Factor Price Equalized in Japanese Regions?

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This paper tests the factor price equalization in Japanese regions. The factor price equality is strongly rejected at 1990 as well as at 2000, even if unobserved cross-regional differences in factor quality and in productivity are considered. The regional wages appear negatively related with relative abundance of labor in each region, suggesting disintegrated factor markets within a country. The cross-regional gap in absolute wage levels remains large, though the significant convergence of regional wages is observed during the 1990s. While stronger increasing returns tend to raise wages, the import penetration significantly reduces wages.

JEL Classification Numbers: F11, F14, F16, J31.

1. Introduction

The factor price equalization (FPE) is one of the most fundamental predictions from the Heckscher-Ohlin-Samuelson factor proportion theory of international trade. While the FPE is originally discussed in the international trade context, the conditions for FPE, such as product market integration and factor mobility, is more likely to be satisfied for regions within a country than for different countries in the real world. The question of factor price equality is of critical importance, not only to trade economists, but also to firms deciding where to locate their plants, workers choosing where to live, and governments responsible for regional development policy. This paper tests the FPE hypothesis in the case of Japanese prefectures during the 1990s, when the rapid import penetration is supposed to promote factor price equalization.

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The purpose of this paper is threefold. Firstly, as far as the author knows, this paper is the first attempt at investigating the FPE hypothesis for Japanese regions, taking account of unobserved factor quality differences and Hicks-neutral productivity differences across regions. The results from our study will supplement existing international evidence on FPE, such as Bernard et al. (2002, 2003) from U.K. and Bernard and Scott (2002) from U.S., both of which strongly reject the factor price equality within each country even after controlling for unobserved cross-regional differences. The case of Japan is well suited for this test because this country is relatively small as a geographical area and tremendously densely populated (nearly half of the entire U.S. population within an area slightly smaller than the state of California with population density as high as that of Belgian). These factors are likely to facilitate market integration and FPE. At the same time, regions within Japan vary distinctively in wage, unemployment rate, educational attainment, economic agglomeration, and industrial composition, thus providing us with rich variations for testing the hypothesis.

Secondly, this paper also examines the convergence of regional wages, in addition to the test of static FPE. In analyzing the cross-regional convergence, this paper considers not only the effects of import penetration but also those of economic geography. Various geographic factors are included, such as region-industry specific differences in increasing returns, inter-industry linkages and intra-industry agglomeration.

Finally, the investigation of Japanese regions in the last decade deserves an independent research topic on its own right. Many Japanese general media often report that the rising manufactured imports from low-wage countries, most notably from China, threaten the survival of geographical concentrations of small-sized plants. Since high-wage regions such as Tokyo have shifted their specialization patterns deeply into non-tradables, the competition against imported products is likely to be more intense in low-wage regions in Japan. On the other hand, while rising unemployment rate and falling prices of industrial inputs are supposed to push wages down, the share of labor distribution has rather increased in Japan.[1] Consequently, this paper examines whether or not cross-regional convergence of wages is observed in the 1990s, whether or not the convergence process is affected by the import penetration, and whether or not the FPE is a realistic description of Japanese regions.

The rest of the paper is organized as follows. Section 2 describes our approaches to test the FPE hypothesis. Section 3 describes our data and overviews recent evolutions in Japanese regional wages. Section 4 reports our empirical results. Section 5 concludes.

2. Tests of factor price equalization

2. 1. Test of absolute factor price equalization

This section discusses the tests of FPE hypothesis, taking account of unobserved cross-regional differences. If FPE holds, the rewards for a given factor must be equal across regions. In practice, however, the quality of factors may vary depending on the region. For example, higher wages in some regions may be merely due to higher labor quality, not due to different rewards for the same quality-adjusted labor. Since factor quality is generally not observed, we cannot directly control for quality differences.

Following Bernard et al. (2002) and Bernard and Scott (2002), this paper derives the empirical specification for testing the FPE, without arbitrary controls of unobserved factor quality differences.[2] First, relate observed factor employment to unobserved quality-adjusted factors as follows,[3]

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1 The input WPI, published by Bank of Japan, declined by 15% in 1990-99. While it has declined in many other developed countries, the labor distribution share in factor-price based national income has increased from 67% at 1990 to 74% at 2000.

2 While the final empirical specification for relative FPE is adapted to our data availability, the basic derivation follows Bernard et al. (2002). We choose the same notation to facilitate comparison.

3 For clarity reason, this paper concentrates on the case of two factors of production, but, as shown

$$L_{rj} = \theta_{rj}^{L} \tilde{L}_{rj}, \qquad K_{rj} = \theta_{rj}^{K} \tilde{K}_{rj} \tag{1}$$

where a tilde above a variable indicates that it is an observed value. As is usual, we consider labor (L) and capital (K) as primary factors of production. Observed factor prices will be related to quality-adjusted values as follows,

$$\tilde{w}_{rj}^{L} = \theta_{rj}^{L} w_{r}^{L}, \qquad \tilde{w}_{rj}^{K} = \theta_{rj}^{K} w_{r}^{K} \ . \tag{2}$$

If FPE holds, quality-adjusted factor prices in any region must be at the same level ($w_{rj} = w_{sj}, \forall r, s$).

Consider the following cost function with standard properties.

$$C_{rj} = A_{rj}^{-1} \Gamma_{j}(w) Y_{rj} \tag{3}$$

where A and Y denote Hicks-neutral productivity shifter and output. The vector of quality-adjusted factor prices is summarized by w. By Shepherd's Lemma, the demand of quality-adjusted factor is given by[4]

$$L_{rj} = A_{rj}^{-1} Y_{rj} \, \partial \Gamma_{j} \big/ \partial w_{r}^{L}, \qquad K_{rj} = A_{rj}^{-1} Y_{rj} \, \partial \Gamma_{j} \big/ \partial w_{r}^{K} \ . \tag{4}$$

The equality of absolute factor prices requires identical production technology in any region ($A_{rj}^{-1} = A_{sj}^{-1}, \forall s, r$). From (1), (2) and (4), observed factor shares are equal across regions under FPE.

$$\frac{\tilde{w}_{rj} \tilde{L}_{rj}}{Y_{rj}} = \frac{\tilde{w}_{sj} \tilde{L}_{sj}}{Y_{sj}} \tag{5}$$

Consequently, the simple test of FPE is to regress the ratio of observed labor wage bill share for region r relative to the ratio for Japan as a whole on the set of region dummies,

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in Bernard et al. (2002), allows arbitrary numbers of factors and of goods.

4 The firm is supposed to be a price-taker in factor markets. As shown in Bernard et al. (2002), basic results are robust even if imperfect competition in product market is allowed.

$$\ln\left(\frac{\tilde{w}_{rj}\tilde{L}_{rj}/Y_{rj}}{\tilde{w}_{j}\tilde{L}_{j}/Y_{j}}\right) = \sum_r \alpha_r^L DUM_r + \varepsilon_{rj}^L . \quad (6)$$

The region-specific dummy variables are expressed by *DUM*. The error term is denoted by ε. Under the null hypothesis of FPE, α should be zero for all regions.

2. 2. Test of relative factor price equalization

Although we have so far interpreted FPE as identical *absolute* level of factor prices, Relative Factor Price Equalization (RFPE), which allows absolute factor prices to vary as long as relative factor prices remain constant across regions, is more relevant for describing real-world factor price patterns. This weaker version of FPE allows, not only for factor quality variations, but also for neutral technology differences across regions.

Under RFPE, quality-adjusted factor prices differ across regions by a component, λ, which is common across all factors, because of the Hicks-neutrality of productivity differences.

$$w_{rj}^Z = \lambda_{rs} w_{sj}^Z \quad (7)$$

This equality (7) holds for any factors of production, *z* (*L* or *K*, for example). Moreover, the homogeneity of degree one of the cost function implies, for any factors *z*,

$$\partial\Gamma_j(w)/\partial w_r^Z = \partial\Gamma_j(w)/\partial w_s^Z \quad (8)$$

By combining (1)-(4) with (7) and (8), since unobserved factor quality terms are cancelled out, we obtain the ratio of observed wage bills of one factor over another factor is equal across any regions *r* and *s*.

$$\frac{\tilde{w}_{rj}^L \tilde{L}_{rj}}{\tilde{w}_{rj}^K \tilde{K}_{rj}} = \frac{\tilde{w}_{sj}^L \tilde{L}_{sj}}{\tilde{w}_{sj}^K \tilde{K}_{sj}} \quad (9)$$

Since it is generally difficult to accurately measure the real user costs of capital in each region, this paper compares labor with material inputs in the Japanese case.[5] If the production function is defined in terms of gross output Q, instead of net value-added Y, the material input, M, is obviously one of the primary production factors ($Q = F(L, K, M)$).[6] Besides, relatively high cross-regional mobility of material inputs can be a basis for serving M as the benchmark comparing labor wages across regions. Therefore, our test of RFPE is conducted by the following regression on regional dummies

$$\ln\left(\frac{\tilde{w}_{rj}^{L}\tilde{L}_{rj} \Big/ \tilde{w}_{rj}^{M}\tilde{M}_{rj}}{\tilde{w}_{j}^{L}\tilde{L}_{j} \Big/ \tilde{w}_{j}^{M}\tilde{M}_{j}}\right) = \sum_{r} \alpha_{r}^{LM} DUM_{r} + \varepsilon_{rj}^{LM}, \qquad (10)$$

where the relative wage bill share for Japan as a whole is used as the denominator. If we find α significantly different from zero for a non-negligible number of regions, we should interpret it as the clear rejection of RFPE.[7] We must note that any industry-specific determinants shared by all regions are differenced out since this specification is based on relative share normalized by national average.

Finally, the regional characteristics will be compared between the regions with significantly positive region dummy and those with negative region dummy to check whether or not our regression results are consistent with the prediction from the trade theory. The regions of which the region dummy is significantly positive are expected to have more abundant endowment of labor, lower wage, higher labor wage bill share, and specialize in more labor-intensive industries.

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5 Previous studies also avoid capital. Besides, the wage gap between production/non-production workers has been slim in Japan, in contrast to U.S. and U.K. The limitation of data availability also prevents us from looking at skilled vs. unskilled labor because regional wage data disaggregated by skills or occupation types for each two-digit industry have not been collected since 1992 in Japan.

6 The material input variable is inevitably a composite of various heterogeneous materials. In discussing the relative factor abundance in the region later, however, we will try to control for differences in input compositions across industries by exploiting data from *Input-Output Tables*.

7 Hanson and Slaughter (2002) investigate whether employment changes in U.S. states are consistent with the prediction of Rybczyski Theorem and find that production techniques are very similar across states.

2.3. Convergence of regional wages

While the previous sections discuss the direct test for the static FPE, this paper next examines whether Japanese regions are in the process of transition toward FPE.[8] If factor price is being equalized across regions, the wages in low-wage regions tend to rise faster than the wages in high-wage regions. To examine this catch-up process in regional wages, this paper estimates the following.

$$\Delta \ln\left(\frac{w_{rjt}}{w_{jt}}\right) = \alpha + \beta \ln\left(\frac{w_{rj,t-1}}{w_{j,t-1}}\right) + Z\gamma + u \qquad (11)$$

The subscript *r, j,* and *t* index region, industry, and time, respectively (r=1,2,…,R; j=1,2,…,J; t=1,2,…,T). The labor wage is denoted by *w*. The variables are region-industry specific and normalized by the national average of the respective industry. All the factors common across industries, such as related with labor supply, are captured by region dummies. The error term is denoted by *u*. Heteroskedasticity is considered in estimation. We expect that the coefficient on initial wage level, β, is negative when the cross-regional convergence takes place.

As Quah (1993) has pointed out, however, the cross-regional distribution can diverge even when the initial-condition coefficient is negative. Thus, this test based on the initial wage coefficient is not sufficient. In the terminology of growth literature, we must check the "σ-convergence" in addition to the "β-convergence." For this purpose, this paper will also report whether cross-regional dispersion in wages declines over time.

As the control variables captured by *Z*, this paper considers the following factors. First of all, the import penetration is critical in this context. As the region becomes more deeply exposed to international competition, the factor price in that region is supposed to become closer to that

[8] Bernard et al. (2003) examined a longer period (1970s to 1990s) and found no cross-regional convergence of skill premium in U.K. wages.

in the world market. In the Japanese case, rising imports are mainly originated in low-wage East Asian developing countries, implying downward pressures on Japanese wages. Hanson (1997) also found that a reduction of trade barriers compresses regional wage differentials in Mexican states. Consequently, we expect negative coefficient on the import growth variable. Since region-specific foreign trade data are not generally available for most Japanese regions, however, this paper constructs a preliminary region-industry specific measure of import penetration as follows.

$$Gr(MS_{rj}) = \sum_j \left[\left(\frac{L_{rj}}{L_r} \right) Gr(MS_j) \right] \Big/ Gr(MS_j) \qquad (12)$$

where *Gr(MS)* denotes the growth of import share, which is defined by the share of imports in domestic shipment plus imports minus exports.[9] This index is based on the weighted average of industry import share growths, with industry shares in each region as weights, and normalized by the national average of import penetration of the respective industry.[10]

Next, this paper considers various effects of economic geography on regional wages.[11] All the variables are defined as relative to the national average of the industry. First, to capture regional inter-industry linkages, this paper introduces weighted averages of vertically linked upstream and downstream industries.

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9 To avoid volatile fluctuations, we use average over growths in three intervals: 1985-90, 1990-95, and 1995-2000.

10 Constructing region-specific foreign trade variables from national industry figures with weights derived from the share of industry in each region is not new. See the definition of region-industry specific exchange rates by Bernard and Jensen (2000), for example. To the author's knowledge, *Inter-regional Input-Output Table* is the only source for region-industry specific foreign trade data in Japan, but the table aggregates 47 prefectures only into coarsely broad nine blocks and no figures later than 1995 have yet been published.

11 See Tomiura (2003) for detailed explanations of these geography-related variables.

$$
\begin{aligned}
INP_{rj} &= R\sum_{h\neq j}\left(\frac{X_j^h}{X_j}\right)\left(\frac{Q_{rh}}{Q_h}\right) \\
OUT_{rj} &= R\sum_{h\neq j}\left(\frac{X_h^j}{X^j}\right)\left(\frac{Q_{rh}}{Q_h}\right)
\end{aligned}, \tag{13}
$$

where X_k^h, X_j and X^j denote the intermediate transaction from industry *h* to industry *k*, total input supplied to industry *j*, total output from industry *j*, respectively. *Q* denotes the shipment.[12] While (13) considers inter-industry linkages, the intra-industry agglomeration is also important for regional economic activities. Thus, this paper introduces a measure of this externality as follows.

$$
IIA_{rj} = \frac{L_{rj} / L_r}{L_j / L} \tag{14}
$$

Firms can pay higher wages to their employees when they locate closer to their vertically linked industries or to the agglomeration centers because transport costs can be partly saved.[13]

Second, to describe region-industry differences in technology, especially in the degree of internal increasing returns, this paper uses the average plant size.

$$
SCL_{rj} = \frac{L_{rj} / N_{rj}}{L_j / N_j}, \tag{14}
$$

where *N* is the number of plants. The wages in regions/industries with stronger increasing returns, which are internal to individual firms, tend to be higher because the increasing returns raises the firm's market power in the imperfectly competitive product market, and results in high profits for the firm and high wages for the workers, who may be involved in bargaining

[12] The multiplication by *R* (total number of regions) standardizes the average across regions as one. All the other manufacturing industries are included in defining these two indices.

[13] Along the same logic, Hanson (1997) also studies effect of increasing returns on regional wages, though he uses the geographical distance from the industrial centers as the measures of increasing returns in Mexican states.

over wages or rent sharing.[14]

Third, since labor is quite immobile across regions and often specialized and since knowledge spillover is local, we introduce the following two variables.

$$DIV_{rj} = \left[\sum_{h \neq j} \left(\frac{L_{rh}}{L_r} \right)^2 \Big/ \sum_{h \neq j} \left(\frac{L_h}{L} \right)^2 \right]^{-1} \tag{16}$$

$$SIM_{rj} = \left\{ \sum_y \left[s_{yj} - \sum_{h \neq j} \left(\frac{L_{rh}}{L_r - L_{rj}} s_{yh} \right) \right]^2 \Big/ \sum_y \left[s_{yj} - \sum_{h \neq j} \left(\frac{L_h}{L - L_j} s_{yh} \right) \right]^2 \right\}^{-1} \tag{17}$$

DIV is a measure of industrial diversity of the region, defined by the inverse of the squared sum of shares of all other industries. More diversity tends to stimulate more innovations, and results in higher rent, some of which may be captured by workers through wage rises.[15] On the other hand, *SIM* is a variable constructed for detecting the Marshallian labor pooling, defined by the inverse of a sum of squared deviations of the occupation mix of the industry and the weighted average of occupation mixes of other industries located in the same region. The share of occupation type *y* (professional/technical, production, and others) in industry j's employment is expressed by s_{yj}. Since firms located in regions where more similar industries are located nearby can hire workers who invested more in human capital accumulation from richer pool of more specialized labor supply, the wages in those regions/industries tend to be higher.

Hence, this paper estimates the following reduced-form, which links regional wage growth with initial wage level, import penetration growth, and various geography-related variable.

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[14] While we assumed that a firm is a price-taker in the factor market in the test of FPE in the previous section, this assumption is far from realistic for describing Japanese wage determination. This unrealistic assumption can be relaxed for the convergence regression in this section.

[15] Though inconsistent with the standard geography model developed by Fujita et al. (1999), wages in diversified urban regions will be lower if we note that people are attracted by wider variety of non-tradable consumer goods/services available in these regions.

$$\Delta \ln\left(\frac{w_{rjt}}{w_{jt}}\right) = \alpha + \beta \ln\left(\frac{w_{rj,t-1}}{w_{j,t-1}}\right) + \gamma Gr(MS_{rjt}) + \delta_1 \ln INP_{rj,t-1} + \delta_2 \ln OUT_{rj,t-1} + \delta_3 \ln SCL_{rj,t-1} + \delta_4 \ln IIA_{rj,t-1} + \delta_5 DIV_{rj,t-1} + \delta_6 \ln SIM_{rj,t-1} + u_{rjt} \quad (18)$$

3. Japanese data

3.1. Description of the data

This paper mainly uses data derived from Japan's *Census of Manufacturers* (Kogyo Tokei, in Japanese).[16] Region-industry specific data on a range of variables, including labor wage bill, employment, material expenditure, value-added, and gross outputs, are contained in this census.[17] The whole manufacturing is disaggregated into 21 industries at the two-digit level.[18] The entire Japan is divided into 47 prefectures (ken, in Japanese), which are more like cities than states in the U.S., roughly comparable with commuting areas.[19] As a result, we have 987 observations for each year.[20] For inter-industry linkage and foreign trade figures, this paper exploits data from *Input-Output Tables*.[21] Regional population data are from *Population Census*

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16 This census is rich in industry data, while labor statistics, such as *Wage Census*, contains detailed wage data but aggregate the whole manufacturing as one sector. Although this census is based on manufacturing plants, excluding headquarters, sales branches, and research laboratories, the same is true for the data used by previous studies. See Bernard et al. (2002).

17 All the data in *Census of Manufacturers* are downloaded from the web page of the Japan's Ministry of Economy, Trade and Industry.

18 The factor proportion theory of international trade is more appropriate in describing two-digit industries, while monopolistic competition of differentiated products may be a reasonable approximation for more disaggregated four-digit industries. See the two-tier modeling by Davis and Weinstein (1999), for example. Apparel (14) and textile (15) are aggregated because of the change in the industry classification. The ordnance industry (33) is merged into the general machinery industry (29).

19 Bernard and Scott (2002) divide U.S. into 181 local labor market areas, where the state of California, slightly larger than entire Japan, is divided into only eight areas. According to Japan's *Population Census*, the population share of commuters across prefecture borders is far less than one-tenth in most prefectures. Although Bernard et al. (2002) divide U.K. into more than 100 Postcode Areas, commuting across cities is rather common in Japan.

20 Since some cells are not disclosed, we set these values as the same as national average, but the number of these unavailable cells is small. Moreover, the test based on this imputation makes the rejection of FPE harder and rather strengthens our results.

21 Inter-industry transaction data (X) are drawn from the 90 Sector Table in *1990 Input-Output Benchmark Table*.

(Kokusei Chosa, in Japanese). While the convergence is investigated for 1990-2000, this paper mainly focuses on 1990 in examining the static FPE, since either *Input-Output Benchmark Tables* or *Population Census* for 2000, available only once in five years, has not yet been published.

The summary statistics of variables are shown in TABLE 1. Several points must be noted. First, the cross-regional variation in wages has declined. The dispersion at 2000 is smaller than that at 1990 by 17.6 percent, if the standard deviation is divided by the mean. This constitutes a preliminary evidence for σ-convergence of regional wages. Second, the share of labor wage bill, especially relative to material inputs, remains quite stable in the decade. Thus, the choice between 1990 and 2000 seems not to affect test results for the relative FPE. Finally, while average import share growth in the last decade is moderately around four percent, some regions-industries are seriously hit by deep import penetration (the maximal import share growth exceeding thirty percent).

3.2.Related evidence for Japanese regional wages

(to be added along the following preliminary outlines)

Before reporting results from formal tests of FPE hypothesis, an overview of evolution in regional wages in recent Japan will be informative. This section provides related evidence concerning how active workers move across regions in Japan, how homogeneous the Japanese workers are in various regions, and how similar the industrial structure is in each region in Japan, since these factors are critical for the relevancy of FPE.

First, the cross-regional population mobility is relatively inactive in recent years. The population mobility is mostly taking place through intra-regional migration. The cross-regional mobility is even lower among employees than general population. Though population mobility from relatively underdeveloped regions into urban centers had been active in the 1960s, this inflow of working population has already been saturated. For example, according to Population Census in . This suggests that inter-regional wage differentials may persist due to inactive inter-regional migration in Japan, at least in the recent years.

Second, the skill composition of workers varies significantly across regions in Japan. The share of workers finishing university or higher education is as high as percent in Tokyo, while that in Aomori is as low as percent, according to Population Census in . This implies that workers in different regions may accomplish different tasks, and be paid different rewards, even if they work in the same industry.

Third, the industry composition is also drastically different across regions. For example, the share of textiles and apparels is as low as percent in Tokyo, while that in is as high as percent in . Even within the same two-digit industry, high-wage regions are likely to be specialized in higher value-added, or more distinctly differentiated from products imported from low-wage countries. If the industry composition of some regions is so different from those in other regions in Japan that they belong to the different diversification cone, then, more intense import competition from East Asian low-wage countries tend to push wage down in regions heavily dependent on import-competing industries but has no significant impact on wages in regions specializing in distinctly differentiated products or non-tradable services.

While these pieces of evidence jointly indicate that FPE is not satisfied in Japanese regions, we must wait for formal test results to discuss the Japanese case.

4. Empirical results

4.1. Results from test of absolute factor price equalization

This section reports the results from the tests of FPE in the absolute sense. The results from regressions (6) are summarized in TABLE 2, while estimates for individual prefectures are reported in APPENDIX TABLE. The dependent variable is the share of labor wage bill in value-added output of the region-industry, relative to the national average. The coefficients on regional dummies are found significantly different from zero for seven out of 47 regions in 1990 and four regions in 2000.[22] The decline in number of rejections may be consistent with our previous finding of cross-regional convergence during this period.

As shown in TABLE 2, the significantly negative (positive) sign on the region dummy tends to be found for regions with relatively high (low, respectively) wages, suggesting that higher (lower) wage in these regions result in lower labor wage bill share due to factor substitution. Since this test is on the absolute equality, we cannot exclude the possibility that relative factor prices may be equal across regions.

4.2. Results from test of relative factor price equalization

This section reports the results from the test of the FPE hypothesis in the relative sense. The results from regression (10) are reported in TABLE 3. Again, both in 1990 and in 2000, the equality is significantly rejected in a non-negligible number of regions. Although it is lower than that for U.S. or U.K., this rejection rate should not be neglected.[23] This result is also consistent with the previous finding for Japanese regions because Davis et al. (1997) have found that the fit of the factor proportion trade model improves dramatically when the FPE assumption is dropped in Japanese ten aggregated regions. Consequently, even if we consider unobserved differences in factor quality and in technology, the relative FPE is violated in Japanese regions.

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22 The dummy for Hokkaido prefecture is not distinguished from the constant term. We also confirm that, although some of them are statistically significant, the inclusion of industry-specific dummies does not affect our principal results on region dummies.

23 This finding is robust even if we aggregate 47 prefectures into nine regional blocks. Regression results are available upon request.

This rejection of FPE is also consistent with cross-regional wage dispersion patterns. Figure 1 presents the cross-regional distribution of manufacturing wages in 1990 and 2000. As demonstrated in this figure, the speed of convergence is quite slow and the wage gap remains large.[24] Such a persistent regional difference may imply that different regions are in different cones of diversification. This interpretation will be discussed again later.

4.3. Discussions of relation with factor abundance and specialization

TABLE 4 compares regions with significantly negative region dummy and those with positive dummy. We concentrate on the regressions for testing relative FPE in what follows. As expected, the impressive contrast emerges from this table. First, as consistent with the results from absolute FPE test, the wage in regions with significantly negative/positive region dummy tends to be higher/lower than average by 14 to 25%.[25]

Second, the relative wage bill share of labor tends to be lower/higher in regions with significantly negative/positive region dummy. Combining this with the first finding, our results suggest that higher regional wage promotes less intensive use of labor through factor substitution and results in lower share of wage bill of labor. Although no data on unit price of material input are available in our case, this indication of elastic factor substitution is consistent with previous results from U.S. and U.K.[26]

Third, higher labor wage level and lower wage bill share of labor appear related with relatively scarce supply of labor in the region. The ratio of work force population over the regional availability index of industrial inputs, defined by (13), tends to be lower/higher in

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24 Slow cross-regional convergence is also observed in other countries and for longer periods. See Chapter 11 in Barro and Sala-i-Martin (1995), for example.

25 Since data for the unit price of material inputs are not available in this census, the evaluation of labor wage relative to material unit price is impossible.

26 In his survey of empirical studies, Hamermesh (1993) confirms that labor and material inputs are actually substitutes (pp.104-107).

regions with significantly negative/positive region dummy.[27] This indicates that labor is not perfectly mobile across regions even within a country.

Finally, the specialization pattern tends to differ in regions with significant region dummy. The Gini coefficient, the most commonly used measure for regional specialization, is shown in the same table.[28] If the industrial structure of a region is closer to that of entire Japan, the Gini coefficient of the region will be smaller. The figures in the table show that regions with significantly positive region dummy tend to exhibit specialization patterns distinctively different from that of Japan as a whole.[29] Although direct evidence has not been found at this aggregation level, this suggests the possibility of Japanese regions specializing into different industry compositions. Previous studies indicate the existence of multiple cones of diversification for regions within U.S. and U.K.[30]

If some regions in Japan specialize in industries so different from other regions that FPE fails, then, the rapid growth of low-wage countries must have varied impacts on workers in different regions. In this case, foreign trade changes have a critical regional implication because cheap imports from low-wage countries exert competitive pressures on workers in labor-abundant regions but reduce living costs for workers in labor-scarce regions.[31]

All the four measures shown in TABLE 4 unanimously demonstrate that the deviation

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[27] Shown as “INP” is the sum of INP, defined by (13), over all industries in each prefecture, normalized by the national average.

[28] The specialization is measure by employment shares of two-digit industries in each region, derived from *Census of Manufacturers*, consistently with other variables. For calculating Lorenz curves, the piecewise linear approximation is used as usual.

[29] Since the specialization pattern of Japan as a whole is strongly affected by that of large industrial center regions, the regions with significantly negative region dummy tend to have specialization patterns similar to that of Japan.

[30] Bernard et al. (2002) show that their estimated relative unit-wage levels are consistent with the regional ordering in the factor abundance in U.K.

[31] If low-wage developing countries specialize in completely different industries, however, the negative impact of imports from them will disappear in all Japanese regions. Previous studies, such as Debaere and Demiroglu (2003), have found that countries around the world are outside of the rage of single diversification cone.

from the national average becomes larger as the statistical significance of the region dummy becomes stronger, both in negative and positive directions, as we can see figures from the top row to the bottom row of TABLE 4. Therefore, the cross-regional difference of factor price in the Japanese case is possibly due to different patterns of specialization based on difference in relative factor abundance in the region, which is consistent with the factor proportion trade theory.

The existence of multiple cones of diversification, however, is not the sole explanation for the violation of FPE.[32] First, alternative theoretical explanations for cross-regional wage variability include differences in productivity, transport costs, and increasing returns. However, systematically higher technical efficiency, lower transport costs and stronger increasing returns especially for labor-intensive industries in labor-scarce regions, which are necessary to be consistent with our observations, seem empirically implausible. Second, it is possible for real consumption wages to be equal even when nominal wages vary across regions, due to the differences in regional costs of non-tradables. The cross-regional adjustment of wages taking account of differences in amenity and in consumption basket, however, is practically impossible.[33] Finally, data problems may contaminate our results since material inputs, and outputs to some extent, are often inevitably heterogeneous. Given the limited availability of Japanese data, however, there exists no region-industry specific data for disaggregated material inputs or skill-classified workers.[34] As some explanations require implausible assumptions or detailed data publicly not available, a formal test discriminating various interpretations should

[32] Discussions in this paragraph are inspired by Bernard et al. (2002).

[33] Furthermore, the region dummy for Tokyo, where the widest varieties of non-tradable services are undoubtedly available in Japan, is not significant in all our regressions.

[34] Omitted factors, including human capital, do not alter our violation conclusion, while aggregation of heterogeneous products makes a violation more likely, as discussed by Debaere and Demiroglu (2003). All the previous studies on Japanese geography, as far as the author knows, including Davis et al. (1997), which explicitly discussed FPE implications, have used two-digit data.

be left to independent work in the future. Since alternative reasons for factor price variations are not excluded at this moment, we must be cautious in claiming that recent import surges in Japan are affecting workers differently depending on the region.

4.4. Results from convergence regressions

The results from the convergence regression (18) are reported in TABLE 5. The growth rate of regional wages is calculated between the years 1990 and 2000. Notable findings from this table are as follows. First, in all cases shown in the table, the coefficient on the initial wage level is significantly negative at any conventional confidence levels. By combining with our previous finding of smaller cross-regional variation at 2000 than at 1990, we can conclude that regional wages have converged in the 1990s.

Second, the higher import penetration appears related with lower wage growth. This finding of negative impact of import growth on regional wage growth is consistent with the previous finding in Mexican states by Hanson (1997).[35]

Third, the significantly positive effect of increasing returns on regional wages is detected, irrespective of the inclusion of regional dummies. This finding is exactly as expected since workers in industry-region with stronger economies of scale tends to obtain higher wages, possibly due to higher rent earned by the firms.

Fourth, richer availability of input supply in the region tends to raise wages if region-specific factors are controlled for. Although this result depends on the inclusion of regional dummies, the finding of higher wages in regions with more abundant supply of

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35 Related evidence for depressing wage dispersion has previously been provided by Hanson (1997, 2003) on Mexican states during drastic trade liberalization and regional integration by NAFTA. Hanson (1997) finds compression in cross-state wage differentials during 1965-88, although it began before the trade liberalization. Hanson (2003) shows that regional characteristics that matter for the Mexican wage relative to U.S. wage in the 1990s appear related to foreign trade.

material inputs is consistent with the prediction based on the factor abundance trade theory. We have already discussed this issue of higher wage in relatively labor scarce regions in the previous section.

Finally, although it again depends on the exclusion of regional dummies, the labor pooling seems to help raise regional wages, as expected. Other variables are found statistically insignificant. In sum, while we must cautious in discussing results regarding input supply and labor pooling, the significantly positive effect of increasing returns on regional wages should be viewed as robust.[36]

As is consistent with these convergence regression results, the cross-regional distribution curve in Figure 1 becomes less steep in 2000 compared with 1990. However, the cross-regional wage variation remains substantial: the wage in the highest-wage region (Kanagawa) is around twice as high as that in the lowest-wage region (Aomori). The gap of this magnitude is remarkable as a cross-regional variation within a relatively small, developed country with high population density. Thus, again, this persistent cross-regional wage gap is consistent with our previous finding of the violation of FPE.[37]

Furthermore, as overviewed in Section 3.2, ample evidence supporting the rejection of FPE is available, including inactive cross-regional worker mobility and distinctively different industry composition in Japanese regions.

5. Concluding remarks

This paper tests the factor price equality (FPE) in the case of Japanese prefectures, where the

[36] This finding of significant effect of increasing returns on regional wages is consistent with the previous result by Hanson (1997) from Mexican states.

[37] Actually, cross-regional wage differentials are persistent, as the cross-regional correlation between wage at 1990 and at 2000 is as high as 0.96. Bernard and Jensen (2000) also report that wage inequality movements are remarkably heterogeneous across states and cross-regional wage differences are persistent in the U.S. case.

rapid import penetration is likely to pressurize regional wages to equalize. Although the significant convergence of regional wages is observed during the last decade, the cross-regional wage gap remains large. Even if cross-regional differences in factor quality and in productivity are considered, the FPE hypothesis is strongly rejected. This rejection is consistent with our daily observations of persistent industry composition differences and inactive worker mobility across regions in recent Japan.

The principal finding of this paper is consistent with previous results from other countries. Our rejection of factor price equalization, if combined with accumulated evidence from U.S. and U.K. regions, suggests that the disintegration of regional factor markets does not appear an exceptional observation even within a geographically small, developed country.

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TABLE 1 Summary Statistics

	Average	St. Dev	Min	Max
w (1990)	3.387	.6323	2.253	4.864
w (2000)	4.175	.6203	2.921	5.582
$d\ln\left(w_{rj}/w_j\right)$	.0349	.0996	–.4601	.5147
wL/Y (1990)	.0803	.3719	–1.365	7.660
wL/Y (2000)	.0710	.3137	–1.619	1.953
$w^L L/w^M M$ (1990)	.1692	.4286	–1.755	2.267
$w^L L/w^M M$ (2000)	.1756	.4794	–1.895	2.378
Gr(MS)	.0405	.0681	.0035	.3158
INP	–.5848	1.147	–4.110	1.861
OUT	–1.444	3.956	–18.421	2.358
SCL	–.0129	.4947	–1.965	1.802
IIA	–.2804	.8316	–3.610	2.397
DIV	–.2931	.2516	–1.010	.7441
SIM	.0156	.5113	–3.207	3.391

Notes: All the variables, except in the first three rows and *Gr(MS)*, are in logarithm. While *Gr(MS)* is the average over 1985-2000 and log-difference in wages is between 1990 and 2000, other variables are at 1990. The number of observations is 987 in all cases.

TABLE 2 Test of Absolute Factor Price Equalization

	(1) 1990	(2) 2000
# Regions with significant DUM	(–) 7 (+) 0	(–) 1 (+) 3
R^2	0.098	0.116
Wage in (–) DUM regions	1.170	1.193
(+) DUM regions	-------	0.841

Notes: The dependent variable is the share of labor wage bill in value-added in logarithm. The number of observation is 987 for each case. The number of regions with the region dummy significant at 5% is shown in "# Regions" row. Standard errors are evaluated by heteroskedasticity-robust estimates. "Wage" rows are the total manufacturing wages averaged over prefectures with significantly negative/positive region dummies, divided by the wage averaged over all 47 prefectures.

TABLE 3 Test of Relative Factor Price Equalization

	(1) 1990	(2) 1990	(3) 2000	(4) 2000
# Regions (–) DUM	2*** 4** 9*	1*** 4** 10*	4*** 8** 11*	2*** 5** 9*
(+) DUM	1** 3*	1** 3*	1** 2*	1*** 2** 3*
Industry DUM	No	Yes	No	Yes
R^2	0.130	0.299	0.131	0.319

Notes: The dependent variable is the wage bill of labor relative to material inputs in logarithm. The asterisks ***, ** and * denote the significance at 1%, 5% and 10%, respectively, evaluated by heteroskedasticity-consistent estimates. See also Notes to TABLE 3.

TABLE 4 Wages, Factor Abundance, and Specialization Patterns of Regions

Regions w/DUM	Labor wage (w)	Wage bill share ($w^L L / w^M M$)	Abundance (Pop/INP)	Specialization (Gini)
(–)***	1.186	0.7454	0.3588	0.7157
(–)**	1.186	0.7518	0.4947	0.7610
(–)*	1.135	0.8286	0.5855	0.8044
(+)*	0.7718	1.342	2.102	1.256
(+)**	0.7488	1.403	2.886	1.364

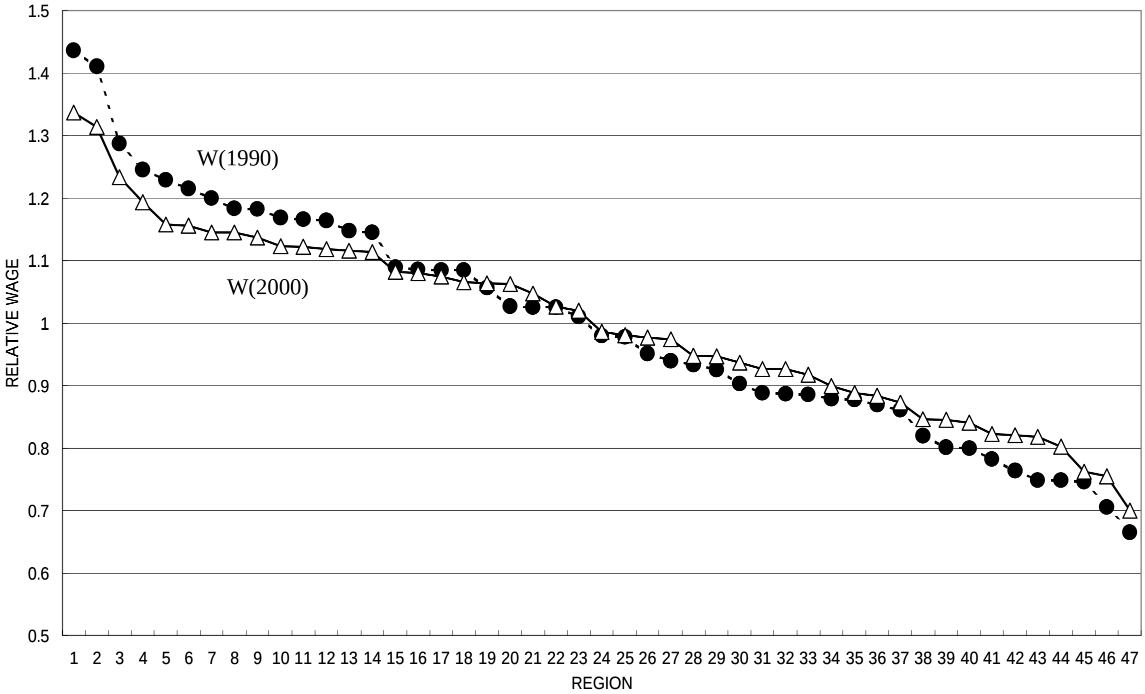
Notes: All the values are expressed as relative to the average over all 47 regions. The significance of region dummies is evaluated in the regression at 1990 without industry dummies, shown in (1) of TABLE 4. Both labor wage and wage bill share are for total manufacturing. "Pop" denotes the work force population in *Population Census*, while "INP" is the input availability defined by (13) in the text. Gini coefficients are calculated based on employment data in *Census of Manufacturers*.

TABLE 5 Convergence of regional wages

	(1)	(2)	(3)	(4)
Initial Wage	–0.2026 (0.0355)	–0.2065 (0.0361)	–0.2285 (0.0587)	–0.1943 (0.0673)
Gr(MS)	-------	–0.0835 (0.0409)	–0.0515 (0.0427)	–0.0679 (0.0421)
INP	-------	-------	–0.0002 (0.0052)	0.0289 (0.0074)
OUT	-------	-------	0.0003 (0.0007)	0.0006 (0.0007)
SCL	-------	-------	0.0293 (0.0106)	0.0242 (0.0141)
IIA	-------	-------	0.0057 (0.0059)	0.0026 (0.0062)
DIV	-------	-------	–0.0208 (0.0130)	–0.0158 (0.0196)
SIM	-------	-------	0.0140 (0.0052)	0.0019 (0.0047)
Region DUM	No	No	No	Yes
R^2	0.210	0.213	0.246	0.314

Note: The dependent variable is the log-difference in wage between 1990 and 2000. Heteroskedasticity-consistent standard errors are in parentheses. The number of observations is 987 in all cases.

Figure 1 Distribution of Regional Wages



Notes: The manufacturing wage of each region is normalized by national average. All the 47 prefectures are arrayed in descending-order of wage at 1990. The dotted line with black circles is for 1990, while the thick line with white triangles is for 2000.

APPENDIX TABLE

ESTIMATES FOR INDIVIDUAL PREFECTURES

Prefecture	(A1990N)	(A2000N)	(R1990N)	(R1990I)	(R2000N)	(R2000I)
2. Aomori						
3. Iwate						
4. Miyagi					(–)*	
5. Akita		(+)*	(+)*	(+)*		
6. Yamagata						
7. Fukushima						
8. Ibaraki	(–)**		(–)**	(–)**	(–)***	(–)**
9. Tochigi	(–)*		(–)*			
10. Gunma	(–)*					
11. Saitama	(–)*					
12. Chiba	(–)**		(–)**	(–)**	(–)***	(–)**
13. Tokyo						
14. Kanagawa					(–)**	(–)*
15. Niigata						
16. Toyama						
17. Ishikawa						
18. Fukui						
19. Yamanashi						
20. Nagano						
21. Gifu						
22. Shizuoka						
23. Aichi	(–)**		(–)***	(–)**	(–)***	(–)***
24. Mie	(–)**		(–)***	(–)***	(–)***	(–)***
25. Shiga	(–)***	(–)**	(–)*	(–)*	(–)*	(–)*
26. Kyoto	(–)*					
27. Osaka			(–)*			
28. Hyogo	(–)**		(–)*	(–)*	(–)*	(–)*
29. Nara	(–)**					
30. Wakayama						
31. Tottori		(+)**				
32. Shimane				(–)*		
33. Okayama					(–)*	
34. Hiroshima						
35. Yamaguchi					(–)**	(–)*
36. Tokushima					(–)**	(–)**
37. Kagawa						
38. Ehime			(–)*	(–)*		
39. Kochi			(+)**	(+)**	(+)*	(+)*
40. Fukuoka						
41. Saga						
42. Nagasaki		(+)***	(+)*	(+)*	(+)**	(+)***
43. Kumamoto						
44. Oita		(–)*	(–)*	(–)*		
45. Miyazaki						
46. Kagoshima						(+)**
47. Okinawa		(+)**				

Notes: The sign and significance of region dummy are shown. In the top row, A (R) corresponds to Absolute (Relative) FPE and I (N) means that the regression includes (no) industry dummies.