ON THE COST FACTORS IN THE LOCATION THEORY OF INDUSTRY

——Principle of Approach and Non-Approach——

By TOSHIO AOKI

Lecturer of Economic Geography

I. *Forces Factors and Cost Factors of Location*

Why does a certain industry orient towards a particular geographical-point and locate itself there? And why do similar or different industries agglomerate or deglomerate in particular regions? According to Alfred Weber, it is due to "the forces (*Kräfte*) which operate as economic causes of orientation, i.e., *the location factors* (*Standortsfaktoren*)."[1] These forces correspond to such natural factors as climate, topography, geology, and natural resources, which are the subjects of discussion in the economico-geographical location theory, and to such social factors as labor, capital, transportation, technology, and the cultural level. Weber maintains on the other hand that "*Location factor is an advatage* (*Vorteil*) which arises at a particular geographical-point or widely at such points where economic activities take place...and the *advantage* is nothing but a saving of *costs* (*Kosten*)"[2] and that "location factors are cost advantage (*Kostenvorteil*) to be strictly distinguished from other advantage because of their nature, that is, they pull a given industrial manufacturing process here and there."[3] Apparently Weber views location factors as forces on one hand and as cost factors on the other.

This is not all. In his opinion, climate, especially the atmospheric humidity, prescribes location by causing machines to gather rust and thereby increasing depreciation cost;[4] the natural conditions of a region prescribe location as they affect transportation cost;[5] population density and the degree of civilization prescribe location as they influence the distance between the location figure and the labor place (*Arbeitsplatz*);[6] and technological development prescribes location by affecting the labor coefficient.[7] Thus Weber views the operation

---

[1] A. Weber, *Ueber den Standort der Industrien*, Erster Teil, *Reine Theorie des Standorts*, 1909, S. 15–16. (To be abbreviated *Reine Theorie* hereafter.)
[2] *Reine Theorie*, S. 16.
[3] A. Weber, *Industrielle Standortslehre*, Grundriss der Sozialökonomik, VI. Abt., 1914, S. 57. (To be abbreviated *Grundriss* hereafter.)
[4] *Reine Theorie*, S. 30.
[5] *Reine Theorie*, S. 42.
[6] *Reine Theorie*, S. 114–115.
[7] *Reine Theorie*, S. 117.

of all forces factors in the light of cost factors while always relating cost factors closely with forces factors in location. According to this view, such forces factors as coldness and snow in Hokkaido, for instance, do not simply prevent location but they increase capital expenditures for things like coal storage equipment and cold proof structures, hence interests and depreciation cost; indirect manufacturing cost such as factory heating cost; and labor cost like cold region allowances, thus interfering with location by raising the manufacturing cost as a whole and decreasing profit.

First, this method may be worthy of attention in the sense that it makes the standardized, quantitative measurement of the heterogeneous action of heterogeneous forces factors on location possible. The only common criteria for standardized quantification will be, at this stage of history, cost and profit which can be expressed in monetary units. Secondly, This method may merit attention in the respect that it enables us to clarify the various concrete forms which agglomeration advantage (*Agglomerationsvorteil*) and contact advantage (*Fühlungsvorteil*) may take and in that it also enables us to put the theory of agglomeration and deglomeration on the basis of measurement. Greenhut's theory of agglomeration[8] may be worth notice as a step forward in this direction. Thirdly, the method may deserve attention in the sense that it gives a quantitative quality to the traditional economico-geographical location theory which tends to devote itself to the mere enumeration and discussion of forces factors, and in that it provides a fundamental key to the propelling of the modernization of economic geography in general.

II. *Stages of Industrial Activities and Cost Factors*

Edgar. M. Hoover divides the activities of a productive enterprise[9] into the following three stages. (a) *Procurement*...purchasing and bringing the necessary materials and supplies to the site of processing; (b) *Processing*...transforming the materials into more valuable forms (products); (c) *Distribution*...selling and delivering the products.[10] The following Profit and Cost Factor Table has been prepared according to this division to show the relationships among the stages of industrial activities, cost factors and prices.

Weber's division of stages is almost the same as Hoover's, the only difference being that Weber uses four divisions with a stage—"Procurement of locational

[8] M. L. Greenhut, *Plant Location in Theory and in Practice: The Economics of Space*, 1956.

[9] What Hoover terms *productive enterprises* include not only manufacturing industries but also extractive industries such as mining and farming, and commercial enterprises involving simple processing like holding goods and dividing them into small lots or different assortments. E. M. Hoover, *The Location of Economic Activity*, Economics Handbook Series, 1948, p. 7. (To be abbreviated *Handbook* hereafter.)

[10] *Handbook*, p. 7.

Profit and Cost Factor Table

Stage of industrial activities	Cost factor				Price	
Procurement	Production cost[4] (wide sense)	Material cost (wide sense) [Procurement cost of materials]	Material cost (narrow sense)	[1]Extraction cost of materials	Price of materials at the source	Procurement[2] price of materials
				(General administration & selling cost)...		
				(Profit)		
			Fuel cost	[1]Transfer cost of materials	... ...	
Processing		Processing cost..........		Labor cost		
				Electric-power cost[3]		
				Rent		
				Interest		
				Depreciation cost		
				Repairing cost		
				Outside processing cost		
				Water cost		
				Communication cost		
				Tax		
				Other factory expenses[5]		
				Manufacturing cost (Factory cost)		
Distribution		Distribution cost		Transfer cost of finished product		
				General administration and selling cost		
				Total cost	Delivered price of finished product	
		Profit				

(1) Includes fuel.
(2) This is a delivered price of materials from the standpoint of enterprise providing raw materials.
(3) See footnote 28.
(4) Production cost in a narrow sense as against in a wide sense includes all costs but the transfer costs of materials and manufactured product.
(5) Includes insurance, building rent, machinery rent, patent right rent, laboratory and research expenses, and miscellaneous factory expenses.

site (*Standortsstelle*) and establishment of fixed capital (material)"[11]—added before that of procurement of raw materials. With regard to the procurement of locational site, land values repell or pull location as they increase or decrease interest costs in proportion to the increase or decrease in capital. Where land is rented, the rent repells or pulls location as it increases or decreases rent cost. With regard to the establishment of fixed capital, the expenditures for establishing fixed capital such as buildings, structures, machinery, and equipment, repell

[11] Weber's four divisions are: "(1) Procurement of a location site (land as a location place) and the establishment of fixed capital (material) (2) Procurement of materials for processing (raw materials and auxiliary materials or half products) (3) Process of transforming materials (4) Sending out of finished products," (Reine *Theorie*, S. 24.). In *Grundriss*, S. 58, Weber explains the second stage as "Procurement and the regular bringing in of materials for processing and of power materials."

or pull location as they increase or decrease costs by yielding interests on loaned capital while being transformed gradually into production cost as depreciation cost. It is clear from above that these pose no particular problem since every one of the costs in what Weber calls the first stage is listed in the Table of Cost Factors given above. In the final analysis, the difference between Hoover's and Weber's division is whether to apply an *ex post* view or an *ex ante* view with an initiation of production process as a starting point. Inasmuch as interest, rents, and depreciation cost, can be estimated for comparison prior to the selection of a location site, Hoover's three-stage-division seems adequate.

Although the above Table of Cost Factors has classified and listed cost factors from the standpoint of manufacturing industries which procure and process raw materials and sell finished products, the Table can be applied also to a case where processing is divided into more than two stages and where each stage is carried out by an individual industry independently. This is because the industries of the second stage either procure for processing half-materials[12] from the industries of the first stage and sell finished products, or sell such products as half materials to the industries of the next stage. The difference lies after all in the degree of processing and in the nature of market, that is, consumers' market or producers' market.

Greenhut has recently introduced an idea of *cost-reducing factors*[13] mainly in the way of explaining locational agglomertion and deglomeration. These factors may be expected to reduce any of the costs given in the Table of Cost Factors, and, therefore, the process of their operation can be traced in the Table.

Next, electric-power (cost) has been either included in material and power costs,[14] or lumped together with fuel and power (costs),[15] or merely brought under the category of power with fuel,[16] or has not been recognized fully as the most important location factor (cost factor) next to materials, fuel, and labor power.[17] However, in view of its uniqueness as a restricting factor of location as well as its general importance, electric-power cost was listed as an independent cost factor, while fuel cost was included, from its nature of locational restriction, in the *material cost in a wide sense,* which in turn was divided into fuel cost and the *material cost in a narrow sense* so that the substitution relation between fuel and electric-power

[12] Ohlin calls semi-manufactured goods and semi-manufactured machinery half materials. (B. Ohlin, *Interregional and International Trade,* 1933, p. 190.) Hence finished parts used in assembly industries are half materials.

[13] M. L. Greenhut, *op. cit.,* pp. 163–177.

[14] *Reine Theorie,* S. 29. *Grundriss,* S. 58.

[15] N. J. G. Pounds, *An Introduction to Economic Geography,* 1951, pp. 179–180. M. L. Greenhut, *op. cit.,* p. 280.

[16] B. Dietrich, *Wirtschaftsgeographie: Methoden-Probleme-Anregungen,* 1933, S. 81. P. H. Schmidt, *Einführung in die allgemeine Geographie der Wirtschaft,* 1932, S. 207–209.

[17] M. L. Greenhut, *op. cit.,* pp. 123–139. E. M. Hoover, *Location Theory and the Shoe and Leather Industries,* Harvard Economic Studies, Vol. LV, 1937, pp. 75–88. (To be abbreviated *Location Theory* hereafter.) Hoover discussed in the chapter on 'the theory of location again' the substitution relation between coal and electric-power and the effect of electric-power on location (*Location Theory,* pp. 292–293). *Handbook,* Part I and pp 180–184.

may be shown.

Profits will be touched upon next, though they are not the main subject of this article. When a given industry extracts materials by itself, there will be no profit involved at the stage of procurement, but when the industry uses purchased materials, as Weber points out, profit is involved in material cost as a cost factor which varies locally, and becomes a location factor.[18] Maintaining that profit constitutes an element of capitalistic economy and not of pure economy (*reine Wirtschaft*), however, Weber does not take profit into consideration.[19] Weber also ignores profit in the stage of distribution on the contention that such profit can never become a locational factor as it is not cost factor but result from pricing.[20] Excepting a few like August Lösch,[21] Я. Г. Фейгин,[22] M. L. Greenhut,[23] and W. Isard,[24] all the location theoreticians after Weber have also ignored profit in the distribution stage or placed it off the focus of study. If one of the purposes of location theory is to clarify the economic laws of location in a capitalistic and socialistic economy, the problem of profits is to become a central point in location theory.

III. *Locational Features of Transfer Costs, Production Costs, Material Costs, and Processing Costs*

First, the concept of these costs may be defined for clarification. The term transfer costs, coined and introduced into location theory by Bertil Ohlin,[25] is more comprehensive than the term transportation costs. According to Ohlin, transfer costs include ordinary transportation costs as well as all other costs that are necessary for overcoming other obstacles to the regional movement of commodities. The obstacles are (1) The reduction in quality and value of easily spoiled goods through transportation, (2) great distance from the market, with the consequent lack of intimate contact with customers, and (3) duties on imports and exports.[26] This article follows Ohlin's concept but it must be noted that, strictly speaking, transfer costs include freight which changes considerably in direct relation to the distance to be covered, packing costs which vary to some degree in relation to distance, and the expenses like loading and unloading cost, junction charge, storage fees, and duties which are not affected by distance. Since freight costs ordinarily occupy a major part of transfer costs, it may safely be said,

[18] *Reine Theorie*, S. 28.
[19] *Reine Theorie*, S. 28–29.
[20] *Reine Theorie*, S. 28.
[21] A. Lösch, *Die räumliche Ordnung der Wirtschaft*, 1940, S. 30–31.
[22] Я. Г. Фейгин, Размещение Производства при Капитализме и Социализме, 1954, стр. 113–114.
[23] M. L. Greenhut, *op. cit.*, pp. 84–100.
[24] W. Isard, *Location and Space-Economy*, 1956, pp. 196–197, 221.
[25] *Location Theory*, p. 39. *Handbook*, p. 8, footnote 4.
[26] B. Ohlin, *op. cit.*, pp. 210–211, 142.

while noting the above, that transfer costs change in close relation to distance in general.

Processing costs and production costs are often confounded and their concepts are not always standardized. According to Hoover, "Processing costs approximate what the census calls *value added by manufacture* for a manufacturing establishment—the difference between cost of materials (including fuel and purchased energy) and value of the finished product at the place of production. Processing costs include direct labor costs, costs of administration, interests, rents and royalties, maintenance and depreciation, and taxes."[27] Hoover apparently does not include material costs in processing costs. As it will become clear later, this view is reasonable since material costs have a locational character different from that of processing costs. It appeares that by purchased energy cost be meant electric-power[28] cost, but it is not reasonable to include this in material costs. It is because the manner in which *weight-commodities* like materials and fuel and a *non-weight-commodity* like electric-power pull location is quite different, and the character of electric-power costs from the locational view-point is similar to that of cost factors such as labor costs, rents, and depreciation costs comprising processing costs. It is reasonable, therefore, to include electric-power costs in processing costs.

Now Greenhut defines that "processing costs (production costs) include all costs other than the transportation charges on materials and finished product."[29] This view confuses processing costs with production costs and seems in content to be defining the concept of production costs. Lösch and Hoover do not define the concept of production costs as such but the former using the term freight (*Fracht*) and the latter, the term transfer costs, both of them interpret production costs as all costs other than freight or transfer costs and use the term in that sense.[30] As mentioned previously, however, the concept of transfer costs is superior in that it is inclusive of all costs involved in transfer, and, therefore, Hoover's view will be used in this article. In other words, production costs are defined here to include all costs other than transfer costs of materials (including auxiliary materials), fuel, and the finished product, or exclude, quantitatively speaking, all transfer costs from the total cost of the finished product.

J. Harry Jones defines the term production costs, from the standpoint of location theory, as inclusive of all costs involved at each stage of procurement, processing, and distribution.[31] This is what is usually termed production costs in economics and the definition is particulary needed where the problem of profits is to be studied from the view-point of location theory. From this point of view,

[27] *Handbook*, p. 67.
[28] Besides fuel and labor power, there are energies like electric power (including atomic energy generated electric power), hydraulic power (including tidal power and hydraulic pressure), wind power, compressed air, solar heat, terrestial heat, and animal power but the most overwhelmingly important purchased energy in modern times is electric power.
[29] M. L. Greenhut, *op. cit.*, p. 124.
[30] A. Losch, *op. cit.*, S. 29–30, 172–173. *Location Theory*, pp. 36, 73–88. *Handbook*, p.8.
[31] J. Harry Jones, *The Economics of Private Enterprise*, 1948, pp. 82–83.

if what excludes transfer costs could be called *production costs in a narrow sense*, what includes transfer costs might be called *production costs in a wide sense*. In this article, the term production costs means the one in a narrow sense.

On the subject of material costs next, these are procurement costs of material including extraction costs of materials and fuel, or the prices of materials and fuel at the source, plus transfer costs involved in each case.

It was Weber and Hoover who mutually supplemented each other in making a significant contribution to the study of locational features of transfer costs and production and processing costs. At the same time, however, both made a similar error as Weber reduced material price differentials into transportation cost differentials and as Hoover resolved labor costs into transfer costs. With regard to sources of materials where the price of materials (including fuel) differs, Weber assumes that "the source of materials where the materials price is low is closer to a location site to be chosen (*möglicher Standort*) and the source where the materials price is high is farther from a location site to be selected."[32] Thus he reduces materials price differentials into transportation cost differentials on the contention that "a differential in the materials price may be expressed ideally as a differential in transportation cost and thus may be fitted into theory (note: transport-orientation theory)."[33] This method has two shortcomings; first, Weber tries to reduce prices into distance or transportation costs but the distance between what? It must start from a location site and extend towards a materials source. This direction is decided pending the selection of a location site and, therefore, cannot be decided before a site is decided. Accordingly, one or more apexes of a location figure are unknown and the figure cannot be formed. Weber says "a location site to be selected" and this means making a location figure with a hypothetical location site. Inasmuch as a location figure is made for the purpose of selecting a location site, Weber's hypothesis is meaningless in the light of the strictness Weber demands. Thus Weber incurred a contradiction similar to that of reducing the distance-tapering-freight-rates into the shortening of distance.[34] Secondly, what Weber means by the materials price is the price at the source which constitutes one of the cost factors comprising production costs. While transportation costs do change in response to changes in distance, however, prices at the materials source do not. In other words, the costs of transporting materials continuously decrease, though gradually step by step, as a location

[32] *Grundriss*, S. 59. In *Reine Theorie*, it is stated that "the place where prices are low is, as it were, far, and the place where prices are high is, as it were, near, if it is to be used for productive purposes (*Produktionsverwendung*)" (S. 33). Productive purposes mean use in a location or a facory, and, therefore, this statement may be interpreted to mean the same thing as the statement in *Grundriss*.

[33] *Reine Theorie*, S. 86–87.

[34] T. Aoki, "Measurement of Tranport-orientation of Industrial Location by Ideal-weight Calculation Method,—An Economic Geographical Reformation and Application of Weber's Theory of Transport-orientation" (in Japanese), *Annals of the Association of Economic Geographers*, published by the Association of Economic Geographers, Meiji Univ., Tokyo, Vol. 1, 1954, p. 41.

approaches the source of materials, but prices at the materials source essentially have no relation to the approaching of location towards the materials source. Therefore, the locational pull of transportation costs is *approaching*, whereas that of prices at the materials source is *non-approaching*. Where an industry extracts materials by itself, prices at the materials source are replaced by material extraction costs whose pull is also *non-approaching*. Weber's weakness lies in that he reduced material price differentials into transportation cost differentials, thus wiping out the difference of their locational character and setting the problem of *non-approach* as that of *approach*. This will be made all the more clear by the following study.

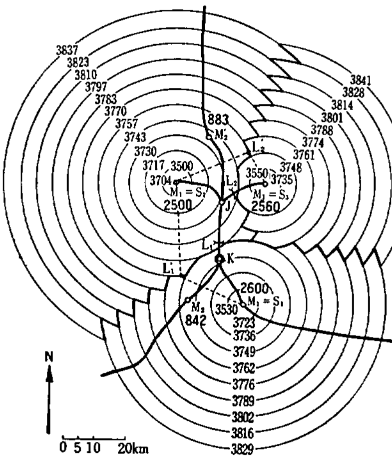
Since other cost factors comprising production costs have a locational feature similar to that of prices at the materials source or material extraction costs, the above study may be expanded on the difference between production costs and transfer costs in locational features. Whereas the locational pull of transfer costs is *approaching*, the pull of production costs is *non-approaching*, and "the basic difference between the locational effects of transfer costs and production costs must be clearly appreciated"[35] and "production-cost advantages...have nothing to do with transfer costs."[36] Accordingly, if transfer costs are uniform regardless of a location place, or "if both materials and markets can be regarded practically as ubiquities, then location becomes purely a mattter of comparative production costs,"[37] or conversely if production costs are uniform leaving no production cost differential, then location becomes a problem of genuine transfer costs, or that of approach alone. Therefore, transfer costs and production costs cannot be mutually dissolved into each other, and actual location generally takes place at a point where a minimum production cost (in a wide sense) is obtainable, the other profit-restricting conditions being uniform, through the competition between production costs and transfer costs.

If Weber's method is to be opposed and if material price differentials at the source are not to be reduced into transportation cost differentials, how should the question of material price differentials be treated? Apparently the solution must take a form of competition between prices at the materials source and transfer costs. To study the problem, the following *isodistance-lines method* (*distance-base contour-line method*)[38] will be used. Inasmuch as the same thing can be said of material extraction costs, the following will deal only with the study of prices at the materials source, and all the other production costs will not be dealt with in order to simplify the study of this problem. The figure is a reduced scale map showing the distribution of railways connecting a consumption place K with

[35] *Location Theory*, p. 76.
[36] *Location Theory*, p. 77.
[37] *Location Theory*, p. 87.
[38] This method, devised by the author of this article, attempted to make locational analysis more realistic through the use of a scaled distance system for the freight rate table for railways and trucks as a base. Hoover's contour-line method, on the other hand, uses a certain amount of freight as a base and thereby increases the distance between contour lines. cf. *Location Theory*, pp. 12–13, 43, 47.

materials sources M_1, M_1', M_1'', M_2, M_2'. In this case, two kinds of materials m_1 ton (its competing sources are M_1, M_1', M_1'') and m_2 ton (its competing sources are M_2, M_2') are required for manufacturing one ton of product. The Gothic style figures attached to each materials source indicate the prices of materials at the source in the required amount of m_1 ton and m_2 ton, respectively. Needless to say, the decision of a minimal total transfer-cost point is not the subject of discussion here but the competition between the price of materials at the source and total transfer costs is the point of discussion.

If material m_1 is to have a *preponderant ideal weight*,[39] M_1, M_1', and M_1'' will become location sites (minimal total transfer-cost points) which will be represented by S_1, S_2, S_3. Draw the isodistance-lines at the intervals of railway scales (which is at 5 km intervals up to 100 km in Japan), put on each line of the three groups the amount of 'prices at the materials sources plus total transfer costs', i.e., 'material costs plus product transfer costs', and obtain balanced points of these costs where the lines of the three groups intersect. If these points are connected in order, serrated line reflecting steplike rates can be obtained. This serrated line



moves into all directions as prices at the materials sources and transfer costs (excepting freights) fluctuate. Since a differential in transfer costs excluding freights is usually very small, the main cause of the movement is the fluctuation of prices at the materials sources. The figures in ordinary type attached to each point of location represent 'prices at the materials sources plus material transfer costs', i.e., material costs, and the difference between the amount attached to the first isodistance-line of each group and the material costs at each locational point within each group is not uniform because the transfer costs excluding freights are not uniform. Next, take a piece of string of the length of the reduced scale railway between S_1 and S_2, fix each end of it at S_1 and S_2 respectively and strain the string over the serrated line as shown by a dotted line on the map to obtain the distance between S_1 and L_1'. Transfer this distance on to the railway and the point L_1 demarcating market areas of S_1 and S_2 will be obtained. The point L_2 demarcating market areas of S_2 and S_3 will be obtained in the same manner. The point for demarcating S_1 and S_3 is not necessary in the case of those material costs illustrated in this map.

[39] I owe Hoover for this term. *Location Theory*, p. 41.

In the first case, where the consumption sphere is spread around the consumption center K to such an extent as to cover every materials saurce and where the material cost differentials among locations are small enough to enable every location to compete side by side, either each location shares the entire market or shares certain markets as well as holds another market in common, according to the position of the point of demarcation for market division. In this case, the manner in which each location controls the consumption center is similar to that of the 3rd and the 4th case to be mentioned next. According to this map, S_1 monopolizes K while controlling a division of market along the railways south of but not reaching L_1, S_2 controls a division of market along the railways north of L_1 and west of L_2, and S_3 controls a division of market along the railways east of but not reaching L_2.

In the second case, where the consumption sphere is expanded to the same extent as in the first case but the material cost differentials are too great to allow the coexistence of locations, the serrated line or rather the point of demarcation for market division shifts in proportion to the differentials and, depending on its position, either one or two locations become incapacitated to control the market and are ousted, thus two surviving locations in the competition share the entire market or share certain markets as well as hold another market in common, or only one winning location monopolizes the entire market. The manner in which the winner of the competition controls the consumption center follows the manner of the fourth case. The location ousted in this locational competition will be able to remain as a location and control the market either by sacrificing part of its profit or by replacing, subsequent to the fluctuation in prices at the materials sources, a location which has been in control of the market. There are points to be studied further about profits but they will not be gone into here.

In the third case, where a consumption sphere does not exist but there is only consumption center K and where the points of demarcation for market division all coincide with the consumption center (where L_1 comes to K, L_2 to J, hence to K, or the demarcation point between S_1 and S_3 comes to K, L_1 to J, hence to K) due to marterial cost differentials, the consumption center is controlled in common by all locations.

In the fourth case, where there is only a consumption center as in the case of the third case and where anyone or all of the demarcation points do not coincide with a consumption center due to material cost differentials, two winning locations control the consumption center in common or only one such location monopolizes it. In the map, only S_1 monopolizes K. The location ousted in this locational competition will be able to continue to remain as a location and control the consumption center if it sacrifices part of its profit or if another consumption center is developed in the vicinity, or if, as a result of the fluctuation of material prices at the sources, it replaces a location which has been in control of the consumption center.

The above discussion assumed that the railway is used for transporting materials and finished products. Where trucks are used, the study is simpler since the road networks can be considered to be usually a surface system, and, therefore, the serrated line may be regarded without change as the line of demarcation for market division for each location. Where other different means of transportation is employed along with railways, or where more than two kinds of materials are used or where materials sources and Consumption centers increase, a map can be drawn theoretically in the same manner. Production costs other than the materials price were previously omitted for the convenience of study, but where this hypothesis is removed and the competition between production costs and transfer costs is studied in general, the isodistance-lines method is also applicable. If this method is used, there is no need to reduce differentials of materials prices at the source to transfer cost differentials. Furthermore, it will supply, though to a degree, a large defect in Weberian theory of ignoring the market area problem[10] and it will also help study location dynamically, hence it will help make the theory of location dynamic to some extent.

Materials prices at the source and material extraction costs have general locational characteristics common to other cost factors comprising production costs. They have a special feature also——that, invariably combined with the transfer cost of materials, they reveal themselves as a cost factor called material cost. This is nothing but a matter of the locational characteristics of material cost. The cost of general administration and selling at the stage of distribution similarly emerges into distribution cost in combination with the transfer cost of the finished product. Since the locational characteristics of distribution costs can be considered to correspond to those of material costs, the discussion on the subject will be omitted at this time. Material costs equal material extraction costs plus material transfer costs where industries extract materials and carry them into the factory by themselves, whereas material costs equal the materials price at the source plus material transfer costs where they purchase materials or half-materials from extracting industries or from half-material industries. As has been explained, material extraction costs and the materials price at the source have no relation to the approach of location to materials sources but the transfer cost of materials decreases in close relation to the approach of location to materials sources. Material cost thus involves two cost factors quite different in locational characteristics, and, therefore, its locating pull is '*at once non-approaching and approaching*'. In this sense material cost can be said to be unique cost factor different from transfer cost, production cost, and processing cost.

When the locational characteristics of material cost are studied from the above-mentioned angle, the locational significance of the so-called ratio of material cost in the theory of industrial location may easily be clarified. Strictly speaking, the ratio of material cost is a numerical value of the percentage of material cost to the total cost of product. In fact the ratio of material cost which is computed

[10] Hoover has pointed out this shortcoming long ago. *Location Theory*, pp. 36–37

from manufactuning cost (factory cost) instead of the total cost is used, but the ratio to the total cost is more accurate and hence desirable than the ratio to manufacturing cost in general because in some cases the margin of error between these two ratios proves considerably wide (particularly this is remarkable in industries with heavy distribution cost) and because the ratio of transfer cost of materials needs to be studied by counterbalancing it against the ratio of transfer cost of the finished product. The ratio of material cost consists of the ratio of material extraction cost or materials price at the source and the ratio of the transfer cost of materials. The former, which is reduced by choosing a low extraction cost site or a low price-at-the-source site, has nothing to do with approach, for it does not decrease as location approaches the materials source. On the contrary, the latter decreases in close relation to the approaching of location to the materials source. The ratio of material cost, therefore, is a numerical value indicating the extent to which material cost can possibly be reduced through the non-approaching *selection* of low material extraction cost sites or low material price-at-the-source sites and through the *approaching* of location to the materials sources. How much this reduction can be realized—it depends on the geographical-point differentials or the regional differentials of material extraction costs or materials prices at the source, and upon the transfer relation between materials and finished product. The ratio of material cost, however, involves not only this problem of non-approach but also that of counterbalancing the transfer cost of materials against the transfer cost of finished product if the degree of the locational pull of materials sources is to be discussed. Therefore, the ratio itself is not a numerical value indicating the degree of locational pull of materials sources. This will be clear from the fact that, for instance, the petroleum refining industry, whose ratio of material cost is remarkably large (77.4%),[41] is located in the consumption center or on the consumption center oriented harbors and gulfs as a result of a strong pull of the consumption center (Where there is a consumption center in the vicinity of a oil production center or where a production center and a consumption center happen to be in the same place, it looks as if the industry were located right in its production center.), or from the fact that the pulp industry, whose ratio of material cost is smaller (55.7%)[42] than that of the petroleum industry, is located in the production center of its materials, or from the fact that the flax-fiber manufacturing industry whose ratio of material cost is small (40.2%),[43] is invariably located in the production center of flax while the beer industry, whose ratio of material cost is larger (50.0%)[44] than that of flax-fiber industry, is invariably located in the consumption center. In order to measure the intensity of the pull of materials sources as shown above, a precise indicator like the *material*

[41] [42] E. B. Alderfer and H. E. Michl, *Economics of American Industry*, 1950, p. 13.

[43] [44] These are the ratios of material cost to total cost computed on the basis of research made by the author in Japan. As for an American example, the ratio of material cost for pottery and related products industry locating in the source of materials (25.5%) is far smaller than that for bread-baking industry locating in a consumption center (54.9%). These American values were taken from E. B. Alderfer and H. E. Michl, *op. cit.*, p. 13.

index and the *ideal material index*[45] must be employed.

A study of Hoover's errors will be made next and the locational nature of processing costs will be clarified. Hoover regards the budget materials which laborers consume as part of raw materials to be used in the factory on the assumption that "If real wages were everywhere uniform—that is, if only the *equalizing* differences of wages existed" and states that "we should not need to consider labor-cost differentials as an independent locational factor at all," and that "One may resolve the labor-cost factor into transfer relations with sources of materials," thus resolving labor cost in the final analysis into transfer cost.[46] In the first place, it need scarcely be said, the hypothesis that real wages are uniform can not exist in reality. Secondly, transfer cost correspondingly changes in close relation to the approaching of location to a materials source and to a consumption place, and, therefore, its locational pull, is *approaching* as well as *continuous*.[48] Labor cost, on the contrary, neither changes in response to the approaching of location to a labor place nor has anything to do with *approach.* Therefore, "each point of location where labor cost is low constitutes, economically speaking, an *attraction center* (*Attraktionszentrum*) which induces production to move from the minimal transportation-cost point. The pull of the center like this, furthermore, is not essentially an *approaching attraction* (*Annäherungsattraktion*)... but an *alternative attraction* (*Alternativattraktion*)."[49] In other words, labor cost attracts location not in an approaching manner in which it pulls location to an intermediate point between the point of minimal transportation cost and a cheap labor place but in an alternative manner in which location either stays at a point where total transfer cost is minimal or deviates towards a cheap labor place. If labor cost is to be resolved into transfer cost as Hoover says, therefore, one will have to reach the strange conclusion that location will be pulled towards a labor place every 1 km or 5 km. Thus labor cost cannot be resolved into transfer cost nor can the labor cost differential be reduced to that of transfer cost. It is Hoover who eliminated the difference of locational nature between labor cost and transfer cost

---

45 If the weight of localized materials necessary to produce P weight of product is to be expressed by $m_1, m_2, m_3, \cdots\cdots, m_n$, and if the horizontal freight rates proportion for weight unit 1 of product and of each material is to be expressed by $\alpha : \beta_1 : \beta_2 : \beta_3 : \cdots\cdots : \beta_n$; $P\alpha, m_1\beta_1, m_2\beta_2, m_3\beta_3, \cdots\cdots, m_n\beta_n$, will be the ideal weights and the ideal material-index will be computed by a formula $\frac{\sum_{k=1}^{n} m_k\beta_k}{P\alpha}$.

Where a given transportation medium is used, the ideal material-index indicates the material-orientation intensity of location more accurately and realistically than the material-index. The ideal material-index is devised and applied to practical locational analysis by the author. See T. Aoki, *op. cit.*

46 *Location Theory,* p. 62.

47 In *Handbook,* Hoover recognizes the impossibility of such a hypothesis in reality, stating that "uniform *real* wages—would imply perfect mobility of labor, which does not exist." (p. 105). Concerning labor cost and transfer cost, however, he has not developed a new view which will take the place of the view be stated in *Location Theory.*

48 I owe the term "continuous" to Hoover. *Location Theorry,* p. 77.

49 *Reine Theorie,* S. 101.

by resolving the former into the latter and it is Weber who grasped the difference correctly. It must be pointed out also that it is reasonable that Weber treated labor location (labor orientation) as a *deviation* from the minimal transportation-cost point.

Other cost factors comprising processing cost have locational characteristics similar to those of labor cost. Hence, the difference of locational nature between transfer cost and labor cost can generally be expanded into the difference between transfer cost and processing cost and can be summarized as follows: that the locational pull of transfer cost is *approaching* and *continuous*, whereas that of processing cost is *non-approaching* and *alternative*, and, therefore, they cannot be resolved into each other, and processing cost acts as a factor to have the primary location of a minimal total transfer-cost point deviate to the secondary location of low processing-cost point.

IV. *Locational Features of Cost Factors Comprising Processing Cost*

In this chapter, the major characteristic features of cost factors comprising processing cost will be studied.

In the first place, labor cost is a cost factor which generally exerts the most powerful deviating action upon location. Its action intensity can be measured by labor coefficient and the coefficient is by far larger in general than other deviation coefficients when various industries of the whole are taken into consideration. Secondly, it is a cost factor that deviates the greatest number of industries. Thirdly, the flexibility of location by labor power is usually far smaller than that by electric-power since the low labor cost area is usually much smaller than the low electric-power cost area.

Next to labor cost, electric-power cost generally exerts the most powerful deviating action upon location and its action intensity is measured by the electric-power coefficient.[50] Secondly, it is a cost factor that deviates a fairly large number of industries belonging to electro-chemical and electro-metallurgical industries.

[50] Electric-power coefficient $= \dfrac{\text{Electric-power cost ratio}}{\text{Locational weight}}$

In this case, however, Electric-power cost ratio $= \dfrac{\text{Electric-power cost}}{\text{Total cost of product}}$

or $\dfrac{\text{Electric-power cost}}{\text{Manufacturing cost of product}}$

It is accurate and therefore desirable to base the computation on total cost of product. Weber's so-called locational ton (*Standortstonne*) is used for locational weight for convenience' sake in comparing coefficients. The electric-power coefficient is a numerical value indicating the intensity of locational orientation towards electric-power and has a value of $0 <$ Electric-power coefficient < 1. The intensity of orientation towards electric-power becomes greater as the value approaches 1. Where no electric-power is used, Electric-power coefficient $= 0$, but this rarely happens nowadays. The electric-power coefficient is devised by the author. See T. Aoki, "Critical reformation of Weber's Orientation-theory of Industrial Location and its Adaptation to Economic Goegraphy" (in Japanese), *The Hitotsubashi Review*, Vol. 33, No. 6, 1955, p. 69.

Thirdly, location is first oriented more often than not towards the low electric-power cost zone and then finally selected in transfer relations since the vastness of the low electric-power cost area helps increase the flexibility of location by electric-power as well as the possibility of finding new sources of materials.

As for the interest, differentiation must be made between the interest cost advantage that arises from interest rate differentials and one that is created by capital saving. "Interest rates vary remarkably from country to country of various nations of the world due to the difference in security and capital abundance but they generally do not vary within a country from locality to locality,"[51] and "Interest rates exhibit a tendency to vary with distance from major financial centers but are rarely a significant factor of location within any one country."[52] Although Lösch illustrated that interest rates go up irregularly with distance from financial centers[53] but generally the differentials in the ratio of interest to total cost due to interest rate differentials are very small. Therefore, interest cost advantage that arises from interest rate differentials is not significant in general as a locational factor.

Interest cost advantage that arises from capital saving poses a locational problem when capital expenditure differentials become large due to regional difference (including geographical-point difference) in natural conditions and social conditions or when land is purchased. With regards to the purchasing of land, Weber computed the interest by taking, as an example, steel manufactory by the Thomas converter (*Thomaswerk*), the price of whose products is cheap considering the size of the factory site, and maintains that interest occupies only 0.02% of cost per ton of steel, and, therefore, land price is not significant as a locational factor.[54] In other words, while land price presents itself as an interest cost factor, interest cost advantage resulting from reduced capital due to land price differentials is not generally significant as a locational factor. Land rents are not significant either as a locational factor since their ratio to total cost is usually small. This is natural in the manufacturing industries where land is utilized most intensively.

As industries agglomerate in a certain area, however, the ratio of rent to total cost in the existing industries, and the ratio of rent or interest due to land price to total cost in the industries to be newly located increases remarkably, and certain industries, or factories doing a part of divided processing, that cannot

---

51 *Reine Theorie*, S. 30

52 *Handbook*, p. 70.

53 A. Lösch, *op. cit.*, S. 300-30-.

54 *Reine Theorie*, S. 31. Weber's way of computation may be explained here. In the case of steel manufacturing by the Thomas converter (Basic converter), approximately 100 hectares of land are necessary to produce 300,000 to 400,000 tons of product annually. In this case the capital expenditures is 50,000 Marks if land price is 5 Marks per Ar or 250,000 Marks if land price is 25 Marks per Ar. If the annual interest rate is set at 2.5%, the differential of interests due to land price differentials will be 5,000 Marks. If the actual amount of product is to be 250,000 tons per year, the interest per ton will be 0.02 Mark, which will be 0.02% of 100 Marks, the cost per ton of steel.

afford rents, will be dispersed from the area of agglomeration. Thus rent as well as interest due to land price becomes "a locational factor as far as agglomerative tendencies exist"[55] and constitutes one of the cost factors that strongly influence the dispersion of industries.

The reduction of capital expenditures due to regional differentials in social and natural conditions becomes interest cost advantage on one hand and depreciation cost advantage on the other. The reduction of capital expenditures due to regional defferentials in social conditions will be, for instance, the reduction of capital expenditures for auxiliary processing and private tracks in an area where railway network and auxiliary industries have been developed. On the matter of the regional differentials in natural conditions, the more strict the natural conditions demanded by the industry or the greater the funds for technological facilities for overcoming natural conditions, and the greater the regional differentials in natural conditions, the greater become the regional differentials in capital expenditures and both the interest differential and the depreciation cost differential become important locational factors.

Thus the proportion of the locational importance of interest and depreciation cost to the industry depends on these conditions mentioned above. In such industries as wrist-watch, sensitive materials (films, printing-paper, dry-plate, and sensitizer emulsion) manufacturing, interest and depreciation cost differentials due to the regional differentials in natural conditions become a determining locational factor, whereas in the spinning industry which must install an apparatus for adjusting temperatures and humidity wherever it locates itself and whose regional differentials in capital expenditures are not so great, interest and depreciation differentials do not constitute a very important locational factor. As for repair costs, they restrict location directly through the differential they create in response to the regional differentials in social and natural conditions and not through the medium of capital expenditures. It must be noted in this connection that, although repair cost, depreciation cost and interest are affected in many cases by non-regional causes, in such cases they do not operate as locational factors. Outside processing costs also constitute an important cost factor, particularly in the case of industries whose degree of dependence on related industries is great.

Water cost is a cost factor whose significance grows greater as industrial agglomeration is intensified. To illustrate, an excessive pumping of subterranean water caused the sinking of the ground as much as 7 to 8 centimeters a year in the manufacturing regions of Osaka and Tokyo-Kawasaki in Japan and the industrial water systems are being constructed. Thus water costs are gradually on the increase. In the United States and West Germany as well, water which has hitherto been rather neglected is becoming an important locational factor.[56]

[55] *Reine Theorie*, S. 32.

[56] C. Langdon White, "Water—A Neglected Factor in the Geographical Literature of Iron and Steel", *The Goegraphical Review*, Vol. 47, No. 4, 1957, pp. 463–489. Hans Seeberger, *Industriestandort und Wasser*, 1957, S. 9.

Tax differentials become a determining locational factor whenever they are relatively permanent in character[57] and whenever total costs, other than taxes, are approximately equal among various locations,[58] and only in the final stage of locational analysis of various sites.[59] In many cases taxes generally do not influence locational choices[60] and it seems that taxes are a relatively unimportant, secondary factor of location.[61]

In conclusion, it may be added that *the principle of approach and non-approach,* which the above study clarified, can be adapted as one of the guiding principles in making a study of the industrialization of the so-called under-developed regions from the standpoint of location theory and of economic geography.

---

[57] Joe Summers Floyd, *Effects of Taxation on Industrial Location,* 1952, pp. 25, 110.
[58] *Ibid.,* pp. 22, 24.
[59] Glenn E. McLaughlin and Stefan Robock, *Why Industry Moves South,* 1949, p. 107.
[60] J. S. Floyd, *op. cit.,* pp. 23–24.
[61] M. L. Greenhut, *op. cit.,* p. 139.