Japan's Prefectural-level KLEMS: Productivity Comparison and Service Price Differences

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Abstract

We compile a prefectural-level KLEMS database for Japan and conduct productivity comparisons for Japanese 47 prefectures. One of the difficulties in compiling regional KLEMS database is how to handle variation in service prices across regions. To cope with this problem, we estimated cross-regional price-level differences in each industry in the service sector based on prefectural-level item-wise data of service prices. For estimation, we applied the Country-Product-Dummy (CPD) method, a method used to estimate absolute purchasing power parities among countries. As a result of re-calculation, the standard deviation of cross-regional TFP difference indices in 2009 decreased by around 13 per cent. In addition, by using the derived cross-regional price difference indices, we confirmed that the Balassa-Samuelson effect, which holds among international economies, also holds among regional economies in Japan.

For the purpose of conducting productivity comparison among Japanese 47 prefectures, we compile Japan's prefectural-level KLEMS database,[2] which we call the Regional-level Japan Industrial Productivity (R-

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2 For R-JIP Database 2017 and its brief technical explanation see the RIETI's website at https://www.rieti.go.jp/en/database/R-JIP2017/index.html. The R-JIP 2017 contains real value added, quantity of labour input (man-hours), quality of labour input, and capital service input, covering 23 industry classifications in 47 prefectures, which are comprehensively measured from 1970 to 2012.

JIP) database. One of the difficulties in compiling regional KLEMS database is how to handle possible variation in the levels of service prices across different regions.[3] Japan is not a geographically large country, and the prices of many easily-transported goods can converge among regions by arbitrage transactions. However, many service prices do not hold the same property because they are produced and consumed at the same time in the same place.

How we handle the possibility of variation in prices of the same product across different regions is more important due to the one of the distinguishing features of the R-JIP database. Faithful to the KLEMS spirit, the databese takes accont of regional differences in labour input composition and their wage levels and measures differences in quality of labour input among regions.[4] Because of this feature of the database, if we ignore differences in output prices among regions, we may obtain biased measurement of productivity differentials that cannot be ignored, particularly for service industries. Tokui *et al.* (2013) and Fukao *et al.* (2015) analyze productivity difference among Japanese prefectures in the manner of Caves, Christensen and Diewert (1982), but these analyses are potentially susceptible to such biases.

In order to cope with this problem, we apply the method of measuring absolute purchasing power parity (PPP), i.e. the Country-Product-Dummy (CPD) method of Rao and Timmer (2000), to the variety of service prices among prefectures to calculate price differences in service among prefectures.[5] Item-wise data of prices of services in each prefecture are available in the Retail Price Survey compiled by the Statistic Bureau of the Ministry of Internal Affairs and Communications.[6] We estimate cross-regional price-level differences in five service industries, namely construction, electricity/gas/water, real estate, transportation and communication, and other services in the private sector.

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3 United Nations *et al.* (2009) points out two main difficulties regarding regional accounts. One difficulty stems from transactions with other regions, and the other from possible variation in prices of the same product across different regions.

4 See the Appendix 4 of Fukao *et al.* (2015) for the detailed characteristics of the R-JIP database and its construction.

5 In the case of comparing productivity levels among different countries, currencies' valuations should be converted, which requires estimation of absolute purchasing power parities. See, for example, Jorgenson, Kuroda and Nishimizu (1987) who conduct such international comparison in their work to estimate differences in productivity levels between Japan and the United States. In case of the EU KLEMS project, which compares productivity levels within the Eurozone with the single currency, values are converted by absolute purchasing power parities to reflect differences in price levels within the zone.

6 We used the results of surveys conducted in the capital city of each prefecture.

Applying estimsted cross-regional price-level differences, productivity comparison among prefectures are recalculated. As a byproduct, we can obtain the cross-regional price difference index in the Törnqvist formula, by taking the difference between cross-regional TFP differences before and after reflecting regional differences in price levels. The index is used to test whether the Balassa-Samuelson effect, which holds among international economies, also holds among regional economies in Japan.[7] If we can find that high labour productivity regions tend to have higher service prices than low labour productivity regions, this relation can be called the regional version of Balassa-Samuelson effect.

In section 1, we explain how to measure regional differences in price levels of services and its results. Section 2 reports the results of our recalculated productivity analysis factoring in the measured price-level differences among regions. Section 3 reports whether the regional version of the Balassa-Samuelson effect holds, by seeing the correlation between cross-regional price difference indices and cross-regional differences in labour productivity.

Measuring Service-Price Differences across Regions

To compare productivity levels in absolute terms among different countries, one must convert prices into a common currency as they are expressed in different currencies. This problem becomes easy when arbitarage by trade is at work so that law of one price holds internationally. However, there are some goods and services that are "non-tradable," thus complicating the issue.

Likewise, in our study of different regions within the same country, although no adjustment for differences in price levels is necessary for goods whose prices can be arbitraged between regions through domestic trade, any goods that "cannot be traded" across regions even in the same country pose the same problem as in the context of the international economy. The service sector is typically known for its "simultaneous consumption and production," where, for many types of services, price arbitrage is unlikely to happen through inter-regional trade.

Hence, our task is to measure different price levels of services across regions. This can be accomplished

7 A phenomenon that poor countries tend to have cheaper domestics prices than rich countries is known as the Balassa-Samuelson effect. The original explanation of this phenomenon is offered by referring to the difference of productivity growth between traded goods and non-traded goods. In rich countries productivity growth tends to be more rapid for traded goods than for non-traded goods, leading to the rise in labour cost and the price of non-traded goods.

by simply applying a method used in international economics to measure absolute purchasing power parities. We use the CPD method à la Rao and Timmer (2000) that measures absolute purchasing power parities based on results of regression analyses of price data collected for individual items in each country.

As for prices of individual items in each region, we use the Retail Price Survey data collected by the Statistic Bureau (of the Ministry of Internal Affairs and Communications) that tracks prices of items in each prefecture over time. The Survey, as one would expect, has changed its composition over years through replacement of items. Some price data may not be necessarily available in all prefectures. Such replacement and missing data in some regions can be handled by the CPD method, which is one of this method's advantages. The Survey makes efforts to ensure consistency in the quality of covered items by specifying them in detail. Although we are rather doubtful of how much they can ensure such consistency in items of the service sector, we would not delve into this topic here.

The CPD method has the additional advantage of only needing price data of individual items, unlike the conventional method of constructing an index that requires data of each item's weight. This is accomplished by using an assumption specific to the CPD method as expressed in the following equation:

$$p_{ir} = \pi_r^* \cdot \eta_i^* \cdot v_{ir}^* \qquad (1)$$

- p_{ir}: Price of item i in prefecture r
- π_r^*: Cross-regional price-level ratio at industry classification level in the R-JIP database
- η_i^*: Relative price among items within the same industry classification in the R-JIP database
- v_{ir}^*: Random disturbance term

This means that the price of a certain item in each region, if ignoring the random disturbance term, can be expressed by a product of the cross-regional price ratio at industry classification level and the relative price of the item within that industry classification. In other words, relative prices of items within an industry classification are assumed to be the same regardless of region.

Under these assumptions, we take the logarithm of both sides of Equation (1) to obtain Equation (2) below:

$$\begin{aligned} \log p_{ir} &= \log \pi_r^* + \log \eta_i^* + \log v_{ir}^* \\ &= \pi_r + \eta_i + u_{ir} \end{aligned} \qquad (2)$$

Equation (2) can be estimated by Or-

dinary Least Squares, using an equation with the following dummy variables:

$$\begin{aligned}\log p_{ir} = {} & \pi_1 D_1 + \pi_2 D_2 + \cdots + \pi_{47} D_{47} \\ & + \eta_1 D_1^* + \eta_2 D_2^* + \cdots + \eta_n D_n^* \\ & + u_{ir} \end{aligned} \tag{3}$$

where these two kinds of dummy variables are defined as below:

- D_r: The value is 1 if p_{ri} on the left side of the equation is data for prefecture r, and equals zero otherwise.

- D_i^*: The value is 1 if p_{ri} on the left side of the equation is data for item i, and equals zero otherwise.

Since this formula will generate perfect multicollinearity among explanatory variables if left as it is, we imposed a restriction where data of the first prefecture is taken as the numeraire, i.e., $\pi_1^* = 1$ or $\pi_1 = \log \pi_1^* = 0$. Here, we decided to take Tokyo as a reference point (r = 1 for Tokyo) and measure relative price levels in all other prefectures. The value of $\widehat{\pi_r}$ thus estimated gives the cross-regional price ratio at industry classification level in the R-JIP database by using the following equation:

$$\widehat{\pi_r^*} = exp(\widehat{\pi_r}) \tag{4}$$

In our measurement of regional differences in service-price levels, we choose five industries: construction, electricity/gas/water, real estate, transportation and communication, and other private service sectors (including private non-profit sectors). In recent years, these five industries account for 40 per cent - a significantly large share - of total nominal value added in the nation.[8] The largest among them is other private service sectors, accounting for between 23 per cent (in 2000) and 29 per cent (in 2009) of value added by all industries.

Other than those five industries, the R-JIP database contains wholesale and retail, finance and insurance, and the government sector as service-sector industries. However, we excluded those three industries from our study of measuring regional differences in price levels due to conceptual

8 The share was stable at between 43 per cent and 44 per cent during the period from 2000 to 2008. It jumped to 47.5 per cent in 2009 due to the Global Financial Crisis precipitated by the collapse of Lehman Brothers, decreasing value added by manufacturing industries.

Table 1: Number of Items by Industry: 1970-2010

R-JIP industries		1970	1980	1990	2000	2010
16	Construction	15	16	17	17	19
17	Electricity/Gas/Water	13	15	24	28	27
20	Real estate	3	3	9	7	7
21	Transportation and Communication	8	8	18	35	49
22	Other private service industries	39	50	78	85	98
Total		78	92	146	172	200

Source: Statistical Bureau's Retail Price Survey.

difficulty in measuring prices.[9] But in the next section, our analysis of productivity levels output of government sector is adjusted by regional differences in price levels of other private service sectors. Consequently, we made adjustment to the productivity analysis for regional differences in price levels, covering six industries in the service sector, which account for between 50 per cent and 60 per cent of total value added by all industries.

Table 1 shows the number of items in those five industries covered in the Retail Price Surveys at intervals of ten years from 1970 to 2010. The total number of items for all of those five industries in the Survey gradually increased from 78 in 1970 to 200 in 2010.[10] Because the number of data points in a single year is not sufficient to estimate the intended regression equation, we pooled data for every five years up to a year whose last digit was zero or five (for instance, an estimating equation for 1970 used data from 1966 to 1970) and conducted regression at intervals of five years. Accordingly, the approximate number of data points used for each estimating equation is the number of items in Table 1 times 47 (prefectures) times 5 (years).[11] Since our regression uses pooled data of five years, we add year dummies to our regression equation (3) in order to control a macroeconomic shock at a specific year.

Using these data we estimate Equation (3) for five service industries at intervals of five years from 1970 to

9 The value added shares in 2009 of the three industries excluded from adjustment for regional price differences in this study are respectively 13 per cent for the wholesale and retail industries, 6 per cent for the finance and insurance industries, and 12 per cent for the government service. For the wholesale and retail industries, one possible method would be to calculate cross-regional price difference index based on regional differences in commercial margins. This method, however, requires significantly large numbers of merchandise items and data points. As such, we will address this issue in the future.

10 In construction such prices as the cost of hiring carpenters, plasterers, and installing water supply, kitchen facilities, and bath facilities are included. In electricity/gas/water such prices as various types of charges of electricity, gas and water as well as paraffin oil are include. In real estate rents of various types of housing are included. In transportation and communication fares of various types of transport (train, bus, and taxi) and various types of telephone services are included. In other private service industries prices for haircuts, laundry, house cleaning, newspapers, hospital charges, various types of private education, and various types of food services are included.

11 The actual numbers of data points used for estimation are somewhat less than these numbers because some data were missing for items that were not used in certain prefectures.

2010.[12] We can obtain quite robust estimated coefficients for each prefecture dummies. As estimated coefficients of Equation (3) are expressed in logarithmic form, we used the exponential function of Equation (4) to obtain regional relative price levels relative to Tokyo (= 1). These results are shown for the five service industries in 1970, 1990 and 2010 in Tables A1-A5 in the Appendix.[13]

Among those five industries, the real estate industry shows the largest differences in relative price levels across regions. This reflects large differences in levels of rents of various properties across regions in the itemwise data used in the estimation.[14] In the electricity, gas and water industry, regional differences narrowed during the period between 1970 and 1990 but started widening in 2010, showing fluctuations, presumably in reflection of energy price movement during this period. Similar trends are observed in the transportation and communication industry. We also believe this is due to the inclusion of the transportation industry that greatly consumes energy.

Most notable among all is other private service industries (including non-profit private services). In this industry, relative price levels in most of the prefectures had been lower than those in Tokyo from the beginning and price differentials relative to Tokyo have been growing even wider in recent years in many prefectures. To illustrate this trend, we show the case of Hokkaido in Chart 1, which shows changes in price levels in this industry relative to Tokyo every five years. The falling price relative to Tokyo occurred from 1980s through the first half of the 1990s. After that, the situation has been stable. Other private service industries (including non-profit private services), accounting for between 20 per cent and 30 per cent of value added by all industries, may also have a significant effect on the measurement of productivity, which is recalculated as described in the next section.[15]

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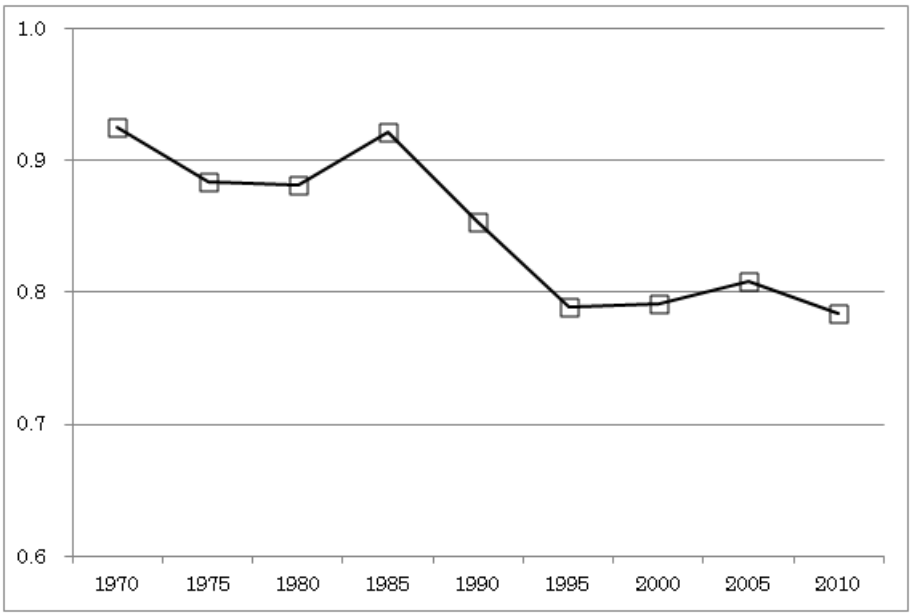
12 Estimation for 1970 uses 45 prefectural dummies because of lack of data of Okinawa prefecture, which is still under the administration of US government. Estimations for 1975 and thereafter use 46 prefectural dummies including reverted Okinawa.

13 Available at: http://www.csls.ca/ipm/36/Tokui_appendix.pdf.

14 Although regional differences in levels of rent on real estate may be divergent from those of real estate brokerage fees, their possible influence on recalculated productivity should be small because the real estate industry accounts for 2 per cent - not a large share - of value added by all industries.

15 The impact of regional price differences in the service industry (private sector and non-profit) is even greater, because they are also applied to the government service industry when we conduct productivity analysis as mentioned above.

Chart 1: Changes in Relative Price in Other Private Service Industries (including Non-profit Private Serrvices) in Hokkaido, Tokyo=1, 1970-1=2010



Source: Drawn from Table A5 (see Online Appendix).

Productivity Analysis Corrected for Regional Differences in Service-Price Levels

Using the R-JIP database, indices to compare productivity levels across prefectures have been developed and analyzed by Tokui *et al.* (2013) and Fukao *et al.* (2015). Their studies, as shown below, measured relative productivity levels of individual industries in each prefecture (hereinafter referred to as relative TFPs), by assuming a translog production function based on value added for each industry and each prefecture, and by using the method of Cave, Christensen and Diewert (1982) for constructing an index for cross-sectional productivity comparison. Adjustment for quality was made only to labour input. For capital input, industry-specific quality was taken into consideration, but regional quality differences were not.

$$RTFP_{ir} = \log\left(\frac{V_{ir}}{\overline{V_i}}\right) - \frac{1}{2}(S_{ir}^K + \overline{S}_i^K)\log\left(\frac{K_{ir}}{\overline{K}_i}\right) - \frac{1}{2}(S_{ir}^L + \overline{S}_i^L)\left[\log\left(\frac{H_{ir}}{\overline{H}_i}\right) + \log\left(\frac{Q_{ir}^L}{\overline{Q}_i^L}\right)\right] \quad (5)$$

- V_{ir}: Real value added by industry i in prefecture r
- K_{ir}: Real capital stock in industry i in prefecture r
- H_{ir}: Labour input in man-hours in industry i in prefecture r
- Q_{ir}^L: Labour quality in industry i in prefecture r

Variables with a bar on top represent the national averages (geometric means) of individual industries, which are expressed by the following equations:

- $\log \overline{V}_i = \frac{1}{47} \sum_{r=1}^{47} \log V_{ir}$
- $\log \overline{K}_i = \frac{1}{47} \sum_{r=1}^{47} \log K_{ir}$
- $\log \overline{H}_i = \frac{1}{47} \sum_{r=1}^{47} \log H_{ir}$
- $\log \overline{Q}_i^L = \frac{1}{47} \sum_{r=1}^{47} \log Q_{ir}^L$

Here, S_{ir}^K represents the cost share of capital and S_{ir}^L the cost share of labour. Those with a bar on top are the national averages (arithmetic means) of the respective shares of individual industries, which are obtained from:

- $\overline{S}_i^K = \frac{1}{47} \sum_{r=1}^{47} S_{ir}^K$
- $\overline{S}_i^L = \frac{1}{47} \sum_{r=1}^{47} S_{ir}^L$

The prefecture- and industry-specific relative TFPs are multiplied with value-added weights and aggregated over all industries with the following equations to derive the relative TFP for each prefecture. S_{ir}^V stands for the value-added weight of an industry in a particular prefecture. The symbol with a bar on top is the national average (arithmetic mean) of the industry.

$$RTFP_r = \sum_{i=1}^{23} \frac{1}{2}(S_{ir}^V + \overline{S}_i^V) RTFP_{ir} \tag{6}$$

$$\overline{S}_i^V = \frac{1}{47} \sum_{r=1}^{47} S_{ir}^V$$

Our previous analyses (Tokui *et al.* (2013) and Fukao *et al.* (2015)) utilize the R-JIP database, whose nominal value added by prefecture and industry is derived by breaking down national totals from the Japan Industrial Productivity (JIP) database by multiplying the prefectural shares caluculated from the Prefectural Accounts as well as the Census of Manufactures.[16] To obtain real value added, we apply industry-level deflators from the JIP database. Our previous analyses implicitly assumed that price-levels by industry were identical across prefectures.

In this study, we estimate differences in price levels across prefectures for each service industry as derived in Section 1. We use these estimated results to recalculate relative TFPs. To distinguish the symbol for the real

16 The JIP database is Japan's KLEMS project and covers 108 industries at the multinational level. For details of the JIP database, see Fukao *et al.* (2007) and the RIETI's website at https://www.rieti.go.jp/en/database/JIP2015/index.html. Although Japan's SNA is now based on the 2008 SNA, the Prefectural Accounts are still based on 1993 SNA. For consistency, value added and investment of the R-JIP database are also based on 1993 SNA.

value added by an industry in a prefecture that reflected regional differences in price levels of output from the previously used symbol, we expressed it by ($V_{ir}^{\#}$) with the superscript #. The cross-regional price difference for output of industry i is denoted P_{ir} (for those industries that were not subject to our adjustment for regional price differences, the index always takes the value of 1.) Then the relationship between the two can be expressed as follows:[17]

$$V_{ir}^{\#} = \frac{V_{ir}}{P_{ir}} \tag{7}$$

Since the numerator of (7) is value added, a more exact approach would be double deflation,[18] not simply deviding by the price index. But to construct deflatos consistent with double deflation we need input-output tables for each prefecture. A lack of consistent prefectural input-output tables is the main reason why we cannot use double deflation. In this article we restrict the application of regional price-level adjustment to service sectors, in which the ratio of intermediate inputs to the value of output is relatively low compared with non-service sectors, especially manufacturing. This provides some justification for this procedure. By letting the variables in the above equation with a bar on top denote the respective national averages (geometric means) of the industry, we obtain:

$$\log\left(\frac{V_{ir}^{\#}}{\overline{V}_i^{\#}}\right) = \log\left(\frac{V_{ir}}{\overline{V}_i}\right) - \log\left(\frac{P_{ir}}{\overline{P}_i}\right) \tag{8}$$

- $\log \overline{V}_i^{\#} = \frac{1}{47}\sum_{r=1}^{47} \log V_{ir}^{\#}$
- $\log \overline{P}_i = \frac{1}{47}\sum_{r=1}^{47} \log P_{ir}$

Relative TFPs that factor in cross-prefectural price level gaps can be computed by replacing real value added in Equation (5) with the newly calculated $V_{ir}^{\#}$, which gives us the following equation.

17 P_{ir} in the denominator of (7), which is in capital letters, is the cross-regional price ratio derived by CPD method, while p_{ir} in (1), which is in small letters, is price row of individual service items.

18 The EU-KLEMS project produces output PPPs, intermediate input PPPs, labour input PPPs, and capital input PPPs to convert the corresponding nominal values into real values. See Inklaar and Timmer (2008) to know the method used in the EU KLEMS project. Our R-JIP database has already dealt with labour input PPPs, as labour input values are obtained while taking into account regional differences in the compositions of worker attributes and wages. The database, however, does not factor in capital input PPPs on the assumption that there is no regional difference in capital cost in each industry. Also, instead of implementing double deflation by calculating output PPPs and intermediate input PPPs as EU KLEMS do, which is a more exact approach, we settle with a simplified method in which we derive regional price differences in each industry as the equivalent of output PPPs and apply them to value added in a single deflation approach, as our study is limited to the service sector. If we could use input-output table by prefecture compiled under the same standard, we would be able to obtain value added PPPs in a manner consistent with the R-JIP database with output PPPs and intermediate input PPPs. This is an issue to be addressed in future.

$$RTFP_{ir}^{\#} = \log\left(\frac{V_{ir}^{\#}}{\overline{V}_{i}^{\#}}\right) - \frac{1}{2}\left(S_{ir}^{K} + \overline{S}_{ir}^{K}\right)\log\left(\frac{K_{ir}}{\overline{K}_{i}}\right) - \frac{1}{2}\left(S_{ir}^{L} + \overline{S}_{i}^{L}\right)\left[\log\left(\frac{H_{ir}}{\overline{H}_{i}}\right) + \log\left(\frac{Q_{ir}^{L}}{\overline{Q}_{i}^{L}}\right)\right] \quad (9)$$

Comparing this equation and the original Equation (5) and considering the relationship expressed in Equation (8), we found the following relationship between the newly calculated and previously calculated TFPs.

$$RTFP_{ir}^{\#} = RFTP_{ir} - \log\left(\frac{P_{ir}}{\overline{P}_{i}}\right) \quad (10)$$

The prefecture- and industry-specific relative TFPs obtained above can be aggregated over all industries in the way we do with Equation (6) so that we can compare levels of prefectural productivity, as with the following equation:

$$RTFP_{r}^{\#} = \sum_{i=1}^{23}(S_{ir}^{V} + \overline{S}_{i}^{V})RTFP_{ir}^{\#} \quad (11)$$

Substitution of Equation (10) into this equation produces Equation (12), which reveals that the difference between the newly calculated and previously calculated prefectural relative TFPs can generate a value that represents cross-prefectural price-gap index values for output for individual industries aggregated over all industries with the Törnqvist Index.

$$RTFP_{r}^{\#} = RFTP_{r} - \sum_{i=1}^{23}(S_{ir}^{V} + \overline{S}_{i}^{V})\log\left(\frac{P_{ir}}{\overline{P}_{i}}\right) \quad (12)$$

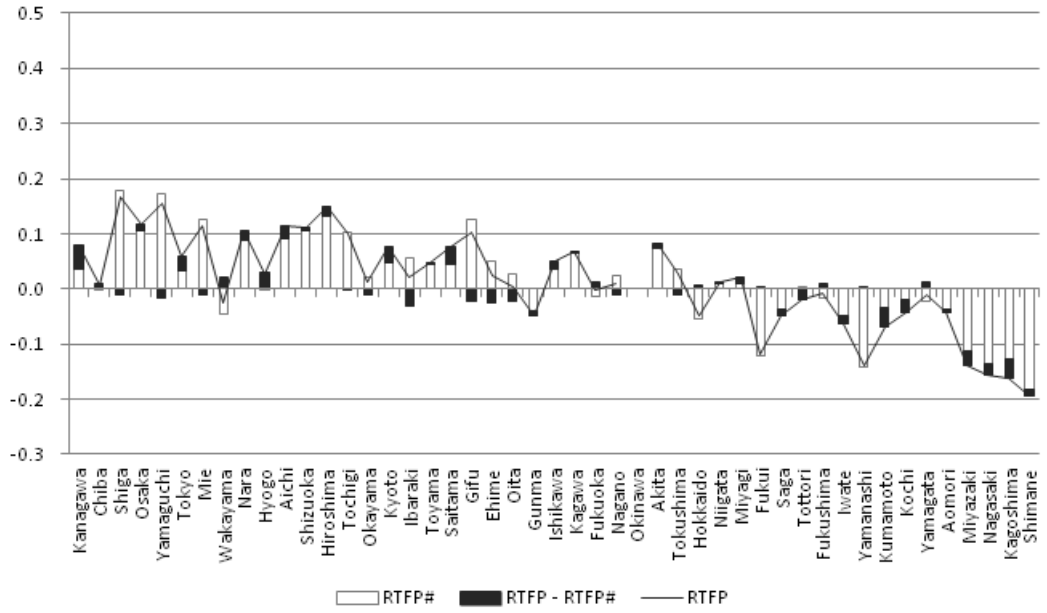
Now, let us look at the result of the calculated relative TFPs that reflect differences in price levels among prefectures.[19] Chart 2 shows calculated results for 1970 and 2009 respectively. Lines on the charts are relative TFPs previously calculated before price adjustment. The white bar graphs show newly calculated relative TFPs. The black portions of bars show the magnitude of corrections made by adjusting for relative price levels in the service sector. In prefectures where relative price levels in service industries are high, their relative TFPs that have been inflated without such adjustment decrease and in prefectures with lower service-price levels, adjustment goes in the opposite direction.

In each chart, the horizontal axis represente prefectures, which are sorted in the decending order of labour productivity from left side

19 Here, the relative TFP is recalculated based on the R-JIP Database 2014 covering the data period between 1970 and 2009.

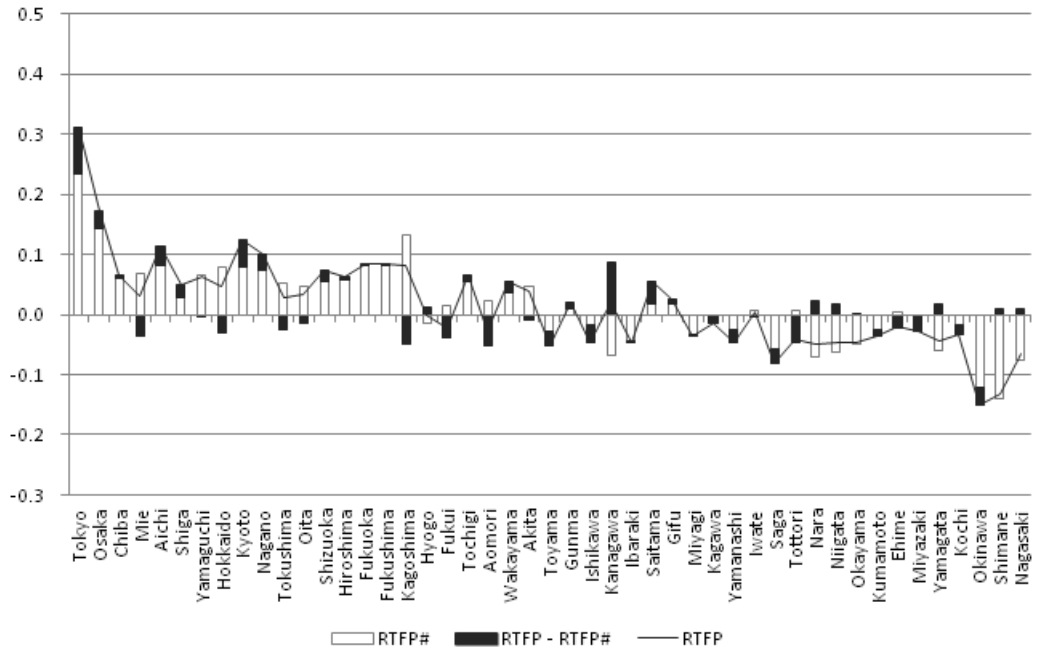
Chart 2: Relative TFPs Reflecting Differences in Price Levels among Prefectures, 1970 and 2009

(a) 1970



The horizontal axis represents prefectures, which are arrenged in order of labour productivity. Prefectures with higher labour producitivity are placed on the left side. See Chart 3: Panel A.

(b) 2009



The horizontal axis represents prefectures, which are arrenged in order of labour productivity. Prefectures with higher labour producitivity are placed on the left side. See Chart 3: Panel B.
Source: Authors' calculations based on Statistical Bureau's Retail Price Survey and R-JIP database.

to right side. By taking account of regional price differences, TFP tends to be revised downward in high labour productivity prefectures and TFP tends to be revised upward in low labour productivity prefectures. In other words, service price-levels are high in high labour productivity prefectures and low in low labour productivity prefectures. While on regional-version of Balassa-Samuelson effect we discuss more in detail in the next section, this tendency revealed in Chart 2 is additional evidence that we can observe something like the Balassa-Samuelson effect across domestic regions.

Comparison between Chart 2: Panel A for 1970 and Chart 2: Panel B for 2009 shows that incorporation of regional differences in price levels of services produces greater impact on regional differences in relative TFPs in 2009. This is for two reasons mentioned in the previous section. First, the value-added weight of service industries in all industries become larger in 2009. Second, in other privte service industries (including non-profit private services), which has a large weight, regional price differences become wider.

It is hard to tell whether the degree of differences in relative TFPs across prefectures narrowed or widened on the whole only by looking at Chart 2 after making the corrections. Hence, we calculate standard deviations that show degrees of dispersion of the newly calculated and the previously calculated relative TFPs across prefectures and compare them at 10-year intervals as shown in Table 2. The result shows that, in all years, the values for relative TFPs that reflect prefectural price-level differences are smaller than those without reflecting such price-differentials. This means that the measures of cross-regional productivity gaps have been somewhat exaggerated by not considering regional price-level differentials in the service sector. Differences between the two is larger in and after 1990. For instance, our result shows that for 1970, the standard deviation of cross-regional TFP difference index values decreases by around 7 per cent from 0.089 per cent to 0.083 per cent, while for 2009, the standard deviation of the index decreases by around 13 per cent, going from 0.079 to 0.069.

Let us conclude this section by looking at how cross-prefectural differences in labour productivity are decomposed (into capital-labour ratio, labour quality, and relative TFP) based on our results of newly calculated relative TFPs obtained by reflecting regional differences in service-price levels. Chart 3 illustrates the results of the decomposition for 1970 and 2009. Forty years ago, regional differences in capital-labour ra-

Table 2: Comparison of Standard Seviations of Two Regional TFP Indexes for Japanese Prefectures

	1970	1980	1990	2000	2008	2009
Old regional TFP	0.089	0.074	0.080	0.069	0.084	0.079
New regional TFP	0.083	0.070	0.065	0.055	0.072	0.069

Source: Authors' calculations.

tios (bars in black) played a major role in regional differences in labour productivity. Their influence has gradually decreased in recent years to be replaced by regional differences in relative TFPs (bars in white), which plays a significant role. This is the same results found by Tokui *et al.* (2013), Fukao *et al.* (2015), and others.

To put it another way, although factoring into regional differences in service price levels has an effect of moderately correcting overestimation of cross-regional differences in relative TFPs, the effect is not significant enough to reverse the conclusion that regional gaps in relative TFPs have become an important factor in explaining regional differences in labour productivity in recent years.[20]

Regional Differences in Service-Price Levels and the Balassa-Samuelson Effect

Our results, so far, showed not only that regional differences in productivity still exist even within Japan, but also that regional differences in price levels are observed in the service sector. This led us to the question of whether such regional differences in price levels observed within Japan are consistent with the Balassa-Samuelson effect, which is well-known in international economics.[21] Balassa (1964) and Samuelson (1964) explained why absolute purchasing power parities across countries do not converge to one even in the long-run because of differences in productivity between the tradable and non-tradable goods sectors. The Balassa-Samuelson effect explains why domestic prices tend to be high in developed countries than in developing countries.

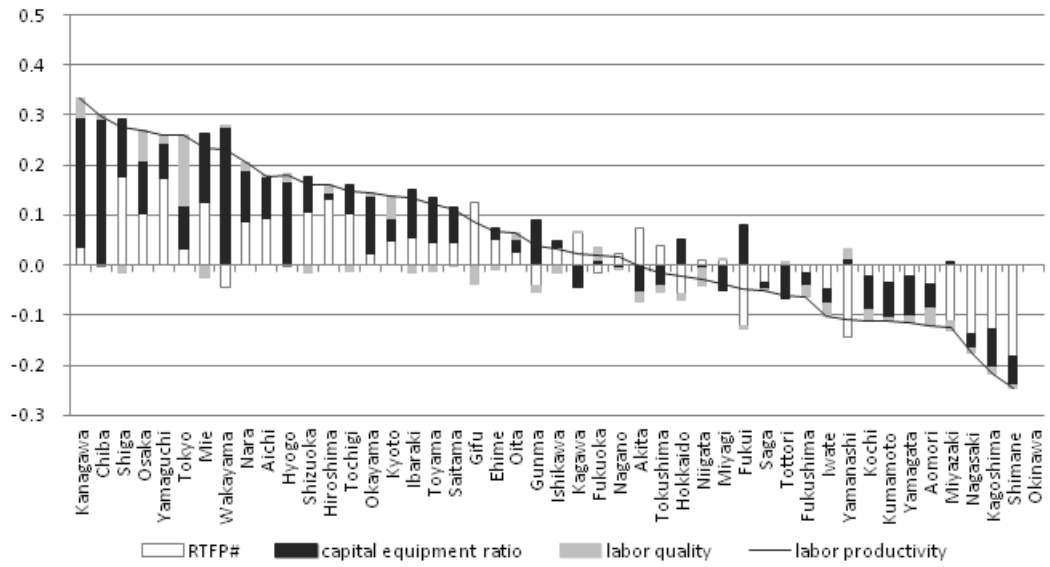
If the comparison between developed and developing countries corresponds to, within a country, dif-

20 Tokui *et al.* (2013) and Fukao *et al.* (2015) conduct more detailed analyses and conclud that many of the differences in relative TFPs, the major source of regional differences in labour productivity still remaining in recent years, are caused by regional differences in the service sector. It is important that this study has confirmed the importance of regional differences in relative TFPs, even after factoring in regional price differences in the service industry.

21 We defines the "Balassa-Samuelson (BS) effect" as the phenomenon that prices of services (non-tradable goods) are higher in relatively rich countries and lower in relatively poor countries. As a mechanism behind such phenomenon observed, they focused on differences in productivity levels between traded and non-traded goods. This article, however, does not include discussion of such underlying mechanism.

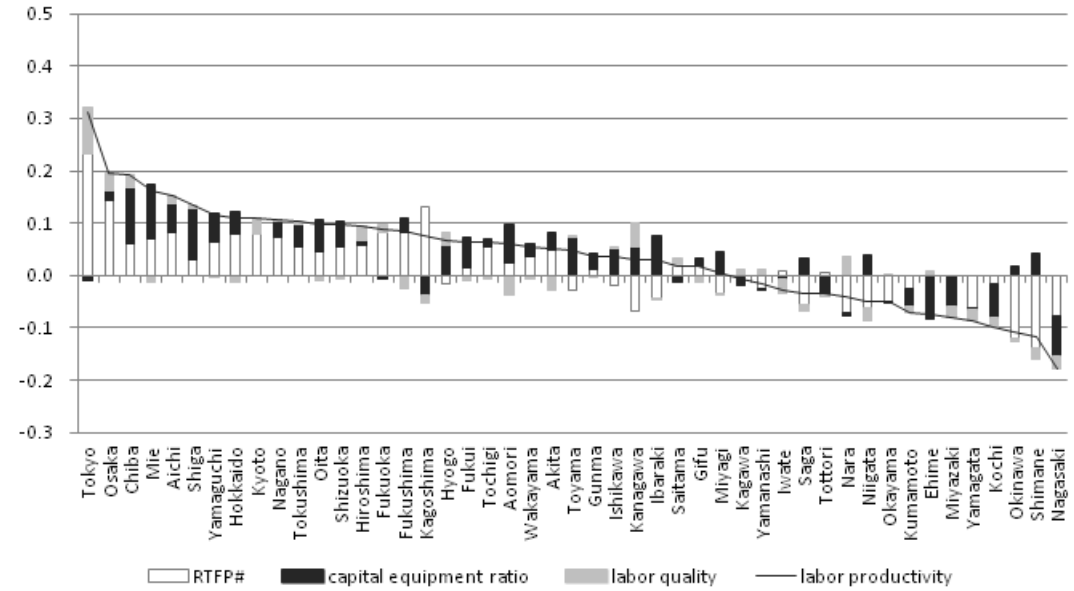
Chart 3: Decomposition of Differences in Regional Labour Productivity, 1970 and 2009

(a) 1970



The horizontal axis represents prefectures, which are arrenged in order of labour productivity. Prefectures with higher labour producitivity are placed on the left side.

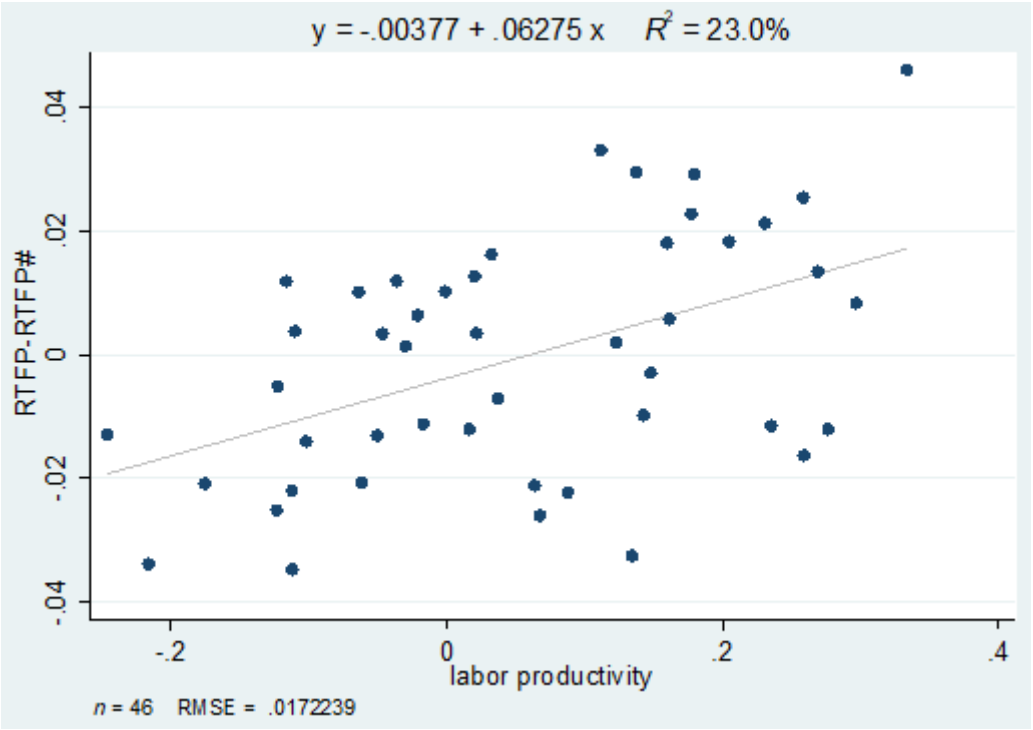
(b) 2009



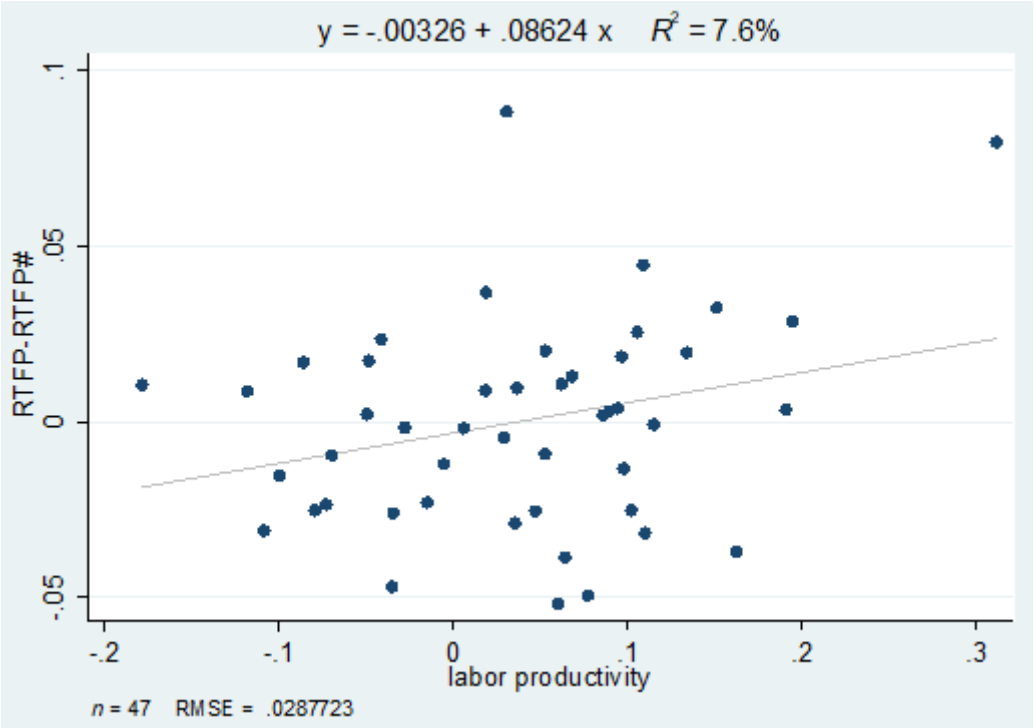
The horizontal axis represents prefectures, which are arrenged in order of labour productivity. Prefectures with higher labour producitivity are placed on the left side.
Source: Authors' calculations.

Chart 4: Correlation between Regional Differences in Price Levels and Differences in Labour Productivity, 1970 and 2009

(a) 1970



(b) 2009



Source: Drawn based on authors' calculations.

Table 3: Correlation Coefficients between Regional Differences in Price Levels and Differences in Labour Productivity and Their Significance Level from 1970 through 2009

	1970	1980	1990	2000	2008	2009
Correlation coef.	0.480	0.371	0.612	0.332	0.322	0.276
Significance level	0.001	0.010	0	0.023	0.028	0.06

Source: Authors' calculations.

ferences between regions with high and low labour productivity, we would expect that in regions with high labour productivity relative price levels should be higher due to higher prices of non-tradable services. As we can obtain cross-regional price difference indices by using Equation (12) as explained in the previous section, we can look at the correlation between these values and levels of regional labour productivity to test whether the domestic version of the Balassa-Samuelson effect holds.

Our cross-regional price difference index, which appears in the second term of equation (12), depends by its construction not only on price differences of each industry but also their value-added share in each region. But we take into calculation only regional price-level differences in service industries and assume that there are no price-level differences in non-service industries by arbitrage transactions among regions.

Chart 4 is a scatter plot diagram to analyze correlation between cross-regional price difference indices and differences in labour productivity at prefecture level for 1970 and 2009. The chart shows a regression line where the cross-regional price difference index is regressed on the labour productivity difference. These scatter plots indicate weak positive correlation between the two. Table 3 summarises these scatter plots in correlation coefficients between the two variables and their level of significance. With the exception of 2009, in nearly all years in the table, the correlation coefficient is significant at the 1 per cent or 5 per cent level.[22] We can conjecture that in regions with high labour productivity levels, wages become relatively higher in excess of productivity differences in the service sector, which raises relative price levels of services in these regions.

22 We observe much higher correlation between cross-regional price difference and labour productivity in 1990. 1990 is one of the years of the "bubble economy" in Japan, in which service industries boomed especially in megalopolis regions. Theses regions are places with high labour productivity, which experienced economic boom causing higher service prices in those years. It is the background of unusuary high correlation in that particular year.

Conclusion

The objective of this study has been to correct the shortcoming of the R-JIP database, which has been published without reflecting regional differences in price levels in service industries, even though service industries are thought to have gained importance in cross-regional productivity analysis. Based on the R-JIP database, earlier studies conclude that, as the underlying factors to explain regional differences in labour productivity in Japan in recent years, differences in productivity levels within an industry, as measured by relative TFPs, came to play a more important role, and among industries, differences in relative TFPs in service industries were becoming more important.

To estimate cross-regional relative price levels, we use item-wise price data compiled by the Retail Price Survey, and we apply the CPD method that is developed to measure absolute purchasing power parities. The results are then incorporated into our productivity analysis to make recalculation.

Our study finds out that although factoring in regional differences in service price levels has an effect of moderately correcting overestimation of regional differences in relative TFPs, an effect is not large enough to change the conclusion that cross-regional differences in relative TFPs have become an important factor in explaining the regional differences in labour productivity in recent years. Furthermore, we test an intra-national version of the Balassa-Samuelson effect by calculating the correlation between the cross-regional price difference index values, a byproduct of our productivity analysis, and regional differences in labour productivity. We find that relationships indicative of the Balassa-Samuelson effect can be observed among Japanese regions.

The issue of regional price-level differences in service industries discussed in this study, while not going so far as to significantly correct the previous studies on decomposition of regional differences in labour productivity, is likely to gain more importance because the share of service industries in the total value added of all industries has been expanding and because regional price-level gaps have widened in other private service industries. This suggests that, in cross-regional productivity analysis, it is necessary to carefully handle regional price-level differences arising from service industries' salient feature of simultaneous consumption and production.

We conclude by highlighting two major issues that could not be addressed in this study. First, we did

not adjust for regional price-level differences in the wholesale and retail industry due to unavailability of appropriate item-wise data that would fit the method used in this study. However, the wholesale and retail industry, accounting for more than 10 per cent of total value added, might affect our result. Therefore, we need to devise ways to include it in our adjustment for regional price-level differences by imposing some assumption, such as an assumption that regional price-level differences for merchandise are refleted in regional price-level differences in commercial margins. Second is the issue of the deflation of value added given that output is measured by value added in the R-JIP database. In principle, it is preferable to adopt double deflation. That, however, requires input-output tables by region, indicating the needs to refine and expand our database.

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