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AGGLOMERATION ECONOMIES AND
TWO CONTRASTING TRANSPORTATION COSTS:
COMPLEMENTARY AND SUBSTITUTE PERSPECTIVES

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Agglomeration Economies and Two Contrasting Transportation Costs: Complementary and Substitution Perspectives

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Abstract: Two contrasting attributes of transportation costs are introduced in this analysis. These are categorized as internal and external to the firm or the industry. It is shown that the trade-off interaction between agglomeration economies and transportation costs in established location theory solely refers to the external nature of transportation costs to the firm. This paper reveals that there is another type of transportation costs which is internal to the firm and plays an important role in the structure of the production linkages within the industry. An alternative model is demonstrated to clarify the roles of these two types of transportation costs as substitute and complementary effects to agglomeration economies.

1 Introduction

The notion of agglomeration economies was formally introduced to location analysis by Alfred Weber (1909) and these economies are referred to as a trade-off factor of transportation costs, particularly with respect to economy of labor. As an additional element, urbanization type of agglomeration economies were formally introduced by Hoover (1937) and their role in urban industrial location is systematically detailed by Fujita and Thisse (2002). While the trade-off relationship is one of the essential components in established location theory, it is necessary to revisit this issue when the role of transportation costs is examined with respect to location decisions of the firm that is involved in forward and backward linkages during the production process. Both types of linkages have become the focus of attention in the recent new economic geography literature. The nature of vertical specialization and trade was examined by Hummels

et al., (1995). They analyzed the changes in trade patterns of particular products by increased opportunities of vertical specialization, which can be referred to as a part of agglomeration economies. In addition, agglomeration and interstate trade were examined by Parr *et al.*, (2002) in terms of the establishment and firm. In their analysis, the impact of changes in transportation costs on trade patterns in the metropolitan area was considered in the context of hollowing-out processes. Regarding the relationship between production scale and plant dispersion, Jones and Kierkowski (2005) investigated the mechanism of fragmentation of production with respect to vertical integration, disintegration and international trade. More recently, the reduction of communication costs and structural changes in operation were examined by Silva and Hewings (2007); they applied principal-agent theory (see Hart, 1995) to the spatial framework of firms' contracts, providing a study of recent operational changes in the aero-space industry in the United States.

One of the formal approaches to location decisions of the firm is the Weber location-triangle model (Weber, 1909), which has been expanded in various ways. Moses (1958) attempted an initial generalization of the location triangle framework with homogeneous production function. Khalili *et al.* (1974) demonstrated a more generalized framework, allowing the relaxation of the homogeneous restriction. Furthermore, Hwang and Mai (1992) included the notion of market demand in addition to the previously established supply-side approaches. However, it is apparent that there are few applications of these advanced location-triangle framework to recent spatial economic analysis. This may be partly due to the absence of important economic factors, which are dropped from the original Weber model during the process of generalization. In order to identify these excluded elements, the first part of this paper reviews the established trade-off relationship between agglomeration economies and transportation costs.

In the second part, a revised framework of this relationship and location forces in the location triangle is examined. The final part of the paper deals with the alternative model framework of the location decisions of the firm and further extensions are explored.

2 Trade-Off Interaction between Agglomeration Economies and Transportation Costs

Agglomeration economies are spatially-constrained parts of internal and external economies. With respect to internal economies, these can be divided into three types with respect to scale, scope and complexity. First, economies of scale are situations where an increase in output level achieves a lower unit cost of production. This is also referred to as economies of horizontal integration. Secondly, economies of scope or lateral integration are economies in which a variety of production brings more efficient production to the producer. Finally, economies of complexity are relevant to the advantages of vertical specialization or vertical integration within the firm. This can be generated by the division of labor in conventional economic theory. In the framework of location economics, these three types of economies can be categorized as spatially constrained internal economies, if location proximity enables the firm to have such cost-saving opportunities.

In terms of external economies, it is also possible to divide them into three parts in terms of scale, scope and complexity. If these economies are available at a particular location, each element can be referred to localization, urbanization and activity-complex economies or spatially-constrained external economies (Parr, 2002). First, localization economies are opportunities for labor cost savings, joint action for input extraction and specified services within the industry. This type can be exemplified by the cutlery industry in Sölingen in Germany or the pottery industry in southern part of Japan. Secondly, urbanization economies are advantages of administrative accessibility, well-organized infrastructure, variety of labor supply and highly

advanced system of transportation and communication. These are generally found in the metropolitan area, possibly together with urbanization diseconomies such as higher land prices, congestion and pollution. Finally, activity-complex economies are cost saving opportunities which rely on trade between different firms in a production chain. This type of economies can be observed at the automobile assembly plant in Chicago (the Ford Campus), which has a spatial concentration of parts' suppliers located within the Campus.

As introduced earlier in this paper, it is argued that these elements of agglomeration economies have a trade-off interaction with transportation costs in established location theory. This notion can be geometrically represented as figure 1.

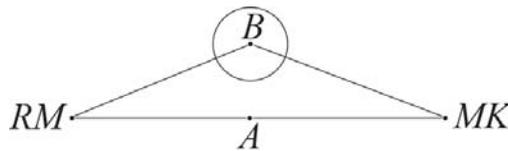


Figure 1. Agglomeration economies and transportation costs

In the figure, the following scenario can be considered: it is assumed that there is a producer who engages in production at either location A or location B . In addition, the producer needs one unit of input per product which is available at RM and the product is sold at the market site MK . Furthermore, the relevant transportation costs are assumed to be higher as shipping distance increases. In this circumstance, the optimal firm location can be determined at A where the distance to both input and output can be minimized. However, if there exist certain economic benefits within a circle in the figure, which the agglomeration economy is available, this producer may choose the point B as the optimal location instead of point A from the following scenario. The producer is willing to choose this distant location B , if the cost saving from agglomeration

economies exceeds additional transport cost burden to access this location which is located farther from the minimum total transportation costs location *A*. This is so called a trade-off interaction between agglomeration economies and transportation costs, and is commonly accepted in the established location analysis. However, there are other types of transportation costs, which have no trade-off interaction with agglomeration economies and have a positive relationship to each other, as shown in the following section.

3 Firm Location, Agglomeration Economies and Transportation Costs

While the presence of transportation costs is regarded as substitute force in agglomeration economies within the established framework, there is another type of transportation costs, which works together with these economies as a complementary role. This can be observed in a circumstance where production is organized into several processing stages and the condition of spatial proximity to each stage minimizes costs of their transportation. This complementary term of transportation costs has an opposite force to the conventional transportation costs in location theory. In this way, the relationship between agglomeration economies and these costs can be linked as illustrated in figure 2.

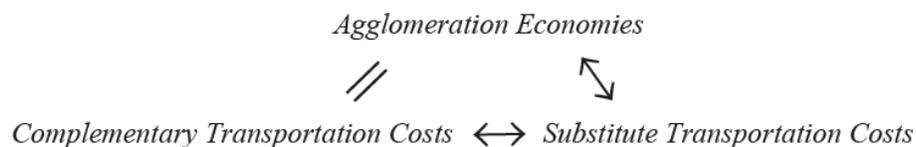


Figure 2. Agglomeration economies and two opposite forces of transportation costs

While this relationship has not yet been analyzed in established location theory, it is important to consider when the optimal location of a firm that is part of a value chain or production is examined.

Those two types of transportation costs can be clearly distinguished by an application of the commonly-known Weber-Moses approach. Here, there are two different input sites, RM_1 and RM_2 , in addition to the point of consumption as the market MK as shown in figure 3. In a simple model, the optimal firm location is specified as a point where all relevant transportation costs for inputs and outputs are minimized. This point is indicated as P in figure 3 and it can be geometrically observed in this particular case that transportation costs for input RM_1 are relatively higher than those of input RM_2 and output MK .

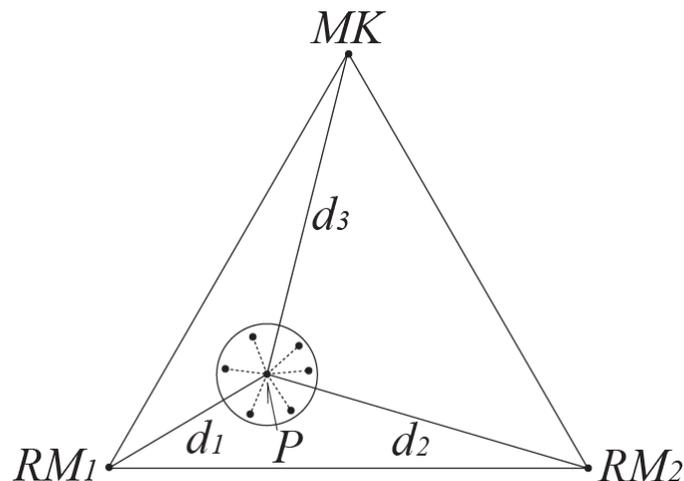


Figure 3. The location triangle and optimal firm location

In the long run, by contrast, if there are significant reductions in transportation costs for input RM_1 and increases of those for output MK together with the improvement of production efficiency, the optimal firm location might gravitate to P' as shown in figure 4.

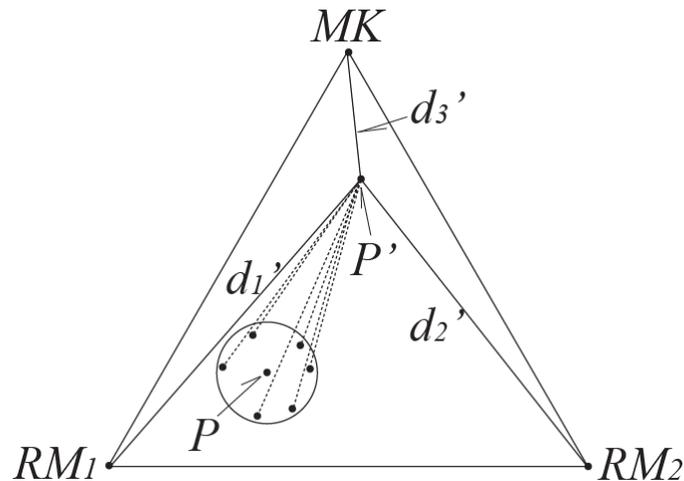


Figure 4. An alternative firm location

This process of location decision-making is a basic idea of the Weber-Moses approach. However, the alternative framework may suggest a different outcome, if the existing location P is within an available area of agglomeration economies. In this case, the producer may have no immediate incentive to move to the location P' , where the total of transportation costs is minimized. In order to satisfy this condition, the opportunities of agglomeration economies at the existing location should be much higher than a minimization of aggregate substitute transportation costs, which have distances of d_i ($i=1,\dots,3$). In addition, the following scenario can also be considered in this circumstance of complexity of linkages. If the production relies on certain forward and backward linkages within the industry at location P , the shift to P' causes an additional complementary transportation-cost burden between this firm and his suppliers, which have distances of d_j ($j=1,\dots,6$) and illustrated as broken lines in the figure. The complementary type of transportation costs is working together with agglomeration economies in this way and generates certain forces to sustain spatial proximity to other related firms within the industry.

4 Additional Factors for Multi-Stage Firm Operation

If the firm relies on economic activity of other processing stages or closely related firms, the values of time saving, transaction costs and face-to-face negotiations should also be considered, in addition to the complementary effect of transportation costs as examined in the previous section. A reduction of transportation distance can be treated as saving of time which enables the production to reduce certain levels of opportunity cost. The location proximity reduces these losses with the cost of the complementary type of transportation. Moreover, transactions cost and face-to-face negotiation are referred to as costs for communication and managerial arrangement, which are reduced by spatial proximity to other firms within the industry.

When there are significant levels of time-saving factors, transaction costs and substitute transportation costs, firms may consider either production concentration or dispersion. For instance, they may be willing to establish branch plants when the effects of agglomeration economies and complementary transportation costs become relatively lower than the increase of the relevant substitute transportation costs. In this scenario, the firm will have a dispersed-plant structure and it causes certain increase in processing costs, fixed cost, and transactions and complementary transportation costs for the production. By contrast, this dispersion may contribute to savings on those substitute transportation costs which used to be borne as a result of sustaining the economies of agglomeration at a particular location. More formally, conditions of dispersion of the firm can be expressed with the following expression:

$$\sum_{i=1}^3 (s_i d_i x_i - s'_i d'_i x_i) > \sum_{j=1}^6 (c_j d_j m_j - c'_j d'_j m_j) + (p'_c - p_c) + (p'_f - p_f) + (p'_t - p_t) + (p'_r - p_r)$$

The above each symbol represents cost element of operation at location P and P' . In addition,

s_i ($i = 1, \dots, 3$) = substitute transportation costs, c_j ($j = 4, \dots, 6$) = complementary transportation

costs, $d_i; d_j$ = distance between two sites, c_t = time-saving opportunity cost, c_p = production cost (which is relevant to horizontal integration), c_f = fixed cost level (which is related to lateral integration) and c_r = transactions costs (which is relevant to vertical integration). As shown in this equation, it is necessary to include those additional factors when the analysis of optimal firm location involves production-chain during the processing operation, in addition to the established trade-off interaction between agglomeration economies and transportation costs. There are similar findings regarding on this location-decision making. Jones and Kierkowski (2005) argued that economies of scale encourage fragmentation of production, which achieves lower unit cost of production. However, fragmentation itself may potentially cause increases of transportation costs due to presence of physical distance. From this point, they found that those costs are declining with quantities transported as well as reductions of costs in communication and coordination. As a result, significant reductions of substitute transportation costs in the above expressions can be accepted as a result of fragmentation of production which is achieved by economies of scale. By contrast, fragmentation of production may not be found, if such reductions are not expected.

5 Further Aspects

There are further economic elements which can be applied to this analysis, although the scope of the paper is limited to the relationship between agglomeration economies and transportation costs. First, if the relevant supply and demand nodes are located in peripheral areas of the region, the transportation network system should be considered more in detail (see, for example, Vickerman, 1991). Reconsidering figure 1, the following scenario can be considered. Assume that the transportation network between *RM* and *MK* via *B* is a modern motorway. In this case, it may possible for the firm to choose a more distant location *B* than *A* for reasons of time savings and

reducing potential risks of damaging products during the shipment. Regarding transportation costs in terms of the logistics-system efficiency, the notion of total logistics costs, systematically formulated by McCann (1998), should also be introduced, especially if the analysis deals with an industry that employs large scale production or just-in-time systems. This advanced framework reveals various hidden costs of processing in manufacturing industries and enables us to investigate a more accurate evaluation of industrial location and its relevant communication costs. Secondly, if the optimal firm location is suggested within a metropolitan area due to the advantages of urbanization economies, the notion of urbanization diseconomies should also be emphasized (such as the high price of land, crime rate, traffic congestion and air or water pollution).

Finally, if the forward and backward linkages of the production involve a negotiation processes between these upstream and downstream sectors, it might be more useful to employ the framework of principal-agent theory. As the approaches focus on the system of internal economies, the advanced framework of game theory should also be applied to external economies. The application to the external economies enables location analysis to examine the negotiation process among related and distant firms considering a particular location. These applications to industrial location theory may have a possibility for further investigations of agglomeration economies and transportation costs.

6 Concluding Comments

In this paper, two types of transportation costs are examined, which are substitute and complementary effects in agglomeration economies. During the analysis, it was found that the Weber-Moses approach ignores agglomeration economies with the result that location decisions of

the firms may be different from the original Weber location model. In addition to the important roles of agglomeration economies themselves, it becomes clear that the impacts of two different types of transportation costs on location decisions of the firm also need to be considered in the analysis. Regarding the methodological connection with the new economic geography literature, as explored in the previous section, it is necessary to attempt further detailed investigations in terms of the structures of factor cost, production and cost functions, and the roles of internal and external economies. Moreover, if the economic space is considered as a uniform plain, spatial competition in terms of central-place system has to be included in the analysis.

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