INFORMATION AND TRANSPORT IN INDUSTRIAL LOCATION

Hideo NAKAMURA, Takayuki UEDA, and Takashi NISHIO

Department of Civil Engineering
University of Tokyo
Hongo 7-3-1, Bunkyo-ku
Tokyo 113, Japan

INTRODUCTION

In this paper, the relation between information and transport will be discussed in the case of industrial locations including a manufacturing sector.

It has been noted that the improvement of high-speed passenger transport such as the Shinkansen in Japan stimulates the locations of various industries, including manufacturing firms, into concerned regions. (See NAKAMURA and UEDA(1989).) As a reason for such location changes, it was pointed out that high-speed passenger transport made firms' communication more convenient, and that it reduced employees' resistance to relocation, which was seen as a merit in laborforce management. Tele-communication technology has recently been highly developed to make communication more and more convenient. If passenger-carried information can be also carried by a tele-communication network, then, without passenger transport improvement, such technology can be expected to stimulate industrial location into regions which have advantages in freight transport, such as motorways.

Then, in what cases can high-speed passenger transport stimulate industrial locations from the point of communication ? This features a qualitative analysis for investigating such a question.

1.COMMUNICATION AND GENERATION OF PROFIT

1.1.Firm's process of creating information

Information which a firm collects in communication can not realize profit directly. A firm itself creates new information from collected information, and then makes profit by utilizing it in the process of production and sale. In this procedure, it can be suggested that a firm recognizes a large amount of information initially, and then, selects those items or areas that it perceives as valuable. The firm then arranges and reorganizes these

additions in association with its own accumulated knowledge; that is known as editing. This procedure can be regarded as the process of creating new information, where a firm generates the value added to its products.

Even if information is valuable, a firm may not always recognize it due to a lack of ability or knowledge. Abilities for this process, include matching, arranging, and reorganizing information with accumulated knowledge, and extracting information from knowledge. These abilities determine efficiency in creating new information. In this paper, this group of abilities will be referred to as "editing ability". The majority of knowledge very important to this process, is stored by experts employed in firms. Thus editing ability depends on them as well. Therefore, firm's process of creating new information depends hihgly upon the quality of its experts.

1.2.Utilization of created information in firm's activities

Then, how does a firm utilize newly-created information in its activities ? The economic benefit of a firm, or, profit is the difference between the revenue gained by selling its products and the cost necessary for production and/or distribution. In terms of revenue, products embodied with newly-created information can makes it possible for a firm to enjoy more revenue by enlargement of its market share. In terms of cost, the information created for new production technology enables reduced production costs, which also leads to higher profit. The former effect on profit can be called "product improvement", and the latter "process improvement2. In both cases, the information collected in communication, which is already transformed into newly-created information, can affect the profit level of firm. (See Figure 1.)

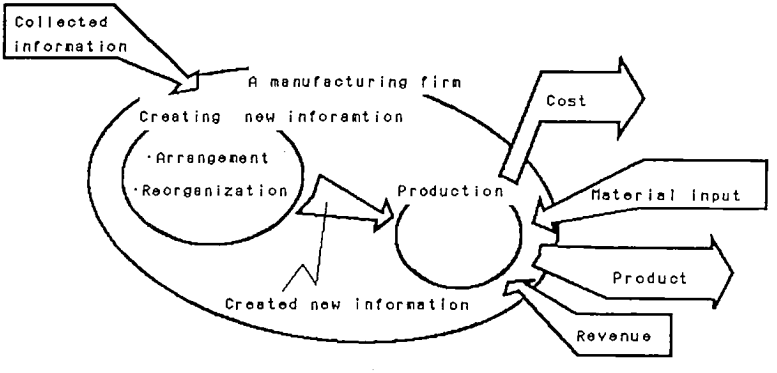

Figure 1 Generation of economic value in a manufacturing firm

2.ROLE OF PASSENGER TRANSPORT IN COMMUNICATION

2.1.Communication behavior

Communication with various partners and by several different modes gives a firm certain items of information. For this communication, a firm should pay some kinds of cost such as time or charge which will be called "communication cost" in the remainder of this paper. How a firm chooses communication partners and communication modes is examined in this section.

First, it can be supposed that a firm chooses communication partners who are expected to offer suitable items of information for its creating process of new information, and modes as well. Then, it is reasonable that a firm should choose them so as to minimize total costs of communication. Considering both aspects, a firm qualifies each item of information to collect from partners by modes, and then chooses suitable one using a cost minimizing principle.

Consequently, the question whether or not tele-communication can take the place of transport should be examined in light of the comparison of the above mentioned factors between modes.

2.2.Comparison of communication modes

2.2.1.Face-to-face and non-face-to-face mode

Communication modes can be broadly categorized into two types as follows :

Face-to-face mode: a sender and a receiver of information directly meet at a place. This type of mode includes a business meetings, technical seminars and so on.

Non-face-to-face mode: a sender and a receiver communicate over a distance. In this type of mode, some kinds of media are necessary for carrying information. Furthermore, this can be categorized into two types. One is communication by an electric cable which carries the information transformed into electric pulse. It includes communication by facsimile, telephone, television, and video conference. The second is communication by substantial media which carries information stored into substantial goods such as paper or tape. This includes floppy disk, magnetic tape, card, letter, magazine, and books, which should be transported. In the remainder of this paper, communication by electric cable will be considered mainly as a non-face-to-face mode.

2.2.2.Performance level and pattern of communication

Here, it should be noted how communication can be quantified for the comparison between modes. Since the amount of information exachanged in communication cannot be obsereved directly, the following points will be considered. Firstly, the amount of information exchanged in communication increases with the time spent in communication itself. The time mentioned here includes not only the time spent in conversation, but also time spent thinking or preparing. The other is that the amount of information exchanged in each mode differs, even if the same time is spent. Considering these two points, the concept for the quantitive comparison of communication is called "performance level of communication" (W) in this paper. This is defined as the function of time (t) as mentioned above, and pattern coefficient (α) which is strongly dependent upon the pattern of communication in the mode; this means $W = f(\alpha, t)$ where $f(\cdot)$ represents increasing function, and, in general, it can be assumed $W = \alpha t$ for purposes of this discussion. Since the time spent in communication should be discussed from the point of communication cost, the characteristics of communication modes will be compared.

One of the notable characteristics of communication pattern in the face-to-face mode is that human body carried by transport mode is not only a receptacle of information, but is also embodied with editing ability. Communication in a meeting where humans endowed with editing ability come together, may differ in characteristics of communication modes. This is because they may exchange information edited on-the-spot in more flexible way than in other modes, through catching atmosphere and look of speakers by their five senses. In other words, editing on-the-spot combined with flexibility leads to the exchange of more sophisticated and certified information. Thus, new information can be created through cooperative ways at the meeting; that is a synergetic effect of face-to-face communication. The other is that information is usually united with services offered by a sender, or exchanged simultaneously with doing something together. Examples of the former type of communication pattern are consulting services, business presentation, and repair services by engineers. In the latter, business lunches or dinners, parties, and social activities related to business are noted.

The information in both patterns of communication can not be carried except in the face-to-face mode. Judging from the above mentioned characteristics, it can be suggested in general that the face-to-face mode enables higher performance level of communication than the othermodes.

2.2.3.Communication cost

The perfomance level of communication defined in the previous subsection is dependent on the cost necessary in each communication mode. What kind of costs should be paid for communication in each mode ? Firstly, the cost for the same performance level will be discussed ignoring the quality of inforamtion. In the non-face-to-face mode, charge for using a cable network, time cost for communication itself are spent. The time cost mentioned here is minutes multiplied by a time value. The charge for cable network usually consists of a fixed part and a part proportional to the communication time. Contrary to this, in the face-to-face mode, transport charge and travel time are necessary to meet with face to face, further time cost is necessary for communication in addition to traveling time. In this mode, travel cost is regarded as a fixed cost. Components of communication cost for each mode are illustrated in Figure 2.

Which mode is cheaper ? When considering time and money cost, the communication cost for low performance levels is generally higher in the face-to-face mode than in the non-face-to-face mode. However, comparing average costs, face-to-face mode can be cheaper than non-face-to-face when the performance level is high as shown in Figure 3.

Furthermore, communication in the face-to-face mode has another merit when many people meet together. Since receivers may share the communication cost, a receiver can save the communication cost. An example is when participants invite a lecturer by paying transports costs and a honorrarium, they share communication costs for recieving information.

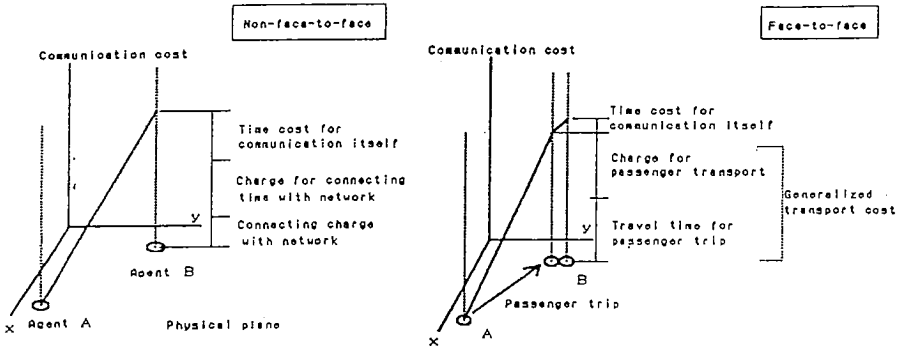

Figure 2 Components of Communication Cost

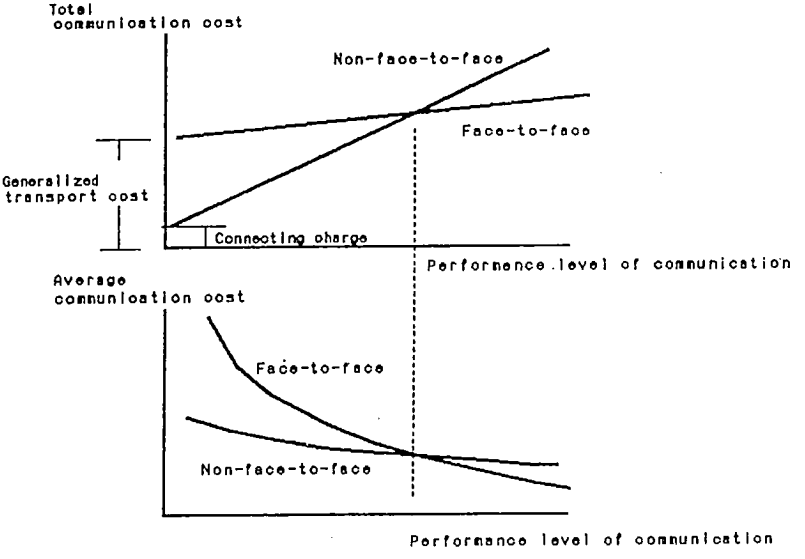

Figure 3 Comparison of Average Communication Costs

3.COMMUNICATION AND LOCATION BEHAVIOR

3.1.Regional condition and advantage in communication

Communication behavior depends upon quality of information collected and costs for communication, as shown in the previous section. Similarly regional advantage in communication is also dependent upon them. Here, the problem is related to how regional conditions can influence the advantage in a firm's communication.

Recalling the communication behavior mentioned in 2.1., it can be noted that newly-created information per communication cost, (as an indicator of efficiency in creating new information) may be represented as a kind of potential. This potential increases with quality of information collected, and decreases as a unit cost for communication increases. Thus, it can be regarded as an indicator of advantage in a firm's communication.

The communication cost in the face-to-face mode is more sensitive to physical distance than that in the non-face-to-face mode. Travel costs incurred when visiting part-

ners to communicate, depend upon their locations. As a consequence, when a firm takes its communication mainly in the face-to-face mode, location governs advantages in a firm's communication. On the contrary, when the majority of a firm's communication is in the non-face-to-face mode, such an advantage is not so dependent on the location so far as a unit communication cost is not as sensitive to a physical distance.

From the above discussion, it can be said that in a firm-agglomerating region, potential of convenience in communication is high in general because a firm can save communication costs in the face-to-face mode, that is, intra-regional travel costs. This is one of major reasons for urban agglomeration documented in other literature sources. In addition to the above discussion, it should be noted that the agglomeration of firms affects potential in other ways. Firstly, since content and value of information is uncertain before collection, a firm should pay a kind of search cost. Assuming that the search cost is included in the communication cost, agglomeration of firms reduces this cost, thus affecting the potential level. The other effect is that a firm-agglomerated region generally has core of partners communicating with many firms, examples of which are banks or governments. These agents provide highly sophisticated and certified information, which is created from communication with various firms. Thus, agglomeration can affect the potential through quality of information. In conclusion, agglomeration of firms reduces communication costs, and raises up quality of information.

3.2. Location surplus of firm and its components

It has been already discussed in Section 1. that communication behavior of firms is reflected in profits over time. It goes without saying that profit depends upon the convenience of communication as well as other varying factors. Most of these factors are dependent upon location, and therefore govern location choice behavior of firms, assuming that firm chooses a region where it can enjoy the highest level of profit. With the emphasis of the above aspect of location behavior, the profit is termed "location surplus" in this paper.

What kinds of factors do determine the level of location surplus and how important is the advantage of communication among them ?

Location surplus is defined as the difference of the revenue and the cost at the place to locate. First, in order to discuss the above question, revenue and cost of a manufacturing firm will be divided into their components, as summarized in Table 1.

Table 1 Components of location surplus (example,- manufacturing firm -)

Revenue R	Communication cost C1	Cost for creating process of new information C2	Freight transport cost C3	Production cost C4
Created new information (K) Quantity of products (Q) Price of product (p)	Created new information (K) Communication flow (I) Quality of information (q) Unit communication cost (c) Knowledge (W) Editing ability (E)	Created new information (K) Labor cost of experts ($a_w w$) Equipment cost for data processing ($a_I I$) Facility cost ($a_r r$)	Created new information (K)	Created new information (K)
			Quantity of products (Q) Unit freight cost ($c_Q Q$)	Labor cost ($a_w^* w$) Equipment cost ($a_I^* I$) Facility cost ($a_r^* r$)

Location surplus = $R-C_1-C_2-C_3-C_4$

$R = p(Q, K)Q$, $C1 = \Sigma c_{ij} I_{ij}$, $C2 = K(a_w + a_I + a_r)$, $C3 = c^Q Q$, $C4 = Q K^{-U}(a_w + a_I + a_r)$

a : Input coefficient, u : Parameter determing effect of new information on production

3.2.1.Revenue

Revenue R is the quantity of sales multiplied by price, which depends on the balance of demand and supply in markets. New information created by a firm effects its revenue through a differentiating strategy of products. For example, new design or new functions of products enable a firm to realize higher prices or market shares over other competing firms.

3.2.2.Cost

The first component C_1 is the communication cost discussed in the previous section, and the second C_2 is the cost for the creation process of new information within a firm. This includes wages for expert staff, equipment cost for computers, and facility cost for offices. The third C_3 is the freight transport cost for products or materials. The final component C_4 is production costs, which include labor costs, equipment costs, and facility costs or land rent for factories.

3.3.Location surplus and types of firm

on the basis of the above examined factors, the question how regional advantage in communication affects the current tendency of industrial location will be discussed . Firms will be broadly categorized into two types, firms of relatively high performance level and those of relatively low performance levels. It should be noted that level mentioned here is relative not absolute.

3.3.1 A firm of high performance level of communication

Currently, not all manufacturing firms produce bulky products. In the case of a firm which produces fashionable wears or commodities, a differentiating strategy with design or function of products determines its revenue. Therefore, such a firm must collect information related to market trends. Thus, communication cost C_1 becomes a more important component of location surplus and factors highlighted in conventional location theories are insufficient in explaining the behavior of all manufacturing firms.

On the other hand, a firm in the so called high-tech sector can reduce its production cost C_4 by R&D. This depends on communication cost C_1 as it does with firms illustrated above. It is often pointed out that such firms tend to locate in industrial parks, and that the development of such parks require high speed transport modes and proximity to

public research institutes or universities. The reason for these views may be explained on the basis of the potential of communication discussed in the previous section. High speed transport modes reduce communication cost in the face-to-face mode, and public research institutes or universities can be interpreted as the core agents in communication, mentioned in subsection 2.3. These conditions realize a high level of communication potential in industrial parks. Furthermore, the growth of agglomeration of firms in such parks raises up potential and therefore creates "a snow-balling effect".

It goes without saying that location surplus of other type of firms such as service sectors can be explained similarly, if differences in importance of each component of locaiton surplus are considered. Since firms of service sector do not produce substantial goods, they do not need a large lot of land or equipment for production purpose ; this means that C_i in Table 1 is small. In particular, the product of service business such as consulting practices or investigation, is newly-created information. In such a case, advantage in communication, especially in the face-to-face mode, significantly determines the location surplus of a firm. Therefore, the location within large regions which are agglomerated by firms, is advantageous even though high office rent must be paid.

3.3.2. A firm of low performance level of communication

In general, heavy industry manufacturing firms which have occupied major parts of the manufacturing sector, needs a large size of land lot for factory. This means that the input coefficient of facility a_i in cost component C_i is large. As a result, a region where land prices are relatively lower than metropolitan areas, is favorable for a firm to locate. On the other hand, when freight transport cost C_j is remarkably high, a manufacturing firm tends to locate in metropolitan areas to save freight costs to their main markets.

In the case of primary industries such as agriculture, forestry, and fishing, location surplus in such a sector is largely dependent upon natural conditions such as climate, terrain, and fertility than on advantages in communication. These condition govern the level of location surplus related to production costs.

In the case of service businesses providing daily life services,

location surplus is supposed to be more dependent upon the amount of demand within its territory, rather than advantages in communication. Then, the numbers of locating firms in each region, which are categorized into such a service business, are almost proportional to population regarded as a proxy of regional demand. The case of a service business providing information or knowledge (such as computer software business or design business) is unique, if information standardized as to carry in the non-face-to-face mode, or reduced communication in the face-to-face mode. As a result, non-metropolitan cities may be more advantageous to locate than metropolitan areas, when comparing costs except communication cost.

3.4.Location change due to passenger transport improvement

The final question to be discussed in this paper is the condition under which the improvement of high-speed inter-regional transport, such as air port or Shinkansen, significant influence location changes of firms through advantage in communication.

Transport improvement effects various component factors of location surplus in both direct and indirect ways; a result of which the level of location surplus varies. The direction of location change originates from the region where the increment of location surplus is greater to the region where this increment is smaller. (See UEDA(1990).) However, unless the gap of increments is greater than the relocation cost, location changes do not enable firms to enjoy higher levels of location surplus than previously. (See NAKAMURA and UEDA(1989).)

Transport improvement directly affects travel cost to spend for communication in face-to-face mode. Regarding number of trips as a proxy of communication flows, the reduction of communication cost can be measured as users' benefit and is equivalent to the increment of location surplus.

In the case that items of information collected in the face-to-face mode and the non-face-to-face mode are highly substitutable, a firm chooses a cheaper mode for the majority of its communication. When face-to-face mode can be cheaper in average cost than non-face-to-face, as already explained in 3.2., since a firm chooses the face-to-face mode in general, it can reduce its communication cost significantly because of transport improvement. However, when the non-face-to-face mode has already been cheaper, a slight reduction of transport costs can't affect a firm's communication behavior. As a result of such a case, it can be supposed that transport improvement hardly causes remarkable location changes.

Contrary to the above cases, when substitution of items of collected information is almost impossible, a firm has its communication in both the face-to-face and the non-face-to-face modes even though each may be expensive. In this case, it can be suggested that the reduction of travel costs can effect location surplus so significant as to realize location changes. Transport improvements generally result in higher land prices in concerned regions as an indirect effect which reduce the increment of location surplus by the direct effect. The magnitude of location change is determined by the equilibrium, where location surplus in concerned regions is balanced with that in other regions. Therefore, it is suggested in general that such an indirect impact on location changes cannot be generated by the improvement of tele-communication.

4.CONCLUSION

This paper discussed the process through which a firm can enjoy profit, with the concept of creation of new information. Communication in the face-to-face mode accompanied with passenger trips was compared with the other modes in terms of cost and other characteristics. Incorporating these factors into the concept of location surplus, the case that passenegr trasnport improvement can stimulate industrial location changes with raise in the convenience of communication was analyzed qualitatively.

This paper focused on firms, specifically manufacturing firms, to illustrate familiar examples. However, households as well as firms can be analyzed by replacing "production" with "consumption", and "revenue" with "gross utility".

There still remains a task for future research. Since the analysis in this paper is conceptual and descriptive, empirical analysis should be attempted despite poor the availability of socio-economic data.

BIBLIOGRAPHY

NAKAMURA, H. and UEDA, T..The impacts of Shinkansen on regional development, Proc. of 5th WCTR, 1989.

UEDA, T.. A model analysis of impact of transport improvement on household's location changes through opportunity of life activity, Infrastructure Planning review , No. 9, Japan Society of Civil Engineering, 1991