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Theories of New Economic Geography and Geographical Concentration of Manufacturing Industries in Japan*

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1. Introduction

This paper investigates the changing geographical pattern of manufacturing industries in Japan between 1985 and 1995 and explores factors of their geographical concentration. We start with an estimation of the geographical concentration of manufacturing industries using the coefficient of localization based on manufacturing employment and establishment data at the prefecture level. We then conduct a regression analysis to test some hypotheses of geographical concentration of manufacturing industries, which have been derived from new theories of trade and economic geography. In the regression analysis, we consider the following four factors of geographical concentration: internal economies of scale, transportation costs, inter-industry linkages, and factor intensity.

We follow basically the approach used by Amiti (1998, 1999), which investigated the effects of scale economies, inter-industry linkages, and factor intensity on the geographical concentration of manufacturing industries for EU countries using manufacturing employment and output data from EUROSTAT and UNIDO. In addition to these factors, however, we consider unit transportation costs as a possible factor of geographical concentration. Furthermore, our analysis is based on regional data rather than country data. As a measure of unit transportation costs, we use the ratio of intermediate transportation inputs to total inputs. We expect that scale economies, inter-industry linkages, and factor intensity have positive effects, while transportation costs have a negative effect, on the geographical concentration of manufacturing industries.

2. Hypotheses

According to the Heckscher-Ohlin theory, a region will tend to specialize in producing goods that are intensive in the factors with which the region is relatively well endowed. It is predicted that labor abundant regions will specialize in labor-intensive industries and export labor-intensive goods, while capital abundant regions will specialize in capital-intensive industries and export capital-intensive goods; and thus it is expected that more factor-intensive (either labor-intensive or capital-intensive) industries have a higher level of geographical concentration.

In the Heckscher-Ohlin theory, comparative advantage, resulting from factor abundance, determines the pattern of *inter-industry* trade between regions. On the other hand, in a model of new trade theory, as advanced by Krugman (1979), internal economies of scale (i.e., economies of scale at the firm level) and the love-of-variety effect in consumers' preferences play a key role in trade; the theory predicts that regions specialize within industries, thereby bringing about *intra-industry* trade, rather than *inter-industry* trade. Suppose that firms can ship their goods freely between regions without any transportation costs. In the model, it is possible to show that even though regions are identical in every respect (i.e., identical in technology, tastes, and factor endowments), they find it advantageous to trade by specializing in different sets of varieties within industries.

By engaging in intra-industry trade, a region would reduce the number of varieties it produces, but increase the number of varieties available to its consumers. Through intra-industry trade, each firm producing a variety can reduce the average cost by expanding its production for a larger market, while the consumers can have access to more varieties. There are thus gains from intra-industry trade. There are two positive welfare effects: the decrease in prices brought about by the increased production level and the love-of-variety effect, i.e., the effect of more varieties available to consumers.

In the new trade theory, neither firms nor the factors of production are mobile between regions, and thus each region's market size is given constant. Given their exogenously determined location, firms will make a decision on the varieties they want to produce. Models of the new economic geography are also based on internal economies of scale and the love-of-variety effect in consumers' preferences. However, labor and firms are mobile, and their location and the distribution of market size are determined endogenously (Fujita, Krugman, and Venables, 1999; Krugman, 1991a, 1991b).

In models of the new economic geography, developed by Krugman (1991a, 1991b), the geographical concentration of 'footloose' manufacturing production in general depends on some combination of strong internal economies of scale, as represented by large fixed costs, low transportation costs, and a large share of manufacturing in expenditure. These models predict a core-periphery pattern of economic geography in a country, with a manufacturing core on the one hand and an agricultural periphery on the other. While these models do not ask why a particular industry within the manufacturing sector is concentrated in a particular region, and thus do not determine the pattern of regional specialization within the manufacturing sector, they suggest important factors of geographical concentration of manufacturing industries: internal economies of scale, transportation costs, and market size as a source of demand for footloose production.

Our paper considers these factors to analyze the geographical concentration of Japanese manufacturing industries. Specifically, it conducts a multiple regression analysis to test the following hypotheses. First, manufacturing industries with larger internal economies of scale tend to have a higher level of geographical concentration. Second, manufacturing industries with smaller unit transportation costs tend to have a higher level of geographical concentration. Finally, manufacturing industries that have stronger inter-industry linkages tend to have a higher level of geographical concentration. In addition to these hypotheses, we will also test the hypothesis predicted by the Heckscher-Ohlin theory of trade: more factor-intensive manufacturing industries tend to have a higher level of geographical concentration.

3. Indices used in the Empirical Analysis

As a measure of the geographical concentration of a manufacturing industry, we use the following index (GC).

$$GC_i = \frac{1}{2}\sum_{k=1}^{K}\left|S_i^k - S_n^k\right|, \tag{1}$$

where K is the total number of regions in the country, and S_i^k and S_n^k are, respectively, the employment (or establishment) share of region k in manufacturing industry i and the employment (or establishment) share of region k in all manufacturing industries. The index ranges from 0 to 1. If manufacturing industry i has the same geographical distribution as all manufacturing industries, i.e., $S_i^k = S_n^k$ for all k, then the index value will be 0. On the other hand, if the industry is concentrated in a single region k', i.e., $S_i^{k'} = 1$ and $S_i^k = 0 \text{ for } k \neq k'$, then it will approach 1, since we have

$$GC_i = \frac{1}{2}\left(\left|1 - S_n^{k'}\right| + \sum_{k \neq k'}\left|0 - S_n^k\right|\right) \approx \frac{1}{2}(2) = 1.$$

This index is usually termed the coefficient of localization (Isard, 1960) or the coefficient of concentration (Hoover and Giarratani, 1985).

In Krugman (1979, 1991a, and 1991b), internal scale economies are modeled by a simple linear production function:

$$L_i = \alpha + \beta x_i,$$

where L_i is the amount of labor necessary to produce x_i of variety i, and the coefficients α and β are the fixed and marginal labor input requirement. One measure of internal economies of scale is the ratio of average costs to marginal costs. However, it is difficulty to obtain average and marginal costs for each manufacturing industry. Therefore, this study uses the ratio of the number of employees to the number of establishments (average establishment size) as a measure of internal economies of scale for a manufacturing industry (ES):

$$ES_i = \frac{E_i}{H_i}, \qquad (2)$$

where E_i and H_i are, respectively, total employment and the total number of establishments in industry i.

As a measure of unit transportation costs, we use the ratio of total transportation inputs to total input (TR). On the other hand, to measure inter-industry linkages, we employ the total (direct and indirect) backward linkage index (TBLI) and the total (direct and indirect) forward linkage index (TFLI); these indices are based, respectively, on the input (or Leontief) inverse, which is derived from the ordinary demand side input-output (I-O) model and the output inverse, which is derived from the supply-side I-O model (Miller and Blair, 1985).

Suppose that $(\mathbf{I} - \mathbf{A})^{-1}$ and $(\mathbf{I} - \mathbf{B})^{-1}$ are, respectively, the input (or Leontief) inverse and the output inverse. If the elements of $(\mathbf{I} - \mathbf{A})^{-1}$ and $(\mathbf{I} - \mathbf{B})^{-1}$

are denoted, respectively, by α_{ij} and β_{ij}, then total backward linkage and forward linkage indices for industry k will be given, respectively, by:

$$\text{TBLI} = \frac{\sum_i \alpha_{ik}}{1/n \sum_i \sum_j \alpha_{ij}} \quad \text{and TFLI} = \frac{\sum_j \beta_{kj}}{1/n \sum_i \sum_j \beta_{ij}}. \tag{3}$$

The backward linkage of an industry refers to the extent to which the industry's production is interconnected to those industries from which it purchases inputs; the total backward linkage index presents the relative magnitude of total output multiplier effects. On the other hand, the forward linkage of an industry refers to the extent to which the industry's production is interconnected to those industries to which it sells its output; the total forward linkage index presents the relative magnitude of total input multiplier effects.

As in Amiti (1999), we use the following index as a proxy for factor intensities (FI):

$$\text{FI}_i = \left|\text{FS}_i - \overline{\text{FS}}\right|, \tag{4}$$

where FS_i is the share of payments to a factor (either labor or capital) in value added in industry i and $\overline{\text{FS}}$ is the average share in the nation. The larger the deviation from the average factor share is, the larger the index value will be, whether the industry is labor-intensive or capital-intensive.

4. The Data

This study used manufacturing data by prefecture for 1985 and 1995 from the Industrial Statistics, which were compiled by the Research Institute of Economy, Trade, and Industry of the Ministry of Economy, Trade, and Industry (METI). The data set contains statistics on the number of establishments, the number of employees, salaries and wages, output, raw material costs, value added, and fixed assets for 155 3-digit SIC (standard industrial classification) manufacturing sectors and 47 prefectures.

The study also used the Japanese 186-sector national input-output (I-O) tables for 1985 and 1995, compiled by the same research institute. The tables include 109 manufacturing industries. Since the sector classification for manufacturing industries employed by the I-O tables differs greatly from the one used by the Industrial Statistics, we reorganized substantially both the I-O tables and the manufacturing data from the Industrial Statistics so as to have the same sector classification. This resulted in the 161-sector I-O tables including 83 manufacturing industries. In the empirical analysis however, we used data for 80 manufacturing industries, since in the manufacturing data from the Industrial Statistics, 3 industries did not have any activities in either 1985 or 1995 or both. The 80-sector 3-digit classification and the corresponding 2-digit classification are found in Table 4.1. On the other hand, table 4.2 presents 47 prefectures, which are grouped into 11 regions, and figure 4.1 presents the map of Japan, where three metropolitan regions, Tokyo Metropolitan Area (TMA), Tokai, and Kinki, are highlighted.

The geographical concentration of a manufacturing industry and its plant-level scale economies were measured, respectively, by equations (1) and (2), where establishment and employment data by prefecture from the Industrial Statistics were used. To calculate the total backward and forward linkage indices based on equation (3), we used the national I-O tables. Also, to measure unit transportation cost and factor intensity, we used data on transportation inputs and value added from the national I-O tables.

5. Regional Growth Patterns of Manufacturing Industries between 1985 and 1995: A Shift and Share Analysis

Before examining the geographical concentration of manufacturing industries during 1985-95, it would be instructive to analyze the growth patterns of regional economies over the period by using manufacturing employment data by sector. Specifically, we conducted a shift and share analysis to analyze regional differences in the growth pattern of manufacturing employment.[1] The sector classification used in this shift and share analysis is the 2-digit industrial classification (22 industries), as presented in table 4.1. Shift and share analysis aims to examine the factors

[1] For ordinary shift and share analysis, please see, for example, Armstrong and Taylor (1985).

determining the growth of a region by comparing the region's growth with the growth of the nation as a whole. It decomposes the region's actual total growth into three components: the regional share component, the industry-mix shift component and the competitive shift component.

5.1. Changes in the Structure of the Manufacturing Industry in Employment

Table 5.1 presents changes in the structure of the manufacturing industry between 1985 and 1995. Japan as a whole contracted at an annual average rate of 0.6% over the period, losing 597 thousand employees altogether (from 10,967 thousand to 10,370 thousand employees). The textile industry recorded the largest negative growth rate at -7.8%. It lost 387 thousand employees, which was the largest among 22 manufacturing industries (2-digit SIC industries), accounting for 65% of the total decrease in manufacturing employment.[2] It therefore reduced its employment share substantially from 6.4 to 3.0% during the period. This reflects the fact that Japan has lost its comparative advantage in labor-intensive manufacturing activities, as compared to surrounding Asian countries in the late 1980s, during which the Japanese yen appreciated substantially from around 250 yen to 120 yen to the U.S. dollar in line with the so-called Plaza Agreement signed in 1985.

Electrical machinery lost 96 thousand employees during the period, which was the second largest next to the textile industry. However, it contracted at a much slower rate than the textile industry; thus its employment share remained the same at 16.4%. Wood products and iron and steel industries reduced their employments by 73 and 72 thousand employees, which were the third and fourth largest decrease next to the electrical machinery industry. On the other hand, food products, wearing apparel, publishing and printing, and plastic products industries recorded positive employment growth rates; thus their shares increased over the period. In 1995, the electrical machinery industry still had the largest employment share at 16.4%, which was followed by food products (11.2%), non-electrical machinery (10.9%), metal

[2] The textile and wood products industries contracted in all regions in the period.

products (8.5%), and transportation equipment (8.3%).

5.2. *Changes in the Geographical Distribution of the Manufacturing Industry in Employment*

Table 5.2 shows changes in the geographical distribution of the manufacturing industry by region between 1985 and 1995. There have been significant changes in the geographical distribution. Among the 11 regions, 6 regions experienced negative growth rates. Especially, Tokyo Metropolitan Area (TMA), which includes the capital city of Tokyo, and Kinki, which includes Osaka as the center of business in the western part of Japan, recorded very large negative growth rates. In 1985, TMA and Kinki together accounted for 41.4% of total manufacturing employment; but the share declined to 38.0% in 1995. They lost 593 thousand manufacturing employees altogether in the period, accounting for most of the employment reduction in Japan. Only these two regions, in fact, reduced their employment shares.

North Kanto, Tokai, Chugoku, and Shikoku also contracted; but their employment shares either grew slightly or remained constant. On the other hand, the northern most region of Hokkaido, Tohoku, Hokuriku (the region facing the Japan sea), and the southern most regions of Kyushu and Okinawa realized positive growth rates, and thus gained their employment shares. In sum, there seems to have been a shift in manufacturing employment in this period from the two metropolitan regions of TMA and Kinki to the remote regions of Hokkaido, Tohoku, Hokuriku, Kyushu, and Okinawa, even though these metropolitan regions still occupied 38% of total manufacturing employment. These five remote regions together increased their employment by 87 thousand.

It should be noted that Japan experienced the rising and declining trend of regional income inequality in the late 1980s and the early 1990s, which corresponds closely to the rise and collapse of the bubble economy (Akita and Kataoka, 2003). In the late 1980s, financial institutions increased their loan for investment in stocks and real estate, especially in TMA, as it became one of the major international financial and information centers in the world, following the deregulation and liberalization of the financial sector in Japan. As a result, the prices of stocks and real estate increased conspicuously, and their respective capital gain brought huge wealth to the investors.

However, this bubble economy collapsed in the early 1990s with a drastic fall in the prices of stocks and real estate, and the Japanese economy entered a period of long recession. Financial institutions have suffered from huge bad loans as a result of excess lending for investment in stocks and real estate. Geographically, the bubble period and the subsequent period of long recession were associated with the rise and fall of TMA. In terms of per capita GDP, TMA grew at 6.2 % in 1985-90, in which Japan as a whole grew at 5.1%. However, in 1990-2000, the growth rate of TMA dropped substantially to -0.4%, while Japan as a whole registered a growth rate of 0.7%. It should be noted that Kinki's comparable figures for these two periods were 4.8 and 0.7%, respectively. Therefore, Kinki grew less rapidly than Japan as a whole in 1985-2000.

5.3. Shift and Share Analysis in Employment between 1985 and 1995

Table 5.3 presents the results of the shift and share analysis for 11 regions. As mentioned above, the two metropolitan regions, TMA and Kinki, contracted at much faster rates than Japan as a whole. In 1985, they accounted for 23.1 and 18.3% of total manufacturing employment, respectively; but their shares declined to 20.8 and 17.2% in 1995. There are, however, notable differences in the pattern of contraction between TMA and Kinki: while the competitive-shift component was wholly responsible for the contraction of TMA, the industry-mix shift and competitive-shift components contributed equally to the contraction of Kinki.

In TMA, all but food products industry experienced a negative growth. Especially, metal products, non-electrical machinery, electrical machinery, and transportation equipment industries, which together had half of TMA's total manufacturing employment in 1985, experienced large negative growth rates (-1.2, -1.9, -2.3, and -2.3%, respectively). These four industries together accounted for two thirds of the employment contraction due to the competitive shift effect. They lost 232 thousand employees in the period altogether; many of them seem to have been relocated to other regions or abroad.

In Kinki, the textile industry was responsible for a large negative industry-mix shift, as it accounted for 10.4% of total manufacturing employment in 1985 in Kinki, the third largest next to the non-electrical machinery and electrical machinery industries, while it recorded the largest negative growth rate in Japan at -7.8%, which was compared with Japan's overall growth rate of -0.6%. In Kinki, The textile industry lost 111 thousand employees during the period, which was more than a quarter of the nation's employment decrease in the textile industry. In Kinki, the textile industry reduced its employment share substantially, from 10.4 to 5.5% in the period. On the other hand, iron and steel, metal products, and electrical machinery industries contributed to a large negative competitive shift. They accounted for more than half of the employment contraction due to the competitive shift effect.

Tokai (which includes Aichi as its main prefecture) contracted also. However, since transportation equipment, electrical machinery, plastic products, and metal products industries grew at 0.6, 0.5, 2.8, and 0.6%, respectively, the region had a large positive competitive shift; it thus reduced its manufacturing employment by only 36 thousand employees. The region increased its employment share slightly from 17.6 to 18.2%. It should be noted that the transportation equipment industry employed 346 thousand in Tokai in 1995, which was 40% of its total employment in Japan. Tohoku also had a large positive competitive shift; wearing apparel, non-electrical machinery, and transportation equipment industries contributed a lot to its positive competitive shift, which grew at 3.7, 1.5, and 3.3%, respectively. The wearing apparel industry employed 135 thousand in Tohoku in 1995, which was the largest in Japan and about 20% of its total employment. It should be noted that the electrical machinery industry had the largest share in Tohoku, accounting for 24.7% in 1995, although it contracted slightly in the period. Tohoku as a whole grew at 0.4%, increasing its share to 10.4 from 9.5% in the period.

Hokkaido and Kyushu had a similar growth pattern; they had positive industry-mix and competitive shifts. Hokkaido recorded the highest growth rate in Japan at 1.3%. Most industries experienced positive employment growth. Among them, the food products industry, which accounted for 35.1% of Hokkaido's total employment in 1985, grew at 1.7%; thus its share increased to 36.3% in 1995. The metal products and electrical machinery industries also contributed to Hokkaido's employment growth, as they grew at 3.5 and 4.9%, respectively. On the other hand, in Kyushu, the electrical machinery industry grew at a relatively high rate (2.6%) and contributed a lot to the region's competitive shift; it accounted for almost 70% of the shift. Its share in the region increased significantly from 12.5 to 15.9% over the period. The wearing apparel industry also played a prominent role in the employment growth of Kyushu, as it grew at 2.4%. North Kanto also had positive industry-mix and competitive shifts, although it contracted slightly. The non-electrical machinery and transportation equipment industries grew at 1.3 and 0.9%, respectively, and thus contributed to a large positive competitive shift. They raised their employment shares to 12.4 and 9.0% in 1995. In North Kanto, the electrical machinery still had the largest share at 25.1%, even though it contracted slightly in the period.

6. Empirical Evidence

6.1. Geographical Concentration of Manufacturing Industries

According to the geographical distribution of manufacturing employment by prefecture in 1985 and 1995, 7 out of 47 prefectures decreased their employment shares over the period; however, except Fukui, they are all located in TMA or Kinki, two metropolitan regions. Especially, Tokyo, Kanagawa, and Osaka experienced a large decrease. In 1985, Tokyo had the largest employment share at 8.8%, which was followed by Osaka (8.7%), Aichi (8.6%), Kanagawa (6.4%), and Saitama (5.4%). But in 1995, Aichi became the largest prefecture in manufacturing employment, with a share of 8.9%, which was followed by Osaka (7.8%), Tokyo (6.9%), Kanagawa (5.8%), and Saitama (5.3%). Tokyo, in fact, lost 245 thousand employees over the period, which was more than 40% of total decrease in manufacturing employment in the period.

We measured the geographical concentration of a manufacturing industry using the geographical concentration index, as defined in section 3 (equation (1)), where the geographical distribution of employment (or establishment) in the industry is compared with the geographical distribution of manufacturing employment (or establishment) in the nation as a whole. We calculated the index of geographical concentration for 80 industries by using employment and establishment data, and ranked these 80 industries in descending order by the level of their geographical concentration in employment in 1985. Table 6.1 exhibits only top 20 industries and bottom 20 industries. If we compare 1995 with 1985, 47 out of 80 industries (59%) experienced a decrease in geographical concentration, when measured by employment, and 57 out of 80 (71%) experienced a decrease, when measured by establishment. This is in contrast to the EU, where most industries have raised their level of geographical concentration in the 1980s (Amiti, 1998; and Brulhart and Torstensson, 1996).

When geographical concentration is measured by employment, plated steel was the most geographically concentrated industry in 1985, which was followed by synthetic fiber, car and bicycle tires, china and porcelain, airplane manufacturing, pig iron and steel, clock and watch, oil products, boiler and turbine, and paper. But, out of these top 10 industries, 8 industries experienced a decrease in geographical concentration. Especially, plated steel, synthetic fiber, china and porcelain, and pig iron and steel exhibited a large decrease. On the other hand, boiler and turbine experienced a significant increase in concentration. A similar pattern is observed when geographical concentration is measured by establishment.

It is interesting to note that 18 out of the top 20 geographically concentrated industries in 1985 are either heavy and chemical industries or processing and assembling industries (10 industries and 8 industries, respectively), when measured by employment. Among the top 20 industries, only paper industry and silk and spinning industry are light industries.[3] On the other hand, among the bottom 20 industries in 1985, 8 industries are light industries; only 5 heavy and chemical industries appear among the bottom 20. This suggests the existence of structural differences between heavy and chemical industries and other industries.

Table 6.2 presents establishment size, unit transportation costs, and factor intensity for 80 industries. Again, only top 20 and bottom 20 industries are presented

[3] In terms of the 2-digit industrial classification, shown in table 4.1, industries from 12 through 19 are light industries (25 3-digit industries), industries from 20 through 28 are heavy and chemical industries (28 3-digit industries), and industries from 29 through 34 are processing and assembling industries (27 3-digit industries).

in the table (in terms of the index of geographical concentration). Except boiler and turbine industry and rolling steel and steel tube industry, all top 20 industries reduced their establishment sizes in the period. In 1985, pig iron and steel had the largest establishment size at 1,210 employees, which was followed by synthetic fiber (345), car and bicycle tires (218), plated steel (118), and oil products (84); but their establishment sizes were reduced substantially. Even though the largest size was still registered by pig iron and steel in 1995, it was 549 employees, less than a half of the size in 1985. Synthetic fiber and car and bicycle tires reduced their sizes to 210 and 117, respectively. It is interesting to note that most of the top 20 industries decreased both their levels of geographical concentration and establishment sizes. On the other hand, boiler and turbine industry and rolling steel and steel tube industry raised both their levels of geographical concentration and establishment sizes.

Bottom 20 industries had much smaller establishment size. On average, the bottom 20 industries had 14 and 15 employees per establishment in 1985 and 1995, respectively, which were compared to 128 and 78 employees for the top 20 industries. This indicates a positive relationship between the level of geographical concentration and establishment size, which is a proxy for the internal economies of scale.

Though there are some exceptions, many of the top 20 industries have a larger factor intensity than the bottom 20 industries. On average, the top 20 industries had a factor intensity of 0.119 in 1985, which was much larger than 0.83 registered by the bottom 20 industries. Again, there seems to be a positive relationship between the level of geographical concentration and factor intensity, i.e., more factor-intensive industries tend to have a higher level of geographical concentration. On the other hand, there seems to be a negative relationship between the level of geographical concentration and unit transportation costs.

These relationships will be examined statistically in the next section.

6.2. Regression Results: Factors of the Geographical Concentration of Manufacturing Industries

In order to examine factors of the geographical concentration of manufacturing industries, we conducted a multiple regression analysis, in which we tested the hypotheses discussed in section 2. In total, we estimated six regression models, where the index of geographical concentration (GC), the dependent variable, was assumed to be a linear function of the following five independent variables: establishment size (ES) as a proxy for the internal economies of scale, factor intensity (FI), unit transportation costs (TR), total backward linkage index (TBLI), and total forward linkage index (TFLI). In the first three models (Models 1, 2, and 3), employment data from the Industrial Statistics were used to measure the index of geographical concentration, whereas in the last three models (Models 4, 5, and 6), establishment data were used.

In these models, we also introduced two dummy variables to distinguish three types of manufacturing industries: light industries, heavy and chemical industries, and processing and assembling industries.[4] The following provides the definition of these two dummy variables.

D_1 = 1 if an industry belongs to the category of light industries; and 0 otherwise.

D_2 = 1 if an industry belongs to the category of heavy and chemical industries; and 0 otherwise.

To estimate these regression models, we used panel data on 80 manufacturing industries for 1985 and 1995. Table 6.3 exhibits the regression results. Since the White's heteroscedasticity test indicated the existence of heteroscedasticity, we presented *t* values based on White's heteroscedasticity-corrected variances and standard errors.

In all models, the coefficients associated with establishment size (ES) and factor intensity (FI) are significant at the 1% significance level; these coefficients are both positive, which are expected by the new trade theory and the Heckscher-Ohlin theory, respectively. While the coefficient associated with unit transportation costs (TR) is significant at the 1% significance level in Models 1, 2, and 3, it is significant at the

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[4] To see whether there is a significant structural shift between two years, we also introduced a time dummy; but the result was insignificant.

10% significance level in Models 4 and 5 and at the 5% significance level in Model 6. However, the coefficient is negative in all models, which coincides with our expectation based on the theory of the new economic geography. It should be noted that the coefficients of the total backward and forward linkage indices (TBLI and TFLI, respectively) are insignificant in all models.

From these results, it can be concluded that the geographical concentration of manufacturing industries seems to have been determined by some combination of internal economies of scale, transportation costs, and factor intensity, at least during the 1985-1995 period. However, backward and forward inter-industry linkages do not seem to be a significant factor in determining the geographical concentration of manufacturing industries. In other words, manufacturing industries with larger internal economies of scale and smaller unit transportation costs tend to have a higher level of geographical concentration. Furthermore, more factor intensive industries tend to have a higher level of geographical concentration. On the other hand, the extent of inter-industry linkages does not seem to affect the level of geographical concentration.

It should be noted that both the differential intercept coefficient and the differential slope coefficient associated with establishment size (ES), as represented by the dummy variable for heavy and chemical industries (D_2), are significant at the 1% significant level in all models. Since the differential intercept coefficient is positive, while the differential slope coefficient is negative, it may be concluded that heavy and chemical industries tend to have a higher level of geographical concentration than other industries when they have smaller establishment size, but their levels of geographical concentration would not increase as much as other industries with establishment size, *ceteris paribus*. Conversely, light industries and processing and assembling industries tend to have a lower level of geographical concentration when their establishment size is smaller; but their concentration level increases rapidly with establishment size, *ceteris paribus*. Since the differential slope coefficient associated with factor intensity (FI), as represented by the dummy variable for heavy and chemical industries (D_2), is also negative, though not very significant, heavy and chemical industries have the same pattern for factor intensity

(FI) as for establishment size (ES).[5]

7. Conclusion

This study attempted to investigate the factors determining the geographical concentration of manufacturing industries in Japan by using manufacturing data by prefecture from the Industrial Statistics and national input-output tables for 1985 and 1995. As opposed to the EU experiences, where country data were used to analyze geographical concentration, many Japanese manufacturing industries experienced a decrease in geographical concentration between 1985 and 1995. In this period, Japan underwent significant structural changes, due mainly to the rise and collapse of the bubble economy along with the rapid appreciation of the yen against the U.S. dollar. Japan as a whole decreased its manufacturing employment by about 600 thousand employees; but most of the decrease took place in the two metropolitan areas: Tokyo Metropolitan Area (TMA) and Kinki. Japanese textile industry suffered a lot from the rapid appreciation of the yen and lost its competitiveness in the world market. It relocated their manufacturing plants to neighboring Asian countries where labor costs are much lower, and reduced its employment conspicuously in Japan. About two thirds of the total decrease in manufacturing employment is accounted for by the textile industry.

Despite these large structural changes occurred in the period, our study found that economic forces behind the geographical concentration of Japanese manufacturing industries seem to comply with theories of the new trade and economic geography. We found in the regression analysis that the geographical concentration of manufacturing industries seems to be determined by some combination of internal economies of scale, transportation costs, and factor intensity. However, inter-industry linkages were found to be an insignificant factor of geographical concentration. As conjectured by the theories of the new trade and economic geography, Japanese manufacturing industries with larger internal

[5] We found that the differential slope coefficient for transportation costs (TR) was not significant; therefore, we removed the corresponding terms in these regression models.

economies of scale and smaller unit transportation costs tend to have a higher level of geographical concentration. Japanese manufacturing data also support the Heckscher-Ohlin theory that labor or capital abundant regions tend to specialize in labor- or capital-intensive industries. According to the regression analysis, labor- or capital-intensive industries tend to have a higher level of geographical concentration.

We found also that heavy and chemical industries seem to have a distinct relationship between the level of geographical concentration and internal economies of scale and between the level of geographical concentration and factor intensity. Heavy and chemical industries tend to have higher levels of geographical concentration than other industries when their establishment size or factor intensity is small, but their levels of concentration will not increase as much as other industries with establishment size or factor intensity.

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Figure 4.1. Map of Japan

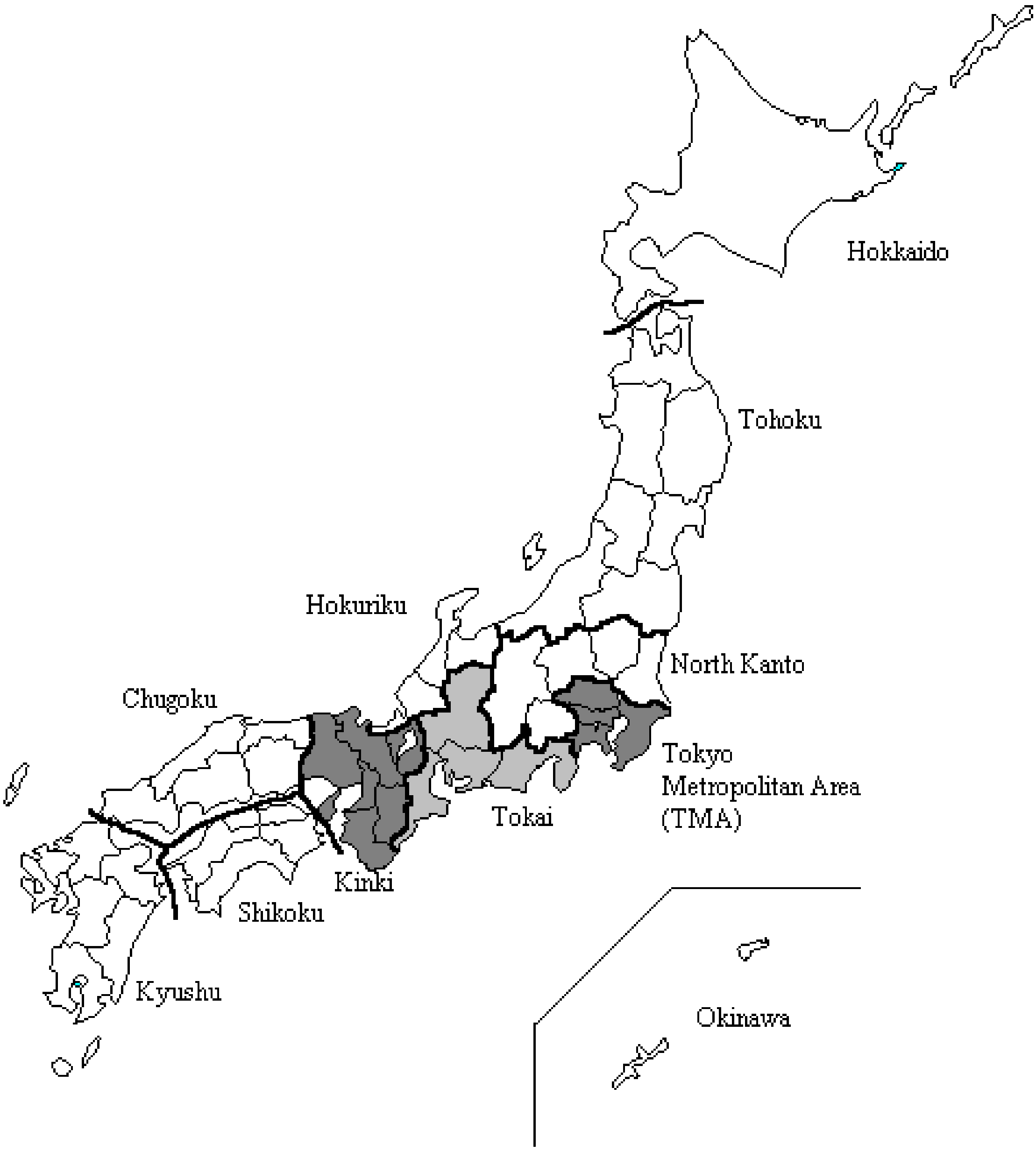

Table 4.1. Sector Classification

2-digit Industrial Classification		3-digit Industrial Classification	
12	Food products	121	Meat & diary products
		122	Marine products
		123	Vegetable products
		124	Sugar, seasoning, oil products
		126	Rice & flour milling
		127	Bread & cake
		129	Other food products
13	Beverage	131	Other beverages
		132	Alcohol beverage
14	Textile industry	141	Silk & spinning
		143	Yarning & weaving
		145	Knitting
		146	Dyeing
		147	Other textile products
15	Wearing apparel	151	Manufacturing of clothes
		152	Other clothes
		159	Other wearing apparel
16	Sawmill & wood products	161	Saw mill & plywood
		163	Other wooden products
17	Furniture & fixture	171	Furniture & fixture
18	Paper & paper products	182	Paper
		183	Paper products
		185	Paper boxes
		189	Other paper products
19	Publishing & printing	191	Publishing & printing
20	Industrial chemical	201	Chemical fertilizer
		202	Inorganic chemical products
		203	Organic chemical products
		204	Synthetic fiber
		205	Synthetic detergent & paint
		206	Medicines
		209	Other chemical products
21	Petrochemical & coal products	211	Oil products
		213	Coal products
22	Plastic products	221	Plastic products
23	Rubber products	231	Car & bicycle tires
		232	Other rubber products
24	Leather products & fur	241	Leather, fur & other leather products
		243	Leather shoes
25	Nonmetallic mineral products	251	Glass products
		252	Cement & concrete
		253	Other ceramics
		254	China and porcelain
26	Iron & steel industry	261	Pig iron & steel
		264	Rolling steel & steel tube
		265	Plated steel
		266	Cast & pig iron
		269	Other iron & steel
27	Nonferrous basic metal	271	Nonferrous metal refining
		273	Other nonferrous metals
		274	Electric wire & cable

28	Metal products	281	Other metal products
		282	Metal products for heating & kitchen
29	Nonelectrical machinery	291	Boiler & turbine
		292	Other nonelectrical machinery
		293	Construction machinery
		294	Machine tools
		297	Machinery for other products
		298	Machinery for office
		299	Other non-electrical machinery
30	Electrical machinery	301	Electrical machinery for industry
		302	Electrical machinery for households
		303	Electric bulb & lighting tools
		304	Communications equipments
		305	Computers
		306	Electronic medical & other equipments
		307	Electronic measurement instruments
		308	Electronic components & parts
		309	Other electric machinery
31	Transportation equipment	311	Automobile manufacturing
		312	Railroad vehicle manufacturing
		313	Bicycle manufacturing
		314	Shipbuilding industry
		315	Airplane manufacturing
		319	Other transportation equipments
32	Precision machinery	321	Other precision machinery
		325	Optical instruments
		327	Clock & watch
34	Other manufacturing	341	Other manufacturing
		343	Toys

Table 4.2. Classification of Regions

Region		Prefecture	
1	Hokkaido	1	Hokkaido
2	Tohoku	2	Aomori
		3	Iwate
		4	Miyagi
		5	Akita
		6	Yamagata
		7	Fukushima
		15	Niigata
3	North Kanto	8	Ibaragi
		9	Tochigi
		10	Gunma
		19	Yamanashi
		20	Nagano
4	Tokyo Metropolitan Area (TMA)	11	Saitama
		12	Chiba
		13	Tokyo
		14	Kanagawa
5	Tokai	21	Gifu
		22	Shizuoka
		23	Aichi
		24	Mie
6	Hokuriku	16	Toyama
		17	Ishikawa
		18	Fukui
7	Kinki	25	Shiga
		26	Kyoto
		27	Osaka
		28	Hyogo
		29	Nara
		30	Wakayama
8	Chugoku	31	Tottori
		32	Shimane
		33	Okayama
		34	Hiroshima
		35	Yamaguchi
9	Shikoku	36	Tokushima
		37	Kagawa
		38	Ehime
		39	Kochi
10	Kyushu	40	Fukuoka
		41	Saga
		42	Nagasaki
		43	Kumamoto
		44	Oita
		45	Miyazaki
		46	Kagoshima
11	Okinawa	47	Okinawa

Table 5.1. Changes in the Structure of the Manufacturing Industry in Employment

2-Digit Industrial Code	Name	1985 Number	1985 % Share	1995 Number	1995 % Share	Growth 85-95	Growth Rate (%)
12	Food products	1,057,915	9.6	1,164,789	11.2	106,874	1.0
13	Beverage	105,163	1.0	97,753	0.9	-7,410	-0.7
14	Textile industry	697,063	6.4	310,135	3.0	-386,928	-7.8
15	Wearing apparel	579,382	5.3	639,614	6.2	60,232	1.0
16	Sawmill & wood products	301,731	2.8	229,046	2.2	-72,685	-2.7
17	Furniture & fixture	268,802	2.5	246,273	2.4	-22,529	-0.9
18	Paper & paper products	270,079	2.5	264,753	2.6	-5,326	-0.2
19	Publishing & printing	546,794	5.0	572,678	5.5	25,884	0.5
20	Industrial chemical	342,914	3.1	342,887	3.3	-27	0.0
21	Petrochemical & coal products	28,646	0.3	24,102	0.2	-4,544	-1.7
22	Plastic products	385,967	3.5	453,569	4.4	67,602	1.6
23	Rubber products	145,492	1.3	129,457	1.2	-16,035	-1.2
24	Leather products & fur	89,392	0.8	72,324	0.7	-17,068	-2.1
25	Nonmetallic mineral products	457,501	4.2	423,717	4.1	-33,784	-0.8
26	Iron & steel industry	274,132	2.5	202,060	1.9	-72,072	-3.0
27	Nonferrous basic metal	144,901	1.3	148,284	1.4	3,383	0.2
28	Metal products	861,739	7.9	882,336	8.5	20,597	0.2
29	Nonelectrical machinery	1,156,705	10.5	1,133,887	10.9	-22,818	-0.2
30	Electrical machinery	1,799,657	16.4	1,704,067	16.4	-95,590	-0.5
31	Transportation equipment	890,320	8.1	860,506	8.3	-29,814	-0.3
32	Precision machinery	263,453	2.4	197,379	1.9	-66,074	-2.8
34	Other manufacturing	299,667	2.7	270,107	2.6	-29,560	-1.0
	Total	10,967,415	100.0	10,369,723	100.0	-597,692	-0.6

Table 5.2. Changes in the Geographical Distribution of the Manufacturing Industry in Employment

	Region	1985 Number	1985 Share	1995 Number	1995 Share	Growth 85-95	Growth Rate (%)
1	Hokkaido	211,171	1.9	240,713	2.3	29,542	1.3
2	Tohoku	1,040,682	9.5	1,078,719	10.4	38,037	0.4
3	North Kanto	1,164,761	10.6	1,158,940	11.2	-5,821	-0.1
4	TMA	2,534,297	23.1	2,160,345	20.8	-373,952	-1.6
5	Tokai	1,924,783	17.6	1,888,961	18.2	-35,822	-0.2
6	Hokuriku	366,290	3.3	368,290	3.6	2,000	0.1
7	Kinki	2,003,760	18.3	1,785,186	17.2	-218,574	-1.1
8	Chugoku	658,782	6.0	620,821	6.0	-37,961	-0.6
9	Shikoku	314,578	2.9	302,167	2.9	-12,411	-0.4
10	Kyushu	723,814	6.6	739,983	7.1	16,169	0.2
11	Okinawa	24,497	0.2	25,598	0.2	1,101	0.4
	Total	10,967,415	100.0	10,369,723	100.0	-597,692	-0.6

Table 5.3. Shift and Share Analysis in Employment by Region during 1985-95

	Total Growth (A)	Regional Share (B)	Total Shift (C) = (A) - (B) = (D) + (E)	Industry Mix Shift (D)	Competitive Shift (E)	Annual Growth Rate (%)
Hokkaido	29,542	-11,508	41,050	9,660	31,390	1.3
Tohoku	38,037	-56,714	94,751	-3,446	98,197	0.4
North Kanto	-5,821	-63,476	57,655	5,082	52,573	-0.1
TMA	-373,952	-138,112	-235,840	65,169	-301,009	-1.6
Tokai	-35,822	-104,895	69,073	-26,166	95,239	-0.2
Hokuriku	2,000	-19,962	21,962	-29,882	51,843	0.1
Kinki	-218,574	-109,199	-109,375	-47,460	-61,915	-1.1
Chugoku	-37,961	-35,902	-2,059	11,417	-13,476	-0.6
Shikoku	-12,411	-17,144	4,733	4,875	-142	-0.4
Kyushu	16,169	-39,446	55,615	9,658	45,957	0.2
Okinawa	1,101	-1,335	2,436	1,094	1,342	0.4
Total	-597,692	-597,692	0	0	0	-0.6

Table 6.1. Geographical Concentration of Manufacturing Industries

Top 20 Industries

3-Digit Code	Name	Geographical Concentration in Employment			Geographical Concentration in Establishment		
		1985	1995	Change	1985	1995	Change
265	Plated steel	0.844	0.745	-0.099	0.828	0.673	-0.155
204	Synthetic fiber	0.796	0.749	-0.047	0.742	0.634	-0.108
231	Car & bicycle tires	0.777	0.756	-0.021	0.584	0.589	0.005
254	China and porcelain	0.698	0.636	-0.062	0.637	0.595	-0.042
315	Airplane manufacturing	0.648	0.642	-0.006	0.531	0.505	-0.026
261	Pig iron & steel	0.627	0.569	-0.058	0.546	0.511	-0.035
327	Clock & watch	0.614	0.644	0.030	0.551	0.571	0.020
211	Oil products	0.611	0.596	-0.015	0.436	0.427	-0.009
291	Boiler & turbine	0.609	0.683	0.074	0.361	0.427	0.066
182	Paper	0.581	0.568	-0.013	0.573	0.545	-0.028
201	Chemical fertilizer	0.566	0.520	-0.046	0.502	0.497	-0.005
312	Railroad vehicle manufacturing	0.506	0.462	-0.044	0.344	0.376	0.032
264	Rolling steel & steel tube	0.498	0.510	0.012	0.438	0.434	-0.004
314	Shipbuilding industry	0.497	0.487	-0.010	0.481	0.472	-0.009
141	Silk & spinning	0.494	0.504	0.010	0.507	0.491	-0.016
307	Electronic measurement instruments	0.481	0.466	-0.015	0.447	0.413	-0.034
243	Leather shoes	0.473	0.487	0.014	0.520	0.516	-0.004
313	Bicycle manufacturing	0.472	0.605	0.133	0.503	0.546	0.043
241	Leather, fur & other leather products	0.469	0.482	0.013	0.481	0.490	0.009
325	Optical instruments	0.466	0.503	0.037	0.519	0.537	0.018

Bottom 20 Industries

124	Sugar, seasoning, oil products	0.254	0.217	-0.037	0.348	0.329	-0.019
232	Other rubber products	0.254	0.223	-0.031	0.329	0.285	-0.044
298	Machinery for office	0.251	0.252	0.001	0.243	0.250	0.007
269	Other iron & steel	0.245	0.261	0.016	0.191	0.187	-0.004
159	Other wearing apparel	0.215	0.231	0.016	0.174	0.190	0.016
126	Rice & flour milling	0.212	0.181	-0.031	0.281	0.280	-0.001
297	Machinery for other products	0.202	0.189	-0.013	0.218	0.186	-0.032
281	Other metal products	0.198	0.176	-0.022	0.271	0.248	-0.023
171	Furniture & fixture	0.190	0.174	-0.016	0.175	0.161	-0.014
299	Other non-electrical machinery	0.183	0.174	-0.009	0.225	0.199	-0.026
341	Other manufacturing	0.179	0.136	-0.043	0.161	0.124	-0.037
163	Other wooden products	0.177	0.210	0.033	0.148	0.208	0.060
221	Plastic products	0.174	0.166	-0.008	0.193	0.170	-0.023
301	Electrical machinery for industry	0.174	0.159	-0.015	0.189	0.149	-0.040
282	Metal products for heating & kitchen	0.170	0.160	-0.010	0.143	0.134	-0.009
294	Machine tools	0.169	0.178	0.009	0.205	0.191	-0.014
129	Other food products	0.166	0.150	-0.016	0.261	0.244	-0.017
292	Other nonelectrical machinery	0.164	0.164	0.000	0.139	0.123	-0.016
127	Bread & cake	0.135	0.145	0.010	0.217	0.201	-0.016
185	Paper boxes	0.114	0.117	0.003	0.144	0.138	-0.006

Table 6.2. Establishment Size, Unit Transportation Costs, and Factor Intensity

Top 20 Industries

3-Digit Industrial Code	Name	Establishment Size		Unit Transportation Costs		Factor Intensity	
		1985	1995	1985	1995	1985	1995
265	Plated steel	118.3	73.0	0.024	0.035	0.122	0.099
204	Synthetic fiber	345.3	210.3	0.036	0.031	0.086	0.065
231	Car & bicycle tires	217.9	117.0	0.024	0.018	0.071	0.074
254	China and porcelain	10.7	9.9	0.031	0.031	0.086	0.036
315	Airplane manufacturing	80.7	71.1	0.005	0.009	0.075	0.123
261	Pig iron & steel	1210.5	548.7	0.045	0.060	0.229	0.201
327	Clock & watch	51.8	44.3	0.017	0.021	0.108	0.088
211	Oil products	84.0	68.7	0.009	0.029	0.230	0.262
291	Boiler & turbine	65.2	86.6	0.031	0.023	0.016	0.002
182	Paper	63.1	69.1	0.048	0.031	0.002	0.141
201	Chemical fertilizer	35.2	26.5	0.034	0.037	0.111	0.165
312	Railroad vehicle manufacturing	26.0	21.1	0.013	0.018	0.174	0.237
264	Rolling steel & steel tube	71.9	74.4	0.017	0.014	0.191	0.007
314	Shipbuilding industry	27.3	22.2	0.019	0.018	0.215	0.120
141	Silk & spinning	72.6	40.8	0.015	0.029	0.227	0.170
307	Electronic measurement instruments	29.9	28.8	0.018	0.016	0.031	0.053
243	Leather shoes	9.7	9.6	0.017	0.029	0.004	0.078
313	Bicycle manufacturing	18.4	17.6	0.015	0.021	0.269	0.101
241	Leather, fur & other leather products	6.2	5.8	0.020	0.027	0.096	0.075
325	Optical instruments	19.4	18.7	0.010	0.020	0.045	0.135

Bottom 20 Industries

124	Sugar, seasoning, oil products	17.0	19.7	0.037	0.050	0.001	0.042
232	Other rubber products	16.3	16.9	0.019	0.021	0.041	0.080
298	Machinery for office	32.9	33.9	0.014	0.020	0.175	0.050
269	Other iron & steel	12.8	14.6	0.038	0.044	0.097	0.035
159	Other wearing apparel	7.5	7.8	0.016	0.025	0.074	0.140
126	Rice & flour milling	11.9	12.8	0.037	0.063	0.321	0.353
297	Machinery for other products	18.7	18.5	0.021	0.020	0.006	0.007
281	Other metal products	9.5	10.6	0.021	0.030	0.106	0.096
171	Furniture & fixture	6.4	6.6	0.021	0.038	0.003	0.076
299	Other non-electrical machinery	11.7	11.5	0.026	0.026	0.088	0.059
341	Other manufacturing	7.0	7.1	0.033	0.052	0.090	0.037
163	Other wooden products	5.3	5.7	0.027	0.057	0.079	0.012
221	Plastic products	14.9	16.5	0.021	0.021	0.047	0.091
301	Electrical machinery for industry	28.8	28.2	0.018	0.018	0.056	0.070
282	Metal products for heating & kitchen	9.6	10.7	0.024	0.035	0.081	0.050
294	Machine tools	12.1	10.8	0.023	0.017	0.037	0.069
129	Other food products	9.8	15.0	0.028	0.036	0.171	0.188
292	Other nonelectrical machinery	14.8	16.5	0.023	0.023	0.030	0.062
127	Bread & cake	17.4	22.4	0.025	0.039	0.065	0.105
185	Paper boxes	12.2	13.8	0.026	0.037	0.066	0.034

Table 6.3. Regression Results
Based on White Heteroskedasticity-Consistent Standard Errors & Covariance

Dependent Variable: Geographical Concentration in Employment

	Model 1			Model 2			Model 3		
Variable	Coefficient	t-Statistic		Coefficient	t-Statistic		Coefficient	t-Statistic	
C	0.2550	2.1971	**	0.2346	6.4719	***	0.2450	8.1829	***
D_1	0.0155	0.6237							
D_2	0.2100	4.5415	***	0.1985	4.7841	***	0.2010	4.9095	***
ES	3.7068	5.6587	***	3.5688	5.8062	***	3.5944	5.8449	***
FI	0.5113	2.9675	***	0.5259	3.1095	***	0.5264	3.0609	***
TR	-2.1894	-3.6423	***	-2.1115	-3.5485	***	-1.9850	-3.6003	***
TBLI	-0.0229	-0.2083							
TFLI	0.0113	0.3159		0.0171	0.4958				
D_2*ES	-3.2856	-4.8769	***	-3.1569	-4.9352	***	-3.1753	-4.9444	***
D_2*FI	-0.5234	-1.8277	*	-0.5384	-1.8978	*	-0.5026	-1.7995	*
R^2	0.3255			0.3239			0.3231		
Adj. R^2	0.2850			0.2928			0.2965		

Dependent Variable: Geographical Concentration in Establishment

	Model 4			Model 5			Model 6		
Variable	Coefficient	t-Statistic		Coefficient	t-Statistic		Coefficient	t-Statistic	
C	0.2299	2.1159	**	0.2348	6.3415	***	0.2071	6.9309	***
D_1	0.0518	2.0584	**	0.0516	2.0696	**	0.0385	1.6456	
D_2	0.2002	4.9766	***	0.2001	5.0058	***	0.1838	4.6514	***
ES	3.2578	6.4728	***	3.2584	6.5203	***	3.0778	6.5014	***
FI	0.5287	3.3754	***	0.5297	3.3775	***	0.5436	3.6413	***
TR	-0.8979	-1.8591	*	-0.9036	-1.8341	*	-1.2262	-2.5217	**
TBLI	0.0049	0.0485							
TFLI	-0.0547	-1.6048		-0.0544	-1.5824				
D_2*ES	-2.8999	-5.5711	***	-2.8993	-5.5843	***	-2.7427	-5.5305	***
D_2*FI	-0.4559	-1.8835	*	-0.4591	-1.9628	*	-0.5852	-2.5214	**
R^2	0.2579			0.2579			0.2477		
Adj. R^2	0.2134			0.2186			0.2131		

(Notes) * Significant at the 10% significance level
** Significant at the 5% significance level
*** Significant at the 1% significance level
n = 160