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Changes in Agglomeration Economies and Linkage Externalities for Japanese Urban Manufacturing Industries:1990 and 2000*

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Urban agglomeration economies are usually divided into two categories: urbanization economies and localization economies. In the 1970s and 1980s, a number of attempts were made to estimate urbanization economies and/or localization economies directly in the production function. Since the work by Glaeser et al. in 1992, however, historical effects on agglomeration called dynamic externalities in agglomeration are tried to estimate indirectly by use of the growth equation of urban labor force extensively. These externalities are called MAR in a dynamic sense, whereas traditional agglomeration economies are evaluated in static sense.

Alongside urbanization and localization, more traditional sources of industrial concentration are found in various 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 whereas 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 clarify theose agglomeration concepts, and to construct an estimable model of linkage effects among industries as well as agglomeration economies, and to estimate these effects separately within the framework of the Translog production function. In this model intermediate inputs play an important role as linkage effects. Also, in order to investigate the change of agglomeration economies the estimations are implemented using data for 1990 and 2000.

The empirical analysis is based on two-digit data for manufacturing industries in Japanese cities. The estimated results regarding agglomeration economies vary significantly among the two-digit industries, but most of the agglomeration effects have fallen since 1990.

JEL Classification: R3

Keywords: agglomeration economies, urbanization, localization, linkage externalities, urban productivity

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1. Introduction

In the urban economic context, the characteristics of agglomeration economies have been classified into two categories: localization economies and urbanization economies, both of which are very important factors for the existence of modern cities. Both agglomeration economies are originally stemmed from Marshall's classical textbook of 1920 (Marshall ,1920).

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

Localization economies are often attributed to Marshallian externalities. According to Marshall's textbook, there are three 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," in the Nishijin district in Kyoto is able to construct a kind of Kimono exhibition facility, which is then commonly used as shared input. Localization will also make it 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 frames in a particular agglomerated area such as Ohta-ku in Tokyo can easily find skilled craftsmen already working their.[2] Knowledge spillovers and the resulting innovation involve a different feature of localization economies from the above two examples. In a dynamic context of externalities knowledge spillovers and innovation are typical outcomes of localization economies which are external to firms but 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 these localization economies as *Marshall-Arrow-Romer* externalities.

The geographic concentration of various types of activities in a particular area also brings

[1] A detailed explanation of these sources of agglomeration economies can be found in the review article by Rosenthal and Strange (2004). The theoretical foundations of urban agglomeration are presented by Fujita and Thisse (2002) and Duranton and Puga (2004).

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

economic benefits to firms externally. These economic benefits are called the economies of urbanization, because, as a city expands, more economic activities take place within it. Thus urbanization economies remind us of the diversity of urban activities. Jacobs (1969) states that urban diversity in a densely populated area facilitates face-to-face communication, which yields technological spillovers among agents, and is hence an important driving force of urban growth.[3] In urban productive activities, these urbanization economies are external to individual firms and industries while they are internal to the urban area as a whole.

There exists another benefit for individual firms, and in particular, for smaller firms that locate in a large urbanized area. These firms are then 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) noted, large cities have a role of as a sort of warehouse and this allows smaller firms to specialize in their own production without having to acquire every production tool.

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

On the other hand, like the flip side of a coin, there certainly exist some cost advantages from the concentration of firms. 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 their 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 by 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 the agglomeration of upstream firms is a significant matter to the downstream firms because the proximity of the firms that are suppliers/demanders of their inputs/outputs will cause a saving in transportation cost as a pecuniary externality. These inter-dependencies lead to the agglomeration of economic activities. Toyota city and the surrounding areas in Aichi Prefecture, Japan, provide a good example of this type of

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

agglomeration. In these areas there are very famous automobile company Toyota Corp. and many related industries. According to the regional IO table of Aichi Prefecture in 2000, in an automobile industry about 70% of total intermediate inputs are supplied by 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. Furthermore, forward and backward linkages are mutually dependent, because the downstream firms provide 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 synergistically by the input/cost and output/demand linkages.

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 if there exist intra-industry transactions of intermediate inputs and outputs in a particular area, then this is regarded as a localization economy. Horizontal linkages are one of the sources of localization economies, while vertical linkages make up some parts of urbanization economies.

Demand linkages stand 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 goods or intermediate goods to locate close to the firms that supply those products. Particularly, in urban economics, the 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, because 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

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[4] In Aichi Prefecture there are a number of cars and 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.

(1999) and more recently empirical works on agglomeration effects are summarized by Rosenthal and Strange (2004). Following Rosenthal and Strange, city size effect as urbanization economies on urban productivity ranges from roughly 3 to 8%.[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 in estimating 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 (1998).[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 the cost function of food manufacturing at the US state level incorporating agricultural products 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 a 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 technological externalities as affecting output, whereas pecuniary externalities as doing 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 the recent paper by Rigby and Essletzbichler (2002), their 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

[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).

metropolitan size effects. However, as Henderson et al. (p.92, 2001) stated, empirical studies on agglomeration economies still need to clarify the relationship among the sources of localization economies, linkage externalities, and urbanization economies.

In this paper I extend the production function model to incorporate inter-industry linkage externalities as well as agglomeration economies of urbanization and localization. In next section, I begin to formulate a firm level production function, and to specify the linkage externalities in profit maximizing behavior. The derived demand function for intermediate inputs reflects the linkage externalities of upstream industries, while the value-added production function is subject to an influence from the agglomeration of downstream industries including final demand. Section 3 describes model to be estimated and the data used in the estimation. The empirical results and some interpretations are presented in section 4. Finally, section 5 provides concluding remarks and addresses the direction of further research.

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.

Manufacturing firms produce goods by adding values to intermediate inputs. From the firm's behavior to maximize its value-added, we assume the value-added production function at the individual firm level. The intermediate input is a derived demand which is determined by output level. Hence, the (value-added) production function and the intermediate input (derived-demand) function are expressed 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 of intermediate input, which is called the price index of intermediate input which is assumed to be same for all firms in industry i.

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

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

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 i in which firm j belongs to, $V_i = \sum_j v_{j\in i}$, and E^D is the vector of 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] It is assumed that the labor-market pooling and knowledge spillovers which are the principal features of localization economies are reflected in this variable. The role of city size, N, which is usually measured by city population or population density, is a representative variable suggested by Jacobs, which explain urbanization economies. High population or high population density allows easy face-to–face contact in leisure as well as in business, and this 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 such as capturing market-size effect. The outputs of manufacturing firms are used not only as final demand goods, but also as intermediate input demands 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 mainly demanded by manufacturing firms as an intermediate input rather than as final consumption goods.[10] In modern cities, the areas where manufacturing plants are agglomerated do not necessarily mean (large) urbanized areas.

In turn, $m_{j\in i}$, the left hand side of equation (3), implying the demand for intermediate input, depends upon the price of the intermediate input with a given output level. It is assumed that the price of the intermediate input depends upon the local agglomeration of

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

[10] Of course, among manufactures, the outputs of some industries are mainly demanded as final consumption: for example, apparel, leather products, and electrical machinery. On average, the percentage of intermediate demand to total domestic demand across all manufacturing industries is about 70% according to the national IO table of 2000.

firms in the same industry due to the scale economies of intermediate input production. Thus, the price of intermediate input is a function of the degree of localized intermediate production such as

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

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

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

where the variable E^U, which specifies E in equation (3), stands for the agglomeration of upstream industries which externally shift the intermediate input demand function through forward linkage effects.[11] By a formulation like equation (6), the price effect of the concentration of intermediate input will be captured to some extent 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 equations (4) and (6) directly without individual firm (or plant) level data. In the next section, in order to overcome this difficulty and to identify the agglomeration effects, we aggregate a firm-level specification into the 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 the empirical implementation of the above mentioned model, a functional form must be specified. The functional form adopted here is Translog, which is a 2nd order approximation of the general function, in which constant returns to scale are assumed. The specification of the production function (2) is

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

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 $\left(E_i^D\right)$, respectively. E_i^D, which is

[11] At this point, I dropped the external effects on production function (4) in order to capture clearly the external effects on intermediate input demand.

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).

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

Equation (8) demonstrates that at a firm level the economies of localization are external while industry level localization economies are internalized. This is reflected in the degree of $\left(\alpha_K + \alpha_L\right)/\left(1-\alpha_S\right)$.

The 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 into the industry level, the cost-share equations are rewritten as

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

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

The specification of equation (6) is as follows:

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

where $\gamma's$ are parameters to be estimated and E^U is an appropriately weighted average of other (upstream) industries' activities.[12] 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 define the variables representing demand linkage E^D and input linkage E^U clearly.

First, let us denoted x_{ik} as intermediate input to industry k from industry i, including non-manufacturing sectors at the regional level. The total intermediate input for industry k is

[12] In equation (10) we impose homogeneous degree one restriction $\gamma_K + \gamma_L = 1$ as in the production function.

given by $\sum_i x_{ik}$. Thus the weight of the 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 the value-added for industry k at the regional (prefectural) level.

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

$$E_k^U = \sum_i w_{ik}^U Q_i \tag{11}$$

where Q_i is the output of industry i at the prefecture level. The equation (11), the definition of E_k^U, means the agglomeration of each industry's output which is weighted by the corresponding 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

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

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

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

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

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

and

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

Similarly, equation (11) is

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[13] Q_i, M_i, and, V_i are the values of the regional level. Here region means prefecture which is larger 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. The data for regional output, intermediate input, and value-added by industry are available from the *Annual Report on the Prefectural Account.*

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

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

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 order to investigate the changing effects of agglomeration economies I compare two time periods, 1990 and 2000.

In the estimation main data are from the Census of Manufactures for 1990 and 2000, which provides data for capital, labor, money wage, the value of shipment, the value of intermediate input, and value-added. Capital is measured in terms of tangible fixed assets, labor is the number of employments, and money wages are annual payments to employees. Monetary data are all expressed in ten thousand yens. In the Census of Manufactures the gross value-added is defined as total shipment minus the value of intermediate input including raw material costs.[16]

City size is measured by daytime population from the Census data in 1990 and 2000 because daytime population is preferable to resident population in viewpoint of economic activities.

Intermediate input/intermediate demand x_{ik} and final demand D_i^F all come from the regional IO tables for 1990 and 2000. It is of course preferable to use the regional IO tables by region.

Table 1 shows the industrial classification of manufactures in Japan and the number of the observations used in the estimations of 1990 and 2000.

4. Empirical Results

By estimating equations (13), (14) and (15) for twenty one 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, (b)

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

[16] The value of intermediate input in the Census of Manufactures does not include outsourcing costs such as factory maintenance service. Outsourcing service costs can be identified using the regional IO tables.

localization economies, which are captured by the value-added of an industry and are reflected in the industry production function as scale effects, (c) localization economies, which induce input-cost effects due to high demand for intermediate inputs and are reflected in intermediate input demand function, (d) backward linkage effects, which are the elasticity of productivity with respect to the input-weighted sum of downstream industries' output and final demand, (e) forward linkage effects, which are the productive elasticity with respect to the output-weighted sum of upstream industries.

Table 2 shows estimated parameters of the production function and intermediate demand function for 1990 and 2000. The number of samples in the estimation of each industry and each year corresponds to the number appearing in Table 1.

4.1 Agglomeration Economies and Linkage Effects in 1990 and 2000

In both in 1990 and 2000, most of the industries exhibit positive values for the urbanization parameter. In 2000, industries with t-value over 2.0 are nine industries while in 1990 twelve industries exceed 2.0. The average value of urbanization economies over non-negative industries is 0.028 in 1990 and 0.025 in 2000. Although the average urbanization effect over industries seems to be almost unchanged after ten years, urbanization effects fell in more than half of industries: in particular, in Lumber and Wood Products (SIC-16) and Leather Products (SIC-24) fell significantly. These changing city size effects of urbanization economies can be seen in Figure 1. On the other hand, in some of industries such as Food Products (SIC-12) and Precision Instrument and Machinery (SIC-32) urbanization effects increased. In both years, industries belonging largely to the light industry category such as Food Industry (SIC-12), Beverage Industry (SIC-13), Furniture and Fixtures (SIC-17), and Printing and Publishing (SIC-19) received relatively high urbanization economies. Precision Instrument and Machinery (SIC-32) also received stronger urbanization economies than other machinery industries.

Backward (demand/output) linkage effects, which are caused by the agglomeration of demanders for upstream industries' output, are similar to the concept of urbanization economies, whereas the agglomerated area of demanders does not necessarily correspond to an urbanized area. In 2000, Furniture and Fixtures (SIC-17), Electrical Machinery (SIC-30), Textile Mill Products (SIC-14), Food Products (SIC-12), and Lumber and Wood Products (SIC-16) are the top five industries which enjoy backward (demand) linkage effects. In most of the industries, the magnitude of backward linkage effects fell between 1990 and 2000.

From Figure 2 we can see that only three industries, which are Chemical (SIC-20), Leather Tanning, Leather Products (SIC-24), and Iron and Steel Industry (SIC-26), increased a little in backward/demand effects. We can imagine that some factories, in industries in which the magnitudes of backward effects fell, hah moved abroad to East Asian countries or elsewhere in these ten years, and there were assembling and processing there in order to make products. The average values of backward linkage effects over industries are 0.056 and 0.042 in 1990 and 2000, respectively.

With regard to the economies of localization, which are measured by the industry value-added, the estimated parameters of α_S show the combined effects of labor market pooling and common usage of facilities as capital.[17] All industries except Food Products (SIC-12) show positive signs as anticipated and the average values over industries in individual years are 0.053 in 1990 and 0.048 in 2000. As a contrast to the change in urbanization economies, the degree of localization economies measured by industrial value-added has decreased little between the two years, as seen in Figure 3. Among them three industries, which are Rubber Products (SIC-23), Leather Tanning, Leather Products (SIC-24), and Non-electrical Machinery (SIC-27), decreased significantly in α_S. The reason for these decreases may be the effect of the large Hanshin-Kobe-Awaji of 1995, because earthquake occurred in 1995 because there are among the cities where those industries are now agglomerated, as represented by the city of Kobe.

Also, most of the industries, 18 of 21, show high t-values which are greater than 2.0. Localization economies measured by the industry value-added, as a whole, have stronger effect on productivity in the sense of elasticity than the urbanization economies measured by the city's daytime population.[18]

On the other hand, estimates of γ_S, measured by intermediate input at the industry level, reflect the scale economies of intermediate input demand within the same industry. A large demand for intermediate goods may also generate Marshall's scale economy in intermediate input production. Figure 4 plots parameter estimates of γ_S's for 1990 and 2000. The estimated values increased in eleven industries of the twenty-one industries between the two years. The average values of γ_S over individual industries are respectively 0.097 in 1990 and 0.105 in 2000, which are relatively high compared with other agglomeration effects such

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

[18] This result is consistent with previous studies such as Nakamura (1985) and Henderson (1986), although the difference between localization and urbanization effects has expands recently.

as urbanization and localization. Among others, machinery-related industries such as electrical machinery show relatively higher values, and they increased those magnitudes over these ten years. In these industries it seems that the agglomeration of supply firms for intermediate inputs is effective in assembling parts for manufacturing products.

The concentration of input-supply firms in a particular area may induce forward linkage externalities if intermediate inputs are furnished within the region. The forward linkage effects deriving from input/cost linkages to upstream industries are obtained by estimating an intermediate input demand function (15), not by a production function (13), because the agglomeration of upstream industries affects the intermediate demand of downstream firms through the price effect, rather than through productivity, measured by value-added per worker. Figure 5 shows the forward linkage effects in the two years by industry. The apparel industry and furniture, printing and publishing, ceramics and glass product, and steel exhibit relatively higher values of the forward linkage effect. The average effect of forward linkages over twenty-one manufacturing industries is 0.050 in 2000 and 0.064 in 1990, which means the elasticity of intermediate demand. These values say that demand increases by 0.50% and 0.64% when the agglomeration of upstream industries increases by 10% in each year.

4.2 Comparison among Agglomeration Effects in 2000

In this subsection, the kinds of agglomeration effect which were categorized and estimated in the previous sections are compared using the results for 2000.

We start by comparing between urbanization economies and backward linkages. The relationship between urbanization economies and backward linkage effects is shown in Figure 6 in which the SIC numbers are plotted. The simple average of the estimated values of backward (demand) linkage effects is 0.042, which is greater than the average of urbanization effects, 0.025. The simple correlation coefficient between them is 0.626. This implies that the urbanization proxy by population (density) and the industrial demand linkage measured by regional IO table are different effects on productivity, while those effects are interrelated.

The industries receiving relatively higher backward linkage effects than urbanization economies are Furniture and Fixture (SIC-17), Electrical Machinery (SIC-30), Textile Mill Products (SIC-14), and Lumber and Wood Products (SIC-16). About 50% of Textile output excluding final demand is shipped to Apparel industries. Also, the output of Lumber and Wood Products, Furniture and Fixtures, and Ceramic, Stone, and Clay (mainly limestone) are supplied to the Construction and Building industries. General Machinery (SIC-29) receives backward linkage effects while it does not enjoy urbanization economies. Since most of the amount of output by General Machinery is demanded by Electrical Industry, the agglomeration of electrical industries will yield a backward linkage externality.

Figure 7 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 the two economies (correlation coefficient ranged from 0.454 to 0.468 in each year). In particular, the estimated values of (α_S, γ_S) with respect to Petroleum Products (SIC-21), Transportation Equipment (SIC-31), and Electrical Machinery (SIC-30) are relatively high and statistically significant. Unlike the Petroleum Industry, Transportation Equipment and Electrical Machinery tend to purchase their intermediate inputs from their corresponding industrial groups, which are classified into the same industrial category at the two-digit, more than all other industries, and their average firm sizes are relatively large compared to other industries. This will be the reason for receiving both high intermediate scale and localization economies.

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

Figure 8 plots urbanization economies and localization economies in order to examine their relative importance to the manufacturing firms being located in cities. We can intuitively find a negative relationship between the two economies, i.e., there is a tendency for firms belonging to an industry which enjoys relatively strong urbanization economies to enjoy less localization economies, and vice versa. The correlation coefficient between the two agglomeration economies is negative and -0.667. The simple average of the estimated parameters α_P's over non-negative twenty industries is 0.025 which is smaller than that of the localization parameters α_S's, 0.048. A typical example is found in the Food Products industry in which the urbanization effects located in large and high density cities are the strongest among the twenty-two industries, although localization economies accruing from the concentration of firms in the same industry are fairly small.

The average value of input/cost linkage effects, 0.050, is greater than that of output/demand linkage effects, 0.042, while there are considerable variations among industries with respect to the relative magnitude of linkage effects. Figure 9 plots two linkage effects by industries. Furniture and Fixtures (SIC-17) receives benefits from both agglomerations: backward linkage mainly comes from the urban population as a final demand effect and forward is probably from the concentration of the lumber and wood products industry as an upstream industry.

In investigating the source of the relative strength of forward/backward effects, it will be useful to go back to the industrial input/output transactions. For example, firms producing furniture and fixtures purchase goods from lumber and wood products as intermediate inputs, and companies that print and publish purchase papers from the pulp and paper product industry, also as intermediate input. The Beverage Industry (SIC-13) purchases inputs from the food product industry, and so on. Figure 9 shows that such industries have surely receive relatively high forward linkage effects.

In contrast, by investigating regional IO tables, we see that most of the output of Fabricated Metal Product (SIC-28) is 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 these magnitudes of vertical linkages of industries.

5. Conclusions

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

The estimated results for urbanization and localization economies are similar to those in Nakamura (1985), but the magnitudes of both economies are 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.

Table 3 summarizes the effects of agglomeration economies on the average of all manufacturing industries. All agglomeration effects except intermediate input scale economies fell over the ten years. Only the scale for intermediate input has raised its magnitude as well as indicating the highest value among others. This implies that the volume of intermediate demand is becoming important for manufacturing productive agglomerations.[19]

[19] Of course, not less of intermediate inputs are also purchased from outside the region including foreign countries.

The forward linkages show the second highest agglomeration economies, which are larger than the localization economies. The forward linkage effects are generally stronger than the backward linkage effects, although there are significant differences across industries with regard to the extent to which industries receive agglomeration effects. Both linkage external effects are greater than urbanization and localization economies, while the magnitude of linkage effects has decreased more than that of urbanization and localization economies.

Table 3 Summary of Agglomeration Effects: Industry Average

	Urbanization Economies	Localization Economies	Intermediate Input Scale Economies	Backward Linkage Effects	Forward Linkage Effects
1990	0.028	0.052	0.097	0.056	0.064
2000	0.025	0.049	0.105	0.042	0.050

In modern cities non-manufacturing industries are becoming important for agglomeration economies, and for consumption agglomeration, in particular. This is valid for large metropolitan areas, but in local medium sized cities manufacturing industries still have important roles in obtaining income from outside regions. When local government sets out to vitalize regional economies, it is preferable to do so by forming industrial agglomerations in which there are industrial linkages among industries as well as within an industry. The estimated results in this paper suggest the importance of forming inter-industrial linkage within a city or region, because this 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 the location behavior of firms into the production model. Also time series evidence is necessary to make clear the trend of agglomeration benefit for manufacturing firms. All of these matters will be the important subject future research.

Table 1

Industries at the Two-Digit SIC Level

SIC Code	Industry	# of Obs. 1990, 2000
12	Food Products	633, 643
13	Beverages, Tobacco, and Feed	283, 299
14	Textile Mill Products	304, 299
15	Apparel and Related Products	520, 525
16	Lumber and Wood Products	413, 421
17	Furniture and Fixtures	345, 387
18	Pulp, Paper, and Allied Products	360, 384
19	Printing and Publishing	471, 529
20	Chemical and Allied Products	287, 310
21	Petroleum and Coal Products	61, 55
22	Plastic Products	415, 448
23	Rubber Products	179, 187
24	Leather Tanning, Leather Products, and Fur Skins	87, 81
25	Ceramic, Stone and Clay, and Glass Products	571, 585
26	Iron and Steel Industry	272, 281
27	Non-ferrous Metal Industry	199, 196
28	Fabricated Metal Products	562, 603
29	Non-electrical General Machinery	533, 568
30	Electrical Machinery	554, 565
31	Transportation Equipment	383, 397
32	Precision Instruments and Machinery	244, 245
34	Miscellaneous Manufacturing Industries	N.A.

Note. The difference of the number of observations between 1990 and 2000 is due to several reasons: increase in the number of cities, deficiency of capital stock data or value-added data because of decrease in the number of establishments, and so on.

Table 2
Parameter Estimates of Agglomeration Effects

Year	SIC Code	α_N	α_S	α_D	α_K	γ_S	γ_U	R^2
1990	12	0.059 (4.11)	-0.016 (-1.43)	0.081 (8.18)	0.442 (55.28)	0.080 (6.36)	0.058 (2.66)	0.440 0.440
2000	12	0.068 (4.78)	-0.007 (-0.60)	0.062 (5.73)	0.445 (53.93)	0.097 (8.18)	0.056 (3.05)	0.438 0.409
1990	13	0.050 (3.84)	0.020 (1.34)	0.035 (1.29)	0.528 (39.59)	0.136 (7.35)	0.044 (1.08)	0.480 0.541
2000	13	0.045 (3.80)	0.028 (0.98)	0.031 (1.08)	0.480 (38.43)	0.159 (8.75)	0.102 (2.30)	0.474 0.514
1900	14	0.031 (3.01)	0.037 (4.02)	0.075 (7.61)	0.354 (48.36)	0.088 (3.86)	0.083 (3.58)	0.431 0.440
2000	14	0.026 (2.44)	0.026 (2.47)	0.050 (3.09)	0.324 (42.36)	0.078 (2.88)	0.077 (3.12)	0.385 0.292
1990	15	0.034 (2.73)	0.040 (5.04)	0.071 (8.37)	0.296 (55.19)	0.127 (8.19)	0.158 (7.54)	0.298 0.319
2000	15	0.029 (2.91)	0.033 (3.54)	0.042 (3.79)	0.268 (49.90)	0.112 (7.26)	0.144 (6.45)	0.279 0.310
1990	16	0.046 (4.28)	0.032 (2.08)	0.082 (9.57)	0.353 (53.74)	0.077 (4.34)	0.018 (0.75)	0.269 0.262
2000	16	0.033 (3.41)	0.018 (1.64)	0.062 (4.38)	0.303 (48.43)	0.066 (2.81)	0.029 (1.03)	0.239 0.263
1990	17	0.054 (3.91)	0.033 (2.26)	0.093 (9.69)	0.359 (45.57)	0.083 (3.97)	0.131 (6.10)	0.359 0.307
2000	17	0.046 (2.91)	0.039 (3.26)	0.091 (6.60)	0.285 (42.01)	0.071 (3.37)	0.120 (4.21)	0.349 0.315
1900	18	0.014 (1.03)	0.047 (4.36)	0.024 (2.88)	0.437 (52.73)	0.056 (3.05)	0.016 (0.77)	0.541 0.554
2000	18	0.015 (1.38)	0.046 (4.05)	0.014 (1.40)	0.401 (47.11)	0.080 (4.20)	-0.011 (-0.45)	0.480 0.500
1990	19	0.045 (3.90)	0.059 (7.50)	0.078 (9.85)	0.345 (43.52)	0.094 (7.43)	0.119 (7.10)	0.513 0.479
2000	19	0.048 (4.70)	0.055 (7.41)	0.061 (7.30)	0.326 (39.22)	0.065 (5.64)	0.108 (5.83)	0.487 0.414
1990	20	0.022 (1.53)	0.055 (4.34)	0.017 (1.03)	0.480 (33.86)	0.042 (1.91)	0.035 (0.95)	0.338 0.295
2000	20	0.026 (1.75)	0.058 (5.06)	0.022 (1.85)	0.449 (29.36)	0.055 (3.09)	0.045 (1.20)	0.318 0.301
1990	21	-0.038 (-2.33)	0.095 (3.66)	0.007 (0.20)	0.438 (24.38)	0.148 (6.03)	-0.091 (-1.30)	0.383 0.699
2000	21	-0.033 (-1.99)	0.102 (4.67)	0.005 (0.11)	0.409 (17.98)	0.157 (7.61)	-0.084 (-1.32)	0.354 0.635
1900	22	0.011 (1.09)	0.041 (3.96)	0.070 (6.88)	0.424 (39.57)	0.095 (6.43)	0.076 (3.58)	0.392 0.472
2000	22	0.004 (0.43)	0.045 (4.85)	0.028 (2.82)	0.388 (30.52)	0.101 (7.42)	0.021 (1.09)	0.395 0.477
1990	23	0.008 (0.44)	0.078 (4.59)	0.027 (1.36)	0.404 (31.53)	0.116 (4.78)	0.039 (0.91)	0.365 0.335
2000	23	0.006 (0.35)	0.059 (3.76)	0.008 (0.41)	0.359 (34.15)	0.107 (4.59)	0.074 (1.74)	0.365 0.335
1990	24	0.029 (2.04)	0.068 (3.51)	0.026 (0.65)	0.365 (22.65)	0.167 (5.65)	0.049 (0.68)	0.453 0.497

2000	24	0.019	0.041	0.032	0.340	0.154	0.043	0.434
		(1.42)	(2.28)	(0.85)	(21.64)	(2.66)	(1.29)	0.364
1990	25	0.020	0.058	0.081	0.428	-0.098	0.143	0.449
		(2.14)	(4.19)	(9.28)	(65.32)	(-4.74)	(8.11)	0.384
2000	25	0.011	0.046	0.061	0.407	-0.072	0.094	0.405
		(1.13)	(3.24)	(6.25)	(72.33)	(-3.61)	(4.83)	0.397
1900	26	0.019	0.049	0.037	0.448	0.034	0.173	0.435
		(1.53)	(4.68)	(4.04)	(47.38)	(1.97)	(5.70)	0.375
2000	26	0.017	0.052	0.044	0.367	0.045	0.162	0.414
		(1.30)	(6.03)	(4.01)	(44.72)	(2.17)	(4.89)	0.398
1990	27	0.013	0.033	0.034	0.437	0.034	0.003	0.385
		(0.97)	(2.18)	(2.03)	(40.84)	(2.98)	(0.07)	0.429
2000	27	0.016	0.045	0.020	0.391	0.076	-0.014	0.438
		(1.24)	(3.44)	(1.49)	(37.18)	(5.52)	(-0.30)	0.527
1990	28	0.020	0.037	0.063	0.369	0.079	-0.003	0.383
		(2.19)	(3.51)	(10.08)	(70.54)	(6.77)	(-0.18)	0.324
2000	28	0.014	0.022	0.045	0.335	0.091	-0.043	0.374
		(1.45)	(2.35)	(6.10)	(62.77)	(6.81)	(-2.41)	0.367
1990	29	0.010	0.073	0.073	0.371	0.149	0.061	0.417
		(1.09)	(10.44)	(9.17)	(54.48)	(14.19)	(3.16)	0.429
2000	29	0.001	0.055	0.052	0.330	0.159	0.040	0.371
		(0.10)	(7.39)	(5.62)	(50.42)	(15.05)	(1.97)	0.470
1900	30	0.027	0.073	0.081	0.386	0.165	0.093	0.467
		(2.48)	(7.71)	(7.81)	(53.20)	(11.10)	(4.96)	0.490
2000	30	0.028	0.081	0.072	0.389	0.183	0.069	0.481
		(2.64)	(9.99)	(6.43)	(52.95)	(13.33)	(2.80)	0.429
1990	31	0.004	0.076	0.047	0.375	0.180	0.043	0.433
		(0.36)	(10.07)	(3.97)	(46.19)	(13.64)	(1.47)	0.531
2000	31	0.008	0.077	0.026	0.339	0.198	-0.016	0.430
		(0.71)	(9.86)	(1.97)	(43.07)	(17.24)	(-0.56)	0.556
1990	32	0.037	0.043	0.071	0.357	0.194	0.103	0.426
		(2.39)	(3.46)	(5.58)	(32.86)	(8.89)	(4.14)	0.366
2000	32	0.046	0.044	0.056	0.333	0.206	0.059	0.386
		(3.27)	(3.31)	(3.98)	(26.01)	(8.56)	(1.90)	0.329

Notes. Numbers in the parentheses present t-values. R-squares are for the production function and intermediate demand function from upper row.

Figure 1 Urbanization Economies

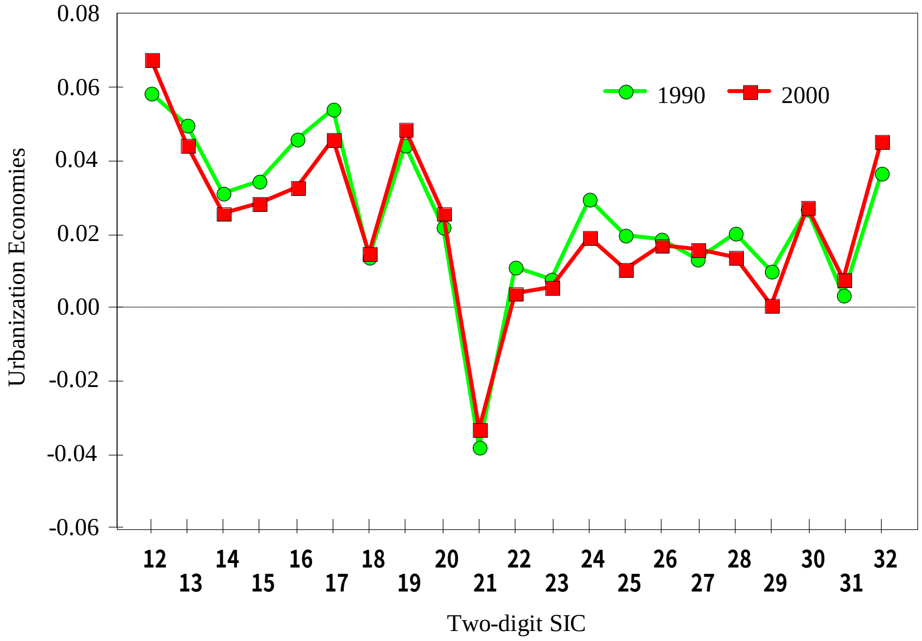


Figure 2 Backward Linkage Effects

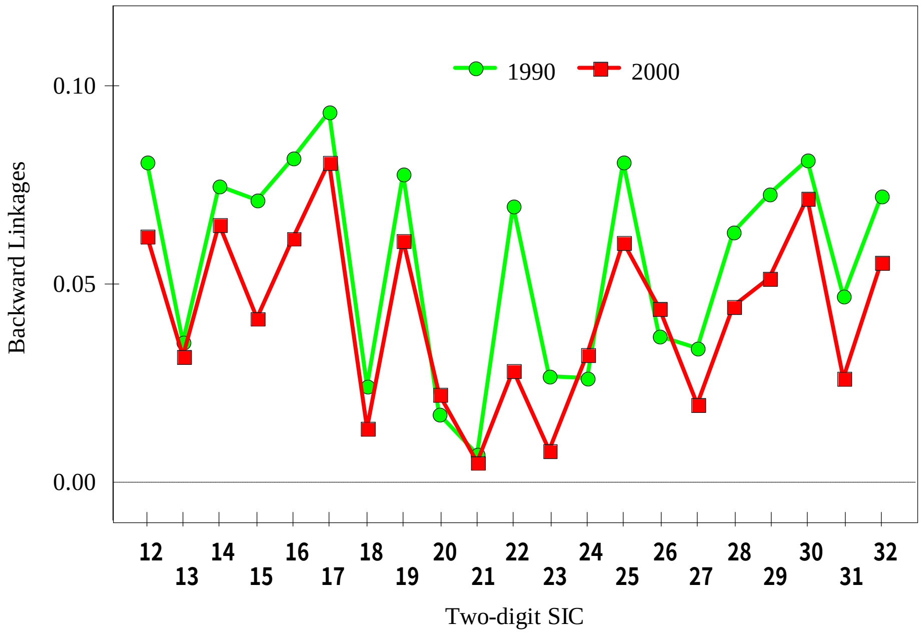


Figure 3 Localization Economies

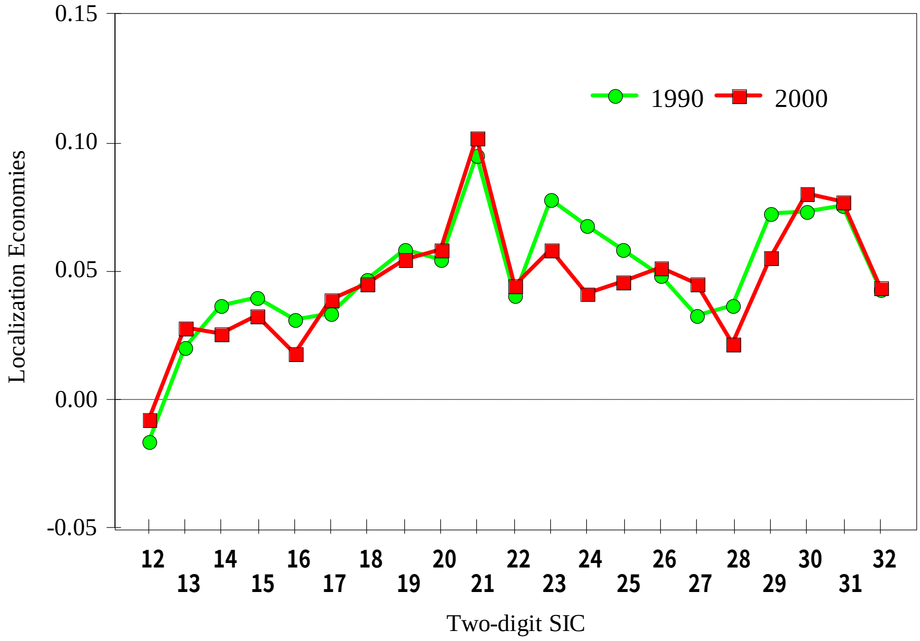


Figure 4 Scale Economies for Intermediate Input

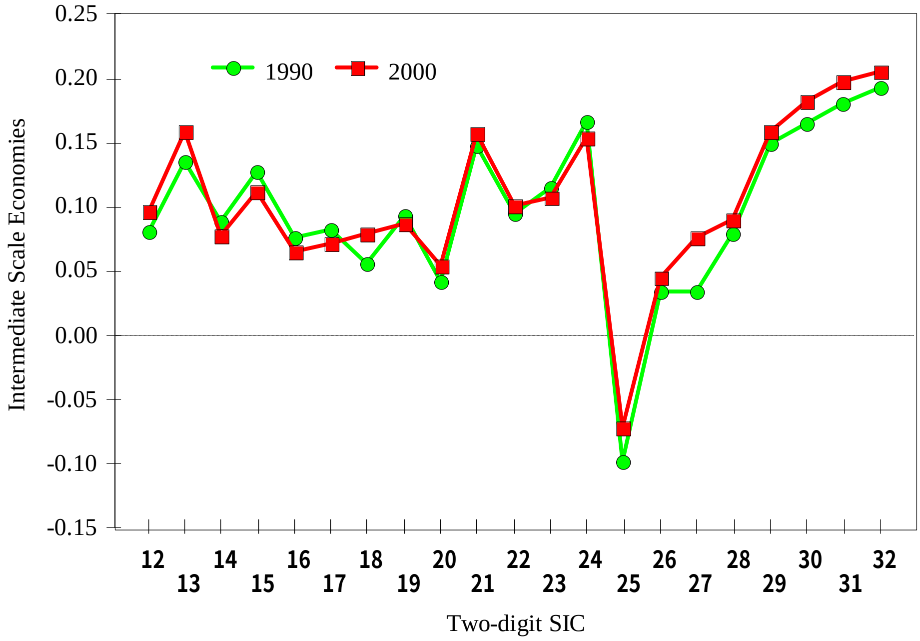


Figure 5 Forward Linkage Effects

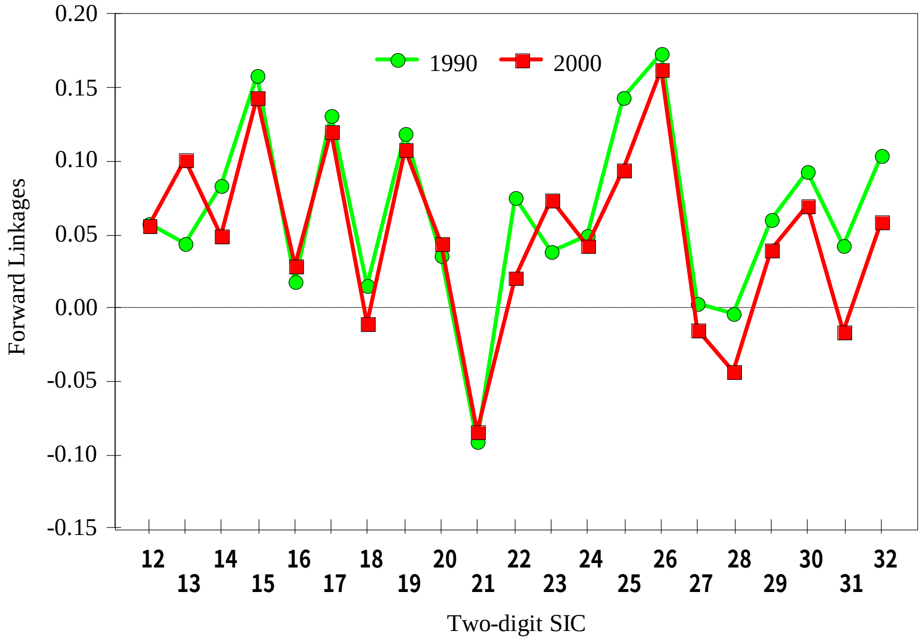


Figure 6 Urbanization Economies vs. Backward Linkages: 2000

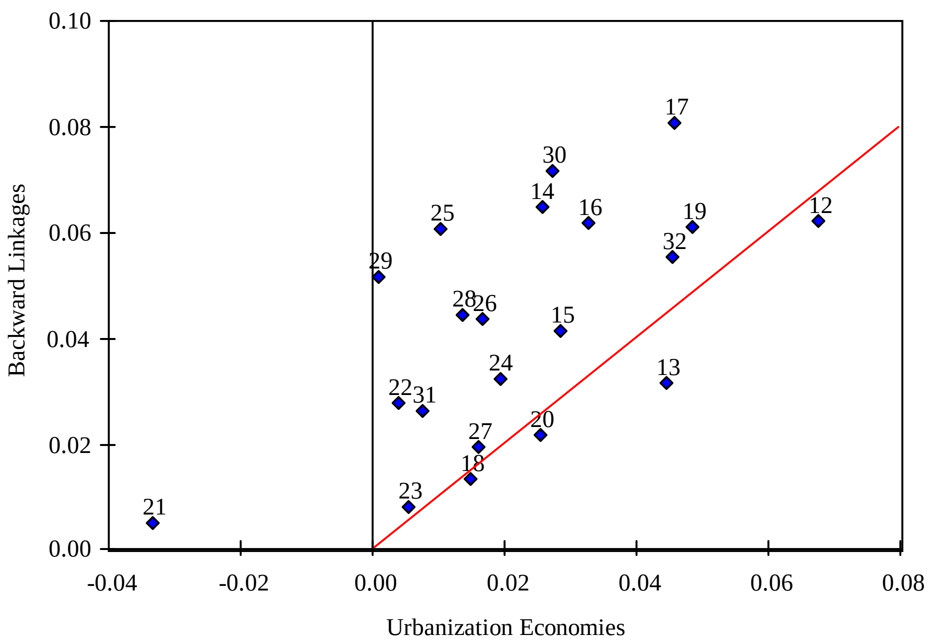


Figure 7 Intermediate Scale Economies vs. Localization Economies: 2000

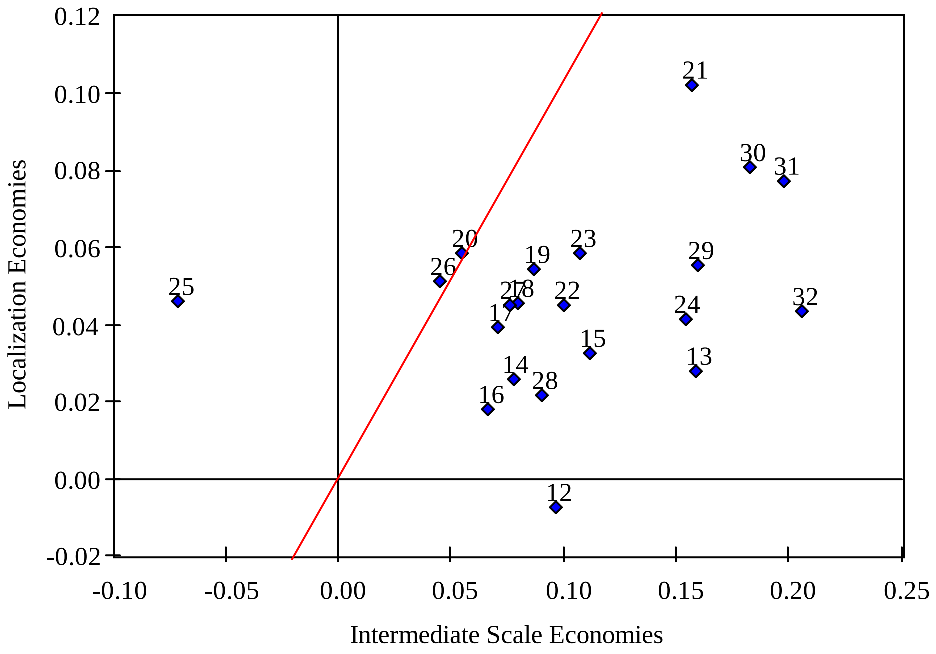


Figure 8 Urbanization Economies vs. Localization Economies: 2000

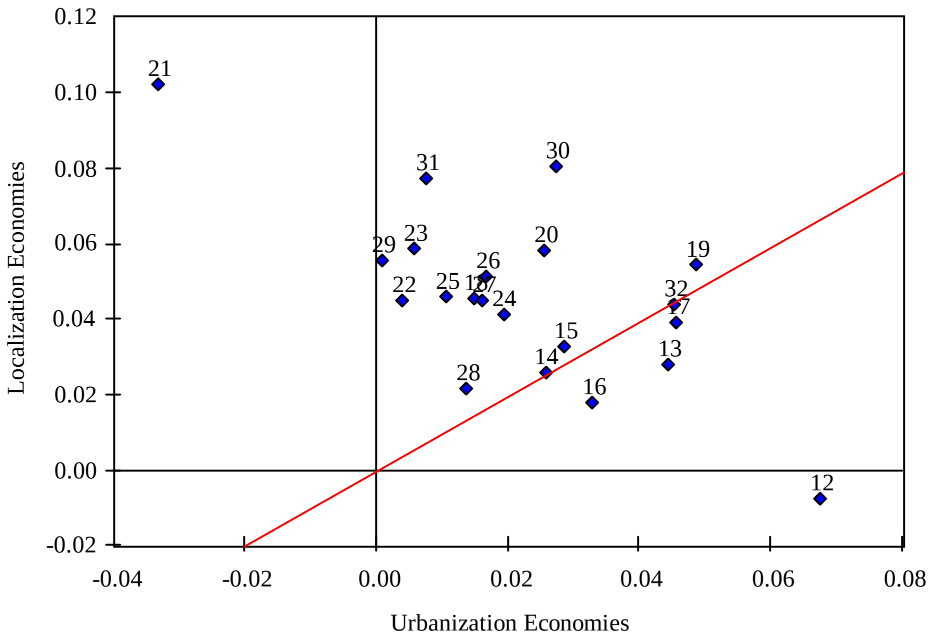
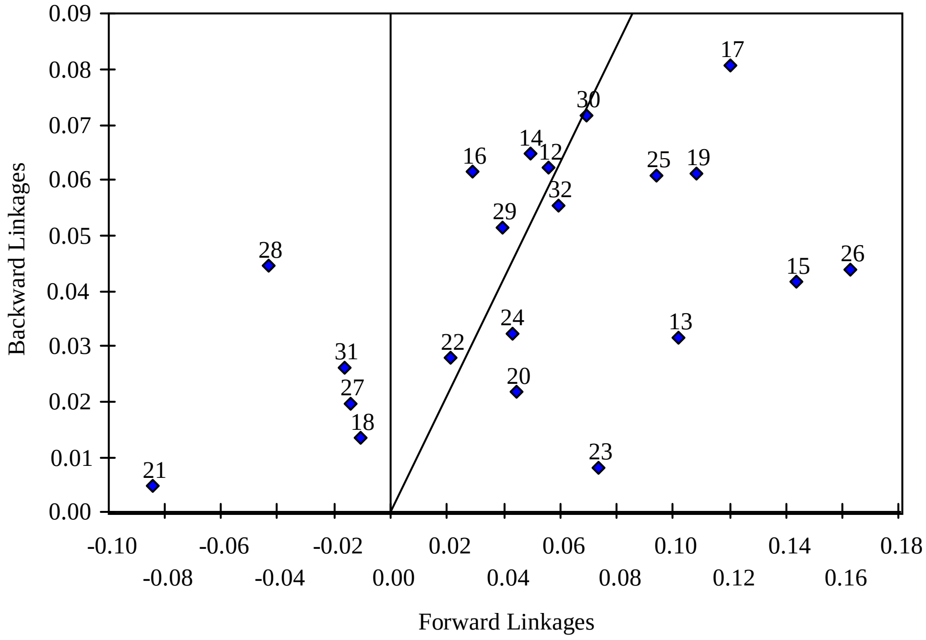


Figure 9 Forward Linkages vs. Backward Linkages: 2000



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