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The Role of Structural Transformation in Regional Productivity Growth and Convergence in Japan: 1874 - 2008

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Abstract

Japan's regional convergence of productivity levels throughout the 20th century can be best described as a cumulative process of "catching up, forging ahead, and falling behind". Using a novel dataset spanning 135 years (1874 – 2008), this study finds support for a crucial role played by structural transformation in convergence. The pace of productivity catch-up and convergence accelerated in the mid-1950s with the help of structural transformation, particularly in the period from 1955–1965. Structural transformation explains, on average, about 30% of the aggregate productivity growth, and its effect intensified in prefectures with faster movements of labor across sectors and larger sectoral productivity gaps. However, since the early 1970s, its contribution to the convergence was frequently offset by within-sector productivity growth, in turn thwarting the pace of convergence. These counter-balancing effects contributed to the diverse pathways of productivity catch-up at the prefecture level.

JEL Classifications: O40, O10

Keywords: Economic Growth and Aggregate Productivity, Japan

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I. Introduction

Japan was the first Asian country to industrialize on the Western model and its remarkable growth in the 20th century is a well-known story. Early modernization began in the 1860s during the Meiji period, leading to steady growth by the first half of the 20th century. The real per capita GDP in Japan as a proportion of that in the US increased from 30% in 1870 to 41% in 1940. While the devastation of World War II brought this ratio down to 11% in 1945, Japan's post-war recovery was astonishing. In only 45 years, it nearly paralleled the US level by reaching 85% of US per capita GDP. Japan achieved a high and homogenous standard of living throughout its 47 prefectures especially in the second half of the 20th century. The process of catching up with the Western countries is well documented, however, less well known is the process of regional economic convergence. Studies show that reallocation of labor between the primary, secondary and tertiary[1] industry sectors, more commonly known as structural transformation[2], is crucial in helping us understand not only the process of economic growth and convergence across nations (Duarte and Restuccia, 2010), but also convergence in regional development (Caselli and Coleman, 2001; Hnatkovska and Lahiri, 2014). In this spirit, this study analyzes the long-term regional economic performance in Japan and in particular examines the role of structural transformation in regional productivity growth and convergence over a period of 135 years, specifically from 1874 to 2008.

We begin by highlighting some key observations.

A. Catching-up in aggregate productivity

[1] This classification is similar to the one more commonly used as agriculture, manufacturing and services.
[2] Movement of labor and other resources from less productive to more productive sectors undeniably contributes to productivity growth. In his seminal contribution, Kuznets (1955) argued that structural transformation through resource allocation can significantly impact on growth and convergence. Some of the notable early contributions on this topic include Clark (1957), Chenery (1960) and Kuznets (1966). See Herrendorf, Rogerson and Valentinyi (2014) for a comprehensive literature survey.

The process of Japan's regional convergence through productivity catch-up started in the late 19th century when the process of industrialization really gained momentum. As depicted in panel A of Figure 1.1, between 1874 and 1940 the average rate of aggregate labor productivity (over 46 prefectures) benchmarked to the level of Tokyo increased from 32% to 47%. During the post-war miracle growth period, 1955 - 1970, Japan's aggregate productivity rose remarkably but in this phase the regional disparity in productivity also narrowed to an unprecedented level. Since the 1970s, the average prefectural (leaving out Tokyo) labor productivity level remained in the vicinity of 75% of that in Tokyo. The Gini coefficient of aggregate labor productivity followed a downward trend between 1909 and 1940, but it continued to drop at a faster rate in the second half of the 20th century (Panel B of Figure 1.1). Especially in the high-growth era (1955-70), there was a sharp decline in the regional inequality in aggregate labor productivity from .17 to .11.

[Figure 1.1 is about here]

B. Diverse trajectories of productivity catch-up

We also find diverse pathways of productivity catch-up across prefectures. Compared to Tokyo's aggregate labor productivity level, some prefectures depict a process of sustained catch-up, while others follow a rollercoaster path of convergence. For example, in 1874, Hokkaido was among the top three prefectures (the other two being Tokyo and Osaka) in terms of productivity, and its aggregate labor productivity level was about 70% of that in Tokyo (Panel A, Figure 1.2). The gap in aggregate productivity level remained the same in 2008 after it increased between 1974 and 1890, decreased from 1890 to 1970, and then again increased between 1970 and 2008. On the other hand, Fukushima followed a path of sustained productivity catch-up, and its productivity level as a percentage of that in Tokyo increased from 26% in 1874 to 87% in 2008. Another prefecture, Kochi, reflects a somewhat similar trend but there were periods of oscillation in between. The case of Kanagawa lies at the other extreme. It steadily grew and then overtook Tokyo's productivity level in the early 1970s. Yet since then its productivity growth has faltered and dropped by almost 30% over the next 40 years[3]. The pace of structural transformation also varied across prefectures. As shown in the bottom panel (B) of Figure 1.2, Kochi and Ishikawa experienced a lagged structural transformation. Especially in Kochi, participation in the primary sector remained at around 60% until 1955. The sectoral reallocation of labor experienced in Fukuoka and Kanagawa is in sharp contrast to this. In Kanagawa prefecture, participation in the primary sector dropped sharply from 72% in 1874 to 20% in 1940. While in most of the prefectures participation in agriculture dropped below 10% by 1990, there were prefectures (like Kochi) with almost one-fifth of its total labor hours still employed in the primary sector.

[Figure 1.2 is about here]

C. Leapfrogging

Diversity in productivity catch-up has also been associated with frequent changes in the productivity ranking of the prefectures. In Appendix 1, we show the full ranking of prefectures for the nine benchmark years. While Tokyo remained at the top of the productivity ranking in most of the periods, in the 1970s it was trailing behind four prefectures: Kanagawa, Wakayama, Chiba and Osaka. While Tokyo regained its position back by the early 1990s, the productivity growth in Kanagawa, Wakayama, Chiba and Osaka significantly faltered in the next forty years. Between 1970 and 2008, Kanagawa dropped from 1st to 12th position, Osaka from 4th to 15th position, Chiba from 3rd to 22nd position and the most striking case was Wakayama which fell from 2nd to 35th position. Kyoto on the other hand, continued to be in the top ten until 1970, but failed to sustain its productivity level thereafter. Leapfrogging was

[3] We elaborate on these different typologies of catching-up in section 2.

particularly significant in the high growth era (1955-70), with some prefectures making remarkable jumps: Chiba (from 26th to 3rd), Okayama (35th to 18th), Yamaguchi (11th to 6th), among others. We discuss such trends in greater detail in section 3.

In the presence of disparities in the pace of structural transformation and sectoral differences in productivity, a sectoral analysis could potentially explain the diversity in regional economic performance. Lagged structural transformation in some prefectures could be associated with a slow growth spell, whereas changes in the sectoral productivity gap over time could produce different growth outcomes with similar levels of structural transformation but different sectoral composition of production. The average productivity level in the secondary sector was similar to that in the primary sector in 1874, but it gradually increased and caught up with the level of tertiary sector productivity by 1940 (Appendix 6). In the post-war period, the average real labor productivity level became the highest in the secondary sector, followed by the tertiary and primary sectors, respectively. We argue that a systematic study through the lens of structural transformation could explain the diverse regional productivity growth patterns. We follow two steps: firstly, we identify the role of structural transformation in productivity growth; and secondly, we analyze the role of structural transformation in regional productivity convergence through productivity catch-up and re-ranking of prefectures[4]. Building on a simple theoretical framework, and drawing on insights from the existing literature we use a set of growth decomposition techniques for empirical purposes. We primarily use a novel historical dataset comprising sectoral productivity and employment shares at the prefectural level for nine benchmarks years spanning a period of 135 years, from 1874 to 2008[5]. We also use yearly data on the same variables available from 1955 to 2008.

[4] Following the literature on growth convergence (Barro and Sala-i-Martin, 1992), regional productivity convergence refers to sigma-convergence while productivity catch-up refers to beta-convergence.

[5] Benchmark years are 1874, 1890, 1909, 1925, 1935, 1940, 1955, 1970, 1990 and 2008. See Fukao et al. (2016) for a detailed analysis on the methodology and description of this dataset.

We summarize the main findings as follows. (1) The process of structural transformation in Japan gained momentum at the turn of the 19th century and throughout the 20th century reallocation of labor was primarily from agriculture to manufacturing and services. A somewhat different trend emerged in the early 1990s as labor started being reallocated from manufacturing to services. Together, they show similar trends found in other industrialized countries. (2) Structural transformation played a crucial role in productivity growth and regional convergence of productivity. Growth in aggregate productivity was positive throughout (1874 to 2008). Meanwhile, between-sector growth (structural transformation), on average, explained one-third of the aggregate productivity growth, and its contribution surged in the second half of the 20th century. The pace of productivity catch-up and the convergence accelerated in the mid-1950s with the help of structural transformation, particularly during 1955–1965. We also find evidence that its role intensified in prefectures that experienced faster movements of labor across sectors and larger sectoral productivity gaps. (3) Finally, we label Japan's regional convergence of productivity levels as a process of "catching up, forging ahead, and falling behind". We argue that the diverse pathways of prefectural productivity catch-up are partly explained by two counter-balancing channels of growth. Since the early 1970s, the contribution of structural transformation to the convergence was frequently offset by within-sector productivity growth, which in turn thwarted the pace of convergence. These counter-balancing effects contributed to the diverse pathways of productivity catch-up at the prefecture level.

This study is related to some key areas within the broad theme of structural transformation, productivity growth and inequality. First, it contributes to a regional analysis of economic performance. There is a growing body of literature looking at regional inequality issues in Japan. Kataoka and Akita (2003), using data at the prefecture level, argue that regional inequality increased in the 1980s due to different secondary and tertiary sector inequalities in GDP per capita. On the other hand, in the 1990s regional inequalities decline to due stable employment shares in different sectors. In another study, Higashikata (2013) finds that prefectural income inequality from the 1990s to 2000s has declined, the causes being rates of TFP growth, migration between prefectures and public capital stock growth. On a similar note, Kakamu and Fukushige (2005) show that in the 1990s, despite increasing individual income inequality, interregional inequality between prefectures in fact decreased. On the other hand, Song (2015) attributes the Koizumi administration's fiscal decentralization and reforms as the cause of higher regional inequality since the early 2000s. However, historical analysis of economic performance at the prefectural level has been almost nonexistent mainly due to the data constraints[6]. Consequently, there is a knowledge gap on the pathways of regional economic performance in Japan especially in the pre-war period.

Studies on the US show a divergent trend of regional income from 1840 to 1900, and convergence thereafter (Easterlin, 1960; Williamson, 1965; Barro and Sala-i-Martin, 1992; Kim, 1998). According to Kim (1998), early dissimilarities in factor endowments led to regional specialization and divergence in industrial structures contributing to regional divergence in the late 19th century; later on as industrial structures became similar across regions it led to convergence of the capital-labor ratio. Similar trends in regional economic performance have been found in Britain (Crafts, 2005), France (Combes et al., 2011), Italy (Felice, 2011), Spain (Martinez-Galarraga Roses and Tirado, 2013) and Portugal (Baidia-Miro, Guileva and Lains, 2012). Caselli and Coleman (2001) using a two-sector (agriculture and non-agriculture) and two-region (North and South in the US) model of structural transformation, argue that as production technology in non-agriculture industries improved over time, it led to convergence of regional incomes between the North and South. This was

[6] The notable exception is a recent study by Fukao et al. (2015).

accompanied by a drop in the share of agricultural laborers as well as a decline in the cost of mobility from agriculture to non-agriculture.

This study also contributes to the literature on the role of structural transformation in productivity growth. In one of the earlier studies, Syrquin (1986) showed that about 10-30% of growth in per capita income was accounted for by a shift in the labor force from agriculture to manufacturing in the first half of the 20th century. Similar conclusions are drawn in a recent study by Timmer and de Vries (2009). They find that about 75%-79% of growth is explained by a within-sector productivity surge, possibly explained by a range of factors including capital intensity, pace of capital deepening and the total factor productivity growth (Harberger, 1998), which we purposely avoid in this study as we are primarily interested in examining the role of structural transformation. McMillan, Rodrik and Verduzco-Gallo (2014), in a recent study, argue that structural transformation may fail to provide the right kind of growth impetus for various reasons. They distinguish between growth enhancing (mostly in Asia) and growth reducing structural transformation (as seen in many countries in Africa and Latin America). They also point out that growth enhancing structural transformation may not necessarily lead to convergence if the degree and contribution of structural transformation to economic growth varies across countries (or regions).

Finally, we devote much of this study to understanding the link between structural transformation and regional income inequality over a sufficiently long period of time. This is another major contribution this study makes. The need for studies on inequality histories has been repeatedly emphasized (Williamson, 1991). In a recent analysis, Herrendorf, Rogerson and Valentinyi (2014) voice similar concerns by emphasizing the usefulness of documenting the process of structural transformation over a long period of time along with development and growth. Difficulties in putting together a long-term time series data especially at the subnational level has bottlenecked such efforts in the past. We overcome this hurdle to a considerable extent in this research.

The rest of the paper is organized as follows. In section 2 we discuss the role of structural transformation in aggregate productivity growth. We consider a simple theoretical framework, followed by a discussion on the empirical findings. Section 3 elaborates on the role of structural transformation in regional convergence in productivity. We divide this section into three parts. In the first part, we examine the pathways of regional productivity catch-up, the second part discusses productivity catch-up and regional convergence and finally in the third part, we analyze the relationship between the process of structural transformation and regional convergence in productivity. In section 4, we discuss the policy implications of the main findings. Our focus is on: firstly, the synergy between the roles of between-sector and within-sector growth; and secondly, the pathways through which structural transformation leads to regional convergence. Section 5 concludes this paper with a summary of the main themes covered here.

2. The role of structural transformation in aggregate productivity growth

As discussed at the beginning of this study, we observed diverse trends in: (1) the pace and magnitude of structural transformation; and (2) productivity catch-up to Tokyo with evidence of leapfrogging. In this section, we discuss the process of structural transformation in greater detail, and then elaborate on its contribution to productivity growth. We consider a simple framework of productivity growth decomposition, which we use in the subsequent sections to evaluate the role of structural transformation behind regional convergence in aggregate productivity.

2.1. The process of structural transformation, 1874-2008

We use a novel data set on sectoral producivity and employment on 47 Japanese prefectures and over nine benchmark years (1874, 1890, 1909, 1925, 1940, 1955, 1970, 1990 and 2008) spanning over a period of almost 135 years. The data on real aggregate labor productitivity for the period from 1874-1940 (unit:Yen) measured in 1934-36 prices and for the period from 1955–2008 (unit: 1000 Yen) measured in 2000 prices. For this reason, we do not compare the figures on productivity growth between 1940 and 1955. By-employment is considered while calculating man-hour input shares, which we use as a proxy for sectoral employment level. See Fukao et al. (2015) for a detailed discussion on the data estimation methodology[7]. While our theoretical model assumes a two-sector framework, for empirical purposes we use three sectors of production: primary, secondary and tertiary. The primary sector consists of agriculture, forestry and fishery while the secondary sector consists of mining, manufacturing and construction. The tertiary sector comprises commerce, services and other industries including transport, communications and utilities.

The process of structural transformation in Japan started during the Meiji era (1874-1909). Two early initiatives that helped reallocation of labor across sectors were the abolition of barrier stations and the caste system (hereditary status for the Samurai, farmers, merchants, craftsmen, etc.) in 1868 and granting official permission in 1872 to farmers to engage in commercial activities. At the same time, restrictions on selection of job and residence from the Tokugawa period were also removed. In the period from 1874 to 1890, the share of manufacturing activities increased in all prefectures particularly in the silk-reeling prefectures of eastern Japan (Nagano and Yamanishi). Around this time new industrialized areas arose with specializations in heavy industry, machinery and shipbuilding, etc., in Aichi, Akita, Fukuoka and Nagasaki (Fukao et al., 2015b). Later on, the turn of the twentieth century saw

[7] Detailed descriptions of data and estimation techniques are available in Fukao, Kyoji, Jean-Pascal Bassino, Tetsuji Makino, Ralph Paprzychi, Tokihiko Settsu, Masanori Takashima and Joji Tokui (2015), *Regional Inequality and Industrial Structure in Japan: 1874-2008*, Maruzen Publishing.

further expansion of high productivity manufacturing sectors mainly in the urbanized areas through a gradual diffusion of technology (Tanimoto, 1998; Nakabayashi, 2003; Tanimoto et al., 2006; Nakamura, 2010). Heavy manufacturing-based industrialization evolved with the expansion of electricity, chemicals, metals and machinery (Fukao et al., 2015b). The manufacturing sector's expansion was concentrated in the rich industrial prefectures due to the introduction of new imported technologies such as electricity (Minami, 1965) and expansion of heavy and chemical industries and increasing competition between large manufacturing firms (Nakamura, 1983). Apart from a growing emphasis on modernization through industrialization, labor productivity in agriculture was relatively higher compared to manufacturing in the Meiji era, which also helped release labor from agriculture[8].

[Figure 2.1 is about here]

However, there were factors that dampened the labor reallocation process. Conversion of dry fields to paddy fields (Fukao et al., 2015b) and opening of new foreign markets for Japanese silk and tea (Nakamura, 1983) were partly responsible for this slowdown. Saito (1998) studied 25 counties in 5 prefectures (Aichi, Niigata, Nagano, Yamanishi and Shizouka) and concluded that the level of income across peasant households wielded a decisive influence on migration as peasants were able to earn from both agriculture and cottage industries through prototype industries. For all these reasons, the labor market remained essentially fragmented until the turn of the 19th century. Other factors, such as institutional barriers related to agricultural (Hayashi and Prescott, 2008), reallocation of capital to war industries and labor to munitions (Okazaki, 2016) or cost linkages and suppliers of inputs between prefectures (Davis and Weinstein, 2001) perhaps also contributed to a relatively slow process of structural transformation. Some statistics help clarify these issues. The labor force in the primary sector

[8] This mechanism was first discussed by Baumol (1967). In more recent studies, it is labelled as the substitution effect (Rogerson, 2008; Duarte and Restuccia, 2010).

declined from 15.4 million in 1874 to 13.1 million in 1909. At the same time, the dependency ratio (proportion of non-working to working people) rose from 60% in 1874 to 92% in 1909 as a result of significant population growth from 40 million in 1874 to 49 million in 1909. Since the manufacturing and services industries absorbed most of this population expansion, these demographic shifts could have slowed down the process of structural transformation.

From the experiences of the countries that embarked on early industrialization, the typical features of structural transformation entail a steady fall in the share of employment in the primary sector (predominantly agriculture), a consistent increase in the share of employment in the tertiary sector (services) and a hump-shaped pattern in the share of employment in the secondary sector (mainly manufacturing) over time. As depicted in Figure 3.1 (Panel B), employment shares measured in terms of man-hour inputs in Japan reveal similar broad trends. Over the 135 years since 1874, the employment share in the primary sector fell from 72% to 5%, whereas in the tertiary sector it rose from 16% to 69%. During the same period, the secondary sector's employment share grew from 14%, peaked at 34% in the 1970s and then eventually dropped to 26% in 2008. The value-added trends in sectoral shares to GDP are consistent with the literature on growth and structural transformation in early industrialized coutnries[9]. McMillan, Rodrik and Verduzco-Gallo (2014) argue that the speed with which structural transformation takes place is the key factor that distinguishes leading countries from lagging countries. A similar argument can be made for the 47 prefectures in Japan. We find regional differences in economic performance as well as in the pace of structural transformation. To summarize, Japan's structural transformation, specifically the reallocation of labor from agriculture to non-agricultural sectors, follows similar trends found in other industrialized countries.

[9] See Herrendorf, Rogerson and Valentinyi (2013).

2.2. A framework linking structural transformation to productivity growth

We consider a theoretical framework to understand the role of structural transformation behind aggregate labor productivity growth across 47 Japanese prefectures over the period 1874-2008. To keep it simple, we make the following assumptions:

- A multi-sector framework, where agriculture is represented by A and non-agricultural sectors (manufacturing, services, etc.) are represented by N.
- There are only two regions, H and L. Production of A and N takes place in both regions. In the context of Japan, H can be thought of as Tokyo and L represents the other prefectures[10].
- Labor reallocates from A to N in both H and L between two points in time, t and $t+1$. θ_{kN}^{t} and θ_{kA}^{t} denote sectoral labor shares in region k and period t in non-agriculture (N) and agriculture (A), respectively. So, we can write: $\theta_{kA}+\theta_{kN}=1$. Population growth affects both θ_{kA} and θ_{kN} at the same rate.
- Define structural transformation in region k as $\Delta\theta_{kN}=\theta_{kN}^{t+1}-\theta_{kN}^{t}$ or equivalently $-\Delta\theta_{kA}$ (since, $\Delta\theta_{kA}+\Delta\theta_{kN}=0$). We are primarily interested in modeling the regional differences in the pace of structural transformation between t and $t+1$[11].
- V_{k}^{t} represents aggregate labor productivity in region k in the initial period t, and $V_{H}^{t}>V_{L}^{t}$. Using the distribution of aggregate productivity level in period t, region H is located at the top-quantile, whereas region L is located at the bottom-quantile. The productivity ranking could change in period $t+1$, and it depends on the relative regional productivity growth.
- Production of both A and N continues throughout. Sectoral value added shares of aggregate labor productivity in region k are positive and lie between 0 and 1. They are represented by V_{kN}^{t} and V_{kA}^{t} for non-agriculture (N) and agriculture (A) sectors, respectively.

[10] For empirical purposes we consider 47 regions (prefectures).
[11] While reallocation of labor has predominantly been from agriculture to non-agriculture sectors, labor reallocation within non-agricultural sectors (e.g., manufacturing to services) became prominent only in the 1990s

The aggregate labor productivity in region k can be written as the sum of sectoral labor productivity (V_{ki}) multiplied by the corresponding sectoral labor share (θ_{ki}) for any period in time, where $i \in A, N$ (equation 1)[12].

(1) $$V_k^t = \sum_{i=A,N} V_{ki}^t \theta_{ki}^t$$

A standard decomposition framework shows the aggregate labor productvity growth as the sum of two factors. First, growth in labor productivity through caiptal acumulation, technological changes or reduction in misallocation of resources between firms within a sector. Second, growth in labor productivity through labor movement from a low-productivity sector to a high-productivity sector. Following a variant of the canonical shift-share decomposition (Fabricant, 1942) methodology (de Vries et al., 2013; Foster-McGregor and Verspagen, 2016), we write changes in the aggregate labor productivity between t and $t+1$ as:

(2) $$\Delta V_k = \sum_{i=A,N}(\theta_{ki}^t)(\Delta V_{ki}) + \sum_{i=A,N}(\Delta\theta_{ki})(V_{ki}^t) + \sum_{i=A,N}(\Delta\theta_{ki})(\Delta V_{ki})$$

On the right hand side of equation (2), we have three terms. The first term shows the contribution of own-sector productivity growth. The second term displays the static effect of reallocation of labor through differences in the sectoral productivity level at the beginning of each period. And the third term measures the dynamic effect of relocation of labor through the differences in sectoral productivity growth over a period. The last two terms together measure the contribution of reallocation of labor across sectors or structural transformation to changes in aggregate labor productivity. We rewrite equation (2) as:

[12] We use a three-sector framework consisting of P (primary / agriculture), S (secondary / manufacturing) and T (tertiary / services) for our empirical analysis. In this case, equation (1) can be re-written as $V_k^t = \sum_{i=P,S,T} V_{ki}^t \theta_{ki}^t$

(3) $\Delta V_k = \Delta V_k{}^{WS} + \Delta V_k{}^{ST}$

Where $\Delta V_k{}^{WS}$ and $\Delta V_k{}^{ST}$ represent the contribution to aggregation labor productivity growth from within-sector and structural transformation, respectively.

2.3. Empirical evidence

[Figure 2.2 is about here]

2.3.1. Decomposition outcomes of annual productivity growth

Figure 2.2 (Panel A) plots the decomposition outcomes for the aggregate labor productivity growth (measured as log differences in real aggregate productivity) across the benchmark years. To obtain the annual average figures, we divide the productivity growth in each period by its length (measured in years). The detail outcomes are given in Appendix 4 (last column). The annual average labor productivity growth in the period from 1955 to 1970 outpaced growth rates in other periods (measured at roughly 6%, based on logarithmic approximation). Since the Meiji restoration in the 1860s, productivity growth followed an upward trend over the next 50 years mainly driven by industrialization and modernization in the secondary and tertiary sectors. The role of capital behind this growth surge (until 1925) is undeniable. Capital stock increased by more than 7 times between 1878 and 1940 (Nakamura, 1971). In 1874, about 74% of capital stock was in the primary sector, which dropped to nearly 17% in 1940. This fueled the remarkable growth that occurred in the secondary sector especially heavy manufacturing and related industries in the early 20th century. In addition, as argued by Nakamura (1983), the roles played by the Meiji central government and local authorities was vital, as indicated by the establishment of railway networks, modernization of maritime transportation, introduction of postal and telegraphic systems and a national bank system. The growth rate of productivity faltered in the inter-war period, 1925–40. A possible explanation for this situation could be the reallocation of capital to war industries and labor to munitions (Okazaki, 2016).

The contributions of within-sector growth and between-sector static growth to aggregate labor productivity growth (the first term in equation 2) have been positive throughout, however the magnitudes varied over time (Panel B, Figure 2.2). Until 1925, more than 80% of the productivity surge was explained by within-sector growth. The contribution of structural transformation became larger in the post-war era. In the high growth period, 1955-70, the contribution of structural transformation to annual average growth rose to about 35%. In the 1980s and 1990s, it continued to explain about one-third of the aggregate labor productivity growth. Within the contribution of structural transformation, the dynamic between-sector effect was positive in only two periods: 1909–1925 and 1955-1970.

2.3.2. Decomposition outcomes of annual productivity growth, by productivity quintiles

Next we discuss the decomposition outcomes by productivity quintiles. To understand the process of productivity catch-up, we compare the decomposition outcomes across the productivity quintiles (Panel A, Figure 2.3). The outcomes suggest that productivity catch-up became more prominent in the post-war period. Prefectures at the bottom quintile showed the highest rate of productivity growth. Structural transformation contributed to aggregate productivity catch-up in the post-war period. Productivity catch-up was evident in the phase from 1874-1890, but the relationship is unclear in the years between 1890 and 1940 (Panel B, Figure 2.3). In the first three periods - 1874-1890, 1890-1909 and 1909-1925 - the contribution of structural transformation across productivity quintiles suggests regional divergence. Overall, in the pre-war periods, the contribution from between-sector growth (structural transformation) does not indicate any clear sign of convergence whereas in the post-war period, the contribution from between-sector growth was closely linked to productivity catch-up.

[Figure 2.3 is about here]

To gain insights on productivity catch-up at a more disaggregate level, we compare the decomposition outcomes of productivity growth at the prefecture level between two periods: 1909–1925 and 1955–1970 (Figure 2.4). We consider these two periods because they are the high-growth periods in the pre-war and post-war eras, respectively. In the period from 1909–1925, the Japanese economy grew mainly based on light proto-industries, whereas from 1955-70 the emphasis shifted from light industry to heavy manufacturing industries (Fujita and Tabuchi, 1997). In Figure 2.4, prefectures in both panels are arranged in the ascending order of the base year aggregate labor productivity. The upper panel of Figure 2.4 shows labor productivity growth between 1925 and 1940 across 47 prefectures, with Okinawa placed on the far left position and Tokyo on the far right. While prefectures on average grew between 2 to 4 percent (logarithmic approximation to the actual growth rate), we do not find any sign of productivity catch-up. The highest growth in this period is achieved by Gumma. In the period from 1955–1970, the average growth rate in aggregate labor productivity almost doubled compared to 1909–1925. In this period, data is missing for Okinawa and as a consequence we plot figures for 46 prefectures. Between 1955 and 1970, Chiba experienced the highest growth rate, closely followed by Saitama whereas Tokyo's productivity growth rate was the lowest. These findings attest to the remarkable productivity catch-up during this period.

[Figure 2.4 is about here]

We summarize the main outcomes from this section. First, we find positive growth in aggregate productivity for the entire period from 1874 to 2008, whereas the productivity growth accelerated in the post-war periods. Second, on average the within-sector effect explained about two-thirds of the productivity growth, while the contribution of structural transformation surged during the post-war periods. Third, the incidence of productivity catch-up became prominent in the second-half of the twentieth century.

3. The role of structural transformation in regional convergence in productivity

As introduced earlier, the process of regional convergence in Japan gained momentum in the second half of the 20th century. The average productivity level over 46 prefectures as a percentage of Tokyo's productivity grew from 32% in 1874 to 47% in 1940 and then to almost 78% in 1970. Between 1955 and 1970, all prefectures in terms of labor productivity converged to Tokyo. Similarly, in the period from 1909 to 1925, except for Okinawa, the remaining prefectures caught up with Tokyo's level of productivity. However, the rate of productivity catch-up in 1909-1925 was less than 10% of that experienced in 1955-1970. This remarkable incidence of productivity catch-up was also associated with diverse pathways of prefectural economic performance. In this section, we use three steps to systematically understand the role of structural transformation behind regional convergence. First, we discuss the diverse pathways of regional productivity catch-up. Then we elaborate on the link between productivity catch-up and regional convergence. Finally, we discuss the role of structural transformation in the whole process of regional convergence through productivity catch-up.

3.1. Pathways of prefectural productivity catch-up

To understand the process of productivity catch-up more closely, we divide the period of analysis into two halves: pre-war (1874-1940) and post-war (1955-2008). Benchmarking

Tokyo's productivity level, we group prefectural economic performance into four broad categories: (1) sustained catch-up, (2) decline and then catch-up, (3) catch-up and then decline and finally (4) oscillatory showing no specific trends of productivity catch-up (Table 3.1). Based on the findings, there was no consistent pattern of productivity catch-up across the pre-war and post-war periods. Only three prefectures (Fukushima, Tochigi and Gifu) experienced sustained catch-up in both periods. We highlight some factors that were arguably responsible for the diverse productivity catch-up.

Following the Meiji restoration in the 1860s, the government set a number of goals under the slogan of *fukoku kyohei* (rich country, strong military) to expand productive capacity, reach full employment, and increase exports (Johnson, 1982). Structural transformation was costly as it required technology spillover, capital stock and markets for new non-agricultural industries. Nonetheless, a system of proto-industrialization[13] emerged during the Meiji period (Saito, 1983; Smith, 1988). The growing demand for Japanese products (silk, tea, etc.) in the early 20th century made it profitable for some prefectures (Gumna, Yamanishi). Big cities like Osaka, Kyoto and Tokyo benefited from it, as slow but steady growth of heavy manufacturing industries evolved around the urban periphery (Fukao et al., 2015b). Other prefectures such as Aichi, Kanagawa, Hyogo and Fukuoka followed the path of sustained catch up in the pre-war period because of their ideal location for industrialization. Since the northern part of Japan was less attractive as a sailing route, Yokohama, Kobe, Osaka, and Fukuoka became the hub of trade and commerce as prominent ports (Nakamura, 1983). For the same reasons, in the first half of the 20th century, the economic performance of some of these prefectures was adversely affected by location (Aomori, Miyazaki, Okinawa, etc.). Conversely, good location helped prefectures like Gifu to consistently perform well (Fujita and Tabuchi, 1997). In Appendix 3 we summarize these events for selected prefectures.

[13] Proto-industrialization essentially means development of rural regions in which a large part of the population lived entirely or to a considerable extent from industrial mass production for inter-regional and international markets. See Saito (1983) and Smith (1988) for how this applied to Japan.

[Table 3.1 is about here]

Another pattern of economic development appeared where there was a definite reversal of fortune. Yamaguchi had once been the most powerful domain in the Edo period, and specialized in indigenous industries (salt, pepper, wax, etc.) in the 19th century. However, with a changing economic environment and growing demand for other types of agricultural commodities, it lost its competitiveness over time. Yamanishi is another example in that it had specialized in non-rice production industries but the demand for its products declined over time. Ehime followed a similar trend and it benefited from industrial policies in the Edo period especially for its production of cheaper non-rice cereal products. As imports of rice significantly declined in the first half of the 20th century (Nakamura, 1983) due to the conversion of dry fields to paddy fields (Fukao et al., 2015b), productivity growth in Ehime like Yamaguchi and Yamanishi also gradually faltered. As a result, in the post-war period, a sizable number of prefectures (19 out of 46) followed an oscillatory productivity growth path. Some prefectures like Aomori, Nara, Chiba and Tottori had a rollercoaster ride. They experienced a sharp increase in economic performance between 1955 and 1970, but faced a downturn in the 1970s and the 1980s, and then recovered again in the period from 1990-2008. In summary, we indeed find very diverse pathways of productivity growth across prefectures. Next, using our existing framework, we establish a link between regional convergence and productivity catch-up.

3.2. Productivity catch-up and regional convergence

In sub-section 2.3.2, we briefly discussed evidence of productivity catch-up across productivity quintiles. Now, we elaborate on the relationship between productivity catch-up and regional convergence in productivity using a theoretical framework. To measure the regional disparity in aggregate labor productivity, we use the generalized Gini (also known as S-Gini) index. Following Donaldson and Weymark (1980) and Yitzhaki (1983), we write the covariance expression of the generalized Gini in period *t* as:

(4) $$G^t(x) = -x\, Cov\left(\frac{V^t}{\mu(V^t)}, [(1 - F(V^t)]^{x-1}\right)$$

where V^t represents regional aggregate labor productivity in period *t*; $F(V^t)$ represents the cumulative distribution function of $V^t$and $\mu(V^t)$ is the mean of V^t; and x shows the degree of inequality aversion. The standard Gini index is obtained when $x = 2$. With $x > 2$ a higher social weight is given to the poorer regions compared to the standard Gini index, and $x < 2$ gives a lower social weight to the poorer regions compared to the standard Gini index. Ranking of a region based on the aggregate labor productivity scale is given by $F(V^t)$, which shows the proportion of regions with aggregate productivity up to that level[14]. Changes in inequality between t and $t + 1$ can be written as:

(5) $$\Delta G(x) = G^{t+1}(x) - G^t(x).$$

Next we consider a concentration coefficient (Schechtman and Yitzhaki, 2003; Lambert, 2001), which reveals the relationship between two random variables. Unlike the Gini coefficient, which measures the cumulative proportions of a variable plotted against the cumulative frequencies of that variable, the concentration coefficient shows the degree of association between two variables, and its value lies in the range [-1, 1][15]. Using the concentration coefficient, we write a hypothetical cumulative distribution of aggregate

[14] Recall that in our simple theoretical framework, we work with only two regions, *L* and *H*.
[15] The Gini coefficient takes values in the range [0.1]. The concentration coefficient measures the cumulative proportions of one variable plotted against the cumulative frequencies of another variable.

productivity in period $t+1$ plotted against the cumulative distribution function in period t, as follows:

(6) $$C_t^{t+1}(x) = -x\, Cov\left(\frac{V^{t+1}}{\mu(V^{t+1})}, [(1-F(V^t)]^{x-1}\right).$$

$C_t^{t+1}(x)$ indicates the productivity level in period $t+1$ with the regions being arranged according to the productivity ranking of period *t*. Following the lead of Jenkins and Van Kerm (2006), we simply add and subtract equation (6) from equation (5) to obtain the following expression:

(7) $$\Delta G(x) = \left[-x\, Cov\left(\frac{V^{t+1}}{\mu(V^{t+1})}, [(1-F(V^{t+1})]^{x-1}\right)\right] - \left[-x\, Cov\left(\frac{V^{t+1}}{\mu(V^{t+1})}, [(1-F(V^t)]^{x-1}\right)\right]$$
$$+ \left[-x\, Cov\left(\frac{V^{t+1}}{\mu(V^{t+1})}, [(1-F(V^t)]^{x-1}\right)\right] - \left[-x\, Cov\left(\frac{V^t}{\mu(V^t)}, [(1-F(V^t)]^{x-1}\right)\right].$$

Equation (7) can be written as $\Delta G(x) = [G^{t+1}(x) - C_t^{t+1}(x)] + [C_t^{t+1}(x) - G^t(x)]$, which shows changes in the generalized Gini index between two periods decomposed into two factors: productivity catch-up and re-ranking of regions. The first two terms in equation (7) represent an index of mobility through re-ranking of regions in terms of the aggregate productivity level, and we call it $Rank(x)$. Similarly, the last two terms in equation (7) show regional productivity catch-up or simply productivity growth between two periods keeping the ranking of the regions same as in period *t*, we call this term $Progress(x)$. Thus, any changes in the generalized Gini index are represented as the difference between two factors, i.e., $\Delta G(x) = Rank(x) - Progress(x)$. Since equation (7) is an accounting identity, it is sufficient to analyze two of them at once. For example, considering there is no change in inequality, i.e., $\Delta G(x) = 0$, an increase in $Progress(x)$ must be matched by an equal increase in the value of $Rank(x)$.

Next, using the simple framework discussed in section 2.2, we show the ways in which disparity in regional productivity growth determine the values of $Rank(x)$, as follows:

$$
(8) \qquad Rank(x)\begin{cases} = 0 \; if \begin{cases} \Delta V_L < \Delta V_H \\ \Delta V_L = \Delta V_H \\ \Delta V_L > \Delta V_H \; and \; V_L^{t+1} < V_H^{t+1} \end{cases} \\ > 0 \; if \; \Delta V_L > \Delta V_H \; and \; V_L^{t+1} > V_H^{t+1} \end{cases}
$$

The productivity ranking of regions remains unchanged if the productivity growth is higher or equal in H compared to L. When there is productivity catch-up, i.e., $\Delta V_L > \Delta V_H$, we have two possibilities depending on the aggregate productivity ranking in the final period, $t+1$. Despite a productivity catch-up, if $V_L^{t+1} < V_H^{t+1}$, then it leaves the ranking unchanged. $Rank(x)$ takes a positive value only when the productivity catch-up alters the productivity ranking in period $t+1$, i.e., $V_L^{t+1} > V_H^{t+1}$.

$$
(9) \qquad Progress(x)\begin{cases} = 0 \; if \; \Delta V_L = \Delta V_H \\ > 0 \; if \; \Delta V_L > \Delta V_H \\ < 0 \; if \; \Delta V_L < \Delta V_H \end{cases}
$$

Disparity in regional productivity growth also determines the value of $Progress(x)$. Since $Progress(x)$ directly measures the productivity catch-up across regions, using our simple 2-region framework, it takes a positive value when $\Delta V_L > \Delta V_H$ and a negative value when $\Delta V_L < \Delta V_H$. It remains unchanged if the rate of change in the aggregate productivity level is homogenous across regions between t and $t+1$. Going one step further, O'Neill and Van

Kerm (2008) show that $\Delta G(x)$ can be interpreted as the σ-convergence and the term $Progress(x)$ can be interpreted as β-convergence[16].

3.2.1. Empirical evidence

In Appendix 2, we compare changes in the generalized Gini coefficient or different levels of x (for a value of x = 2, it indicates the standard Gini coefficient; any larger value gives greater weights to the poorer regions). Changes in the generalized Gini coefficient are consistent (in the same direction) across different values of x, except in two periods: 1874-1890 and 1925-1940. In the 1874 to 1890 period, higher weights (x > 2) to the poorer regions indicate a drop in inequality, whereas (x ≤ 2) indicates a rise in inequality. In the period from 1925 to 1940, for x = 2, this indicates a drop in inequality but for x ≥ 2, we find an increase in regional inequality in productivity. Thus higher weights to the poorer regions indicate growing disparity in regional productivity level over time. In the other five periods, 1890–1909, 1909–1925, 1955–1970, 1970–1990 and 1990–2008, the directions of changes in the Gini coefficient suggest regional convergence. Overall, it can be said that regional convergence in aggregate productivity has been the dominant trend for the entire period, from 1874 to 2008.

---

[16] In the growth literature, following Barro and Sala-i-Martin (1993), the β-convergence simply portrays the phenomenon when the poor regions grow at a faster rate compared to the rich regions. If the dispersion in the welfare measure within a group of regions or countries decreases over time, then we call it the σ-convergence. Using our framework, we spell out a possible mechanism through which productivity catch-up could be associated with regional disparity in aggregate productivity as follows:

- No β-con & no σ-con $\begin{cases} if\ \Delta G(x) = 0\ \&\ Progress(x) = 0 \\ if\ \Delta G(x) > 0\ \&\ Progress(x) < 0 \end{cases}$

- β-con, but no σ-con $if\ \Delta G(x) < 0\ \&\ Progress(x) > 0\ \&\ |Rank(x)| > |Progress(x)|$

- β-con & σ-con $\begin{cases} if\ \Delta G(x) < 0\ \&\ Progress(x) > 0\ \&\ Rank(x) = 0 \\ if\ \Delta G(x) < 0\ \&\ Progress(x) > 0\ \&\ |Rank(x)| < |Progress(x)| \end{cases}$

It reiterates the fact that the β-convergence is a necessary but not a sufficient condition for the σ-convergence to occur.

In Panel A of Table 3.2, we show the empirical outcomes of equation (7). We consider the case of only x = 2, i.e., the standard Gini coefficient of aggregate labor productivity. In the left column, the figures show changes in inequality as a percentage of the base period Gini coefficient. In the earlier sections, we discussed the incidence of productivity-catch up based on Figures 2.3 and 2.4. Now we provide a statistical estimate of the term *Progress*, which measures productivity catch-up or β-convergence. Across all periods, despite its estimated value suggesting productivity catch-up, on average the magnitude of the β-convergence in the post-war periods is much larger. In these periods, estimates suggest a 35% drop in the base year Gini coefficient, whereas the same statistic for the pre-war period is estimated to be approximately 10%. The most intense productivity catch-up experienced in the high-growth period, 1955-1970, whereas the inter-war period, 1925-1940, shows almost no productivity catch-up. On the other hand, estimates of re-ranking are also higher for the post-war era. As explained in equation (8), it could be partly driven by the significant the β-convergence also experienced in the post-war periods.

Since the sign of the σ-convergence is determined by the net effects of two factors, i.e., “Rank” and “Progress”, the β-convergence is not a sufficient condition for the σ-convergence to occur, as we discussed earlier. We find convergence in regional productivity in all periods, except for two periods: 1874-1890 and 1925-1940. Regional diversity in aggregate productivity grew in these two periods but to a negligible extent. As the estimates suggest, in both of these periods, re-ranking of regions outweighed the productivity catch-up leading to a divergence in productivity. In the pre-war periods, the rate of regional convergence was the highest in the period from 1909 to 1925. In the post-war periods, the period from 1955 to 1970 stands out, with an almost 37% drop in the Gini coefficient measured in 1955. Overall, productivity catch-up was associated with regional convergence in aggregate labor productivity, especially in the post-war periods.

[Table 3.2 is about here]

3.3. Structural transformation and regional convergence

As a next step, we link the process of structural transformation to regional inequality in productivity. We use our existing framework. From section 2.2, equation (3) shows the growth in aggregate labor productivity is decomposed into two additively separable terms: the contribution from within-sector growth and the contribution from structural transformation or between-sector growth. From equation (7), changes in the Gini coefficient measure of aggregate productivity are also additively separable into two factors, $Rank(x)$ and $Progress(x)$. As shown in equations (8) and (9), these two factors are functions of the differences in productivity growth across regions. Next, we consider two hypothetical distributions of productivity growth under the following conditions:

First, there is no contribution from the within-sector growth to aggregate productivity growth, ${\Delta V_k}^{WS} = 0$[17]. In this scenario, using equation (8) and (9), both $Rank(x)$ and $Progress(x)$ can be redefined as:

(10)
$$Rank(x)^{ST} \begin{cases} = 0 \ if \begin{cases} {\Delta V_L}^{ST} < {\Delta V_H}^{ST} \\ {\Delta V_L}^{ST} = {\Delta V_H}^{ST} \\ {\Delta V_L}^{ST} > {\Delta V_H}^{ST} \ and \ {V_L^{t+1}}^{ST} < {V_H^{t+1}}^{ST} \end{cases} \\ > 0 \ if \ {\Delta V_L}^{ST} > {\Delta V_H}^{ST} \ and \ {V_L^{t+1}}^{ST} > {V_H^{t+1}}^{ST} \end{cases}$$

and

(11)
$$Progress(x)^{ST} \begin{cases} = 0 \ if \ {V_L}^{ST} = {\Delta V_H}^{ST} \\ > 0 \ if \ {V_L}^{ST} > {\Delta V_H}^{ST} \\ < 0 \ if \ {V_L}^{ST} < {\Delta V_H}^{ST} \end{cases}$$

[17] Since equation (3) shows an accounting identity, it is possible to identify a relationship between ΔV_k and ${\Delta V_k}^{ST}$ only if we assume no within-sector growth or ${\Delta V_k}^{WS} = 0$.

where ${V_L^{t+1}}^{ST}$ and ${V_H^{t+1}}^{ST}$ are productivity levels in L and H in period $t+1$ when ${\Delta V_k}^{WS} = 0$, respectively. Thus, equations (10) and (11) are results of simply replacing ΔV_k by ${\Delta V_k}^{ST}$ from equations (8) and (9) ${\Delta V_k}^{WS}$, respectively. $Rank(x)^{ST}$ measures the re-ranking of regions when aggregate productivity growth is driven only by between-sector growth. On the other hand, $Progress(x)^{ST}$ directly measures the extent of aggregate productivity catch-up through between-sector growth.

Second, there is no contribution from the between-sector growth to aggregate productivity growth, ${\Delta V_k}^{ST} = 0$. Following equations (11) and (12), we can define $Rank(x)^{WS}$ and $Progress(x)^{WS}$.

Now, based on additively separable properties of equations (3), we can express $Rank(x)$, which measures the re-ranking of regions based on aggregate productivity growth over time, as the sum of three factors:

(12) $$Rank(x) = Rank(x)^{ST} + Rank(x)^{WS} + \varphi^{Rank}$$

where φ^{Rank} denotes adjustment error[18]. In a similar way, we can write:

(13) $$Progress(x) = Progress(x)^{ST} + Progress(x)^{WS} + \varphi^{Progress}.$$

Using equations (12) and (13), equation (7) can be rewritten as:

[18] This can be thought as equivalent to an adjustment error in a standard shift-share decomposition.

(14) $$\Delta G(x) = Rank(x)^{ST} - Progress(x)^{ST} + Rank(x)^{WS} - Progress(x)^{WS} + \varphi^{Rank} - \varphi^{Progress}.$$

Equation (14) decomposes the changes in the Gini coefficient of productivity further into the contributions from structural transformation and within-sector growth with an adjustment error factor[19]. If the adjustment error is negligible, then the first two terms in equation (14) provide an estimate of the contribution of structural transformation in regional convergence in productivity.

3.3.1. The contribution of structural transformation to productivity convergence

Panel B of Table 3.2 shows the Gini decomposition outcomes for the between-sector growth. The estimates of "Progress" indicate the β-divergence in the pre-war period and the β-convergence in the post-war period. The estimates of re-ranking show slightly higher values in the post-war period compared to the pre-war period. The outcomes on the regional convergence closely follow the productivity-catch up trend. Following β-divergence, we find evidence for the σ-divergence in the periods until 1940 and σ-convergence from 1955 onwards. Between 1955 and 1970, structural transformation-led growth alone contributed to almost 30% drop in the Gini coefficient of aggregate productivity measured in 1955. In Panel C of Table 3.2, we present the Gini decomposition outcomes for within-sector component of aggregate growth. The findings suggest productivity catch-up through within-sector productivity growth in all periods. However, compared to between-sector growth, a reverse trend is indicated. The level of productivity catch-up was much higher in the pre-war periods through within-sector productivity growth. At the same time, within-sector productivity growth led to regional convergence in all periods except the period from 1970 to 1990.

[19] In Appendix 7 we show that the distribution of the adjustment term is close to zero except in a few periods.

We summarize the main outcomes. Two diverse trends of regional convergence are visible. In the pre-war periods, the regional convergence in aggregate productivity was mainly driven by within-sector productivity growth. From 1874 to 1940, the role of between-sector productivity growth (structural transformation) was outweighed by the within-sector productivity growth in favor of convergence. In contrast, in the post-war periods, regional convergence was primarily driven by the between-sector productivity growth and except for the period between 1970 and 1990, its role in regional convergence is reinforced by the within-sector productivity growth. Out of the seven periods we study, these two forces lead to regional convergence by reinforcing each other's contributions only in 1955–1970 and 1990–2008. We discuss this issue in greater detail in the next section.

4. Discussions

4.1. Synergy between the roles of within-sector and between-sector growth

McMillan, Rodrik and Verduzco-Gallo (2014) argue that growth enhancing structural transformation may not necessarily lead to convergence if the degree and contribution of structural transformation to economic growth varies from region to region. Estimated statistical figures on the role of structural transformation in regional convergence as discussed in the previous section suggest similar evidence. In addition to the varying degree and contribution of structural transformation, we also find evidence of the counter-balancing effects between the contributions from between-sector growth and within-sector growth. We analyze the implications of it for region-specific trends in productivity growth using a more disaggregated dataset on the annual figures of sectoral productivity and employment levels available for the post-war period, 1955–2008. For convenience we divide it into eleven sub-periods. Figure 4.1 shows the estimated outcomes on *Progress*, *Rank* and changes in the Gini coefficient in the top, middle and the bottom panels, respectively. For each sub-period, we compare the contributions from within-sector growth and between-sector growth to *Progress*, *Rank* and changes in the Gini coefficient (measured as a percentage of the Gini coefficient of aggregate productivity in the base year of each period). We find that the pace of regional convergence slowed down between 1965 and 1990, after it gained momentum. Two possible explanations. On one hand, the degree of productivity catch-up became smaller as the contributions from the two growth components counter-balanced each other. On the other, the estimated value of *Rank* grew in this period with contributions from both components of growth. However, since the early 1990s the magnitude of contributions of both between-sector growth and within-sector growth to regional convergence became smaller[20].

[Figure 4.1 is about here]

To understand the implications of these growth outcomes at the prefecture level, we focus on three adjacent periods: 1960–1965, 1965–1970 and 1970–1975. The period from 1960–1965 shows regional convergence and in this period contributions from both growth components move in the same direction. Between 1965 and 1970, regional divergence occurs as within-sector growth offsets and outweighs the between-sector growth effect. The period from 1970 to 1975 again shows quite different outcomes, regional divergence but between-sector growth playing a dominant role. Despite the annual productivity growth averaging at around 6% throughout these periods, convergence occurred only in 1960–1965. Also, the average contribution of structural transformation to productivity growth was around 35% of aggregate productivity growth. It was, however, associated with productivity catch-up only in the period between 1960 and 1969. How are prefectural growth experiences linked to these outcomes?

[20] High fertility rate in the mid-1950s produced new workers in the late 1960s and reallocation of factories to the nearby prefectures of urban peripheries became more common compared to reallocation of labor from the rural areas to the urban industrial hubs. Reallocation of factories to prefectures like Chiba, Kagawa, Mie was also partly driven by government regulations to curb the growth air and water pollution level in the industrial belts. All these factors were responsible for the transformation of Osaka-Tokyo industrial hub to Pacific Industrial belt system (Fujita and Tabuchi, 1997). The reversal of fortune also partly explains the sluggish growth for some prefectures that were primarily dependent on chemical and oil industries.

We compare growth performance of the leaders (Chiba, Kagawa, Mie, Saitama and Tochigi) versus the followers (Akita, Kyoto, Saga, Shizuoka and Tottori). The leaders sustained leapfrogging (with an average growth rate around 9%), whereas the followers failed to catch up with the rest (with an average growth rate around 5-6%). In Table 4.1, the first column shows the average annual aggregate productivity growth between 1960 and 1974. Chiba was clearly an outlier with its remarkable productivity growth being approximately 10%. The average contribution of structural transformation to productivity growth was higher for the leaders compared to the followers. This supports the role played by between-sector growth in productivity catch-up, especially in the 1960s. Thus a higher contribution of structural transformation helps in productivity catch-up even though it does not necessarily lead to convergence. For the next step, we find the mechanisms through which structural transformation contribute to aggregate productivity growth.

[Table 4.1 is about here]

4.2. Mechanisms of structural transformation

Using our existing theoretical framework, we analyze the mechanisms that underpin the changes in the contribution of structural transformation to regional convergence through productivity growth. From equation (2) in section 2.2, we can write the contribution of structural transformation to aggregate productivity level as $\Delta V_k{}^{ST} = \sum_{i=A,N}(\Delta\theta_{ki})(V_{ki}^{t}) + \sum_{i=A,N}(\Delta\theta_{ki})(\Delta V_{ki})$. After some simple algebraic calculation, between-sector effect can be written as a product of two factors: firstly, changes in the share of employment in the non-agricultural sectors; and secondly, the sectoral productivity gap.

(15) $\Delta V_k{}^{ST} = (\theta_{kN}^{t+1} - \theta_{kN}^{t})(V_{kN}^{t+1} - V_{kA}^{t+1})$[21]

or $\Delta V_k{}^{ST} = (\Delta\theta_{kN})(PG_k)$

PG_k represents the gap in the aggregate labor productivity between non-agricultural and agricultural sectors in region k. Thus the direction of the changes in the contribution of structural transformation depends on the product of the level of structural transformation and productivity gap in the final period. If both factors move in the same direction, then the process of structural transformation makes a positive contribution to the aggregate productivity level. To put it differently, reallocation of laborers from agriculture to non-agriculture leads to aggregate productivity gain when the labor productivity in non-agriculture sector is higher than that in the agriculture sector[22]. However, structural transformation from agriculture to non-agriculture might reduce the aggregate labor productivity level if labor productivity in the agricultural sector is higher than in the non-agricultural sectors. If the productivity gap becomes zero, or there is no sectoral difference in labor productivity then labor reallocation does not lead to any gain or loss in aggregate productivity. On the basis of equation (15), we can write the conditions on the partial relationship between the process of structural transformation and productivity catch-up (the β -convergence) and regional convergence (the σ-convergence), holding the contribution of within-sector effect constant.

[1] The between-sector growth (contribution of structural transformation) is associated with productivity catch-up (the β convergence) if $(\Delta\theta_{LN})(PG_L) > (\Delta\theta_{HN})(PG_H)$.

Using equation (14), we can rewrite equation (11) as follows:

[21] For a three sector model, with P (primary), S (secondary) and T (tertiary) sectors, equation (15) for region k can be written as $\Delta V_k{}^{ST} = (\theta_{kT}^{t+1} - \theta_{kA}^{t})(V_{kT}^{t+1} - V_{kA}^{t+1}) + (\theta_{kS}^{t+1} - \theta_{kN}^{t})(V_{kS}^{t+1} - V_{kA}^{t+1})$. We assume that reallocation of labor takes place from P to S and P to T.

[22] Equation (15) supports the contention that changes in aggregate labor productivity are associated with reallocation of labor from a low-productivity to a high-productivity sector in the presence of sectoral productivity differences (Kuznets, 1955).

$$Progress\ (\beta \text{ convergence}) \begin{cases} = 0\ if\ \ (\Delta\theta_{LN})(PG_L) = (\Delta\theta_{HN})(PG_H) \\ > 0\ if\ \ (\Delta\theta_{LN})(PG_L) > (\Delta\theta_{HN})(PG_H) \\ < 0\ if\ \ (\Delta\theta_{LN})(PG_L) < (\Delta\theta_{HN})(PG_H) \end{cases}$$

The second condition suggests that poor regions catch up with the rich regions when $(\Delta\theta_{LN})(PG_L) > (\Delta\theta_{HN})(PG_H)$. Next we write down the conditions pertaining to regional convergence.

[2] The between-sector growth (contribution of structural transformation) is associated with regional divergence in aggregate productivity (the σ divergence) if one of the following conditions is met:

(1) $\dfrac{(\Delta\theta_{LN})(PG_L)}{(\Delta\theta_{HN})(PG_H)} > 1$

(2) $\dfrac{(\Delta\theta_{LN})(PG_L)}{(\Delta\theta_{HN})(PG_H)} < 1\ \&\ |\ Rank^{ST}(x)| > |Progress^{ST}(x)|$

[3] The between-sector growth (contribution of structural transformation) is associated with regional convergence (the σ convergence) if one of the following conditions is met:

(1) $\dfrac{(\Delta\theta_{LN})(PG_L)}{(\Delta\theta_{HN})(PG_H)} > 1\ \&\ |\ Rank^{ST}(x)| = 0$

(2) $\dfrac{(\Delta\theta_{LN})(PG_L)}{(\Delta\theta_{HN})(PG_H)} < 1\ \&\ |\ Rank^{ST}(x)| > |Progress^{ST}(x)|$

From equations (7), (8) and (9) and (15), it is straightforward to prove statements [2] and [3].

4.2.1. Empirical Findings

The last three columns of Table 4.1 show empirical evidence on the mechanisms of structural transformation at the prefecture level[23]. In the third last column, we report percentage point changes in employment shares in the primary sector. The outcomes suggest that on average the pace of reallocation of labor from the agriculture sector was higher for the leaders (20 pp) compared to the followers (12 pp). Based on condition [1], this could be directly linked to a higher contribution of structural transformation to aggregate productivity growth even in the absence of a sectoral productivity gap. We compare the productivity gap between the tertiary and primary sectors (column 9) and the same between the secondary and primary sectors (the last column). On average the productivity gap between the tertiary sector and primary sector was higher for the leaders (3.36) compared to followers (2.98). Similarly, the productivity gap between the secondary sector and primary sector was higher for the leaders (2.25) compared to the followers (1.78). From these findings, we can conclude that pace of labor reallocation and sectoral productivity gap are closely related to the differences in the contribution of structural transformation to aggregate productivity growth.

5. Conclusion

This study attempts to understand the pathways of regional productivity growth, catch-up and convergence in Japan and how the process of structural transformation is associated with them. We use a novel sectoral value-added and employment data for nine benchmark years spanning a period of nearly 135 years, from 1874 to 2008. We provide evidence that the process of structural transformation in Japan follows similar trends found in other industrialized countries. The main outcomes suggest diverse trajectories of prefectural economic performance. We find positive growth in aggregate productivity for the entire period from 1874 to 2008, while the growth rate was much stronger in the post-war periods.

[23] For this reason, we only discuss the empirical evidence on condition [1] here. Empirical evidence on conditions [2] and [3] are provided in section 3.3.3.

On average, the within-sector effect explained about two-thirds of the productivity growth, while the contribution of structural transformation improved in the second-half of the twentieth century. In general, the contribution of structural transformation to both aggregate productivity catch-up and regional convergence heightened during the post-war periods; in particular, in the high-growth era of 1955-1965. Additionally, we also find that a higher contribution of structural contribution to aggregate productivity growth could lead to productivity catch-up but it does not necessarily lead to regional convergence in productivity. Since the early 1970s, the contribution of structural transformation to convergence was often curbed by within-sector productivity growth. Consequently, it slowed down the pace of regional convergence. At the prefecture level, the contribution of structural transformation to aggregate productivity growth became larger in the presence of faster structural transformation and a larger sectoral productivity gap.

In this study, we purposely restrict our analysis to structural transformation as a possible explanation of the regional convergence in productivity levels. However, the role of capital deepening and the total factor productivity growth, among others, are equally important. We find that within-sector growth on average explains about two-thirds of aggregate productivity growth. Regional data on these factors are unavailable from 1874 to 1955, and it bottlenecks the possibilities of examining the role these factors in the convergence process. At the same time, while we discuss the mechanisms of structural transformation through the pace of labor reallocation and sectoral productivity gap, we do not study the economic factors that could influence the pace of structural transformation or contribute to the sectoral productivity gaps. In a recent study, Herrendorf, Herrington, and Valentinyi (2015) find that differences in technical progress across sectors constitute the dominant force behind structural transformation whereas other differences across sectoral technology are of second order importance. In the context of regional economic performance in Japan, it is imperative that we understand the forces behind the diverse processes of structural transformation across prefectures. We take this task up in our next study.

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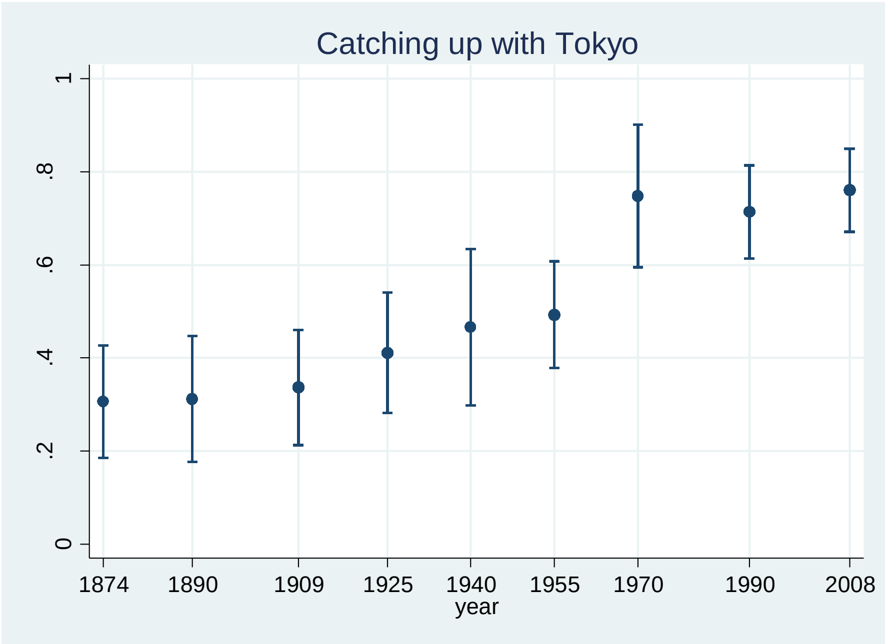
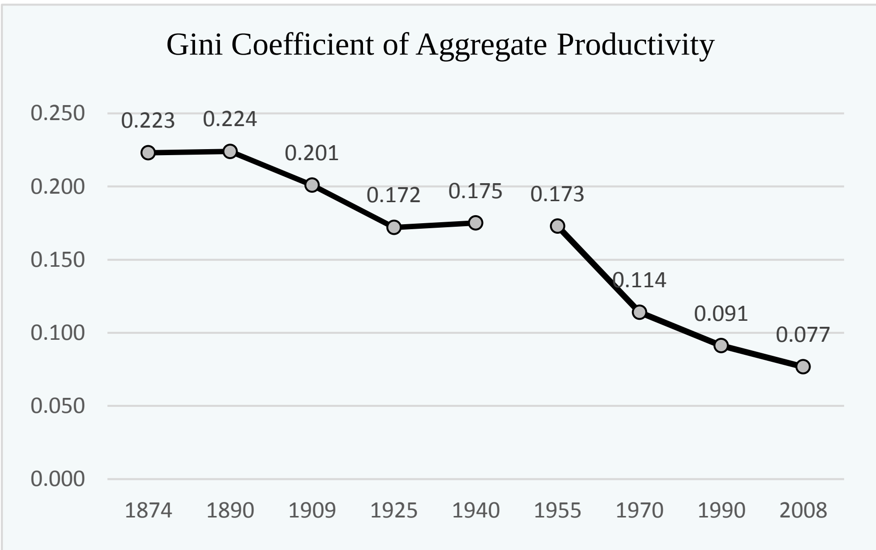


A. Average prefectural aggregate labor productivity (relative to Tokyo)

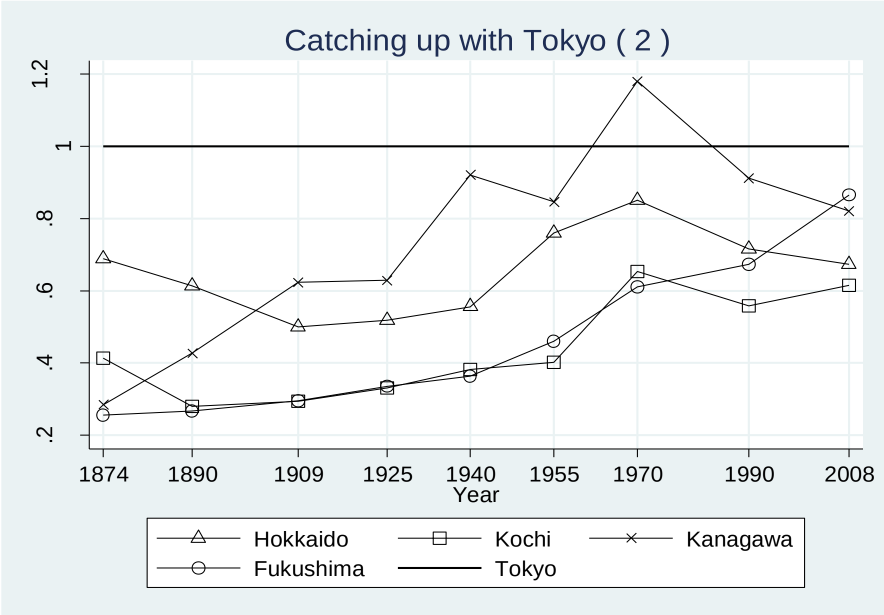
Note: The scattered points indicate the average labor productivity measured as a percentage of that of Tokyo. The vertical range indicates the spread (2 standard deviations) around the mean.



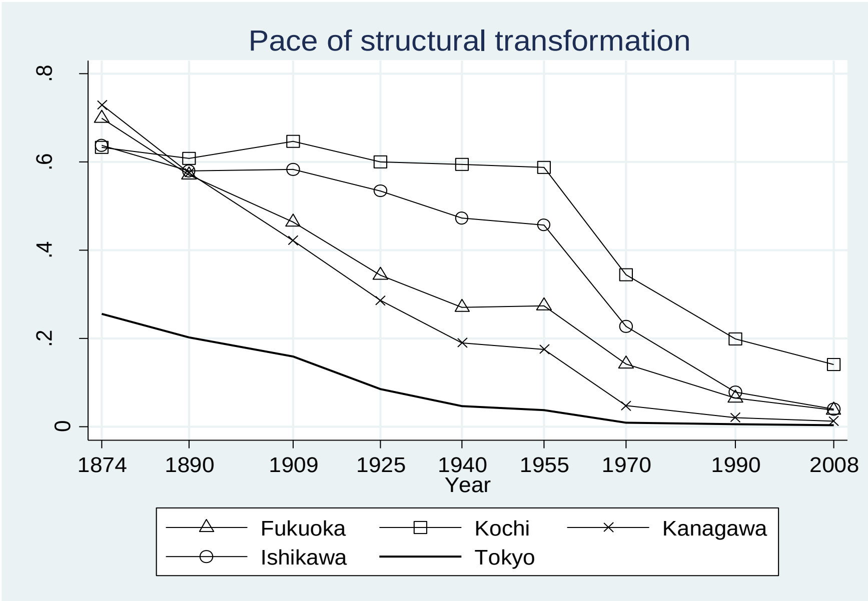
B. Regional disparity in aggregate labor productivity

Figure 1.1 Convergence of aggregate labor productivity, 1874-2008

Note: In both figures, real GDP figures are used with constant prices at 1934-36 average prices for the period from 1874-1940 (unit: yen) and constant prices at 2000 for the period from 1955-2008 (unit: million yen).



A. Labor productivity (relative to Tokyo) in some prefectures, 1874-2008

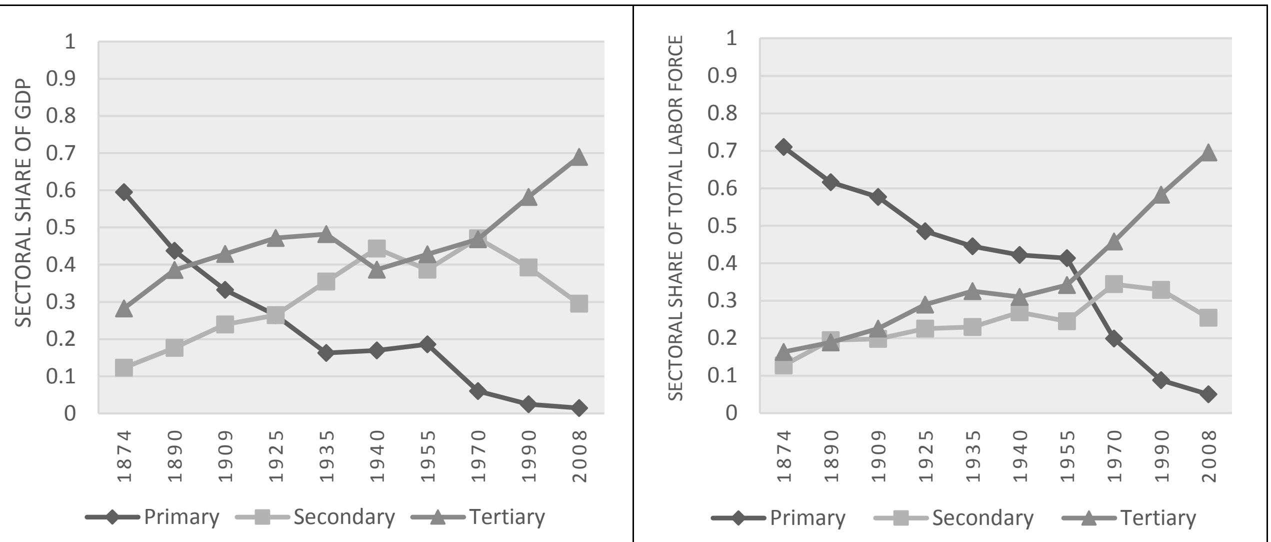


B. Employment share in primary scetor in some prefectures, 1874-2008

Note: By-employment is considered while calculating man-hour input shares. See Fukao et al. (2015) for a detailed discussion on the data estimation methodology. The primary sector consists of agriculture, forestry and fisheries.

Figure 1.2 Convergence and Structural Transformation in some prefectures

Note: In both figures, real GDP figures are used with constant prices at 1934-36 average prices for the period from 1874-1940 (unit: yen) and constant prices at 2000 for the period from 1955-2008 (unit: million yen).



A: Value-added shares

B: Man-hour input shares

Figure 2.1: Structural Transformation in Japan

Note: By-employment is considered while calculating man-hour input shares. See Fukao et al. (2015) for a detailed discussion on the data estimation methodology. In both figures, real GDP figures are used with constant prices at 1934-36 average prices for the period from 1874-1940 (unit: yen) and constant prices at 2000 for the period from 1955-2008 (unit: million yen).

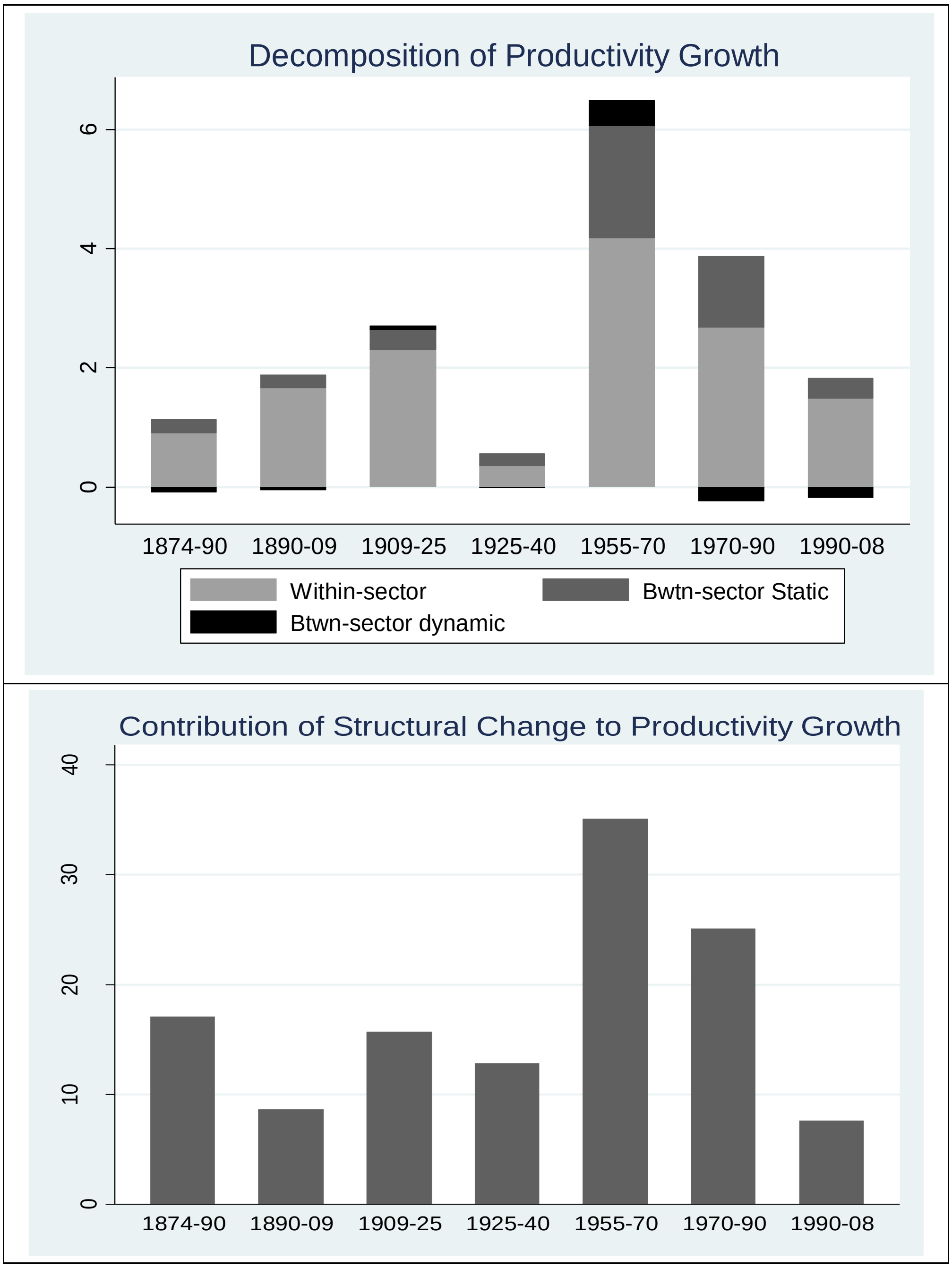


Figure 2.2 Decomposition of Aggregate Labor Productivity Growth (Annual)

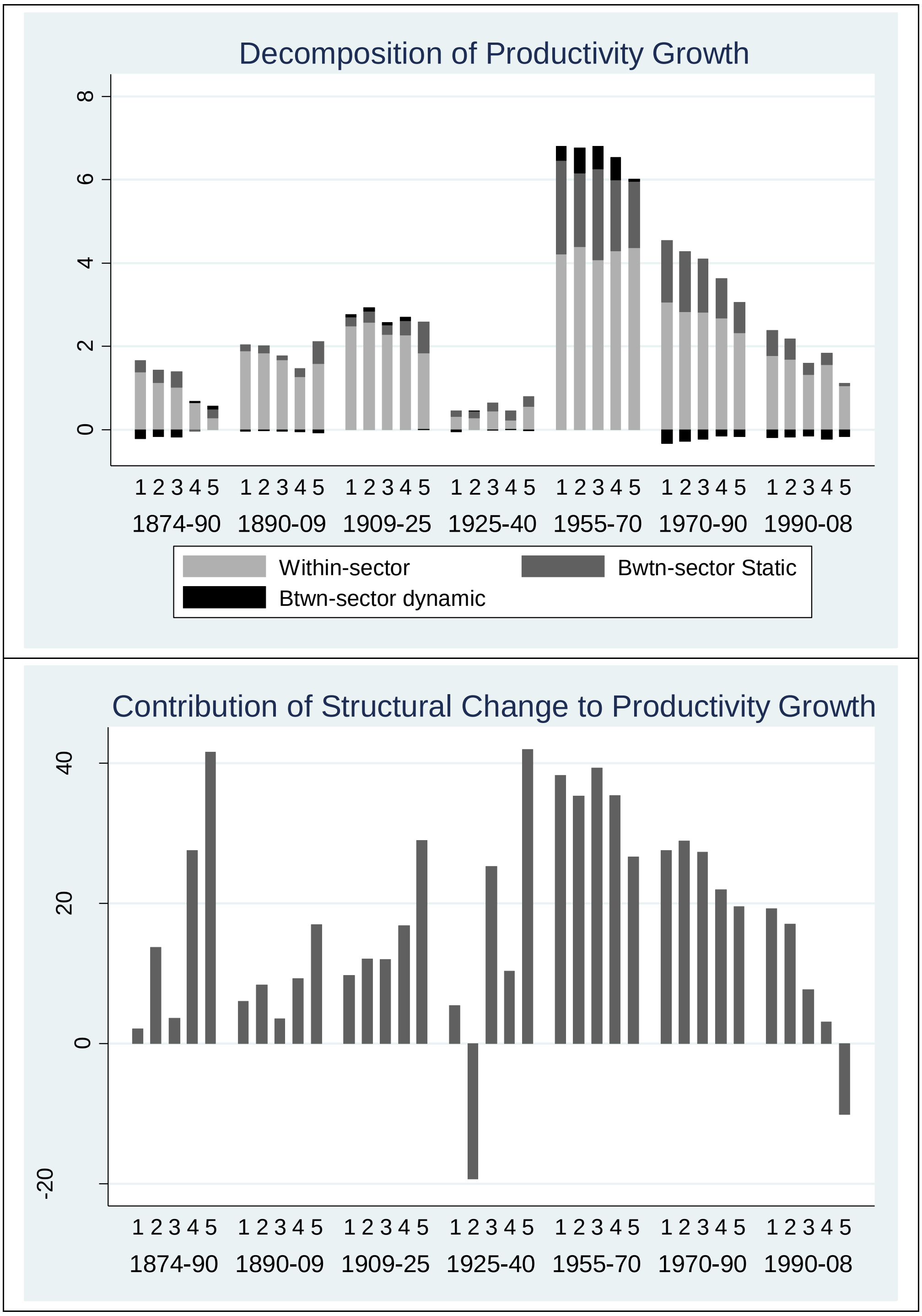


Figure 2.3. Decomposition of aggregate labor productivity growth by income quintiles

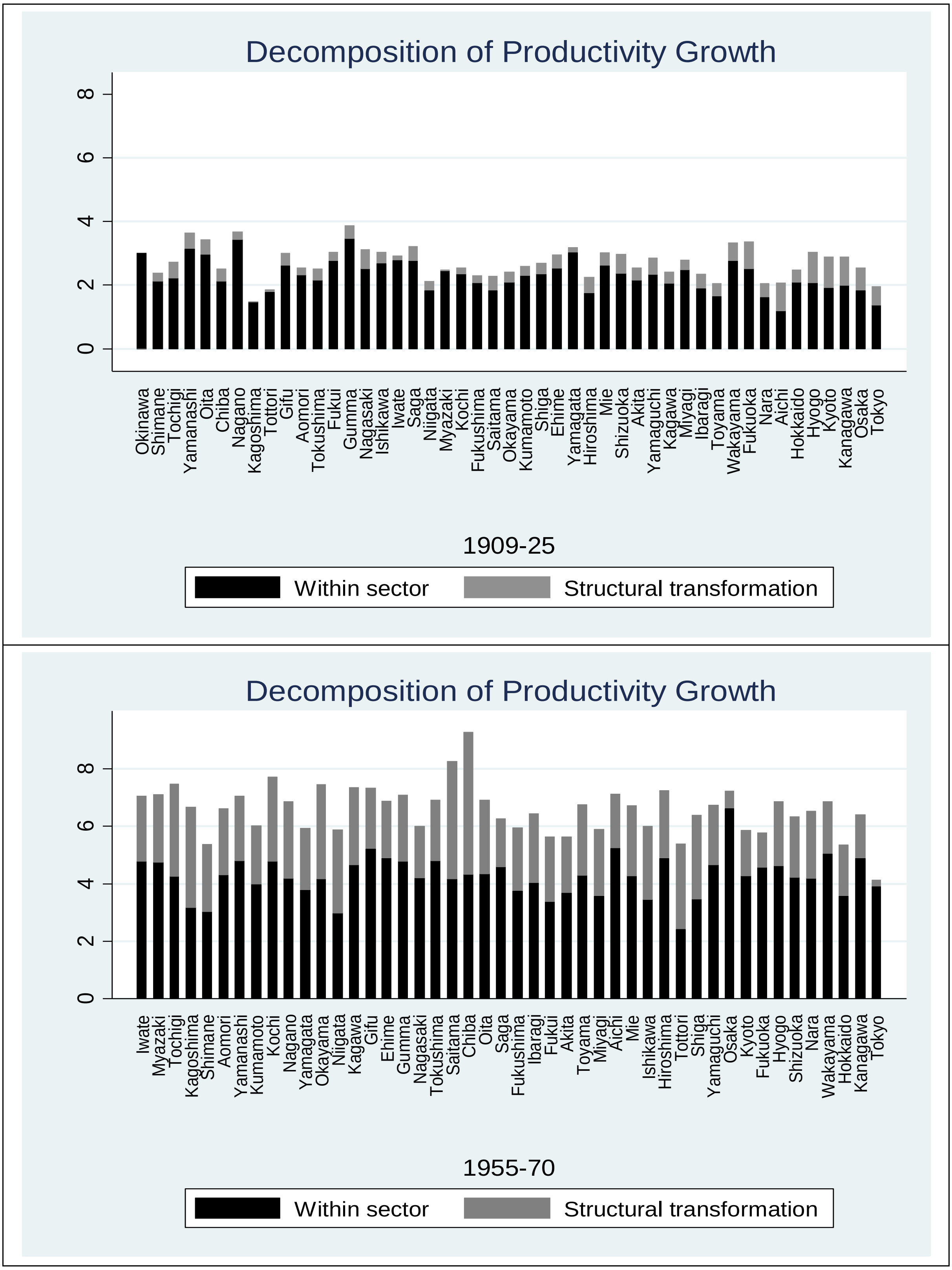


Figure 2.4 Decomposition of aggregate labor productivity growth by prefectures

Note: prefectures are ranked in ascending order based on initial year's productivity level

Table 3.1. Pathways of Catching-up

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="5">1940-2008</td></tr>
<tr><td>Sustained catch-up</td><td>Decline then catch-up</td><td>Catch-up then decline</td><td>Oscilatory</td><td>Total</td></tr>
<tr><td rowspan="5">1874-1940</td><td>Sustained catch-up</td><td>7 Fukushima
8 Tochigi
21 Gifu</td><td>15 Niigata
23 Aichi</td><td>5 Akita
12 Chiba
29 Nara
31 Tottori
34 Hiroshima
44 Oita</td><td>3 Iwate
14 Kanagawa
16 Toyama
28 Hyogo
40 Fukuoka
43 Kumamoto
45 Myazaki</td><td>18</td></tr>
<tr><td>Decline then catch-up</td><td>18 Fukui
25 Shiga
32 Shimane</td><td></td><td>1 Hokkaido
11 Saitama
22 Shizuoka
24 Mie
30 Wakayama
36 Tokushima
39 Kochi</td><td>33 Okayama
35 Yamaguchi
37 Kagawa
38 Ehime
42 Nagasaki</td><td>15</td></tr>
<tr><td>Catch-up then decline</td><td>9 Ibaragi
20 Nagano</td><td></td><td>4 Miyagi</td><td></td><td>3</td></tr>
<tr><td>Oscilatory</td><td>10 Gumma
17 Ishikawa
19 Yamanashi
46 Kagoshima</td><td></td><td>2 Aomori
6 Yamagata
41 Saga</td><td>26 Kyoto
27 Osaka
47 Okinawa</td><td>10</td></tr>
<tr><td>Total</td><td>12</td><td>2</td><td>17</td><td>15</td><td>46</td></tr>
</table>

Table 3.2 Evidence on Productivity catch-up and convergence

	Change in S-Gini (x=2)	Rank	Progress	β-convergence	σ-convergence
A. Decomposition outcomes for aggregate labor productivity growth					
1874 - 1890	0.5	9.3	8.8	Yes	No
1890 - 1909	-11.6	3.7	15.4	Yes	Yes
1909 - 1925	-14.4	3.2	17.6	Yes	Yes
1925 - 1940	1.3	5.4	4.1	Yes	No
1955 - 1970	-36.8	11.6	48.4	Yes	Yes
1970 - 1990	-19.5	12.5	32	Yes	Yes
1990 - 2008	-14.1	19	33.2	Yes	Yes
B. Decomposition outcomes for the contribution of structural transformation to aggregate labor productivity growth					
1874 - 1890	6.9	1.2	-5.7	No	No
1890 - 1909	4.1	0.5	-3.6	No	No
1909 - 1925	4.7	0.3	-4.4	No	No
1925 - 1940	16	3.5	-12.6	No	No
1955 - 1970	-29.9	8.3	38.2	Yes	Yes
1970 - 1990	-25.9	2.9	28.7	Yes	Yes
1990 - 2008	-15.5	0.6	16	Yes	Yes
C. Decomposition outcomes for the contribution of within-sector aggregate labor productivity growth					
1874 - 1890	-8	9.2	17.2	Yes	Yes
1890 - 1909	-15.2	3.6	18.8	Yes	Yes
1909 - 1925	-18.1	3.8	21.9	Yes	Yes
1925 - 1940	-3.2	15.3	18.5	Yes	Yes
1955 - 1970	-0.1	8	8.1	Yes	Yes
1970 - 1990	10	11.8	1.9	Yes	No
1990 - 2008	-3.3	13.8	17.2	Yes	Yes

Note: All figures are given as a percentage of initial S-Gini

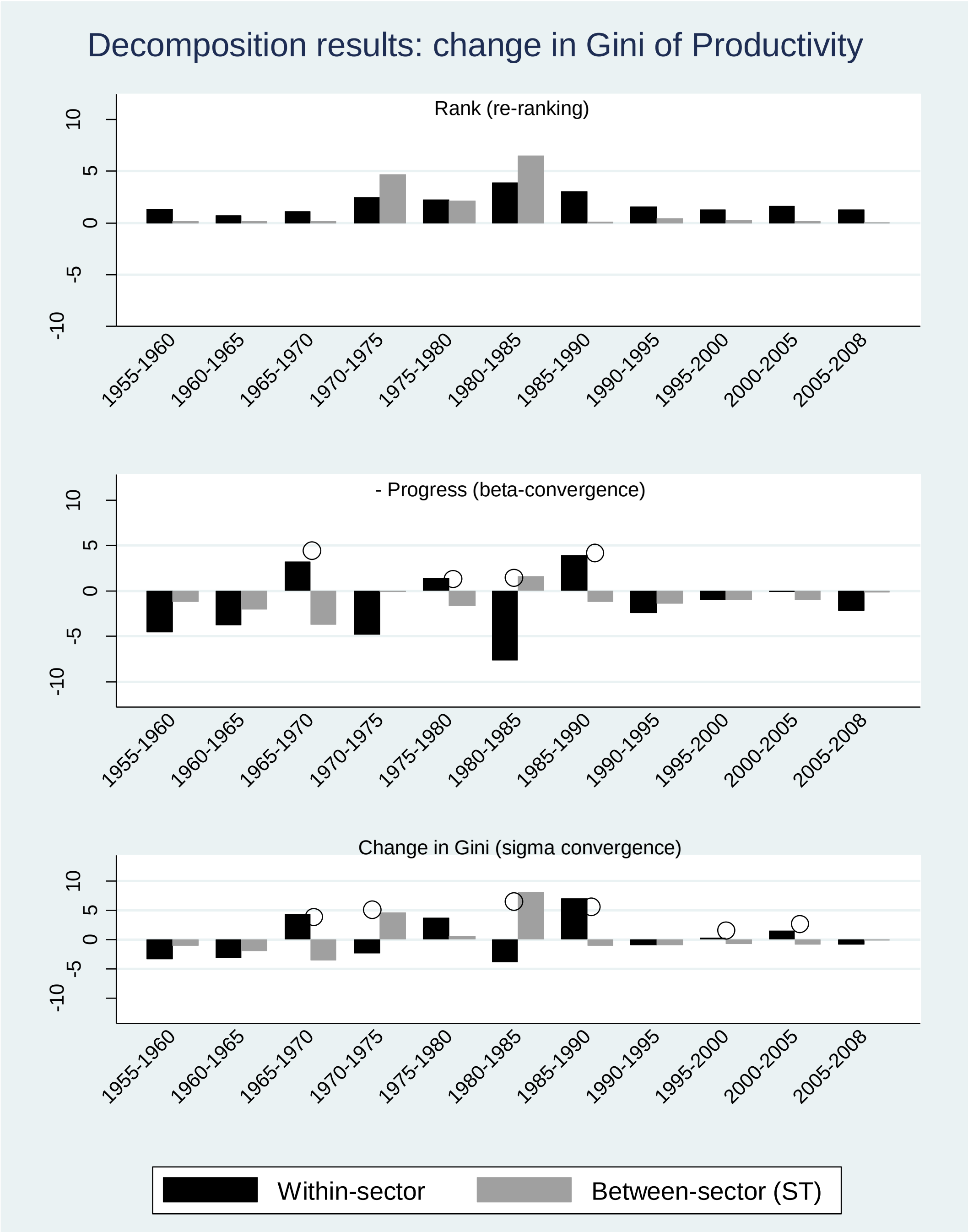


Figure 4.1 Decomposition of changes in the Gini coefficient of aggregate productivity: 1955-2008

Note: Marked years indicate the contributions of the within-sector and between-sector effects moving in the opposite directions.

Table 4.1 Evidence on the mechanisms of structural transformation

	Average Growth (1960 - 1975)	Within-sector growth			Between-sector growth			Δ in primary emp (pp)	Prod gap (T - P)	Prod gap (S - P)
		1960 - 1965	1965 - 1970	1970 - 1975	1960 - 1965	1965 - 1970	1970 - 1975			
Leaders										
Chiba	9.96	6.76	6.71	3.62	4.97	4.71	3.09	-0.24	3.70	4.26
Kagawa	7.80	5.44	6.51	4.76	2.04	2.28	2.38	-0.17	2.89	1.70
Mie	6.97	5.51	6.82	2.02	1.73	2.23	2.62	-0.16	3.39	2.40
Saitama	7.87	5.67	7.15	2.04	3.20	3.01	2.54	-0.19	3.48	1.55
Tochigi	7.50	5.42	5.67	3.55	2.28	2.63	2.95	-0.20	3.35	1.34
Followers										
Akita	5.40	4.71	2.39	3.47	2.18	1.60	1.85	-0.14	2.95	2.12
Kyoto	5.66	4.40	6.76	2.84	1.13	0.93	0.93	-0.07	2.91	1.56
Saga	5.98	6.14	3.43	4.12	1.28	1.47	1.49	-0.12	2.72	1.24
Shizuoka	4.99	3.57	4.80	2.17	1.69	1.42	1.33	-0.12	3.35	1.57
Tottori	5.62	2.03	4.13	3.86	2.82	2.31	1.70	-0.16	2.99	2.14

Appendix 1 Ranking of Prefectures based on real aggregate labor productivity

Prefecture	1874	1890	1909	1925	1935	1940	1955	1970	1990	2008
Aichi	28	12	7	10	8	8	17	12	7	5
Akita	41	29	16	24	27	29	20	35	39	25
Aomori	19	13	37	39	45	44	41	37	45	44
Chiba	47	45	42	43	41	45	26	3	4	22
Ehime	21	32	21	21	19	14	31	28	30	37
Fukui	8	17	35	32	20	25	21	38	21	9
Fukuoka	13	8	9	6	4	4	8	17	20	33
Fukushima	31	27	26	35	39	35	23	40	31	7
Gifu	42	37	38	36	30	26	32	27	23	32
Gumma	20	36	34	14	35	32	30	33	25	30
Hiroshima	34	34	19	28	15	13	14	10	8	8
Hokkaido	3	3	6	7	12	10	3	11	24	39
Hyogo	7	5	5	3	5	5	7	7	5	17
Ibaragi	33	15	12	23	26	31	22	26	12	6
Ishikawa	25	18	32	26	23	20	15	21	18	21
Iwate	30	30	31	31	28	19	46	44	46	43
Kagawa	12	21	14	22	21	16	33	20	22	29
Kagoshima	32	42	40	46	46	46	43	45	42	36
Kanagawa	23	6	3	5	3	3	2	1	2	12
Kochi	6	24	27	37	34	33	38	31	47	46
Kumamoto	35	22	23	19	29	28	39	39	38	40
Kyoto	4	4	4	4	6	6	9	13	16	19
Mie	17	20	18	12	17	23	16	9	11	2
Miyagi	29	26	13	17	33	34	18	23	29	31
Myazaki	26	23	28	30	22	21	45	42	43	45
Nagano	45	41	41	29	44	38	37	34	36	18
Nagasaki	14	19	33	15	18	18	29	41	41	42
Nara	11	7	8	8	10	11	5	8	9	34
Niigata	39	33	29	38	24	24	34	32	35	28
Oita	44	43	43	34	31	30	25	22	28	20
Okayama	27	31	24	33	16	22	35	18	17	23
Okinawa	38	47	47	47	47	47	n.a.	n.a.	33	47
Osaka	2	2	2	2	1	1	10	4	6	15
Saga	22	16	30	20	25	27	24	30	37	27
Saitama	24	35	25	42	40	39	27	19	19	38
Shiga	9	14	22	25	11	15	12	14	3	3
Shimane	40	46	46	41	36	40	42	46	40	41
Shizuoka	36	39	17	13	14	17	6	15	14	4
Tochigi	43	44	45	44	43	42	44	29	15	10
Tokushima	10	28	36	40	32	36	28	24	32	13
Tokyo	1	1	1	1	2	2	1	5	1	1
Tottori	46	38	39	45	42	41	13	25	34	24
Toyama	16	11	11	18	13	9	19	16	13	16
Wakayama	5	9	10	9	9	12	4	2	26	35
Yamagata	18	10	20	16	38	43	36	43	44	26
Yamaguchi	15	25	15	11	7	7	11	6	10	11
Yamanashi	37	40	44	27	37	37	40	36	27	14

Appendix 2

		x=1.5	**x=2 (Standard Gini)**	x=2.5	x=3	x=3.5	x=4
1874 - 1890	Change	1.7	0.5	-0.8	-1.8	-2.7	-3.3
	Rank	8.3	9.3	9.6	9.5	9.3	9.1
	Progress	6.6	8.8	10.3	11.3	12	12.4
1890 - 1909	Change	-12.1	-11.6	-11.4	-11.3	-11.4	-11.5
	Rank	3.4	3.7	3.9	4	4	3.9
	Progress	15.4	15.4	15.3	15.3	15.3	15.4
1909 - 1925	Change	-15.9	-14.4	-13.1	-12	-11	-10.1
	Rank	2.4	3.2	4	4.7	5.4	6.1
	Progress	18.3	17.6	17	16.7	16.4	16.3
1925 - 1940	Change	-0.8	1.3	3.2	4.5	5.3	5.7
	Rank	5.7	5.4	5.6	5.8	6	6
	Progress	6.5	4.1	2.4	1.3	0.7	0.3
1955 - 1970	Change	-39.3	-36.8	-34	-31.6	-29.6	-28
	Rank	12.9	11.6	11.1	10.9	10.8	10.6
	Progress	52.2	48.4	45.2	42.5	40.4	38.7
1970 - 1990	Change	-20.6	-19.5	-19.4	-19.4	-19.3	-19.1
	Rank	15.5	12.5	10.1	8.6	7.8	7.3
	Progress	36.1	32	29.5	28	27	26.4
1990 - 2008	Change	-12.7	-14.1	-15.4	-16.4	-17.3	-18
	Rank	18.3	19	19.1	18.9	18.6	18.4
	Progress	31	33.2	34.5	35.3	35.9	36.4

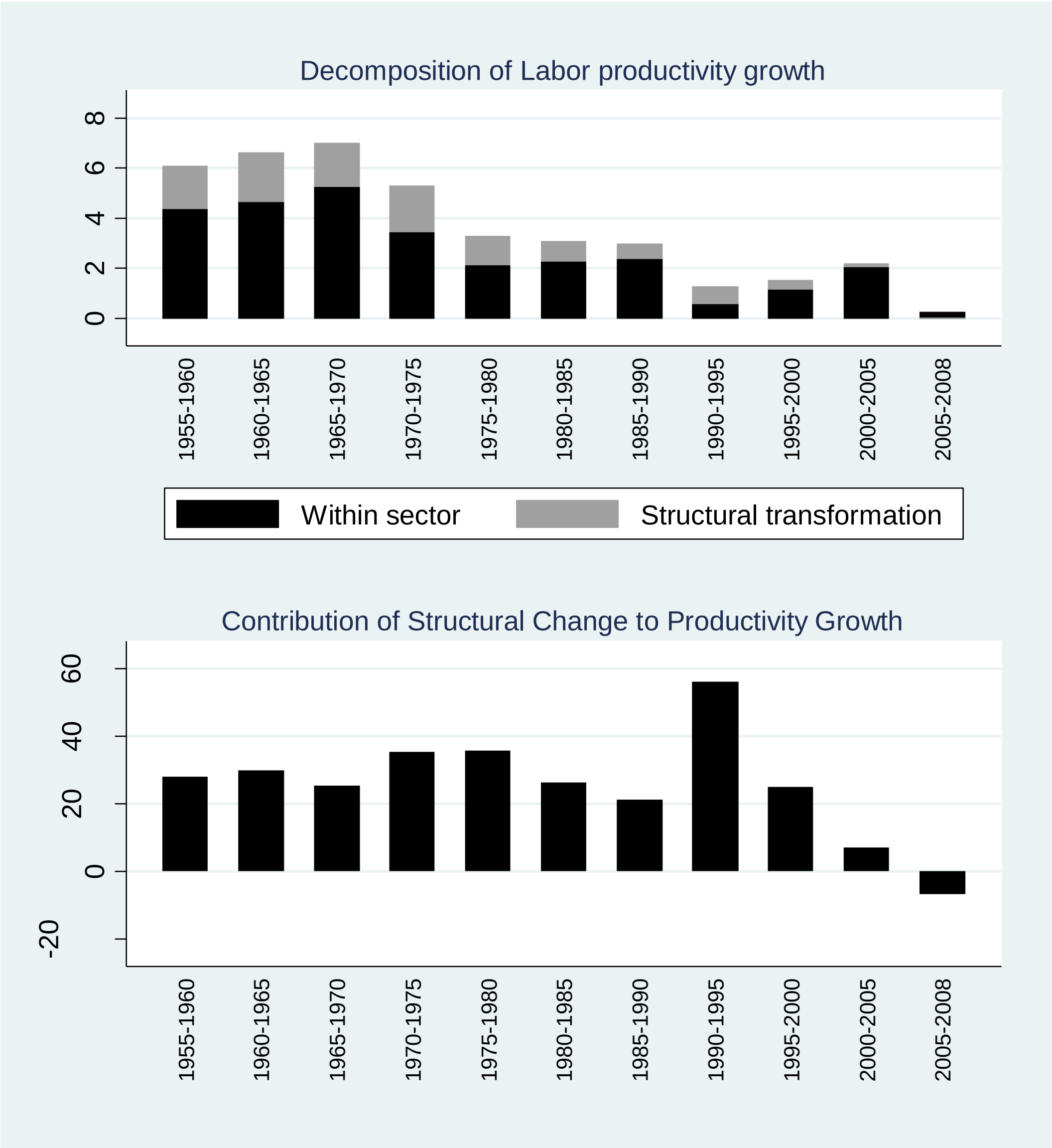
Appendix 3

		1874-1940		1940-2008	
		Status	Reasons	Status	Reasons
1	Hokkaido	Decline then catch-up		Catch-up then decline	Initially specialized in agriculture --> obsolete then convergence
2	Aomori	Oscilatory	Location is extremely bad --> left behind	Catch-up then decline	Initially specialized in agriculture --> obsolete then convergence
4	Miyagi	Catch-up then decline	Specialized in silk industry?	Catch-up then decline	Initially specialized in agriculture --> obsolete then convergence
5	Akita	Sustained catch-up		Catch-up then decline	Initially specialized in agriculture --> obsolete then convergence
7	Fukushima	Sustained catch-up		Sustained catch-up	Initially very poor but location is not extremely bad --> convergence
10	Gumma	Oscilatory	Initially rich because of big cities, rice production, silk industry,	Sustained catch-up	Initially very poor but location is not extremely bad --> convergence
14	Kanagawa	Sustained catch-up	extremely good location for industrialization	Oscilatory	Initially rich because of big cities
15	Niigata	Sustained catch-up		Decline then catch-up	Specialized in manufacturing industry?
19	Yamanashi	Oscilatory	Initially rich because of big cities, rice production, silk industry,	Sustained catch-up	Initially very poor but location is not extremely bad --> convergence
21	Gifu	Sustained catch-up	initially very poor, but location helped in convergence	Sustained catch-up	Initially very poor but location is not extremely bad --> convergence
23	Aichi	Sustained catch-up	extremely good location for industrialization	Decline then catch-up	Specialized in manufacturing industry?
26	Kyoto	Oscilatory	Initially rich because of big cities, rice production, silk industry,	Oscilatory	Initially rich because of big cities
27	Osaka	Oscilatory	Initially rich because of big cities, rice production, silk industry,	Oscilatory	Initially rich because of big cities
28	Hyogo	Sustained catch-up	extremely good location for industrialization	Oscilatory	Initially rich because of big cities
38	Ehime	Decline then catch-up	In Edo-period, location was good or industrial policies were taken by big feudal domains --> obsolete	Oscilatory	Location is extremely bad --> left behind
40	Fukuoka	Sustained catch-up	extremely good location for industrialization	Oscilatory	Initially rich because of big cities
45	Myazaki	Sustained catch-up		Oscilatory	Location is extremely bad --> left behind
47	Okinawa	Oscilatory	Location is extremely bad --> left behind	Oscilatory	Location is extremely bad --> left behind

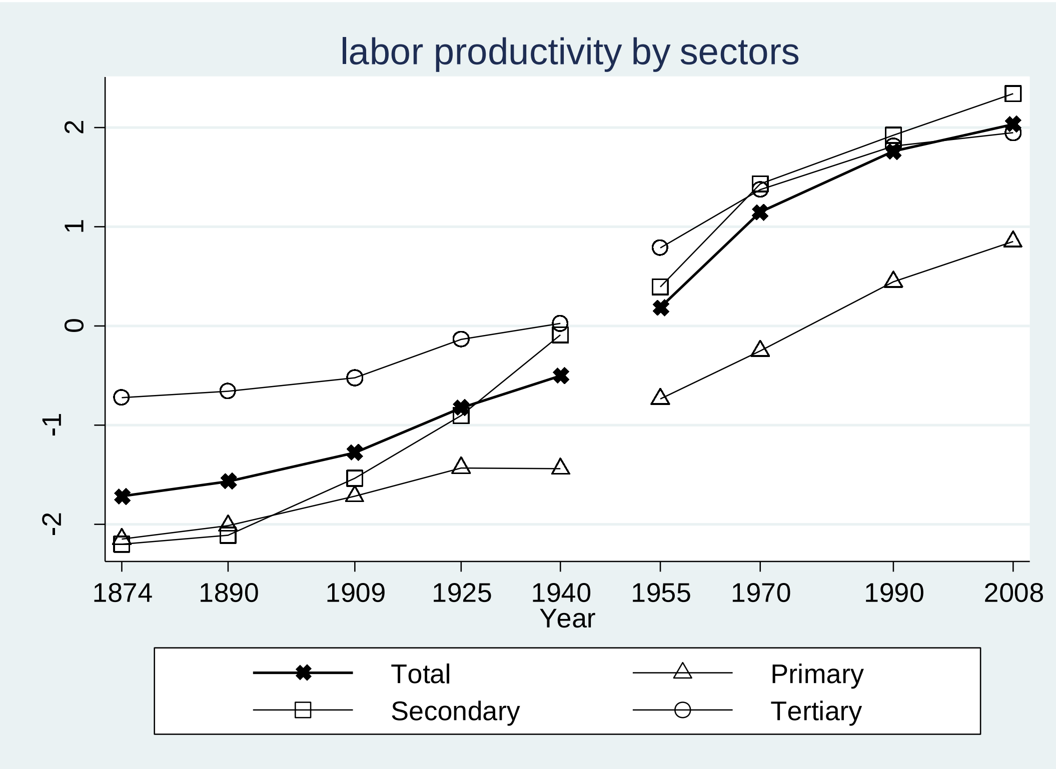
Appendix 4. The detailed Growth decomposition outcomes

			Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	**Total**
1874-90	Annual Growth		0.852	1.317	1.259	0.138	1.631	**1.040**
	Within-sector	Primary	0.678	1.158	0.954	-0.032	0.656	**0.688**
		Secondary	0.136	-0.013	0.085	0.181	0.310	**0.139**
		Tertiary	0.069	0.050	0.060	0.071	0.079	**0.066**
	Between-sector	Static	0.066	0.341	0.295	-0.074	0.582	**0.239**
		Dynamic	-0.097	-0.219	-0.135	-0.008	0.005	**-0.092**
1890-09	Annual Growth		1.581	1.764	1.618	2.013	2.261	**1.837**
	Within-sector	Primary	0.970	0.946	0.862	1.019	0.975	**0.953**
		Secondary	0.390	0.676	0.564	0.567	0.798	**0.594**
		Tertiary	0.152	0.090	0.136	0.161	0.004	**0.110**
	Between-sector	Static	0.097	0.103	0.077	0.292	0.597	**0.227**
		Dynamic	-0.028	-0.050	-0.021	-0.026	-0.112	**-0.047**
1909-25	Annual Growth		2.671	2.775	2.880	2.619	2.593	**2.711**
	Within-sector	Primary	1.092	1.179	1.173	1.071	0.785	**1.063**
		Secondary	0.695	0.734	0.746	0.726	0.834	**0.746**
		Tertiary	0.621	0.498	0.593	0.414	0.243	**0.480**
	Between-sector	Static	0.171	0.275	0.271	0.351	0.757	**0.359**
		Dynamic	0.092	0.089	0.096	0.057	-0.027	**0.063**
1925-40	Annual Growth		0.610	0.515	0.198	0.802	0.623	**0.543**
	Within-sector	Primary	-0.156	-0.342	-0.341	-0.053	-0.207	**-0.221**
		Secondary	0.750	0.812	0.599	0.812	0.863	**0.763**
		Tertiary	-0.146	-0.129	-0.228	-0.175	-0.267	**-0.189**
	Between-sector	Static	0.178	0.167	0.184	0.264	0.251	**0.208**
		Dynamic	-0.016	0.007	-0.016	-0.046	-0.017	**-0.018**
1955-70	Annual Growth		6.539	6.571	6.709	6.829	6.279	**6.588**
	Within-sector	Primary	1.805	1.834	1.770	1.517	0.947	**1.579**
		Secondary	1.199	1.211	1.470	1.282	2.210	**1.474**
		Tertiary	1.127	1.120	1.123	1.098	1.566	**1.205**
	Between-sector	Static	1.995	2.007	1.838	2.338	1.343	**1.903**
		Dynamic	0.414	0.400	0.507	0.593	0.213	**0.427**
1970-90	Annual Growth		3.884	3.907	3.894	3.738	3.060	**3.701**
	Within-sector	Primary	1.228	1.314	1.183	0.930	0.435	**1.022**
		Secondary	0.695	0.526	0.773	0.868	1.081	**0.788**
		Tertiary	0.887	0.924	0.876	0.875	1.103	**0.932**
	Between-sector	Static	1.326	1.459	1.303	1.304	0.562	**1.193**
		Dynamic	-0.252	-0.316	-0.241	-0.239	-0.120	**-0.234**
1990-08	Annual Growth		1.910	1.912	1.751	1.733	0.898	**1.649**
	Within-sector	Primary	0.361	0.398	0.277	0.298	0.136	**0.295**
		Secondary	0.785	0.683	0.883	1.043	0.517	**0.784**
		Tertiary	0.473	0.499	0.382	0.313	0.311	**0.397**
	Between-sector	Static	0.471	0.479	0.386	0.337	0.086	**0.355**
		Dynamic	-0.181	-0.147	-0.177	-0.257	-0.153	**-0.183**

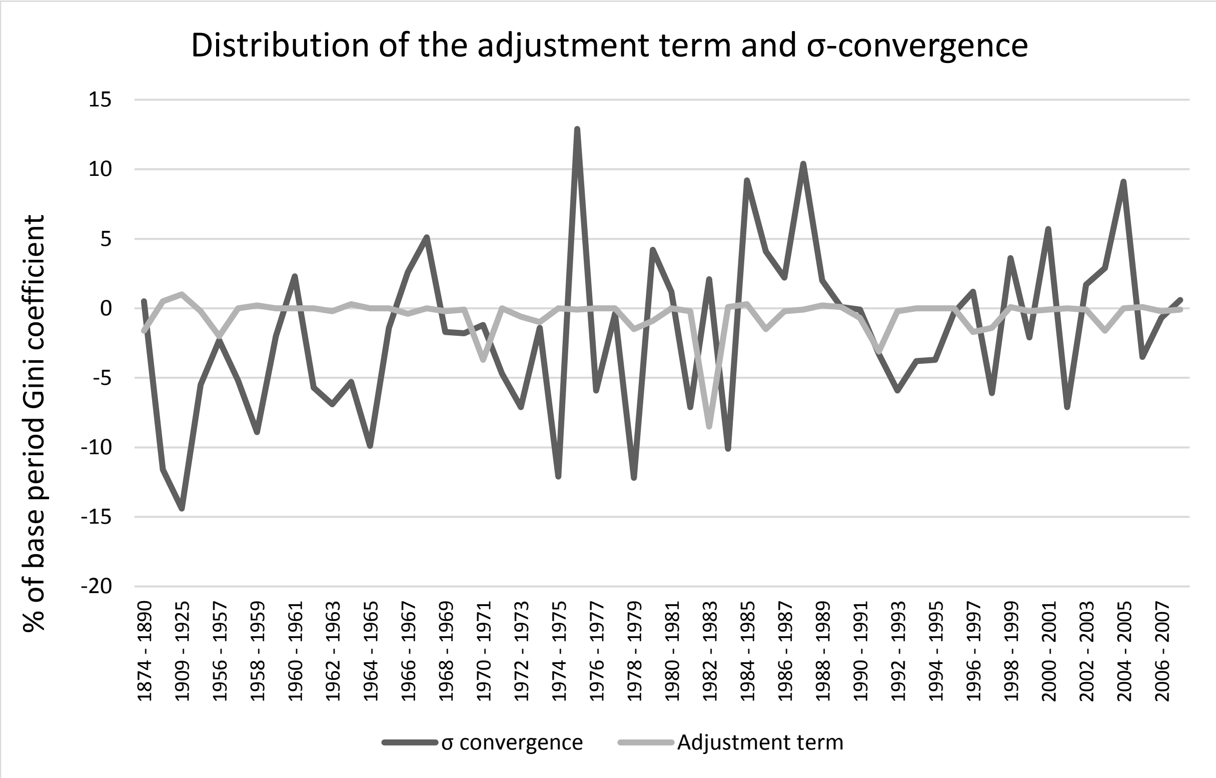
Appendix 5 Productivity growth: 1955-2008



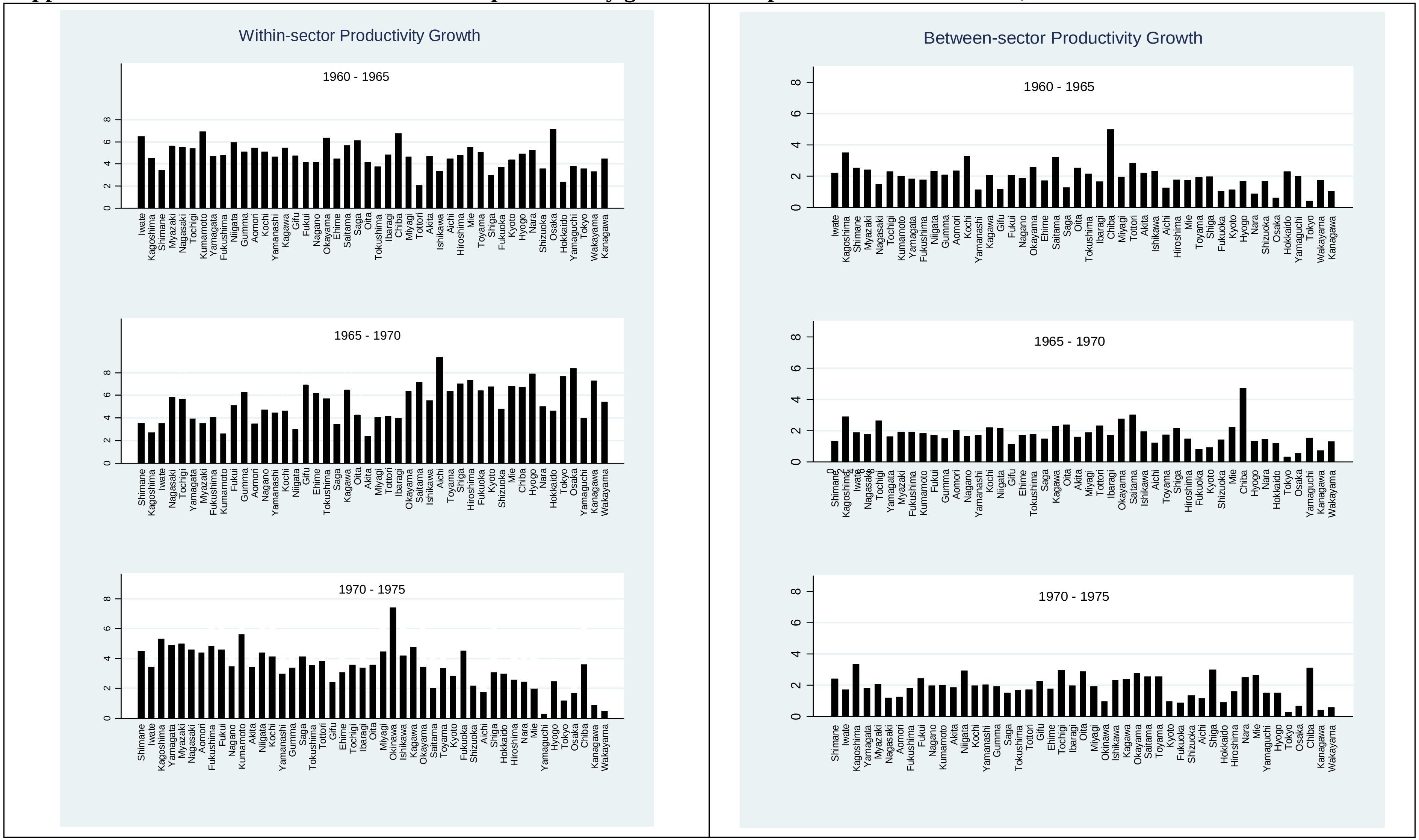
Appendix 6 Sectoral labor productivity: 1874-2008



Appendix 7 Distribution of the adjustment term (Equation 14)



Appendix 8 Within-sector and between-sector productivity growth at the prefecture level: 1960-65, 1965-70 and 1970-75



Note: prefectures are ranked in ascending order based on initial year's productivity level