Agglomeration Economies and Linkage Externalities in Urban Manufacturing Industries: A Case of Japanese Cities

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Agglomeration economies are usually divided into two categories: urbanization economies and localization economies. In 80's a number of attempts have been devoted to estimate urbanization economies and/or localization economies. After the work by Glaeser et al. in 1992, however, historical effects on agglomeration called dynamic externalities in agglomeration are tried to estimate extensively. These externalities are named as MAR in a dynamic sense, and traditional agglomeration economies are evaluated in static sense.

Besides urbanization and localization, more traditional sources of industrial concentration are found in industrial linkages, such as customer and supplier linkages or backward and forward linkages. These linkage effects come from the concentration of different kinds of industries while localization economies mean the benefit from the concentration of firms within the same industry. Also, linkage effects are often referred as pecuniary externalities.

This paper tries to make clear those agglomeration concepts and construct an estimable model of linkage effects among industries as well as agglomeration economies, and to estimate these effects separately within a framework of the Translog production function. In this model intermediate inputs play an important role as linkage effects.

The empirical analysis is based on two-digit data for manufacturing industries in Japanese cities. Estimated results with regard to agglomeration economies vary significantly among the two-digit industries.

JEL Classification: R3

Keywords: urban agglomeration, linkage externalities, urban productivity

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1. Introduction

In the urban economic context, characteristics of agglomeration economies have been classified into two categories: localization economies and urbanization economies, which are very important factors for the existence of modern cities. Both agglomeration economies are originally stemmed from his classic textbook, Marshall (1890).

The concentration of firms which belong to the same industrial classification in a particular area usually yields common economic benefits to the industry as a whole. These benefit called localization economies. From the viewpoint of cost structure, localization economies exist when long run average production costs of firms in a particular industry decrease as the total output of the industry expands, which means that external economies to individual firms in a particular industry are transformed into internal scale economies by aggregating into the industry level.

Localization economies often attributed to Marshallian externalities. According to Marshall's textbook, the sources of localization economies are identified as three sources: input sharing, labor market pooling, and knowledge spillovers.[1]

An example of input sharing is when an apparel manufacturer, in particular 'Kimono' at Nishijin district in Kyoto is able to construct a kind of Kimono exhibition facility which is commonly usable as shared input. Localization will also make possible to purchase a great variety of relatively inexpensive intermediate inputs from a nearby company that specializes in upstream manufacturing. An example of labor market pooling is when a manufacturing firm producing metal frame in a particular agglomerated area such as Ohta-ku in Tokyo can easily find skilled craftsmen already present.[2] Knowledge spillovers and resulting innovation have a different feature of localization economies from above two sources. In a dynamic context of externalities knowledge spillovers and innovation are typical outcomes of localization economies which are external to firms while internal to an industry within a city. A strong geographical linkage among firms within the same industry will promote innovative activities. Glaeser, Kallal, Scheinkman and Shleifer (1993) define those localization economies as *Marshall-Arrow-Romer* externalities.

The geographic concentration of various types of activities in a particular area also brings economic benefits to firms externally. These economic benefits are being called the economies of urbanization because it has more economic activities as a city becomes larger

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[1] A detail explanation for these sources of agglomeration economies is found in the review article by Rosenthal and Strange (2004).

[2] Ohta-ku is very famous in the concentration of small sized firms which manufacture primary metals.

and larger. Thus urbanization economies remind us the diversity of urban activities. Jacobs (1969) states that urban diversity in a densely area facilitates face-to-face communication which yields technological spillovers among agents, and hence it is an important driving force of urban growth.[3] In urban productive activities, these urbanization economies are external to individual firms and industries while those are internal to urban area as a whole.

There exists another benefit to individual firms, in particular, smaller firms which locate in the large urbanized area. Those firms area are able to make use of many kinds of specialized services in large urban areas which do not exist in smaller urban areas. As Goldstein and Gronberg (p.92, 1984) described, large cities have a role of a sort of warehouse and it allows smaller firms to specialize in their own production without having every production tool.

According to Rosenthal and Strange (2004), Marshall as well as Jacobs also refers to the value of urban diversity in which complementary in labor supply can reduce risk generated by economic fluctuations. These agglomeration economies are usually associated with urban productivity advantages of firms or industries whether external economies are subject to those of Marshall or Jacobs.

On the other hand, like the flip side of the coins, cost advantages from the concentration of firms certainly exist. In order to save transportation cost the inter-related firms in transaction tend to locate nearby to each other. This is a traditional Weber's (1909) location decision problem.

Manufacturing firms use various intermediate inputs, and the share of intermediate inputs to total inputs is relatively high compared to other industrial sectors such as service industries. Some industries producing manufacturing goods are also demanded for firms as intermediate inputs rather than final consumption goods. Therefore, downstream firms will prefer to locate close to upstream firms which are suppliers in order to save transportation costs for their intermediate inputs. Also agglomeration of upstream firms is significant matter to the downstream firms because the proximity of the firms that are suppliers/demanders of their inputs/outputs will cause saving transportation cost as a pecuniary externality. These inter-dependencies lead to agglomeration of economic activities. Toyota city and surrounding areas in Aichi Prefecture, Japan, is a right example of this type of agglomeration. In these areas there are very famous automobile company Toyota Corp. and many related industries. The regional IO table of Aichi Prefecture in 2000 says that in an automobile industry about

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[3] Glaeser et al. (1993), Henderson et al. (1995), and Rosenthal and Strange (2003) find the contribution to urban growth of Jacob's externality.

70 % of total intermediate inputs are supplied from car related industries such as car parts and car accessories.[4]

According to the old but pioneering work by Hirschman (1958) in the field of development economics, input-cost linkages are forward linkages and demand linkages are backward linkages respectively. Furthermore, forward and backward linkages are mutually dependent because the downstream firms give a backward linkage to the upstream firms while output growth in upstream firms may provide more efficient production via intermediate demand for downstream firms. This is a circular and cumulative causation suggested by Myrdal (1957) and the economies of agglomeration are generated by input/cost and output/demand linkages synergistically.

The intermediate inputs come from firms in the same industry as well as from other industries.[5] If we find out the agglomeration of firms in the same industry and there exist intra-industry transactions of intermediate inputs and outputs in a particular area, it is regarded as localization economies. Horizontal linkages are the one of the sources of localization economies while vertical linkages are some parts of urbanization economies.

Demand linkages stands for the incentive for producers of final goods or intermediate goods to locate close to their customers while cost linkages refer to the incentive for economic agents that demand final or intermediate goods to locate close to the firms that supply those products. Particularly, in urban economics, proximity to suppliers of intermediate inputs implies the possibility of pecuniary externalities. Therefore, the industry production function treats urbanization economies as an external factor.

In empirical studies urbanization economies have been measured by urban population size or population density as urbanization economies are the scale effects related to the varieties of urban areas.[6] On the other hand, total employment or value-added in an industry is often adopted as a measurement of localization economies.

There are a number of studies which investigate agglomerative economic effects on urban and/or regional productivities. Studies before 1998 are well reviewed by Eberts and McMillen (1999) and more recently empirical works on agglomeration effects are summarized by Rosenthal and Strange (2004). Following Rosenthal and Strange, city size effect as

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[4] In Aichi Prefecture there are a number of car and its related companies associated with Toyota Corp.

[5] Of course this partly depends upon the level of industrial classification.

[6] In this respect, Rigby and Essletzbichler (2002) point out the ambiguity of urban population as a surrogate for urbanization economies.

urbanization economies on urban productivity ranges from roughly 3 to 8 percent.[7] The relative importance on urban manufacturing productivity of urbanization and localization economies is examined by Nakamura (1985) and Henderson (1986). In particular, Nakamura first succeeded to estimate both economies separately in the Translog production model by aggregating the firm level production function. Both Nakamura and Henderson show the localization economies are stronger factor than urbanization economies in manufacturing productivity while there are considerable variations among industries.

With regard to linkage externalities, however, there are not so many works in the field of urban economics while the importance of empirical investigation is addressed by Krugman (1991).[8] Midelfart-Knarvik, Overman, and Venables (2001) and Rigby and Essletzbichler (2002) estimated effects of linkage externalities on productivities by constructing linkage indices using input-output tables in EU countries and US, respectively. Cohen and Morrison Paul (2005) estimated cost function of food manufacturing at the US state level incorporating agricultural product in own and neighboring states as linkage externalities. This study stressed on linkage effects as pecuniary externalities which consist of localization and urbanization.

Marshall's externalities including Jacobs' idea are mixture of technological and pecuniary ones. In the studies of agglomeration economies the distinction of these two externalities has been ambiguous. Midelfart-Knarvik and Steen (1999) tried to separate technological externalities and pecuniary externalities. They treat that technological externalities affect output while pecuniary externalities do value-added. However, their distinction about the reflection of externalities is questionable, because the value of output is defined as the sum of intermediate input and value-added.

Following recent paper by Rigby and Essletzbichler (2002), the estimated results by using surrogate variables for urbanization and localization economies such as urban population and industry employment are difficult to interpret since the concept of agglomeration is not based upon original Marshall's micro economic foundation. They constructed three indexes based upon Marshall's definition of externalities as well as other production factors, and obtained significant estimates of linkage externalities as well as metropolitan size effects. However, as Henderson et al (p.92, 2001) stated, empirical studies on agglomeration economies still needs to clarify the relationship among sources of localization economies, linkage externalities, and urbanization economies.

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[7] For examples, Shefer (1973), Sveikaukas (1975), Segal (1976), and Moomaw (1981).

[8] In national level, not regional or city wide level, linkage externalities are estimated by Bartelsman et al. (1994).

In this paper I extend production function model into incorporating inter-industry linkage externalities as well as agglomeration economies of urbanization and localization. In next section, I begin to formulate a firm's level production function and specify linkage externalities in profit maximizing behavior. The derived demand function for intermediate inputs reflects linkage externalities of upstream industries while value-added production function receive an influence from the agglomeration of downstream industries including final demand. In section 3, the model to be estimated and data used in the estimation are described. Empirical results and interpretations are served in section 4. Finally, section 5 concludes the paper.

2. A Production Function Model with Agglomeration Economies

The value of output, usually called the value of shipment $\left(q_{j\in i}\right)$, is the value-added $\left(v_{j\in i}\right)$, plus the value of intermediate input $\left(m_{j\in i}\right)$, i.e.,

$$q_{j\in i}=v_{j\in i}+m_{j\in i}\,. \tag{1}$$

where $j\in i$ denotes firm j which belongs to the industry i.

The manufacturing firms produce goods by adding values to intermediate inputs. From the firm's behavior to maximize value-added, the value-added production function and the intermediate input demand function are respectively derived as

$$v_{j\in i}=v_i\left(k_{j\in i},l_{j\in i};E\right), \tag{2}$$

$$m_{j\in i}=m_i\left(p_i,q_{j\in i},E\right), \tag{3}$$

where $k_{j\in i}$ is capital input, $l_{j\in i}$ is labor input, E is the vector with elements of external factors, and p_i is the value per unit intermediate input called price index of intermediate input which is assumed to be same to all firms in industry i.

In an urbanized area there exist externalities which affect value-added and the value intermediate input. By taking it into account, a more specific formulation of the value-added production function (2) with urban external effects which imply urbanization and localization economies, and inter-industry linkages is given by

$$v_{j\in i}=g_i\left(N,V_j,E^D\right)f_i\left(k_{j\in i},l_{j\in i}\right) \tag{4}$$

where the function g denotes Hicks neutral productivity, and its argument N is city size, V_i is the total value-added of the industry in which firm j belongs to, $V_i=\sum_j v_{j\in i}$, and E^D

is other external factors which directly affect urban productivities.

The total value-added of the industry i, V_i, represents the degree of concentration of firms in the same industry.[9] The labor-market pooling and knowledge spillovers which are principal features of localization economies are assumed to be reflected in this variable. The role of city size, N, which is usually measured by city population or population density, is a representative variable explaining urbanization economies suggested by Jacobs. High population or high population density allows an easy face-to–face contact in leisure as well as in business, and it means the concentration of various types of activities which will be the source of innovative nature enhancing productivity.

The remaining external factor E^D in the first blanket of equation (4) is the variable representing demand-side concentration i.e., market size effect. The outputs of manufacturing firms are not only used as final demand but also as intermediate input demand for firms in other industries which are called downstream industries. The concentration of downstream industries will cause so-called backward linkage effects by saving transport costs. The demand-side effects indicating backward linkages explain a mechanism of urbanization economies. Demand-side concentration, however, does not necessarily correspond to the concept of urbanization economies in urbanized areas, because manufacturing output is demanded for manufacturing firms as an intermediate input rather than final consumption goods.[10] In modern cities the areas where manufacturing plants are agglomerated do not necessarily mean (large) urbanized areas.

In turn, $m_{j\in i}$, left hand side of equation (3), implying demand for intermediate input, depends upon the price of intermediate input with a given output level. It is assumed that the price of intermediate input depends upon local agglomeration of firms in the same industry due to the scale economies of intermediate input production. Thus, the unit of intermediate input is a function of the degree of localized intermediate such as

$$p_i = p_i\left(M_i; q_{j\in i}\right) \tag{5}$$

and also $q_{j\in i}$ is a function of $k_{j\in i}$ and $l_{j\in i}$, then equation (3) is rewritten as

$$m_{j\in i} = h_i\left(M_i, E^U\right) n_i\left(k_{j\in i}, l_{j\in i}\right), \tag{6}$$

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[9] An alternative measurement of localization economies is the number of employment in the industry like Henderson, Lee, and Lee (2001). The value-added is better proxy for localization than employment since the local concentration of firms is reflected in capital as well as employment.

[10] In Appendix A it is shown that more than half manufacturing industries, particularly heavy industries, provide those outputs as intermediate inputs.

where the variable E^U stands for agglomeration of upstream industries which externally shift intermediate input demand function through forward linkage effects. By the formulation like equation (6), the price effect of the concentration of intermediate input will be to some extent captured in the price of M .

Our model described above treats three types of agglomeration factors in urban manufacturing production (4) and two types of agglomeration factors in intermediate input function (6). It is difficult to estimated directly equations (4) and (6) without individual firm (or plant) level data. In the next section, in order to overcome this difficulty and identify agglomeration effects we aggregated a firm level specification into industry level in which firms in the same industry have identical production technologies across cities.

3. Estimation Model and Data Description

3.1. Estimation Model

For empirical implementation the above mentioned model a functional form must be specified. The functional form adopted here is Translog which is 2nd order approximation of general function in which constant returns to scale is assumed. The specification of production function (2) is

$$\begin{aligned}\ln v_{j\in i} &= \alpha_0 + \alpha_N \ln N + \alpha_S \ln V_i + \alpha_D \ln E_i^D + \alpha_K \ln k_{j\in i} + \alpha_L \ln l_{j\in i} \\ &+ \frac{1}{2}\beta_{KK}\left(\ln k_{j\in i}\right)^2 + \frac{1}{2}\beta_{LL}\left(\ln l_{j\in i}\right)^2 + \beta_{KL}\left(\ln k_{j\in i}\right)\left(\ln l_{j\in i}\right)\end{aligned}, \quad (7)$$

where $\alpha's$ and $\beta's$ are parameters to be estimated, and the homogeneity restriction is posed. $\alpha_N, \alpha_S, and\ \alpha_D$ are the elasticities of value-added with respect to city size (N), industry size (V_i), and linkages to downstream industries (E_i^D), respectively. E_i^D, which is defined later, is an appropriately weighted average of other (downstream) industries' activities and final demands.

The production function at the industry level is obtained by aggregating individual firms' production function (7).

$$\begin{aligned}\ln V_i &= \frac{\alpha_0}{1-\alpha_S} + \frac{\alpha_N}{1-\alpha_S}\ln N + \frac{\alpha_D}{1-\alpha_S}\ln E_i^D + \frac{\alpha_K}{1-\alpha_S}\ln K_i + \frac{\alpha_L}{1-\alpha_S}\ln L_i \\ &+ \frac{1}{2}\frac{\beta_{KK}}{1-\alpha_S}\left(\ln K_i\right)^2 + \frac{1}{2}\frac{\beta_{LL}}{1-\alpha_S}\left(\ln L_i\right)^2 + \frac{\beta_{KL}}{1-\alpha_S}\left(\ln K_i\right)\left(\ln L_i\right)\end{aligned}. \quad (8)$$

Equation (8) demonstrates that at a firm level economies of localization are external while industry level localization economies are internalized which are reflected in the degree of

$(\alpha_K + \alpha_L)/(1-\alpha_S)$.

Input cost-share equations are derived from the Translog production function:

$$S_K = \alpha_K + \beta_{KK} \ln k_{j\in i} + \beta_{KL} \ln l_{j\in i}$$
$$S_L = \alpha_L + \beta_{LL} \ln l_{j\in i} + \beta_{LK} \ln k_{j\in i}$$

where S_K and S_L are capital input cost share and labor input cost share, respectively, and by homogeneity restrictions $\beta_{KK} + \beta_{KL} = \beta_{LL} + \beta_{LK} = 0, \beta_{KL} = \beta_{KK}$. By aggregating these cost-share equations in to industry level, cost-share equations are rewritten as

$$S_K = \alpha_K + \beta_{KK} \ln K_i + \beta_{KL} \ln L_i$$
$$S_L = \alpha_L + \beta_{LL} \ln L_i + \beta_{LK} \ln K_i , \quad (9)$$

It is noted that under individual firm's maximizing behavior all agglomeration effects are external.

The specification of equation (6) is as follows:

$$\ln m_{j\in i} = \gamma_0 + \gamma_U \ln E_i^U + \gamma_S \ln M_i + \gamma_K \ln k_{j\in i} + \gamma_L \ln l_{j\in i} \quad (10)$$

where $\gamma 's$ are parameters to be estimated and E^U is an appropriately weighted average of other (upstream) industries' activities.[11] An aggregation into the industry level yields

$$\ln M_i = \frac{\gamma_0}{1-\gamma_S} + \frac{\gamma_U}{1-\gamma_S} \ln E_i^U + \frac{\gamma_K}{1-\gamma_S} \ln K_i + \frac{\gamma_L}{1-\gamma_S} \ln L_i$$

At this point we would define the variables representing demand linkage E^D and input linkage E^U clearly.

First, let denoted x_{ik} as intermediate input to industry k from industry i including non-manufacturing sectors.[12] The total intermediate input for the industry k is given by $\sum_i x_{ik}$. Thus the weight of intermediate input from industry i for the output in industry k, w_{ik}^U is defined as

$$w_{ik}^U = \frac{x_{ik}}{\sum_i x_{ik} + V_k^*}, i \neq k ,$$

where V_k^* is value-added for industry k in national level.

Using this weight, the agglomeration of upstream industries for industry k, E_k^U is written as

$$E_k^U = \sum_i w_{ik}^U Q_i \quad (11)$$

where Q_i is output of industry i. The equation (11), definition of E_k^U, means the

11 In equation (10) we put homogeneous degree one restriction $\gamma_K + \gamma_L = 1$ as in the production function.

12 x_{ik} is national level.

agglomeration of each industry's output which is weighted by correspondent industry's input share for industry k.

The weight of downstream industries and local final demand with regard to industry i are respectively denoted by

$$w_{ik}^{D} = \frac{x_{ik}}{\sum_k x_{ik} + D_i^F} \quad \text{and} \quad w_{iF}^{D} = \frac{D_i^F}{\sum_k x_{ik} + D_i^F},$$

where D_i^F is final demands for the output of industry i in national level. Using this weight, the agglomeration of downstream industries for industry i, E_i^D, is written as

$$E_i^D = \sum_k w_{ik}^D M_k + w_{iF}^D V_i . \text{[13]} \tag{12}$$

In the estimation, in order to reduce multicollinearity, estimate equations are reformulated as follows:

$$\ln\frac{V_i}{L_i} = \frac{\alpha_0}{1-\alpha_S} + \frac{\alpha_N}{1-\alpha_S}\ln N + \frac{\alpha_D}{1-\alpha_S}\ln E_i^D + \frac{\alpha_K}{1-\alpha_S}\ln\frac{K_i}{L_i} + \frac{\alpha_S}{1-\alpha_S}\ln L_i + \frac{1}{2}\frac{\beta_{KK}}{1-\alpha_S}\left(\ln\frac{K_i}{L_i}\right)^2 + \frac{\beta_{KL}}{1-\alpha_S}\left(\ln\frac{K_i}{L_i}\right) \tag{13}$$

and

$$S_L = \alpha_L - \beta_{KL}\ln\frac{K_i}{L_i} . \text{[14]} \tag{14}$$

Similarly, equation (11) is

$$\ln\frac{M_i}{L_i} = \frac{\gamma_0}{1-\gamma_S} + \frac{\gamma_D}{1-\gamma_S}\ln E_i^U + \frac{\gamma_K}{1-\gamma_S}\ln\frac{K_i}{L_i} + \frac{\gamma_S}{1-\gamma_S}\ln L_i \tag{15}$$

Three equations are estimated simultaneously imposing cross restrictions with disturbance terms. The estimation is conducted by the I3SLS (Iterative three-stage least squares) method with instrumental variables because some variables on the right side are simultaneously determined with left side variables.[15]

3.2. Data Description

In the estimation main data are from Census of Manufactures in 2000, which provides data for capital, labor, money wage, the value of shipment, intermediated input, and value-added.

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[13] Q_i, M_i, and, V_i are values of regional level. Here region means prefecture which is wider municipal area than cities. There are 47 prefectures in Japan while the number of cities is about 670. The linkage externalities will be beyond city areas.

[14] Capital share equation is dropped from the estimation because $S_K + S_L = 1$.

[15] Instrumental variables are capital stock at the end of previous year, city total employment, city population, and so on.

Capital is measured in terms of tangible capital asset, labor is the number of employments, and money wages are annual payments for employees. Monetary data are all in ten thousand yens. In a Census of Manufactures the gross value-added is defined as total shipment minus the value of intermediate input including raw material costs.

City size is measured by daytime population from Census data in 2000, and also daytime population density, which reflects spatial concentration as in the model by Ciccone and Hall (1996), is adopted as an alternative measure of urbanization.

Intermediate input/demand x_{ik} comes from the national IO table in 2000. It is of course preferable to use regional IO table by regions, but a few regional IO tables in 2000 is not yet appeared.

Table 1 shows industrial classification of manufactures in Japan and the number of the observations used in the estimation.

4. Empirical Results

By estimating equations (13), (14) and (15) for twenty two two-digit manufacturing industries of Japanese cities by the 3SLS with instrumental variables, we can obtain parameter estimates of several sources concerning agglomeration economies; (a) urbanization economies, which are measured by the elasticity of productivity with respect to daytime population or its density, (b) localization economies, which are captured by the value-added of an industry and reflected in industry production function as scale effects, (c) localization economies, which induce input-cost effects due to high demand for intermediated inputs, (d) backward linkage effects, which are the elasticity of productivity with respect to input-weighted sum of downstream industries output and final demand, (e) forward linkage effects, which are the productive elasticity with respect to output-weighted sum of upstream industries.

Table 2 shows estimated parameters of the production function and intermediate demand function. The number of samples in the estimation of each industry corresponds to the number appearing in Table 1.

Most of the industries exhibit positive values of urbanization parameter whereas industries with t-value over 2.0 are nine industries which mainly belong to light industries such as Food Industry (SIC-12). Some of industries receive urbanization benefits from spatial density of population rather than from city population. Examples of these industries are Textile and Mill Products (SIC-14), Apparel (SIC-15), and Printing and Publishing (SIC-19).

Economies of urbanization are similar to backward (demand/output) linkage effects which are caused by the agglomeration of demanders of their output. Ceramic, Stone and Glass Products (SIC-25), Apparel (SIC-15), and Furniture and Fixtures (SIC-17) are the top five industries which enjoy demand linkage effects. From Figure A in Appendix we can recognize that outputs of these industries relatively go toward the final demanders such as household consumers. As contrast, Leather Tanning, Leather Products and Fur Skins (SIC-24) shows low backward linkage effects while does the highest value of urbanization economies of all manufacturing industries. This is because that Leather Tanning and Leather Products have a weaker linkage to downstream than industries with both high urbanization economies and backward linkages such as Ceramic, Stone and Glass Products, Apparel, and Furniture and Fixtures. The relationship between urbanization economies and backward linkage effects are shown in Figure 1 in which the SIC numbers are plotted. Simple average of estimated values of demand linkage effects is 0.031, which is greater than the average of urbanization effects, 0.022.

With regard to economies of localization, estimated parameters of α_S show combined effects of labor market pooling and common usage of facilities as capital.[16] All industries except Food Products (SIC-12) show positive signs as anticipated and the average value is 0.050. Also, most of the industries, 18 of 22, are showing high t-values which are greater than 2.0. Localization economies measured by industry value-added, as a whole, have stronger effect on productivity in a sense of elasticity than urbanization economies measured by city daytime population density.[17] On the other hand, estimates of γ_S, measured by intermediate input at the industry level, reflect scale economies of intermediate input demand within the same industry. A large demand for intermediate goods by concentrating of firms in a particular area induces forward linkage externalities.

Figure 2 shows the relationship of localization economies accruing from the industry scale in terms of value-added and from the scale of intermediate inputs. These two types of localization economies (α_S, γ_S) are positively correlated while there is not strong correlation between two economies (correlation is 0.48). In particular, estimated values of (α_S, γ_S) with respect to Petroleum Products, Transportation Equipment, and Electrical Machinery are relatively high and statistically significant. Aside from the petroleum industry, Transportation

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[16] Technological (knowledge) spillovers are also an important attribute of localization economies in a dynamic agglomeration. In this study, however, the analysis is focused on cross sectional study of cities. It is difficult to treat dynamic effects in the cross section analysis.

[17] This result is consistent to previous studies such as Nakamura (1985), Henderson (1986), while the difference between localization and urbanization effects expands recently.

Equipment and Electrical Machinery tend to purchase their intermediate inputs from their correspondent industrial groups, which are classified into two-digit category, more than all other industries, and their average firm sizes are relatively large to other industries. This will be the reason for receiving high localization economies.

In contrast, Chemical and Allied Products (SIC-20) and Iron and Steel Industry (SIC-26) shows relatively low values of localization economies associated with intermediate inputs while high values of localization economies related to scale effects of value-added.

In an industry level economies of localization are internalized and scale parameter $\alpha_S/(1-\alpha_S)$ will exhibit the degree of returns to scale when α_S is greater than zero. The implied estimates of scale parameter $\alpha_S/(1-\alpha_S)$ are appeared on the second column in Table 3. The average value of industry scale economies for positively signed industries is 0.057. All manufacturing industries except Food Product (SIC-12) exhibit scale economies and eighteen industries show significant values of internalized scale economies. The representative industries receiving relatively high degree of scales are Chemical and Allied Products (SIC-20), Electrical Machinery (SIC-30), and Transportation Equipment (SIC-31), which are showing greater than 0.08.

Figure 3 plots urbanization economies and localization economies in order to examine relative importance to manufacturing firms being located at cities. We intuitively can find negative relationship between two economies, i.e., there is a tendency that firms belonging to an industry which enjoys relatively strong urbanization economies enjoys less localization economies, and vice versa. The correlation coefficient between two agglomeration economies is negative and -0.606. The simple average of estimated parameters α_P's over twenty industries is 0.022 which is smaller than that of localization parameters α_S's, 0.050. Typical example is found in Food Products industry in which urbanization effects locating large and high densely cities are the strongest among twenty two industries though localization economies accruing from the concentration of firms in the same industry are fairly small.

Forward linkage effects deriving from input/cost linkages to upstream industries are obtained by estimating intermediate input demand function (15) not production function (13), because the agglomeration of upstream industries directly affects intermediate demand of downstream firms rather than productivity measured by value-added per worker. The average effect of forward linkages over twenty two manufacturing industries is 0.051, which means the elasticity of intermediate demand, and says demand increases by 0.51 percent when the agglomeration of upstream industries increases by 10 percent.

The average value of input/cost linkage effects, 0.051, is greater than that of output/demand linkage effects, 0.033 while there are considerable variations among industries with respect to the relative magnitude of linkage effects. Figure 4 shows plots of two linkage effects by industries. Apparel and Related Products (SIC-15) receives benefits from both agglomerations; backward linkage mainly comes from urban population as a demand effect and forward is probably from the concentration of textile industry as an upstream industry. As a contrast, Iron and Steel Industry (SIC-26) receive more localization economies from total value-added than from total intermediate inputs.

In case of investigating the source of relative strength of forward/backward effects, it will be useful to go back to industrial input/output transactions. Fore examples, Furniture and Fixtures purchases from lumber and wood products as intermediate inputs, Printing and Publishing purchases from output of paper product industry, Beverage Industry purchase from food product industry, and so on. Figure 4 shows that such industries have surely receive relatively high forward linkage effects.

On the contrary, most portion of output of Fabricated Metal Product (SIC-28) are shipped to construction industry as an intermediate demand. Thus, the concentration of construction firms will induce backward linkage to Fabricated Metal Product. The elasticity parameters, α_D and γ_U indicate magnitudes of vertical linkages.

5. Conclusions

In this paper, I provide an explanation for the relation between agglomeration economies of urbanization and localization and Marshall’s three sources of agglomeration in a framework of the production function, and estimated using production function and intermediate demand function.

Estimated results for urbanization and localization economies are similar to those in Nakamura (1985), but magnitudes of both economies become weaker. These economies of agglomeration also show a negative relationship, i.e., industries receiving high urbanization benefits experience relatively lower economies of localization, and vice versa.

From Table 3 on the average of manufacturing industries forward linkages show the highest agglomeration economies, which are larger than localization economies. Forward linkage effects are generally stronger than backward linkage effects, but effects vary significantly among industries.

In modern cities non-manufacturing industries is becoming important for agglomeration economies, in particular, for consumption agglomeration. It is valid for large metropolitan areas, but for local medium sized cities manufacturing industries still have important roles for obtaining income from outside regions. When local government intends to vitalize regional economies, it is preferable to form industrial agglomerations in which industrial linkages among industries as well as within an industry. The estimated results in this paper suggest an importance to form inter-industrial linkage within a city or region, and it will contribute to regional economic vitalization.

Although this paper investigates agglomeration effects on productivities, location decision and agglomeration economies often determined simultaneously. Thus it is necessary to incorporate locational behavior of firms into production model. Also time series evidence will be needed for making clear the trend of agglomeration benefit for manufacturing firms. All of these matters are the important subject of future research.

Table 1
Industries at the Two-Digit SIC Level

SIC Code	Industry	Numbers of Observations
12	Food Products	674
13	Beverages, Tobacco, and Feed	299
14	Textile Mill Products	238
15	Apparel and Related Products	545
16	Lumber and Wood Products	422
17	Furniture and Fixtures	395
18	Pulp, Paper, and Allied Products	394
19	Printing and Publishing	550
20	Chemical and Allied Products	319
21	Petroleum and Coal Products	55
22	Plastic Products	448
23	Rubber Products	187
24	Leather Tanning, Leather Products, and Fur Skins	81
25	Ceramic, Stone and Clay, and Glass Products	590
26	Iron and Steel Industry	275
27	Non-ferrous Metal Industry	205
28	Fabricated Metal Products	617
29	Non-electrical General Machinery	580
30	Electrical Machinery	578
31	Transportation Equipment	402
32	Precision Instruments and Machinery	248
34	Miscellaneous Manufacturing Industries	197

Table 2
Parameter Estimates of agglomeration Effects

SIC Code	α_{ND}	α_N	α_S	α_D	α_K	γ_S	γ_U	R^2
12	0.058	0.057	-0.013	0.052	0.445	0.102	0.041	0.378
	(4.58)	(3.36)	(-1.10)	(3.68)	(19.69)	(7.46)	(2.40)	0.375
13	0.027	0.033	0.060	0.049	0.462	0.253	0.108	0.375
	(1.01)	(2.29)	(3.52)	(2.47)	(17.61)	(8.15)	(3.41)	0.476
14	0.042	0.038	0.039	0.034	0.265	0.110	0.064	0.313
	(2.18)	(2.31)	(3.29)	(1.82)	(15.05)	(3.98)	(2.80)	0.262
15	0.026	0.034	0.037	0.058	0.269	0.164	0.183	0.299
	(2.32)	(2.19)	(2.73)	(4.41)	(11.63)	(7.27)	(7.15)	0.316
16	0.047	0.025	0.022	0.057	0.253	0.063	0.020	0.299
	(4.25)	(2.43)	(2.01)	(3.76)	(13.76)	(2.83)	(0.94)	0.233
17	0.044	0.013	0.020	0.058	0.292	0.061	0.113	0.217
	(3.04)	(1.01)	(1.95)	(4.19)	(9.60)	(2.58)	(4.15)	0.305
18	0.001	-0.014	0.050	0.010	0.309	0.070	-0.011	0.468
	(0.03)	(-1.03)	(4.07)	(0.86)	(18.56)	(3.17)	(-0.53)	0.489
19	0.025	0.048	0.066	0.050	0.221	0.086	0.116	0.373
	(2.13)	(2.86)	(8.06)	(4.66)	(14.48)	(5.78)	(6.01)	0.413
20	-0.019	0.010	0.088	0.024	0.373	0.064	0.004	0.378
	(-0.74)	(0.51)	(6.97)	(1.68)	(12.19)	(2.49)	(0.11)	0.395
21	-0.053	-0.057	0.152	-0.001	0.516	0.264	-0.112	0.353
	(-1.08)	(-1.44)	(4.12)	(-0.22)	(25.57)	(8.15)	(-1.83)	0.657
22	0.011	-0.006	0.041	0.033	0.364	0.099	0.024	0.382
	(0.93)	(-0.52)	(3.92)	(2.63)	(17.63)	(6.26)	(1.30)	0.472
23	-0.004	0.004	0.054	0.004	0.315	0.107	0.062	0.365
	(-0.15)	(0.27)	(3.04)	(0.19)	(19.64)	(3.55)	(2.59)	0.335
24	0.065	0.014	0.030	-0.015	0.214	0.178	0.075	0.435
	(2.86)	(0.63)	(1.23)	(-0.96)	(20.81)	(2.76)	(2.82)	0.364
25	0.011	0.012	0.032	0.058	0.278	-0.021	0.100	0.375
	(1.17)	(1.08)	(2.33)	(4.68)	(16.19)	(-1.94)	(5.43)	0.377
26	0.019	-0.015	0.063	0.032	0.356	0.024	0.222	0.374
	(1.22)	(-1.16)	(5.54)	(2.46)	(23.83)	(1.46)	(4.98)	0.375
27	0.007	-0.012	0.059	0.021	0.328	0.201	0.009	0.332
	(0.05)	(-0.81)	(3.57)	(1.98)	(22.34)	(7.46)	(0.08)	0.504
28	0.016	0.009	0.023	0.038	0.319	0.084	-0.041	0.343
	(1.75)	(0.80)	(3.13)	(3.98)	(21.56)	(6.00)	(-1.78)	0.324
29	0.035	0.025	0.047	0.027	0.380	0.170	0.021	0.371
	(3.47)	(1.46)	(4.58)	(2.49)	(29.24)	(9.40)	(1.11)	0.434
30	0.038	0.028	0.093	0.042	0.426	0.217	0.069	0.481
	(3.47)	(1.55)	(9.51)	(2.98)	(26.09)	(10.46)	(2.98)	0.389
31	0.019	0.011	0.082	0.013	0.315	0.245	0.038	0.421
	(1.40)	(0.98)	(10.07)	(0.97)	(21.62)	(17.73)	(1.45)	0.556
32	0.050	0.048	0.055	0.019	0.301	0.102	0.022	0.226
	(1.88)	(2.44)	(2.87)	(1.02)	(20.11)	(7.46)	(0.61)	0.299
34	0.020	0.017	0.037	0.057	0.293	0.130	0.085	0.383
	(0.70)	(1.25)	(1.87)	(2.83)	(23.83)	(7.46)	(2.41)	0.391

Notes. Numbers in the parentheses present t-values. R-squares are for the production function and intermediate function from upper raw. α_{ND} denotes the parameter of daytime population density while α_N does that of daytime population. Other parameter estimates indicate the estimated adopting daytime population density.

Table 3

Implied Estimates of Agglomeration Effects in Industry levels

SIC Code	$\frac{\alpha_{ND}}{1-\alpha_S}$ Urbanization	$\frac{\alpha_S}{1-\alpha_S}$ Scale Economies	$\frac{\gamma_U}{1-\gamma_S}$ Forward Effects	$\frac{\alpha_D}{1-\alpha_S}$ Backward Effects
12	0.057 (4.65)	-0.013 (-1.47)	0.046 (2.41)	0.051 (3.66)
13	0.029 (0.92)	0.064 (3.68)	0.114 (3.45)	0.052 (2.58)
14	0.044 (2.17)	0.041 (3.16)	0.072 (1.80)	0.036 (1.82)
15	0.027 (2.33)	0.038 (2.59)	0.219 (7.15)	0.060 (4.38)
16	0.048 (4.30)	0.023 (1.97)	0.021 (0.74)	0.058 (3.75)
17	0.045 (3.07)	0.020 (1.86)	0.120 (4.22)	0.059 (4.19)
18	0.001 (0.03)	0.053 (3.86)	-0.012 (-0.53)	0.011 (0.96)
19	0.059 (4.15)	0.071 (7.52)	0.127 (6.21)	0.054 (4.65)
20	-0.021 (-0.73)	0.096 (5.44)	0.004 (0.11)	0.027 (1.01)
21	-0.061 (-1.07)	0.137 (3.37)	-0.152 (-1.82)	-0.001 (-0.02)
22	0.012 (0.93)	0.043 (3.76)	0.027 (1.31)	0.034 (2.64)
23	-0.004 (-0.15)	0.057 (3.28)	0.069 (2.61)	0.005 (0.19)
24	0.067 (4.05)	0.031 (2.19)	0.092 (2.85)	-0.015 (-0.36)
25	0.012 (1.18)	0.033 (2.67)	0.098 (5.50)	0.060 (5.06)
26	0.021 (1.28)	0.067 (5.19)	0.125 (5.15)	0.034 (2.46)
27	0.007 (0.02)	0.063 (4.07)	0.011 (0.15)	0.022 (1.82)
28	0.016 (1.76)	0.024 (3.06)	-0.044 (-2.67)	0.039 (4.22)
29	0.037 (3.20)	0.049 (4.28)	0.025 (1.11)	0.028 (2.49)
30	0.042 (3.68)	0.102 (9.68)	0.089 (3.99)	0.047 (2.78)
31	0.020 (1.40)	0.089 (9.25)	0.051 (2.52)	0.014 (0.87)
32	0.053 (3.89)	0.058 (2.71)	0.029 (0.61)	0.020 (0.67)
34	0.020 (1.71)	0.038 (2.47)	0.098 (2.49)	0.059 (1.82)
mean	0.024	0.054	0.057	0.034

Notes. Numbers in the parentheses present t-values.

Figure 1 Urbanization Economies vs. Backward Linkages

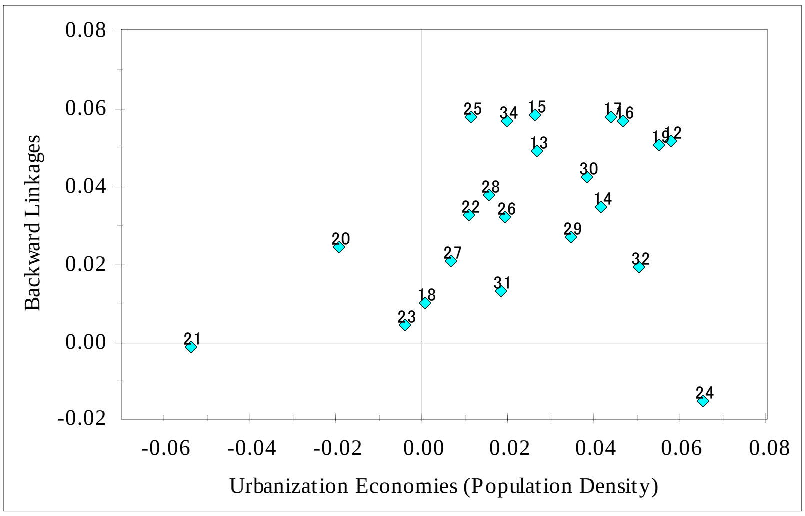


Figure 2 Localization Economies

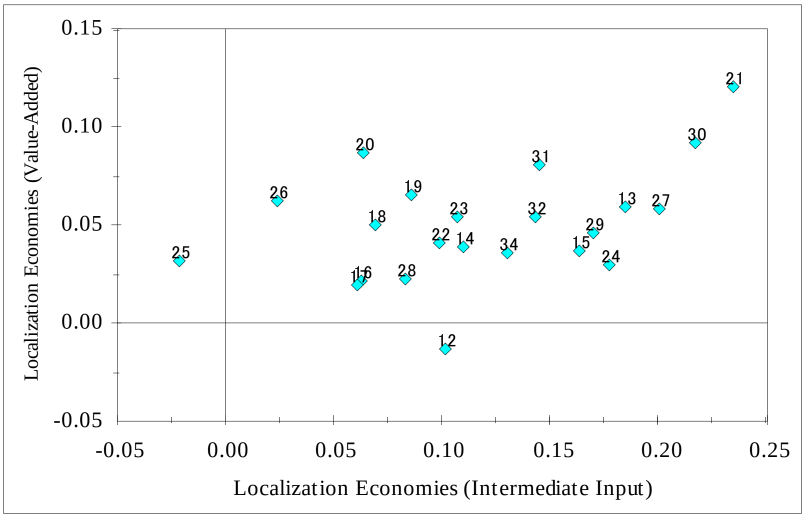


Figure 3 Urbanization Economies vs. Localization Economies

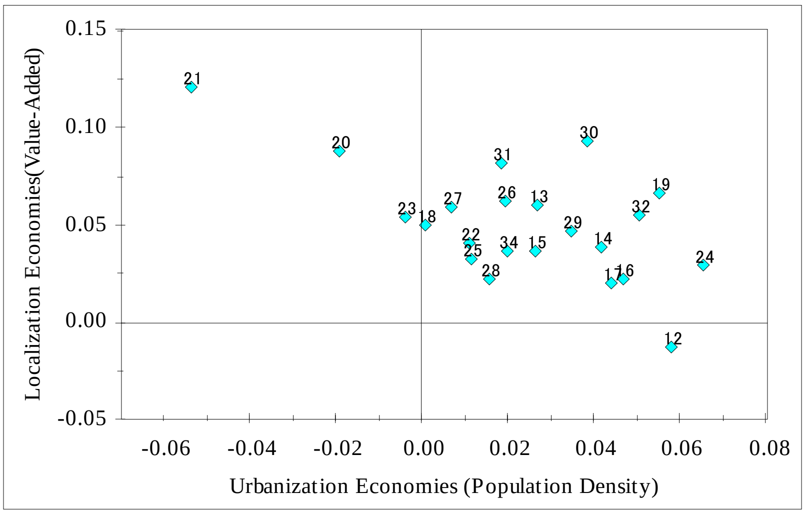
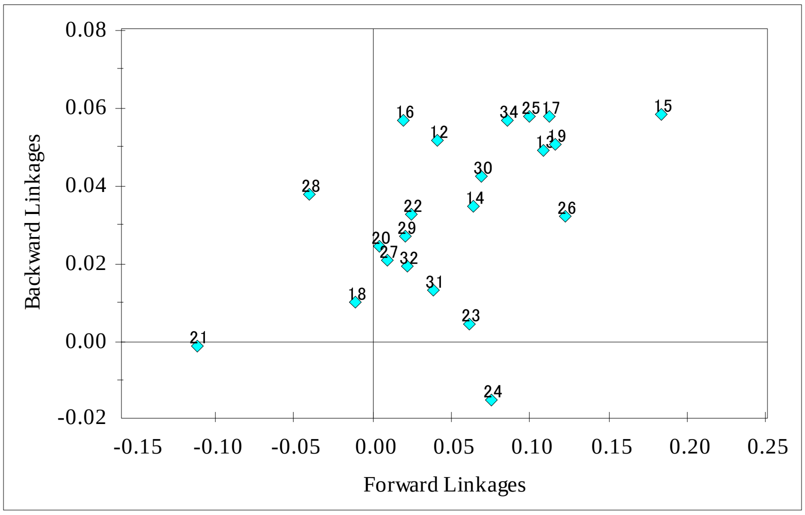
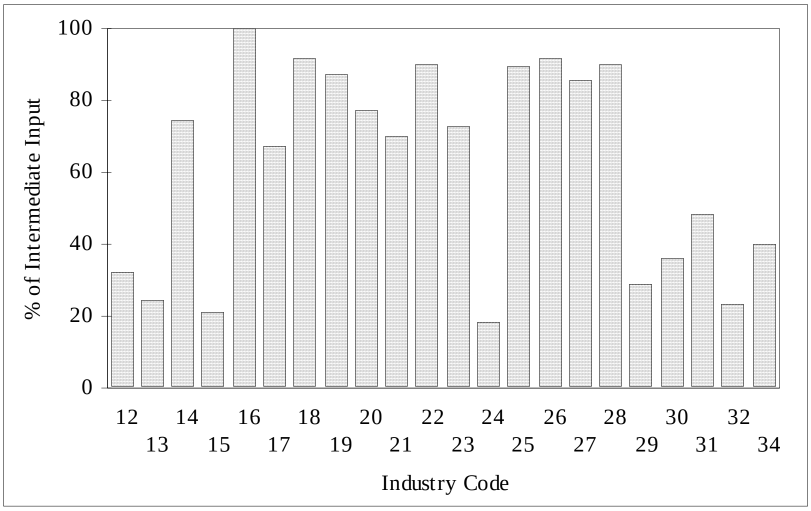


Figure 4 Forward Linkages vs. Backward Linkages:



Appendix: % of intermediate in total input by industries



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