Factor Intensity Reversals, Revisited*

Kozo Kiyota† — Keio University and RIETI

Yoshinori Kurokawa‡ — University of Tsukuba

First Version: September 15, 2016
This Version: November 26, 2016

Abstract

Little evidence for factor intensity reversals (i.e., reversals of the capital/labor ratios) between countries or regions has been found in the previous empirical studies. This supports Samuelson's (1951) impression that a factor intensity reversal has much less empirical importance than theoretical interest. Based on the newly developed Japanese prefecture-level data, however, we argue that the abandonment of factor intensity reversals in the empirical analysis has been premature. Specifically, we find that the degree of factor intensity reversals is stronger than that of the previous studies on average. While factor intensity reversals are less severe at the aggregated-eight-region level, they are prevalent at the 47-prefecture level. Moreover, the degree of factor intensity reversals has increased over the last two decades. Finally, we emphasize that the degree of factor intensity reversals is stronger when we use the disaggregated industry-level data than when we use the aggregated one, thereby weakening a possible criticism that several factor intensity reversals may be found due to the aggregation of industries.

Keywords: Factor intensity reversals, Capital, Labor, Prefecture, Japan

JEL Classifications: F11, F14

*We are very grateful to Makoto Hasegawa, Kaoru Hosono, Tomohiko Inui, Daisuke Miyakawa, Ryo Nakajima, Michio Naoi, Masao Ogaki, Hisamitsu Saito, Yoshimasa Shirai, Michio Suzuki, Miho Takizawa, and Kimiko Terai for their useful comments. We also thank seminar participants at Keio University and the RIETI. This study was conducted as part of the Project "Microeconomic Analysis of Firm Growth" undertaken at the Research Institute of Economy, Trade, and Industry (RIETI). The study utilizes the micro data from the questionnaire in the Census of Manufacture, which is conducted by the Ministry of Economy, Trade, and Industry (METI). The usual disclaimers apply.

†Address: 2-15-45 Mita, Minato-ku, Tokyo 108-8345 Japan; Tel.: +81-3-5427-1597; E-mail address: kiyota@sanken.keio.ac.jp.

‡Address: 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8571 Japan; Tel.: +81-29-853-7426; E-mail address: kurokawa.yoshi.fw@u.tsukuba.ac.jp.

"In connection with the two factor case, I have the impression that the phenomenon of goods that interchange their roles of being more labor intensive is much less important empirically than it is interesting theoretically" (Samuelson, 1951, pp. 121–22).

1 Introduction

Samuelson's (1951) well-known impression is that a factor intensity reversal, a reversal of the capital–labor ratio, has much less empirical importance than theoretical interest. Here, a factor intensity reversal means that a good/an industry is relatively capital intensive compared to other goods/industries within a country/region but relatively labor intensive within another country/region. In fact, little evidence for factor intensity reversals between countries or regions has been found in the previous empirical studies (e.g., Fuchs, 1963; Leontief, 1964; Ball, 1966; Moroney, 1967).[1] Therefore, factor intensity reversals have been abandoned in the empirical analysis for a long time.

This problem, whether factor intensity reversals exist or not, is an important issue particularly in the analysis of the Heckscher–Ohlin model. This is because all of the major four theorems of the standard Heckscher–Ohlin model (i.e., Stolper–Samuelson theorem, Rybczynski theorem, factor price equalization theorem, and Heckscher–Ohlin theorem) assume no factor intensity reversals. Although some trade economists, such as Deardorff (1986) and Bhagwati and Dehejia (1994), have called this assumption into question and taken seriously the possibility of factor intensity reversals, so far the empirical studies on the Heckscher–Ohlin model have ruled out the possibility of factor intensity reversals since little evidence has been found as mentioned above.[2]

Recently, however, some studies such as Kurokawa (2011) and Sampson (2016) have documented empirically that there exist skill intensity reversals: a good/an industry is relatively high-skill intensive within a country but relatively low-skill intensive within another country.[3] Note that these studies focused on skill intensity rather than capital intensity. Whether factor intensity reversals in the case of capital and labor also exist in recent years or not is a different question.[4] Therefore, noting that the availability of the data on capital and labor has recently been improved significantly from the data in the

[1]At first sight, Minhas (1962) seemed to show evidence for factor intensity reversals by doing both parametric test (i.e., estimates of elasticity and distribution parameters of production functions) and non-parametric tests (i.e., the examination of the rank correlation of capital intensities). However, his parametric test is criticized by Fuchs (1963) and Leontief (1964) because the test results are sensitive to the ratio of distribution parameters and the specification of the production function. For example, Fuchs (1963) showed that the estimated elasticities of substitution were less dispersed if the production function includes a dummy variable that allows for the differences between developed and developing countries. The non-parametric test is also criticized by Ball (1966) and Moroney (1967). For example, Ball (1966) showed that the test results were sensitive to whether or not the agricultural industry is included.

[2]For example, Tomiura (2005), Bernard, Redding, Schott, and Simpson (2008), and Bernard, Redding, and Schott (2013) asked whether factor price equalization held in Japan, the United Kingdom, and the United States, respectively. These studies found that factor price equalization did not hold even within a country. Similarly, Kiyota (2012) confirmed that, in Japan, the average manufacturing wage rate in Kanagawa prefecture is almost twice as high as that in Aomori prefecture. However, all of these studies ignored the possibility of factor intensity or skill intensity reversals.

[3]Reshef (2007) also seriously takes the possibility of skill intensity reversals.

[4]In this paper, the word "factor intensity reversal" refers to a capital intensity reversal and is distinguished from a skill intensity reversal. Of course there are production factors other than capital and labor such as land, but we focus on capital and labor as neoclassical trade models such as the Heckscher–Ohlin model usually do. We, however, note that even in the case of more than two factors, we can still define capital intensity, the capital/labor ratio, as in the case of two factors. Moreover, the meaning of a factor intensity reversal in such a case remains the same as that in the case of two factors: the ranking of capital intensity among sectors is not the same between countries/regions. For example, see Wong (1990) for factor intensity reversals in the case of multiple factors.

1960s, it is worth revisiting the issue of the factor intensity reversal controversy in the 1960s with new data on capital and labor.

In fact, Table 1 indicates that several factor intensity reversals might have existed between 47 prefectures in the Japanese manufacturing industries in 2005.[5] The table shows the capital/labor ratios for the manufacturing industries in 47 prefectures in 2005. Note that a "prefecture" corresponds to a U.S. "state." The industries and the prefectures are sorted in order of capital intensity and relative capital abundance, respectively. The color of each cell indicates the capital intensity of a given industry in a given prefecture. Light gray, gray, dark gray, and black mean that the capital intensity is in the first, second, third, and fourth quartiles, respectively. In the absence of factor intensity reversals, the ranking of industry capital intensities within a country (or region) will be the same between countries (or regions). If there is no factor intensity reversal, therefore, cells gradually become dark from left to right and from top to bottom in Table 1: like a map of ocean depth by gradient tints, the left cells in the upper rows will be lighter gray whereas the right cells in the lower rows will be darker gray or black.[6] As can be seen, however, Table 1 indicates the existence of factor intensity reversals. For example, transportation machinery was more capital intensive than were pulp and paper in Aichi, where Toyota is located. In contrast, pulp and paper were more capital intensive than was transportation machinery in Ehime, where the plants of Daio Paper Corporation are located. Similarly, general machinery was more capital intensive than was transportation machinery in Nagasaki, whereas transportation machinery was more capital intensive than was general machinery in Kyoto.

=== Table 1 ===

This paper now examines whether or not factor intensity reversals indeed existed, using the prefecture-level data in Japan over the period 1973–2009. An advantage in using Japanese prefecture-level data is that identical technology across prefectures is plausible within a country as compared with the situation across countries. One of the key assumptions in the Heckscher–Ohlin model is the identical technology across countries or regions. If one industry in a country/region employs different production technology from the industry in another country/region, it is impossible to classify the industry as the same industry. Indeed, Harrigan (1997) found that technology differences as well as factor supplies were important determinants of the international specialization of production. Bernstein and Weinstein (2002) pointed out that the use of international data was sometimes subject to problems such as measurement error and government policy. The use of national data can overcome some of these problems. Bernstein and Weinstein (2002) and Kiyota (2012) used the Japanese regional data to test the empirical validity of the Heckscher–Ohlin model. Indeed, Moroney (1967) also used U.S. regional data in 1957 in examining the existence of the factor intensity reversal. Another advantage in the use of Japanese prefecture data is that, as we will see in Section 2, real capital stock and labor inputs data are available at the prefecture-industry level in Japan. While such data are available at the country level, to the best of our knowledge, it is not at the state or prefecture level in many countries.[7] This study thus focuses on Japan.

[5]In Section 2, we present more detailed explanations about the data. Kiyota (2012) also shows a similar table for Japan in 2000, although his focus is not on factor intensity reversals but on the existence of multiple cones of diversification.

[6]See Table A1 for a hypothetical example of no factor intensity reversal.

[7]Note that because the U.S. Bureau of Economic Analysis provides net capital stock for the nation but not for individual states, Garofalo and Yamarik (2002) and Yamarik (2013) estimated state-by-state capital stock. Their estimates, however, are not at the state-industry level but at the state-aggregate-level.

In contrast, there is a disadvantage in so far as factors are more mobile in a cross-region analysis than in a cross-country analysis. One of the key assumptions in the Heckscher–Ohlin model is no mobility of factors across countries or regions. It is fortunate, however, that domestic labor mobility is relatively low in Japan.[8] According to the Ministry of Internal Affairs and Communications (2000), the migration rate of manufacturing workers among prefectures was 6.6 percent from 1995 to 2000.[9] This implies that the annual domestic migration rate in Japan is about 1 percent, which is almost the same as the international migration rates of some OECD countries, such as Switzerland.[10]

A contribution of our paper is as follows. We revive and add to the factor intensity reversal literature. Minhas (1962) seemed to show evidence for the reversals, but his results have been criticized and rejected.[11] We now show strong evidence weakening the criticisms. We also perform several robustness checks: 1) the sample includes agriculture and mining industries; 2) 47 prefectures are aggregated into eight regions; 3) the analysis takes into account human capital; 4) we compare different years; and 5) the industries are disaggregated at 4-digit level. In particular, we emphasize that the degree of factor intensity reversals is stronger when we use the disaggregated industry-level data than when we use the aggregated one. We can thus weaken a possible criticism that several factor intensity reversals may be found due to the aggregation of industries.

The rest of this paper is organized as follows. Section 2 explains the data and methodology used in this paper. Section 3 presents the results, and Section 4 uses more disaggregated data. Section 5 concludes the paper and indicates opportunities for future research.

2 Data and Methodology

2.1 Data

We use the Regional-Level Japan Industrial Productivity (R-JIP) Database 2014 for real capital stock and labor.[12] It provides us with the information on capital and labor input for each year, as does the National Bureau of Economic Research manufacturing database. One of the notable features of the database is that the information is available at the prefecture-industry level. The data cover 47 prefectures in Japan for the period from 1970 to 2009. Note again that a "prefecture" corresponds to a "state" in the United States. The data include 13 manufacturing industries and the agriculture and mining industries.[13] The 47 prefectures can be aggregated into eight regions.[14]

In the R-JIP Database 2014, capital stock is defined as the net real capital stock. The unit is one million of Japanese yen (2000 constant price). Labor is measured as

[8]We acknowledge that capital mobility would not be low compared to labor mobility in Japan. Using Japanese prefecture-level data, however, can still be compatible with the Heckscher–Ohlin model assuming factor intensity reversals. In such a model, the isoquant curves of two sectors have more than one intersection, and multiple diversification cones exist. Then the rental/wage ratios differ between countries/regions that are located in different cones. In that case, even if we allow capital mobility across countries/regions, as long as labor mobility is low it is possible that the countries/regions remain in different cones and thus differences in the rental/wage ratios remain.

[9]The migration rate refers to the inflows divided by the total labor force in manufacturing.

[10]For more details, see OECD (2006, p.32, Chart I.1.).

[11]For the criticisms on Minhas's (1962) results, see footnote 1.

[12]The data are available at http://www.rieti.go.jp/jp/database/R-JIP2014/index.html. The Japan Industrial Productivity (JIP) Database has been widely used in several studies (e.g., Dekle et al., 2010; Dekle et al., 2015).

[13]See Table A2 for the classifications of prefectures and industries.

[14]See Table A2 for the region classification.

man-hour (i.e., number of workers times per worker working-hours divided by 1,000).[15] Section 3.1 will focus on the year 2005 as in Table 1 that we have seen in Section 1. In Section 3.2, we will look at the period 1973–2009. Note that the reason why we use the data from 1973 is that Okinawa prefecture was returned to Japan in 1972.

2.2 Methodology

Using the data on capital and labor from the R-JIP Database 2014, we first calculate capital intensity by industry and by prefecture.[16] We then calculate Spearman's rank correlations of industry capital intensity, ρ, for all prefecture pairs, and their mean, $\overline{\rho}$. Spearman's rank correlation presents the correlation of rankings of capital intensity between two different prefectures. It takes values from -1 to 1. The value 1 indicates a perfect agreement among rankings of capital intensity between two prefectures; the value 0 indicates no agreement; and the value -1 indicates a perfect negative association. In other words, the smaller value of ρ suggests the larger degree of factor intensity reversals between two prefectures.

Following Moroney (1967), we also calculate Kendall's coefficient of concordance, W. Kendall's W is another useful statistic to measure the uniformity of rankings among m ($m > 2$) sets of rankings. It takes values from 0 (no agreement among ranks) to 1 (perfect agreement). It can easily be calculated by using the following linear relationship with the mean of Spearman's rank correlations, $\overline{\rho}$.[17]

$$\overline{\rho} = \frac{mW - 1}{m - 1}. \tag{1}$$

It should be noted that instead of a parametric approach, this paper takes a non-parametric approach, such as Spearman's rank correlations, to measure the degree of factor intensity reversals. There are mainly two reasons for it. First, we ensure the comparability of our findings with previous studies by following the non-parametric approach taken by Minhas (1962) and Moroney (1967). Minhas (1962) showed that Spearman's rank correlation of capital intensities for 20 industries between Japan and the United States was 0.730. Moroney (1967) analyzed factor intensity reversals between regions in the United States and found higher rank correlations, 0.8774 – 0.9074, than that of Minhas (1962). As can be seen, like our paper Moroney (1967) also analyzed factor intensity reversals at the region level. While he focused on the U.S. regions, we do on Japan's prefectures. Second, by taking a non-parametric approach, our results do not depend on the specification of production function.

Note also that there is no single criterion in the correlation regarding whether factor intensity reversals exist or not. Because the previous studies often referred to the correlations reported by Minhas (1962) (i.e., 0.730) and Monorey (i.e., 0.8774 – 0.9074), we also consider these values as reference values.[18]

[15] For more detailed explanations for how to measure capital and labor, see Tokui et al. (2013).

[16] As we have noted in footnote 4 in Section 1, even if we add factors other than capital and labor to our analysis, we can similarly define/calculate capital intensity, the capital/labor ratio, and discuss capital intensity reversals between prefectures.

[17] See p. 315 in Agarwal (2007).

[18] Minhas (1962) argued that "the difference between unity and .730 is large enough to provide room for reversals in relative capital-intensity to take place" (p.148).

3 Empirical Results

3.1 Evidence for 2005

As we have seen in Section 1, Table 1 indicates that several factor intensity reversals might have existed between 47 prefectures in the Japanese manufacturing industries in 2005. To see the degree of factor intensity reversals, we calculate Spearman's rank correlations, ρ, between all prefecture pairs. Here, the number of prefecture pairs is 1,081 ($= 46 + 45 + \ldots + 1$). We then obtain the mean of Spearman's rank correlations, $\overline{\rho}$, of 0.645 (the standard deviation is 0.186). It is much lower than values obtained by Moroney (1967), who concluded that few factor intensity reversals existed between regions in the U.S. manufacturing industries in 1957: 0.8774 (six regions & 14 industries) and 0.9074 (five regions & 16 industries). Note that the lower $\overline{\rho}$, the more the factor intensity reversals.

Does this value 0.645 mean that several reversals existed in 2005? The answer seems yes because the value is even lower than the value obtained by Minhas (1962) (i.e., 0.730), who argued that several reversals existed.[19]

While his results have been criticized and rejected as mentioned in Section 1, our results can withstand the criticisms. Thus we can no longer say that few factor intensity reversals existed at least between 47 prefectures in the Japanese manufacturing industries in 2005. We also calculate Kendall's W. It is 0.652, which is also much lower than values (0.8955–0.9228) obtained by Moroney (1967). This reconfirms our above argument based on $\overline{\rho}$.

3.1.1 Inclusion of the agriculture and mining industries

Ball (1966) found that the test results of factor intensity reversals showed by Minhas (1962) were sensitive to whether or not the agricultural industry is included. Specifically, the rank correlation increased considerably if the analysis excluded one agricultural industry (i.e., from 0.732 for all industry to 0.833 for manufacturing). One may thus be concerned that our above results are sensitive to the inclusion of agricultural and mining industries. To address this concern, we add the agriculture and mining industries to the previous analysis that has focused only on the manufacturing industries in 47 prefectures in 2005.

Table 2 shows capital intensities for all industries including the agriculture and mining in 47 prefectures in 2005. The mean of Spearman's rank correlations, $\overline{\rho}$, is now 0.649 (the standard deviation is 0.171), which is slightly higher than the previous value 0.645 with the focus only on the manufacturing industries. In other words, $\overline{\rho}$ for the case focusing only on the manufacturing industries is lower than that for the case including the agriculture and mining industries. This lower value of Spearman's rank correlation implies that the factor intensity reversals are more prevalent when we focus only on the manufacturing industries than when we include the agriculture and mining industries.

=== Table 2 ===

Moreover, Kendall's W is now 0.657. It is also slightly higher than the value 0.652 when the analysis focuses only on the manufacturing industries. This again indicates that the case focusing on the manufacturing industries does not show fewer factor intensity reversals. Interestingly, while previous studies such as Ball (1966) showed that the case

[19] We also compute 95 percent confidence interval, assuming that ρ follows normal distribution. The 95 percent confidence interval is between 0.634 and 0.656 (the number of observations is 1,081 and the standard error is 0.006), implying that the rank correlation obtained in this study is significantly lower than that of the previous studies.

focusing on the manufacturing industries showed fewer factor intensity reversals, our Japanese data indicate the opposite pattern.

3.1.2 Aggregation of prefectures

Another concern may be that our results are sensitive to the aggregation of prefectures. For example, Moroney (1967) focused on aggregated five or six regions in the United States while our study has focused on disaggregated 47 prefectures. The aggregation of the prefectures may affect the results. To address this concern, we repeat the analysis in the previous sections, with aggregated eight regions. Here, the number of region pairs is 28 $(= 7 + 6 + \ldots + 1)$.

Tables 3 and 4 are the aggregated eight regions counterparts for Tables 1 and 2, respectively. Tables 3 and 4 indicate that few factor intensity reversals might have existed between eight regions in 2005. In fact, the mean of Spearman's rank correlations, $\overline{\rho}$, is now 0.831 (the standard deviation is 0.097) for the case of only the manufacturing industries; it is 0.844 (the standard deviation is 0.079) for the case including the agriculture and mining industries. These values are higher than those in Minhas (1962), and are close to those in Moroney (1967), although still smaller. The results indicate that in 2005, the degree of factor intensity reversals is less severe at the aggregated-eight-region level than at the 47-prefecture level but still not negligibly small. Kendall's W also indicates similar patterns. It is now 0.853 for the case of only the manufacturing industries; it is 0.864 for the case including the agriculture and mining industries. These values are also close to those in Moroney (1967), although still smaller.

=== Tables 3 & 4 ===

3.1.3 Human capital

One may be further concerned that our results are driven by the differences in human capital across prefectures because man-hour that measures labor in our analysis does not take into account the differences in skill level (human capital). For example, consider that the capital/labor ratio of an industry is relatively large within prefecture A but relatively small within prefecture B. If, however, the skill level of labor used in prefecture A is higher and thus the labor productivity is higher, then it can happen that for the industry in prefecture A, man-hour used is smaller and thus the capital/labor ratio is larger. This indicates that the same amount of man-hour does not necessarily mean the same level of skill (human capital).

Therefore, to crudely take into account the differences in human capital across prefectures, here we use wage bill rather than man-hour as labor input. This approach is also employed by Hsieh and Klenow (2009) to take into account the differences in hours worked and human capital. The data on wage bill by prefecture-industry are also available in the R-JIP Database. The unit of wage bill is one million of Japanese yen.

Table 5 presents the results for 47 prefectures in the Japanese manufacturing industries in 2005. As in Table 1, actual capital intensities depart from the pattern presented in Table A1. This suggests the existence of factor intensity reversals. The mean of Spearman's rank correlations, $\overline{\rho}$, is 0.503 (the standard deviation is 0.231), which is lower than that of Table 1. These results together suggest that our main messages hold even when we take into account the differences in human capital.

=== Table 5 ===

3.2 Evidence for 1973–2009

In Section 3.1, we found that in 2005, factor intensity reversals were less severe between aggregated eight regions in the case focusing only on the manufacturing industries or in the case including the agriculture and mining industries. However, factor intensity reversals were prevalent between 47 prefectures in the same year in both cases, but more existed in the former case. In this section, to see whether the above results also hold for other years, we construct a table that shows the mean of Spearman's rank correlations, $\overline{\rho}$, and its standard deviation for each of the years 1973–2009 as well as Kendall's W.

The analysis consists of 47-prefecture-level and aggregated-eight-region-level analyses. In each analysis, we compare two cases: (1) only the manufacturing industries and (2) the manufacturing plus agriculture and mining industries.

We first present the 47-prefecture-level analysis. Table 6 shows that $\overline{\rho}$ takes the range from 0.603 to 0.750 for the case focusing only on manufacturing and from 0.612 to 0.753 for the case including agriculture and mining, over the period 1973–2009. The table also shows that Kendall's W takes from 0.611 to 0.755 for the former case and from 0.620 to 0.759 for the latter case, over the same period. As can be seen, the values of $\overline{\rho}$ and W are much smaller than those obtained by Moroney (1967) and even smaller than those obtained by Minhas (1962). Thus the results indicate that several factor intensity reversals existed between 47 prefectures in both cases during 1973–2009, but more existed in the case of only manufacturing. Moreover, the degree of factor intensity reversals between 47 prefectures has tended to increase over the last two decades as indicated by both $\overline{\rho}$ and W that have tended to decrease from 1985.

=== Table 6 ===

We next present the aggregated-eight-region-level analysis. Table 7 shows that both $\overline{\rho}$ and W are over 0.8 in both cases during the period 1973–2009, and they are even over 0.9 for some years. These values are close to those obtained by Moroney (1967). Thus, like previous studies, our results indicate that factor intensity reversals were less severe between aggregated eight regions over 1973–2009.

=== Table 7 ===

It is worth pointing out that as shown in Table 6, the standard deviation of Spearman's rank correlations for all prefecture pairs has also increased recently like the mean ρ, both in the case focusing only on manufacturing and in the case including agriculture and mining. To see more details, Figure 1 shows the distribution of Spearman's rank correlations for all prefecture pairs for the years 1975, 1985, 1995, and 2005, with the focus on the manufacturing industries. As can be seen, the distribution across prefecture pairs was concentrated from 1975 to 1985, but it was dispersed from 1985 to 1995 to 2005. This indicates that differences in the degree of factor intensity reversals between prefecture pairs have recently increased. Figure 2 shows the similar changes of the distribution for the case including the agriculture and mining industries.

=== Figures 1 & 2 ===

4 Intra-industry Heterogeneity

One may be further concerned about intra-industry heterogeneity because our 13 manufacturing industry classification might be too aggregated to address the issue of identical technology across prefectures. For example, transportation machinery includes not only automobiles but also other transportation machineries such as trains, ships, and airplanes. If different prefectures specialize in different products within an industry, it may be natural to find the differences in factor intensity. Thus a possible criticism is that factor intensity reversals between prefectures may be found due to the aggregation of industries; in other words, if industries are disaggregated, then fewer factor intensity reversals between prefectures may be found.

We want to address this concern, but a problem arises with the availability of the data in Japan. Other than the R-JIP Database, there is no time-series data on real capital stock and labor that uses the same industry classification throughout the period at the prefecture-industry level. Therefore, here we utilize confidential plant-level data from the Census of Manufacture published by the Japanese Ministry of Economy, Trade and Industry. It is annual census and is compulsory for plants with more than three employees. For plants that have more than or equal to 30 workers, it records such information on tangible assets and the number of workers.[20] Though it is annual census, we cannot trace the same industry throughout the period due to the revision of the industry classification.[21] We thus focus on the year 2005. The industry classification is available at the 4-digit industry level: 560 manufacturing industries in 2005. Note that the information on the tangible assets in an industry in a prefecture is not available if none of the plants in the industry in the prefecture has more than 30 workers. As a result, the information on tangible assets and the number of workers is available for 552 manufacturing industries in 2005.

Table 8 presents the results. Capital stock is measured by the nominal tangible assets whose unit is one million yen. Labor is measured by the number of workers. As in Table 1, the industries and the prefectures are sorted in order of capital intensity and relative capital abundance, respectively. Note that industries consist of 552 manufacturing industries, which prevents us from reporting the name of each industry.

=== Table 8 ===

The color of each cell indicates the capital intensity of a given industry in a given prefecture. Note that some prefectures report no production at the 4-digit industry level. Accordingly, we now add white which means no production. As in the previous tables, light gray, gray, dark gray, and black mean that the capital intensity is in the first, second, third, and fourth quartiles, respectively.

Similar to Table 1, several factor intensity reversals are confirmed between 47 prefectures even if we utilize plant-level data. We also computed the mean of Spearman's rank correlations, $\overline{\rho}$. The correlations are calculated using pairwise deletion of observations with missing values. The mean of the correlations is 0.360 (the standard deviation is 0.108), which is significantly smaller than that of Moroney (1967) and even smaller than that of Minhas (1962).[22] Our results show that our main messages hold even when we utilize a disaggregated industry classification. In fact, the degree of factor intensity reversals is stronger when we use the disaggregated industry-level data than when we use the aggregated one. Thus we can weaken the possible criticism that several factor intensity reversals may be found due to the aggregation of industries.[23]

[20] For plants that have less than 30 workers, the information on tangible assets is not available.

[21] Another concern in the use of the Census of Manufacture is that the tangible assets are reported as a nominal book value rather than market value.

[22] We also compute 95 percent confidence interval as in the previous section. It is between 0.354 and 0.367 (the number of observations is 1,081 and the standard error is 0.003).

[23] It may be worth mentioning an aggregation problem with the so-called "lens conditions." Debaere (2004) theoretically shows that with more disaggregation of sectors, the goods lens will become even wider, making a violation even less likely. Thus a possible criticism on empirical studies that document the satisfaction of the lens condition is that the lens condition may be satisfied due to the disaggregation

One may be concerned that, if the number of plants in each cell in Table 8 is small, the capital intensity will be affected by a small number of large (or small) plants. To address this concern, we exclude cells whose number of observations is less than 10. The result indicates that the mean of the correlations is 0.473 (the standard deviation is 0.569).[24] Although the rank correlation becomes slightly higher, this result is similar to the result that includes all plants in that the mean correlation is significantly smaller than that of Moroney (1967) and even smaller than that of Minhas (1962).

Another concern may be that, as we confirmed in Section 3, the correlation becomes high if prefectures are aggregated at region level. To address this concern, we compute the rank correlation, aggregating 47 prefectures to eight regions while using the same detailed 4-digit industry level data. The result indicates that the mean of the rank correlation is 0.567 (the standard deviation is 0.045).[25] It is higher than that of the prefecture-level result but it is still smaller than that of the previous studies. In sum, the results suggest that our main messages hold even when we take into account intra-industry heterogeneity (i.e., even when we utilize detailed industry-level data).

5 Conclusion

Based on the newly developed Japanese prefecture-level data, we argue that the abandonment of factor intensity reversals in empirical analysis has been premature. Specifically, we have found that the degree of factor intensity reversals is stronger than that of the previous studies on average. Our empirical results have shown that while factor intensity reversals are less severe at the aggregated-eight-region level, they are prevalent at the 47-prefecture level. Besides, the degree of factor intensity reversals has increased over the last two decades. We have also performed several robustness checks: 1) the sample includes agriculture and mining industries; 2) 47 prefectures are aggregated into eight regions; 3) the analysis takes into account human capital; 4) we compare different years; and 5) the industries are disaggregated at 4-digit level. In particular, we have found that the degree of factor intensity reversals is stronger when we use the disaggregated industry-level data than when we use the aggregated one. Thus we have successfully weaken the possible criticism that several factor intensity reversals may be found due to the aggregation of industries.

The implications of our study are threefold. First of all, the "standard" industry classification may not be appropriate to test the empirical validity of the Heckscher–Ohlin model. As was pointed out by Schott (2003) and Kiyota (2012), the "standard" industry classification groups output loosely, according to the similarity of end use (e.g., electrical machinery, transportation machinery) rather than actual factor use (e.g., capital-intensive goods, labor-intensive goods). However, our results show that the same industry can be relatively capital intensive in a prefecture but relatively labor intensive in another prefecture. This indicates that the "standard" industry classification may not be able to capture the actual capital intensity differences between countries or regions. It thus may be important to adapt a theoretically appropriate aggregation method such as "Heckshcer–Ohlin aggregates" developed by Schott (2003).

of industries. Evidence indeed supports this criticism. Bernard et al. (2005) empirically show that lenses created with more disaggregate data are wider than the lenses created with more aggregate data and that the satisfaction of the lens condition is more likely when industries are relatively disaggregated compared to countries or regions.

[24]The 95 percent confidence interval is between 0.435 and 0.511 (the number of observations is 867 and the standard error is 0.019).

[25]The 95 percent confidence inerval is between 0.550 and 0.584 (the number of observations is 28 and the standard error is 0.008).

Second, in this connection, it is important for policy makers to understand the intra-industry capital-intensity heterogeneity. A capital-intensive industry in one country or one region may not necessarily be capital intensive in the same industry in another country or region due to the intra-industry capital-intensity heterogeneity. This in turn implies that industry-specific policies may not work effectively due to the intra-industry heterogeneity. Before designing industrial policies, policy makers need to examine the heterogeneity across countries and/or regions.

Third, the theoretical studies on international trade need to take more seriously into account the empirical validity of the factor intensity reversals. As long as we rely on the end-use industry classification, it may not be surprising to observe factor intensity reversals. It may be a time to relax the assumption of no factor intensity reversals.

Of course, room for future research still exists. A next step is to investigate what are possible factors that have recently increased factor intensity reversals between 47 prefectures in Japan, and how much each of them will be quantitatively important as the cause.

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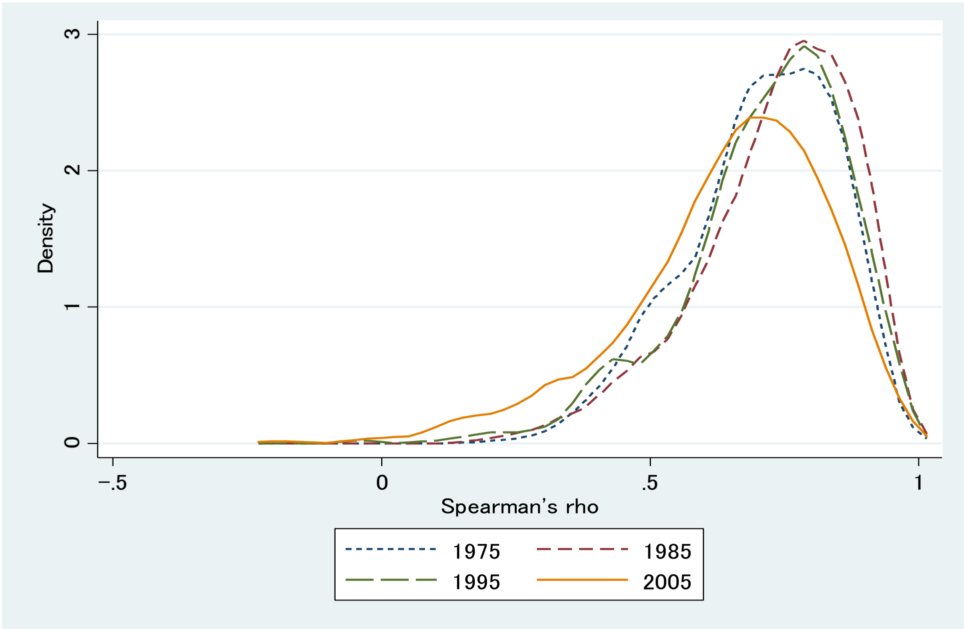
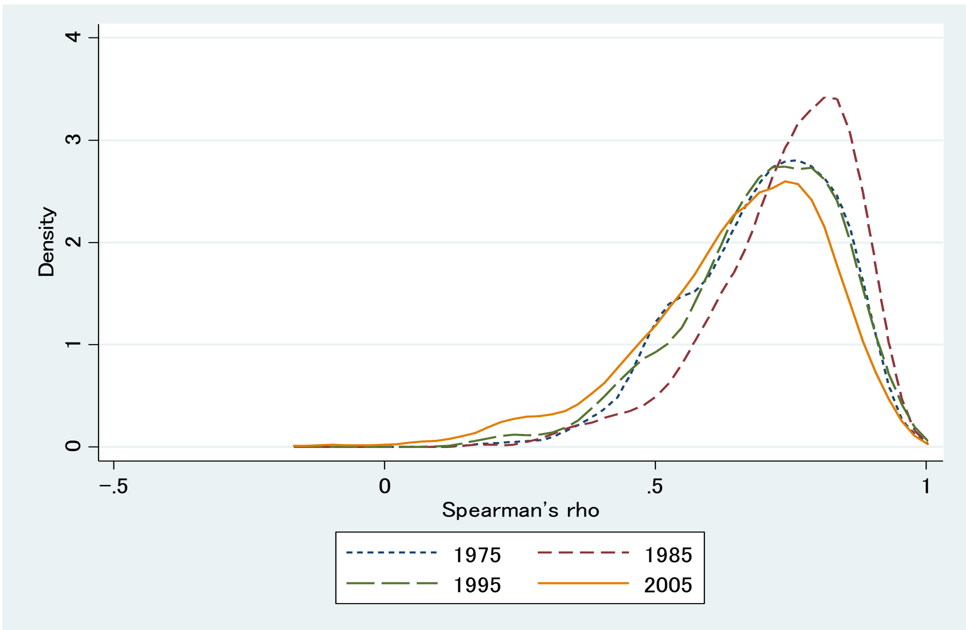
Figure 1: Distribution of ρ, Prefecture Level, Manufacturing



Note: Kernel density function.

Figure 2: Distribution of ρ, Prefecture Level, Including Agriculture and Mining



Note: Kernel density function.

Table 1: Prefecture–Industry Capital Intensity, Manufacturing, 2005

Prefecture	Endowment: prefecture capital-labor ratio (manufacturing total)	Metal products	Other manufacturing	Textile products	Food products	Ceramic, stone and clay products	General machinery	Precision machinery	Pulp and paper	Transportation machinery	Electrical machinery	Primary metal	Chemical products	Petroleum and coal products
Industry average capital labor ratio	10.55	3.86	6.13	6.26	7.12	7.83	8.12	11.55	12.76	13.06	13.14	25.53	27.99	123.48
Tokyo	4.82													
Okinawa	6.09													145.74
Kochi	6.32					13.51					14.62			
Gifu	7.04								13.77				21.41	69.75
Shimane	7.16							14.02						25.70
Akita	7.36							18.62	33.11			16.84	34.17	85.19
Kagoshima	7.53								17.62		13.81		16.54	32.72
Ishikawa	7.74										13.15		19.28	63.42
Yamagata	7.91											14.18	24.08	29.78
Osaka	7.97											18.61	18.15	123.86
Tottori	8.06								25.24					37.98
Kyoto	8.12									19.36			17.34	29.59
Saitama	8.15												18.46	45.91
Iwate	8.17								18.16		13.60	28.08	33.43	59.78
Kagawa	8.55											22.52	23.57	146.45
Niigata	8.61								15.41		13.22	15.32	50.93	129.25
Miyazaki	8.63							17.09	23.40				40.85	65.69
Saga	8.90										16.77	18.87	16.60	50.63
Nara	9.01						15.49				16.14			26.91
Fukui	9.19											24.28	21.63	58.61
Miyagi	9.32								25.00			22.75		174.98
Yamanashi	9.56							14.63			16.72		21.48	
Nagano	9.98							19.60			14.41		14.22	39.76
Hokkaido	10.01								39.16	17.59	15.25	33.94	22.98	227.11
Aomori	10.10								28.90			62.50	31.75	64.52
Gumma	10.12											14.30	30.30	38.16
Shizuoka	10.65			22.18				13.53	18.06			14.84	31.81	35.50
Fukuoka	10.65									16.66		36.32	38.74	95.13
Kumamoto	10.73								24.32		23.76	15.33	23.03	63.34
Fukushima	10.80								13.74		15.07	14.85	45.46	210.63
Toyama	11.27								20.03		17.16	27.10	27.54	128.87
Tokushima	11.49								22.71		17.50	23.52	31.80	241.57
Nagasaki	11.55						14.64				59.39		20.59	216.21
Tochigi	11.62							14.25	16.14		13.18	19.01	25.75	19.93
Aichi	11.98									16.96		22.04	26.33	164.39
Hyogo	12.79								15.83		14.08	33.85	26.04	122.89
Hiroshima	12.86								18.21		30.48	37.19	32.73	22.05
Shiga	12.97		13.68	13.98		15.17		13.73		17.51	14.53	17.86	18.75	63.78
Okayama	14.00							18.96				45.54	45.28	179.37
Ehime	14.09			17.76					18.07		25.53	43.21	51.32	154.74
Ibaraki	14.87						15.33					36.97	44.60	139.30
Kanagawa	14.98					13.45				15.00	14.06	36.14	38.47	152.91
Mie	15.49									16.05	20.71	16.49	48.90	194.24
Wakayama	16.36							30.20				53.98	38.66	235.07
Chiba	16.61										19.85	39.79	50.66	145.67
Oita	17.58							17.87	22.53		28.08	61.49	61.64	148.65
Yamaguchi	20.52			15.08		14.75			27.93		20.28	30.80	61.86	141.21

Notes: The color of each cell indicates the capital intensity of a given industry in a given prefecture. Light gray, gray, dark gray, and black mean that the capital intensity is in the first, second, third, and fourth quartiles, respectively. The industries and the prefectures are sorted in order of capital intensity and relative capital abundance, respectively.

Source: RIETI (2014) R-JIP Database 2014.

Table 2: Prefecture–Industry Capital Intensity, Including Agriculture and Mining, 2005

	Industry average capital labor ratio															
	11.56	3.86	6.13	6.26	7.12	7.83	8.12	11.55	12.76	13.06	13.14	15.61	16.72	25.53	27.99	123.48
Prefecture	Endowment: prefecture capital-labor ratio (all tradables)	Metal products	Other manufacturing	Textile products	Food products	Ceramic, stone and clay products	General machinery	Precision machinery	Pulp and paper	Transportation machinery	Electrical machinery	Agriculture, forestry and fisheries	Mining	Primary metal	Chemical products	Petroleum and coal products
Tokyo	5.14											16.40				
Kochi	7.80															
Osaka	8.16													18.61	18.15	123.86
Gifu	8.27											16.62	23.10		21.41	69.75
Yamanashi	8.84										16.72				21.48	
Saitama	8.88														18.46	45.91
Kyoto	9.00									19.36					17.34	29.59
Saga	9.53										16.77		25.59	18.87	16.60	50.63
Yamagata	9.61												19.05		24.08	29.78
Kagawa	9.85												18.96	22.52	23.57	146.45
Nara	9.94												26.10			26.91
Shimane	10.18															25.70
Ishikawa	10.45											25.90	27.89		19.28	63.42
Kagoshima	10.51								17.62				19.07		16.54	32.72
Kumamoto	10.53								24.32		23.76		19.84		23.03	63.34
Miyazaki	10.53							17.09	23.40						40.85	65.69
Nagano	10.79							19.60					18.46			39.76
Akita	10.95							18.62	33.11			16.58	16.41	16.84	34.17	85.19
Iwate	11.00								18.16					28.08	33.43	59.78
Fukushima	11.09														45.46	210.63
Niigata	11.18											18.45			50.93	129.25
Gumma	11.25											16.30			30.30	38.16
Shizuoka	11.26			22.18					18.06						31.81	35.50
Tottori	11.51								25.24			16.83	30.71			37.98
Aomori	11.59								28.90				20.53	62.50	31.75	64.52
Tochigi	12.12													19.01	25.75	19.93
Fukuoka	12.12									16.66		17.37	36.21	36.32	38.74	95.13
Aichi	12.17									16.96				22.04	26.33	164.39
Nagasaki	12.17										59.39		21.45		20.59	216.21
Fukui	12.19											26.65		24.28	21.63	58.61
Okinawa	12.62											18.86				145.74
Hiroshima	12.88								18.21		30.48		17.52	37.19	32.73	22.05
Miyagi	13.09								25.00			22.41		22.75		174.98
Ehime	13.19			17.76					18.07		25.53			43.21	51.32	154.74
Tokushima	13.44								22.71		17.50	16.92		23.52	31.80	241.57
Okayama	13.63							18.96					17.36	45.54	45.28	179.37
Hyogo	13.97											21.63	107.47	33.85	26.04	122.89
Toyama	14.72								20.03		17.16	37.83	20.40	27.10	27.54	128.87
Kanagawa	14.92													36.14	38.47	152.91
Chiba	15.28										19.85		24.45	39.79	50.66	145.67
Ibaraki	15.42											17.12	29.80	36.97	44.60	139.30
Wakayama	15.50							30.20					145.60	53.98	38.66	235.07
Shiga	15.83									17.51		38.59	17.60	17.86	18.75	63.78
Hokkaido	16.16								39.16	17.59		23.84		33.94	22.98	227.11
Oita	16.22							17.87	22.53		28.08			61.49	61.64	148.65
Mie	16.41										20.71	21.72	16.53	16.49	48.90	194.24
Yamaguchi	17.81								27.93		20.28			30.80	61.86	141.21

Notes and source: See Table 1.

Table 3: Region–Industry Capital Intensity, Manufacturing, 2005

Region	Endowment: prefecture capital-labor retio (manufacturing total)	Metal products	Other manufacturing	Textile products	Food products	Ceramic, stone and clay products	General machinery	Precision machinery	Pulp and paper	Transportation machinery	Electrical machinery	Primary metal	Chemical products	Petroleum and coal products
Industry average capital labor ratio	10.55	3.86	6.13	6.26	7.12	7.83	8.12	11.55	12.76	13.06	13.14	25.53	27.99	123.48
Tohoku	9.17								20.01			26.23	34.86	135.80
Hokkaido	10.01								39.16	17.59	15.25	33.94	22.98	227.11
Kanto	10.19											25.31	23.72	100.43
Chubu	10.42								13.50	14.74		18.37	29.18	113.02
Kyushu	10.60										20.43	35.36	35.35	109.94
Kinki	10.73									13.47	13.52	25.25	23.73	151.20
Shikoku	10.96								16.39		17.46	29.22	37.00	145.63
Chugoku	13.75								16.80		17.74	34.49	49.13	143.06

Notes: Prefectures are aggregated into eight regions. For other notes and source, see Table 1.

Table 4: Region–Industry Capital Intensity, Including Agriculture and Mining, 2005

Region	Endowment: prefecture capital-labor retio (manufacturing total)	Metal products	Other manufacturing	Textile products	Food products	Ceramic, stone and clay products	General machinery	Precision machinery	Pulp and paper	Transportation machinery	Electrical machinery	Agriculture, forestry and fisheries	Mining	Primary metal	Chemical products	Petroleum and coal products
Industry average capital labor ratio	11.56	3.86	6.13	6.26	7.12	7.83	8.12	11.55	12.76	13.06	13.14	15.61	16.72	25.53	27.99	123.48
Kanto	10.74													25.31	23.72	100.43
Tohoku	11.24								20.01					26.23	34.86	135.80
Chubu	11.33											16.34		18.37	29.18	113.02
Shikoku	11.44								16.39		17.46			29.22	37.00	145.63
Kyushu	11.70										20.43		19.81	35.36	35.35	109.94
Kinki	11.74											19.70	42.86	25.25	23.73	151.20
Chugoku	13.61								16.80		17.74			34.49	49.13	143.06
Hokkaido	16.16								39.16	17.59		23.84		33.94	22.98	227.11

Notes: Prefectures are aggregated into eight regions. For other notes and source, see Table 1.

Table 5: Prefecture–Industry Capital Intensity, Alternative Measure of Labor Input, 2005

	Endowment: prefecture capital-labor ratio (manufacturing total)	Metal products	Other manufacturing	General machinery	Ceramic, stone and clay products	Precision machinery	Textile products	Transportation machinery	Food products	Electrical machinery	Pulp and paper	Primary metal	Chemical products	Petroleum and coal products
Industry average capital labor ratio	3.79	1.53	2.46	2.65	3.00	3.68	3.73	3.81	3.90	4.29	4.57	6.88	6.97	25.41
Tokyo	1.28													
Osaka	2.44													
Gifu	3.01													
Nara	3.13													
Kyoto	3.13													
Ishikawa	3.28													
Kochi	3.47													
Shimane	3.49													
Gumma	3.51													
Nagano	3.55													
Aichi	3.62													
Shizuoka	3.63													
Saitama	3.76													
Tochigi	3.85													
Yamagata	3.88													
Niigata	3.97													
Kagawa	4.10													
Hyogo	4.13													
Fukui	4.19													
Kagoshima	4.20													
Yamanashi	4.28													
Tottori	4.29													
Akita	4.32													
Miyagi	4.34													
Iwate	4.37													
Fukuoka	4.41													
Fukushima	4.43													
Kumamoto	4.50													
Tokushima	4.51													
Hiroshima	4.55													
Saga	4.60													
Toyama	4.71													
Okinawa	4.73													
Mie	4.83													
Shiga	4.95													
Miyazaki	5.02													
Ibaraki	5.14													
Okayama	5.32													
Nagasaki	5.33													
Chiba	5.37													
Kanagawa	5.44													
Ehime	5.74													
Aomori	6.18													
Hokkaido	6.38													
Wakayama	6.50													
Yamaguchi	6.95													
Oita	7.24													

Notes and source: See Table 1.

Table 6: Rank Correlation of Industry Capital Intensities, 1973–2009: Prefecture-Level Results

	Manufacturing only				Includes agriculture and mining			
Year	Mean	S.D.	N	Kendall's W	Mean	S.D.	N	Kendall's W
1973	0.679	0.150	1,081	0.686	0.691	0.140	1,081	0.697
1974	0.682	0.146	1,081	0.689	0.681	0.143	1,081	0.688
1975	0.706	0.139	1,081	0.712	0.697	0.138	1,081	0.704
1976	0.716	0.138	1,081	0.722	0.708	0.138	1,081	0.715
1977	0.728	0.136	1,081	0.734	0.720	0.131	1,081	0.726
1978	0.734	0.140	1,081	0.740	0.731	0.132	1,081	0.736
1979	0.735	0.146	1,081	0.740	0.736	0.134	1,081	0.741
1980	0.727	0.142	1,081	0.733	0.733	0.127	1,081	0.738
1981	0.731	0.137	1,081	0.736	0.740	0.124	1,081	0.745
1982	0.735	0.135	1,081	0.740	0.736	0.123	1,081	0.741
1983	0.750	0.127	1,081	0.755	0.753	0.113	1,081	0.759
1984	0.727	0.144	1,081	0.733	0.734	0.128	1,081	0.740
1985	0.734	0.145	1,081	0.739	0.739	0.131	1,081	0.745
1986	0.726	0.141	1,081	0.732	0.727	0.130	1,081	0.733
1987	0.720	0.145	1,081	0.726	0.725	0.129	1,081	0.731
1988	0.711	0.154	1,081	0.717	0.723	0.136	1,081	0.729
1989	0.697	0.168	1,081	0.704	0.707	0.149	1,081	0.713
1990	0.709	0.156	1,081	0.715	0.709	0.147	1,081	0.716
1991	0.719	0.144	1,081	0.724	0.714	0.138	1,081	0.720
1992	0.716	0.147	1,081	0.722	0.700	0.140	1,081	0.707
1993	0.705	0.152	1,081	0.711	0.685	0.144	1,081	0.692
1994	0.705	0.157	1,081	0.711	0.694	0.146	1,081	0.700
1995	0.712	0.155	1,081	0.718	0.695	0.147	1,081	0.701
1996	0.712	0.151	1,081	0.718	0.692	0.145	1,081	0.699
1997	0.700	0.150	1,081	0.706	0.685	0.144	1,081	0.692
1998	0.697	0.151	1,081	0.703	0.681	0.143	1,081	0.688
1999	0.693	0.151	1,081	0.700	0.677	0.143	1,081	0.684
2000	0.678	0.163	1,081	0.685	0.665	0.152	1,081	0.673
2001	0.657	0.181	1,081	0.664	0.649	0.163	1,081	0.657
2002	0.654	0.180	1,081	0.661	0.649	0.162	1,081	0.657
2003	0.649	0.186	1,081	0.656	0.651	0.170	1,081	0.658
2004	0.659	0.181	1,081	0.666	0.664	0.165	1,081	0.671
2005	0.645	0.186	1,081	0.652	0.649	0.171	1,081	0.657
2006	0.625	0.197	1,081	0.633	0.638	0.177	1,081	0.645
2007	0.622	0.189	1,081	0.630	0.635	0.174	1,081	0.643
2008	0.603	0.199	1,081	0.611	0.612	0.189	1,081	0.620
2009	0.618	0.184	1,081	0.626	0.615	0.180	1,081	0.624

Notes: Rank correlation of capital intensities is calculated for different prefecture pairs. The number of correlations is 1,081 (= the number of prefecture pairs (46 + 45 + ... + 1)).

Source: RIETI (2014) R-JIP Database 2014.

Table 7: Rank Correlation of Industry Capital Intensities, 1973–2009: Region-Level Results

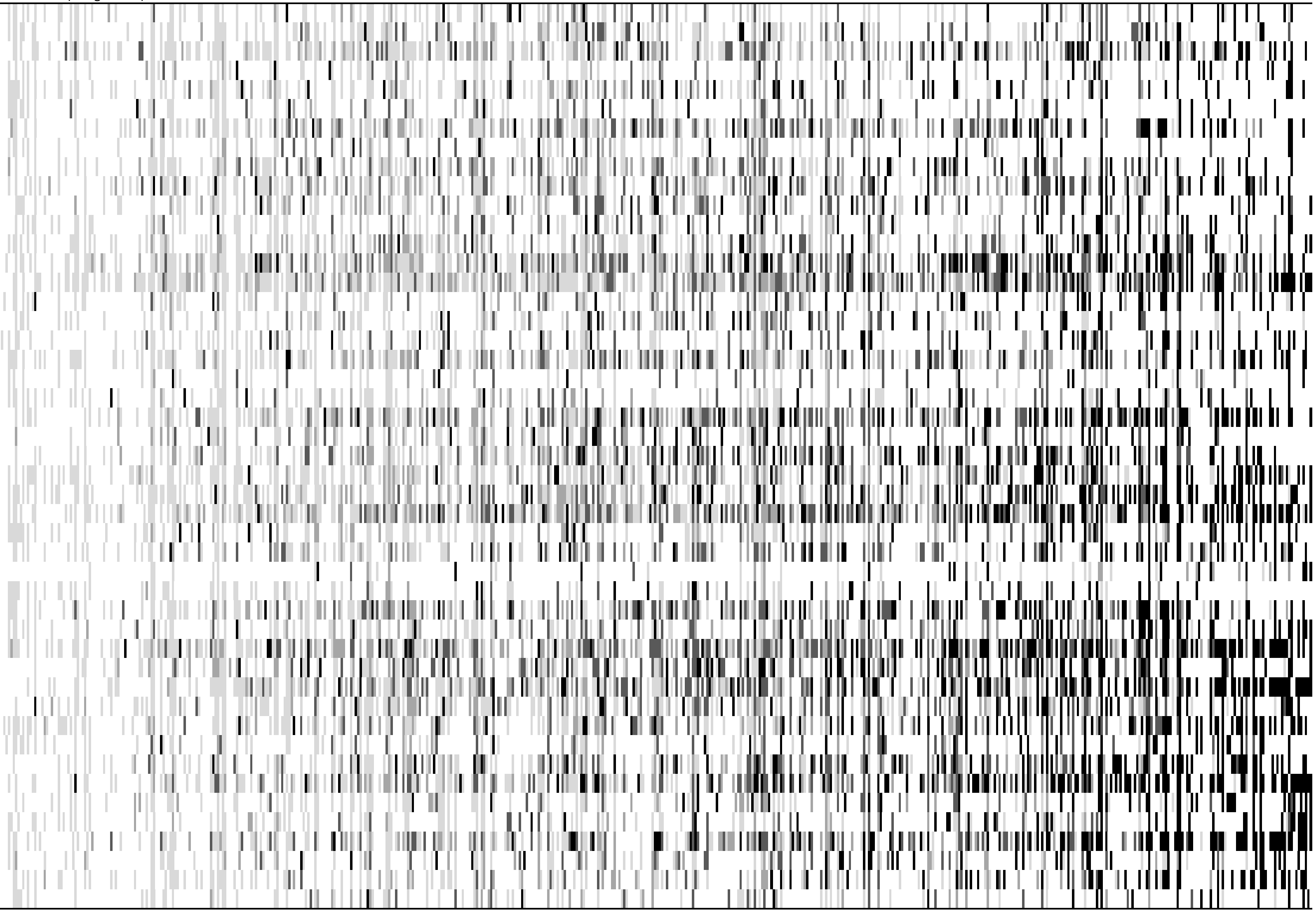
	Manufacturing only				Includes agriculture and mining			
Year	Mean	S.D.	N	Kendall's W	Mean	S.D.	N	Kendall's W
1973	0.827	0.083	28	0.848	0.821	0.084	28	0.843
1974	0.823	0.086	28	0.845	0.818	0.083	28	0.841
1975	0.839	0.082	28	0.859	0.828	0.084	28	0.849
1976	0.840	0.084	28	0.860	0.827	0.083	28	0.848
1977	0.853	0.076	28	0.872	0.850	0.073	28	0.869
1978	0.874	0.062	28	0.890	0.861	0.065	28	0.878
1979	0.871	0.064	28	0.887	0.863	0.067	28	0.880
1980	0.867	0.068	28	0.884	0.861	0.069	28	0.878
1981	0.891	0.057	28	0.905	0.877	0.069	28	0.892
1982	0.888	0.067	28	0.902	0.873	0.075	28	0.889
1983	0.887	0.070	28	0.901	0.881	0.068	28	0.896
1984	0.892	0.055	28	0.905	0.883	0.057	28	0.898
1985	0.898	0.059	28	0.911	0.894	0.057	28	0.907
1986	0.890	0.059	28	0.904	0.890	0.057	28	0.904
1987	0.882	0.061	28	0.897	0.885	0.054	28	0.900
1988	0.880	0.056	28	0.895	0.882	0.056	28	0.897
1989	0.884	0.061	28	0.899	0.886	0.059	28	0.900
1990	0.892	0.053	28	0.906	0.895	0.053	28	0.908
1991	0.898	0.055	28	0.910	0.897	0.054	28	0.910
1992	0.905	0.055	28	0.917	0.899	0.059	28	0.912
1993	0.898	0.054	28	0.911	0.887	0.061	28	0.901
1994	0.896	0.059	28	0.909	0.888	0.061	28	0.902
1995	0.890	0.063	28	0.904	0.886	0.064	28	0.900
1996	0.871	0.080	28	0.887	0.881	0.071	28	0.896
1997	0.862	0.081	28	0.880	0.870	0.074	28	0.886
1998	0.860	0.083	28	0.878	0.855	0.085	28	0.873
1999	0.853	0.086	28	0.872	0.853	0.084	28	0.871
2000	0.850	0.086	28	0.869	0.834	0.085	28	0.855
2001	0.847	0.083	28	0.866	0.832	0.075	28	0.853
2002	0.828	0.090	28	0.850	0.821	0.077	28	0.843
2003	0.825	0.102	28	0.847	0.831	0.082	28	0.852
2004	0.827	0.109	28	0.849	0.832	0.094	28	0.853
2005	0.831	0.097	28	0.853	0.844	0.079	28	0.864
2006	0.826	0.099	28	0.848	0.842	0.084	28	0.861
2007	0.827	0.104	28	0.849	0.817	0.104	28	0.840
2008	0.821	0.101	28	0.843	0.829	0.090	28	0.851
2009	0.818	0.094	28	0.840	0.825	0.086	28	0.847

Notes: Rank correlation of capital intensities is calculated for different region pairs. The number of correlations is 28 (= the number of region pairs (7 + 6 + ... + 1)).

Source: RIETI (2014) R-JIP Database 2014.

Table 8: Prefecture-Industry Capital Intensity, 4-Digit Industry Level, 2005

Prefecture	Endowment	Industries (4-digit level)
Akita	510.5	
Yamagata	575.3	
Tokyo	583.2	
Kagoshima	598.9	
Iwate	614.7	
Shimane	618.7	
Gifu	635.1	
Tottori	636.9	
Nagano	641.3	
Kyoto	659.0	
Ishikawa	668.7	
Saga	679.0	
Miyagi	692.4	
Saitama	705.4	
Osaka	706.3	
Fukui	727.6	
Nara	740.2	
Kagawa	746.3	
Niigata	767.2	
Kochi	771.2	
Miyazaki	776.7	
Shizuoka	780.9	
Yamanashi	805.0	
Gumma	805.1	
Fukuoka	819.2	
Fukushima	822.8	
Aichi	828.4	
Kumamoto	839.3	
Toyama	855.4	
Okinawa	883.3	
Nagasaki	908.8	
Tochigi	913.6	
Hokkaido	933.7	
Hyogo	958.8	
Shiga	964.3	
Kanagawa	976.0	
Hiroshima	1081.7	
Okayama	1093.8	
Tokushima	1102.7	
Mie	1167.8	
Ibaraki	1196.5	
Ehime	1232.2	
Oita	1363.5	
Chiba	1380.6	
Wakayama	1415.9	
Yamaguchi	1558.5	
Aomori	1579.8	



Notes: The color of each cell indicates the capital intensity of a given industry in a given prefecture. White means no production. Light gray, gray, dark gray, and black mean that the capital intensity is in the first, second, third, and fourth quartiles, respectively. The industries and the prefectures are sorted in order of capital intensity and relative capital abundance, respectively.

Source: Ministry of Economy, Trade and Industry (2007) Census of Manufacture, 2005.

Table A1: Hypothetical Prefecture–Industry Capital Intensities

	Industry average capital labor ratio													
	141	123	126	129	132	135	138	141	144	147	150	153	156	159
Prefecture	Endowment: prefecture capital-labor ratio (manufacturing total)	Food products	Textile products	Pulp and paper	Chemical products	Petroleum and coal products	Ceramic, stone and clay product:	Primary metal	Metal products	General machinery	Electrical machinery	Transportation machinery	Precision machinery	Other manufacturing
Hokkaido	118	100	103	106	109	112	115	118	121	124	127	130	133	136
Aomori	119	101	104	107	110	113	116	119	122	125	128	131	134	137
Iwate	120	102	105	108	111	114	117	120	123	126	129	132	135	138
Miyagi	121	103	106	109	112	115	118	121	124	127	130	133	136	139
Akita	122	104	107	110	113	116	119	122	125	128	131	134	137	140
Yamagata	123	105	108	111	114	117	120	123	126	129	132	135	138	141
Fukushima	124	106	109	112	115	118	121	124	127	130	133	136	139	142
Ibaraki	125	107	110	113	116	119	122	125	128	131	134	137	140	143
Tochigi	126	108	111	114	117	120	123	126	129	132	135	138	141	144
Gumma	127	109	112	115	118	121	124	127	130	133	136	139	142	145
Saitama	128	110	113	116	119	122	125	128	131	134	137	140	143	146
Chiba	129	111	114	117	120	123	126	129	132	135	138	141	144	147
Tokyo	130	112	115	118	121	124	127	130	133	136	139	142	145	148
Kanagawa	131	113	116	119	122	125	128	131	134	137	140	143	146	149
Niigata	132	114	117	120	123	126	129	132	135	138	141	144	147	150
Toyama	133	115	118	121	124	127	130	133	136	139	142	145	148	151
Ishikawa	134	116	119	122	125	128	131	134	137	140	143	146	149	152
Fukui	135	117	120	123	126	129	132	135	138	141	144	147	150	153
Yamanashi	136	118	121	124	127	130	133	136	139	142	145	148	151	154
Nagano	137	119	122	125	128	131	134	137	140	143	146	149	152	155
Gifu	138	120	123	126	129	132	135	138	141	144	147	150	153	156
Shizuoka	139	121	124	127	130	133	136	139	142	145	148	151	154	157
Aichi	140	122	125	128	131	134	137	140	143	146	149	152	155	158
Mie	141	123	126	129	132	135	138	141	144	147	150	153	156	159
Shiga	142	124	127	130	133	136	139	142	145	148	151	154	157	160
Kyoto	143	125	128	131	134	137	140	143	146	149	152	155	158	161
Osaka	144	126	129	132	135	138	141	144	147	150	153	156	159	162
Hyogo	145	127	130	133	136	139	142	145	148	151	154	157	160	163
Nara	146	128	131	134	137	140	143	146	149	152	155	158	161	164
Wakayama	147	129	132	135	138	141	144	147	150	153	156	159	162	165
Tottori	148	130	133	136	139	142	145	148	151	154	157	160	163	166
Shimane	149	131	134	137	140	143	146	149	152	155	158	161	164	167
Okayama	150	132	135	138	141	144	147	150	153	156	159	162	165	168
Hiroshima	151	133	136	139	142	145	148	151	154	157	160	163	166	169
Yamaguchi	152	134	137	140	143	146	149	152	155	158	161	164	167	170
Tokushima	153	135	138	141	144	147	150	153	156	159	162	165	168	171
Kagawa	154	136	139	142	145	148	151	154	157	160	163	166	169	172
Ehime	155	137	140	143	146	149	152	155	158	161	164	167	170	173
Kochi	156	138	141	144	147	150	153	156	159	162	165	168	171	174
Fukuoka	157	139	142	145	148	151	154	157	160	163	166	169	172	175
Saga	158	140	143	146	149	152	155	158	161	164	167	170	173	176
Nagasaki	159	141	144	147	150	153	156	159	162	165	168	171	174	177
Kumamoto	160	142	145	148	151	154	157	160	163	166	169	172	175	178
Oita	161	143	146	149	152	155	158	161	164	167	170	173	176	179
Miyazaki	162	144	147	150	153	156	159	162	165	168	171	174	177	180
Kagoshima	163	145	148	151	154	157	160	163	166	169	172	175	178	181
Okinawa	164	146	149	152	155	158	161	164	167	170	173	176	179	182

Notes: Hypothetical capital–labor ratio is presented in each cell. Light gray, gray, dark gray, and black mean that the capital intensity is in the first, second, third, and fourth quartiles, respectively.

Table A2: Prefecture and Industry Classification

Panel A. Region and prefecture classification

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

Panel B. Industry classification

Industry ID	Industry
1	Agriculture, forestry and fisheries
2	Mining
3	Food products
4	Textile products
5	Pulp and paper
6	Chemical products
7	Petroleum and coal products
8	Ceramic, stone and clay products
9	Primary metal
10	Metal products
11	General machinery
12	Electrical machinery
13	Transportation machinery
14	Precision machinery
15	Other manufacturing

Source: RIETI (2014) R-JIP Database 2014.