LOCATION THEORY

AND THE

OPTICAL INDUSTRY

A THESIS

PRESENTED TO

THE FACULTY OF GRADUATE STUDIES

UNIVERSITY OF MANITOBA

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE

MASTER OF ARTS

---

by

George Kosarych

October, 1971

ACKNOWLEDGEMENTS

I gratefully acknowledge the assistance of all those who have aided me at various stages in the preparation of this thesis. My wife's unfailing encouragement and patience have been indispensable. I wish to thank my advisor, Professor Clarence Ekstrand, for his useful criticisms of an earlier draft. Particular thanks are due to Mrs. Susan Hart for typing this thesis.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

This thesis represents an attempt to apply the principles of location theory to the Canadian ophthalmic goods manufacturing industry. Almost all previous location studies have involved large corporations which are either material or market oriented. Very few economists, if any, have attempted to apply location theory to an apparently footloose industry such as the optical industry.

There were a number of reasons for the selection of the optical industry. The Manitoba government has had considerable interest in investigating this industry since they believed that "excessive" profits were being made. Personal experience suggested that several idiosyncratic characteristics of the optical industry would make a location study a worthy analysis.

There were three paramount reasons for selecting the optical industry for analysis. The optical industry is a part of the medical industry. The Hall Commission Report of 1964 recognizing the magnitude of the medical industry within the Canadian economy made a number of important recommendations concerning the optical industry.[1] The Report recommended the inclusion of eye glasses as part of the Canadian

---

[1]Canada, Federal Task Force Study, Report of the Hall Commission on Health Services, 1964.

Medicare plan and secondly that the provincial health services agencies make special arrangements for bulk purchases of spectacle frames and lenses. Recommendations of this nature not only reflected the importance of the optical industry as a component of the medical care sector but also was suggestive of the industry on its own merit. Finally, the fact that branch offices were located in Manitoba made it convenient to obtain personal interview information.

1. The Evolution of Location Theory

Location theory has undergone many changes in recent years. Early classical economists examined location from a purely competitive approach. Their formal analysis was related to a static and spaceless economy. They deemed the optimum location problem trivial compared to the stability and growth of an economy. Spatial theory was first integrated into traditional price theory by the incorporation of spatial cost.

The German historical school of economic thought arose as a reaction to the theories of traditional classical economists. Adherence to the school of thought stressed the point that theory should not be devoid of practical significance but rather should conform to the conditions of social reality. As a direct precipitate of this pattern of thought, Von Thünen attempted to incorporate a theory of location into the general framework of economics.[2]

---

[2]J.H. Von Thünen, Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie, (Berlin: Schumacher-Zarchlin, 1875).

In contrast the marginalists relied heavily upon theoretical discussions concerning the factors affecting cost and demand. As could reasonably be expected many of their assumptions were inapplicable to the spatial dimension analysis. Since the structure of spatial systems is characterized by discontinuity resulting from the existence of nodal centres, population clusters and transhipment points, it made it difficult to reconcile these discontinuities with the smooth continuous functions which characterized more traditional price theory.

The early part of the twentieth century witnessed the development of location theory within general equilibrium models. This was probably due to the influence of the neoclassical school and its particular attention on general equilibrium analysis.

The relative neglect of spatial theory in the past, however, does not mean that the subject is of minor importance. "It partly reflects the longevity of classical modes of thought and the belated development of techniques of analysis appropriate for regional analysis."[3] Part of the increased interest in spatial economics in recent years has been fostered by the realization that the spatial factor has a significant bearing on the development problems of regional economics. Also, many economists are becoming more aware of the need that a complete

[3] H.W. Richardson, Regional Economics, (London: Camelot Press Ltd., 1969).

economic theory should include the space dimension.

Various governments and private companies have undertaken location cost comparison studies in recent years. In particular, governments, especially those in relatively poorer areas, have conducted such studies in order to make private industry aware of the savings that could accrue to those initiating or expanding its facilities within their boundaries. On the other hand private firms have conducted similar studies when they have considered either expansion or new plant location. Ultimately, the objective of location analysis has been either to attract capital to particular regions or to realize greater profits through the selection of an optimum plant location.

This thesis will attempt to definitively analyze a number of the important practical implications of location theory analysis. Within this theoretical framework the optical industry will be examined. However, before actually embarking upon this limited area of analysis, Chapter II will examine the various leading theories of location.

The first part will survey the location theories of Von Thünen[4], Weber[5], and Hoover[6]. All three emphasize input cost as the location determinant. The second part of the

---

[4]Von Thünen, loc.cit.

[5]Alfred Weber, Theory of the Location of Industires, trans. C.J. Friedrich (Chicago: University of Chicago Press, 1929).

[6]E.M. Hoover, The Location of Economic Activity, (Toronto: McGraw-Hill Co., 1963).

chapter will emphasize the market area approach and discuss briefly the theories of Lösch[7], Fetter[8], Hotelling[9] and Smithies[10], Lerner and Singer[11], and Chamberlain[12]. The last part of the chapter will examine Melvin Greenhut's theory which attempts to combine the cost and interdependence theories of location.[13]

Chapter III will discuss the theoretical model of location which has been deemed suitable for application to the optical industry. The model is essentially a combination of models presented by Leon Moses[14] and D.H. Smith[15].

---

[7]A. Lösch, Economics of Location, trans. W.H. Waglom, (New Haven: Yale University Press, 1954).

[8]F.A. Fetter, "The Economic Laws of Market Areas," Quarterly Journal of Economics, XXXIX (1924), 520-29.

[9]H. Hotelling, "Stability in Competition," Economic Journal, XXXIX (1929), 41-57.

[10]A. Smithies, "Optimum Location in Spatial Competition," Journal of Political Economy, XLIX (1941), 423-439.

[11]A.P. Lerner and H.W. Singer, "Some Notes on Duopoly and Spatial Competition," Journal of Political Economy, XLV (1939), 445-86.

[12]E.H. Chamberlain, Theory of Monopolistic Competition, (Cambridge: Harvard University Press, 1946).

[13]M. Greenhut, Plant Location in Theory and in Practice, (Chapel Hill: University of North Carolina Press, 1956).

[14]Leon N. Moses, "Location and the Theory of Production," Quarterly Journal of Economics, LXXII (1958), 259-72.

[15]D.M. Smith, "A Theoretical Framework for Geographical Studies of Industrial Location," Economic Geography, 42 (April, 1966), 95-113.

Chapter IV examines the optical industry, dealing with the structure, conduct and performance of the ophthalmic goods industry in Manitoba. Factors such as barriers to entry, inventory control, price competition and market demand will be discussed.

Chapter V will deal with the influence of various locational cost factors on the site-selection of an ophthalmic goods manufacturing plant and an appraisal of an Ontario and Manitoba location for a plant will be carried out with particular conformance to the location factors discussed in previous chapters.

The last chapter (Chapter VI) will summarize and conclude the study.

CHAPTER II

LEADING THEORIES ON LOCATION

In recent years there has been an increasing importance attached to the study of spatial economics. This importance has undoubtedly arisen from the realization that the way in which economic activity is spatially distributed has a significant bearing on the development problems and choice of location of various industries. In recognition of the potential importance of the spatial aspect of price theory the spatial dimension will be considered as an integral element in the analysis of the optical industry.

Basically, there were two distinct approaches towards the development of location theory by economists. These may be termed the "least cost" and the "market area" approaches. The least cost approach arises largely from German origin. It deals with the role of transport and operating costs in the location of industrial activity. This approach emphasizes the search for the least cost location by abstracting from demand. Essentially, it assumes a given market centre, different costs from place to place, and competitive pricing. The market area approach is an outgrowth of monopolistic competition analysis. It considers the location pattern of firms when they are faced with competition from other firms for markets. It focuses attention on the determinants of the size and shape of the market area for a firm or industry. Costs are assumed to remain constant in space but buyers are conceived to be scattered over an area. Thus demand for the output of the firm is the variable factor and firms maximize profits by attempting to control the largest market area.

The procedure adopted in this thesis will be essentially that of the least cost approach since demand will be assumed to be given. Before presenting the economic model which will form the theoretical basis for analysis of this industry the remaining part of this chapter will survey all leading theories critically noting each theory's advantages and disadvantages. These theories will ultimately form the basis of the model for analyzing the optical industry.

1. Least Cost Theories

i) Von Thünen[1]

Johann Heinrich von Thünen was one of the first economists to initiate interest in a least cost theory of plant location. Although he was primarily concerned with agricultural locations, his theory within its inherent limitations proves to be readily adaptable to manufacturing industries.

Von Thünen postulated a homogeneous land surface with a marketing centre spatially separated from the production or cultivating centre. He assumed that labour and capital were equal in cost and productivity at all locations. Thus, the

---

[1] Von Thünen, loc. cit.

location decision rested entirely upon the cost differences arising from varying land rents and transportation expenses.

In essence, von Thünen assumed location as given with the problem bring that of determining the type of production to be carried out. Although his theory provides an adequate point of departure, his assumptions are too restrictive for our purposes.

ii) Weber[2]

Alfred Weber's theory of location is procedurally opposite from von Thünen's. Weber's theory assumes a given branch of industry with a determined type of production and the place of location is sought.

Weber assumed an uneven deposit of fuel and raw materials and several consumption centres. However, he confined his geometrical representations and general discussions to a given market point. His approach was heavily biased towards an analysis of costs. The optimal location decision involved the optimum substitution between the factor inputs.

He suggested three general determinants of location: transportation cost, labour cost and the agglomeration (deglomeration) forces. There were two variable general factors: those which were primarily causes of the regional distribution of industry (regional factors), and those which were secondary causes of a regional distribution of industry (agglomerating

---

[2]Weber, *loc. cit.*

and deglomerating factors), being themselves effects of the regional factors. By analyzing one given industrial process Weber deductively found two general regional factors of cost: transportation costs and labour costs. He isolated transportation costs as a separate element since the problem of location as he saw it was one of spatial distribution. Weber stated that these three general determinants drew industry closer together or dispersed it, depending upon the respective strength of each force.

Weber's theory of location involved substitution between transport costs and non-transport costs. Transport costs as he defined them included shipping costs, material costs at given sites and agglomerating factors. Non-transport costs included labour costs and land costs (i.e. rental, police and fire protection, economies of scale, etc.). He conceived of a series of isodapanes (points of equal transport costs) surrounding the minimum transfer cost point. The following provides a brief illustration of Weber's weight triangle thesis with an explanation on how he used this technique to obtain the minimum transport location.[3]

Weber introduced the weight triangle technique when he first discussed transport orientation. He regarded the following factors as given:

a) location and the size of the places of consumption

---

[3]Ibid., pp. 48 - 53.

b) location of the available material deposits

c) the raw material is turned into the finished product at some single place of production.

Thus within this framework transport costs alone influence the choice of location.

Weber imagined himself stationed at one of the points of consumption. From this place, he concluded that there must be, for every kind of product consumed at that place, certain deposits of material (raw and power materials) the use of which would result in the lowest transportation costs. The deposits most advantageously located would be employed for such production as necessary to fulfill the demand at the particular place of consumption. Thus he created "locational figures", one for each place of consumption and material deposit (as indicated below).

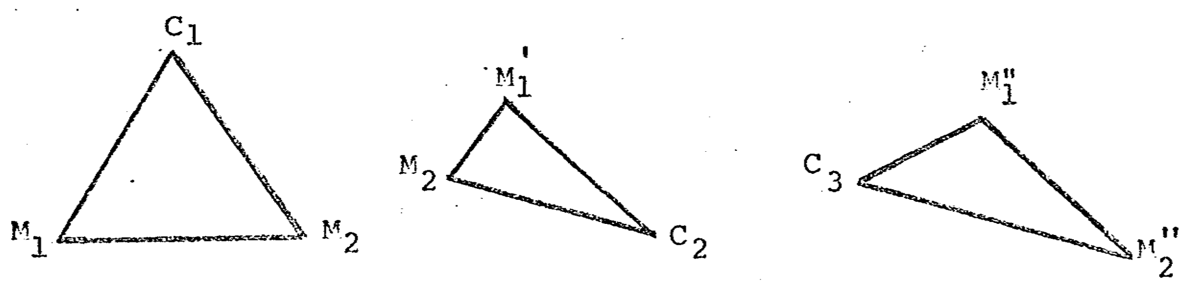

Figure 1 Figure 2 Figure 3

If we suppose that we are dealing with a product composed of two materials which are found in scattered deposits, the locational figures would be represented by triangles. One corner of each triangle would be the place of consumption, and the other two corners would be the most advantageous places of material deposits as shown in figures 1, 2 and 3.

If we assume that nothing but the cost of transportation influences the selection of the location, it is evident that these locational figures must give the only possible mathematical basis of orientation. Weber applied these locational figures to a real situation seeking to illustrate the outstanding elements of the structure of orientation.

Suppose materials are divided into ubiquities and localized raw materials where ubiquities are materials readily available, thus lacking a significant location pull whereas localized raw materials are available only at some locations and therefore influence the choice of site. Weber explained how production must find the points of minimum transport (MTP) cost. These points will be transportational locations.

According to Weber the location always shows the following transportational relations: the entire weight of the materials must be moved to this location from the material deposits; and the weight of the product must be moved from the point of production to the place of consumption. This means that this location is connected with the "corners" of the locational figures by lines along which the weights of the material and product move. Along the lines of the material deposits run the respective material weights, and along the component of the place of consumption runs the weight of the product. Figure 4 is an example of such a case. This figure shows a case of a process of production using 3/4 of

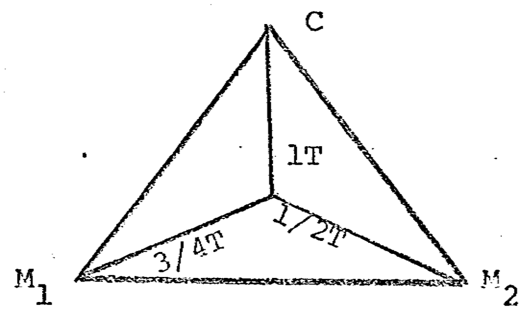

Figure 4

a ton of one localized material and 1/2 ton of another being necessary to produce one ton of the product.

Weber suggests that these weights represent the force with which the corners of the locational figures assist in determining the optimal location points. It follows that the ultimate location will be determined by the relative "pulls" of the locational components.

Weber then stated that on the basis of this same general concept, "weight figures" can be mathematically deduced for any kind of production. Such weight figures are formed by line segments whose length is proportionate to the size of the relative pulls exerted by locational components. If the locational figure is a triangle, using our previous example, the component weights can be defined as: $1 = a_1$, $3/4 = a_2$, $1/2 = a_3$, resulting in a weight triangle similar to Figure 5.

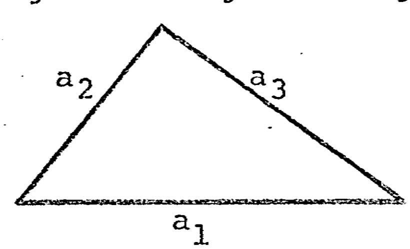

Figure 5

Weber states the following proposition regarding the eventual point of location:[4]

1. If it is impossible to form a figure out of the linear segments corresponding in length to the component weights, i.e., if one segment is as long or longer than all the rest together, the location always lies in the corner of this component. This becomes evident by merely observing the mechanics of the "weights", for if the one pulling weight is as great or greater than all the rest put together, it cannot be moved by them from its corner.

2. If, however, a weight figure can be constructed, i.e., if no one weight is as great or greater than all the rest together, the locational figure becomes important. The location can be discovered by a simple construction.

Obviously if one is analyzing a locational triangle at least two corners can be seen from any point of location. The size of the angle mapped from this point to one of the corners depends upon the relative size of the component weights of these corners compared to the other corners. If the relative size is large, the angle will be large; and therefore, the location lies upon a lower arc connecting the two corners, thus being necessarily close to the corners. This reasoning applies for the reverse situation. If the third corner lies within the determining arc which contains the other two, this

[4]*Ibid.*, pp. 55 - 57.

occurs either when the component weights of the two corners in comparison with the third are small, (Fig. 6), or when the third corner lies near the connecting line of the other two corners (Fig. 7).

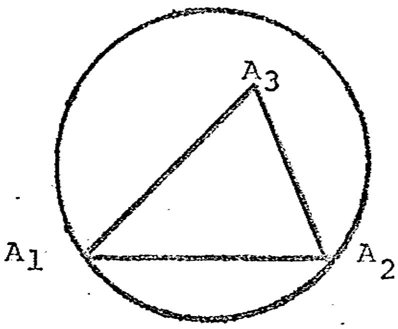

Figure 6

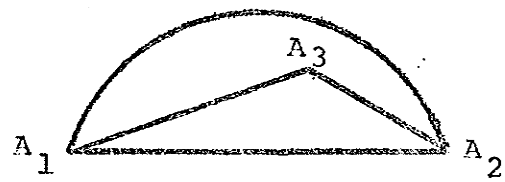

Figure 7

The factor ultimately determining the optimal locational point is the proportion of the weight used of localized material to the weight of the product. Ubiquities are important only as far as they increase the weight of the product. Weber called this proportion of weight of localized material to the weight of the product as the "material index" of production. This material index (or locational weight) measures the total weight to be moved. The locational weight has a minimum value of one when the material index (M.I.) has the value 0 (which it would have when ubiquities only had been used), and rises parallel to the material index: M.I. = 1/2, L.W. = 1-1/2, etc.

In general, industries having a high locational weight are attracted towards materials; those having low locational weight are attracted towards consumption centres. Thus all industries whose M.I. $\leq$ 1 (and whose locational weight) is therefore not greater than two) lie at the place of consumption.

Furthermore, for production to be located at a material source, the material concerned must be weight losing and it is necessary that the M.I.> 1 and that their portion of the material index be equal to that of the remainder plus the weight of the product. Stated more simply, their weight must be equal to or greater than the weight of the product plus the weight of the rest of the localized materials. In intermediate cases, where M.I.> 1 but a weight-losing material source is not dominant, the weight triangle is a useful device for solving the locational problem.

Returning to our earlier discussion of isodapanes, Weber suggested that the curve furthest away from the minimum isodapane represented sites of highest transfer burdens. The critical isodapane is the one which exceeds the least cost transfer point by an amount equal to the maximum non-transfer cost economies at an alternative site. If the optimum cost site is within the critical curve, the non-transfer cost advantage is worth more than the difference in transport costs. If it lies outside the critical isodapane, the economy of production is less than the extra transport cost that would be entailed in the shift.[5]

Although Weber provides an analytical framework for location theory, it has its significant disadvantages for our purposes. First, his framework is purely competitive. All

[5]Greenhut, loc. cit., 12 - 14.

buyers are assumed to be concentrated at given market centres, and each seller locates with respect to his access to some buying point. Each seller is assumed to have an unlimited market, for price is a datum and demand for the output of a firm is infinite relative to its supply. There are, therefore, no monopoly gains derived from location. Weber, therefore, assumed a market type in which demand does not play an active role in determining location. This is a serious gap in his theory and for applicability to the optical industry.

(2) A second vital drawback of his theory is its exclusion of what he calls "institutional and special factors." Weber excludes interest rates, insurance, taxes, rates of depreciation of fixed capital, climate and management from his location theory because he felt they are essentially institutional in origin or that they are special in nature. However, it is readily recognized an examination of any particular industry could result in these factors becoming very important.

(3) A final weakness in his analysis using isodapanes is that it runs solely in terms of orientation. His analysis applies only in the case where a market and source of material is given. If we recognize the existence of other markets, other material sources or rival producing points, his analysis breaks down because it is not stated in terms of market areas. Weber, himself, recognized one of the considerations -- i.e. "the replacement of material deposits," -- as a weakness in

his presentation. Thus the factors of production may alter according to location.[6]

Another weakness in Weber's theory is supplemented by Hoover.

iii) Hoover[7]

E.M. Hoover's approach considers demand as well as cost determinants. However his book is written largely within the framework of cost analysis.

Hoover separates cost factors of location into two groups: transportation and production factors. Cost of procuring the raw materials and the cost of distributing the finished products are considered as transport costs while the agglomerative forces and institutional cost factors are treated as partial determinants of production costs. His main contribution here lies not in theoretical originality, but in the penetrating discussions of the influence of these location factors.

Hoover gives a more rigorous treatment of freight costs than Weber. He points out that transfer costs per unit do not usually increase proportionately with distance but rather tend to decrease with distance. This nonproportionality in costs would have the effect of widening Weber's more distant isodapanes. Thus, although in reality costs in total certainly are more important, in marginal terms transport costs become less important as distance increases.

---

[6] *Ibid.*, 115.

[7] Hoover, *loc. cit.*

In addition, Hoover penetrates much further than Weber into a number of other location factors. He not only examines Weber's general orientation factors (transportation, labour, agglomerating) that affect plant location but in his opinion, all possible locational factors such as institutional forces and climate. Therefore, Hoover's theory is less restricted than that of Weber and it follows that it becomes more realistic.

However, his theory is basically still quite similar to Weber's.

> "The locational choice is again a problem of substitution among costs: new production costs and transportation cost, the ultimate objective being the minimization of these expenses. In choosing, from among alternative sites, the Hoover adjustment is fundamentally one of a little higher transportation cost in exchange for a reduction in processing burdens, or vice versa."[8]

One can criticize Hoover, as one did Weber, for his failure to give an adequate treatment of the importance of locational interdependence. He gives a brief treatment of market and supply areas but ultimately assumes the plant location as given. Thus he does not explain the influence that demand has on the basic plant location decision.

2. Market Area and Locational Interdependence Theories

i) August Lösch[9]

Lösch analyzed the demand factors in attempting to derive

---

[8]Greenhut, loc. cit., 21.

[9]Lösch, loc. cit.

a market area. His main assumptions were:

1. no spatial differences in resources, labour and capital over a homogeneous plain.

2. uniform population densities, constant tastes and no income differentials.

3. firms geographically spread apart so that their market areas and demand available to them are not affected by the location of rival firms.

Lösch concluded that the demand for a good is an inverse function of its factory price and it transport costs.

Lösch began by assuming that a representative individual had a typical demand curve. Let d, in Figure 8, be such a demand curve for a product. If OP is the price of a product at the point of production, those individuals living at P will buy PQ units of the product. Farther away the price will

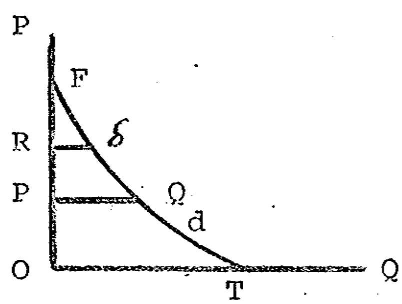

Figure 8

be higher by the amount of the freight, and quantity demanded consequently smaller. Still farther away, at F, where freight costs are PF, no units will be sold. Thus PF will be the extreme sales radius of the product and total sales in this district will be equal to the volume of the cone that results from rotating the triangle PQF on PQ as an axis (Figure 9). Lösch suggests that the volume of the cone must be multiplied by a constant that is given by the population density. The result will be the total demand, D, at the product price OP.

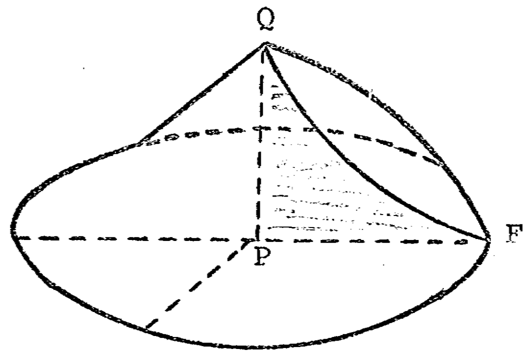

Figure 9

Expressed algebraically,

$$D = b\ (\pi \int_0^R f\,(p + t)\ t\ dt)$$

where D = total demand as a function of f.o.b. price p;

b = twice the population of a square in which it costs 1 mark to ship 1 unit along one side;

$\pi = 3.14$;

d = f (p + t) individual demand as a function of price at the place of consumption;

p = price at the production point;

t = shipping costs per unit from the production point to consumer;

R = greatest possible shipping cost (PF in Figure 8).

The derivation is as follows. The volume of a solid of revolution is equal to the area of the generating surface times the path of its centre of gravity. Let the surface PQF in Figure 8 have the area F, and let the ordinate of its centre of gravity (for P as the origin) be Y_o. The centre of gravity therefore revolves along the path $2\pi Y_o$, and the area of the generating surface $2\pi Y_o \times F$ or,

$$2\pi \int_0^R f(p + t)\ t\ dt$$

and according to the formula for centre of gravity,

$$Y_o F = \int_0^R f(p + t)\ t\ dt.$$

The population density is $\frac{b}{2}$ and thus we obtain the above formula for D as a function of the product price p.

Lösch's demand cone thus tells us what the level of demand will be as a function of the net mill price and how demand is distributed over space.

One can effectively criticize this theory on a number of grounds. Firstly, his third assumption is irrelevant if a firm decides to locate on a site in a highly developed industrial area where the locations and actions of existing firms in the industry influence the decision of the firms in question. His demand cone provides little guide as to where a firm should locate to maximize demand. If transport costs are uniform, then the firm can locate anywhere under his assumptions. Thus location is indeterminant. If costs vary over space, location is determined at the peak of the demand cone but it is the cost factors and not demand that determines location.[10]

[10]Richardson, loc. cit.

ii) Other Locational Interdependence Theories

There are a number of noted economists who centred their interest upon locational interdependence. We shall briefly examine some of these theories by presenting the central issue that each theory seeks to resolve. All these theories are concerned mainly with the competitiveness of market structure analysis.

Frank A. Fetter attempted to resolve the extent and shape of market tributary territory as related to any given levels of market prices and of freight rates.[11] He considered two producing markets trading under something like true competitive conditions.

Fetter suggested that the location of a point of indifference in delivered costs to any buyer between two markets was determined by the combination of base prices and freight rates. The freight rate from one market may exceed that from the other to any location only by the amount of the difference in base prices at the two markets. The location is on the boundary, or point of indifference, with respect to two markets when the sum of base prices and freight is exactly equal. On either side of such a point, in the direction of the two markets, as the freight rates are higher or lower, the delivered cost from one market must be greater or smaller than that from the other.

If freight rates varied in exact proportion to distance,

---

[11]Fetter, loc. cit.

and goods could be shipped on a perfectly straight route from each market to every point in the territories considered, assuming likewise that the two base prices were alike to all buyers at the same time, the boundary line between the territories tributary to two geographically competing markets for like goods would be a hyperbolic curve. At each point on this line the difference between freights from the two markets would equal the difference between the market prices, whereas on either side of this line the freight difference and price differences would be unequal. The relation of prices in the two markets determines the location of the boundary line; the lower the relative price the larger the tributary area. Fetter called this the general law of market areas.

Harold Hotelling showed that differences in location and the existence of transportation costs produced a market imperfection and a tendency for agglomeration.[12] To come to this conclusion (i.e. price fixing) he made the following assumptions:

1. two producers are located at two different points of a straight line in a market.

2. at each unit of distance one unit of the commodity is demanded with zero price elasticity.

3. each buyer pays the price charged by the producer from whom he buys plus a fixed transportation cost per unit

[12] Hotelling, loc. cit.

of distance.

4. there is no cost of production.

5. each producer assumes that the price of the other producer is given regardless of the price he charges.

6. a producer sells to all buyers who can purchase more cheaply from him than from his rival.

In his analysis, Hotelling concluded that an infinitesimal price reduction did not give the undercutting firm the whole market but resulted merely in a slight increase of his market. A small reduction in the price of one producer overcomes the additional transportation cost over a small additional distance. Consequently, undercutting is less profitable and ceases at a higher price even though the rival's price is assumed to be unaffected by one's own.

If relocation was possible and costless and producers were willing to compete in price and location, Hotelling speculated that their locational movements would follow a particular pattern. The two producers would perform a "hopping over" sequence until each producer was located beside each other at the centre of the market. The centre location would be one of stability and prices would be equal. Thus the Hotelling case illustrated the tendency for agglomeration.

Arthur Smithies attempted to generalize the theory of spatial competition.[13] Smithies modified Hotelling's assump-

[13] Smithies, loc. cit.

tion of complete inelasticity of the demand function by assuming an identical demand function, which was elastic, at every point of a linear market. In addition to Hotelling, he considered cases where each competitor made his adjustments expecting reactions from his rival.

Smithies formulated the following structural assumptions:

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

2. At every point of the market there can be only one price, and there are identical demand functions relating price to quantity sold per unit of time at that point.

3. There are two competitors, A and B, having single locations.

4. The competitors are subject to constant marginal costs. Fixed costs are ignored.

5. There is a uniform freight rate per unit of distance for both competitors, which is independent of distance and of the price and quantity of the goods transported.

6. Each competitor will sell on an f.o.b. mill basis.

7. Each competitor is free to move his location instantaneously and without cost.

8. Each competitor will attempt to fix his mill-price and his location so as to maximize his instantaneous rate of profits in respect of his total sales.

9. The relation of demand conditions is such that, in all the cases under examination, there are sales at every point of the market.

The model resulting from his assumptions led to a linear market which was competitive. Each competitor's policy depended on his estimate of his rival's reactions in respect both of price and location. Smithies then examined three cases.

In the first case each competitor, in making an adjustment, assumed that his rival would set a price equal to his own and would adopt a location symmetrical with his own, Smithies' analysis showed that the equilibrium position they would finally achieve would be the same as if they had acted jointly as a monopolist.

In his second case, he assumed that his rival would have the same price reactions as in the first case but he would keep his location unchanged. In this case the competitor would move closer to the centre to increase his territory. Equilibrium would be achieved with each competitor at an equal distance from the centre of the market and closer to it than the quartiles. Neither would retire towards the quartile because he would believe that any gains to be made would be offset by losses to his rival whom he did not expect to retreat.

In the third case, each competitor assumed that both the price and the location of his rival will be fixed independently of his own. Thus there was competition in both prices and location as in the case examined by Hotelling. Smithies analysis showed that in some conditions no equilibrium is possible, thus making the possibility of economic warfare imminent.

If there was zero elasticity of demand, as Hotelling assumed, the producer by altering his position does not affect his position in the "hinterland" (i.e. noncompetitive region) since he can pass on to the consumer his entire freight charges without affecting profits. Thus equilibrium will necessarily be achieved. However equilibrium at the centre would be stable only if one assumed that each competitor sells only in his own hinterland and does not attempt to invade the hinterland of his rival. Thus Smithies stated that he prefers to say that the forces of competition that eliminate the competitive region also destroy the inviolability of the hinterland, and that once the competitors have come together they compete as duopolists in the entire market.

A.P. Lerner and H.W. Singer modified Hotelling's assumption of complete inelasticity of the demand function by postulating that demand was inelastic over a price range extending from zero to a finite upper limit.[14] They confined themselves to the extreme competitive assumption that each competitor fixes his price and location assuming that the rival will not react to his actions.

Lerner and Singer suggested that there would be no equilibrium solution but complete instability in location in the Hotelling-type analysis if there were three or more producers. They theorized that a perpetuating cycle would occur whereby

---

[14]Lerner and Singer, loc. cit.

the initial observation would find three firms at the centre of the linear market; then two at one quartile and one at the other; then all three at one quartile and eventually all three back at the centre. The underlying force behind the analysis is the assumption by each competitor that the location of the others are fixed. A point will arise whereby the relocation movements become unprofitable because the market in the middle may have grown while the market outside may have diminished. This point will be reached when two firms are at one quartile and the third is at the other. Then the middle man would supply a quarter of the market just as he would if he went outside.

Edward H. Chamberlain took exception to Hotelling's argument.[15] He posited the theory that when prices and everything else but location remained equal, two firms would locate at the quartile and the third competitor some place between them. This resulted from the continual shifting of sellers seeking advantage.

Chamberlain's hypothesis is predicated upon a given price and an infinitely inelastic demand curve. Thus if there were more than two sellers, Chamberlain advocated that a complete dispersion would occur. Let us now examine critically the theories of Fetter, Hotelling, Smithies, Lerner and Singer, and Chamberlain as a group.

---

[15]Chamberlain, loc. cit.

All these economists substantially abstracted the derivation of cost which is important in one's bargaining position and in the long-run it determines whether one will stay in the industry. They attempted to explain the location decision of firms as the endeavor to control the largest market area. They appraised the influences on industrial location of the shape of the industry's demand curve and the height of the freight rate.

The locational interdependence theories lead to the following conclusions:[16]

1. The tendency to disperse depends upon the height of the freight cost, the elasticity of the demand function, and the slopes of the marginal costs.

2. Each seller seeks to control the largest market area. His choice of location is determined by the type of interdependence between the seller and existing rivals.

3. Each seller becomes a spatial monopolist when sellers and buyers are separated geographically from rivals and all use the f.o.b. mill price system.

4. Effective demand varies at alternative sites because of freight costs and the location of rivals.

5. The force of dispersion becomes stronger as the number of firms becomes larger.

There is a serious limitation to these theories of locational interdependence. They abstract from cost in the same

---

[16]M.L. Greenhut, Microeconomics and the Space Economy, (Chicago: Scott Foresman and Co., 1963), 173.

way as the least cost theories abstract from demand. Thus they are only one-sided theories which present a special type of explanation of the underlying forces of spatial location.

3. Integration of Leading Theories

i) Greenhut

Melvin Greenhut attempted to determine the conditions of locational equilibrium when firms seek to maximize profits, with costs allowed to vary and demand influences affected by the possibility of locational interdependence.[17] Greehnut made his theory more flexible by considering personal factors. He revealed that in practise the selection of a plant-site involves conjectures not only of all cost factors but all demand forces. Furthermore, a personal factor of location existed in practise which expressed itself through cost, demand, and psychic benefits. Let us briefly review Greenhut's general theory of plant location.

Greenhut's theory is also presented in mathematical terms. He assumed that satisfactions are an end and the analysis of profit was the means to the end. Personal gratifications are considered as cost deductions or else, demand additions.

For purposes of methodological aids, Greenhut imagined first a well developed economy and, subsequently, the innovation of a new product. Assuming zero costs everywhere and

---

[17]Greenhut, Plant Location In Theory and In Practise.

and identical demands, it would follow that the innovating firm would locate in the centre of the market. Further, it would follow under the profit-maximizing nondiscriminatory f.o.b. mill price system, the innovator would limit his sales radius. Over this restricted area, the net-mill price would be greater than zero and its value depending upon the ratio of the freight rate per unit of distance to the highest price that a consumer would pay. Later rivals could and would locate anywhere. If the postulate of zero cost was discarded, cost differentials would exert their force directly and indirectly, through locational interdependence, on the ultimate locations.

Suppose each firm entering the competitive scene, sought that site where its sales to a given number of buyers could be served at the lowest total cost. Thus, demand would be included in the discussion for the entry of more competitors would change costs as well as relative demands. In time, the successful attempts of competitors to locate at the profit-maximizing site would so shrink the relative demand as to cut profits. Therefore, a state of locational equilibrium would eventually emerge. Such equilibrium would find (1) marginal revenues equaled with marginal costs, (2) average revenues tangent to average costs, and (3) concentrations and scattering of plants in such order that relocation of any one plant would occasion losses.

If the demand curve for a given product changes, it follows that profits or losses will result. This influences the relocation of existing firms and the site selection of new firms. Thus demand itself becomes an active determinant of location in every respect.

Variations in cost factors would similarly affect spatial orderings. However, its reverberations may appear indirectly on the side of demand through its impact on location interdependence. Finally, the purely personal factors are forces to be reckoned with not only from the standpoint of particular site-selection but general equilibria in space. Variations in psychic income may cause different ascriptions to cost data and encourage relocation and subsequent distortions of all existing relationships.

4. Summary

The theories we have reviewed all have some weaknesses underlying their development. The location theories that minimize total costs are deficient, to a large degree, as a basis for empirical application because they neglect the spatial variations in demand. Similarly, the Löschian approach and similar theories adopted many uniformity assumptions which abstracted from spatial cost differences or minimized the importance of cost differences.

These traditional location theories have many limitations. They have usually assumed the production of a single product. Multi-product plants may alter considerably the profit-maximizing location. The models discussed all have theoretical relevance given their assumptions. However, if we try to apply it, they have intractable drawbacks. One should attempt to simulate the realistic conditions operating in the competitive systems.

Melvin Greenhut has innovatively developed an alternative formulation of a profit-maximizing theory of location. He has attempted to fuse the two approaches. However, the acceptance of spatial variations both in demand and cost makes the formulation of a theory of plant location an extremely complex matter and probably impossible to effectively apply. Thus we must discard Greenhut's theory on this basis. In addition, it is a general theory of location and as stated earlier, we would wish to adopt a theory more adaptable to the optical industry.

Therefore, in order to simplify the complex situation in the real world, we shall adopt a model which can demonstrate the choosing of the optimal location in simple graphical terms. Since demand and prices are relatively constant in the optical industry, we have adopted a least cost approach. This would enable us to examine the spatially variable supplies and costs of materials and labour which is impossible under Löschian-type theories.

CHAPTER III

THEORETICAL LOCATION MODEL FOR OPTICAL INDUSTRY

In this chapter we will discuss the theoretical structure to be used in analyzing the optical industry. The theoretical constructs will be drawn primarily from the models of Leon Moses[1] and D.M. Smith[2].

We have adopted a least cost approach since it provides a more practical application in the empirical research of the optical industry. Since our application will consider investigation into the effect upon the optical location of spatially variable supplies of materials and labour, the least cost approach appears to be the most realistic one.

Assume that we have a profit-maximizing entrepreneur. Profit-maximization requires a proper adjustment of output, input combination, location and price. The analysis and formulation makes a valuable contribution in putting the spatial setting into the theory of production. It also provides a good departure point for our empirical study and a useful tool in explaining the present status or organization of the optical industry.

Let us make the following assumptions:

---

[1]Leon N. Moses, "Location and the Theory of Production," Quarterly Journal of Economics, LXXII (1958), 259-72.

[2]D.M. Smith, "A Theoretical Framework for Geographical Studies of Industrial Location," Economic Geography, 42 (April, 1966), 95-113.

a) The production firm employs two transportable inputs.

b) There is a single product produced.

c) there is a single market point.

The following figure depicts the locational problem:

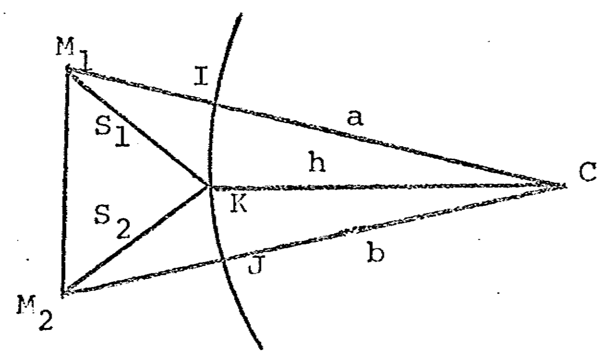

Figure 1

The notation is as follows:

P_1, the price of the first input at its source.

P_2, the price of the second input at its source.

r_1, the transport rate on the first input.

r_2, the transport rate on the second input.

s_1, the distance from M_1 to the locus of production of the final product.

s_2, the distance from M_2 to the locus of production of the final product.

P_1^1, the price of the first input delivered to the locus of production of the final product.

P_2^1, the price of the second input delivered to the locus of production of the final product.

Assume inputs are sold f.o.b. Let C_1 represent the market; M_1 and M_2 be the two sources of material; and K be the production centre. The distance that the final product is shipped is a constant, h. Let us draw an arc cutting the triangle at I and J. The arc is a segment of the circle with the centre C and radius h. All points along the arc are a fixed distance from C and any point along the arc can be considered as a possible location for the production plant.

If the base prices and transportation rates are known, the prices of the two materials delivered to a production point, K, can also be determined.

$$P_1^1 = P_1 + r_1 s_1$$

$$P_2^1 = P_2 + r_2 s_2$$

We can also form a ratio of these prices:

$$\frac{P_1^1}{P_2^1} = \frac{P_1 + r_1 s_1}{P_2 + r_2 s_2}$$

This ratio is the constant slope of the system of iso-outlay lines when production takes place at K. If we have fixed factor proportions, each point along the arc IJ will be characterized by a definite ratio of delivered prices on the two inputs. This ratio defines the slope of the system of iso-outlay lines at that point.

Let us now bring in expenditure into this simple model.

The two iso-outlay lines in Figure 2 both represent the same total expenditure on the two material inputs. AB is the system of iso-outlay lines associated with production at I whereas DE is one associated with production at J.

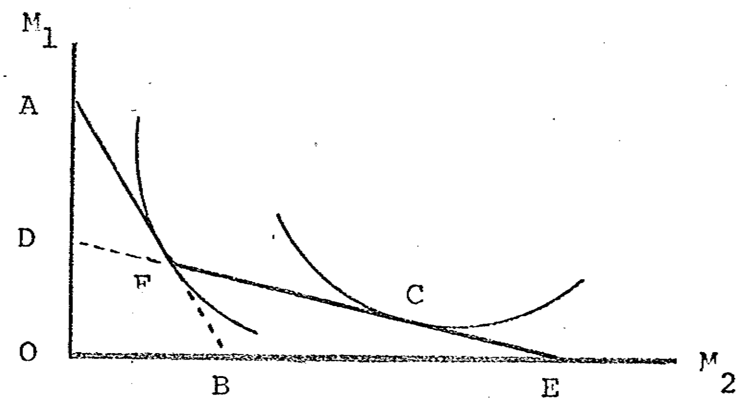

Figure 2

If all locations along the arc IJ are considered and if there are an infinite number of points along the arc IJ, line AFE becomes a smooth curve. It becomes a curve because each point along the arc has a unique ratio of delivered prices on the two inputs. Let us call this smooth curve the "locational iso-outlay curve." Each point along this curve corresponds to a particular location along the arc IJ, and shows the one combination of factors which the cost-minimizing firm would purchase at that particular location given the dollar expenditure, transport rates, and base prices of the inputs.

If continuous spatial substitution is possible, then there is only one combination of inputs which is optimal for each location. The combination of inputs which are uneconomic for each location can be decided with reference to the production function.

If different levels of expenditure are considered, then a system of locational iso-outlay curves will be generated as depicted in Figure 3.

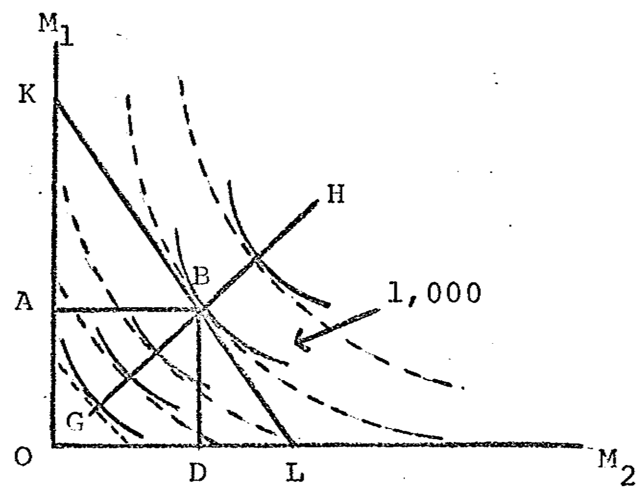

Figure 3

All these curves pertain to locations along the arc IJ of Figure 1 but each represents a different level of expenditure upon the inputs. The slope of the line KL defines a point along the arc IJ of Figure 1. Therefore, if the firm desires to deliver a fixed number of units of the product to the market, example 1,000, optimality is characterized by the tangency condition, at B.

This point B represents a particular combination of inputs and a particular location along IJ. The firm should choose the location at which the ratio of the delivered prices of the inputs is equal to the slope of the isoquant. In the example the firm uses OA units of M_1 and OD units of M_2. The marginal rate of outlay substitution will be equal to the marginal rate of input substitution. The optimum location along the arc IJ is where total expenditure is a minumum. At this location the factors will be combined so that the ratio of their marginal productivities is equal to the ratio of their delivered prices.

If the production function is not homogeneous of the first degree there is no single optimum location along the arc IJ. The optimum location varied with the level of output. Furthermore, there was no reason why there should exist only one point of tangency for each output or level of expenditure.

Let us now consider regional variations in the money price of a given input. For this case, consider two inputs, a single localized raw material M, and labour, L. Labour is available at the source of the material input and at the market. Assume that the market price is lower at the latter.

The price differentials give rise to a V-shaped iso-outlay

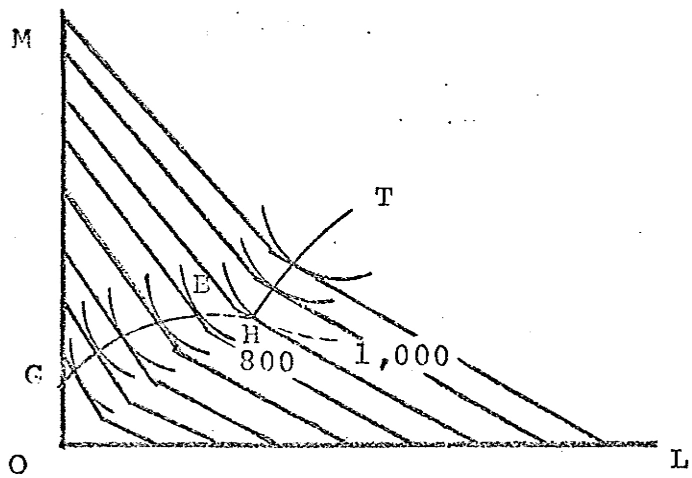

Figure 4

line as in Figure 4. The more steeply shaped portions of these lines represent combination of inputs which can be purchased for a given expenditure if the firm locates at M. The more gently shaped portion of each outlay line shows the combination of inputs which can be purchased for the same expenditure if the firm locates at C.

Figure 4 shows a system of isoquants and locational iso-outlay lines. Each of the tangency points indicates the best location for producing a given output and the best combination of inputs for producing that output at that location.

According to the expansion line which joins the point of tangency, location at the raw material site is superior for output levels up to 800 units, whereas location at the market site is superior for outputs of more than 1,000 units.

Let us now briefly consider changes in the transportation distance of the product from the production centre to the market. We can employ total cost and total revenue curves to explain the results arising from changes in transportation costs. Furthermore, demand is related with the derivation of the total revenue curves. Changes in demand would alter the total revenue curve and hence the optimum output and location. Thus, the optimum location is seen finally to depend on the following factors: base price on inputs; transportation rates on inputs and on the final product; the geographic position of materials and markets; the production function; and the demand function. We can consider these primary factors.

The model developed here can be used to explain the present location and organization of the optical industry. In establishing a least cost site of production, we shall be examining various factors influencing the location of a plant. For such purposes we must expand this model further.

As for any industry, costs vary from place to place because of varying costs of production and marketing. The profitable location will be where total revenue exceeds total cost by the greatest amount. If prices and demand are fixed, location will be primarily decided upon by varying total cost.

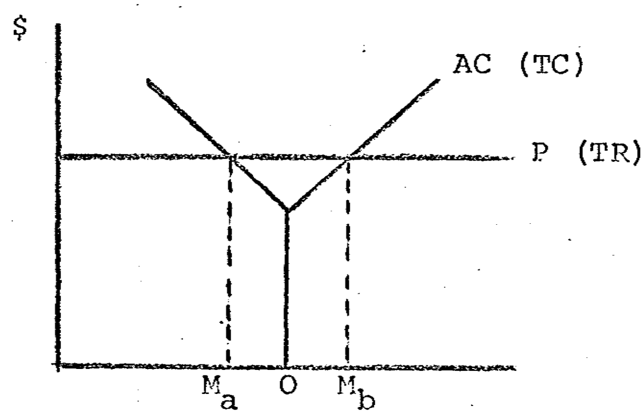

Figure 5

In Figure 5, costs are variable in space while demand is constant and the price P is the same everywhere. The average cost per unit of production, the line AC which may be termed the space cost curve, rises from point O which represents the point of minimum costs. M_a and M_b are points where AC = P. Spatial variations in total cost and total revenue impose limits to the area in which an industry can be undertaken at a profit.

Let us now illustrate how a space cost curve can be derived in practice in our hypothetical model and how optimum location and spatial margins arise. The space cost curve is a cost curve, devised by holding the firm's output constant, showing how costs of production vary over space. It is, therefore, an iso-outlay curve showing how the average unit costs of producing a given level of output vary over space. Changes in levels of output require a new space cost curve.

The shape of the space cost curve is indeterminant and there may be multiple low cost locations separated by distance. The following are some of the main factors affecting the shape of the space cost curve:

1. Differences in entrepreneurial skill.

2. Subsidies or taxes at certain locations.

3. Effects of external economies arising from agglomeration.

4. Elements of chance.

5. Personal factors.

6. Raw materials may occur in isolated pockets distributed over space.

7. Population concentration are distributed unevenly.

As was stated earlier, in a position of equilibrium, the iso-output curve will be tangent to an isoquant. The slope of the isoquant will equal the price ratio of the two inputs. Since the price ratio of the two inputs tends to vary over space due to differences in costs and availability, the slope of the isocost line will change, which, in turn will affect the level of output. All these factors can be incorporated into the model. There also exists the possibility of a multiple solution to the problem of finding the optimal location for the above reasons.

If we draw a simple space cost curve, we can deduce two general conclusions. "Firstly, spatial variations in average production costs impose limits to the locations at which production can be undertaken at a profit. Secondly, the steeper the gradient of the cost line, the more localized the plants are likely to be."[3]

For simplicity, let us assume that there is only one least cost location and that costs at other sites are a function of the distance from the least cost point. If we also rule out discontinuous low cost locations, a V-shaped space cost curve is realistic.

If there are economies of production of the commodity, a space cost curve for a higher level of output will be represented by a downward shift in the curve. Generally speaking, changes in the basic cost of a productive resource will not change the optimal least-cost location.

Differences in managerial skill will result in a shift of the space cost curve but optimal locations will only change if managers can operate more effectively in some geographical environment.

---

[3]Richardson, loc. cit., 64.

Effects of taxes or subsidies can change the optimal location. The same applies to changes in the cost of an input at alternative sites. Subsidies or lower input costs at a particular point will lower that portion of the space cost curve and vice versa.

The main advantage of the space cost curve approach is its incorporation of the spatial effect. However, because the cost curve is an iso-outlay curve the scope for a marginal cost/marginal revenue approach is extremely limited unless we use multi-dimensional curves dealing with variations in output as well as changes in location to solve the problem of optimum location and optimum output simultaneously. Secondly, the space cost curve can be combined with a diagramatical analysis of spatial variations in demand. Thirdly, the concept lends itself more readily to empirical application. It may be necessary to assume that costs vary regularly with distance from the limited number of examined sites to allow us to join series of discontinuous points into a continuous curve. This is realistic if we assume that urban sites are potentially the least cost locations for the optical industry. We can then make an approximation by drawing a line through a number of representative towns and cities and plot the variations in space cost along this line.[4]

In sum, the model presented in this chapter provides a good theoretical basis for application to the optical industry.

---

[4] *Ibid.*, 68 - 69.

However, we shall not attempt to apply it, per se., to the industry and derive the discussed graphs. Instead, we will use a more widely recognized technique, i.e. location cost comparisons, to compare costs for two locations. Again let us stress that this model developed here is the underlying explanatory "backbone" of this technique.

CHAPTER IV

THE OPTICAL INDUSTRY

This chapter is concerned with the structure, conduct and performance of the optical industry. Although this study is mainly confined to the Manitoba manufacturers of ophthalmic goods, some reference will be made to the industry in its national perspective. The information in this chapter was obtained through discussions with people associated with the optical industry, an analysis of government statistics and company reports, and other readings.

1. Internal Operations

i) Basic Material Input

The basic raw material used to make ophthalmic lenses is sand. Sand suitable for glass-making is found chiefly in Pennsylvania, West Virginia, Illinois and Missouri. Optical glass requires as much as 99.8 per cent silica in the sand. Only minute quantities of foreign substances can be tolerated. For example, the iron oxide content cannot exceed one-twentieth of one per cent; otherwise the clarity of the product is affected. The alumina content cannot be greater than one-tenth of one per cent. In addition to the freedom of impurities, glass sand must have certain physical characteristics. For example, fusion is facilitated when the particles are small, uniform and angular.[1]

It is estimated by people in the industry that one of every four or five persons in Canada wears spectacles. We will verify this estimate empirically later.[2] Changing fashions and extensive institutional advertising have given rise to a wide variety of styles and designs of spectacle frames and mountings. In each style there must be a range of sizes to fit the different users. Lenses for the spectacles must provide the corrective element necessary for both eyes of the user and thus may be in any two of hundreds of combinations of corrective powers. The lenses may differ in quality or in shape according to the style desired.

ii) Manufacturing Function

Manufacturers of ophthalmic goods include those firms which produce spectacle frames, mountings and parts, and those engaged in basic lens manufacture. The typical procedure in fitting a prescription for spectacles is as follows:

The manufacturer receives the order from a retailer. He selects the appropriate lens and then shapes it by sanding it in the presence of a liquid solution. The strength of the

---

[1]S. Vance, Industry Structure and Policy, (Englewood Cliffs: Prentice-Hall, 1961), 336.

[2]This estimate was also made by; Report of Commissioners, Optical Goods: Investigations into an Alleged Combine in the Manufacture and Sale of Optical Goods in Canada, A Report Prepared Under the Combines Investigation Act, (Ottawa: Department of Justice, April 24, 1948), 7.

lens is then verified. It is cut to the shape of the selected frames. A production worker then heats the frames and inserts the glass lens. If the purchaser requires safety glasses, the glass is hardened through extreme heat. Safety lenses are then tested by dropping a small iron ball on them.

iii) Wholesaling Function

The main functions of the wholesaler are to carry a diversified line of lenses according to consumer's requirements. The wholesaler's sales to the retailer may be in quantity lots or in single items. Single-vision lenses are usually received by the wholesaler in uncut finished form. Stock sales to retailers are usually made in the same form. A prescription sale usually requires further finishing of the uncut lens. This is always necessary if the prescription sale is a safety spectacle.

The wholesaler will ordinarily edge the lenses to the shape desired, possibly harden the lenses, or even drill holes necessary to attach it to the mountings. Some manufacturers also perform the wholesaler's functions. If the retailer orders a bifocal lens or a single-vision lens of high power not commonly carried in stock, the wholesaler must use grinding equipment to produce the required lens from a rough blank or semi-finished lens.

iv) Retailing Function

There is no universal term recognized to describe all those who perform the retail function of supplying spectacles to the public. The term "dispenser" is used most frequently for that purpose. However, an optician who is a licensed dispenser is only one of a number of trades and professions involved in the retail function.

Most consumers obtain their spectacles from optometrists who not only supply the completed spectacle but also perform the services of examining eyes and prescribing corrective lenses. Spectacles are also supplied by wholesalers, druggists and jewellers. All those involved in the retail function, except optometrists, fill prescriptions issued by medical doctors. In general, the various functions of manufacturers and distributors are not as clearly defined as in some trades. American Optical Company and Imperial Optical Company account for the largest proportion of the manufacture and wholesale distribution of ophthalmic goods in Canada.[3]

v) Eye Examination

Eye examinations and refractions may be made by a medical doctor known as an ophthalmologist or oculist. An oculist is qualified to refract, prescribe glasses and give medical or surgical treatment as required. An optometrist is qualified to test eyes for refraction, fill prescriptions or supply the

---

[3]This conclusion was reached after the examination of confidential company reports and discussions with company representatives.

lenses in the frames or mountings chosen by the wearer. An optician, wholesaler or druggist normally fills the prescription prescribed by the oculist. They are skilled technicians qualified to perform all the technical functions involved. In many cases, they edge and drill lenses as well as surface lenses.

2. Market Demand

The optical industry can best be characterized by an oligopoly model. Oligopolistic behaviour is conditioned by the demand and cost curves of the firm and industry. We shall deal with the cost conditions in the next chapter.

Published data of the quantity figures showing total sales of ophthalmic goods in the province of Manitoba is not obtainable because there is no legislation requiring them to do so. Thus market demand has been estimated by an alternative method. A complete survey of one year of data from welfare statistics was provided by the Manitoba Department of Health and Social Services. The purchases of ophthalmic goods by welfare recipients is tabulated in Table 1. The ratio of purchases of spectacles by recipients to the number of eligible welfare recipients was then applied to the total population of the province in order to estimate total demand in Manitoba. Although it could be argued that this sample could have an upward or downward bias, discussions with manufacturers and an analysis of the confidential reports prepared by these companies suggested that our estimates were fairly close.

Table 1

PURCHASES OF OPHTHALMIC GOODS BY WELFARE RECIPIENTS IN MANITOBA

	Item	Number	Cost
1.	Complete pairs of glasses	4,559	$62,321.84
2.	Bifocal lenses	717	4,030.66
3.	Single-vision lenses	3,065	11,553.34
4.	Frames	1,702	6,706.98
5.	Cases	1,288	938.39
6.	Mailing charges		193.45
7.	Miscellaneous (Including hinges, nose pads, temples, tinting, etc.)		4,174.20
			$89,918.86

Source: Survey of Manitoba's Department of Health and Social Services' statistics, April 1, 1969, to March 30, 1970.

Table 1 shows the cost of materials for the fiscal year April 1, 1969, to March 30, 1970. Thus for approximately 34,000 recipients of social allowances and health services, the total expenditure of ophthalmic goods was $89,918.86. Items 2 - 7, in Table 1 represents roughly thirty per cent of the total expenditure. Item 1, $62,321.84, represents seventy per cent of the total expenditure. For our purposes, we wanted item 1 broken down into a more detailed format represented by items 2 - 7. In order to do this we multiplied each component (2 - 7) by 10/3 since such items represent thirty per cent of the total expenditure. By so doing, the total expenditure was estimated as in Table 2. These estimates were approved by knowledgable people within the provincial government.

Manitoba's population as of 1970 was estimated at 978,000.[4] Thus the 34,000 welfare recipients represent approximately 3.4 per cent of Manitoba's population. If we project the estimates in Table 2 to the entire Manitoba public, we would get a projection of total demand for ophthalmic goods as illustrated in Table 3. Thus one can say that one of every five persons wears eye-glasses. Again discussions with people in the industry verified this estimate.

It is practically impossible to determine the elasticity

---

[4]Canada, Dominion Bureau of Statistics, <u>Canadian Statistical Review</u>, (March, 1970), 18.

Table 2

DETAILED BREAKDOWN OF OPHTHALMIC GOODS PURCHASES

	Item	Number	Cost
1.	Bifocal lenses	2,390	$13,435.00
2.	Single-vision lenses	10,216	38,511.00
3.	Frames	5,673	22,356.00
4.	Cases	4,293	3,128.00
5.	Mailing		645.00
6.	Miscellaneous		11,914.00
			$89,989.00

Source: Survey of Manitoba's Department of Health and Social Services' statistics, April 1, 1969, to March 30, 1970.

Table 3

PROJECTED TOTAL DEMAND FOR
OPHTHALMIC GOODS FOR ENTIRE MANITOBA PUBLIC

Item	Quantity[1]
Bifocal lenses	70,000
Single-vision lenses	301,000
Frames	167,000
Cases	126,000

[1] Quantities rounded off to nearest thousand.

Source: Survey of Manitoba's Department of Health and Social Services' statistics, April 1, 1969, to March 30, 1970.

of the demand curve for ophthalmic goods. Even though eye spectacles can be classified as a basic necessity, it is false to assume that demand is inelastic since a certain price fluctuation could result in people owning more (or fewer) pairs of eye spectacles. It is possibly safe to assume that at present price ranges, demand is a function of population size and from our analysis it can be estimated as approximately twenty per cent of the population. All we have determined is one point on the demand curve. To determine the elasticity of demand one must obtain at least one other point. If people were able to purchase eye spectacles at zero cost (e.g., everyone could purchase eye spectacles under a medicare plan) then we would be in a better position to speculate about its demand elasticity. In any case, an estimate of elasticity of demand is not needed for our analysis since we are mainly concerned with comparison of costs existing presently.

3. Structure

The optical industry is characterized by relatively few enterprises. In Manitoba, there are six manufacturers of ophthalmic goods: Kahn Optical, American Optical, Plastic Contact Lenses, Central Optical, Viscount Optical, and Imperial Optical. The leading two manufacturers, American Optical and Imperial Optical, account for more than 60 per cent of the industry's output in the province.[5]

[5]Interview with company representatives.

The intense competition, the importance of reputation, multitude of patents and the control of the resources required to manufacture blanks have limited the number of new firms entering the field. These characteristics have also perpetuated the existing structure during recent years.

The two large manufacturers have their headquarters based in Eastern Canada. The headquarters also perform the warehousing function. They ship blanks, semi-finished lenses or finished lenses (mainly for single-vision lenses) to their branch offices throughout Canada. American Optical has its Canadian headquarters in Belleville, Ontario. A company spokesman stated that the Belleville office receive the uncut blanks from Corning Ltd. and Pilkington Glass Company, two large United States based corporations. American Optical supply approximately 80 per cent of the lenses to Imperial Optical. The Belleville plant finish approximately 30 per cent of one side and 70 per cent of both sides of the single-vision lenses as well as some bifocal lenses. The Winnipeg branch office receives the lenses by request to the head office. The Winnipeg office naturally finish both sides of the optical glass. Single-vision lenses account for approximately 60 per cent of the sales for American Optical. Yearly sales of prescriptions in Manitoba are nearly 6,000. The plant has an output of fifty to a hundred pairs of spectacles per day. The Winnipeg office has a territory bounded by Portage la Prairie on the west, Flin Flon in the north and the Lakehead in the east.

We have analyzed the structure of the industry by examining the number of firms in the Manitoba industry. Our analysis will show that the industry is essentially an oligopoly. We can expect that some of the characteristics and behaviour of oligopolistic firms in theory should be present in this industry. This fact will be borne out in the following sections.

4. Barriers to Entry

The entry of new firms into an industry is generally conceded to have a major impact upon prices and competition. In conventional economic analysis, entry occurs in response to the long-run rate of profit; the higher the rate of profit, presumably, the greater the likelihood of entry. To say whether a barrier to entry is high or low requires measurement. Ideally this should be the measurement of the response of potential entrants to various levels of profits. Since this information is unavailable, a substitute must be used. For such purposes, I shall briefly evaluate the barrier to entry in the optical manufacturing industry through an examination of the market and technology of the industry.

Professor Bain has classified the sources of barriers to entry under four categories: scale economies, capital requirements, product differentiation, and an absolute cost barrier.[6]

---

[6] J.S. Bain, Barriers to New Competition, (Cambridge: Harvard University Press, 1956).

He describes the scale economy barrier as a direct function of the proportion of the industry capacity required for a minimum-sized efficient plant. If a new entrant must have a high percentage of industry capacity to be an efficient competitor, entry with such capacity would either increase costs or generate a price war. In either case, profits will be reduced and entry discouraged. Alternatively, the entry at less than optimum scale increases the entrant's costs and so reduces his profits, again discouraging entry.[7]

The development of a lens for spectacles is carried out in numerous discrete production units. The difference between large and small plants is largely in the number of such units. There are certain economies of scale in material-handling facilities as well as accounting procedures. Hence if appreciable economies of scale exist in the industry, then only two firms realize it.

Economies of scale for the firm as opposed to the single plant is nebulous for their source is organizational rather than technological. Each plant must possess the basic equipment necessary for operation. The manufacturing process for producing lenses is very labour-intensive because of the precision required. Thus machinery which can produce lenses in greater quantities does not exist.

Ophthalmic goods have a national market, whereas transportation costs and service creates regional markets for the

---

[7]*Ibid.*, 53 - 56.

industry. This evidence suggests that barriers to entry is low compared to other manufacturing industries. However, the administrative economies of scale involves the important question: are large firms more efficient decision-making bodies than small firms? Research and marketing advantages of large firms must be considered. Finally, the analysis of vertical integration is an important factor in barriers to entry in this industry. Thus the size of the barrier to entry attributable to economies of scale essentially depends upon whether a new entrant must be vertically integrated to become as large as the present leaders. Since the two largest firms presently control the source of raw materials in North America, barriers to entry can be considered as very high.

A second type of entry barrier is the necessity of raising capital. The amount of capital required to purchase the necessary machinery for an optical manufacturing plant is approximately $100,000 to $125,000.[8] Compared to other industries, this appears fairly low and we can conclude that capital requirements provides a relatively low barrier to entry in the manufacture of ophthalmic goods.

Product differentiation is another barrier to entry. A new entrant would have to spend some monies to gain retailer's acceptance of his product. There is some product differentiation through service, reliability and so forth. However,

---

[8]Interview with company officials.

the typical retailer purchases from several sources of supply. Thus this factor does not create a significant barrier to entry in the optical industry.

The final barrier to entry is an absolute cost advantage. If a new firm has to operate at a cost disadvantage, entry will be discouraged. The main factor affecting absolute costs in this industry is the patent. The processes and styles are heavily patented. In addition, sufficient know-how of the operation is not that readily available to the public. The scarce essential resources are completely controlled by existing firms. In fact, almost all existing firms in the industry have to purchase the materials which are processed to the blank stage, from American Optical or Imperial Optical. Thus the absolute cost barrier of entry can be considered high.

In summary, barriers to entry into the optical industry are very important factors in preserving the market share supplied by the existing firms. Public policy and direct government intervention may be argued by some to encourage further entry. However, one cannot see the government getting involved since the industry has not been a problem with its limited market coupled with low profits.

5. Inventory Control

Manufacturing enterprises must regularly accept a variety of risks. One of the major areas of risk-bearing is in the field of inventory control. This is prominent in the case of mountings and frames but not the case for lenses.

There is an ever present danger that inventory will be inadequate to meet present and future needs. Manufacturers and retailers must carry a complete assortment of styles and sizes. This raises a number of costs, including charges for storage, insurance and interest.

Inventory valuation is directly affected by the specific accounting technique used in making such valuation. This is particularly true during periods of rising costs of raw materials. The cost of material used in a specific year is based largely on prevailing raw material prices and not upon prices actually paid on materials purchased in prior years but consumed in the current year. In this instance, over a period of time, materials remaining in inventory tend to carry price tabs prevailing in previous years.

The significance of inventory valuation and cost is highlighted on the data summarized in Table 4. The combined value of inventory held by the manufacturers in 1967 was in excess of $370,000. The importance of inventory is further accentuated by the relatively low inventory turnover ratios characterizing the industry. Inventories as a percentage of value of shipments or own manufacture have been increasing in the last six years as can be seen in Table 5.

Earnings of the major companies can be significantly influenced by inventory fluctuations. As a rule, the industry is forced to carry rather large stocks of finished goods as Tables 4 and 5 bear out. A company spokesman believed that

Table 4

VALUE OF INVENTORIES IN MANITOBA - 1967

Year	Manufacturing Material and Supplies $,000	Non-Manufacturing Production Materials and Purchases $,000	Total $,000
1968 close	279	91	370
1968 open	257	75	332
1967 close	195	137	332
1967 open	203	130	333
1966 close	201	125	326
1966 open	174	119	293
1965 close	117	145	262
1965 open	103	125	228
1964 close	103	125	228
1964 open	103	129	232
1963 close	103	129	232
1963 open	100	130	230

Source: Canada, Dominion Bureau of Statistics, Cat. No. 47-206, (1963-68).

Table 5

INVENTORIES AS PERCENTAGE OF
VALUE OF SHIPMENTS OF OWN MANUFACTURE

Year	Percentage
1968	22
1967	17
1966	20
1965	14
1964	14
1963	15

Source: Canada, Dominion Bureau of Statistics, Cat. No. 47-206, (1963-68).

relatively wide price swings could result in sizeable profits or losses. However, because of the structure and conduct of the industry, prices do not fluctuate widely and I believe profits become relatively stable.

6. Pricing Policies and Competition

Pricing policy within the optical industry is rather confusing. Most spectacles tend to be sold at retail prices suggested by the manufacturer. However, there are frequent departures from such established prices by retailers depending upon the keenness of competition. Manufacturer's and wholesaler's prices have been rising at an average rate of approximately 5 per cent per year.

From the foregoing it can readily be inferred that the industry is not very competitive. Whatever competition is prevalent, it rarely manifests itself in price-cutting.

The relative absence of price-cutting does not mean that ophthalmic goods prices remain constant. Price quotations usually rise whenever the two largest firms, American Optical and Imperial Optical, take the initiative. Opticians in the industry noted that when this occurs, the rest of the industry generally follows suit.

Although only two companies share practically the entire Canadian market, competition, but not price competition, between these two companies is very active. In particular, there is considerable emphasis on new styles. The great surge in spectacle "styling" has created serious distribution problems since most wholesalers and retailers balk at carrying too many different products.

Price competition is less important than product differentiation. Product differentiation results in magnified profits from the successful development of efficient systems and procedures of manufacturers. Technological changes have resulted in cheaper production costs and better quality. During periods when few or no technical changes are made, differentiation is centred upon style factors. Patents protecting such styles, offer appearances as a feature that attracts the prospective buyer. Eye appeal has more than once been the strategic factor in the success or failure of a particular style.

7. Value Added

There is considerable diversity in the degree to which various components of the optical industry add value to manufacturing. The relatively skilled processing required in the basic grinding and polishing of some lenses and not others implies that value added is significant and can vary between locations and from year to year.

In 1968, the entire optical and allied products group, as classified by the Census of Manufacture, had an annual sales volume of nearly $33 million (see Table 6) with value added in excess of $16 million.

Table 6

VALUE ADDED AND VALUE OF SHIPMENTS OF OWN MANUFACTURE

Year	Manitoba		Canada	
	Value of Shpt. of Mfg.	Value Added	Value of Shpt. of Mfg.	Value Added
1968	1,245	671	33,007	16,228
1967	1,124	608	31,969	15,260
1966	1,015	565	29,799	15,095
1965	838	471	24,645	13,247
1964	760	428	23,588	12,554
1963	704	395	21,909	11,745

Source: Canada, Dominion Bureau of Statistics, Cat. No. 47-206, (1963-68).

In Manitoba, the value of shipments of own manufacture was $1,245 million (Table 6) whereas the value added amounted to $671 thousand. In five years, 1963 - 68, the value of own manufacture in Manitoba has increased 61 per cent compared to 43 per cent for Canada (Table 7). One may interpret this as an indication that more and more of the manufacture of ophthalmic goods has been shipped to Manitoba firms. The percentage change in total value added over this period has been 60 per cent for Manitoba as compared to 54 per cent for Canada. However, it is observed that the value added has become a greater percentage of the value of own manufacture in Canada than in Manitoba. The reason for this may be that wage rates have increased much faster in Canada as a whole than in Manitoba as we shall see in the next section.

8. Labour

Working conditions in the grinding and cutting phase of the industry demands control and maintenance of mechanical equipment. Skilled technicians are necessary to operate the complex and articulate mechanisms. Each position requires at least three months training according to managers in the industry.

From Table 8 we can see that total salaries and wages in the optical manufacturing industry of Manitoba account for over 60 per cent of the total value added. This is in contrast to the petroleum industry where the use of a greater

Table 7

PERCENTAGE CHANGES IN VALUE OF OWN MANUFACTURE AND VALUE ADDED

Year	Manitoba: % change in Value of Own Mfg.	Manitoba: % change in Value Added	Canada: % change in Value of Own Mfg.	Canada: % change in Value Added
1967-8	+ 11	+ 10	+ 3	+ 12
1966-7	+ 11	+ 8	+ 7	+ 3
1965-6	+ 21	+ 20	+ 21	+ 28
1964-5	+ 10	+ 10	+ 4	+ 4
1963-4	+ 8	+ 8	+ 8	+ 7
	61	56	43	54

Source: Canada, Dominion Bureau of Statistics, Cat. No. 47-206, (1963-68).

Table 8

TOTAL WAGES AS PERCENTAGE OF TOTAL VALUE ADDED

Year	Manitoba	Canada
1968	61%	60%
1967	62%	62%
1966	58%	62%
1965	62%	67%
1964	67%	62%
1963	56%	62%

Source: Canada, Dominion Bureau of Statistics, Cat. No. 47-206, (1963-68).

proportions of machinery results in labour's share of value added being 30 per cent.[9] Wages paid to production and related workers in 1968 averaged $3,535 per year in Manitoba compared to an average of $5,600 per year earned by other production workers in Manitoba doing similar work.[10]

9. Profit Margins

Profit margins computed as a percentage of sales or net worth have not been consistently high. For an example let us estimate the profit for 1968. As per Table 9, wages amounted to $516,000. Therefore $326,000 ($842,000 - $516,000) of the industry's value added went to rents, profits, interest or capital, and capital investments. Thus one would make a reasonable estimate that the profits in the Manitoba industry would be in the vicinity of $100,000 to $150,000 per year.[11] Since the total value of shipments in Manitoba was approximately $1-1/2 million, the profit rate is around 10 per cent. From this, one can conclude that the profits in the manufacturing industry are not excessive.

---

[9] Vance, Op. cit., 212.

[10] Calculated from: Canada, Dominion Bureau of Statistics, Scientific and Professional Equipment Manufacturers; Catalogue No. 47-206, (1963 - 68).

[11] The profit total is purely a calculated estimate which is believed to be fairly accurate partly based on available statistics.

Table 9

TOTAL WAGES AND VALUE ADDED - MANITOBA

Year	Total Salaries and Wages $,000	Value Added $,000
1968	516	842
1967	460	740
1966	389	675
1965	346	558
1964	324	483
1963	290	514

Source: Canada, Dominion Bureau of Statistics, Cat. No. 47-206, (1963-68).

CHAPTER V

APPLICATION OF LOCATION THEORY TO THE OPTICAL INDUSTRY

This chapter compares in considerable detail the relative costs of an optical manufacturing plant in Manitoba with a similar plant in Ontario. The materials contained in this chapter consist entirely of cost data and information developed for a hypothetical manufacturing plant attempting to choose between the two locations.

Cost data pertaining to each of the plant's requirements such as labour, transportation, occupancy , taxes and government aid have been developed for each location under study.

Most of the census data has been ferreted out of the Dominion Bureau of Statistics publications.[1]

It is difficult to separate the influence of cost of raw materials, fuel and electricity, and contract work from the influence of value added on certain ratios. The industry in one part of the country, say Manitoba, may show a lower ratio of cost of materials to value added than in another part such as Ontario. Whether the difference in ratios is due to differentials in value added or to cost of materials is a major

---

[1]Canada, Dominion Bureau of Statistics, Scientific and Professional Equipment Manufacturers, Catalogue No. 47-206, (1963-68).

problem. To overcome this problem we shall use the following enumeration:

Notation:

W_M , the average annual wage per worker in Manitoba.

W_O , the average annual wage per worker in Ontario.

M_M , the cost of materials per worker in Manitoba.

M_O , the cost of materials per worker in Ontario.

VA_M , the value added per worker in Manitoba.

VA_O , the value added per worker in Ontario.

A_M , the ratio $\frac{M_M}{VA_M}$ in per cent.

A_O , the ratio $\frac{M_O}{VA_O}$ in per cent.

B , the ratio $\frac{M_M}{VA_O}$ in per cent.

C , the difference in productivity in per cent.

D , differences due to lower cost of materials in per cent.

If $\frac{M_M}{VA_M} < \frac{M_O}{VA_O}$, it suggests an advantage in cost of materials in Manitoba as compared with Ontario. The difference can be attributed to material cost advantages or to differences in value added. M. Greenhut suggests a method of deriving a partial separation.[2] To accomplish this, he

[2] M.L. Greenhut, Plant Location in Theory and in Practise, (Chapel Hill: University of North Carolina Press, 1956), 318.

places the same value of materials for the average worker in one location as was used by the average worker in another location. For example, he would compare the ratio $\frac{M_M}{VA_M}$ with $\frac{M_M}{VA_O}$. This change would give a B per cent ratio of cost of materials to value added as compared with the actual A_M per cent ratio. The differences in productivity, C, accounting for a certain percentage of the discrepancy between the ratios $\frac{M_M}{VA_M}$ and $\frac{M_O}{VA_O}$ can then be calculated:[3]

$$C = \frac{M_O\ VA_M - M_M\ VA_O}{VA_M\ (M_O - M_M)}$$

The lower cost of material must account for the remaining differential, D, (i.e. 100% - C = D), since it is the only factor which has not been abstracted by assumption. The results and this procedure must assume that the average worker in both locations uses the same amount of material as will be explained later. We shall use Greenhut's method in analyzing D.B.S. data to arrive at some conclusions concerning labour productivity, cost of materials and costs of fuel and electricity between Manitoba and Ontario.

1. Productivity of Labour

The productivity of a worker can be suggested by the ratio of value added per worker to wages per worker. In order to use such data to suggest comparative advantages or disadvantages of

---

[3]The differences in productivity, C, is derived from the following equation: $\frac{M_O}{VA_O} - \frac{M_M}{VA_M} = C\ \left(\frac{M_O}{VA_O} - \frac{M_M}{VA_O} \right)$.

different locations we must assume equal use of materials in each location in the manufacturing process.

> "Some workers, by being more wasteful in their use of raw materials, may contribute a greater total value added per unit of time than others. It is the net value added per worker which is vital in comparisons of productivity. This net concept requires a deduction from the total value added figure of an amount equal to the different quantities of raw materials, fuel, power and contract work that are consumed in manufacture.... It can be only crudely approximated by the analyst who is using census or like data."[4]

People in the industry believe that labour's use of raw materials, fuel and electricity, etc., is approximately the same. In addition, there is no difference in capital use.

Therefore, we are in a position to use the ratio of value added per worker to wages per worker as a measure of productivity in arriving at some conclusion concerning cost differences.

Tables 10 and 11 show that this ratio is 187.6 per cent for Manitoba and 166.5 per cent for Ontario. The labour in Manitoba is thus more cost efficient than in Ontario. This is due to the fact that value added per worker is approximately equal for both locations but that wages are lower in Manitoba.

2. Materials

The average annual wage per worker in Manitoba was 53 per cent of the value added per worker in 1968. At the same time the average annual wage per worker in Ontario was 60 per

---

[4]Greenhut, Op. cit., 326.

cent of the value added per worker.[5]

The ratio of cost of materials to value added was 98.8 per cent in Manitoba and 102.7 per cent in Ontario (see Table 10). This suggests an advantage in costs to Manitoba. Using Greenhut's method we shall attempt to estimate how much of the difference can be attributed to material cost advantages or to differences in value added.

In order to separate the material costs from the value added, we shall place the same value of materials for the average Ontario worker as was used by the average worker in Manitoba (see Table 10). This change would give a 98.5 per cent ratio of cost of material to value added in Ontario as compared with a 102.7 ratio actually recorded. The difference in productivity would be negligible between Ontario and Manitoba ratios because the value added per worker figures are approximately equal. The lower cost of materials in Manitoba accounts for almost the entire differential. This is so since lower cost of materials inside Manitoba is the only factor which has not been abstracted by assumption. It must, therefore, account for the ratio of 102.7 per cent rather than 98.5 per cent. Again we must note that all workers use the same amount of materials. Otherwise, the larger ratio of cost of materials to value added suggests either that the cost of

---

[5]As calculated from statistics contained in: Canada, Dominion Bureau of Statistics, Scientific....

Table 10

COST OF MATERIALS PER WORKER

	Manitoba ($) (1)	Ratio in % to Prior Item in Column 1 (2)	Ontario ($) (3)	Ratio in % to Prior Item in Column 3 (4)	Ontario ($) (5)	Ratio in % to Prior Item in in Column 5 (6)
Wager per Worker	3,681.60	--	4,160.00	--	4,160.00	--
Value added per worker	6,905.60	187.57	6,926.40	166.50	6,926.40	166.5
Cost of Material per worker	6,824.00	98.8	7,113.60	102.7	6,824.00	98.5

Source: Calculated from: Canada, Dominion Bureau of Statistics, Cat. No. 47-206, (1963-68).

materials is higher in Ontario or that the workers inside Manitoba use smaller quantities of raw materials in fabricating the finished product.

3. Fuel and Electricity

Using the procedure in the previous section, we can substitute fuel and electricity costs for raw material costs. In 1968, the cost of fuel and electricity was 1.20 per cent of value added in Manitoba and 1.80 per cent in Ontario. The ratios (1.20 per cent to 1.80 per cent) indicate an advantage for Manitoba. However, before we can conclude as such we must account for the productivity differences between the two provinces.

Table 11 is a replica of Table 10 except for the substitution of fuel and electricity for raw materials. The cost of fuel and electricity to value added is 1.20 per cent in Manitoba and 1.80 per cent in Ontario. This gives a value of $83.20 for cost of fuel and electricity per worker in Manitoba and $124.80 for Ontario. If we use the same reasoning to estimate how much of the difference can be attributed to fuel and electricity cost advantages or to differences in value added we should conclude that the entire difference is attributed to cost advantages for fuel and electricity rather than value added as witnessed by our previous analysis.

In Table 11 we again placed the same value of cost of fuel and electricity (instead of materials) in column 5 for

Table 11

COST OF FUEL AND ELECTRICITY PER WORKER

	Manitoba ($) (1)	Ratio in % to Prior Item in Column 1 (2)	Ontario ($) (3)	Ratio in % to Prior Item in Column 3 (4)	Ontario ($) (5)	Ratio in % to Prior Item in Column 5 (6)
Wages per Worker	3,681.60	--	4,160.00	--	4,160.00	--
Value added per Worker	6,905.60	187.57	6,926.40	166.50	6,926.40	166.5
Cost of Fuel and Electricity per Worker	83.20	1.20	124.80	1.80	83.20	1.20

Source: Calculated from: Canada, Dominion Bureau of Statistics, *Cat. No. 47-206*, (1963-68).

the average Ontario worker as was used by the average worker in Manitoba. This change would give a 1.20 per cent ratio of cost of fuel and electricity to value added in Ontario as compared with a 1.80 ratio. The difference in productivity would account for none of the discrepancy between Ontario and Manitoba ratios. Again we must assume that the average worker in both provinces uses the same amount of fuel and electricity. The lower cost of fuel and electricity in Manitoba accounts for the entire differential in cost of fuel and electricity.

4. Labour

The relative importance of different cost factors varies between industries. Obviously with labour costs accounting for over 60 per cent of the value added, the labour component is the most important. We shall proceed to establish labour cost estimates for Manitoba and Ontario. These estimates assume that labour specifications will not vary between locations (i.e. equal quantity labour inputs per unit of output). Also, management and professional personnel are excluded from the estimate since we shall assume that salaries of such personnel do not differ significantly between locations studied.

Table 12 shows the hourly wage scales for production and related workers. The wage data was calculated from information obtained from the Dominion Bureau of Statistics.[6]

The industry in Manitoba presently employs approximately

---

[6]Canada, Dominion Bureau of Statistics, Op. cit.

Table 12

AVERAGE HOURLY EARNINGS PER PRODUCTION WORKER

$

	1968	1967	1966	1965	1964	1963
Manitoba	1.77	1.85	1.66	1.52	1.37	1.39
Ontario	2.00	1.93	1.76	1.60	1.50	1.41
Canada	1.97	1.88	1.70	1.58	1.49	1.41

Source: Calculated from: Canada, Dominion Bureau of Statistics, Cat. No. 47-206, (1963-68).

one hundred production workers. If we estimate the annual cost for labour in 1968 based on a forty hour work week (2,080 hours annually) we come up with the result illustrated in Table 13. The industry would have realized an annual savings of $47,840 in labour costs in Manitoba during 1968. Table 14 shows the percentage changes in hourly earnings from 1963 to 1968. The result indicates that Manitoba's wages are rising more slowly than Ontario's. The average yearly per cent change in hourly earnings shows a rise of 5.2 per cent for Manitoba and 7.4 per cent for Ontario. Table 14 provides evidence that the gap between the two provinces is not narrowing. If this continues, the labour cost savings of a Manitoba location would increase every year. Thus we can conclude that a Manitoba location provides a definite saving in terms of labour costs, based on our assumptions, in the past and possibly in the future.

5. Transportation

Transportation cost factors are important in the determination of plant location. It is claimed that variability of these costs at alternative sites is much less than other factor costs if we compare locations having the required facilities and service.

Company spokesmen stated the time factor is very important and the materials require prompt rather than low-cost movement. The time factor forces utilization of speedier means

Table 13

ESTIMATED ANNUAL LABOUR COSTS

	Number of Employees	Estimated Average Hourly Rates	Estimated Annual Cost
Manitoba	100	$1.77	$368,160
Ontario	100	2.00	416,000
		Difference	$ 47,840

Source: Calculated from: Canada, Dominion Bureau of Statistics, Cat. No. 47-206, (1963-68).

Table 14

PERCENTAGE CHANGES IN HOURLY EARNINGS - 1963-1968

	Manitoba	Ontario	Canada
1967-8	-4	4	5
1966-7	11	10	11
1965-6	9	10	8
1964-5	11	7	6
1963-4	-1	6	4
Five Year Total	26	37	34
Average Percentage Per Year	5.2	7.4	6.8

Source: Canada, Dominion Bureau of Statistics, Cat. No. 47-206, (1963-68).

of delivery. Motor trucking from one location to another is widely used. In many cases, remote locations have to be served by air transport. The supplier prefers truck transport to rail facilities for shipments because of the belief that greater care is exercised by trucking companies in handling.

The industry minimizes freight cost by locating near the market. This is mainly due to the large source of demand and the time factor. The industry requires a location having a good distribution facility from the wholesaler to the retailer offering various channels for its marketing complex.

Presently, the branch offices in Winnipeg and Brandon receive regular shipments (twice a month) from the distribution centres in Ontario. If production was doubled in Manitoba, there would be some savings in transport costs because of the reduction in the number of deliveries required. However, the savings are estimated to be minimal. The only important necessity is that the manufacturing process takes place in either Brandon or Winnipeg. If the industry was to be located in a remote area, transport costs would then become more significant.

6. Taxation

Any investor is interested in the level of local taxes he would have to pay in various locations. Average municipal tax rates are almost impossible to compare meaningfully. Methods of determining values for assessment purposes are specified by law, either provincial or municipal. Since assessed values, which usually bear little direct relationship to current market values, may vary widely between municipalities, tax rates themselves give no real indication of the actual tax burdens. Even when the relative assessments are taken into consideration, differences in methods of financing and in the allocation of responsibilities between provincial and municipal governments in each of the provinces further complicate any comparison of tax burdens between municipalities.

Other taxes which would affect location are provincial corporation taxes and provincial sales taxes. The 1971 provincial corporation income tax rate was 13 per cent in Manitoba and 12 per cent in Ontario. In terms of variations in corporate income tax burdens, this means an Ontario location presently enjoys a comparative advantage. Both Manitoba and Ontario have a 5 per cent sales tax. Therefore, to us it is not necessary to estimate purchases subject to sales taxes.

We may conclude that it is very difficult to compare and estimate the savings accruing from differences in municipal tax rates. In general, most governmental studies which have compared average municipal tax rates suggest that tax costs are lower in Winnipeg and Brandon than in the Toronto area.[7]

---

[7]This conclusion was arrived at after a survey of various location cost comparison studies prepared by the Manitoba Government.

Although we cannot estimate the savings, we can suggest that a Manitoba location should benefit from a municipal tax burden standpoint. However, there are definite tax burdens on profits because the provincial corporate income tax rate is one per cent higher in Manitoba than in Ontario. Unless we had an accurate estimate of the profits that could be earned, we cannot suggest the amount of savings. Earlier it was estimated that profits in Manitoba ranged from $100,000 to $150,000 per year in the industry. Thus a Manitoba location would pay a higher tax, approximately $1,000 to $1,500 per year, than Ontario. This amount would seem to be too small to become an important factor in the decision of a plant location.

7. Government Incentives

Direct government aid can have a significant effect on plant location decision making. Both the Ontario and the Manitoba governments are vitally interested in assisting any industry to locate or expand its facilities within their respective provinces. The Manitoba Department of Industry and Commerce, for instance, will supply funds for technical assistance, expanding existing plants and manpower development.

The Federal Government has set up a program called the Regional Development Incentives Act. Various regions in Manitoba and Ontario qualify for aid from the Department of Regional Economic Expansion. Under this program new companies set up in designated areas are eligible for government grants of up to 25 per cent of capital costs plus a maximum of $5,000 per job created.

Therefore, the provincial and federal government programs of assistance together can definitely finance a major portion of the cost of transfer of manufacturing operations from the Toronto area to a Manitoba or another Ontario location.

8. Occupancy and Capital Costs

If production is doubled, the cost of occupancy should not increase since work could be done in two shifts rather than the present one. However, the occupancy cost per unit would definitely decrease in Manitoba. If the extra production in Manitoba is a direct transfer from Ontario, supposedly the industry does not gain or lose by the transfer unless occupancy rates differ between the two provinces. Occupancy rates are not available from the industry. If the increase in production in Manitoba is not a result of a decrease in production in Ontario but a result of a cancellation in expansion in Ontario, then there would be definite locational advantage in Manitoba.

An increase in production in Manitoba would not necessitate an increase in capital spending for equipment. Instead, present equipment could be utilized twice as much. Thus the unit cost of output would definitely fall. Again this reasoning depends on the assumptions discussed for occupancy.

CHAPTER VI

CONCLUSION

Although there are a number of theoretical constructs of location theory appropriate to practical analysis, many of the techniques deployed by economists in simulation exercises have serious limitations in applied analysis. For example, costs of materials, labour, and transportation are main elements of location theory. But the use of a demand cone or Weberian triangle technique in analyzing these elements is not applicable since the assumptions underlying them are too restrictive. To circumvent the problem of utilizing models sterile of practical analysis, a central theme of this thesis has been a consideration of factors deemed important in determining location decisions. Put plainly, a central objective of this thesis has been to evaluate how economical a Manitoba location would be compared to an Ontario location for the optical manufacturing industry. In studying the costs of various locational factors, the author has come to the conclusion that in the case of the optical industry, it can justifiably locate in either province. If a cost advantage does lie in the favour of one province, then Manitoba must be considered the favoured location.

The primary factor which contributes to Manitoba's relatively favourable cost position is the labour factor. The wage data calculated showed that the wage rate was lower in Manitoba compared to Ontario. If we assume that productivity of labour is the same for the two locations, and we have no reason to believe otherwise, the unit cost of production would be lower in Manitoba. According to our calculations and assumptions, the Manitoba based industry would have realized a savings of $47,840 in labour costs in 1968 by having its manufacturing plant in Manitoba rather than in Ontario.

In our analysis of the transportation cost factor it was noted that the industry required a location with good distribution facilities offering quick delivery. Under such conditions it was argued that the difference in transportation costs between the two locations would be of minimal importance.

The costs of material as well as fuel and electricity were shown to be cheaper in Manitoba. This conclusion was based on the assumption that the average worker in both provinces used the same amount of material, fuel and electricity. The Manitoba location would realize a savings in 1968 of $28,960 for materials and $4,160 for fuel and electricity.

With reference to taxes, an Ontario location would save approximately $1,000 - $1,500 per year because of its lower provincial corporate income tax. This amount would seem to be too small a factor to effectively influence location.

The various government incentive programs are not significant in influencing location. There are locations in both

Manitoba and Ontario which are designated areas eligible for federal assistance under the Regional Development Incentives Act. Although it appears that a Manitoba location would obtain more aid from the provincial government than in Ontario, in practice the Ontario government, because of its great financial base, could offer equal incentives for the industry to remain and expand in Ontario. Thus, government incentives may not be a factor influencing location.

It was stated that capital utilization and occupancy were factors favouring production in Manitoba. Even though the machines in Manitoba presently are used only eight hours per day, one can argue that further capital utilization would shorten the life-time of the equipment. This is possibly true for some of the equipment but it would be of negligible importance in other instances. Overall there would be some savings due to greater capital utilization but by how much, we cannot say. Savings due to occupancy are possible but they seem to be of minor significance. Because of government subsidies, a transfer of production into Manitoba may not lead to greater capital utilization but an expansion in facilities and machinery.

After examining the various elements of location theory relevant to the optical industry, we found that the most important factors affecting location were labour and cost of materials. On the basis of our analysis and assumptions, our general conclusion is that the optical industry is a footloose industry.

Analysis of the locational factors chosen proved that a Manitoba location was more favourable but due to incomplete data availability the advantages of a Manitoba location could be offset by other factors such as lower productivities of labour and capital.

Much of the information and data used as a basis for analysis was obtained from or was influenced by company personnel, but without exception, when information was requested, the best possible source was made available.

Are the results of this study of any use to the company? The answer to this question is not a simple one, but it seems safe to volunteer a qualified "yes." The usefulness of these results would depend upon the company's attitude towards studies of this nature. Even if none of the information given by the results is used, the company may benefit from the accumulation of the data and the format in which it was analyzed. From an academic standpoint the study has sought to utilize the theoretical precepts of location theory in analyzing a location problem of a relatively small industry. The industry chosen was of particular interest since it was not obvious at the outset that the industry was either a market or material based industry. Although the analysis of a footloose industry presented problems which on a few occasions were seemingly intractable, the end result it is hoped suggested ways in which location theory could be used as an effective tool of analysis.

BIBLIOGRAPHY

Books

Bain, J.S. Barriers to New Competition. Cambridge: Harvard University Press, 1956.

__________. Industrial Organization. New York: Wiley Press, 1968.

Berry, B.J.L. Geography of Market Centres and Retail Distribution. Englewood Cliffs: Prentice-Hall, 1967.

Chamberlain, E.H. The Theory of Monopolistic Competition. Cambridge: Harvard University Press, 1946.

Dean, W.H. The Theory of Geographic Location of Economic Activities. Ann Arbor: Edwards Bros. Inc., 1938.

Greenhut, M.L. Microeconomics and the Space Economy. Chicago: Scott Foresman & Co., 1963.

__________. Plant Location in Theory and in Practise. Chapel Hill: University of North Carolina Press, 1956.

Hoover, E.M. The Location of Economic Activity. Toronto: McGraw-Hill Co., 1963.

__________. Location Theory and the Shoe and Leather Industries. Cambridge: Harvard University Press, 1937.

Isard, W. Location and Space-Economy. New York: Wiley Press, 1956.

__________. Methods of Regional Analysis. New York: Wiley Press, 1960.

Lefeber, L. Allocation in Space. Amsterdam: North-Holland Publishing Co., 1958.

Losch, A. The Economics of Location. Translated by W.H. Woglom. New Haven: Yale University Press, 1954.

McKee, D.L., Dean, R.D., and Leahy, W.H. Regional Economics: Theory and Practice. Toronto: Collier-Macmillan Canada Ltd., 1970.

__________. Spatial Economic Theory. Toronto: Collier-Macmillan Canada Ltd., 1970.

Peck, M.J. Competition in the Aluminum Industry. Cambridge: Harvard University Press, 1961.

Richardson, H.W. Regional Economics. London: Camelot Press Ltd., 1969.

Shubin, J.A. Managerial and Industrial Economics. New York: Ronald Press Co., 1961.

Vance, S. Industry Structure and Policy. Englewood Cliffs: Prentice-Hall, 1961.

Von Thunen, J.H. Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie. Berlin: Schumacher-Zarchlin, 1875.

Weber, Alfred. Theory of Location of Industries. Translated by C.J. Friedrich. Chicago: University of Chicago Press, 1929.

Articles and Periodicals

Devletoglow, N.E. "A Dissenting View of Duopoly and Spatial Competition," Economicia, May 1965, 140-160.

Fetter, F.A. "The Economic Laws of Market Areas," Quarterly Journal of Economics, XXXIX (1924), 520-520.

Hotelling, H. "Stability in Competition," Economic Journal XXXIX (1929), 41-57.

Lerner, A.P. and Singer, H.W. "Some Notes on Duopoly and Spatial Competition," Journal of Political Economy, XLV (1939), 445-486.

Moses, L.N. "Location and the Theory of Production," Quarterly Journal of Economics, 72 (1958), 249-272.

Smith, D.M. "A Theoretical Framework for Geographical Studies of Industrial Location," Economic Geography, 42 (April 1966), 95-113.

Smithies, A. "Optimum Location in Spatial Competition," Journal of Political Economy, XLIX (1941), 423-439.

Public Documents

Canada, Dominion Bureau of Statistics. Canadian Statistical Review. Vol. 45. Catalogue No. 11-003.

Canada, Dominion Bureau of Statistics. Scientific and Professional Equipment Manufacturers. Catalogue No. 47-206. Annual Census, 1963 to 1968.

Report of Commissioners. Optical Goods: Investigations into an Alleged Combine in the Manufacture and Sale of Optical Goods in Canada, A Report Prepared Under the Combines Investigation Act. Ottawa: Department of Justice, April 24, 1948.

Reports

A Comparison of Industrial Location Costs for an Electrical Equipment Plant. Prepared by Arthur D. Little Inc. for the Department of Industry and Commerce, Government of Manitoba. Winnipeg: March 1969.

A Comparison of Location Costs for a Case Goods Furniture Manufacturing Plant. Prepared by the Department of Industry and Commerce, Government of Manitoba. Winnipeg: 1970.

Locational Costs Comparison of Rapeseed Crushing in Western Manitoba as Against the Toronto Area. Prepared by the Department of Industry and Commerce, Government of Manitoba. Winnipeg: January 1968.