THE THEORY OF INDUSTRIAL LOCATION: ALFRED WEBER'S CONTRIBUTION REAPPRAISED

by

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ABSTRACT

Compared with the amount of concern displayed by economists over the problem of time and the dynamics of economic theory, relatively little has been said on the economics of space. Work on location theory has been discontinuous although there has been somewhat of a spurt in the last decade or so which can perhaps be related to the concurrent growth of regional science.

Earlier works on location analysis tended to apply themselves to giving explanations to historical trends. This paper is by no means a survey of all the literature in the field and its restricted basis is the work by Alfred Weber entitled Ueber den Standort der Industrien published in 1909. This is perhaps the most interesting of the classical location analyses both in its depth and scope. At the same time, it is typical in its concern with historical experience, particularly in its search for the causes of the great locational shifts of industries in the period of the European industrial revolutions.

In more recent writings Weber must be one of the most cited classical works. At the same time, the cursory treatment he receives perhaps does him less than justice. In this paper some pains are taken to organise the more important aspects of Weber's thought which, it is believed, has some value in its own right. After a short introduction, Section 2 considers Weber's analytical framework. This is followed in the next three sections by a treatment of his categories of locational forces which may attract industry. Industry, in effect, may be transport-oriented, labour-oriented or attracted to social and industrial agglomerations. Section 6 contains an example of how Weber applied his theory. This should perhaps help illuminate the theory's value in Weber's own context.

Few of the later writers in location theory have set out with Weber's historical bias. They have been concerned with various other questions such as optimal firm location or extending the traditional economic theory of production to include spatial variables. Points of continuity and divergence between these writers and Weber are drawn in the last part of the paper, in Sections 7 and 8. Finally, some attempt is made to draw together the various strands of location theory, which have been uncovered, and to evaluate the general state of this branch of economic science.

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1. INTRODUCTION.

If modern writings on location theory are to be taken as a guide, then the works of Alfred Weber[1] belong to the realms of antiquity. Further, the author of the Theory of the Location of Industries might be imagined to be of the crude pioneering type - working with shoddy tools and great perseverance. This last attribute will always, of course, be admired. But at the same time from the standpoint of latter-day intellectual sophistication such classic, pioneering exercises have a tendency to be regarded as rather tedious.

This interpretation of the value of Weber's work might be misleading. For without a doubt Weber's analytical tools and the resulting insights, which he achieves, have a somewhat modern flavour to them especially when applied to the field of economic history. In fact, it will be argued in a later section[2] that Weber's analysis of the great locational shifts which characterise the industrial revolution in nineteenth-century Europe, was half a century ahead of its time.

On the other hand, it would seem that the questions which to-day occupy the attention of location analysts were of much less significance to Weber. Lösch[3], for example, asks: Given (n-1) locations, how do we determine the nth location? This is the formulation of the problem which Isard[4] and Hoover[5] also adopt. And from such a starting

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[1] A. Weber, Ueber den Standort der Industrien (Tübingen, 1909). English translation with introduction and notes by C.J. Friedrich, Alfred Weber's Theory of the Location of Industries (Chicago: University of Chicago Press, 1929).

[2] See below, section 6, p. 23.

[3] A. Lösch, The Economics of Location (New York: John Wiley & Sons, Inc., 1952).

[4] W. Isard, Location and Space Economy (Cambridge, Massachusetts: Massachusetts Institute of Technology, 1956).

[5] E. Hoover, Jr, Location Theory and the Shoe and Leather Industry (Cambridge, Massachusetts: Massachusetts Institute of Technology Press, 1937) and E. Hoover, Jr, The Location of Economic Activity (New York: McGraw Hill, 1948).

point it is only a short step into the micro-economic field of operations research to seek with respect to location some set of criteria of profitability for the individual producer. It would not be surprising, then, if the Weberian framework were to fall short in answer to this type of question.

Such reflections suggest that the present paper be divided into two main parts. In earlier sections Weberian location analysis will be developed, always keeping in mind the specific location problems which seemed of most interest to Weber himself. At a later stage recent attempts to reformulate the Weberian hypotheses can be dealt with. With respect to this last point it will be advanced that despite significant outpourings of literature on the economics of location in the past two decades and despite a surfeit of what Leon Moses calls "esoteric paraphernalia"[6] the integration of location theory with general production theory has proceeded at a fairly slow pace.

In summary, the objective of this paper is to assess the work of Alfred Weber after sixty years of further development in the theory of industrial location. With these terms of reference in mind the first step will be to review each stage of Weber's theory against the background of his analytical framework.

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[6] L. Moses, "Location and the Theory of Production," Quarterly Journal of Economics, Vol. LXXII (1958), pp. 259-72.

2. ALFRED WEBER'S ANALYTICAL FRAMEWORK.

2.1 Introduction.

The economic and non-economic variables determining the location of an industry may seem to form a network of complex, diverse elements, often, in individual instances, so arbitrarily composed that there appears to be no place for more than an analysis of the individual case.

> If we approach the individual manufacturer with a question concerning the choice of his location, he will at most give us a quaint concotion of general and particular reasons, unless he points to the past and says: 'I am here because this industry grew up here'.[7]

Nonetheless, according to Weber, some attempt to discover general formulas for the solution of the different locational factors and to ascertain their operational limits is absolutely necessary from the point of view of economic theory.

It is a pity that an economist of the stature of Alfred Marshall did not share Weber's views on the appropiateness of analysing space economics. His contention that "the influence of time . . . [is] more fundamental than that of space"[8] has been a major force, according to Isard, for the state of imbalance exhibited by later British and U.S. economists who, for the most part, have abstracted from space and thus conduct all their economic theories as if in "a wonderland of no spatial dimensions."[9] A reaction against this state of affairs has inevitably come about with some significant attempts to introduce space as a variable in general equilibrium analysis. Under these circumstances the earlier work of Alfred Weber can now command some

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[7] Weber, op. cit., p. 17.

[8] A. Marshall, Principles of Economics (London: Macmillan, 1920), Book V., ch. XV, Section 1.

[9] Isard, op. cit., pp. 24-25.

re-examination.

2.2 The Terms of Reference of Weber's Pure Theory of Location.[10]

Given the need for a general theory of "locational factors," which can be defined as advantages to be obtained when an economic activity takes place at one point rather than elsewhere, then the primary question to be asked is: Are there any general causes of location which concern every industry? If we know these we are able to inquire how far the orientation of industry can be explained by them. Next, by ascertaining further facts, we can investigate the particular causes of the phenomena not explained by the general factors. These causes must be explained by the specific characteristics of particular industries and are not recognised in advance but only through particular investigations.[11] In short, a general theory can only be expected to take account of general locational factors. The first step, then, is to enumerate the general factors in question.

The general locational factors can be regarded as falling into two sub-categories. In the first place, the dimension of space introduces factors which pull an industry to and fro because of various regionally operating variables. Three such variables can be distinguished:

(i) the relative "prices" of deposits of raw materials,

(ii) the costs of transportation,

and (iii) the costs of labour.[12]

Of these, the relative price differential of raw materials from various sources can be expressed in terms of transportation costs. For theoretical purposes it is equivalent to thinking in terms of "cheap"

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[10] Weber, op. cit., pp. 18-40.

[11] Atmospheric humidity, for example, would be a locational disadvantage for a very particular set of industries.

[12] The question has been raised as to whether this is, in fact, purely a regionally operating factor. See Isard, op. cit., p. 25.

deposits situated relatively near to the plant and "dear" deposits further away. Consequently, we can work with two general, regionally operating, locational factors, namely the costs of transportation and the costs of labour.[13] Being strictly a function of space, regional factors can all be analysed from the point of view of the individual, isolated production process.

All the other factors of location work between industries[14] and therefore are not to be found in any examination of an isolated production process. They are grouped together under the title "agglomerative factors" and work to create groupings of industrial processes in agglomerations of various sizes - agglomerations which are not ascribed to regional factors.[15] The aggregate of agglomerative factors is treated as a "uniform agglomerating force."[16] This is the third and last of the general locational factors.

On these foundations it is now possible to construct an entire abstract theory of general locational factors.

2.3 Procedure of Analysis.[17]

A start is made by assuming that all isolated processes of production will at first be pulled to their optimal points of transportation costs. This can be regarded as a basic network of industrial location or orientation. On top of this, then, apparently the differences of costs of labour (the second locational factor)

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[13] Weber, op. cit., p. 34.

[14] Weber is often accused of omitting this interdependence factor.

[15] I.e., agglomerations which are not labour or transport oriented.

[16] Weber, op. cit., p. 35.

[17] Ibid.

represent a force altering the initial network determined by the first locational factor. The most advantageous places of labour costs create a "first distortion" of the basic transportational network of industrial location. Lastly, every agglomerating tendency - in other words, the entire group of all other locational factors which have not so far been taken into account - is nothing but a second altering force competing with the other two locational factors.

3. TRANSPORT ORIENTATION.

3.1 Introduction.

In this section the major assumption is that no other factor affects location apart from transportation costs and the problem to be solved is simply: How will transportation costs influence the location of industry? The answer which Weber gives is that an industry will move to the point where its transportation costs are minimized.

3.2 Theoretical Solution.

We may conceive movement as being made up of three separate components:

(i) the distance to be moved,

(ii) the weight of the material inputs and outputs to be moved,

and (iii) the "effort" or costs of moving given materials over unit distance.[18]

Weber's theoretical discussion is based on the assumption that all factors affecting transportation costs can be expressed in either weight or distance units.[19] Thus, if the freight rates vary because of the varying costs involved in transporting different products (or even because different transport media are used), then all these local differences which are reflected in the ton-mile freight rate can be expressed by prolonging or shortening proportionally the particular distance to be moved.[20]

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[18] Isard, op. cit., pp. 81-90.

[19] Weber, op. cit., p. 45.

[20] The problem of progressively declining rates with increasing distance of haul would be awkward to fit into this framework. However, there does not seem to be an essential point here.

Weber realised multiple sources and multiple destinations to be the rule rather than the exception, and on the basis of the above reasoning offers a solution to situations with many sources of raw materials input (say M_1, M_2, M_3 and M_4) and centres of product consumption (C). This can be worked through for the sake of completeness using Cotterill's[21] example of a zinc smelting industry set out in Table I. and Figure 1.a.

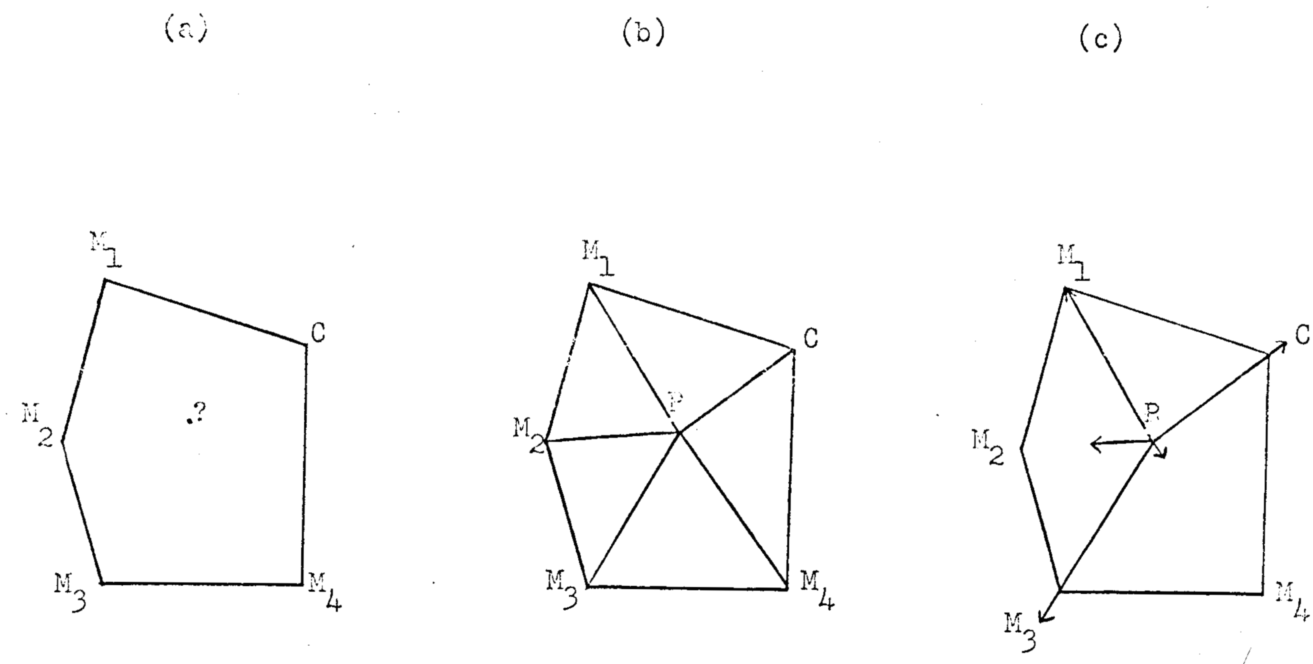
Table I. Zinc Smelting Industry, Locational Components.

Parameters	Location	Unit Distance D	Weight (tons) W	Freight rate per ton/mile R $	Net distance inputs D . W . R = Q
Outputs					
Slab Zinc	C	1.00	0.54	2.10	1.14
Inputs					
Zinc Concentrate	M_1	1.00	1.00	1.00	1.00
Reduction Coal	M_2	1.00	0.37	1.10	0.41
Heating Coal	M_3	1.00	1.08	1.10	1.19
Fireclay	M_4	1.00	0.10	0.50	0.05
Total Inputs		-	2.55	-	2.65

Source: C. Cotterill, op. cit.

[21] C. Cotterill, Industrial Plant Location: Its Application to Zinc Smelting (St. Louis, 1950).

Figure 1: Locational Force Diagrams.



Source: P. Haggett, Locational Analysis in Human Geography (New York: St. Martin's Press, 1966), p. 147.

In Figure 1.b. a trial location, P, is chosen within the locational figure. Distances from this trial point to the consuming centre and four material sources are measured and weighted by the values for weight and freight rate. The length of each vector is now made proportional (Fig. 1.c) to the net movement input given in Table I. column Q so that the line drawn to the heating coal source at M_3 is very long in comparison to that towards the fireclay source at M_4. Figure 1.c is now a force model representing the pull of each vertex of the locational figure. The point of minimum transport costs is that point where all attracting forces are balanced and equilibrium is obtained.[22]

In terms of the relative position of the optimal point we can state the following proposition:

Theorem I: The location will be near the individual corners or far away from them according to the relative weight of their locational components.23

3.3 The Character of Particular Industries and Transport Orientation.

The next question to be examined here concerns how characteristics of various industrial processes will affect the outcome of the locational struggle. To understand this more fully the following distinctions are necessary:

(a) between the use of localised materials, which are found in specific locations and thus have to be transported to the site of production, and ubiquities, which may be found at any geographical location (e.g., earth or water over large areas) and thus do not incur transportation costs as raw materials but, on the other hand, may enter into the weight of the final product.

(b) between the use of pure materials, which do not lose weight in the production process and weight-losing materials (e.g., fuel).

What determines the transport location is not the ratio of the weight of

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22 The simplest solution is that which solves similar problems in physics, i.e., using vector analysis to find where the force polygon is 'closed' and all forces are in balance.
See H. Campbell, Matrices, Vectors and Linear Programming (New York: Appleton, Century, Crofts, 1965), ch. 2.

23 Weber, op. cit., p. 54.

used materials to the weight of product but rather that of the weight of used localised materials per ton of product. This ratio is defined as the material index. Ubiquities are of importance only to the extent that they increase the weight of the final product and thus tend to reduce the material index. One last definition is that of the locational weight, namely, the total weight to be moved in the locational figure per ton of product.[24]

Transport location can now be seen to depend on two factors which determine the material index and the locational weight of every industry. One is the size of weight losses of localised materials during the process of production, which increases the material index and tends to attract industry towards the raw materials. The second factor is the weight of the ubiquities entering into the final product, which will serve to lower the material index and pull industry towards the place of consumption.[25] For example, in the case below, "beer" has a low material index because of the preponderance of non-weight-losing ubiquities (i.e., water) in its production. However, "zinc" has a high material index related to the dominance of weight-losing localised materials in its production.

Table II. Beer and Zinc - Calculation of the Material Index.

	Localised Materials (tons)		Ubiquities		Material
	Pure	Weight-losing	Pure	Weight-losing	Index
a. per ton of BEER	-	0.2	1.0	-	0.2
b. per ton of ZINC	-	5.0	-	-	5.0

[24] This equals the: (weight of localised materials + weight of product) / (weight of product).

[25] This can be thought of in terms of the force patterns introduced previously.

We can now infer the following propositions:

Theorem 2: All industries whose material index is less than 1 will tend to lie at the point of consumption.

Theorem 3: All industries whose material index is greater than 1 will tend to be attracted towards the raw material sources.

Theorem 4: Pure materials can never bind production to their deposits as the material index they create is never more than 1.

Theorem 5: Weight-losing material may pull production to its deposit if its weight in the production process is greater or equal to the weight of the product plus the remainder of the raw materials.[26]

We have now provided a solution to transport orientation. It is now necessary to find out to what extent industries will move from such a transport location when areally differentiated wage costs are introduced.

[26] An example of such an industry would be the production of salt by the evaporation of sea water.

4. LABOUR ORIENTATION.

4.1 Introduction.

Labour costs can only become factors in location by varying from place to place. The actual level of these costs, the particular circumstances which give rise to them - and even whether they actually exist - are all matters of complete indifference. Weber's pure theory conceives them as a "possibility" and investigates the theoretical results of this possibility.[27]

Thus, labour costs are assumed to vary from point to point with each point considered to be a labour location, whose attracting power is based on such differences in labour costs. Further, it is necessary to introduce the attracting power as a fixed quantity, so that mathematical quantification can proceed. In this way the differences in cost between labour locations are to be regarded as "given," and as given with unlimited attracting power. In other words, each labour location is blessed with an infinitely elastic supply of labour at a fixed wage rate.

Up until now, we have been concerned with the point of minimum transport costs as defined by the locational figure of raw material sources and consuming centres, and the material index. The question now becomes: Of what significance is it that in the infinite area around the transport-oriented location there are perhaps points at which a ton of product can be produced with lower labour costs?[28]

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[27] Weber, op. cit., p. 97.

[28] Ibid., p. 101.

4.2 Theoretical Solution.

The first thing to note is that this is an issue of alternatives. There is no benefit to the industry in merely approaching the labour location. It has either to move to the labour location or stay where it is at the point of minimum transport costs.

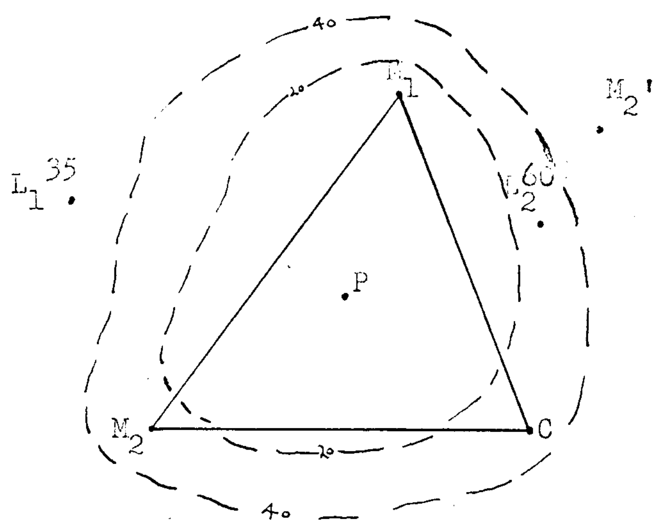
As every marginal deviation of the industrial location from the point of minimum transport costs gives an added cost in terms of lengthening routes and therefore costs, we can state:

Theorem 6: A location can be moved from the point of minimum transport costs to a more favourable labour location only if the savings in the cost of labour, which this new location makes possible are larger than the additional costs of transportation, which are involved.

This theorem is illustrated in operation by the introduction of the concept of an isodapane, which we define as an imaginary line joining all points of equal cost of deviation from the minimum transport point. Thus, around the minimum transport location are a series of isodapanes, the value of which increases outwards.

Every labour location must also lie on an isodapane of the respective locational figure. This isodapane indicates how high the costs of moving the industry from the minimum point of the locational figure to the labour location would be. Now if the index of labour economies is greater than the deviation costs as indicated by the isodapanes, then the industrial location will be moved to the labour location (see Figure 2).

Figure 2:



The Attraction of Labour Locations.

(Isodapanes are drawn around the minimum transport point, P, of locational triangle M_1, M_2, C. — M_2' is an unutilised raw material source.

Each bears an index of deviation costs incurred by moving away from P.

L_1 and L_2 are labour locations having indices of economy 35 and 60 respectively.

In this case the industry would move to L_2).

4.3 The Character of Particular Industries and Labour Orientation.

There are two general characteristics of industries which determine the degree of attraction of labour locations:

(i) the index of labour costs,

(ii) the locational weight.

When the index of labour costs, which is defined as the average cost of labour which must be applied to a ton of product, is large, a large quantity of labour costs will be available for 'compression,' with correspondingly large potential indices of economy of the labour locations.[29] In this case, a labour location would have a high potential attracting power. Similarly, industries with a low index of labour costs will be less attracted to labour locations.

The locational weight influences the extent to which an industry may be "deviated" through its effect upon the distance, and of lesser importance, the form of the isodapanes. A low locational weight, that is, a small mass of material per ton of product, gives a wide spacing of isodapanes and thus a greater chance that the industry can be "deviated."[30]

Weber connects these two influences by introducing the idea of the labour coefficient. This is given by the amount of labour costs which will arise in an industry for one ton of locational weight to be moved and leads to:

Theorem 7: The labour orientation of an industry is determined by its labour coefficient.[31]

An example serves to illustrate the operational significance of this theorem more fully:

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[29] *Ibid.*, p. 107.

[30] Certain environmental factors will be important here too, e.g., the geographical distance between transport and labour locations.

[31] This theorem is also a function of freight rate. From the table (III) it can be seen that every reduction in the freight rate would increase the sphere of attraction of labour locations.

Table III. Extent of Attraction of Various Industries to a Labour Location X.

	Labour Coefficient. (labour cost per locational ton) $	Savings at Labour Location X. 10% of labour costs. $	Freight rate per ton mile $	Extent of Potential Deviation to a Labour Location. MILES
(a) CLOTHING	1500	150	0.5	300
(b) POTTERY	55	5.5	0.5	11
(c) SLAB ZINC	1	0.1	0.5	0.2

According to Weber "the entire - and immensely different - manner of orientation"[32] of these three industries can be explained by such a tabulation.

Having determined the factors determining the varying attractions of a low cost labour supply to various industries, the final general locational force can be introduced.

[32] Weber, op. cit., p. 102.

5. FACTORS LEADING TO AGGLOMERATION.

5.1 Introduction.

This section of Weber's theory is rather crucial in evaluating his whole approach to location theory. So far two factors have been examined - the transport factor and the labour supply factor. According to Weber, these work regionally and can be an object of pure theory independent of particular economic and social conditions.[33] On the other hand, all other possible advantages, which pull industry "hither and thither" are "social or cultural phenomena, the consequence of particular economic or social conditions."[34] Forces are set up which lead to local accumulation or distribution of industry. In Weberian terms these are forces promoting degrees of agglomeration and they operate only within the framework formed by the general, regional factors. In short, we have now to deal with interdependence of advantages arising from and promoting "social concentration."

"Social concentration" is rather a vital concept here and at the same time open to various interpretations. It will be argued here that this concept subsumes demand factors, the spatial significance of which becomes more and more important as economic development proceeds. For among the factors of agglomeration Weber stresses that "social concentration" produces economies "because the concentrated industry permits a large unified market for its products."[35] Thus, there are often advantages in the size of the market and the relation of the industrial location with respect to the areal form of the market. Treating this in a summary fashion, Weber indicates that the size of the market will

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[33] Weber, op. cit., p. 22.

[34] Ibid., p. 128.

[35] Ibid., p. 130.

allow economies of large scale production, development of "labour organisation" and external cost economies with respect to utilisation of a general apparatus of roads, water supply and so forth. Centrality in the market, reducing long hauls to customers and reducing storage may represent a decline of wasteful temporary tying up of stocks. Lastly, marketing organisation may need to be less developed if the manufacturer is not geographically isolated from his customers.

Thus, to the extent that Weber considers the pull of the market with respect to its size and geographical distribution, he is concerned basically with "demand" factors. However, to have reflected the market pull purely in terms of cost factors rather than profits is certainly an oversight. The significance of the omission is open to question. To sum up the problem, Weber has considered that social concentration may tend to lower cost curves. He has not commented upon the effects of social concentration on firms' demand curves. But, when all is said and done, the addition of this last factor as a force of agglomeration can be accomodated without damaging the Weberian framework.

5.2 Theoretical Solution.

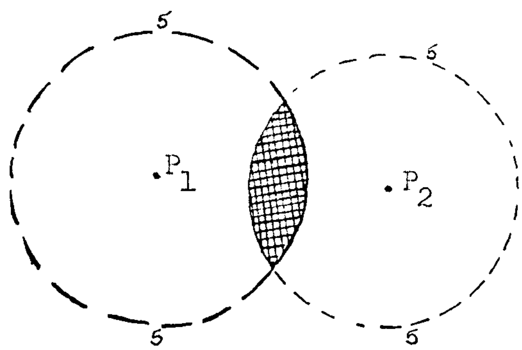
The question as to when industries will agglomerate is solved by a further application of the isodapane technique.[36] For simplicity's sake, units of agglomeration can be conceived as a series of levels. Each level of agglomeration will have an index of economy equivalent to the cost reduction or increased profits to be obtained by firms moving to share a location. In Figure 3 there are two firms at P_1 and P_2. If they could merge then they would make up a particular unit of agglomeration with a particular index of economy, say, $5 per unit of

[36] Ibid.

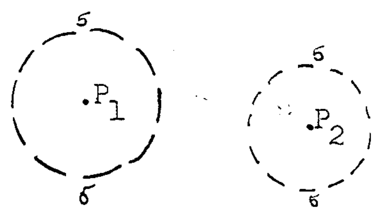
product. The question which must be asked is whether there exists some common geographical area where the firms can get together so that the extra costs involved in transport and labour are less than $5. Basically, the answer is that if the isodapanes representing $5 deviation costs per unit ton of product based on P_1 and P_2 intersect, then, within the intersection lie points of mutual benefit to both firms. Thus, in Figure 3.a. agglomeration will take place profitably,[37] in b. it will not.

Figure 3: Possibilities of Agglomeration.

(a)



(b)



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37 Weber's analysis must be considered as long run. The problem of fixed capital investment does not arise.

5.3 The Character of Particular Industries and Agglomeration.

From the above it can be deduced that there are two characteristics of industries which will determine their deviation tendencies towards agglomeration:

(i) the locational weight,

(ii) the function of economy (or better, of profitability).

The locational weight need not take up any more space here than is needed to note that, as in the labour location analysis, it is this factor which determines the space of the isodapanes and thus the likelihood of their intersection. A geographical factor important here, also, will be the spacing of the production points to start with. The closer production points, the more the chance of intersection.

The function of profitability can be split up into those factors which reduce costs and those which increase demand. In the former case agglomeration will produce economies mainly through elaboration of the plant and the labour force. Thus, the larger the value added through manufacture the larger the possible reduction in costs to be obtained through agglomeration and the corresponding critical isodapanes of the locational figures will be further extended. Thus, the attracting force of the unit of agglomeration will increase. Improved technology which, on the one hand, would tend to lower the consumption of fuel by machines and, on the other hand, would tend to reduce the reliance on localised fuel resources (i.e., the increasing use of grid electricity instead of coal) would certainly accelerate the processes of agglomeration.

The type of industry, which is likely to be strongly attracted by an existing social concentration with respect to raising its demand curve or lowering its cost curves, would seem to be of the type which has to rely on a high density of consumers. However, Weber himself does not mention this case. Perhaps if we were forced to look for apologies, then an important fact would be that mass-produced consumer goods were a novelty in Weber's day. At least they had not developed into the leading sector in economic development of advanced countries as they were to do later. Weber's interest was in the leading sectors in the industrial revolution in Europe in the nineteenth century. These were predominantly, especially outside Britain, the capital goods industries. The vital factor of consumer demand is obviously of less import here.

6. THE APPLICATION OF WEBER'S THEORY OF INDUSTRIAL LOCATION.

Weber's major interest was economic history. Volume Two of the book, which was to relate the pure theory as outlined above to the great locational changes in Germany's industry between 1860 and 1900 never appeared. However, the aim of the theory is clear, namely, to answer the question: What causes industry to change its location? Weber's answer is that location changes with economic development because the process of economic development alters the force of individual locational factors. Moreover, since all the factors which determine location can be classified under one of the three broad locational-force headings of transport, labour and agglomeration, the whole of the location side of economic history is to be viewed as an attempt to move to a new equilibrium as the forces of the various locational factors change for individual industries, making the old equilibrium partly irrational.

> . . . each particle of industrial production which moves to a certain place under the influence of locational factors creates a new distribution of consumption on account of the labour which it employs at its new location, and this may become the basis for further regroupings . . .[38]

In a historical setting, therefore, we can analyse structural changes in industry, the growth of some industrial locations and the decline of others. The present reflects the past character of a region. This, for Weber, is what location theory and regional studies are all about.

In his analysis of the decline of rural handicraft and other neighbourhood industries we are able to see the kind of application which Weber saw for his theoretical constructs. This subject, put into a broad historical context, can be analysed under each of the three

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[38] Weber, op. cit., p. 213.

locational force headings to illustrate the extent to which such a regional problem can be attributed to the changing weight of each force.

Firstly from the point of view of transportation:

> The rapid concentration of population and the rapid technical development with its mechanisation of production and its transition to the use of metal both tended to destroy the condition which had prevailed up to that time, the condition that industrial location, in so far as it was determined by transportation, coincided with the places of consumption. This removal of the location of industrial production from the places of consumption implied the destruction of the crafts, for the crafts presupposed that industrial location and the place of consumption coincided.[39]

Thus the inevitable collapse of this kind of industrial organisation.

But, the decline of handicrafts can also be viewed with respect to the attraction of labour locations. This decline:

> . . . was hastened by the fact that the railways facilitated the deviation of industry towards the most favourable labour locations. Local indices of labour costs, the differences in which . . . had been rather veiled . . . by costs of transportation, became suddenly apparent and of practical significance when railway rates began to decline rapidly.[40]

Lastly, another way to view industrial development is as a gigantic process of agglomeration:

> For all industries the discovery of the fact that their index of manufacture was capable of great reductions within new, highly developed frameworks of production meant their gradual adjustment . . . (The) revolution does not appear in its full severity until the rapid rise of population is accompanied by an equally rapid decline in transportation rates . . .[41]

Such applications of the theory serve to deny one source of criticism, which is found in the interpretation of Weber as only considering transport to be of importance to location. For example,

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[39] *Ibid.*, p. 75.

[40] *Ibid.*, p. 119.

[41] *Ibid.*, p. 170.

Smith[42] finds Weber's theory to be inefficient because there is no perfect correlation between the material index and the industrial location. But the fault lies less in Weber and more in Smith for narrowly interpreting the Weber thesis. That transport orientation, labour orientation or agglomerative factors are not going to determine locations singly, except in extreme cases, is explicit in Weber. Complex interaction of the three locational factors will be the most likely probability present in a host of intermediate cases. Weber's theory, to repeat, is not a transport-orientation dogma but an attempt:

> . . . to disentangle the knot of causes, which confronts us everywhere in reality, and to isolate and group the elements composing it.[43]

However, this would only be one aspect of criticism that a defender of Weber would have to overcome and the more basic attacks on his methodology will need to be handled separately.

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[42] W. Smith, "The Location of Industry," Institute of British Geographers, Vol. XXI (1955), pp. 1-18.

[43] Weber, op. cit., p. 17.

7. THE NEO-WEBERIAN CONTRIBUTION.

7.1 Introduction.

A good deal of the writing in location economics post-Weber has been framed in terms of a critique of the Weberian analysis. But, in most instances, these contributions cannot be viewed as much more than a rigorous restatement of Alfred Weber's position.

7.2 The Contribution of August Lösch.[44]

The major effort of August Lösch is directed to the problem of whether it is possible to work through to an optimal solution to the question of location by means of a series of partial solutions. In particular, he shows that "if variability in demand is taken into account all of Weber's constructions on the supply side become meaningless."[45] However, to relate the nature of this problem solely to the fact that Weber supposedly omitted to analyse demand seems to be a little wide off the mark. In the first place, the difficulties which are said to be inherent in the location problem when demand is introduced are also present within the confines of the supply side taken by itself. If we return to our locational Figure 2 on page 15, it might have been noted that the move suggested by economies of labour costs to L_2 could easily have altered the whole nature of the location figure by opening up a new source of raw materials (e.g., at M_2'). Secondly, demand could be introduced into the existing framework of the problem if it can be assumed to be fixed in space and over time. If

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[44] Lösch, op. cit.,

[45] Ibid., p. 28.

this were the case, then the locational figure technique with weighted vertices representing demand poles as well as those representing raw materials poles could be relied upon to come up with a solution.

Thus, the problem, which Lösch has visualised, does not stem from any omission of analysis of demand as such but from the static nature of the method of analysis. And if time is allowed to enter the picture, then, the conclusions, which Lösch arrives at, are still valid. In short, under such circumstances "there is no scientific and unequivocal solution for the location of the individual firm."[46]

7.3 <u>The Contribution of Walter Isard.</u>[47]

Isard's contributions to the economics of location certainly fall into the category of rigorous restatement. The novelty of this author's approach lies in the emphasis on factors which Weber seemingly neglected. One major contention is that the space economy is not as continuous as Weber's simplifying assumptions might imply. Transportation most obviously is not physically continuous and this, along with varying transport rates, topography, the presence of junction and transshipment points will impose important discontinuities and distortions. Because Isard believes such variables to be significant, "only under severe limitations," he feels, "is Weberian doctrine generally applicable." Particularly, Weber's reliance on technical factors - reducing a whole host of minor but distinct economic variables to units of weight and distance - is too inhibiting for Isard. "Ultimately all such empirical, technical functional observations must be translated into economic terms."[48] Such refinement is one of Isard's more significant

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[46]<u>Ibid.</u>, p. 29.

[47]Isard, <u>op. cit.</u>,

[48]<u>Ibid.</u>, p. 36, footnote 37. An interesting empirically-oriented study attempting to integrate the complexity of real world freight-rate structures and the "quality" of transportation with raw material costs and market factors can be found in M. Fulton and L. Hoch, "Transportation Factors affecting Locational Decisions," <u>Economic Geography</u>, Vol. XXXV (1959), p. 51.

achievements.

However, perhaps the most important line of thought in Isard is his introduction into location theory of the analytical concepts of substitution as found in production theory. Substitution between different transport expenditures on raw materials, between these transport expenditures and immobile labour costs, and between all such expenditures and shipping expenditures on the final product are all explored to move the Weberian framework towards a synthesis with orthodox economic theory.

7.4 Some Less Important Criticisms.

A few less well-founded criticisms might be introduced at this stage concerning the "emphasis" of the Weberian analysis.

Both Isard and Lösch have taken Weber to task for downplaying demand factors. So far we have suggested that such an oversight might not have the dramatic consequences first imagined. But, it is possible to go much further than this, to suggest that demand factors are already contained in Weber's framework under the broader heading of agglomerative factors. The reasons for some de-emphasis lie in the fact that Weber's was "pure" theory and that he was concerned only with the conceptual possibility of agglomerative factors. We are not concerned with whys and wherefores, with the multitude of items that may compose the "uniform agglomerative factor," or even whether it exists in the real world. All that matters is that there is a conceptual possibility that firms can derive advantages through social and industrial concentration. This possibility is all that matters for broad theoretical considerations. Isard's painstaking categorisation of agglomerative factors with special emphasis on market demand may add some needed rigour but does nothing to change the basis of Weber's locational system. In any case, to the extent that Weber did allow some empirical data to creep into his initial "pure theory" volume, there is no doubt of his awareness of those factors whose omission Isard is at pains to point out.

In the same way, criticism which runs in terms of an inherent over-emphasis on transport in the Weberian analysis cannot be taken too seriously. Haggett[49] argues that Weber's system is out of date. Obviously in the total picture transport costs may have become less important since Weber's day but this hardly proves Haggett's assertion that "there is a reduced need for eccentric locations"[50] and that industry will be more and more thrown into line with the urban hierarchy. The problem can in fact be much better stated in Weber's own terms, namely, there has been a recent strengthening of the pull of agglomerative and labour locations with respect to many branches of industry. In the previous section this was shown to be the result of falling transport costs and, to a lesser extent, population growth. Further, there is an increasing tendency for the material index of industries to drop and, thus, to increase the consumption centre's locational advantage (i.e., light industry). The picture is made clearer by thinking of the problem in this way rather than in the vague terms of Haggett-type generalisations. This is even more important when we consider after all the continuing strength of heavy industries (metal refining, petro-chemicals, etc.) in the process of continued economic development and their continued locational reliance on transportation factors.

In summary, as has been clarified earlier, the optimal transportation point is only a methodological starting point. The main reason

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[49] P. Haggett, Locational Analysis in Human Geography (New York: St. Martin's Press, 1966).

[50] Ibid., p. 148.

for this is that transport is the factor most capable of quantitative analysis. There is nothing in Weber either explicit or implicit to suggest that transport is the be all and end all of location analysis.

7.5 Conclusion.

In this section some aspects of the work of more recent authors in industrial location economics have been considered. Their contributions have been described as a restatement - perhaps this does their faculty for originality something less than justice. Nevertheless, it is contended that only marginal additions have been made to the original formulation of the location problem by Alfred Weber.

On the other hand, developments in the literature initiated by the work of Leon Moses have taken location theory far towards integration with production theory. For this reason these developments deserve consideration in their own right.

8. LOCATION ECONOMICS AND PRODUCTION ECONOMICS - A SYNTHESIS.

8.1 Introduction.

It has been asserted that much of the supposed criticism of Weber examined thus far has in effect added little to the theory of location. To some extent, the analysis has been made more rigorous and some elaborate substitution mechanisms have been worked out. But, many underlying problems of Weber's technique remain concealed.

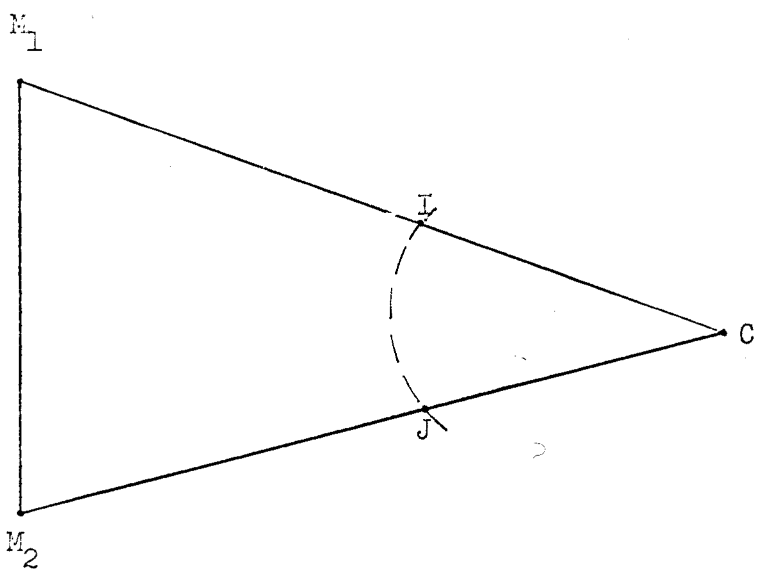
In the first place, it might be wondered whether there could be more than one optimum location for each activity. The existence in the real world of branch factories would suggest that this is so. More particularly, while the series of partial solutions, by which an optimal Weberian solution is reached, can be defended, it remains difficult to see how such a solution to the location problem of the individual firm fits as an integral part of the general theory of production. After all, it is not particularly obvious that the solution of optimum location and optimum level of production are separable. However, this is the case in all the analyses which have been considered so far. Economies of scale enter the picture only after an optimum location has been chosen. At this stage a decision is made on what level of output should be produced. A hidden assumption with all these authors, including Weber, Lösch, Isard and Hoover, seems to be that the location is chosen under conditions of constant returns to scale. Thus, location is chosen independently of the scale of operations. The conclusion that the optimal location with regard to minimising costs is the point of minimum transport costs does not follow merely from assuming no geographic variations in the prices or qualities of inputs at alternative sources. Also implied is an assumption of linear production functions.

Leon Moses[51] comes close to overcoming these problems by allowing factor substitution and thus altering the conditions of optimality in location. His major conclusion is that location, which has previously been treated in isolation, should be treated as an integral part of the profit maximisation process of individual firms, so that "profit maximisation requires a proper adjustment of output, input combination, location and price."[52]

8.2 The Model.[53]

Let us return to the simple problem of a firm using two transportable inputs, M_1 and M_2, with a market located at point C (Figure 4).

Figure 4



Source: L. Moses, op. cit., p. 259.

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[51] L. Moses, "Location and the Theory of Production," Quarterly Journal of Economics, Vol. LXXII (1958), pp. 259-72.

[52] Ibid., p. 259.

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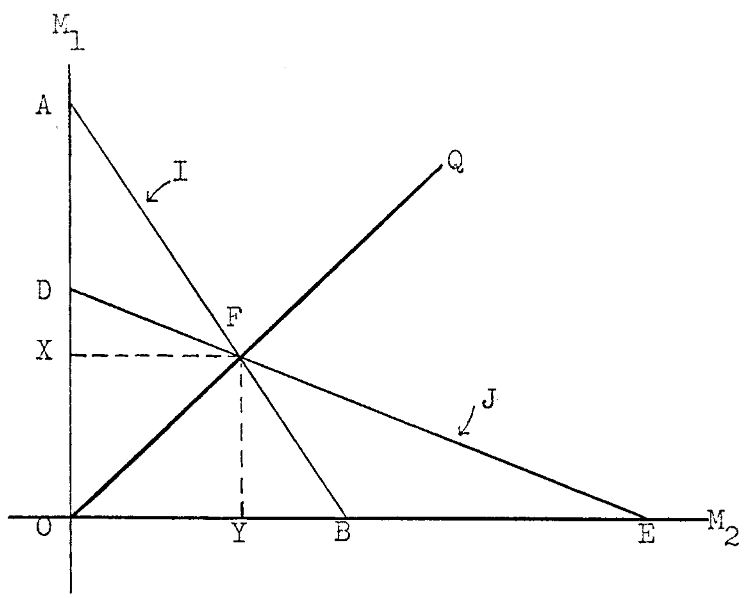
To simplify the problem let us assume that the distance which the final product has to be shipped remains constant and that the freight rates on the final product are fixed. Thus, an arc can be described in the locational figure cutting the triangle in I and J. All points on the arc IJ can be considered to have equal marketing costs. Initially, only points on this arc are to be considered as potential locations.

Now each movement along the curve from I to J <u>increases</u> the distance, which M_1 has to be shipped and thus, with given freight rates, alters the ratio of delivered prices of M_1 and M_2. For each point, then, on IJ, <u>given an expenditure level</u> on raw materials, there exists a resource transformation curve whose slope will be determined by the ratio of delivered prices at that point. Therefore, for a given outlay, AB in Figure 5 represents the iso-outlay curve associated with production at a given point, say I, and DE represents an iso-outlay curve associated perhaps with point J.

<u>Figure 5</u>



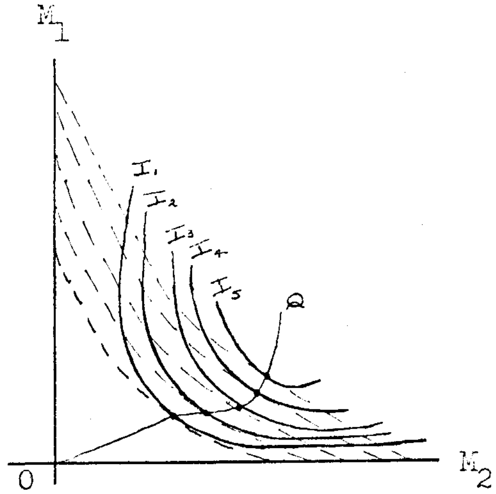
If we were to restrict our location choice to I or J, we could say the following from Figure 5: If M_1 and M_2 are to be combined in a ratio greater than OX/OY then location I will be most favoured and if M_1 and M_2 are to be combined in a ratio less than OX/OY, then location J will be most favoured. The optimal location now depends on the shape of the isoquants which are superimposed on Figure 5.

It is now necessary to make this analysis more general. There are an infinite number of locations between I and J. It follows that there are an infinite number of iso-outlay curves, each with its own slope. The iso-locational outlay frontier, AFE of Figure 5, will tend to become a continuous curve as more points on arc IJ are considered. Each point on this frontier represents not only a unique input combination but also a unique location. Extending this further we can see that for each level of expenditure, which so far has been a constant, there will be a different locational iso-outlay curve. Thus, in Figure 6.a. the dashed lines represent a series of locational iso-outlay curves for various levels of expenditure and the solid lines represent isoquants. Optimality is characterised by the expansion path OQ, the locus of tangency points between locational iso-outlay curves and isoquants.

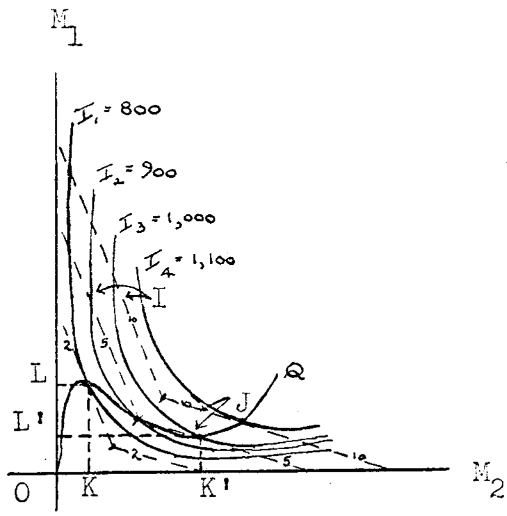
From the information contained in Figure 6.a. it is possible to derive a long-run total cost curve which implies certain optimal locations, outputs and inputs for any such arc IJ. For the simple two point case of Figure 6.b. considering again only points I and J, the long-run total cost curve is given in Figure 6.c. Any point on this curve, say A, represents, for an output of 800 units, a minimum outlay of 2 units which can purchase an optimum amount of resources

Figure 6

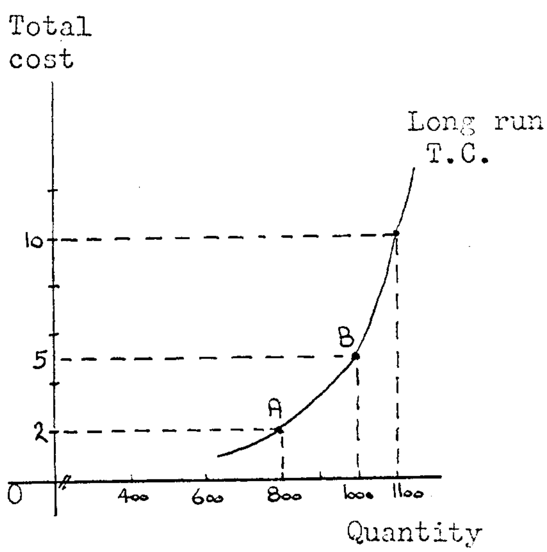
(a)



(b) 2 location case:
(When output is less than 800 optimum location at I
When output is greater than 900 optimum location at J).



(c) 2 location case: derivation of total cost curve



OL of M_1 and OK of M_2. Moreover, this optimum situation arises at a specific location I. Similarly, point B represents an optimum output of 1,000 units which is obtained for an expenditure of 5. This expenditure purchases and transports OL' of resource M_1 and OK' of resource M_2 to the optimal location which in this case is J.

We are now in a position to derive some propositions:

Theorem 9: The optimum location varies with output.

Theorem 10: The optimum location is only by chance the point of minimum transport costs.

Theorem 11: There may be more than one "optimum" in the above sense depending on the shape of the iso-outlay curves and the isoquants. If this is the case, then it will be necessary to find an "optimum optimorum."

8.3 Conclusion.

Moses has been basically concerned with the integration of location theory with the theory of the firm. To this end, he has been successful. The inseparability of optimum output, optimum location and optimum input has been proved. Thus, in the final analysis, the optimum location is seen to depend on base prices of inputs, transport rates on input and final product, the geography of the locational figure, the production function and the demand function.[54]

[54] Moses, op. cit., p. 269.

9. CONCLUSION.

In this paper we have been concerned with various forms of the pure theory of location. We have seen that what pure theory describes holds only under its simple assumptions.

We began with Alfred Weber, whose preliminary question concerned the great locational shifts of European industries during the industrial revolution. It was asserted here that Weber simplified down to the essentials but at the same time did not oversimplify. Weber's insights in economic history have been far ahead of their time.

In later sections the nature of the enquiry was changed. We discussed where the optimal firm location could be found. It is in this context that Weber's system both oversimplifies and misses some of the essentials. The integration of location and production theory has awaited more recent authors who have produced formulations far removed, in terms of analytical technique, from the constructs of Alfred Weber. In short, we have now progressed to the stage of finding theoretical solutions to the long-run static equilibrium location problem.

However, there is still the ghost of August Lösch to be dealt with. His questions concerning dynamic elements in a previous section have been left unanswered. To some extent we have been guilty of studying space and ignoring time. And we cannot deny that when we introduce time there is no solution to the location problem. In fact, in a dynamic situation the only way a firm could know if it were optimally located would be to remain in a constant state of migration. The only practical solution for the firm might, indeed, be one of trial and error.

Nevertheless, our theory's static nature does not make it useless. Lösch himself admits that we must make the best of our limited capacities of understanding. If we can derive propositions, (even although they are dogmas), which "give a clue to the mastery of much more intricate cases," then this is a very important achievement.[55]

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[55]Losch, op. cit., p. 358.

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