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Regional Factor Inputs and Convergence in Japan: A macro-level analysis, 1955-2008*

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Abstract

Using the Regional-Level Japan Industrial Productivity (R-JIP) Database, which provides data on aggregate industry value added and production factor inputs by prefecture for 1955-2008, we examined the reasons for the decline in prefectural economic inequality from the supply side. In addition, we focused on the role of capital accumulation and changes in total factor productivity (TFP) in economic convergence. We examined how the relatively rapid capital accumulation in low-income prefectures was financed and what brought about the decline in differences in TFP. The main findings of the analysis are as follows.

1) In 1955, the most important reason for prefectural labor productivity differences was differences in TFP, followed by differences in capital-labor ratios and then by differences in labor quality. Differences in capital-labor ratios and TFP declined substantially between 1955 and 2008, leading to a dramatic reduction in prefectural labor productivity differences. On the other hand, depending on the period, prefectural differences in labor quality either did not contribute to the contraction in labor productivity differences or in fact worked in the direction of increasing such differences.

2) During the high-speed growth era from 1955-1970, the main factor underlying the decline in prefectural labor productivity differences was the decline in TFP differences. On the other hand, from 1970 onward, Japan experienced a strong decline in regional differences in inputs, so that the contribution of variation in inputs to variation in output steadily dropped after 1970.

3) Migration from poorer to richer prefectures and the decline in prefectural TFP differences from 1955 to 2008 consistently contributed to the decline in per capita gross prefectural product (GPP) differences, although the contribution of the decline in prefectural TFP differences to β-convergence—for the period as a whole—was more than twice as large as the contribution of migration. On the other hand, capital accumulation actually worked in the direction of increasing prefectural inequality in the period 1955-1970, but from 1970 onward, it consistently operated in the direction of reducing inequality.

4) The accumulation of social capital, measured in relation to working hours, in post-war Japan, was concentrated in prefectures with lower per capita GPP. Given that the accumulation of social capital likely raises the efficiency of economic activity and hence has a positive effect on TFP, the emphasis on improving social infrastructure in poorer rural areas very likely contributed to the decline in prefectural TFP differences. Meanwhile, the expansion of firms with high labor productivity into rural areas and technology transfers to technologically lagging prefectures through intra-firm technology diffusion, as well as the growing agglomeration of industry in rural areas through the expansion of manufacturing in rural areas, also likely contributed greatly to the decrease in prefectural TFP differences.

Keywords: Regional factor inputs, Convergence, R-JIP, TFP, Prefectural labor productivity differences

JEL classification: D24, J61, R11, R53

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1. Introduction

As seen in Fukao et al. (2015), Japan experienced a decline in prefectural inequality in income and labor productivity from the end of the 19th century onward. The aim of this paper is to more closely examine this trend focusing on the post-war period, for which it is possible to obtain prefecture-level estimates of capital stock and labor quality. Such data allow us to analyze in detail the decline in differences in labor productivity from the supply-side. Specifically, we examine the 53-year period stretching from 1955, the first year for which the *Prefectural Accounts* are available, to 2008, the most recent year for which data on prefectural capital stock are currently available.[1] It should be noted that the data that we use here are for prefectures as a whole; that is, for the total of all industries. However, for the period from 1970 onward, it is possible to estimate labor productivity and total factor productivity disaggregated into 23 industries. An even more detailed analysis of economic convergence using these data by industry for the shorter period from 1970 to 2008 is provided in Tokui, Makino, and Fukao (2015).

Let us start by providing a simple explanation of the analytical framework employed in this paper. Assuming a neoclassical production function with constant returns to scale, labor productivity in prefecture r, denoted by V_r/H_r (real value added per man-hour), depends on the capital stock per man-hour in that prefecture, Z_r/H_r (which we will refer to as the capital–labor ratio),[2] on labor quality, $Q^L{}_r$, and on total factor productivity (TFP), A_r:

$$\frac{V_r}{H_r} = F\left(\frac{Z_r}{H_r}, Q^L{}_r, A_r\right). \tag{1}$$

As argued in Fukao et al. (2015), if prefectural differences in capital input and TFP remain unchanged, the movement of labor from prefectures with high labor productivity to prefectures with low labor productivity reduces prefectural differences in labor productivity, and Fukao et al.

[1] The research of this paper was conducted as part of a project, "Regional-Level Japan Industrial Productivity Database: Database Refinement and Its Analysis," at the Research Institute of Economy, Trade and Industry (RIETI).

[2] In this context, it should be noted that there is considerable heterogeneity in capital assets. Some capital assets have relatively high user costs (unit costs for the use of a capital asset for one period), because they depreciate rapidly and prices fall due to technical progress (information and communications equipment is an example), while other capital assets (such as structures) have comparatively low user costs due to low rates of depreciation. The fact that firms use both types of capital assets in production means that the higher the user cost of a capital asset, the higher the marginal product (capital service) of that capital asset is likely to be. Given these considerations, it has become common in growth accounting analyses to take differences in user costs across capital assets into account and estimate the capital service input. Unfortunately, however, because the necessary data are not available, we have been unable to prepare prefectural capital stock data by type of capital assets, so that in this paper we measure capital service input using the total value of real capital stock.

(2015) examined the role of the movement of labor over the extremely long period from 1874 to 2008. However, as equation (1) shows, differences in labor productivity across prefectures also depend on the capital–labor ratio as well as TFP and labor quality, something that we could not take into account in Chapter 4 of Fukao et al. (2015) due to the lack of necessary data. Against this background, the purpose of this paper, focusing on the period from 1955, is to estimate prefectural capital input, labor quality, and TFP and to examine how differences in these affected prefectural differences in labor productivity.[3] A detailed description of how these data are estimated is provided in Appendix 3 of Fukao et al. (2015).

The remainder of this paper is organized as follows. In the next section, we decompose prefectural differences in labor productivity from a cross-sectional perspective for the first and the last year of our observation period (1955 and 2008) into differences in the capital–labor ratio, differences in labor quality, and differences in TFP. This kind of analysis is called level accounting and has been used in numerous studies, including Hall and Jones (1999), Easterly and Levine (2001), and Inklaar and Timmer (2008), for the comparison of labor productivity differences across countries. These studies indicate that the main reason for differences in labor productivity across countries is differences in TFP. What is more, the finding that the largest part of labor productivity differences across countries is due to TFP differences applies not only to differences between developed and developing countries, but also to differences among advanced countries. For instance, using Inklaar and Timmer's (2008) data, Fukao (2012) compared (price-adjusted) labor productivity in the European Union (using the average of the EU15), Japan, and the United States in 2005 using the United States as the reference point. He found that labor productivity in the EU15 was 25% lower and in Japan 42% lower than in the United States, with TFP accounting for 14 and 44 percentage points respectively. Although one would expect TFP differences across regions within a particular country to be smaller than across countries, differences in capital–labor ratios are also likely to be smaller. Thus, a priori there is no reason to expect one or the other to make a larger contribution to regional labor productivity differences. We examine this issue in the next section. Moreover, we examine what the reasons for the observed decline in labor productivity differences between 1955 and 2008 are.

Section 3, using growth accounting, then examines the mechanisms that brought about the decline in regional inequality during the post-war period. There are a large number of empirical

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[3] In this context, it should be noted that as a result of the expansion of major metropolises such as Tokyo and Osaka during the postwar period, commuting from surrounding prefectures such as Saitama and Nara increased. Given that the GPP data in the *National Accounts* are for output within each prefecture, this means that when examining equation (1), it is necessary to measure labor input not on a residence basis but on the basis of where people work. In the analysis in this and the next chapter, our data are adjusted to take this into account.

studies focusing on economic convergence during the postwar period, ranging from Barro and Sala-i-Martin (1991), who initiated this kind of study, to more recent studies, such as Montresor, Pecci, and Pontarollo (2012) on regional labor productivity differences within the EU. Studies on regional convergence in Japan include those by Barro and Sala-i-Martin (1992b) and Shioji (2001), but although these produce interesting results, they do not estimate prefectural capital stocks and therefore treat convergence as a "black box" – that is, they have little to say about the mechanisms underlying convergence. Against this background, Section 3 seeks to quantitatively examine the mechanisms driving convergence. Our results indicate that the reduction in regional differences in both TFP and capital–labor ratios played a substantial role.

The capital–labor ratio in a particular prefecture increases if either labor moves out of the prefecture or capital accumulation continues. In Chapter 4 of Fukao et al. (2015), we examined the impact of the movement of labor through internal migration on prefectural income inequality. Comparing top and bottom income prefectures in terms of per capita GPP, we found that migration from poorer to richer prefectures more or less consistently contributed to a reduction in prefectural income inequality from the start of the Meiji era until the present. Moreover, we found that from 1970 onward, capital stock in poorer prefectures grew at a faster rate than in richer prefectures and this further contributed to the reduction in prefectural income inequality. Finally, we found that for the post-war period, for which data are available, no brain drain – that is, that it is in particular well-educated workers that tended to migrate from poorer to richer prefectures – could be observed.

Taking advantage of the wider range of prefectural data available for the post-war period, Section 4 examines the role of factor movements in greater detail, thus complementing the analysis in Chapter 4 of Fukao et al. (2015). Specifically, by looking at the relationship between per capita GPP at the start of the period and the subsequent average capital stock and TFP growth, we examine how capital accumulation and TFP growth contributed to the decline in per capita GPP differences between 1955 and 2008. Next, we examine whether prefectures with higher rates of growth in capital stock have higher saving rates or whether, alternatively, they registered capital inflows. Finally, we examine what caused the decrease in prefectural TFP growth differences. Section 5 summarizes and discusses the results obtained in this paper.

2. Sources of prefectural differences in labor productivity: Cross-section analysis

In this section, we examine the causes of prefectural differences in labor productivity. Following Caves, Christensen, and Diewert (1982) and Tokui, Makino, Fukao, et al. (2013), we decompose cross-section prefectural differences in labor productivity into differences in the capital–labor ratio, differences in labor quality, and differences in TFP. To some extent, the analysis shares similarities with that of Tokui, Makino, Fukao, et al. (2013), who conduct a similar exercise using the Regional-Level Japan Industrial Productivity (R-JIP) Database, which provides data on economic activity and factor inputs for each prefecture broken down into 23 industries for the period 1970–2008. However, our aim here is to focus on the entire post-war period from 1955 onward, which means that we have prefectural capital stock and other data only at the aggregate level, that is, for the total of all industries. That being said, in Tokui, Makino, and Fukao (2015), we use disaggregated industry data from the R-JIP Database from 1970 onward to examine regional convergence in even more detail.

Let us start by explaining our decomposition approach. Prefectures are indexed by r (=1, 2, …, 47). Since Okinawa was returned to Japan by United States only in 1972, we use data for 46 prefectures until then. Prefecture r's nominal value added is denoted by V_r, real capital stock by Z_r, man-hours by H_r, labor quality by $Q^L{}_r$ (obtained by dividing a labor input index by man-hours), the cost share of capital by $S^K{}_r$, and the cost share of labor by $S^L{}_r$ (=1–$S^K{}_r$). Because this is a cross-section analysis, we omit the time subscript.

The national averages of value added, real capital stock, man-hours, and labor quality are defined by the following equations:

$$\log\overline{V} = \frac{1}{47}\sum_{r=1}^{47}\log V_r\,,\quad \log\overline{Z} = \frac{1}{47}\sum_{r=1}^{47}\log Z_r\,,$$

$$\log\overline{H} = \frac{1}{47}\sum_{r=1}^{47}\log H_r\,,\quad \log\overline{Q}^L = \frac{1}{47}\sum_{r=1}^{47}\log Q_r^L\,.$$

Moreover, the national averages of the cost shares of capital and labor are defined by the following equations:

$$\overline{S}^K = \frac{1}{47}\sum_{r=1}^{47}S_r^K\,,\quad \overline{S}^L = \frac{1}{47}\sum_{r=1}^{47}S_r^L\,.$$

Prefectures' relative TFP, $RTFP_r$, is then defined as follows:

$$RTFP_r = \log\left(\frac{V_r}{\overline{\overline{V}}}\right) - \frac{1}{2}\left(S_r^K + \overline{S}^K\right)\log\left(\frac{Z_r}{\overline{\overline{Z}}}\right) - \frac{1}{2}\left(S_r^L + \overline{S}^L\right)\log\left(\frac{Q_r^L}{\overline{Q}^L}\frac{H_r}{\overline{\overline{H}}}\right). \tag{2}$$

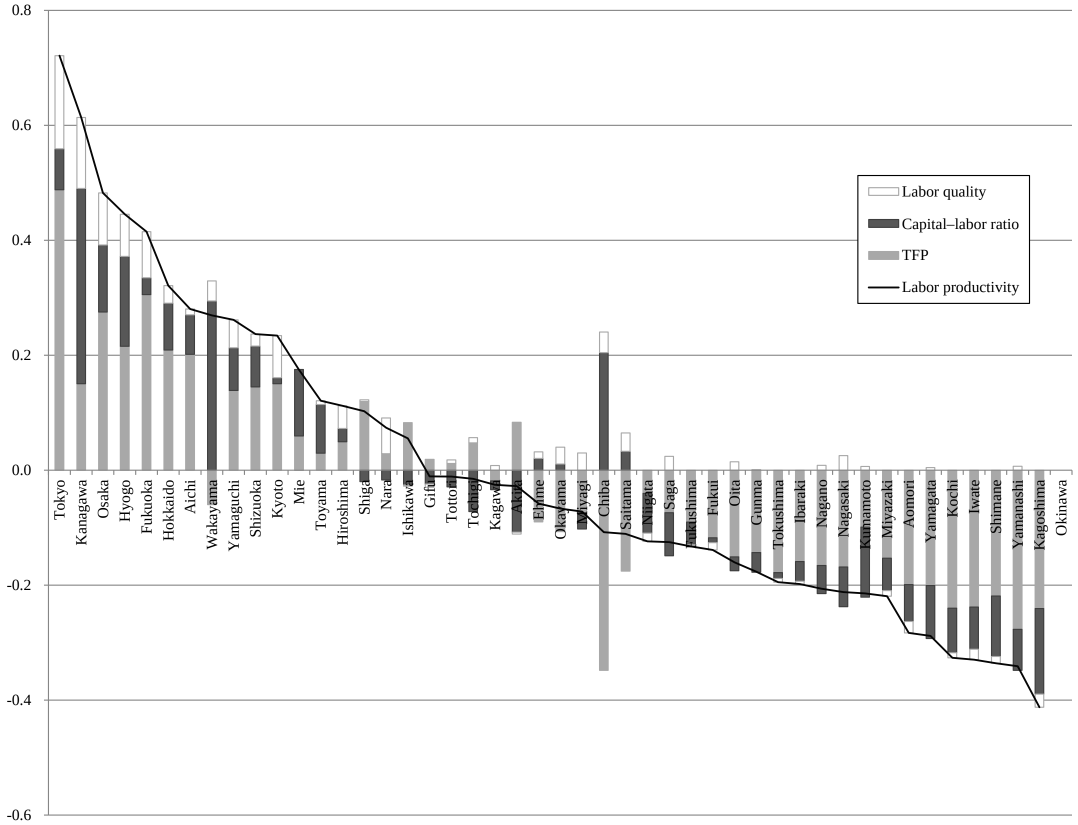
As mentioned previously, this cross-sectional definition of the relative productivity level follows Caves, Christensen, and Diewert (1982). While they do not refer to this as TFP, the two are closely related, and following the literature, we will refer to this as TFP here.

Using the fact that $S^L{}_r = 1 - S^K{}_r$, transforming the equation above we obtain the following:

$$\log\left(\frac{V_r}{\overline{\overline{V}}}\right) - \log\left(\frac{H_r}{\overline{\overline{H}}}\right) = RTFP_r + \frac{1}{2}\left(S_r^K + \overline{S}^K\right)\left\{\log\left(\frac{Z_r}{\overline{\overline{Z}}}\right) - \log\left(\frac{H_r}{\overline{\overline{H}}}\right)\right\} + \frac{1}{2}\left(S_r^L + \overline{S}^L\right)\log\left(\frac{Q_r^L}{\overline{Q}^L}\right). \tag{3}$$

Equation (3) shows that the divergence of each prefecture's labor productivity from the national average can be decomposed into the part caused by differences in TFP, that caused by differences in the capital–labor ratio, and that caused by differences in labor quality. The results of employing this kind of level accounting using equation (3) for 1955, the starting point of our data, are shown in Figure 1.

Figure 1. Causes of prefectural differences in labor productivity in 1955 (log)



The level accounting analysis for 1955 suggests the following. The prefecture with the highest labor productivity in 1955 was Tokyo, whose labor productivity was 72.1% above the national average. On the other hand, the prefecture with the lowest labor productivity was Kagoshima, with a level 41.2% below the national average, so that the difference between the two amounted to about 113 percentage points. Most of this gap was due to the difference in TFP between the two prefectures: while Tokyo's TFP was 48.8% above the national average, that of Kagoshima was 24.1% below the national average, for a difference of about 73 percentage points. In other words, TFP accounted for almost two thirds (73/113=0.646) of the difference in labor productivity between the top and the bottom prefecture.

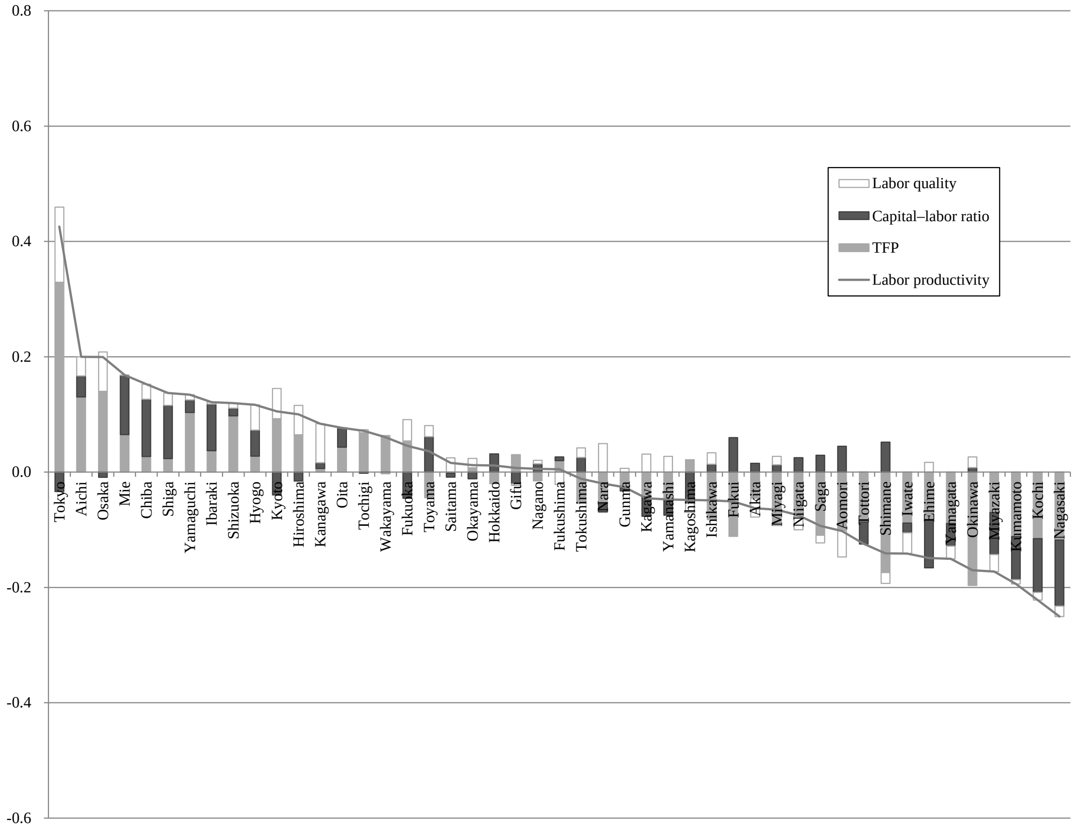
Further, in most prefectures, TFP accounted for most of the divergence of labor productivity from the national average, although there are some notable exceptions (Kanagawa, Wakayama, and Chiba). This means that the contribution of differences in the capital–labor ratio was smaller than that of differences in TFP. However, a notable pattern that emerges is that, generally speaking, in prefectures with above-average labor productivity the capital–labor ratio made a positive contribution and in prefectures with below-average labor productivity it made a negative contribution to the labor productivity gap vis-à-vis the national average, although there are again some exceptions such as Chiba.

Finally, differences in labor quality made a much smaller contribution to labor productivity differences than TFP or capital–labor ratios. In addition, although there is a tendency for labor quality to be higher in prefectures comprising a large city, for other prefectures it is difficult to discern a clear pattern in the contribution of labor quality.

Summing up, in 1955, differences in TFP, capital–labor ratios, and labor quality all contributed to differences in labor productivity and together gave rise to large prefectural differences in labor productivity. Further, differences in TFP made the largest contribution to labor productivity differences, followed by differences in capital–labor ratios. On the other hand, the contribution of labor quality differences was rather small.

Next, Figure 2 shows the results of level accounting for 2008, the last year in our dataset. The labor productivity difference in 2008 between the top prefecture (Tokyo, 42.6%) and the bottom prefecture (Nagasaki, -25.1%) is 68 percentage points, which is considerably smaller than that in 1955. The main reason for this decline is the decline in the differences in TFP. Although labor productivity still tends to be higher in prefectures with high TFP, the difference in TFP between the top and the bottom prefecture had shrunk considerably: Tokyo's TFP was only 32.9% above the national average, while Nagasaki's was only 11.8% below the national average, so that the gap was about 45 percentage points. In other words, both the gap in labor productivity overall and in TFP had fallen by about two fifths.

Figure 2. Causes of prefectural differences in labor productivity in 2008 (log)



Regarding the contribution of differences in the capital–labor ratio, the situation in 2008 was very different from that in 1955. Specifically, in many prefectures with above-average labor productivity, including Tokyo and Osaka, the contribution of the capital–labor ratio to relative labor productivity is actually negative, while among the 23 prefectures with below-average labor productivity, the contribution is positive in 10 prefectures (Tokushima, Ishikawa, Fukui, Akita, Miyagi, Niigata, Saga, Aomori, Shimane, and Okinawa). In other words, unlike in 1955, there no longer is a clear relationship between differences in the capital–labor ratio and differences in labor productivity. Finally, like in 1955, the contribution of differences in labor quality was not very large.

Next, in order to examine in more detail how differences in TFP, capital–labor ratios, and labor quality contributed to prefectural differences in labor productivity, we calculate the covariance between the three terms on the right-hand side of equation (3) and the log of prefectural relative labor productivity (i.e., the left-hand side of equation (3)) for certain years during our observation period. This allows us to decompose the dispersion of the log of prefectural relative labor productivity (the square root of which approximately corresponds to the coefficient of variation of prefectural differences in labor productivity) into the sum of the covariances between the log of prefectural relative labor productivity and the supply-side determinants of prefectural labor productivity differences. The results are shown in Table 1.

Table 1. Factor decomposition of the dispersion in the log of prefectural relative labor productivity

	1955	1970	1990	2008
Dispersion of labor productivity differences	0.070	0.050	0.025	0.017
Contribution of TFP differences	0.042	0.025	0.014	0.011
Contribution of differences in capital–labor ratio	0.019	0.018	0.006	0.003
Contribution of differences in labor quality	0.008	0.007	0.004	0.003

The factor decomposition of the dispersion of labor productivity yields similar results as Figures 1 and 2 regarding the mechanism underlying the reduction in prefectural labor productivity differences. That is, regardless of the year, TFP differences made the largest contribution to differences in labor productivity, followed by differences in the capital–labor ratio, and then differences in labor quality, whose contribution has been small throughout. Moreover, differences in these three factors decreased over time, so that prefectural differences in labor productivity steadily declined.

However, looking at the changes over the 15–20 year intervals shown here, the main factor responsible for the reduction in labor productivity differences varies depending on the period in question. During the high-speed growth era from 1955 to 1970, the driving force of the decline in labor productivity differences was the decline in TFP differences, while differences in the capital–labor ratio and labor quality hardly declined at all. On the other hand, between 1970 and 1990, it was a decline in differences in the capital–labor ratio that made the largest contribution to the decline in labor productivity differences, although a decline in TFP differences and labor quality differences also played a role. Finally, from 1990 to 2008, differences in labor quality declined only marginally. Again it was the reduction in differences in TFP and the capital–labor ratio that made the largest contribution to falling labor productivity differences, but the extent of that reduction was much smaller than in 1970–1990.

Let us consider the reasons for the trends observed here. In the case of the decline in differences in the capital–labor ratio, this seems to be relatively straightforward to explain. During the high-speed growth era from 1955–1970, manufacturing activities to a considerable degree were concentrated in metropolitan areas. However, toward the end of that period – i.e., from the late 1960s – labor shortages as well as the introduction of environmental regulations meant that firms increasingly started to set up factories in rural areas. Since manufacturing sector activities tend to be more capital-intensive than non-manufacturing sector activities, this relocation reduced differences in the capital–labor ratio. Moreover, it likely was the largest and most productive firms that relocated production to the countryside, so that advanced technology was diffused across Japan. This process therefore – at least in part – also explains the decline in TFP differences. Finally, as we shall show later, since 1955 the Japanese government has also substantially invested in social capital in rural parts of Japan. This policy likely further contributed to reducing productivity differences (on this issue, also see Fukao and Yue, 2000).

On the other hand, we are not entirely sure about the main engine of TFP convergence driving the decline in productivity differences from 1955 to 1970. As we have shown in Chapter 4 of Fukao et al. (2014), there was substantial migration from rural to urban prefectures during the high-speed growth era. Given that in the 1950s and 1960s agriculture still played a non-negligible role in the economy (as shown in Table 3.1 in Chapter 3 of Fukao et al. (2015), the output share in 1955 was 19%, falling to 6% in 1970), a possible reason therefore is that the departure of workers in rural prefectures increased the land–labor ratio in the agricultural sector in these prefectures, which in our data would be picked up as a TFP increase. Another possibility is that the TFP convergence reflects increases in social capital in lagging regions. Fukao and Yue (2000), for example, show that, during the period 1955–1973, rapid increases in social capital in rural regions contributed to the catching-up of these regions in labor productivity. It is, of course, possible, that the decline in TFP differences during this period is the result of a combination of factors, including the ones considered here as well as other, as yet unidentified, factors.

Next, let us compare our results with the results of level accounting analyses for the United States (Turner et al., 2010) and OECD countries (Caselli, 2005). In order to examine the proportion of cross-sectional variation in labor productivity accounted for by differences in physical and human capital intensity and differences in TFP, the studies employed the following framework. They assume the following production function in per-worker terms:

$$y_r = A_r y_{KHr} \, ,$$

where y_r denotes the gross value added per worker of region (or country) r, A_r denotes the TFP of r, and y_{KHr} denotes the contribution of physical and human capital per worker to labor productivity in region r. Both studies do not take differences in working hours per worker across regions (or countries) into account and assume a Cobb-Douglas production function with a capital share of one third. In this case, y_{KHr} can be expressed by $k_r^{0.333} h_r^{0.666}$, where k and h denote the physical and human capital stock per worker in region (or country) r. Taking the variance of the log value of both sides of the above equation yields the following equation to decompose the variance in (the log of) labor productivity:

$$\text{var}[\ln(y_r)] = \text{var}[\ln(A_r)] + \text{var}[\ln(y_{KHr})] + 2\times\text{covar}[\ln(A_r), \ln(y_{KHr})].$$

Turner et al. (2010) and Caselli (2005) use the ratio of the variance of inputs to the variance of output, var[ln(y_{KHr})]/ var[ln(y_r)], to measure the contribution of the variation in inputs to the variation in output.

In the case of our level accounting equation (3), the log values of y_r and y_{KHr} can be derived as follows:

$$\ln(y_r) = \ln\left(\frac{V_r}{\overline{\overline{V}}}\right) - \ln\left(\frac{H_r}{\overline{\overline{H}}}\right),$$

$$\log(y_{KHr}) = \frac{1}{2}\left(S_r^K + \overline{S}^K\right)\left\{\ln\left(\frac{Z_r}{\overline{\overline{Z}}}\right) - \ln\left(\frac{H_r}{\overline{\overline{H}}}\right)\right\} + \frac{1}{2}\left(S_r^L + \overline{S}^L\right)\ln\left(\frac{Q_r^L}{\overline{Q}^L}\right).$$

In contrast to Turner et al. (2010) and Caselli (2005), we have data on working hours at our disposal and measure both labor productivity and factor inputs per man-hour. Further, our level accounting differs from theirs in that we take regional differences in input cost shares into account.

Table 2 compares our results with those of the other two studies. Looking at the variance of labor productivity, var[ln(y_r)], across regions, the values for Japan are comparable to those for the United States from 1920 onward. Moreover, both for Japan and the United States, the values steadily declined over time (except during the period 1840–1880 in the United States) and are much smaller than the corresponding value in the cross-country comparison across OECD countries. Thus, both Japan and the United States experienced a decrease in labor productivity differences across regions, and such regional differences are considerably smaller than differences across countries of a relatively similar level of economic development, indicating that convergence mechanisms operate more smoothly across regions within countries than across countries.

Next, looking at the variance of inputs, var[ln(y_{KHr})], this remained the same in Japan from 1955 to 1970, indicating that other factors - namely, the decline in regional TFP differences – appear to have been the main engine of convergence during this period. This result is consistent with the findings of the factor decomposition shown in Table 1. However, after 1970, the variance in inputs declined and became very small even in comparison with the low level observed for the United States in 1960 and 2000. As a result of this decline, the contribution of variation in inputs to the variation in output in Japan fell after 1970 and became much smaller than in the United States and the OECD countries.

In sum, the level accounting results indicate that although differences in labor productivity across Japan's prefectures declined steadily from 1955, the main engine of that convergence changed over time. During the period 1955–1970, the main engine was convergence in TFP levels, while the degree of regional variation in input levels remained essentially unchanged. On the other hand, from 1970 onward, Japan experienced a strong convergence in regional input levels, so that the contribution of variation in inputs to variation in output steadily fell after 1970. Moreover, looking at the most recent year for which data in each of the studies are available, we find that the variance of inputs in Japan was less than half of the US value and only about 6% of the variance across OECD countries.

Table 2. Level accounting across regions and countries

	Unit of observation	Year	var[ln(y_r)]	var[ln(y_{KHr})]	Contribution of inputs
			a	b	c=b/a
This study	Prefectures in Japan	1955	0.070	0.016	23%
		1970	0.050	0.016	32%
		1990	0.025	0.006	25%
		2008	0.017	0.003	20%
Turner et al. (2010)	States in the United States	1840	0.112	0.074	66%
		1880	0.184	0.065	35%
		1920	0.075	0.027	36%
		1960	0.027	0.008	31%
		2000	0.026	0.008	31%
Caselli (2005)	Countries	1996	1.297	0.500	39%
	OECD	1996	0.083	0.050	61%
	Non-OECD	1996	1.047	0.373	36%

3. Growth accounting

This section examines the mechanism driving convergence in prefectural labor productivity using growth accounting. Let us start by explaining our growth accounting approach. Define the TFP growth rate of prefecture r from year t to $t+\tau$, $\Delta\log A_{r,t}$, as follows:

$$\Delta \log A_{r,t} = \Delta \log V_{r,t} - \frac{1}{2}\left(S^K_{r,t+\tau} + S^K_{r,t}\right)\Delta \log Z_{r,t} - \frac{1}{2}\left(S^L_{r,t+\tau} + S^L_{r,t}\right)\Delta \log\left(H_{r,t} Q_{r,t}\right), \quad (4)$$

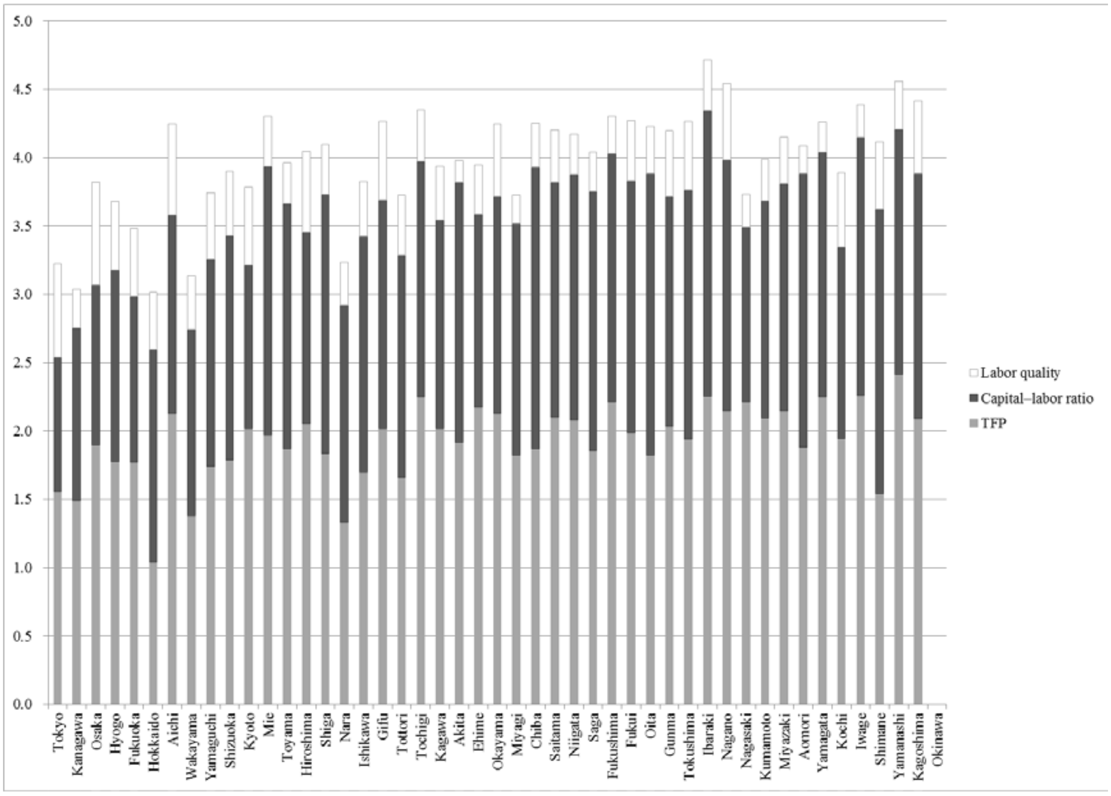
where Δ represents the difference between year t and year $t+\tau$ in prefecture r's real value added, $V_{r,t}$, capital stock, $Z_{r,t}$, man-hours, $H_{r,t}$, and labor quality, $Q_{r,t}$, for year t. $S^K{}_{r,t}$ and $S^L{}_{r,t}$ respectively stand for the cost shares of capital and labor in prefecture r in year t, with the sum of the two equaling 1 for each year. It should be noted that because capital investment in equation (4) is measured simply as the total real capital stock and not as capital services taking into account differences in marginal productivity of capital across different types of capital stock, the contribution of improvements in the quality of capital to labor productivity are included in TFP increases. Next, rearranging equation (4) yields the following:

$$\begin{aligned}\Delta \ln V_{r,t} - \Delta \ln H_{r,t} = \Delta \ln A_{r,t} + \frac{1}{2}\left(S^K_{r,t+\tau} + S^K_{r,t}\right)\left(\Delta \ln Z_{r,t} - \Delta \ln H_{r,t}\right) \\ + \frac{1}{2}\left(S^L_{r,t+\tau} + S^L_{r,t}\right)\Delta \ln Q_{r,t}.\end{aligned} \qquad (5)$$

The left-hand side of equation (5) shows the growth rate of labor productivity in prefecture r from year t to year $t+\tau$, that is, the growth rate of real value added minus the growth rate of man-hours. Meanwhile, the terms on the right-hand side respectively show the contribution of TFP growth, the contribution of increases in the capital–labor ratio (real capital stock/man-hours), and the contribution of increases in labor quality to labor productivity growth.

The results of this growth accounting for the period 1955–2008 are shown in Figure 3. Prefectures are arranged in descending order in terms of their labor productivity in 1955. The figure shows that, generally speaking, the higher a prefecture's labor productivity in 1955 was, the lower was its subsequent labor productivity growth, indicating that β-convergence took place. Looking at the factors contributing to labor productivity growth, we find that, generally speaking, the lower initial labor productivity was, the larger was the contribution of TFP growth and increases in the capital–labor ratio to labor productivity growth, so that these two factors contributed to the reduction of labor productivity differences. In contrast, in the case of labor quality, we find that the higher a prefecture's initial labor productivity was, the larger was the labor productivity growth contribution of improvements in labor quality, so that labor quality worked in the direction of increasing differences in labor productivity.

Figure 3. Prefectural growth accounting: 1955–2008 (annual rates in %)



Note: TFP includes improvements in the quality of capital.

In order to examine how each factor contributed to the reduction in labor productivity differences across prefectures, we decompose the β-convergence coefficient following Fukao and Yue (2000). Specifically, we proceed as follows. Denoting the log difference on the left-hand side in equation (5.5) for prefecture r from year t to the next benchmark year t+τ by GYL_r and the three terms on the right-hand side by $GTFP_r$, GKL_r, and GQ_r, respectively, and, moreover, denoting labor productivity (real GPP per man-hour) in prefecture r in year t by YL_r, we can represent the coefficient of unconditional β-convergence of labor productivity, β_{YL}, as follows:

$$\beta_{YL} = \frac{\sum_r \left(GYL_r - \overline{G}\,\overline{YL}\right)\left(YL_r - \overline{YL}\right)}{\sum_r \left(YL_r - \overline{YL}\right)\left(YL_r - \overline{YL}\right)} .$$

Variables with an upper bar denote the simple average for all prefectures. Given the definition of $GTFP_r$, the equality GYL_r = $GTFP_r$ + GKL_r + GQ_r always holds, so that we obtain the following equation:

$$\beta_{YL} = \beta_{TFP} + \beta_{KL} + \beta_{Q},$$

where the β's on the right-hand side represent the estimated coefficients of simple linear regressions of each of the items on the right-hand side of equation (5) on labor productivity at the starting period. For example:

$$\beta_{TFP} = \frac{\sum_r \left(GTFP_r - \overline{G}\overline{TFP}\right)\left(YL_r - \overline{YL}\right)}{\sum_r \left(YL_r - \overline{YL}\right)\left(YL_r - \overline{YL}\right)}.$$

In other words, the coefficient of unconditional β-convergence for labor productivity is equivalent to the sum of the regression coefficients obtained when conducting simple regressions of each of the sources of growth (shown in the growth accounting exercise above) on labor productivity in the initial period. The results of this factor decomposition of β-convergence based on the above approach are shown in Table 3. It should be noted that because the periods examined in Table 3 differ in length, we transformed all values that change over time into annual rates of change in order to make it possible to compare the results for the different periods.

Table 3. Factor decomposition of *β*-convergence in labor productivity

	1955-1970		1970-1990		1990-2008		1955-2008	
Coefficient of regressing labor productivity growth on labor productivity level in the starting year of the period	-0.028	***	-0.015	***	-0.015	***	-0.014	***
	(0.004)		(0.004)		(0.005)		(0.001)	
Contribution of TFP growth	-0.018	***	-0.010	**	-0.009	**	-0.008	***
	(0.005)		(0.004)		(0.005)		(0.001)	
Contribution of increases in the capital-labor ratio	-0.007	***	-0.009	***	-0.009	***	-0.007	***
	(0.003)		(0.003)		(0.002)		(0.001)	
Contribution of labor quality improvements	-0.002		0.003	***	0.003	**	0.002	*
	(0.002)		(0.001)		(0.002)		(0.001)	

Notes:

1. Standard errors in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

2. TFP growth includes capital quality improvements. Moreover, results for periods including the year 1970 exclude Okinawa.

The results in the table allow the following observations. We find evidence of β-convergence for all periods. However, the speed of β-convergence slowed from 1970 onward. Looking at the contribution of each factor to convergence, the table shows that TFP and the capital–labor ratio contributed to convergence in all periods. Of the two, the contribution of TFP growth to convergence was noticeably greater than that of the increase in the capital–labor ratio in the 1955–1970 period, but in subsequent periods as well as for the period as a whole, the contribution of the two factors is more or less the same. On the other hand, labor quality did not contribute to convergence in any of the periods and in fact from 1970 onward actually clearly worked in the direction of divergence. The results are consistent with those presented in Figure 3.

Looking at the results in Table 3 here and those in Table 1 earlier, the two may at first glance appear to be inconsistent. To recall, Table 1 indicated that until 1990 the reduction in differences in labor quality contributed to the reduction in labor productivity differences. In contrast, the results in Table 3 suggest that, depending on the period in question, labor quality improvements either did not contribute to convergence or actually worked against it. However, it is important to note that the approaches underlying the results in the two tables differ. Those in Table 1 are based on a cross-section analysis focusing on σ-convergence in the distribution of productivity differences, where the dispersion of the log of prefectural relative labor productivity (the square root of which approximately corresponds to the coefficient of variation of prefectural differences in labor productivity) is decomposed into the sum of the covariances between the log of prefectural relative labor productivity and the supply-side determinants of prefectural labor productivity differences. In contrast, the results in Table 3 are based on a decomposition of β-convergence in a time-series dimension. As is well known, results often differ depending on whether one focuses on σ-convergence or β-convergence due to factors such as idiosyncratic shocks across regions and terms of trade effects.

4. Economic convergence and the role of migration, capital accumulation, and TFP

The analysis in Sections 2 and 3 showed that, along with the reduction in prefectural differences in TFP, the reduction in prefectural differences in the capital–labor ratio made a large contribution to economic convergence. In particular, we found that from 1970 onward prefectures with high labor productivity tended to experience a slower increase in the capital–labor ratio and vice versa. This kind of pattern could be the result either of labor moving from low-productivity to high-productivity prefectures or of more rapid capital accumulation in low-productivity than in high-productivity prefectures. In this section, we examine which of these two mechanisms is responsible for the reduction in prefectural differences in the capital–labor ratio and prefectural economic inequality more generally in Japan.

As mentioned in the introduction to this paper, the analysis in this section is complementary to that in Chapter 4 of Fukao et al. (2015). Therefore, to make the analysis here directly comparable to that in Chapter 4 of Fukao et al. (2015), we focus on the impact of migration, capital accumulation, and TFP growth not on labor productivity – as we did in the preceding sections – but on per capita GPP.

In order to examine the extent to which labor migration as well as prefectural differences in capital accumulation, improvements in labor quality, and TFP growth each contributed to economic convergence, we conduct the decomposition outlined below. In doing so, we treat Greater Tokyo (Tokyo, Kanagawa, Chiba and Saitama) and Greater Osaka (Osaka, Kyoto, Hyogo, Nara, and Shiga) as one area each to remove the distorting impact of commuting.[4]

We start by transforming equation (4), which defines TFP growth in prefecture *r* from year *t* to *t*+*τ*, to obtain the following equation:

$$\begin{aligned}\Delta \ln A_{r,t} &= \Delta \ln V_{r,t} - \Delta \ln N_{r,t} - \frac{1}{2}\left(S^K_{r,t} + S^K_{r,t+\tau}\right)\Delta \ln Z_{r,t} \\ &- \frac{1}{2}\left(S^L_{r,t} + S^L_{r,t+\tau}\right)\left(\Delta \ln H_{r,t} - \Delta \ln N_{r,t}\right) - \frac{1}{2}\left(S^L_{r,t} + S^L_{r,t+\tau}\right)\Delta \ln Q_{r,t} \\ &+ \frac{1}{2}\left(S^K_{r,t} + S^K_{r,t+\tau}\right)\Delta \ln N_{r,t},\end{aligned} \tag{6}$$

where $N_{r,t}$ stands for the population of prefecture *r* in year *t*. Using this relationship, we obtain the following equation decomposing growth in per capita GPP:

$$\begin{aligned}\Delta \ln V_{r,t} - \Delta \ln N_{r,t} &= \Delta \ln A_{r,t} + \frac{1}{2}\left(S^K_{r,t} + S^K_{r,t+\tau}\right)\Delta \ln Z_{r,t} \\ &+ \frac{1}{2}\left(S^L_{r,t} + S^L_{r,t+\tau}\right)\left(\Delta \ln H_{r,t} - \Delta \ln N_{r,t}\right) + \frac{1}{2}\left(S^L_{r,t} + S^L_{r,t+\tau}\right)\Delta \ln Q_{r,t} \\ &- \frac{1}{2}\left(S^K_{r,t} + S^K_{r,t+\tau}\right)\Delta \ln N_{r,t}\end{aligned} \tag{7}$$

[4] As mentioned in Chapter 4 of Fukao et al. (2015), the population and output shares of prefectures in the Greater Tokyo and Greater Osaka areas differ considerably in the post-war period as a result of commuting. This means that the output produced by commuters from, e.g., Saitama, is counted toward the output of Tokyo, thus distorting the per capita GPP of the two prefectures. Because the analysis in Chapter 4 of Fukao et al. (2015) covers both the pre-war period, when there was little commuting, and the post-war period, we did not treat the major urban agglomerations as one area each. However, because in this paper we focus on the post-war period only, we remove this distortion.

The equation implies that increases in prefectures' per capita GPP can be decomposed into the contributions of TFP growth, capital accumulation, increases in per capita working hours, improvements in labor quality, and decreases in the population.

In order to examine the role that each of these factors played in the reduction in differences in per capita GPP, let us decompose the β-convergence coefficient for per capita GPP – that is, the coefficient when regressing the growth in per capita GPP on the left-hand side of equation (7) on per capita GPP in the starting year of the period – on the factors on the right-hand side of equation (7). To do so, as explained in Section 3, we can conduct a simple regression of each term on the right-hand side on per capita GPP in the starting year of the period and compare the regression coefficients. As in Section 3, for the regression we transform all values representing changes over time into annual rates.

The results of the decomposition are presented in Table 4 and show the following. First, as in the case of labor productivity, we find evidence of β-convergence in per capita GPP in all periods. Second, TFP growth consistently in all periods worked in the direction of reducing regional income inequality. The contribution of TFP growth to economic convergence was particularly large in the 1955–1970 period. Third, the population growth rate also consistently in all periods worked in the direction of reducing regional income inequality, and again the effect was particularly large in 1955–1970. As seen in Chapter 4 of Fukao et al. (2015), regional migration in Japan was particular pronounced during this period as the post-war baby boomer generation grew up, accelerating convergence. Fourth, although capital accumulation worked in the direction of divergence in 1955–1970, after that it worked in the direction of convergence. Exactly the same pattern can be observed for per capita working hours. Fifth, turning to labor quality, no clear effects can be observed during 1955–1970, but subsequently it worked in the direction of divergence. As explained in Chapter 4 of Fukao et al. (2015), the reason that labor quality worked in the direction of divergence likely is not that there was a brain drain, with better-educated individuals migrating from richer to poorer areas, but that those born in richer areas received more education.

Table 4. Factor decomposition of β-convergence in GPP per capita

	1955-1970		1970-1990		1990-2008		1955-2008	
Coefficient of regressing per capita GPP grwoth on per capita GPP in	-0.018	***	-0.022	***	-0.020	***	-0.012	***
	(0.005)		(0.004)		(0.005)		(0.002)	
Contribution of TFP growth	-0.022	***	-0.010	**	-0.009	**	-0.009	***
	(0.005)		(0.004)		(0.005)		(0.001)	
Contribution of growth in capital investment	0.004		-0.006	*	-0.006	**	-0.003	*
	(0.004)		(0.003)		(0.002)		(0.002)	
Contribution of growth in per capita working hours	0.008	***	-0.004	**	-0.004	**	0.001	
	(0.002)		(0.002)		(0.002)		(0.001)	
Contribution of improvements in labor quality	0.000		0.003	***	0.003	**	0.003	***
	(0.002)		(0.001)		(0.002)		(0.001)	
Contribution of decline in population growth rate	-0.008	***	-0.006	***	-0.005	***	-0.003	*
	(0.003)		(0.002)		(0.001)		(0.001)	

Notes:

1. Standard errors in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

2. TFP growth includes capital quality improvements. Moreover, results for periods including the year 1970 exclude Okinawa.

Looking at the period 1955–2008 overall, the main factor contributing to the reduction in economic inequality was TFP growth, and although capital accumulation as well as migration also played a role, their contribution to the reduction in regional economic inequality was only about a third as large as that of TFP growth. On the other hand, improvements in labor quality worked in the direction of increasing inequality.

Having examined the relative importance of the different factors of production as well as TFP in economic convergence, let us now look at some of these items in greater detail. The role of migration and improvements in labor quality were already discussed in Chapter 4 of Fukao et al. (2015). The focus of the remainder of this section therefore is on capital accumulation and changes in TFP.

The increase in capital stock in prefecture r from year t to year t+1 can be represented as follows:

$$\frac{\Delta Z_{r,t}}{Z_{r,t}} = \frac{I_{r,t}}{Z_{r,t}} - \delta = \left(\frac{S_{r,t}}{V_{r,t}} + \frac{I_{r,t} - S_{r,t}}{V_{r,t}} \right) \frac{V_{r,t}}{Z_{r,t}} - \delta \, , \tag{8}$$

where $I_{r,t}$ stands for gross investment, δ for the depreciation rate of capital, $V_{r,t}$ for gross value added (GPP), and $S_{r,t}$ for gross savings. On the right-hand side of equation (5.8), $S_{r,t}/V_{r,t}$ represents the share of gross savings in GPP, $(I_{r,t}\text{-}S_{r,t})/V_{r,t}$ is the part of gross prefectural investment that is covered by external savings (savings “imported” from outside the prefecture) relative to GPP, and $V_{r,t}/Z_{r,t}$ is the average productivity of capital (the inverse of the capital coefficient). Meanwhile, $(I_{r,t}\text{-}S_{r,t})/V_{r,t}$, in addition to capital inflows to prefecture r, includes receipts of capital transfers from other prefectures. Below, we will refer to $(I_{r,t}\text{-}S_{r,t})/V_{r,t}$ as the net capital inflow–GPP ratio.

It should be noted that due to the way that investment in social capital is treated in the R-JIP Database, the first equality in equation (8) only holds as an approximation. Specifically, what may be called broad social capital accumulation consists of both the construction of public schools, national hospitals, government office buildings, etc., which in the R-JIP Database is included in the capital stock (Z) in government services, and investment in public roads and port facilities, expenditures for national land conservation, etc. Because the latter, which we will refer to as narrow social capital accumulation, is not classified into specific industries in the fixed capital stock matrix of the Input-Output Tables by the Ministry of Internal Affairs and Communications, on which the R-JIP Database is based, it is not included in changes in Z. This means that whereas narrow social capital is included in the data for gross investment $I_{r,t}$ in equation (8), it is not included in the data for $\Delta Z_{r,t}$.

In previous studies on economic convergence, such as Barro and Sala-i-Martin (1991, 1992b), Sala-i-Martin (1996), and Shioji (2001), it is assumed that the key driver of regional convergence is diminishing marginal returns to capital. That is, it is assumed that capital accumulation in richer, more capital-intensive regions decelerates as marginal returns to capital decline, lowering the rate of per capita output growth. Thus, these studies suggest that, as in a Solow-type closed-economy neoclassical growth model (Solow, 1956), interregional capital and labor movements essentially play no role in regional convergence.

The assumption made in these studies can be directly examined using equation (8). Specifically, they assume that the gross savings rate $S_{r,t}/V_{r,t}$ is identical across prefectures and that gross capital inflows or the ratio of capital transfer receipts $(I_{r,t}\text{-}S_{r,t})/V_{r,t}$ are zero. On the other hand, they assume that the average productivity of capital $V_{r,t}/Z_{r,t}$ of richer prefectures decreases due to diminishing marginal returns to capital and that, as a result, the growth rate of capital stock $\Delta Z_{r,t}/Z_{r,t}$ on the left-hand side also decreases for richer prefectures. Using our database, we can directly examine whether this hypothesis is correct for the convergence in per capita GPP differences in post-war Japan.

Table 5, for the periods 1955–1970, 1970–1990, 1990–2008, and for the entire period from 1955 to 2008 covered by our database, shows the coefficient estimates when regressing the period average of the growth rate of prefectural capital stock $\Delta Z_{r,t}/Z_{r,t}$, the gross investment rate $I_{r,t}/V_{r,t}$, the gross savings rate $S_{r,t}/V_{r,t}$, the ratio of gross capital inflows or capital transfer receipts $(I_{r,t}\text{-}S_{r,t})/V_{r,t}$, and the average productivity of capital $V_{r,t}/Z_{r,t}$. on per capita GPP at the start of the period.

Table 5. Prefectural capital accumulation

	1955-1970		1970-1990		1990-2008		1955-2008	
Growth of capital stock ($\Delta Z/Z$)	0.014	*	-0.024	***	-0.013	**	-0.006	
	(0.008)		(0.008)		(0.005)		(0.004)	
Gross invesment-GPP ratio (I/Y)	-0.079	***	-0.145	***	-0.111	***	-0.091	***
	(0.025)		(0.026)		(0.017)		(0.018)	
Gross savings rate-GPP ratio (S/Y)	0.149	**	0.198	***	0.218	***	0.118	**
	(0.055)		(0.069)		(0.067)		(0.055)	
Gross capital inflows-GPP ratio ($(I-S)/Y$)	-0.228	***	-0.343	***	-0.329	***	-0.209	***
	(0.059)		(0.073)		(0.073)		(0.062)	
Average productivity of capital (Y/K)	-0.024		-0.059		0.125	***	0.020	
	(0.118)		(0.054)		(0.038)		(0.054)	

Notes:

1. The table shows the coefficient estimates when regressing the variable on per capita GPP at the start of the period.

2. Standard errors in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Starting with the regression result for the growth rate of the capital stock, $\Delta Z_{r,t}/Z_{r,t}$, on the left-hand side of equation (8), we find that richer prefectures had a higher growth rate than poorer prefectures in 1955–1970, which tended to contribute to an increase in inequality. However, in each of the subsequent periods, poorer prefectures had a higher growth rate, contributing to a decrease in inequality. This is consistent with the result in Table 4 indicating that capital accumulation contributed to convergence in labor productivity.

Next, looking at the regression for the period average gross investment–GPP ratio ($I_{r,t}/V_{r,t}$) on per capita GPP at the beginning of the period, we find that the gross investment–GPP ratio is larger in poorer prefectures not only in the latter two periods, but also in 1955–1970, although the absolute value of the regression coefficient is smaller than in that later periods.

The result that the regression coefficients for the growth rate of the capital stock and for the gross investment–GPP ratio in the 1955–1970 period have opposite signs (the former is positive, while the latter is negative) is due to the fact that, as explained above, our capital stock data do not include narrow social capital, whereas the gross investment data do. The result thus implies that although richer prefectures accumulated capital other than narrow capital (i.e., capital stock covered in the R-JIP Database) faster than poorer prefectures, investment overall (i.e., including narrow social capital) grew faster in the poorer prefectures, i.e., they had a higher gross–investment GPP ratio, because of the faster accumulation of narrow social capital (with the latter tendency continuing after 1970).

Next, looking at the sources of investment, the gross savings–GPP ratio, $S_{r,t}/V_{r,t}$, tended to be higher in richer prefectures in all periods. On the other hand, net capital inflows or capital transfer receipts, $(I_{r,t}-S_{r,t})/V_{r,t}$, were higher in poorer prefectures in all periods, consistently contributing to the reduction in inequality. Comparing the regression coefficients for net capital inflows/capital transfer receipts and the gross savings–GPP ratio, we find that the former is greater than the latter in all periods, implying that although the gross savings rate was higher in richer prefectures, capital movements and capital transfers exceeding differences in gross saving rates took place, and this likely contributed to the decline in prefectural GPP differences. This finding is in line with the argument by Dekle (1996) that there were substantial capital movements across Japanese prefectures and that although richer prefectures had higher saving rates, these were not linked to higher prefectural investment rates.[5] Reasons for the movement of capital as well as capital transfers from richer to poorer prefectures are the increasing relocation of factories by firms to rural regions especially from the 1970s onward (see, e.g., Yue, 2000) as well as capital transfers by the government from richer to poorer prefectures, which, as pointed out by Fukao and Yue (2000), played an important role.

Finally, looking at prefectural differences in the average productivity of capital, we find that the average productivity of capital tended to be lower in richer prefectures. As seen in Figure 1, in 1955, there were large prefectural differences in the capital–labor ratio, and the average productivity of capital in prefectures with particularly high capital–labor ratios likely was comparatively low due to diminishing marginal returns to capital. Nevertheless, we find that although the estimated coefficient when regressing the period average of the average productivity of capital (V/Z) on the per capita GPP level at the beginning of the period is negative until 1990, it is not statistically significantly different from zero. Moreover, from 1990 onward, probably reflecting the decline in prefectural differences in capital–labor ratios and the existence of TFP differences as seen in Figure 2, the average productivity of capital was in fact significantly higher in richer prefectures. These results suggest that the convergence mechanism assumed in Solow-type growth models, in which regional inequality declines because richer prefectures have a higher capital–labor ratio and lower marginal returns to capital, did not play a central role in the decline in prefectural inequality in post-war Japan.

The above results on the role of capital accumulation in the reduction of prefectural inequality in per capita GPP can be summarized as follows. Before 1970, capital accumulation – measured in terms of the capital stock covered in the R-JIP Database, i.e., excluding narrow social capital – proceeded at a faster pace in richer than in poorer prefectures. However, from 1970, the rate of capital accumulation was consistently higher in the poorer prefectures.

[5] Specifically, Dekle (1996) points out that the cross-section correlation between prefectural private savings rates and private investment rates is close to zero and capital movements between prefectures were extremely active.

Moreover, overall gross investment – as measured by the gross investment–GPP ratio and including narrow social capital – has been consistently higher in poorer prefectures since the start of our observation period in 1955. Turning to the sources of funding for investment, we found that although the gross savings–GPP rate was consistently higher in richer prefectures, there were even greater capital movements and transfers from richer to poorer prefectures. Thus, from 1970 onward, the main reason that capital accumulation contributed to a decline in prefectural inequality was these capital movements and transfers, while the convergence mechanism through diminishing marginal returns to capital assumed in Solow-type growth models played almost no role.

Next, let us consider the role played by TFP growth in the decline in prefectural inequality. Above, we examined the sources of the decline in prefectural inequality using various supply-side approaches, such as level accounting for 1955 and 2008 regarding prefectural differences in labor productivity (Figures 1 and 2), factor decomposition of (the log of) prefectural labor productivity differences (Table 1), growth accounting of labor productivity growth (Figure 3), and the decomposition of β-convergence in labor productivity and per capita GPP (Tables 3 and 4). These different analyses all showed that the major cause of the decline in prefectural labor productivity differences and per capita GPP differences between 1955 and 2008 was the decline in prefectural TFP differences. Let us therefore examine what caused this decline in TFP differences.

Put simply, the major driving force leading to the decline in TFP differences probably was the expansion of high-productivity firms from metropolitan prefectures into more rural prefectures. In response to increasingly stringent regulations on industrial sites to deal with pollution as well as growing labor shortages in metropolitan areas from the late 1960s onward, firms in many manufacturing industries increasingly tended to set up new factories in low-wage rural areas.[6] Given that the technological knowledge accumulated by firms has strong public good characteristics within the same firm, this means that rural areas likely received considerable knowledge transfers. Moreover, the expansion of manufacturing industry into rural areas likely also had the effect of raising labor productivity in these areas through industrial agglomeration effects.

Another potentially important factor likely was the improvement of social infrastructure in rural areas, which the government regarded as vital. To examine this issue, Figure 4 shows the relationship between the narrow capital stock divided by working hours and per capita GPP for each prefecture in 1955, 1970, 1990, and 2008.[7] Specifically, the figure was constructed by first

[6] See, for example, Fukao and Yue (1997), who examined the locational choices of firms in the electrical machinery industry and showed that firms were looking for low-cost labor and expanded into rural areas.
[7] We measure social capital accumulation relative to working hours (rather than per capita) in order to take into account differences in demographic structure.

taking the log of both variables and then calculating the difference from the national average. As mentioned above, narrow social capital, which includes expenditure on public roads, port facilities, and national land conservation, is not included in the capital stock in the R-JIP Database.[8]

As can be seen in Figure 4, the relationship between prefectures' per capita GPP and social capital per working hour changed substantially over time. In 1955, richer prefectures tended to have higher social capital per working hour. However, by 1970, this positive correlation had disappeared, and from 1990 onward there is in fact a strong negative relationship between the two variables. While the correlation coefficient of the two variables is 0.130 for 1955 and -0.179 for 1970, we subsequently observe an extremely large negative correlation, with correlation coefficients of -0.590 for 1990 and -0.482 for 2008 (the null hypothesis of no correlation is rejected at the 1% significance level for both 1990 and 2008). In other words, the poorer a prefecture is, the more narrow social capital investment it has had. Poorer prefectures received large capital transfers from the central government, which contributed to building up narrow social capital.

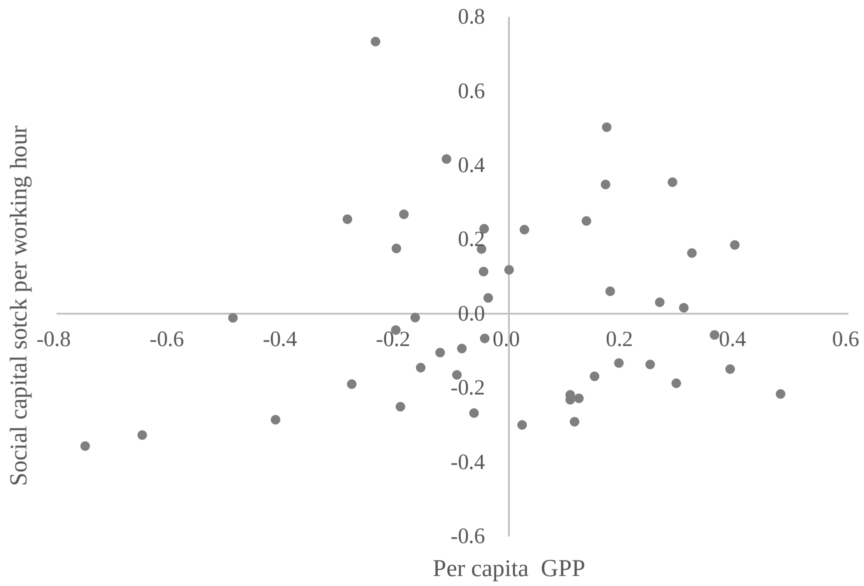
Given that the accumulation of social capital likely increases the efficiency of economic activity and hence has a positive effect on TFP, the fact that social capital accumulation from 1955 onward has consistently concentrated particularly on poorer rural areas very likely contributed to the decline in prefectural TFP differences. At the same time, however, it should also be noted that the rapid accumulation of social capital in poorer regions probably resulted in a misallocation of social capital across regions from the viewpoint of efficiency within the country as a whole. Yoshino and Nakajima (1999), for example, estimating regional[9] production functions for each sector using data for 1975–1994, highlight that the marginal productivity of social capital tended to be much lower in poorer than in richer regions.

Figure 4. Relationship between per capita GPP and prefectural social capital stock per working hour

(a) 1955

[8] We obtained the prefecture-level narrow social capital stock data from Director General for Economic, Fiscal and Social Structure (2012).

[9] They aggregated Japan's 47 prefectures into 11 regions.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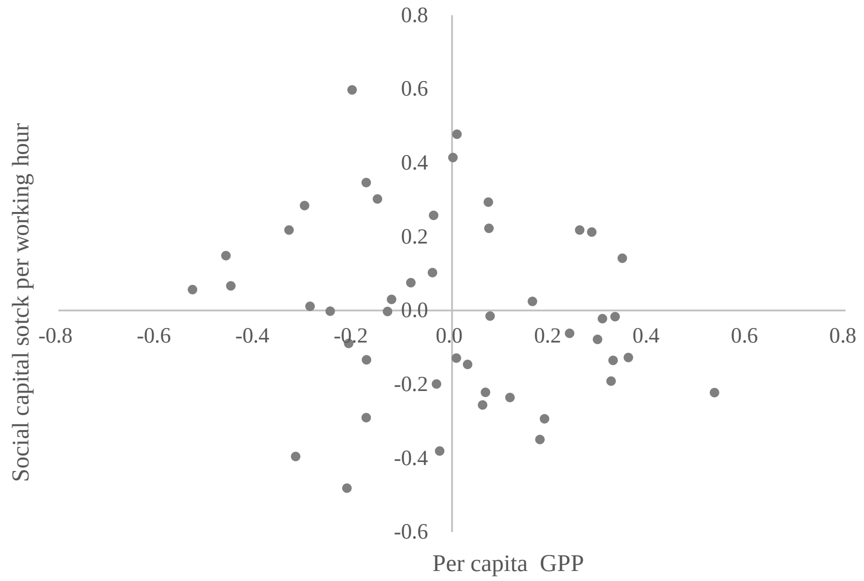
Social capital sotck per working hour
Per capita GPP

(b) 1970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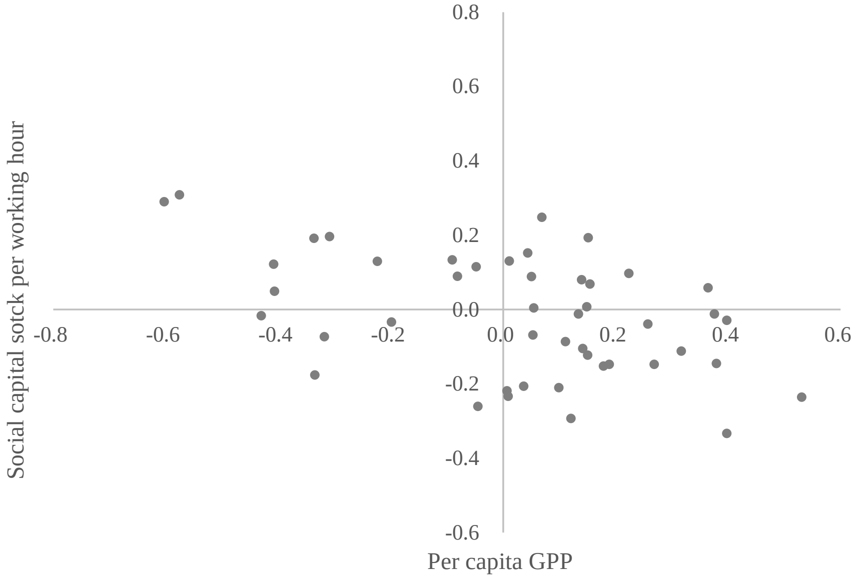
Social capital sotck per working hour
Per capita GPP

(c) 1990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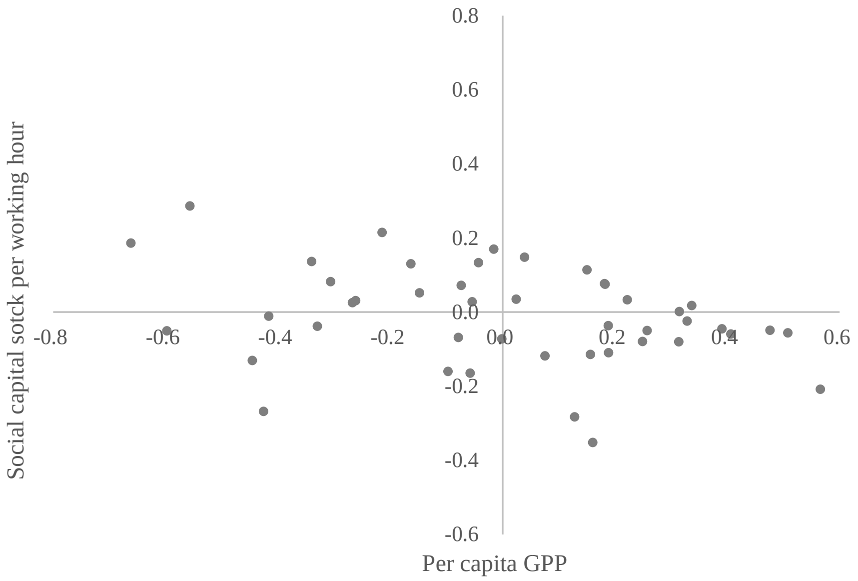
Social capital sotck per working hour
Per capita GPP

(d) 2008



Note: The figure shows the difference from the national average after taking the log of per capita GPP and prefectural social stock per working hour.

5. Conclusion

In this paper, using the R-JIP Database, which provides data on aggregate industry value added and production factor inputs by prefecture for 1955–2008, we examined the reasons for the decline in prefectural economic inequality from the supply side. To this end, we employed a variety of approaches, such as level accounting for 1955 and 2008 regarding prefectural differences in labor productivity (Figures 1 and 2), factor decomposition of (the log of) prefectural labor productivity differences (Table 1), growth accounting of labor productivity growth (Figure 3), and the decomposition of β-convergence in labor productivity and per capita GPP (Tables 3 and 4). We also compared our results with level accounting analyses on the United States (Turner et al., 2010) and OECD countries (Caselli, 2005) (Table 2).

In addition, we focused on the role of capital accumulation and changes in TFP in economic convergence. We examined how the relatively rapid capital accumulation in low-income prefectures was financed and what brought the decline in differences in TFP about.

The main findings of the analysis are as follows.

1. Taking a supply-side approach, we examined three possible factors underlying labor productivity differences across prefectures: differences in capital–labor ratios, differences in labor quality, and differences in TFP. We found that, in the period from 1955 to 2008 all three factors consistently contributed to prefectural differences in labor productivity. In 1955, the most important reason for prefectural labor productivity differences was differences in TFP, followed by differences in capital–labor ratios, and then by differences in labor quality. Differences in capital–labor ratios and TFP declined substantially between 1955 and 2008, leading to a dramatic reduction in prefectural labor productivity differences. On the other hand, depending on the period, prefectural differences in labor quality either did not contribute to the contraction in labor productivity differences or in fact worked in the direction of increasing such differences. As a result of these changes, while TFP differences continued to be the major reason for prefectural labor productivity differences in 2008, the contribution of differences in the capital–labor ratio fell to the same level as the contribution of labor quality differences (Table 1).

2. Taking a closer look at the results for each period, we found that during the high-speed growth era from 1955 to 1970 the main factor underlying the decline in prefectural labor productivity differences was the decline in TFP differences. On the other hand, from 1970 onward, Japan experienced a strong decline in regional differences in inputs, so that the contribution of variation in inputs to variation in output steadily dropped after 1970. As a result, the regional variance of inputs in Japan was less than half of the US value and only about 6% of the variance across OECD countries (Tables 1 and 2). This drop in regional differences in inputs since 1970 was the consequence of a decline in regional differences in the capital–labor ratio (Tables 1 and 3). In contrast, differences in labor quality only marginally contributed to the decline in labor productivity differences during the high-speed growth era and more recently in fact seem to have worked in the direction of increasing labor productivity differences (Table 3).

3. Further, in order to supplement the analysis in Chapter 4 of Fukao et al. (2015) examining the role of migration in the decline in per capita GPP differences, we examined the role of factors other than migration in economic convergence. Specifically, we did so by decomposing β-convergence in prefectural per capita GPP into the contribution of TFP differences, capital accumulation, changes in per capita working hours, changes in labor quality, and migration (Table 4). The results indicate that migration from poorer to richer prefectures and the decline in prefectural TFP differences from 1955 to 2008 consistently contributed to the decline in per capita GPP differences, although – for the period as a whole – the contribution of the decline in prefectural TFP differences to β-convergence was more than twice as large as the contribution

of migration. On the other hand, capital accumulation actually worked in the direction of increasing prefectural inequality in the period 1955–1970, but from 1970 onward consistently operated in the direction of reducing inequality. Meanwhile, changes in labor quality from 1970 onward stymied the decline in inequality. However, the analysis in Chapter 4 of Fukao et al. (2015) suggested that the fact that changes in labor quality worked against convergence likely was not the result of a brain drain in which better educated workers migrated to richer areas, but was caused by the fact that children raised in richer areas received more education.

4. We further examined in this paper why, from 1970 onward, poorer prefectures tended to have higher capital stock growth rates than richer prefectures. Three possible explanations of this pattern offer themselves: (1) the poorer a prefectures, the higher the gross savings–GPP ratio; (2) poorer prefectures received private capital inflows and/or government capital transfers; and/or (3) the richer a prefecture, the higher the capital–labor ratio, so that the capital coefficient (capital stock–GPP ratio) declines over time through diminishing returns to capital, lowering the growth rate of the capital stock (i.e., the convergence mechanism through diminishing marginal returns to capital assumed in Solow-type growth models). Our results show that the gross savings–GPP ratio has tended to be lower in poorer prefectures in all periods from 1955 to 2008, thus ruling out the first possible explanation. Instead, poorer prefectures tended to receive higher capital inflows and/or government capital transfers relative to GPP, and it is this – i.e., the second explanation – that raised the growth rate of the capital stock in poorer prefectures. On the other hand, the convergence mechanism assumed in Solow-type growth models, i.e., the third explanation based on diminishing returns to capital, played almost no role in explaining higher capital stock growth rates in poorer prefectures.

5. Finally, we found that the accumulation of social capital, measured in relation to working hours, in post-war Japan, was concentrated in prefectures with lower per capita GPP. In particular from 1990 onward, there was a clear pattern that the lower per capita GPP, the higher was the social capital stock per working hour. Given that the accumulation of social capital likely raises the efficiency of economic activity and hence has a positive effect on TFP, the emphasis on improving social infrastructure in poorer rural areas very likely contributed to the decline in prefectural TFP differences. Meanwhile, the expansion of firms with high labor productivity into rural areas and technology transfers to technologically lagging prefectures through intra-firm technology diffusion, as well as the growing agglomeration of industry in rural areas through the expansion of manufacturing in rural areas (discussed in greater detail in the next chapter) also likely greatly contributed to the decrease in prefectural TFP differences.

Preceding studies by Barro and Sala-i-Martin (1991, 1992b) as well as Shioji (2001) treated convergence as a "black box." Using a growth accounting framework and the R-JIP Database, we decomposed growth in labor productivity and per capita GPP into supply-side factors such as TFP, capital accumulation, and labor migration. We examined how capital accumulation in each prefecture was financed either through "domestic" saving or capital inflows and capital transfers. In this manner, we opened the "black box" and were able to show that the mechanism assumed in preceding studies played only a negligible role. Opening this black box has shown that convergence cannot be reduced to one simple mechanism, but is a complex process driven by a number of factors that may work in different directions and that may be of varying importance at different points in time.

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