Changing Economic Geography and Import Penetration in Japan

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Abstract

By estimating the labor demand for Japanese 21 manufacturing industries in 47 prefectures during 1985-2000, this paper provides evidence consistent with the prediction that import penetration disperses industry concentrations by weakening input-output linkages among domestic industries. The employment declined more during the 1990s in region/industry with initially larger presence of output customers, especially in industries with rising or high import shares. This paper also finds that local knowledge spillovers and regional availability of immobile specialized labor significantly affect regional growth while the proximity advantage becomes irrelevant for tradable manufactured products.

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1. INTRODUCTION

The import share has risen in many countries, as barriers to border-crossing transactions have substantially been removed. The geographical distribution of industries within a country is likely to be affected by increased flows of foreign goods because import penetration tends to destroy industry concentrations by undermining input-output linkages among domestic industries. Krugman and Livas-Elizondo (1996) construct a theoretical model explaining how giant metropolis, formulated as a result of backward and forward linkages among domestic manufacturers under protectionist trade policy, declines as the country opens its door to foreign trade. The testable implication of their model is clear; the employment growth must be lower after trade liberalization in regions with previously stronger input-output linkages among regional industries.

Empirical investigations of this prediction, however, have been limited, although how international trade affects internal geography is a critical issue.[1] From cross-country regressions, Ades and Glaeser (1995) report that population in the largest city appears negatively related with share of trade in GDP, but they bypassed inter-industry linkages in their reduced-form specifications. On the other hand, Hanson (1998) finds that the impact of his inter-industry linkage variable on regional employment growth becomes substantially smaller in Mexican states after trade liberalization. Paluzie et al. (2001) discover that their vertical linkage variable seems to have a negative effect on geographical concentration in Spanish provinces after Spain joined EU. Neither of them, however, explicitly identifies input suppliers or output customers in defining their linkage indices and associates their regression results with any industry-specific trade-related variables.

The purpose of this paper is threefold. First, this paper is intended to be an early contribution

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[1] Compared with this issue (how trade affects geography), the other issue (how geography affects trade) has been relatively intensively studied by many previous empirical works, including Davis and Weinstein (1998).

to the empirical literature on the relationship among economic geography, inter-industry linkages within a country and the country's import penetration. By combining *Census of Manufacturers* data with *Input-Output Table* data, this paper constructs a relatively direct, region-industry specific index for input-output linkages explicitly based on weighted averages of supplier/customer industries. To preview the result, the regression results from 21 two-digit manufacturing industries in 47 Japanese prefectures reveal that geographical concentrations based on domestic input-output linkages, especially on proximity with output customers, have noticeably been undermined particularly in industries with rising or high import shares. This finding presents evidence in favor of the theoretical hypothesis.

Second, this paper also investigates the relationship of regional employment with non-tradable sectors and immobile factors. This issue is critical in investigating economic geography after trade liberalization because some goods/services are still non-tradable and some factors, such as labor, are immobile across regions even when many products are traded globally. Although we mainly focus on the inter-industry linkages among tradable industries to evaluate the impact of import penetration, we will alternatively include, in defining input-output linkage variables, non-manufacturing industries as well as final demand components such as household consumption. As will be reported in the text, this paper also finds that the industrial diversity of the region and the similarity of labor requirement of regional industries are significant determinants of regional employment in recent years. This implies that local knowledge spillovers and regional availability of immobile specialized labor considerably affect regional growth in the age of globalization, when active international transactions of tradables tend to make domestic input-output linkages irrelevant for manufactured products.

Third, to complement accumulated evidence on the effect of NAFTA and EU on member countries, the investigation of Japanese experiences will be required. Although Japan has not been institutionally involved in any free trade agreement, the import share began to rise after the historic yen appreciation triggered by the 1985 Plaza Accord and Japanese industries have recently been deeply integrated with neighboring Asian developing countries via two-way trade in intermediate products and foreign direct investment.[2] As the Japanese market had traditionally been viewed as closed due to implicit protectionist measures, the experience of Japan after 1985 could be served as an example of rapidly opening/integrating economies. Besides, since relatively scant empirical evidence has been provided for the economic geography in Japan, the discoveries from Japanese data also deserve serious attention in its own right. As the unemployment rate is now among the highest in major developed countries, the unemployment is clearly one of the most serious economic issues in Japan. The spread of international outsourcing is also reported to threaten local employment by replacing traditional transactions among domestic Keiretsu-group firms. Thus, this paper will contribute to our understanding of Japanese regional employment.

The rest of this paper is organized as follows. Section 2 introduces our empirical model and explains variables we construct to capture geographical effects. Section 3 briefly describes the data, while additional explanations are given in Appendix. Section 4 reports the estimation results from Japan's data and discusses their implications. Finally, Section 5 concludes.

2. AN EMPIRICAL MODEL

This section formalizes the specification and explains variables constructed for our analysis. First, consider the profit function Π with standard properties and differentiate it with respect to labor wage. By Hotelling's Lemma, the labor demand is given by

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[2] Formally, Japan has recently concluded the Economic Partnership Agreement with Singapore, but its quantitative impact on Japanese industries is minor and we should view its implication as rather symbolic.

$$L_{rjt} = -\frac{\partial \Pi\left(w_{rjt}, p_{jt}, z_{rjt}\right)}{\partial w_{rjt}} \tag{1}$$

,where *L* and *w* are employment and wage, respectively. The output price is expressed by *p*. Other factors affecting the profit, such as presence of output customers in the same region, are captured by *z*. Some variables vary across industries as well as across regions, while other variables, such as output price, are supposed equal across regions. The subscript *r* and *j* index the region (r=1, 2,…, R) and the industry (j=1, 2, …, J) at time *t*, respectively.

To evaluate the evolving geographical concentration of industries across regions, we must distinguish unobserved region-specific factors, such as natural resources and resident amenity. Since the region-specific effects are not likely to change dramatically over time, we focus on the growth rates. This paper estimates the following log-linear specification.[3]

$$\begin{aligned}\Delta \ln\left(\frac{L_{rjt}}{L_{jt}}\right) &= \alpha + \beta_0 \ln INP_{rj,t-1} + \beta_1 \ln OUT_{rj,t-1} + \gamma \ln WAGE_{rj,t-1} \\ &\quad + \delta_0 \ln IIA_{rj,t-1} + \delta_1 \ln SCL_{rj,t-1} + \delta_2 \ln DIV_{rj,t-1} + \delta_3 \ln SIM_{rj,t-1} + \varepsilon_{rjt}\end{aligned} \tag{2}$$

The error term is expressed by ε. All variables are defined relative to the national average of the corresponding industry, as explained below. Taking deviations from national averages eliminates common factors in *z* and leaves all variables region-industry specific. To avoid the simultaneity problem, all the explanatory variables are one-period lagged. Thus, this paper specifies the relative employment growth as a function of initial conditions of the region industry relative to the national average of the industry.

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[3] This type of specification is standard in analyzing changing economic geography. See Hanson (1998) and Mano and Otsuka (2000), for example.

The definition of the right-hand side variables is explained as follows. First, *WAGE* is defined as the wage of the industry-region relative to the industry's wage averaged across regions. The negative sign for the coefficient on *WAGE*, γ, is expected in the labor demand function.

$$WAGE_{rj} = w_{rj} / w_j \tag{3}$$

Next, to capture the inter-industry linkages, we define the two indices,

$$\begin{aligned} INP_{rj} &= R\sum_{h\neq j}\left(\frac{X_j^h}{X_j}\right)\left(\frac{Q_{rh}}{Q_h}\right) \\ OUT_{rj} &= R\sum_{h\neq j}\left(\frac{X_h^j}{X^j}\right)\left(\frac{Q_{rh}}{Q_h}\right) \end{aligned} \tag{4}$$

,where X_k^h, X_j and X^j denote the intermediate transaction from industry *h* to industry *k*, total input supplied to industry *j*, total output from industry *j*, respectively.[4] $\left(Q_{rh}/Q_h\right)$ is the region *r*'s share in industry *h* in terms of output/shipment. Thus, these indices are weighted averages of vertically linked upstream and downstream industries within a region. By multiplying by *R* (total number of regions), these indices are standardized so that the average across regions is one. Compared with the intermediate expenditure rate (= $\left(Q_j - ValueAdded_j\right)/Q_j$) often used in previous studies, this definition excels in that we exploit rich matrix-format information from

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[4] This definition closely follows that by Dumais et al. (1997). Several notes should be in order. First, we use shipment share, instead of employment share, to avoid possible simultaneity and to be more consistent with I-O transactions values. Second, we focus on suppliers/customers in own region and omit linkages between neighboring regions. Although introducing gravity-type weights is a possible solution, actual economic costs of transportation depend not only on geographical distance but also on road development. Since the highway network in Japan seems to have Tokyo as the hub, transactions between neighboring regions are not necessarily inexpensive. We should leave the investigation of this issue to future work.

Input-Output Table.[5] This paper mainly focuses on the input-output linkages among tradables, i.e. manufacturing industries to discuss the impact of import penetration, but we will also report comparable results for inputs from all other industries including non-tradables, i.e. non-manufacturing (*INP (all)*), all intermediate outputs supplied to all other industries including non-manufacturing (*OUT (ind)*), and all outputs including those absorbed by final demand such as household consumption (*OUT (all)*). The coefficients on these input-output linkage variables, β, must be negative if geographical concentrations previously established by the proximity to suppliers/customers are being destroyed.[6]

Other geography-related variables are included as follows. First, *IIA* is an index for intra-industry agglomeration, also known as Marshall-Arrow-Romer externalities.

$$IIA_{rj} = \frac{L_{rj} / L_r}{L_j / L} \qquad (5)$$

,where L_r and L are total employment in region r and total employment of the country as a whole, respectively. The definition of this index controls for cases where the region's industry is large solely because that total employment in the region is large. If the further growth of pre-existing industry centers is promoted by the within-industry externality or encouraged by the benefits of regional

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[5] Although some previous studies, such as Amiti (1999) and Paluzie et al. (2001), use it as a convenient proxy, the ratio of intermediate payment is imperfect because, for example, this ratio looks at only downstream industries. We confirmed that this proxy turned out to perform poorly in our regression exercises. Hanson (1998) uses the employment share of two-digit in four-digit industry, but industries do not necessarily predominantly purchase from or supply to other four-digit industries in the same two-digit industries.

[6] We can interpret this test of changing geography by the sign of β as corresponding to β-convergence in the growth literature. Alternative test, roughly corresponding to σ-convergence, is to investigate changes over time in industry distribution across regions, summarized by some measures such as the Gini coefficient. Although many previous studies, including Amiti (1999) and Brulhart (2001), examine changes in Gini coefficients, none of them concerns the impact of international trade on domestic regions within a country as far as the author knows.

specialization, the coefficient on *IIA* is expected to be positive.

Second, *SCL* is a proxy for the economies of scale, defined as the number of employees per plant.[7]

$$SCL_{rj} = \frac{L_{rj} / N_{rj}}{L_j / N_j} \qquad (6)$$

,where N_{rj} and N_j are the number of plants in industry *j* - region *r*, and that in industry *j* in the country, respectively. This average plant size variable is intended to evaluate the region-industry differences in technology, especially in the degree of internal increasing returns.

Third, *DIV* is an index of industrial diversity based on the squared sum of shares of all other industries.

$$DIV_{rj} = \left[\sum_{h \neq j} \left(\frac{L_{rh}}{L_r} \right)^2 \Big/ \sum_{h \neq j} \left(\frac{L_h}{L} \right)^2 \right]^{-1} \qquad (7)$$

This index, defined as the inverse, becomes larger as the employment is more evenly distributed across industries. If the diversity of industries in a region generates positive externalities through cross-fertilization of ideas, the employment in more diversified regions must grow at higher speed.

Finally, following Dumais, Ellison, and Glaeser (1997), this paper introduces *SIM* to measure the similarity of industries located in the same region. As firms requiring similar types of workers locate near each other, workers gain due to insurance from firm-specific shocks or from ex-post appropriation of accumulated human capital, as was pointed out by Rotemberg and Saloner (2000).

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[7] The terms “plant” and “establishment” are used interchangeably in this paper.

Firms also gain from richer pool of specific type of labor supply in the region.[8] If this type of Marshallian labor pooling is significant, the employment grows faster in the regions where industries with more similar labor requirement locate. Let me index the type of occupation, such as professional/technical or production, by *y*. The share of occupation *y* in industry j's employment is expressed by s_{yj}. Naturally, $\sum_y s_{yj} = 1$ for any industry j.

$$SIM_{rj} = \left\{ \frac{\sum_y \left[s_{yj} - \sum_{h \neq j} \left(\frac{L_{rh}}{L_r - L_{rj}} s_{yh} \right) \right]^2}{\sum_y \left[s_{yj} - \sum_{h \neq j} \left(\frac{L_h}{L - L_j} s_{yh} \right) \right]^2} \right\}^{-1} \tag{8}$$

This index is based on a sum of squared deviations of the occupation mix of the industry and the weighted average of occupation mixes of other industries located in the same region. As in other variables, we define this index relative to the national average of the industry. By taking the inverse, this index becomes larger as more similar industries are clustered nearby.[9]

By including these constructed variables on the right-hand side of the regression, we can investigate the changing geographical patterns of employment in regions/industries.[10]

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[8] Although this index is intended to test the Marshallian labor pooling hypothesis, the same index could capture other industrial characteristics because industries require similar types of workers tend to share other industrial attributes.

[9] While Dumais et al. (1997) multiply the original ratio by minus one, we take the inverse as we covert it into logarithm form.

[10] Other variables that could have been included in the regression are factor abundance and technology differential. We constructed proxies following previous studies, such as Amiti (1999) and Palzie et al. (2001), but found that they are statistically significant in no specifications. For the transport costs and information spillover, we have no reliable data. Especially for the transport costs, economic costs of transportation depend on road development. For Mexican regions, Hanson (1998) uses the road distance from a state capital to the nearest U.S. border crossing.

3. DESCRIPTION OF DATA

This section briefly describes the data used in this paper. Appendix will provide additional explanations. The region-specific industry data are derived from Japan's *Census of Manufacturers* (Kogyo Tokei in Japanese). The whole manufacturing is disaggregated into 21 industries at the two-digit level.[11] The total number of regions (prefectures) in Japan is 47.[12] Thus, we have 987 region-industry observations for every year.[13]

To capture the long-term trend, we use *Census of Manufacturers* data in 1985, 1990, and 2000.[14] This choice of sample period enables us to see the effect of import penetration because the import share has generally been on the rising trend during this period. We will split our whole sample period into the employment-expanding 1985-1990 and the employment-shrinking 1990-2000. The direction of employment change has been almost monotonic in each sub-period, as manufacturing employment continued to grow until 1991 and kept declining after that year, roughly corresponding to those before and after the burst of the stock and real estate bubble in Japan.[15] The

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[11] To analyze Japan's economic geography, Mano and Otsuka (2000) use *Census of Manufacturers* data of five two-digit machinery industries. Dekle (2002) depends on one-digit industry classifications (treating manufacturing as a single sector) to estimate productivity growth in 47 prefectures. Davis and Weinstein (1999) use the cross-section data at 1985 of 19 two-digit industries in 40 regions to test the home market effect hypothesis.

[12] The unit of region is prefecture (ken in Japanese), which has much higher population density than U.S. states and is more like U.S. cities. The number of regions in Davis and Weinstein (1999) is 40 as they aggregate regions around Tokyo and those around Osaka, which are as large as some European countries.

[13] Due to the confidentiality considerations, data for some region-industry cells are not published. For computational simplicity, we assume that figures for these cells are equal to the national average. Since these unavailable cells tend to small in employment or output sizes, this may overestimate the impact of these tiny prefectures/industries. However, as the number of unavailable cells is quite small, the biases by this imputation on overall estimates will be small as well.

[14] Although *Census of Manufacturers* data are available annually, the data of *Input-Output Benchmark Table* and of *Population Census* are available once in five years. This choice of the sample intervals is comparable with that by Hanson (1998) as he uses data from 1980-1985 and 1985-1993.

[15] Since we have data for all the years during 1985-2000, we could have split the whole sample into more sub-periods to investigate short-run changes. The trend in employment during the 1990s, however, appears almost monotonic. Hence, we combine all the years in the 1990s focusing on long-run trends. The sample period by Mano and Otsuka (2000) is 1980-1995, which includes both bubble boom years and recession years after the burst of the bubble.

magnitude of employment change is considerable as total manufacturing employment in Japan increased by 2.60% during 1985-1990 but declined by 17.8% during 1990-2000.

The other major data source used for this paper is *Input-Output Table*. We draw inter-industry transaction data X from *Input-Output Table* to calculate *INP* and *OUT*.[16] The data necessary to calculate *SIM* are drawn from the Industry-Occupation Employment Table in *Input-Output Table*, which disaggregates industry employment numbers by occupation types (professional/technical, production, and others). This paper combines this industry-labor requirement matrix with the region-industry employment data in *Census of Manufacturers*.[17]

The descriptive statistics are summarized in Table I. Since all the variables are defined as relative to the national average of each industry, we can confirm that most of the average values across all industries/prefectures are around one (zero for $\Delta \ln(L_{rj} / L_j)$, which is defined in logarithm). Substantial variability across regions/industries is evident from the table.

4. EMPIRICAL RESULTS

4.1. Panel regression results

All industries are pooled in our estimation, while we will discuss differences across industries in the next sub-section. As in usual panel regressions, the constant term α is allowed to vary across industries.[18]

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[16] Among 21 industries, the transport equipment industry has no output purchased as intermediate inputs by other manufacturing industries. To take logarithm, we add negligible 10^{-8}. To check the robustness, we also conduct regressions using the sample excluding this industry.

[17] The professional/technical occupations include scientific researchers, technical professionals and lawyers. These occupations are normally supposed to require college degrees. On the other hand, the production occupation is roughly corresponds to the category of production workers in *U.S. Census of Manufacturing*. Although the employment data of more disaggregated 288 occupation types are available in Input-Output Table, this broad aggregation is appropriate for our purpose because Japanese labor market is not finely segmented by occupation types.

[18] To eliminate all fixed effects, the inclusion of dummies is appropriate but some variables such as *DIV* vary little across industries within a prefecture. See Hanson (1998) for discussions of error

$$\Delta \ln\left(\frac{L_{rj}}{L_j}\right) = \alpha_j + \beta_0 \ln INP_{rj} + \beta_1 \ln OUT_{rj} + \gamma \ln WAGE_{rj} \qquad (9)$$
$$+ \delta_0 \ln IIA_{rj} + \delta_1 \ln SCL_{rj} + \delta_2 \ln DIV_{rj} + \delta_3 \ln SIM_{rj} + \varepsilon_{rj}$$

The standard errors are corrected by White's heteroskedasticity-consistent estimates. To check the robustness, we will report not only the estimates of the full specification (9) but also those omitting geography variables other than input-output linkages. The regression results are shown in Table II.

First, as expected in the labor demand function, the wage is negatively related with employment growth, especially in 1985-90. This implies that manufacturing employment distribution in Japan is shifting toward relatively low-wage regions.[19] This finding is consistent with daily observation, for example, that employment in highest-wage Tokyo has shifted heavily to non-manufacturing activities, such as financial services.

Second, estimated coefficients on the input-output linkage variables, especially on the output linkage variable, are significantly negative in 1990-2000, while they are mostly insignificant in 1985-1990.[20] In other words, the employment declined more during the 1990s in regions where larger output customers are present in the same region at the year 1990. The columns (2) and (5) in Table II confirm that the output linkage is negative in 1990-2000 even if we exclude transport

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structures in a similar specification.

[19] In Europe, Brulhart (2001) finds that 17 out of 32 industries, especially labor-intensive cost-sensitive industries, are concentrated in peripheral (low market potential) countries rather than central (high market potential) countries.

[20] Hanson (1998) discovers that the estimated coefficient on his linkage variable becomes substantially smaller after the drastic trade liberalization in Mexico. Paluzie et al. (2001) also finds that their linkage index has a significantly negative effect on industry concentration in 50 Spanish provinces after Spain joined EU in1986. Both of them are consistent with our results, although they did not exploit information from I-O tables in constructing their linkage variable. Although she finds positive coefficient from five major European countries on the same variable as that by Paluzie et al. (2001), the sample period of Amiti (1998) is 1976-1989, which corresponds to years before the completion of the single market in 1992.

equipment industry, which has no outputs purchased as intermediate inputs by other manufacturing industries. This finding demonstrates that inter-industry linkages are being significantly destroyed during the 1990s in Japan.[21] Although we will discuss this finding again in the next section in relation with industry import shares, our result is at least consistent with the theoretical prediction that import penetration undermines the regional backward and forward linkages since the import share in Japan generally rose during our sample period.[22]

Third, intra-industry agglomeration, *IIA*, is significantly negative, while internal increasing returns to scale, *SCL*, seems insignificant.[23] This suggests that industries have already been excessively concentrated while internal increasing returns are no longer significant for manufacturing in the age of networking and outsourcing.

Fourth, while the industrial diversity of the region, *DIV*, significantly reduced growth during 1985-1990, this effect disappeared or weakly reversed in the 1990.[24] We may interpret it as an indication that the cross-fertilization of ideas becomes more critical for Japanese industries in recent years. This result is also consistent with our experience of declining regions specialized in narrow ranges of industries.

Finally, the mechanism of labor pooling appears working in the 1990s, as evidenced by significantly positive coefficient on the similarity variable.[25] This may be consistent with the

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[21] The impact of this weakening inter-industry linkage is more substantial than general trend of population dispersion because we can confirm the robustness of our result by adding the region's total population as an additional regressor.

[22] The timings of changes in economic geography and in import shares do not necessarily coincide. In the case of Mexican states, Hanson (1998) finds that the breakup of dense manufacturing concentration in Mexico City had already begun before the start of trade liberalization.

[23] This finding is consistent with previous studies of Japanese data (e.g. Dekle (2002) and Mano and Otsuka (2000)). Hanson (1998) also reports that relative plant size and intra-industry agglomeration are negatively or insignificantly related with employment growth in Mexican regions, although significantly positive estimates have been reported for the relative plant size variable in the European cases (see Amiti (1999) and Paluzie et al. (2001)).

[24] Hanson (1998) finds that the industrial diversity has insignificant or negative estimate in a similar specification for Mexican states.

[25] Dumais et al. (1997) also report strong effect of similarity of local industries in U.S. data.

observations after opening trade. As each region becomes more specialized in more involved international division of labor, regions where industries with similar labor requirement locate close each other are more likely to grow. Besides, combined with the results from the diversity variable in the previous paragraph, the effects of specialized human skills, which tend to be relatively immobile, and of knowledge spillovers, which tend to be relatively local, on regional growth have become significant in recent years. Workers are quite immobile across regions even within a country.[26] As a result, regions critically vary in terms of human capital accumulations and of activeness of cross-fertilization of ideas. As trade in goods become more active around the globe, the geographical proximity matters less for transporting tradable goods, but stays important (or becomes more important) for knowledge spillovers and specialized labor supply. We must, however, be cautious in interpreting this as evidence supporting the labor pooling hypothesis, because industries with similar labor requirement may also share many other industrial attributes as well.

4.2. Industry results

The previous section constrained all the coefficients except the constant term to be equal across all industries. The impact of geography, however, is likely to differ depending on the industry. Consequently, we next allow all the coefficients in the equation to vary across industries.

$$\begin{aligned}\Delta \ln\left(\frac{L_{rj}}{L_j}\right) &= \alpha_j + \beta_{0j} \ln INP_{rj} + \beta_{1j} \ln OUT_{rj} + \gamma_j \ln WAGE_{rj} \\ &\quad + \delta_{0j} \ln IIA_{rj} + \delta_{1j} \ln SCL_{rj} + \delta_{2j} \ln DIV_{rj} + \delta_{3j} \ln SIM_{rj} + \varepsilon_{rj}\end{aligned} \qquad (10)$$

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[26] In spite of large variations in unemployment rates and in income levels, the inter-regional labor mobility remains quite low. According to the Census Bureau, less than half of population mobility is across prefectures in Japan. The share of inter-prefecture mobility is still much lower in employment. Similar observations are reported for Europe, for example, by Fiani et al. (1997).

Each equation (10) can be estimated by OLS separately for each industry j (j=1,2,…, 21), but we must note that the error terms in different equations may be correlated because, for example, the region-specific shocks affect different industries located in the same region in the same direction. Hence, we assume that

$$E\left(\varepsilon_{rj}\varepsilon_{sh}\right)=\sigma_{jh} \qquad \text{for } r = s$$

$$\text{zero} \qquad \text{otherwise} \qquad\qquad (11)$$

This structure of error terms (11) requires us to estimate 21 equations of (10) as a system by seemingly unrelated regressions (SUR). The results from SUR estimation for 1990-2000 are summarized in Table III.[27]

For the output linkage variable, *OUT*, nine out of 21 industries have negative coefficients statistically significant at the conventional 5% significance level.[28] This means nearly half of the Japan's manufacturing industries experienced significantly attenuated linkage with output customers located in the same region in the 1990s.

Next, we relate these nine industries with their import penetration ratio, which is defined as usual by import divided by (Q – export + import). As shown in Table IV, during our sample period, the growth rate of import penetration ratio averaged over these nine industries (34%) is considerably higher than that averaged over all 21 industries (23%). Besides, again from the same table, in seven out of these nine industries, the import penetration ratio in each industry grows faster than average of all industries. Consequently, industries with significantly negative output linkages tend to be

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[27] Only the signs of significant coefficients are shown in Table III to save space. Complete estimation results for individual industries will be available upon request.

[28] There is only one industry with positive coefficient on *OUT*, but that industry is heavily regulated and protected by various measures.

industries with import shares increasing at relatively high speed.

The exceptional industries with significantly negative output linkage coefficient but with the growth of import share lower than average are the following only two: printing and publishing and nonferrous metals. Again shown in Table IV, the level of import penetration in the nonferrous metal industry was by far the highest in 1985 (25%> 7% (average)) and has been consistently very high. Thus, although the growth rate is relatively low due to the exceedingly high starting point, the nonferrous metal industry should be obviously regarded as one of the import-competing industries in Japan. In this sense, observing significantly attenuated output linkage for this industry seems rather reasonable.[29]

For the input linkage variable, *INP*, three industries have significantly negative estimates for the coefficient. Among them, the food industry can be interpreted as an outlier because this industry appears to be strongly affected by domestic regulations and import protections. Then, the remaining two industries are petroleum and coal products and electric machinery.

For the petroleum and coal product industry, the largest input supplier in manufacturing is the chemical industry. The import share of chemical products supplied from the chemical industry to the petroleum and coal product industry is as high as thirty percent and the highest among the import shares of chemicals supplied to various industries.

Similarly, for the electric machinery, the largest supplier industry is the nonferrous metal industry. The import share, 21%, of the nonferrous metal products supplied from the nonferrous metal industry to the electric machinery industry is noticeably higher than the import shares of nonferrous metal products purchased by similar machinery industries (transport machinery=10%,

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[29] The other exceptional industry, printing and publishing, is not purely manufacturing and can be regarded as more like a service industry substantially affected by recent information technology changes. Besides, the printing and publishing industry in Japan has been exceedingly concentrated in Tokyo. Thus, the general dispersion trend from Tokyo appears to dictate the geography in this industry.

precision instrument=13%, general machinery=2%).

These pieces of evidence suggest that industries with relatively high import share in major input supplies tend to have significantly diluted linkage with input suppliers in the region.

Combined with the evidence for the output linkages, the investigation of import shares generally indicates that our regression finding of significantly negative coefficients on input-output linkage variables in the 1990s is associated with rising or high import penetration ratios of the industries. All previous studies have confirmed the theoretical hypothesis, but, as far as the author knows, none has explored the relationship between domestic geography and international trade squarely through the input-output linkage, which the theory assigns the pivotal role of translating international trade into domestic geography. For example, Ades and Glaeser (1995) do not refer to any inter-industry linkages, although they relate internal geography with external trade.[30] Hanson (1998) and Paluzie et al. (2001) devise their backward-forward linkage variables, but they do not use rich information from input-output tables and do not associate their results with industry import shares.[31] In this sense, this paper uncovers relatively direct evidence for the prediction that opening economy has dispersion of industries due to undermined backward and forward linkages.

4.3. Alternative definitions of input-output linkage variables

This paper has so far concentrated on the input-output linkages among tradables, i.e. manufacturing industries to discuss the impact of trade liberalization or import penetration. The input-output linkages, however, are not contained within manufacturing. Large portions of inputs to manufacturing are supplied by service industry, while some outputs from manufacturing are absorbed by non-manufacturing industries as intermediate inputs and by household or government

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[30] Ades and Glaeser (1995) report that their finding of negative relation between foreign trade and the largest city size is not robust after controlling for the endogeneity.

[31] Since they compared regression results before and after trade liberalization or regional integration, both Hanson (1998) and Paluzie et al. (2001) do not exploit import share variations across industries.

consumption. Therefore, this section compares alternative definitions of input-output linkage variables.

Table V reports the panel regression results from specifications with alternative input-output linkage variables. All the coefficient estimates are basically robust across different specifications. While the input linkage, either defined by inputs from other manufacturing industries (*INP*) or inputs from all other industries including non-manufacturing (*INP (all)*), is found statistically insignificant, the output linkage, either defined by outputs purchased by other manufacturing industries (*OUT*), outputs purchased by all other industries including non-manufacturing as intermediate inputs (*OUT (ind)*), or all outputs including those absorbed by final demand (*OUT (all)*), is clearly significant.

Consequently, combined with the finding from SUR results that many industries have significantly negative coefficient estimates for the output linkage variable, what is being destroyed in Japan during the 1990s was the proximity advantage of locations close to output customers, including final consumers, rather than that to input suppliers. Since we find around the same coefficient estimates and significance levels for alternative definitions of output linkage variables, not only cost-sensitive manufacturers, but also households have switched to purchase products supplied from other regions. The decline of transportation costs generally and the active restructuring of retail distribution sector in Japan in recent years may partly explain this finding. The surge of import share particularly in final consumption goods and relatively stagnant import of intermediate inputs in Japan are also consistent with our results.

We also find in Table V that the statistical significance and magnitude of coefficient estimate for the industrial diversity of region (*DIV*) and the similarity of labor-requirement of regional industries (*SIM*) are substantially attenuated if we include non-manufacturing sectors and final demand components in defining input-output linkage variables. This contrast is rather natural because the stronger presence of service industry or of consumers in the region tends to be related with more active knowledge spillovers among diversified sectors or richer accumulation of specialized human capital in the region.

5. CONCLUDING REMARKS

This paper has examined the changing economic geography in Japan during 1985-2000, when import shares have increased substantially in many industries. The main results state that inter-industry linkages among industries located in the same region were significantly undermined in the 1990s, particularly in industries with rising or high import shares. Thus, the findings of this paper have not necessarily reject other alternative interpretations, for example, relating observed changes with the spread of information technology, but have provided evidence at least consistent with the prediction based on geography and trade.

Although input-output transactions among regional industries have turned to matter less, this does not mean that the role of geography necessarily diminishes as the country becomes more open. As indicated by our regressions, specific human skills or diversified ideas accumulated and exchanged within a region, instead of manufactured products, affect the location of industries even after global free trade in goods realizes.

Appendix

All the data in *Census of Manufacturers* are downloaded from the web page of the Japan's Ministry of Economy, Trade and Industry. The employment (L) is the number of employees. The wage (w) is defined as the total wage payment divided by L. We aggregate apparel (14) and textile (15) because of the change in the industry classification during our sample period. The ordnance industry (33) is merged into the general machinery industry (29). As a result, we have 21 two-digit industries. Since the unit of region we use is the prefecture (ken in Japanese), we have data for 47 regions.

The inter-industry transaction data (X) are drawn from the 90 Sector Table in Japan's *Input-Output Table* (1990 Input-Output Benchmark Table compiled by the Management and Coordination Agency, Government of Japan). We aggregate I-O sectors to match two-digit Census industries. To calculate *INP* and *OUT*, the shipment values (Q) are derived from *Census of*

Manufacturers for 21 manufacturing industries. To calculate region shares for non-manufacturing industries and final demand components, this paper uses the prefecture-level data for 1990 fiscal year in *Annual Report on Prefectural Accounts 2001*, complied by Cabinet office. The Gross Prefectural Domestic Product by kind of Economic Activity, defined in terms of value-added, is used to calculate region shares because gross output data are not available for Tokyo region. The whole non-manufacturing sectors, except for education and research, are disaggregated into ten sectors (nine industries and public administration), while final demand is disaggregated into private final consumption, government final consumption, private investment, and public investment by using Gross Prefectural Domestic Expenditure data. For education and research sectors in I-O table, region shares are calculated in terms of numbers of full-time teachers in universities and colleges (nationally, locally, and privately owned), although all other service industries are aggregated into one sector. The data on teachers are from *Basic Survey on School Education* by the Ministry of Education and Science.

The industry-specific occupation type data (*s*) are derived from Industry-Occupation Table of Employment Matrix in *Input-Output Table* (Appendix Table 7 in Data Report (2) of 1990 Benchmark Table). From nine occupation types, we pick up the following two occupations: (1) professional or technical occupations (Occupation Classification Code No.1), and (2) mining/production/construction workers and apprentices (No.9). The other seven occupation categories aggregated here as “other” are managerial (No.2), clerical (3), sales (4), service (5), security (6), agricultural, forestry, or fishing (7), and transportation or communication (8). The employee numbers of each occupation type are available for all three-digit industries at the national level in the Industry-Occupation Matrix. In formulating *SIM*, we include all manufacturing industries as well as construction industry and service industry. The region-specific employment data for these non-manufacturing industries are drawn from *Population Census of Japan* (Kokusei Chosa in Japanese) compiled by the Statistics Bureau, the Management and Coordination Agency.

The import and export data are also derived from *Input-Output Table* (1985, 1990 and 1995 Benchmark Tables by the Management and Coordination Agency and 1999 Updated Table by the Ministry of Economy, Trade and Industry) because usual foreign trade data from Custom Clearance Statistics is not compatible with domestic industry classification. The 1999 Updated Table, published in 2002, is the most recent Input-Output Table at the time of this research. The growth rate shown in Table IV is the average of growth rates of three intervals (1985-1990, 1990-1995, and 1995-1999). Since the three industries (beverage, tobacco, and feed (2), furniture and fixture (17) and leather and fur products (24)) are not identified in the 1999 Table due to industry classification changes, the growth rate averaged over 1985-1990 and 1990-1995 are shown for these industries.

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TABLE I
SUMMARY STATISTICS

	Average	St. Dev.	Max	Min
$\Delta \ln(L_{rj} / L_j)$ (1985-1990)	0.044	0.218	1.419	–2.279
$\Delta \ln(L_{rj} / L_j)$ (1990-2000)	0.076	0.257	2.103	–1.324
INP (manufacturing)	1.000	1.101	6.431	0.016
INP (all)	1.000	1.183	8.777	0.074
OUT (manufacturing)	1.000	1.232	10.570	0.006
OUT (industries)	1.000	1.374	11.766	0.082
OUT (all)	1.000	1.245	10.238	0.087
IIA	1.016	0.836	10.987	0.027
SCL	1.114	0.611	6.063	0.140
DIV	0.770	0.195	2.105	0.364
SIM	1.165	1.106	29.685	0.040
WAGE	0.892	0.183	1.570	0.056

(Notes)

1. "Average," "St. Dev.," "Max," and "Min" are the unweighted average, standard deviation, maximum and minimum among all industries/prefectures. All variables are defined as relative to the national average of the industry. See text for abbreviations.
2. All the values except $\Delta \ln(L_{rj} / L_j)$ are those at 1990, while $\Delta \ln(L_{rj} / L_j)$ is the log difference between years.

TABLE II
PANEL REGRESSION RESULTS

Variables	(1) 1985-90	(2) 1985-90	(3) 1985-90	(4) 1990-2000	(5) 1990-2000	(6) 1990-2000
INP	0.0274 (0.0120)	0.0167 (0.0117)	0.0189 (0.0114)	–0.0104 (0.0123)	–0.0131 (0.0124)	–0.0132 (0.0134)
OUT	–0.0234 (0.0132)	–0.0149 (0.0135)	–0.0160 (0.0135)	–0.0295 (0.0129)	–0.0284 (0.0132)	–0.0183 (0.0137)
WAGE	–0.2459 (0.0639)	–0.2348 (0.0663)	–0.3279 (0.0592)	–0.0647 (0.0690)	–0.0741 (0.0734)	–0.2055 (0.0838)
IIA	–0.0556 (0.0144)	–0.0575 (0.0146)	-----	–0.1175 (0.0167)	–0.1150 (0.0169)	-----
SCL	0.0193 (0.0268)	0.0083 (0.0276)	-----	0.0023 (0.0225)	0.0004 (0.0228)	-----
DIV	–0.0778 (0.0288)	–0.0589 (0.0288)	-----	0.0582 (0.0345)	0.0583 (0.0354)	-----
SIM	0.0011 (0.0094)	–0.0026 (0.0095)	-----	0.0277 (0.0138)	0.0278 (0.0142)	-----
R^2	0.1738	0.1759	0.1266	0.2670	0.2709	0.1590

(Notes) The dependent variable is the region-industry employment growth rate relative to the national average of the industry. Industry-specific fixed effect dummy variables are included in the regression. White’s hetroskedasticity-consistent standard errors are in parentheses. The columns (2) and (5) are results from the sample excluding the transport equipment industry.

TABLE III
SUMMARY RESULTS FROM SUR ESTIMATION 1990-2000

	INP	*OUT*	*Wage*	*IIA*	*SCL*	*DIV*	*SIM*	R^2
12. Food manufacturing	(–)		(+)					0.18
13. Beverage, Tobacco & Feed	(+)	(–)			(–)		(–)	0.27
14+15. Apparel & Textile		(–)						0.16
16. Timber & Wooden products			(–)	(+)	(–)		(+)	0.47
17. Furniture & fixture	(+)	(–)		(–)	(+)			0.40
18. Pulp & Paper products				(–)		(+)	(+)	0.11
19. Printing & Publishing		(–)					(–)	0.19
20. Chemical products	(+)		(–)	(–)	(+)	(+)	(+)	0.45
21. Petroleum & Coal products	(–)			(–)	(+)			0.53
22. Plastic products		(–)		(–)		(+)	(+)	0.59
23. Rubber products				(–)	(+)		(+)	0.17
24. Leather & Fur products		(+)				(–)		0.15
25. Ceramic, Stone & Clay products		(–)		(–)				0.27
26. Iron & Steel					(+)		(+)	0.23
27. Nonferrous Metals	(+)	(–)	(+)	(–)				0.49
28. Metal products		(–)		(–)	(+)			0.41
29. General Machinery			(–)	(–)	(+)			0.57
30. Electric Machinery	(–)			(–)	(+)	(+)		0.70
31. Transportation Equipment			(–)		(+)			0.31
32. Precision Instruments		(–)	(+)			(+)		0.50
34. Miscellaneous manufacturing				(–)	(+)			0.24

(Notes)

Shown are the sign of coefficients estimated by Seemingly Unrelated Regression (SUR). Only the estimates significant at the 5% significance level are present. The numbers followed by abbreviated industry names are industry classification codes. The ordnance industry (33) is merged into the general machinery industry (29).

TABLE IV
INDUSTRY IMPORT SHARES

Industry	Import Share at 1985	Growth Rate of Import Share (1985–1999)
12. Food manufacturing	7.06	35.00
13. Beverage, Tobacco & Feed	3.61	56.22
14+15. Apparel & Textile	8.50	48.82
16. Timber & Wooden products	10.55	36.19
17. Furniture & fixture	2.67	55.81
18. Pulp & Paper products	4.31	3.27
19. Printing & Publishing	0.57	4.70
20. Chemical products	7.99	10.52
21. Petroleum & Coal products	13.01	–0.50
22. Plastic products	1.01	49.02
23. Rubber products	5.32	34.57
24. Leather & Fur products	13.11	78.97
25. Ceramic, Stone & Clay products	2.41	24.33
26. Iron & Steel	1.85	12.99
27. Nonferrous Metals	25.18	–0.75
28. Metal products	1.08	32.55
29. General Machinery	2.97	33.31
30. Electric Machinery	4.33	56.64
31. Transportation Equipment	2.92	36.58
32. Precision Instruments	11.75	33.39
34.Miscellaneous manufacturing	12.88	33.61
Average (all 21 industries)	6.81	22.69
Average (with negative *OUT*)	6.31	33.79

(Notes)

All figures are in terms of percentage. The growth rate is expressed by averages over intervals 1985-90, 90-95 and 95-99. The last row corresponds to the average over the nine industries with significantly negative coefficient on the output linkage variable estimated by SUR.

TABLE V
ALTERNATIVE INPUT/OUTPUT LINKAGE VARIABLES

	(1)	(2)	(3)	(4)
INP	–0.0104 (0.0123)	–0.0004 (0.0138)	0.0002 (0.0139)	--------
INP (all)	--------	--------	--------	–0.0117 (0.0218)
OUT	–0.0295 (0.0129)	--------	--------	--------
OUT (ind)	--------	–0.0497 (0.0165)	--------	--------
OUT (all)	--------	--------	–0.0522 (0.0172)	–0.0416 (0.0244)
WAGE	–0.0647 (0.0690)	–0.0546 (0.0672)	–0.0570 (0.0676)	–0.0578 (0.0657)
IIA	–0.1175 (0.0167)	–0.1138 (0.0164)	–0.1150 (0.0165)	–0.1147 (0.0166)
SCL	0.0023 (0.0225)	–0.0070 (0.0237)	–0.0043 (0.0233)	–0.0042 (0.0226)
DIV	0.0582 (0.0345)	0.0369 (0.0342)	0.0386 (0.0343)	0.0432 (0.0343)
SIM	0.0277 (0.0138)	0.0164 (0.0138)	0.0143 (0.0140)	0.0140 (0.0139)
R^2	0.2670	0.2711	0.2714	0.2716

(Notes) The variables *INP, INP (all), OUT, OUT (ind),* and *OUT (all)* are defined as inputs from other manufacturing industries, inputs from all other industries including non-manufacturing, output supplied to all other manufacturing industries, output to all other industries including non-manufacturing, all output including those absorbed by final demand, respectively. The sample period is 1990-2000. Other notes to Table II apply to this table. The column (1) is reproduced from the column (4) in Table II for comparison.