from problems of space. Space in economic theory was first considered in studies published by Hotelling in 1929 and was elaborated upon by Smithies in 1941.

The purpose of this thesis is to take some further steps in the theory of spatial competition by analyzing the assumptions of these two authors with respect to their implications for managerial decision making.

II. Framework of Assumptions

In the following section we shall review the assumptions of Hotelling and Smithies. Later we shall study which assumptions of the models have to be modified to make the model relevant for actual decision making.


A. Assumptions and Conclusions of Hotelling.

Hotelling employed the following set of assumptions: Procedures begin at a given location on an infinitely long straight line.

(1) The buyers of a homogeneous commodity are uniformly distributed along the same line.

(2) In figure 1. Let A and B represent the initial location of two sellers at distances a and b respectively from the two ends of this line. Additional assumptions are:

(3) Each buyer transports his purchases home at a cost C per unit distance.

(4) The cost of production to A and B is zero, and that unit quantity of the commodity is consumed in each unit of time in each unit of length of line. The demand is thus at the extreme of inelasticity. No customer has any preference for either seller except on the basis of price plus transportation cost. In general there will be many causes leading particular classes of buyers to prefer one seller to another, but the collution of such consideration is symbolised by transportation cost.

Implications are: 1) B's price may be higher than A's but if

(3) Op.Cit. 1
B is to sell anything at all he must not let his price exceed A's by more than the cost of transportation from A's place of business to his own.

2) The point of division between the regions served by the two entrepreneurs is determined by the condition that at this place it is a matter of indifference whether one buys from A or from B.

3) Each competitor adjusts his price so that, with the existing value of the other price, his own profit will be a maximum.

4) The boundary between the two regions is the locus of points for which the difference of transportation costs from the two sellers equals the difference of prices, i.e., for which the delivered price is the same whether the goods are brought from A or from B.

5) If transportation is in straight lines (perhaps by aeroplane) at a cost proportional to the distance, the boundary will be a hyperbola, since a hyperbola is the locus of points such that the difference of distances from the foci is constant.

6) If the transportation is not in straight lines, or if its cost is given by such a complicated function as a railroad freight schedule, the boundaries will be of another kind; but it might generalise the term hyperbola (as is done in the differential geometry of curved surfaces) to include these curves also.

Thus Hotelling has confined himself substantially to the extreme competitive assumption that each competitor fixes his price and location.

Hotelling assumes that each firm behaves as if price and location of the rivals remain unaffected by their action. Finally the crucial
assumption in his analysis is inelastic demand which in spatial competition means no customer has any preference for either seller except on the ground of price plus transportation cost. In other words neither competitor makes sacrifices of a lower price at the ends of the market when he invades his rival's territory; thus there is no check on the two producers' moving in agreement.

The conclusions following from his analysis are: There is a tendency for the two competitors to cluster at the center of the road. Given a location for a given producer, let us say A, producer B will tend to gravitate infinitesimally close to A. In this form maximization of profits is obtained for B at the expense of A.

The system of prices devised is socially uneconomic because it leads to needless shipment of goods. Last there exists a tendency for entrepreneurs to imitate each other in the manufacture and labelling of goods.

B. Assumptions and Conclusions of Smithies

Let us examine the assumptions of Smithies' article which presents two sets of assumptions - the structural assumptions which limit the problem as whole and the assumptions as to the character of the competition. The structural assumptions are as follows:

1. There is a linear market bounded at both ends;

2. At each point of the market there is one price; the quantity sold at any point is supplied by the producer who has the lower delivered price at that point;

(4) Ibid., 2
3. There are two competitors, A and B, having single locations;

4. The producers are working with a constant marginal cost, assumed equal to zero for both;

5. Fixed costs are not taken in account;

6. There is a uniform freight rate per unit of distance for both entrepreneurs, which is independent of distance and the price or amount of the commodities transported;

7. Each competitor will sell on an f.o.b. mill basis. This means, he will fix a mill price to prevail at the point where he is located, and his delivered price will be computed by adding to the mill-price the freight cost from his mill to the point of delivery, of figure 2.

8. Each competitor is free to move his location instantaneously and without cost;
9. Each producer will attempt to fix his mill price and his location so as to maximize his instantaneous rate of profits in respect to his total sales;

10. The linear demand curve is relatively elastic;

11. A final structural assumption is that freight rates are assumed to be such that there are sales at every point of the market.

His various assumptions for the character of the competition are:

a. Case where there is a monopolist on the straight line;

b. Case where the monopolist on the straight line has two plants;

c. Case where there are two competitors on the straight road with quasi-co-operation as to prices; competition as to locations;

d. Case where there are two competitors in full competition.

The conclusions deduced from his analysis are: for the monopolistic producer case a, the firm will be located at the median of the road. If the monopolist has two separated plants these will be located at the quantiles of the market line, and will act as a monopolist to their segments of the market. For the case of two producers in full-quasi-co-operation the conclusion is similar to the monopolist with two separated plants. That is, their efforts will be directed to localize in each quantile of the market so as to maximize profits from a half quantity of the market. In quasi-co-operation as to prices, competition as to locations; for this case each competitor believes
to an equal degree that he has one effective strategy for increasing his territory—namely, moving closer to the center while expecting that his rival will not change his location but will meet price competition. Equilibrium will be achieved with each competitor at an equal distance from the center of the market and closer to it than the quantiles. Final conclusion for the case of full competition differs from Hotelling. Each producer will tend to move closer to the center from the quantiles. The prospects of gain from price-cutting and loss from price-raising will result in a lower equilibrium price.

III. Spatial Competition Analysis and Implications for Decisions

We now turn to examining the assumptions of Hotelling and Smithies with the idea of modifying them to improve their relevance to managerial decisions.

--- The consumers of a relatively homogeneous product are not in a straight line but rather they are scattered uniformly over a given geographic area.

--- The buyers of a commodity relatively equal have been assumed to be uniformly distributed along the line. Obviously in reality customers may be randomly distributed.

--- Each buyer transports his purchases home at a cost \( C \) per unit distance; this assumption of Hotelling is equivalent to Smithies' assumption that price is equal cost of production, i.e., price-mill plus freight cost.
In the Hotelling case customer himself pays delivery price; in the Smithies' case producers charge the freight cost per unit-mile at any point of the line. In the real world, it should be better for a company that produces small products to use a distribution system where it can profit on a transportation-cost when the demand function for the product is absolutely inelastic. If the demand function of the product is not inelastic but rather relatively elastic, the above implications will change.

— There are two competitors, A and B, having single location. Generally the market has more than two producers. The spatial model should also be related to fixed costs of the firm. Algebraically the total cost of a producer is \( K+C \times X \) for output \( X \) where \( C \) is a variable cost per unit of output \( X \) and \( K \) is fix cost or overhead capital.

— The economic world does not fit the general assumptions of economic competition, i.e., marginal cost changes from one firm to another.

— The assumption of price and the location of his rival will be fixed independently of his own is usually made in microeconomic theory or there is competition in prices.

and locations which implies that one competitor adopts a price and location policy designed to eliminate his rival's market entirely. Firms generally prefer a cooperative market instead of cut throat competition.

Each competitor is not free to move his location instantaneously and without cost as Smithies unrealistically assumed in his analysis. Many kind of factors affect costs of location some are unmeasurable; e.g., location of raw materials, labor input requirements, skill or unskill workers, degree of overhead capital which include electric power, water systems, road, constraint of social institutions, etc, and finally, location and accessibility of the firm in relation to the market.

A uniform freight-cost per unit-mile independent of distance and the price and amount of the commodities transported is assumed. This particular assumption may hold for certain agricultural products, but in general for all products. In the real world uniform freight-cost assumption will not show the results of the particular calculations which are made in determining the most advantageous route, and lead to other conclusions that are worthy of observation. Even more when there exists no linear relations between

(6) F. E. Ian Hamilton "Models of Industrial Location", in Models in Geography by R. J. Chorley and P. Hagget, P.P. 365.
mill-price and delivered prices such as - discontinuities, increasing or decreasing costs of transportation for farther distances between the producer and the buyer.

-- A crucial assumption for Hotelling is the demand function is absolutely inelastic. This characteristic demand is applicable for many agricultural goods or homogeneous products. On the other hand if the model is used for products of demand relatively elastic such as branded goods, the conclusion of producer A and producer B to cluster toward the center of the road may still hold but in weaker form. The elasticity of demand of particular groups does decrease the tendency to excessive similarity of competing commodities.

-- Each competitor adjusts his price so that, with the existing other prices, his own profit will be a maximum. In the real world each competitor does adjust his price taking account the existing price of the other firm. Furthermore firms try to hold market share or volume of sales and not necessarily do they try always to maximize profits.

IV. Conclusions

Spatial competition must be more precisely defined than the monopolistic and duopolistic models of Hotelling and Smithies which are artificial and remote from actual economic phenomena. These models, though, oversimplified, provide valuable insights. The danger in using Hotelling's and Smithies' analyses lies in trying to generalize from these simplified pictures to cases in the real world involving many more complexities.
Bibliography