INDUSTRIAL AGGLOMERATION EFFECTS ON REGIONAL ECONOMIC GROWTH: A CASE OF JAPANESE REGIONS

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Industrial Agglomeration Effects on Regional Economic Growth: A Case of Japanese Regions*

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Abstract: This paper sheds empirical light on the relationship between industrial agglomeration economies and regional economic growth and its impact on the convergence of the regional disparities in productivity. An empirical analysis, based on Japanese prefectural data for the period 1980–2002, indicates that industrial agglomeration has significant effects on regional growth. Furthermore, industrial agglomeration contributes to economic convergence in the manufacturing industry, while it contributes to increasing disparities across regions in the non-manufacturing industry. These results suggest that an increase in the share of non-manufacturing sectors has the potential to create such regional disparities.

Key words: Industrial Agglomeration, Regional Economic Growth, Economic Convergence

JEL Classification Numbers: R11, R30, R38

1. Introduction

The importance of industrial agglomeration in achieving regional economic growth has discussed in the field of regional science and urban economics. The effects of industrial agglomeration are defined as the product efficiency derived from spatial and industrial interdependency, and they are usually considered to be external to the decision-making process of firms. The nature and sources of industrial agglomeration effects are summarized in Rosenthal and Strange (2004), which discusses this important concept in an organized manner. The empirical studies included in Rosenthal and Strange (2004) investigate whether industrial agglomeration effects are related to the concentration of an industry and/or to city size. Various studies have attempted to identify the impact of industrial agglomeration on labor productivity from the

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viewpoint of city size, demonstrating that a 100 percent increase in the city size is likely to increase labor productivity by 3 to 8 percent. Shefer (1973), Sveikauskas (1975), Segal (1976), Moomaw (1981), Moomaw (1983), and Tabuchi (1986) observe that labor productivity is generally higher in the larger cities. Calino (1979), on the other hand, reveals that population scale has a negative effect on productivity, causing diseconomies rather than economies of agglomeration.

These industrial agglomeration effects are conceptually classified into localization and urbanization economies. Localization economies are those agglomeration effects that accrue to a group of firms that belong to the same industrial sector and are located at the same place. Such externalities are internalized and are realized as economies of scale at an industrial level. Urbanization economies are agglomeration economies that accrue to firms across various sectors. These externalities work as external economies at an industrial level. The empirical impact of localization and urbanization on productivity is examined by Nakamura (1985) and Henderson (1986). Nakamura (1985) estimates the effects of urban agglomeration economies on the productivity of two-digit manufacturing industries by employing the cross-section data pertaining to Japanese cities from the year 1979. He concludes that a 100 percent increase in industry scale as localization economies leads to an increase of 4.45 percent in productivity, while a 100 percent increase in city population as urbanization economies leads to an increase of 3.36 percent. Henderson (1986) estimates the nature and extent of agglomeration economies with respect to two-digit manufacturing industries by employing cross-section data for the U.S. and Brazil, noting that there is almost no evidence of urbanization economies but substantial evidence of localization economies in these countries. Recently, Henderson (2003), on the basis of plant-level data for the U.S., has found localization economies to be stronger.

There is another way to specify the sources of industrial agglomeration effects, i.e., by taking into consideration the degree to which a city’s employment is specialized on the basis of a labor demand function. Glaeser et al. (1992) consider the employment growth of the industries in U.S. cities for the period 1956–1987 and find that diversity, and not regional specialization, encourages employment growth. They suggest that important knowledge spillovers might occur between, rather than within, industries. This view is consistent with the theories of Jacobs (1969). Henderson et al. (1995) consider employment growth for the period 1970–1987 and estimate it separately for two types of industries: those that are mature capital goods industries with stable technologies and those that are rapidly evolving, new high-technology industries. It is shown that there is a positive effect of specialization, though not of diversity, for the mature capital goods industries, while there is evidence of urbanization economies in the new high-technology industries. Moreover, Henderson (1997) estimates agglomeration economies on the basis of data for five capital goods industries in the U.S., finding strong evidence of localization economies but little evidence of urbanization economies. Combes (2000) considers the effects of industrial agglomeration on the local employment growth in France for the period 1984–1993 and finds that sharp differences exist between the results of agglomeration economies in the manufacturing and service industries. In the manufacturing industry, both specialization and diversity have negative impacts on growth in all but a few sectors. In the service industry, specialization continues to have a negative effect, although the effect of diversity has become positive.

In the context of Japanese industries, Mano and Otsuka (2000) attempt to identify the factors that affected the changing patterns of industrial agglomeration during the period 1960–1995. Using prefectural data pertaining to the manufacturing industry, the analysis confirms a decline in the number of existing agglomeration economies. Moreover, they reveal that increasing competition with service sectors has had pervasive impacts on the geographical dispersion of manufacturing industrial sectors. On the basis of data pertaining to 47 Japanese prefectures for the period 1975–1995, Dekle (2002) obtains the same findings as Mano and Otsuka. By estimating the labor demand functions for Japan at the one-digit level, Dekle demonstrates that agglomeration economies are almost nonexistent in the manufacturing industry but existing in the non-manufacturing industry, particularly in the finance, service, and wholesale and retail trade sectors. He thereby concludes that the cross-fertilization of ideas is important, particularly for the non-manufacturing industry, and that there is a tendency toward further geographical concentration in service sectors such as the financial services sector.

These empirical studies report that firms in high-scale areas benefit from industrial agglomeration and that agglomeration effects vary by industry. In particular, industrial agglomeration tends to have stronger influence on non-manufacturing industries, such as service sectors, than manufacturing industries in Japan. And the majority of studies demonstrate that for manufacturing industries, localization economies are more advantageous for production than are urbanization economies, while for non-manufacturing industries, urbanization economies tend to have a stronger influence than localization economies.

This paper is organized as follows. Section 2 discusses research purposes of this study. Section 3 provides an empirical method for analyzing agglomeration economies. Section 4 builds an estimation model and considers the impacts of industrial agglomeration on Japanese regions. Section 5 concludes the paper.

2. Research Purpose

This study extends these previous studies on agglomeration economies regarding two points using the Japanese prefecture level data of industries (manufacturing and non-manufacturing). Hence, the purpose of this paper is twofold. First, we estimate the impact of industrial agglomeration on productivity growth with respect to Japanese regions. Although localization and urbanization economies, which are the major forms of economies found in urban areas, have been considered separately in empirical studies, this study incorporates both types of economies into our model. That is, by employing Japanese prefectural data for the period 1980–2002, we attempt to provide, on the basis of an estimated production function, sufficient clarification of the manner in which agglomeration accelerates economic growth in regions. In particular, we consider the influence of market access while measuring the effects of agglomeration. With regard to the measuring of agglomeration economies, the recent classification of agglomeration economies provided by Parr (2002) incorporates linkage externalities, in addition to localization and urbanization economies. Using agglomeration theory, it has been clarified that the best location for firms should be determined on the basis of market demand and transportation cost and that market linkages affect economic performance through backward and forward linkages (Fujita, 1988; Rivera-Batitz, 1988; Krugman, 1991; and Venables, 1996). Davis and Weinstein (1999), employing Japanese prefectural data, reveal that the extent of geographic concentration depends on the size of the market demand in the concerned region. Nevertheless, this effect has not necessarily been included in the estimations of agglomeration effects as a result of the limitations of the available data, particularly the lack of data on the economic distance between regions.

Secondly, we verify whether interregional disparities are influenced by the improvement in productivity of regional industries that result from industrial agglomeration. That is, we clarify the contribution of industrial agglomeration to the convergence of regional disparities in labor productivity. In Japan, "balanced development of the nation" has been regarded as a policy target for realizing economic growth, and several programs that aim to decrease regional disparities have been formulated. In order to promote local decentralization of high-productivity industrial sectors, the government has developed transportation facilities, industrial sites, and other infrastructure and taken various support measures such as assisting technological development. To evaluate these policies, it is first necessary to assess the extent to which industrial agglomeration contributes to growth in the process of economic convergence. In addition, the wide-ranging interest in regional income disparities has gained a renewed emphasis since the 1980s. Empirical studies concerning convergence are reviewed by Magrini (2004) and Benos and Karagiannis

(2008). A large number of empirical studies have investigated growth rate differentials across countries and regions with respect to the last few decades, focusing on the evolution of economic disparities and the process of convergence among regions. Recently, the research on convergence has begun to focus on the importance of the factors that cause convergence among regions. On the basis of a decomposition analysis, Kilicaslan and Ozatagan (2007) examine the impact of relative population change on regional income convergence in Turkey. They reveal that the existence and pace of regional income convergence may well be related to the degree of relative population change. From the viewpoint of agglomeration economies, Bosker (2007) has been verified whether industrial agglomerations influence interregional disparities in productivity. Concretely, using a sample of 208 European regions over 25 years, ‘standard’ growth regressions are estimated using panel data techniques. And the paper indicates the existence of convergence thorough industrial agglomeration effects. In this paper, we adopt more easily computable method for industrial agglomeration effects on convergence. That is, we attempt to show convergence by decomposing the ‘standard’ growth regressions using cross-section techniques.

3. The Analytical Framework

In general, the production function for estimating industrial agglomeration effects is based on two assumptions. First, it is assumed that agglomeration economies are external factors in the production functions of firms. Second, it is assumed that each firm in the same industry uses identical technology. Further, the production functions to be estimated at the industrial level are obtained by aggregating the production functions of all the firms.

The value-added production function at the firm level is defined as follows:

$$y = g(Z)\, f(k, l), \tag{1}$$

where y is value-added, k denotes the capital input, and l denotes the labor input. Note that $g(Z)$

represents the external economies to a firm and shifts the production function $f(k,l)$. It is assumed that firms are competitive and have a homogeneous production function. Therefore, firms in different regions also have identical production technology.

As mentioned above, agglomeration economies are categorized as localization and urbanization economies. The scale of industrial production Y ($\equiv \sum y$) is adopted as a proxy variable for localization economies. Further, the population density *DENSE*, which is the total population of a region divided by the area of land under use, is used as a proxy variable for urbanization economies.

Next, market access is defined by the following index, which will enable us to measure the spillover effects:

$$ACC_j \equiv \sum_{k \neq j} \left[\left(d_{jk}^{-1} \Big/ \sum_{k \neq j} d_{jk}^{-1} \right) \cdot Q_k \right],$$

where d_{jk} represents the economic distance between regions j and k. The gross output Q_k is used to capture the local market demand. The leading characteristic of this index is that the extent of market access is evaluated not only by market size but also by the economic costs incurred to access the markets.

The agglomeration economies $g(Z)$ are specialized as

$$g(Z) = \alpha_0 DENSE^{\alpha_D} Y^{\alpha_S} ACC^{\alpha_A}, \tag{2}$$

where α_0, α_D, α_S, and α_A are parameters. Table 1 summarizes the forms of agglomeration economies. In this specification, the effect of market demand on labor productivity can be captured independently, i.e., in terms of the influences of home and outside markets. In other words, the influence of the home market is measured as the agglomeration effects, while the influence of the outside market is measured as the spillover effects.

(*Insert Table 1 here*)

Previous studies such as Nakamura (1985) estimate agglomeration economies in terms of localization and urbanization economies, which they treat as separate entities, through the use of the translog production function. Nakamura (1985) states that it is preferable to adopt this function form because it is more flexible than the Cobb–Douglas production function and other types of function forms. Thus, this paper examines the agglomeration economies using this function form. In this function form, the agglomeration economies of both types, i.e., localization and urbanization economies, are external economies at the firm-level. However, at the industrial–level, localization economies are internalized and the two types of agglomeration economies are separated, while market access is determined by the external economies

The following translog functional form is used to estimate the equations:

$$\ln y = \alpha_1 + \alpha_D \ln DENSE + \alpha_S \ln Y + \alpha_A \ln ACC + \alpha_K \ln k + \alpha_L \ln l$$
$$+ \frac{1}{2}\beta_{KK}(\ln k)^2 + \frac{1}{2}\beta_{LL}(\ln l)^2 + \beta_{KL}(\ln k)(\ln l), \tag{3}$$

where the α 's and β 's are parameters to be estimated. The homogeneity restriction implies that $\beta_{KK} + \beta_{KL} = \beta_{LL} + \beta_{KL} = 0$, and the symmetric restriction is given by $\beta_{KL} = \beta_{LK}$. Furthermore, the constant returns to scale is given by $\alpha_K + \alpha_L = 1$. If the parameters α_D, α_S, and α_A are positive, the implication is that respective factor has a positive influence on productivity, while if these parameters are negative, the implication is that agglomeration economies and market access have a negative influence on productivity.

Based on the assumption of identical and constant returns to scale technologies, the production function at the industrial level can be obtained by aggregating the production function of each firm as follows:

$$(1-\alpha_S)\ln Y = \alpha_0 + \alpha_T t + \alpha_D \ln DENSE + \alpha_A \ln ACC + \alpha_K \ln K + \alpha_L \ln L$$
$$+ \frac{1}{2}\beta_{KK}(\ln K)^2 + \frac{1}{2}\beta_{LL}(\ln L)^2 + \beta_{KL}(\ln K)(\ln L).$$

The following equation is obtained by dividing both sides of the above equation by $1-\alpha_S$, subtracting $\ln L$, and using the homogeneity restriction, the symmetric restriction, and the constant–returns–to–scale:

$$\ln\frac{Y}{L} = \frac{\alpha_0}{1-\alpha_S} + \frac{\alpha_T}{1-\alpha_S}t + \frac{\alpha_D}{1-\alpha_S}\ln DENSE + \frac{\alpha_A}{1-\alpha_S}\ln ACC$$
$$+ \frac{\alpha_K}{1-\alpha_S}\ln\frac{K}{L} + \frac{\alpha_S}{1-\alpha_S}\ln L + \frac{1}{2}\frac{\beta_{KK}}{1-\alpha_S}\left(\ln\frac{K}{L}\right)^2, \tag{4}$$

where $K\,(\equiv \sum k)$ and $L\,(\equiv \sum l)$ are the capital and labor inputs, respectively, at the industrial level.

The translog production function yields the following input share equations:

$$\frac{\sum r \cdot k}{Y} = \alpha_K + \beta_{KK} \ln \frac{K}{L} \tag{5}$$

and

$$\frac{\sum w \cdot l}{Y} = \alpha_L + \beta_{KL} \ln \frac{K}{L}, \tag{6}$$

where r and w are the capital cost and wage rate, respectively.

4. Estimating the Industrial Agglomeration Effects

4.1. Data

The data set comprises Japanese prefectural data pertaining to the manufacturing and non-manufacturing industries for the period 1980–2002. Although there are a large number of related regional statistics, it is necessary to compile data from various sources in order to obtain an appropriate set of estimates. The data for this paper is gathered primarily from the Japanese Annual Report on Prefectural Accounts, which is compiled by the Economic and Social Research Institute, Cabinet Office.

Industrial value-added is measured as the nominal value-added deflated by the value-added deflator reported in the System of National Accounts (SNA). We are retroactive and estimate the data before 1990 because we are able to use only the data after 1990 in official statistics. Labor inputs are represented by man-hours. Man-hours are the hours worked indices by industry (Total hours worked) reported in Monthly Labour Survey that is published by Ministry of Health, Labour and Welfare. Capital inputs comprise the fixed capital stock adjusted by its rate of utilization. The fixed capital stocks are obtained from the CRIEPI database[1] in which the stocks are estimated on the basis of gross investment by using the perpetual inventory method. The available data is limited to data pertaining to the manufacturing

[1] http://criepi.denken.or.jp/en/serc/products/database.html

and non-manufacturing industries. The utilization rate—which is the production capacity of a unit of fixed assets—for the manufacturing industry is derived from a set of indexes of the operating ratio that is published by METI. With regard to the non-manufacturing industry, the inverse of the capital coefficient is used to calculate the utilization rate. The interannual variability of the logarithm value of the inverse of the capital coefficient becomes constant in the long term. The rate of deviation from this interannual variability is used as the utilization rate. Labor cost is the total compensation provided to employees, comprising salaries and wages in cash or kind, other employee benefits, and the compensations required by law. Capital services are given by $p_K(r+d)/[1-\tau]$, where p_K is an investment deflator; r, an interest rate; d, an industry- and year-specific depreciation rate; and τ, a corporate tax rate. Economic distance is adopted as the distance weight. The data on economic distance is based on highway travel time. According to "Physical Distribution Census 2000," vehicular transportation accounts for 81.7 percent of Japan's shipment share. On the other hand, the shares of marine, air, and rail transportation are a mere 13 percent, 4.2 percent, and 1.2 percent, respectively. These findings imply that the cost of using vehicular transportation is the most appropriate data with which to determine economic distance. Gross output is measured as the nominal gross output deflated by the gross output deflator.

Figure 1 briefly presents the characteristics of the industrial structure in Japanese prefectures. The production share of the manufacturing industry in terms of regional gross value–added increased during the period 1980–2002 in the majority of the prefectures. However, the prefectures where this share decreased are limited to those containing large metropolitan areas with a high share of value–added, such as Saitama, Tokyo, Kanagawa, Osaka, Hyogo, Nara, and Fukuoka. In addition, the growth contribution of the manufacturing industry exceeds that of the non-manufacturing service sector in the majority of the local regions that have a low proportion of value-added. Although the share of value–added in national economies is low, this finding indicates that the manufacturing industry still plays a major role in the regional economic growth of non-metropolitan regions.

(*Insert figure1 here*)

4.2. Regional growth

Adding the regional and time-specific dummies to the production function in (4), the panel estimation model can be written as:

$$\ln\frac{Y_{jt}}{L_{jt}} = \frac{\alpha_0}{1-\alpha_S} + \frac{\alpha_D}{1-\alpha_S}\ln DENSE_{jt} + \frac{\alpha_A}{1-\alpha_S}\ln ACC_{jt}$$

$$+\frac{\alpha_K}{1-\alpha_S}\ln\frac{K_{jt}}{L_{jt}} + \frac{\alpha_S}{1-\alpha_S}\ln L_{jt} + \frac{1}{2}\frac{\beta_{KK}}{1-\alpha_S}\left(\ln\frac{K_{jt}}{L_{jt}}\right)^2 + \sum_{p=1}^{n}\frac{\alpha_{T,p}}{1-\alpha_S}\cdot regdum_j^{\ p}\cdot t$$

$$+\sum_{p=2}^{n}\alpha_P\cdot regdum_j^{\ p} + \sum_{\tau=2}^{T-1}\alpha_\tau\cdot timedum_t^{\ \tau} + \varepsilon_{jt}\,, \tag{7}$$

where $t = 0,\cdots,T$ and $j = 1,\cdots,n$. In addition, n is the number of regions. It is assumed that technological progress differs across prefectures due to differences in the regional industrial policies. Thus, the prefectural dummy variable *regdum*, multiplied by the time trend t, is included as an independent variable in (7). The value of *regdum* takes one for $p = j$ and zero for $p \neq j$. *Timedum* is a time dummy used to control for business-cycle effects. This variable takes one for $\tau = t$ and zero for $\tau \neq t$.

Klette and Griliches (1996) and Klette (1999) explain that the fact that the production factor is endogenous in the estimation of the production function causes a bias in the ordinary least squares (OLS) estimator. They point out the following two concrete points. First, demand—the influencing element of productivity shock—introduces an upper bias to the OLS estimator. Second, the measurement error of data introduces a lower bias to the OLS estimator. To address the problem of the endogeneity of the production factor, this paper has chosen to use the iterative three-stage least squares (3SLS) method from among all the possible estimation methods. That is, the estimation of the translog production function in (7) and the labor cost share function in (6) is conducted by using the 3SLS method with instrumental variables. The estimation results are summarized in Table 2. To test for the sensitivity of the findings to different estimation techniques, Table 2 presents the OLS estimation results as an alternative estimation method. For each parameter, the upper row contains the estimated value, while the lower row contains the *t* value (enclosed in parentheses). We employed F-statistics to test whether fixed and time effects exist—the null hypothesis that the two effects do not exist is rejected for both the manufacturing and non-manufacturing industries. In addition, the null hypothesis that a spatial error does not exist is not rejected in the Lagrange multiplier (LM) test, which was conducted in order to examine whether the influence of a spatial error exists.

(*Insert Table 2 here*)

The parameter for localization economies (α_S) is significant and has a positive sign for both the industries. The positive value of α_S for the manufacturing industry is 0.0678; or the non-manufacturing industry, it is 0.0803. These findings imply that labor productivity increases by approximately 7 to 8 percent when the industrial scale doubles. These parameters are greater than the parameter for urbanization economies (α_D). The positive value of α_D for the manufacturing industry is 0.0442; for the non-manufacturing industry, it is 0.0268. These positive parameters for agglomeration effects demonstrate that industrial agglomeration positively affects labor productivity. In particular, the parameters imply that as a whole, the agglomeration benefits that arise from specialization are more significant than those that arise from diversity. The parameter for market access (α_A) also shows a positive sign for both the industries, and it is greater than the values of both localization and urbanization economies. These findings imply that linkages with other markets are an important factor in both the industries[2].

The impact of industrial agglomeration on regional economic growth is obtained by using these

[2] According to Harrington and Warf (1995), local demand could be an important driver for the service sector because this sector is, to a large extent, reliant on face-to-face contact, which leads to high transport costs for service delivery.

estimated coefficients. The growth rates of a regional economy are generally divided according to the contributions of capital, labor, and total factor productivity (TFP) (Solow 1957). Agglomeration economies are contained in the TFP, which represents productivity growth or product efficiency. The difference between the initial and final period terms in the production function in (7) yields the following equation:

$$\frac{1}{T}\ln\left(\frac{Y_{jT}}{Y_{j0}}\right)=\frac{\theta_{K,j}}{T}\ln\left(\frac{K_{jT}}{K_{j0}}\right)+\frac{\theta_{L,j}}{T}\ln\left(\frac{L_{jT}}{L_{j0}}\right)$$

$$+\left[\alpha_{T,j}+\frac{\alpha_S}{T}\ln\left(\frac{Y_{jT}}{Y_{j0}}\right)+\frac{\alpha_D}{T}\ln\left(\frac{DENSE_{jT}}{DENSE_{j0}}\right)+\frac{\alpha_A}{T}\ln\left(\frac{ACC_{jT}}{ACC_{j0}}\right)+\frac{1-\alpha_S}{T}\left(\varepsilon_{jT}-\varepsilon_{j0}\right)\right], \tag{8}$$

where $\theta_{K,j}$ and $\theta_{L,j}$ represent the factor elasticity of production. The terms on the right-hand side of the equation correspond to the degree of contribution to value-added growth in capital and labor inputs, technological progress, economies of scale, population density changes, and market access changes, respectively. The Solow residual is the summation of the terms in brackets. The last term is the error component. From the translog production function, the output elasticities of the production factors are obtained as follows:

$$\theta_{K,j}=\alpha_K+\frac{\beta_{KK}}{2}\left(\ln K_{jT}+\ln K_{j0}\right)+\frac{\beta_{KL}}{2}\left(\ln L_{jT}+\ln L_{j0}\right), \tag{9}$$

$$\theta_{L,j}=\alpha_L+\frac{\beta_{KL}}{2}\left(\ln K_{jT}+\ln K_{j0}\right)+\frac{\beta_{LL}}{2}\left(\ln L_{jT}+\ln L_{j0}\right). \tag{10}$$

The growth contribution of localization economies is relatively high in the areas that specialize in the manufacturing industry, such as Aichi, Shizuoka, and Mie prefectures (figure 2). In Japan, there have been secular changes in the location of manufacturing firms, i.e., they have shifted away from large metropolitan areas. Further, the geographical dispersion of manufacturing firms continued both domestically and internationally between the 1980s and 1990s. Therefore, this evidence implies that the geographical dispersion to non-metropolitan areas had enforced the production scale in those areas. In the prefectures with large metropolitan areas, such as Tokyo, Kanagawa, and Osaka prefectures, the effects of localization economies on growth are small with respect to the manufacturing industry, while the non-manufacturing industry receives considerable benefits from localization economies. In particular, the growth contribution of localization economies in the National Capital Region—including Saitama, Chiba, Tokyo, and Kanagawa prefectures—is 0.26 percent per year on average. This evidence implies that the non-manufacturing firms that are located in regions with a high share of gross value-added receive benefits from the economies of scale. On the other hand, the growth contribution of urbanization economies to the manufacturing industry is 0.01 on average, while that of localization economies has fallen below 0.20 percent. Similarly, the growth contribution of the urbanization economies to the non-manufacturing industry is 0.00 on average, while that of localization economies has fallen below 0.18 percent. These findings indicate that the growth contribution of urbanization economies is weak as compared to that of localization economies; therefore, urbanization economies could not be a driving force in regional economic growth (figure 3). This result implies that the geographical concentration of an industry is more important for growth than the diversity of the industrial structure. The implication is consistent with previous studies such as Nakamura (1985) and Henderson (1986, 1997, 2003), particularly with respect to the manufacturing industry. On the other hand, the result is inconsistent with previous studies such as Mano and Otsuka (2000) and Deckle (2002), which demonstrate that urbanization economies tend to have a stronger influence on industrial growth than do localization economies. Further, in both the industries, market access as spillover effects is a more important factor in industrial growth than are agglomeration economies (figure 4). In particular, the growth contribution of market access is greater not only in the areas where factories are concentrated but also in large metropolitan areas such as Tokyo, Osaka, and Kanagawa, and it exceeds the effect of localization economies in almost all the prefectures. This result indicates that road transportation infrastructure strengthens market linkages across regions and contributes to the growth of regional industries.

(*Insert figures 2–4 here*)

4.3. Economic convergence

According to Fujita and Tabuchi (1997), economic disparities across Japanese regions had converged during the postwar period. In this section, the contribution of industrial agglomeration to the convergence of regional disparities in productivity will be evaluated. Convergence is typically verified by the cross-section regressions known as "Barro regressions" (Barro and Sala-i-Martin, 1995). Defining labor productivity as $v \equiv Y/L$, the beta coefficient over period $(0,T)$ is given by

$$(1/T)\ln\left[v_{jT}/v_{j0}\right] = \alpha + \beta \ln v_{j0} + \varepsilon_j . \tag{11}$$

Defining the variable on the left-hand side as $\dot{v}_j \equiv (1/T)\ln\left[v_{jT}/v_{j0}\right]$, the beta coefficient is represented by

$$\beta = \frac{\sum_j (\ln v_{j0} - \overline{\ln v_0}) \cdot (\dot{v}_j - \bar{\dot{v}})}{\sum_j (\ln v_{j0} - \overline{\ln v_0})^2} . \tag{12}$$

If this coefficient shows a negative sign, it is interpreted as evidence of convergence in labor productivity.

Subtraction of the growth rate of labor inputs from both sides of the translog production function in (8) yields the following equation:

$$\dot{v}_j = \alpha_{T,j} + \frac{\theta_{K,j}}{T}\ln\left(\frac{K_{jT}}{K_{j0}}\right) + \frac{\theta_{L,j}-1}{T}\ln\left(\frac{L_{jT}}{L_{j0}}\right) + \frac{\alpha_S}{T}\ln\left(\frac{Y_{jT}}{Y_{j0}}\right)$$

$$+ \frac{\alpha_D}{T}\ln\left(\frac{DENSE_{jT}}{DENSE_{j0}}\right) + \frac{\alpha_A}{T}\ln\left(\frac{ACC_{jT}}{ACC_{j0}}\right) + \frac{1-\alpha_S}{T}\left(\varepsilon_{jT} - \varepsilon_{j0}\right). \tag{13}$$

For convenience, each term on the right-hand side is replaced with $\dot{v}_j(\cdot)$ as follows:

$$\dot{v}_j = \dot{v}_j(T) + \dot{v}_j(K) + \dot{v}_j(L) + \dot{v}_j(S) + \dot{v}_j(DENSE) + \dot{v}_j(ACC) + \dot{v}_j(RES) . \tag{14}$$

From the above definition, the covariance of v_{j0} and $\dot{v}_j$ is obtained as follows:

$$\operatorname{cov}\left(v_{j0,}\dot{v}_j\right)=\frac{1}{N}\sum_j\left(\ln v_{j0}-\overline{\ln v_0}\right)\left(\dot{v}_j-\bar{\dot{v}}\right)$$

$$=\operatorname{cov}\left(v_{j0,}\dot{v}_j\left(T\right)\right)+\operatorname{cov}\left(v_{j0,}\dot{v}_j\left(K\right)\right)+\operatorname{cov}\left(v_{j0,}\dot{v}_j\left(L\right)\right)+\operatorname{cov}\left(v_{j0,}\dot{v}_j\left(S\right)\right)$$

$$+\operatorname{cov}\left(v_{j0,}\dot{v}_j\left(DENSE\right)\right)+\operatorname{cov}\left(v_{j0,}\dot{v}_j\left(ACC\right)\right)+\operatorname{cov}\left(v_{j0,}\dot{v}_j\left(res\right)\right). \quad (15)$$

As a result, the covariance of v_{j0} and $\dot{v}_j$ becomes equal to the total covariance of v_{j0} and each element of $\dot{v}_j$. The division of both sides by the variance in the logarithm of v_{j0} yields the following:

$$\frac{\sum_j\left(\ln v_{j0}-\overline{\ln v_0}\right)\left(\dot{v}_j-\bar{\dot{v}}\right)}{\sum_j(\ln v_{j0}-\overline{\ln v_0})^2}=\frac{\sum_j\left(\ln v_{j0}-\overline{\ln v_0}\right)\left(\dot{v}_j\left(T\right)-\overline{\dot{v}\left(T\right)}\right)}{\sum_j(\ln v_{j0}-\overline{\ln v_0})^2}+\frac{\sum_j\left(\ln v_{j0}-\overline{\ln v_0}\right)\left(\dot{v}_j\left(K\right)-\overline{\dot{v}\left(K\right)}\right)}{\sum_j(\ln v_{j0}-\overline{\ln v_0})^2}$$

$$+\frac{\sum_j\left(\ln v_{j0}-\overline{\ln v_0}\right)\left(\dot{v}_j\left(L\right)-\overline{\dot{v}\left(L\right)}\right)}{\sum_j(\ln v_{j0}-\overline{\ln v_0})^2}+\frac{\sum_j\left(\ln v_{j0}-\overline{\ln v_0}\right)\left(\dot{v}_j\left(S\right)-\overline{\dot{v}\left(S\right)}\right)}{\sum_j(\ln v_{j0}-\overline{\ln v_0})^2}$$

$$+\frac{\sum_j\left(\ln v_{j0}-\overline{\ln v_0}\right)\left(\dot{v}_j\left(DENSE\right)-\overline{\dot{v}\left(DENSE\right)}\right)}{\sum_j(\ln v_{j0}-\overline{\ln v_0})^2}+\frac{\sum_j\left(\ln v_{j0}-\overline{\ln v_0}\right)\left(\dot{v}_j\left(ACC\right)-\overline{\dot{v}\left(ACC\right)}\right)}{\sum_j(\ln v_{j0}-\overline{\ln v_0})^2}$$

$$+\frac{\sum_j\left(\ln v_{j0}-\overline{\ln v_0}\right)\left(\dot{v}_j\left(res\right)-\overline{\dot{v}\left(res\right)}\right)}{\sum_j(\ln v_{j0}-\overline{\ln v_0})^2}$$

or

$$\beta=\beta_T+\beta_K+\beta_L+\beta_S+\beta_{DENSE}+\beta_{ACC}+\beta_{RES}, \quad (16)$$

where

$$\beta_x=\frac{\sum_j(\ln v_{j0}-\overline{\ln v_0})\left(\dot{v}_j\left(x\right)-\overline{\dot{v}\left(x\right)}\right)}{\sum_j(\ln v_{j0}-\overline{\ln v_0})^2} \quad (x=T,K,L,S,DENSE,ACC,RES).$$

Each item on the right-hand side of the equation is the regression coefficient of labor productivity in the initial period to the growth contribution components (Fukao and Yue 2000)[3]. The equation implies that the beta coefficient can be decomposed into the following seven components: the contributions of

[3] Using this method, Fukao and Yue (2000) have clarified the contribution of social capital toward labor productivity disparities for 47 prefectures.

technological progress β_T toward convergence, capital input β_K, labor input β_L, localization economies β_S, urbanization economies β_{DENSE}, market access to other regions β_{ACC}, and the error term β_{RES}. A positive value for β implies that input growth contributes to an increase in labor productivity disparities. On the other hand, if β is negative, then input growth contributes to a reduction in labor productivity disparities.

Table 3 summarizes the decomposition results. The beta coefficient has a negative value for both the industries, and it is also significantly greater than zero at the five percent significance level. This result indicates the existence of economic convergence over the sample periods.

(*Insert Table 3 here*)

However, the factors that contribute to convergence vary by industry. In the manufacturing industry, capital input, localization economies, and other factors contribute to economic convergence. One of the reasons for this is that factory locations in prefectures with large metropolitan areas, such as Tokyo, Kanagawa, and Osaka prefectures, were restricted by the prevailing industrial policy. Specifically, between the 1980s and 1990s, the government implemented a policy that promoted local decentralization with respect to factory locations. As a result, factory locations in the large metropolitan areas were remarkably limited. In addition, fiscal incentives were provided to manufacturing firms to relocate to or open branches in non-metropolitan areas. It is evident that these policies encouraged capital transfer from large metropolitan areas to non-metropolitan areas and improved the scale of production in non-metropolitan areas. Consequently, the contribution of capital input and localization economies toward decreasing the productivity disparity has been strengthened. In contrast, with regard to the non-manufacturing industry, localization economies contribute to the increase in productivity disparity. This result appears to be related to the types of service sectors present in a given area. In other words, high-productivity sectors such as information and technology as well as mobile information sectors are concentrated in the National Capital Region, while labor-intensive, low-productivity sectors such as the medical sector are concentrated in the local areas. Thus, it is suggested that the continued development of service sectors has the potential to increase regional disparities. Urbanization economies also contribute toward the expanding regional disparities in both the industries, although their influence on the beta coefficient is smaller than that of localization economies. This suggests the possibility that urbanization economies lead to a concentration of the population in large metropolitan areas, thus expanding the regional disparities in productivity in both the industries.

5. Conclusion

This paper investigated the effects of industrial agglomeration on regional economic growth, with particular emphasis on economic convergence. The empirical analysis, which was based on Japanese prefectural data, indicated that localization economies had greater effects on regional growth than did urbanization economies. In particular, localization economies in the manufacturing industry were concentrated locally, while those in the non-manufacturing industry were concentrated in the National Capital Region. This empirical evidence suggests that the expansion of industrial scale is preferable to diversity for both the manufacturing and non-manufacturing industries. Furthermore, for both the industries, the empirical analysis indicated that the growth contribution of market access exceeded that of agglomeration economies and that the effects had a remarkable influence on productivity growth. This suggests that it is highly important to develop the road transportation system for promoting interregional access because the economic gains obtained from efficient transport networks to the metropolitan areas are more beneficial than the availability of plentiful labor.

This paper also examined the impact of agglomeration economies, including the market access effects on economic convergence. The results revealed that regional convergence progressed during the sample period of 1980–2002 and that localization economies contributed to economic convergence in the manufacturing industry. This suggests that the development policy promoting local decentralization in the high-productivity sectors was effective in achieving the convergence of regional disparities. In contrast, with regard to the non-manufacturing industry, these effects continued to increase the regional disparities. In particular, the result pertaining to urbanization economies suggests that the concentration of population in large metropolitan areas increased productivity in these areas, thus contributing to the widening of the disparities in regional productivity. Therefore, it appears reasonable to conclude that the expansion of the non-manufacturing industry can potentially create regional economic disparities.

This evidence is significant because it suggests that the existing policy requires revision in light of the changing sectoral composition of industries. Thus, it is necessary to conduct in further detail the industrial analysis that employs sectoral data and is used to obtain policy implications. In particular, in order to investigate whether the growth of service sectors has the potential to increase regional disparities, the data construction corresponding to different sectors will be important. This extension will be a subject for future research.

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Table 1: Agglomeration economies

Agglomeration Economies	Variable	Description
Localization Economies	Y	The scale of industrial production
Urbanization Economies	DENSE	Population density
Spillover Effects	ACC	Market access index

Table 2: Estimation results

	All Industries				Manufacturing Industry				Non-manufacturing Industry			
	3SLS		OLS		3SLS		OLS		3SLS		OLS	
α_0	0.4305		0.4085		0.3186		0.2619		0.4687		0.4500	
	(37.79)	**	(64.96)	**	(13.86)	**	(29.33)	**	(39.92)	**	(61.04)	**
α_S	0.0786		0.0786		0.0678		0.0564		0.0803		0.0792	
	(21.84)	**	(18.65)	**	(10.81)	**	(7.92)	**	(21.07)	**	(17.52)	**
α_D	0.0156		0.0154		0.0422		0.0393		0.0268		0.0262	
	(5.63)	**	(4.75)	**	(7.51)	**	(6.22)	**	(9.22)	**	(7.65)	**
α_A	0.1997		0.1919		0.2865		0.2735		0.2344		0.2332	
	(20.08)	**	(16.91)	**	(14.14)	**	(12.24)	**	(22.60)	**	(19.48)	**
α_K	0.4208		0.4456		0.4987		0.5715		0.4151		0.4523	
	(29.41)	**	(36.85)	**	(20.03)	**	(48.29)	**	(25.96)	**	(30.33)	**
β_{KK}	–0.0326		–0.0375		–0.0186		–0.0286		–0.0374		–0.0407	
	(–13.73)	**	(–72.08)	**	(–4.65)	**	(–34.79)	**	(–14.46)	**	(–51.65)	**
F-statistic	22.3259				11.4533				19.9496			
	[0.00]				[0.00]				[0.00]			
LM-e	0.7240				0.1761				1.3486			
	[0.40]				[0.68]				[0.25]			
Adj- R^2	0.9679		0.9602		0.9559		0.9469		0.9679		0.9447	

Notes: Due to space constraints, the estimation results of the time-trend and time-effect terms have been omitted.

The constant and lag of dependent variables are used as the instrumental variables.

The *t*-statistics are enclosed in parentheses and the *p*- statistics are enclosed in brackets.

LM-e is a test based on the principle of Lagrange multipliers (Burridge, 1980).

** Significant at the 1% level; * significant at the 5% level

Number of observations: 1034

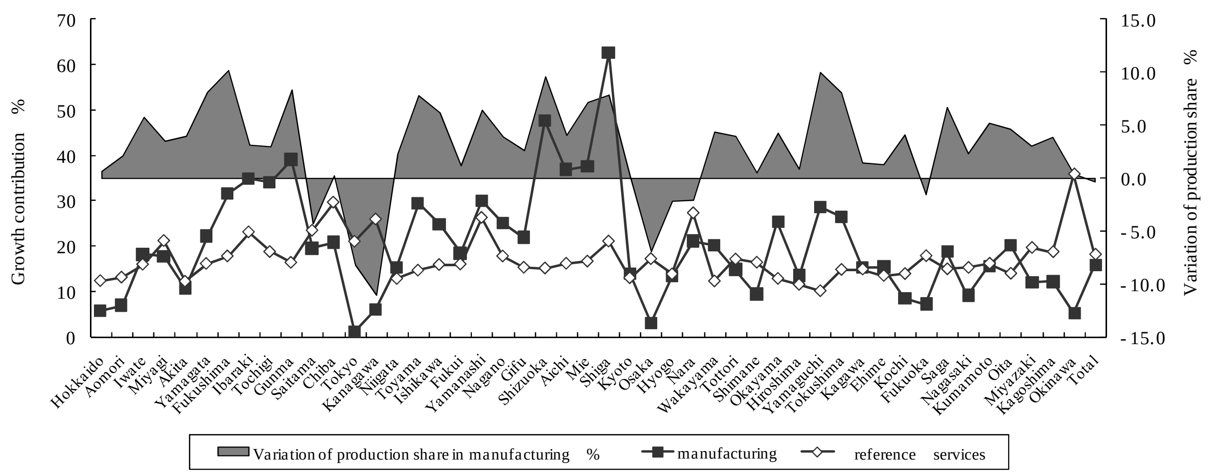

Figure 1: Growth contribution and variation of product share in the manufacturing industry (in %, 1980–2002)

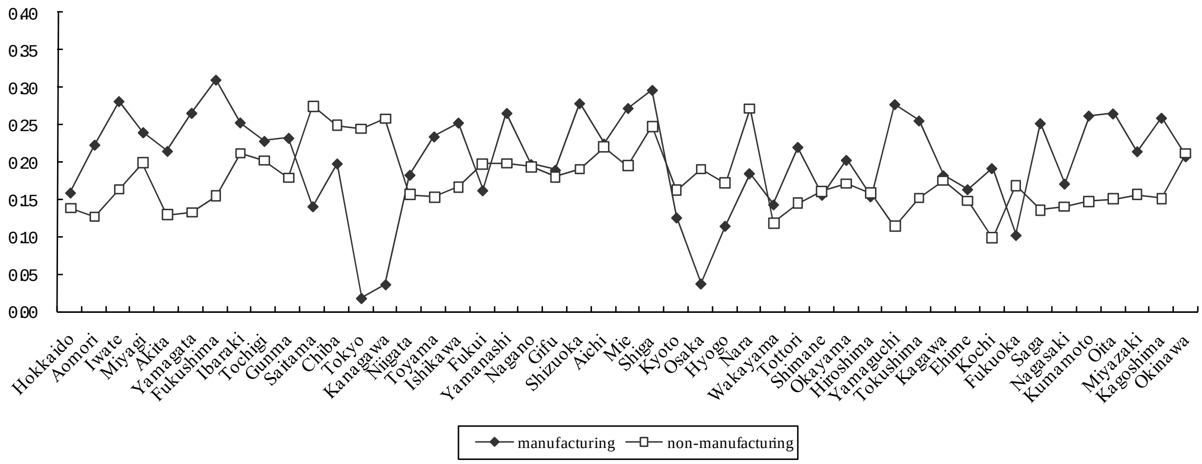

Figure 2: Growth contribution of localization economies (in %, annual rate)

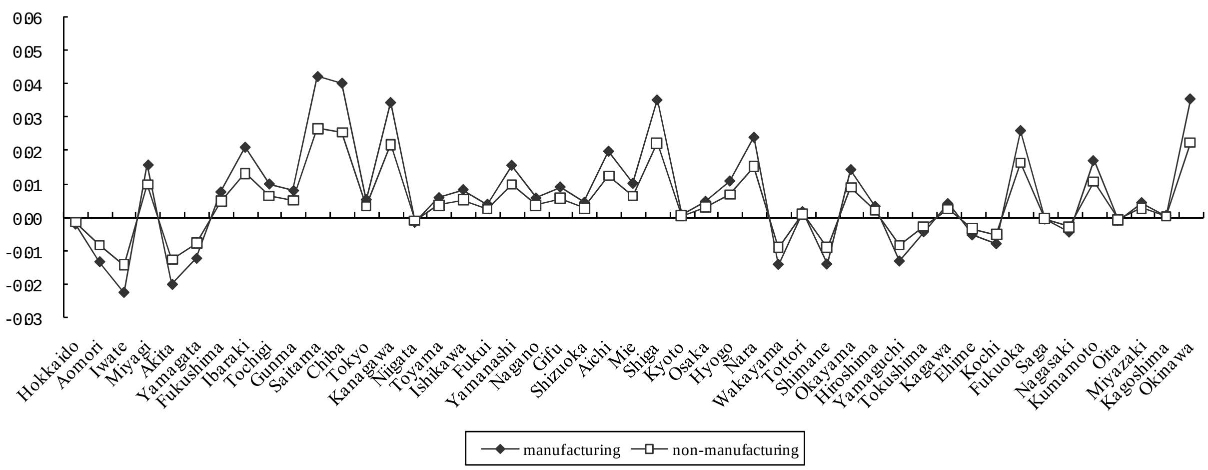

Figure 3: Growth contribution of urbanization economies (in %, annual rate)

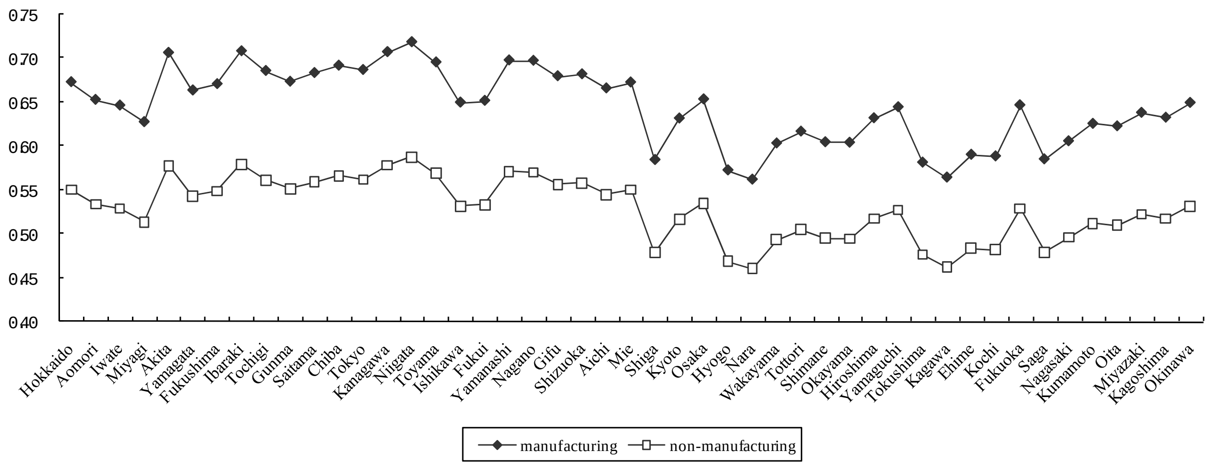

Figure 4: Growth contribution of market access (in %, annual rate)

Table 3: Decomposition results of the β coefficient (1980–2002)

	All Industries		Manufacturing Industry		Non-manufacturing Industry	
Convergence Coefficient	–0.0069		–0.0085		–0.0070	
	(–2.61)	*	(–2.45)	*	(–3.22)	**
Capital	–0.0027		–0.0104		0.0044	
	(–1.16)		(–4.06)	**	(1.85)	
Labor	–0.0062		0.0013		–0.0090	
	(–5.10)	**	(0.72)		(–7.39)	**
Localization Economies	0.0008		–0.0008		0.0016	
	(2.69)	**	(–2.22)	*	(5.24)	**
Urbanization Economies	0.0002		0.0003		0.0003	
	(4.72)	**	(3.39)	**	(4.36)	**
Market Access	0.0003		0.0001		0.0005	
	(1.23)		(0.34)		(1.56)	
Technological Progress	0.0109		0.0083		0.0090	
	(3.25)	**	(1.91)		(2.55)	*
Others	–0.0102		–0.0073		–0.0139	
	(–3.06)	**	(–2.19)	*	(–4.11)	**

Notes: The *t*-values are enclosed in parentheses.

** Significant at the 1% level; * significant at the 5% level

Appendix: Growth Accounts (in %, annual growth rate, 1980–2002) (a) Manufacturing industry

	Product Growth	Capital Growth	Labor Growth	TFP				
				Localization Economies	Urbanization Economies	Market Access	Technological Progress	Other
Hokkaido	2.340	1.108	–0.810	2.042	0.159	–0.002	0.673	1.356
Aomori	3.288	2.571	0.063	0.654	0.223	–0.013	0.653	–0.415
Iwate	4.147	2.408	–0.006	1.745	0.281	–0.022	0.646	0.821
Miyagi	3.533	2.232	–0.255	1.556	0.240	0.016	0.628	1.425
Akita	3.165	2.159	–0.383	1.389	0.215	–0.020	0.706	0.455
Yamagata	3.916	2.582	–0.270	1.604	0.266	–0.012	0.664	0.431
Fukushima	4.573	2.557	–0.437	2.453	0.310	0.008	0.671	1.279
Ibaraki	3.727	2.283	–0.175	1.618	0.253	0.021	0.708	1.048
Tochigi	3.362	2.416	–0.327	1.273	0.228	0.010	0.686	1.661
Gunma	3.422	2.391	–0.264	1.296	0.232	0.008	0.674	1.353
Saitama	2.072	1.994	–0.496	0.574	0.141	0.042	0.683	–0.267
Chiba	2.917	1.239	–0.535	2.213	0.198	0.040	0.692	0.571
Tokyo	0.258	1.096	–1.636	0.799	0.018	0.006	0.687	1.122
Kanagawa	0.530	1.243	–1.125	0.412	0.036	0.035	0.707	0.285
Niigata	2.693	1.867	–0.672	1.498	0.183	–0.001	0.719	–0.108
Toyama	3.450	1.830	–0.547	2.167	0.234	0.006	0.696	1.596
Ishikawa	3.725	2.192	–0.745	2.278	0.253	0.009	0.650	1.702
Fukui	2.388	2.017	–0.860	1.231	0.162	0.004	0.652	0.332
Yamanashi	3.915	3.260	–0.131	0.787	0.266	0.016	0.698	0.955
Nagano	2.904	2.524	–0.586	0.967	0.197	0.006	0.697	0.621
Gifu	2.792	2.180	–0.676	1.288	0.189	0.009	0.680	–0.113
Shizuoka	4.108	2.123	–0.258	2.242	0.279	0.005	0.682	0.881
Aichi	3.310	2.018	–0.397	1.688	0.225	0.020	0.666	0.855
Mie	4.011	1.963	–0.212	2.261	0.272	0.010	0.673	0.887
Shiga	4.370	2.403	0.224	1.743	0.297	0.035	0.585	2.885
Kyoto	1.850	1.579	–1.202	1.473	0.126	0.001	0.632	1.674
Osaka	0.545	1.176	–1.287	0.655	0.037	0.005	0.653	0.290
Hyogo	1.685	1.433	–0.901	1.153	0.114	0.011	0.573	0.999
Nara	2.723	2.251	–0.442	0.914	0.185	0.024	0.562	1.866
Wakayama	2.107	1.129	–1.387	2.366	0.143	–0.014	0.603	1.645
Tottori	3.243	1.900	–0.804	2.147	0.220	0.002	0.617	1.957
Shimane	2.296	2.123	–0.978	1.151	0.156	–0.014	0.605	0.396
Okayama	2.988	1.243	–0.807	2.552	0.203	0.015	0.604	1.625
Hiroshima	2.266	1.241	–0.908	1.934	0.154	0.004	0.632	0.920
Yamaguchi	4.087	1.375	–0.667	3.379	0.277	–0.013	0.645	2.371
Tokushima	3.764	1.924	–1.084	2.924	0.255	–0.004	0.582	2.377
Kagawa	2.684	1.348	–0.896	2.231	0.182	0.004	0.565	1.839
Ehime	2.406	1.359	–0.864	1.912	0.163	–0.005	0.590	1.319
Kochi	2.824	1.897	–1.062	1.989	0.192	–0.008	0.589	1.844
Fukuoka	1.502	1.057	–0.882	1.326	0.102	0.026	0.647	1.336
Saga	3.713	2.470	–0.456	1.698	0.252	0.000	0.585	1.983
Nagasaki	2.518	1.701	–0.867	1.684	0.171	–0.004	0.606	1.112
Kumamoto	3.862	2.266	–0.174	1.771	0.262	0.017	0.626	1.546
Oita	3.904	1.328	–0.443	3.020	0.265	–0.001	0.623	3.521
Miyazaki	3.157	1.704	–0.387	1.840	0.214	0.005	0.638	0.789
Kagoshima	3.819	2.576	–0.809	2.052	0.259	0.001	0.633	1.399
Okinawa	3.058	2.002	–0.766	1.822	0.208	0.036	0.649	0.783

(b) Non-manufacturing industry

	Product Growth	Capital Growth	Labor Growth	TFP				
				Localization Economies	Urbanization Economies	Market Access	Technological Progress	Other
Hokkaido	1.718	1.433	–0.505	0.790	0.138	–0.001	0.551	0.487
Aomori	1.567	2.080	–0.415	–0.098	0.126	–0.008	0.534	–0.015
Iwate	2.032	1.616	–0.463	0.879	0.163	–0.014	0.529	0.127
Miyagi	2.478	1.932	0.079	0.467	0.199	0.010	0.513	0.381
Akita	1.606	1.606	–0.759	0.759	0.129	–0.013	0.578	0.164
Yamagata	1.640	1.634	–0.659	0.665	0.132	–0.008	0.543	0.032
Fukushima	1.919	1.717	–0.350	0.553	0.154	0.005	0.549	–0.035
Ibaraki	2.640	1.609	–0.043	1.074	0.212	0.013	0.579	0.348
Tochigi	2.518	1.603	0.083	0.832	0.202	0.007	0.561	0.146
Gunma	2.225	1.558	0.038	0.630	0.179	0.005	0.551	–0.085
Saitama	3.428	2.073	0.733	0.622	0.275	0.027	0.559	0.010
Chiba	3.103	2.058	0.558	0.486	0.249	0.026	0.566	–0.021
Tokyo	3.047	2.338	0.239	0.470	0.245	0.004	0.562	0.771
Kanagawa	3.221	2.172	0.816	0.233	0.259	0.022	0.579	–0.157
Niigata	1.943	1.826	–0.483	0.600	0.156	–0.001	0.588	0.139
Toyama	1.905	1.287	–0.266	0.884	0.153	0.004	0.569	1.107
Ishikawa	2.070	1.697	–0.089	0.461	0.166	0.005	0.532	0.775
Fukui	2.456	1.402	–0.206	1.260	0.197	0.003	0.533	0.938
Yamanashi	2.466	1.934	–0.174	0.706	0.198	0.010	0.571	0.010
Nagano	2.407	1.819	–0.159	0.747	0.193	0.004	0.571	–0.291
Gifu	2.243	1.892	0.026	0.326	0.180	0.006	0.556	0.276
Shizuoka	2.367	1.966	0.018	0.383	0.190	0.003	0.558	–0.414
Aichi	2.741	1.872	0.257	0.612	0.220	0.013	0.545	0.219
Mie	2.424	1.999	–0.231	0.655	0.195	0.007	0.550	0.529
Shiga	3.087	1.444	0.507	1.136	0.248	0.023	0.478	1.494
Kyoto	2.017	1.938	–0.173	0.252	0.162	0.001	0.517	0.678
Osaka	2.370	1.862	0.093	0.415	0.190	0.003	0.535	0.690
Hyogo	2.138	2.002	–0.065	0.201	0.172	0.007	0.469	0.308
Nara	3.389	1.990	0.415	0.985	0.272	0.015	0.460	1.363
Wakayama	1.467	1.396	–0.487	0.559	0.118	–0.009	0.494	–0.206
Tottori	1.800	2.523	–0.474	–0.249	0.145	0.001	0.505	0.239
Shimane	1.996	2.099	–0.656	0.554	0.160	–0.009	0.495	0.133
Okayama	2.125	1.506	–0.146	0.764	0.171	0.009	0.494	0.563
Hiroshima	1.964	2.171	–0.009	–0.198	0.158	0.002	0.517	0.730
Yamaguchi	1.412	1.655	–0.582	0.339	0.113	–0.008	0.527	0.366
Tokushima	1.883	1.795	–0.565	0.653	0.151	–0.003	0.476	0.418
Kagawa	2.177	1.764	–0.326	0.739	0.175	0.003	0.462	0.768
Ehime	1.836	1.676	–0.310	0.470	0.147	–0.003	0.483	0.242
Kochi	1.215	1.857	–0.620	–0.022	0.098	–0.005	0.482	0.187
Fukuoka	2.098	1.798	0.069	0.231	0.168	0.017	0.529	0.372
Saga	1.685	1.622	–0.319	0.381	0.135	0.000	0.479	0.366
Nagasaki	1.745	1.910	–0.537	0.371	0.140	–0.003	0.496	–0.027
Kumamoto	1.831	1.818	–0.590	0.603	0.147	0.011	0.512	0.038
Oita	1.871	1.694	–0.622	0.799	0.150	–0.001	0.510	0.341
Miyazaki	1.940	1.702	–0.475	0.713	0.156	0.003	0.522	0.035
Kagoshima	1.877	1.903	–0.569	0.543	0.151	0.000	0.518	–0.035
Okinawa	2.640	2.443	0.392	–0.195	0.212	0.023	0.531	–0.117