Regional Business Cycle and Growth Features of Japan

Masaru Inaba
Kansai University

Keisuke Otsu
University of Kent

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Abstract

We study the features of regional business cycles and growth in Japan. We find evidence of unconditional convergence over the 1955-2008 period and conditional convergence over the 1975-2008 period. We also find evidence of financial frictions driving down cross-regional consumption correlation during the 1975-2008 period.

1 Introduction

The postwar Japanese economy has been studied extensively due to its peculiar experience of the postwar rapid growth, bubble economy in the 1980s and lost decade in the 1990s. In this paper we analyze the regional features of the Japanese economy during this period. In specific, we study the regional convergence of income and business cycle comovements among the 47 prefectures over the 1955-2008 period.

Japanese regional convergence has been studied by Barro and Sala-i-Martin (1991) and Shioji (2001). Barro and Sala-i-Martin (1991) find strong evidence of regional convergence over the 1930-1987 period. Shioji (2001) study the convergence of Japanese prefectures over the 1965-1995 period and find that regional public infrastructure capital stock had a modest effect on regional growth. In this paper, we focus on the 1955-2008 period and find evidence of unconditional convergence during the entire period and conditional convergence over the 1975-2008 period.

Regional business cycle features of Japan has been studied by Artis and Okubo (2011). They find that prefectures with similar GDP levels and shorter distance tend to have higher business cycle synchronization over the 1955-1995 period. In this paper, we focus on the cross-region correlation of consumption and find that distortions in the capital market are important in accounting for the consumption pattern.

The remainder of the paper is organized as follows. In section 2 we describe the data facts. In section 3 we conduct analysis on regional convergence and comovement. Section 4 concludes the paper.

2 Data

In this section, we present summary statistics of the expenditure, production and income statistics components of GDP. The main data set we use is the ESRI data set on Japanese prefectural income and product accounts over the 1955-2008 period. The original data sets are compiled in several sub-periods, 1955-1975, 1975-1999, 1990-2009, 2000-2012 due to the change in the SNA basis and reference years for regional price deflators. We choose to terminate our data sample period at 2008 in order to avoid the effects of the 2008/2009 financial crisis and the 2011 earthquake.

All data are converted into 2000 constant price per capita levels. Constant price data are constructed by dividing nominal variables with the GDP deflator. In order to connect the data for the entire period, we splice the nominal variables and GDP deflators using the overlapping years. We use prefectural population data obtained from the Labor Force Survey in order to construct per capita data.

For presentation purposes, we define 9 areas: Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku, Shikoku, Kyushu, Okinawa. The Tohoku area consists of 6 prefectures: Aomori, Iwate, Miyagi, Akita, Yamagata and Fukushima. The Kanto area consists of 7 prefectures: Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo and Kanagawa. The Chubu area consists of 9 prefectures: Niigata, Toyama, Ishikawa, Fukui, Yamanashi, Nagano, Gifu, Shizuoka and Aichi. The Kinki area consists of 7 prefectures: Mie, Shiga, Kyoto, Osaka, Hyogo, Nara and Wakayama. The Chugoku area consists of 5 prefectures: Tottori, Shimane, Okayama, Hiroshima, and Yamaguchi. The Shikoku area consists of 4 prefectures: Tokushima, Kagawa, Ehime and Kochi. The Kyushu area consists of 7 prefectures: Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, and Kagoshima. Hokkaido and Okinawa are areas that consist of single prefectures.

2.1 Regional Output

Table 1 presents the features of per capita regional output over the 1955-2008 period. The first column presents the average level of regional GDP relative to the national level. The regional income in the Kanto area is clearly much higher than other regions at 1.190 while that of Okinawa is 0.626. The variation between the richest and the poorest prefecture is quite large ranging from 1.764 in Tokyo to 0.626 in Okinawa. We also compute the simple average of all per capita prefecture GDP relative to the national level which turns out to be 0.888. This implies that the income distribution among prefectures are skewed with one very rich and large prefecture, Tokyo, and a lot of relatively poor prefectures.

The second column presents the average per capita regional real GDP growth rate. The national output growth was 3.85% where Okinawa area was the highest at 4.26% and Hokkaido area was the lowest at 3.30%. At the prefecture level, Nagano was the highest at 4.71% and Wakayama was the lowest at 2.86%. The simple average of all prefectures is 3.97%, which is slightly higher than the national aggregate growth rate. This is because large prefectures such as Tokyo, Osaka, Kanagawa and Hyogo are growing relatively slow and are bringing down the national aggregate growth rate.

The third column presents the correlation between regional output and national output. Chubu area has the highest correlation coefficient at 0.977 while Okinawa area has the lowest at 0.299 which is clearly an outlier. At the prefecture level, Chiba has the highest correlation at 0.964 while Okinawa has by far the lowest correlation.

Finally, the fourth column presents the standard deviation of the HP filtered per capita regional real GDP relative to that of the national level. The national output standard deviation was 5.40% where the Kinki area was the most volatile at 1.207 and the Okinawa area was the least volatile at 0.846 relative to the national volatility respectively. At the prefecture level, Okinawa was the least volatile while Chiba was the most volatile where the ratios are 0.846 and 1.582 respectively.

Figure 1 plots the Gini coefficient computed from prefecture per capita GDP and private consumption levels over time. This figure shows that inter-prefecture income inequality declined quite dramatically during the rapid growth period falling from 0.14 in 1955 to 0.08 in 1975. Therefore, we find strong evidence of the so-called σ-convergence during the 1955-1975 period. However, after the 1980s, the Gini coefficient temporary rises during the late 1980s and remains higher relative to the 1975 level.

2.2 Expenditure, Production and Income

2.2.1 Regional Expenditure Statistics

The ESRI data set provides annual data of regional expenditure on final consumption and investment of both the household and the government. Table 2 presents the average regional expenditure shares of GDP for private consumption, private investment, public consumption, and public investment over the 1955-2008 period. The national private consumption share is 0.486 where the regional shares range from 0.542 in the Hokkaido area to 0.467 in the Kanto area. At the prefecture level, Nara has the highest share at 0.688 while Tokyo has the lowest at 0.375. The national private investment share is 0.222 where the regional shares range from 0.250 in the Okinawa area to 0.183 in the Hokkaido area. At the prefecture level, the highest is 0.332 in Ibaraki and the lowest is 0.181 in Tokyo. The national government consumption share is 0.151 where the regional shares range from 0.267 in the Okinawa area to 0.124 in the Kanto area. At the prefecture level, the highest is 0.267 in Okinawa and the lowest is 0.096 in Aichi. The national government investment share is 0.075 where the regional shares range from 0.129 in the Hokkaido area to 0.059 in the Kanto area. At the prefecture level, the highest is 0.159 in Fukui and the lowest is 0.052 in Tokyo. It turns out that the expenditure shares of the four expenditure components in Tokyo are significantly lower than those at the national level and add up to only 72.4% of its GDP. In other words, domestic absorption in Tokyo is less than its GDP, which implies that Tokyo is a net exporter of goods and services.

Table 3 presents the intra-regional comovement of the expenditure components. Table 3a lists the intra-regional HP-filtered correlation of output with its expenditure components over the 1955-2008 period. The first column shows the intra-regional correlation between output and private consumption. The national aggregate correlation is 0.699 showing that consumption is procyclical at the national level. At the regional level, the Tohoku area has the highest correlation at 0.822 while the Hokkaido area has the lowest at 0.302. At the prefecture level, the correlation ranges from 0.883 in

Yamagata to 0.248 in Aichi. The second column shows the intra-regional correlation between output and private investment. The national aggregate correlation is 0.783 showing high procyclicality of investment. At the regional level, the Kanto area has the highest correlation at 0.816 while the Okinawa area has the lowest correlation at 0.239. At the prefecture level, the correlation ranges from 0.857 in Saitama to 0.239 in Okinawa. The third column shows the correlation between output and government consumption. The national aggregate correlation is 0.147. At the regional level, the Kyushu area has the highest correlation at 0.751 while the Kanto area has the lowest correlation at -0.225. At the prefecture level, Miyazaki has the highest at 0.798 and Kanagawa has the lowest at -0.391. The fourth column shows the intra-regional correlation between output and government investment. The national aggregate correlation is 0.482. At the regional level, the Kyushu area has the highest correlation at 0.702 and Chubu has the lowest at 0.296. At the prefecture level, Saga has the highest correlation at 0.738 and Kagawa has the lowest at 0.121.

Table 3b shows the HP-filtered standard deviation of each expenditure component relative to that of output over the 1955-2008 period. The first column shows the standard deviation of private consumption relative to that of output. The national aggregate ratio is 0.565 ranging from 1.727 in the Okinawa area and 0.465 in the Kinki area. At the prefecture level, Okinawa has by far the highest ratio while Hiroshima has the lowest correlation at 0.484. A ratio larger than 1 is puzzling because standard business cycle theory will predict consumption smoothing in response to income shocks. The result implies that there are forces in Okinawa that prevent efficient consumption smoothing such as financial frictions. The relative volatility of private investment to that of output is much higher than that of consumption to output with the national aggregate ratio at 2.810. At the regional level, the Okinawa area has the highest ratio at 3.242 while the Kyushu area has the lowest ratio at 2.222. At the prefecture level, Ibaraki has the highest ratio at 4.418 while Miyazaki has the lowest ratio at 1.857. Consumption is less volatile and investment is more volatile than output at the government level as well. The third column shows that the ratio of the standard deviation of government consumption to that of output is 0.842 at the national aggregate level. At the regional level, the Okinawa area has the highest ratio at 1.490 while the Shikoku area has the lowest ratio at 0.606. At the prefecture level, Fukui has the highest ratio at 1.735 while Saitama has the lowest ratio at 0.439. The fourth column shows that the standard deviation of government investment relative to that of output is 2.213 at the national level. At the regional level, the Okinawa area has the highest ratio at 4.769 while the Shikoku area has the lowest ratio at 2.283. At the prefecture level, Okinawa has the highest ratio while Shiga has the lowest ratio at 1.848.

Table 4 presents the comovement between regional and national expenditure components. Table 4a presents the HP filtered correlation of each regional expenditure component with its national aggregate counterpart. The first column shows the correlation of regional consumption and national consumption. At the regional level the Chubu area has the highest correlation at 0.962 while the Okinawa area has the lowest at 0.434. At the prefecture level, Miyagi has the highest correlation at 0.921 while Okinawa has the lowest. The average of the correlation coefficients of all prefectures is 0.747. The second column presents the correlation between regional and national private investment ranging from 0.988 in the Kinki area to 0.736 in the Okinawa area. At the prefecture level, Osaka has the highest correlation at 0.972 while Aomori has the lowest at 0.646. The average of all prefectures is 0.867. The third column presents the correlation between regional and national government consumption ranging from 0.933 in the Chubu area to 0.649 in the Okinawa area. At the prefecture level, Yamaguchi has the highest correlation at 0.901 while Nagano has the lowest at 0.287. The average of all prefectures is 0.731. The fourth column presents the correlation between regional and national government investment ranging from 0.966 in the Chubu area to 0.153 in the Okinawa area. At the prefecture level, Aichi has the highest correlation at 0.930 while Okinawa has the lowest. The average of all prefectures is 0.727.

Table 4b presents the HP-filtered volatility of each regional expenditure component relative to that of their national counterpart. The first column reports the standard deviation of regional consumption relative to that of the national consumption ranging from 2.586 in the Okinawa area to 0.993 in the Kanto area. At the prefecture level, Okinawa has the highest relative volatility while Aichi has the lowest at 0.942. The average of all prefectures is 1.516 showing much greater volatility at the prefecture level compared to the national aggregate, which implies negative covariance of consumption across prefectures. The second column reports the standard deviation of regional private investment relative to that of national investment which ranges from 1.161 in the Kanto area to 0.727 in the Hokkaido area. At the prefecture level, Ibaraki has the highest at 1.578 while Kagoshima has the lowest at 0.640. The average of all prefectures is 1.031. The third column reports the standard deviation of regional government consumption relative to that of national government consumption which ranges from 1.496 in the Okinawa area to 0.976 in the Hokkaido area. At the prefecture level, Wakayama has the highest at 2.105 while Saitama has the lowest at 0.807. The average of all prefectures is 1.397. The fourth column reports the standard deviation of regional government investment relative to that of national investment ranging from 1.823 in the Okinawa area to 0.976 in the Chubu area. At the prefecture level, Okinawa has the highest while Aichi has the lowest at 0.930. The average of all prefectures is 1.333.

2.2.2 Regional Production Statistics

Next, we assess the production factors: labor, capital and productivity. Total factor productivity is computed using a standard Cobb-Douglas production function

$$y_{i,t} = A_{i,t} k_{i,t}^{\theta_i} {l_{i,t}}^{1-\theta_i}, \tag{1}$$

where y is per capita GDP, k is per capita capital stock, l is per capita labor, and A is total factor productivity (TFP) for region i at time t. We assume that the labor income share $1 - \theta_i$ is constant.[1]

The data for labor input is the total man hours series (employment times hours worked per worker) from the R-JIP 2012 database which is available for the 1970-2008 period. For capital stock, we use the perpetual inventory method in order to construct the regional net capital stock series over the 1975-2008 period.[2] The details of the computation is available in the appendix. The labor income share is computed from national income data over the 1975-2008 period as described in the following sub-section.

Table 5 presents the average regional per capita production factors relative to the national level over the 1975-2008 period. The first column shows that labor is relatively abundant in the Chubu area with a ratio of 1.076 while it is relatively scarce in the Okinawa area with a ratio of 0.851 relative to the national level respectively. At the prefecture level, Tokyo has the highest per capita labor input with a ratio of 1.374 while the lowest is in Nara with a ratio of 0.669. The average of all prefectures is 0.992. The

[1] Allowing time varying labor share proves problematic for TFP calculations, especially its growth over time. The computation of the labor share is explained in the following subsection.

[2] The regional private capital stock data published by R-JIP and by ESRI are both gross capital stock series.

second column shows that capital stock is relatively abundant in the Chubu area with a ratio of 1.188 while it is relatively scarce in the Okinawa area with a ratio of 0.691. At the prefecture level, the highest per capita capital is in Mie with a ratio of 1.663 and the lowest is in Saitama with a ratio of 0.643. The average of all prefectures is 0.948. The third column presents the total factor productivity gaps between the regional and national levels defined as

$$\widehat{A_{i,t}} = \frac{y_{i,t}}{y_t} \left(\frac{k_t}{k_{i,t}}\right)^{\frac{\theta_i+\theta}{2}} \left(\frac{l_t}{l_{i,t}}\right)^{1-\frac{\theta_i+\theta}{2}}.$$

At the regional level, the Kanto area has the highest relative TFP with a ratio of 1.137 while the Okinawa area has the lowest with a ratio of 0.865. At the prefecture level, Tokyo has the highest relative TFP with a ratio of 1.335 while Ibaraki has the lowest with a ratio of 0.794. The average of all prefectures is 0.928.

Table 6 reports the intra-regional comovement of production factors over the 1975-2008 period. Table 6a presents the intra-regional HP-filtered correlation of output with its production factors. The first column shows the intra-regional correlation between output and labor. The national aggregate correlation is 0.643. At the regional level, the Kyushu area has the highest correlation at 0.747 while the Okinawa area has the lowest at 0.159. At the prefecture level, Tochigi has the highest correlation at 0.727 while Tokushima has the lowest at -0.089. The average of all prefectures is 0.383. The second column shows the intra-regional correlation between output and capital stock. The national aggregate correlation is 0.434. At the regional level, the Kyushu area has the highest correlation at 0.659 while the Okinawa area has the lowest correlation at 0.183. At the prefecture level, Osaka has the highest correlation at 0.743 while Wakayama has the lowest correlation at -0.103. The average of all prefectures is 0.305. Finally, the third column shows the intra-regional correlation between output and total factor productivity. The national aggregate correlation is 0.846 showing high procyclicality of TFP. At the regional level, the Kinki area has the highest correlation at 0.899 while the Shikoku area has the lowest correlation at 0.645. At the prefecture level, Osaka has the highest correlation at 0.961 while Nagasaki has the lowest correlation at 0.457. Therefore, procyclicality of TFP is consistent at the prefecture level. The average of all prefectures is 0.830.

Table 6b reports the HP-filtered volatility of production factors relative to that of output. The first column shows the standard deviation of labor relative to that of output. The national aggregate volatility of labor relative to output is 0.527. At the regional level, the Shikoku area is the highest at 1.114 while the Kanto area is the lowest at 0.433. At the prefecture level Kagoshima is the highest at 1.328 while Osaka is the lowest at 0.351. The average of all prefectures is 0.671. The second column shows the volatility of capital relative to that of output which is 0.739 at the national level. At the regional level, the Shikoku area has the highest ratio at 0.824 while the Kyushu area has the lowest at 0.645. At the prefecture level Ibaraki has the highest at 0.951 while Wakayama has the lowest at 0.347. Finally, the third column shows that the standard deviation of TFP relative to that of output is 0.791 at the national level. At the regional level the Okinawa area has the highest ratio at 1.057 while the Kyushu area has the lowest at 0.666. At the prefecture level Kagoshima has the highest at 1.164 while Osaka has the lowest at 0.711. The average of all prefectures is 0.932.

Table 7 reports the comovement between the regional and national production factors. Table 7a presents the HP-filtered correlation between regional and national production factors. The first column shows that the correlation between regional and national labor range from 0.962 in the Chubu area to 0.528 in the Hokkaido area. At the prefecture level, Wakayama has the highest at 0.922 while Nara has the lowest at 0.395. The average of the correlation of all prefectures is 0.749. The second column shows that the correlation between regional and national capital range from 0.986 in the Kanto area to 0.548 in the Hokkaido area. At the prefecture level Kanagawa has the highest correlation at 0.974 while Hokkaido has the lowest. The average of all prefectures is 0.866. The third column shows that the correlation between regional and national TFP is highest in the Kanto area at 0.953 while the Hokkaido area is the lowest at 0.396. At the prefecture level, Mie has the highest correlation at 0.872 while Kochi has the lowest at -0.089. The average of all prefectures is 0.577. The fourth column presents the correlation between regional and national output over the 1975-2008 period to match the sample period of the production factors. At the regional level, the Chubu area has the highest correlation at 0.957 while the Okinawa area has the lowest at 0.398. At the prefecture level, Mie has the highest correlation at 0.932 while Kochi has the lowest at 0.086. The order of the ranking is somewhat different from that for the 1955-2008 period. Moreover, the average of all prefectures is 0.664 which is much lower than that of the 1955-2008 period, 0.831.

Table 7b reports the standard deviation of regional production factors relative to that of their national counterpart. The first column reports the standard deviation of regional labor relative to that of the national labor which ranges from 1.643 in the Hokkaido area to 1.014 in the Kinki area. At the prefecture level, Nagasaki has the highest ratio at 2.362 while Gifu has the lowest at 0.876. The average of all prefectures is 1.409. The second column reports the standard deviation of regional capital stock relative to that of national capital stock which ranges from 1.228 in the Kanto area to 0.768 in the Hokkaido area. At the prefecture level, Ibaraki has the highest ratio at 1.939 while Wakayama has the lowest at 0.650. The average of all prefectures is 0.996. The third column reports the standard deviation of regional TFP relative to that of national TFP which ranges from 1.351 in the Kanto area to 0.755 in the Hokkaido area. At the prefecture level, Ibaraki has the highest ratio at 2.060 while Hokkaido has the lowest. The average of all prefectures is 1.367. The fourth column reports the standard deviation of regional output relative to that of national output over the 1975-2008 period to match the sample period of the production factors. At the regional level, the Kanto area has the highest ratio at 1.209 while the Hokkaido area has the lowest at 0.777. At the prefecture level, Fukushima has the highest ratio at 1.696 while Kagoshima has the lowest at 0.582. The average of all prefectures is 1.170 which is roughly the same as the 1955-2008 period. The relative volatility of regional output is consistent with those for the 1955-2009 period.

2.2.3 Regional Income Statistics

In this section we utilize the ESRI regional income statistics to compute the labor income share and capital depreciation rate for each region. The labor income share is defined as

$$\frac{\text{employees compensation} + 0.5\ \times\ \text{indirect business tax} + 0.8 \times\ \text{mixed income}}{GDP}.$$

following Hayashi and Prescott (2002).[3] The capital depreciation rate is defined as

$$\frac{\text{fixed capital depreciation}}{\text{net capital stock}}.$$

The first column in Table 8 reports the average labor income share over the 1975-2008 period. The data shows that the average labor income share

[3]The details of the construction of the labor income share is described in the data appendix.

is 0.593 at the national level where the regional levels range from 0.635 in the Hokkaido area to 0.540 in Okinawa area. The prefecture shares range from 0.645 in Tokyo to 0.489 in Shiga. Figure 2 plots the labor income share over the 1975-2009 period. This figure shows that the labor income share has been falling throughout the 1975-1990 period followed by an increase during the 1990s in all regions. After 2000 the labor income share has been declining until it sharply rises in 2008 in most regions.

The second column shows the correlation between labor income share and the HP filtered output over the 1975-2008 period. The correlation for the national level is -0.462 where that for regional levels vary from -0.496 for the Kanto area to 0.099 for the Shikoku area. Kochi has the highest positive correlation at 0.216 while Hyogo has the highest negative correlation at -0.593. One possible explanation for the counter-cyclicality of the labor share is wage rigidity.

The third column in Table 8 reports the average capital depreciation rate over the 1975-2008 period. The national average is 7.12% ranging from 7.75% in the Kanto area to 6.12 in the Kinki area. The prefecture level depreciation rates range from 9.42% in Saitama to 4.29% in Mie. Figure 3 plots the capital depreciation rate over the 1975-2008 period. This figure shows that the depreciation rate has been falling until the mid 1980s and then has gradually increased. Aggregate depreciation rate should decline when investment on fixed assets that depreciate slower such as structure increases relative to those that depreciate faster such as intangible assets. One potential explanation of the evolution of the depreciation rate is that the share of investment in structure increased during the late 1970s and that of intangible assets, equipment and machinery increased after the 1980s. In order to assess this hypothesis, further analysis of fixed investment by types of assets is needed.

2.3 Efficiency

In this section we assess the regional efficiency. We first compare the marginal product of labor and capital across regions which are defined as

$$mpl_i = (1-\theta_i)\frac{y_i}{l_i}, mpk_i = \theta_i \frac{y_i}{k_i}$$

respectively. Next, we measure distortions in the labor and capital markets as the wedges between marginal products of factors and marginal rates of substitutions of the household choices following Chari. Kehoe and McGrattan (2007). Labor and capital wedges are defined as

$$\omega_{li} = \frac{mrs_{c,l}}{mpl_i}, \omega_{ki} = \frac{mrs_{c',c} - (1-\delta_i)}{mpk_i}$$

where $mrs_{c,l}$ and $mrs_{c',c}$ stand for the marginal rate of substitution between consumption and labor and that between future consumption and current consumption. By definition, a decline in labor and capital wedges will lead to a recession.

The first column of Table 9 presents the regional marginal product of labor relative to its national counterpart over the 1975-2008 period. At the regional level, the Kanto area has the highest ratio at 1.159 while the Okinawa area has the lowest at 0.720. At the prefecture level, Tokyo has by far the highest ratio at 1.409 while Okinawa has the lowest. The average of all prefectures is 0.891. The second column reports the regional marginal product of capital relative to its national level. At the regional level, the Kanto area has the highest ratio with a ratio of 1.105 while the Chugoku area has the lowest at 0.901. At the prefecture level, Shiga has the highest ratio at 1.319 while Ibaraki has the lowest at 0.619. The average of all prefectures is 0.995. Figure 4 plots the Gini coefficients of MPL and MPK computed from prefecture level data over time in order to highlight the regional misallocation of production factors. Interestingly, after the 1990s the regional discrepancy in MPL has been falling while that of the MPK has been rising. This figure implies that the misallocation of labor has been reduced while that of capital has been increasing.

The third column of Table 9 presents the regional labor wedges relative to their national counterpart. At the regional level, the Tohoku area has the highest ratio at 1.103 while the Okinawa area has the lowest at 0.932. At the prefecture level, Akita has the highest ratio at 1.238 while Fukuoka has the lowest at 0.836. The fourth column presents the regional capital wedge relative to its national counterpart. At the regional level, Chubu area has the highest at 1.113 while the Okinawa area has the lowest at 0.881. At the prefecture level, Ibaraki has the highest ratio at 1.321 while Shiga has the lowest at 0.827. The average of all prefectures is 1.014. Figure 5 plots the regional labor wedge. This figure shows that the labor wedge has been declining, i.e. the distortion in the labor market is increasing. One potential explanation is that labor income tax is increasing due to the rapid increase in social security payments as discussed in Gunji and Miyazaki (2012). The figure also shows that the discrepancy across regions seems to be smaller. Figure 6 shows the regional capital wedge over time. Capital wedge fluctuates more frequently than the labor wedge.

3 Analysis

3.1 Growth Accounting

The production function (1) can also be used for growth accounting. Deriving (1) with respect to time we get

$$\frac{\dot{y}_{i,t}}{y_{i,t}} = \frac{\dot{A}_{i,t}}{A_{i,t}} + \theta_i \frac{\dot{k}_{i,t}}{k_{i,t}} + (1-\theta_i)\frac{\dot{l}_{i,t}}{l_{i,t}}. \tag{2}$$

The right hand side decomposes output growth into the contribution of the production factors.

Table 10 presents the regional growth accounting results over the 1975-2008 period. The numbers in each columns correspond to the average per capita output growth rate and the contributions of each production factor to it, that is, the variables on the right hand side on (2). The results for the national level show that labor was declining and reduced output growth by 0.25%. The declining labor is common across all regions except for the Okinawa area and reflects the aging population and decline in labor participation rate. On the other hand, capital growth and TFP growth contributed to output growth by 1.05% and 1.19% respectively.

At the regional level, the Chubu area has the highest regional growth rate of output at 2.28% which is led by capital accumulation which contributes to 1.41%. The Tohoku area has the second highest output growth rate at 2.12% where both capital growth and TFP growth is higher than the national average. The Hokkaido area has the lowest output growth rate at 1.68% and the lowest labor and capital growth rate. At the prefecture level, Fukushima and Nagano have the highest output growth rates at 2.74% and 2.74% which are driven by the high TFP growth at 1.78% and 1.74% respectively. On the other hand, Wakayama has the lowest output growth rate at 0.77% where its TFP growth rate is also the lowest at 0.11%. However, Hokkaido has an output growth rate lower than the national level while its TFP growth rate is much higher than the national level. Therefore the growth pattern is not monotonic.

3.2 Convergence

In the following we further investigate the existence of absolute convergence in levels also known as β-convergence. This concept considers convergence as a negative correlation between the growth in income over time and its initial level. According to a standard textbook Solow-Swan neoclassical growth model, countries who initially have low output due to low capital stock should grow faster because of the high initial marginal product of capital. This can be seen in the following capital law of motion derived from the model

$$\frac{\dot{k}_{i,t}}{k_{i,t}} = s_i A_{i,t} k_{i,t}^{\theta_i - 1} {l_{i,t}}^{1-\theta_i} - (\delta_i + n_i) \tag{3}$$

where s is the savings/investment rate, δ is the depreciation rate, and n is the population growth rate. According to the model, when the current capital stock level is low, the marginal product of capital is high and thus capital accumulation leads to rapid growth in output which increases investment until eventually the marginal product of capital decreases as capital stock approaches its steady state. In addition, a) high TFP leads to a higher steady state capital stock and thus should lead to higher growth during the transition towards the steady state; b) high labor share (low capital share) increases the diminishing of the marginal product of capital and thus should lead to slower growth during the transition; c) higher investment rate accelerates capital accumulation and hence leads to higher growth during the transition; d) higher depreciation rate and population growth rate slows down the accumulation of per capita capital stock and thus leads to lower growth during the transition.

Empirical analysis on regional convergence goes back to Barro (1991) and Mankiw, Romer and Weil (1992) who test absolute convergence among countries. The basic cross-section estimation equation is

$$g_i = \alpha + \beta y_{0,i} + \gamma x_i + \varepsilon_i, \tag{4}$$

where g is the average GDP growth rate and y_0 is the initial GDP level in region i. The initial GDP is expressed as the ratio of regional per capita GDP to national per capita GDP in the initial year. The economic intuition of the Solow-Swan model explained above implies that the coefficient β should be negative. We further add control variables x to the regression according to the model (3) where x consists of the average TFP gap, the labor share, the capital depreciation rate, population growth rate, private investment to GDP ratio, government investment to GDP ratio. Finally, considering the growth accounting results, we also control for the differences in TFP growth rates across prefectures.

Table 11 summarizes the regression results. First we run a regression for the 1955-2008 period with no control variables which is reported as model 1. The coefficient β is negative and significant at the 95% confidence level and the R2 is 0.454. Therefore, we conclude that unconditional regional convergence exists in Japan over the 1955-2008 period. In model 2 we add all control variables and find that the negative effect of initial output is robust. In addition, TFP gap, population growth, private investment rate and TFP growth all have 95% significant effects on growth as expected. Labor share, capital depreciation and government investment rate do not have significant effects.

Next we focus on the 1975-2008 period in order to exclude the postwar rapid growth period.[4] The regression results in model 3 with no control variables show that for this period the initial output has no significant effects on output growth. Moreover the R2 is extremely low compared to that in model 1. Therefore, there is no evidence of unconditional convergence. However, when we add all control variables in model 4, the coefficient on initial output is negative and significant at the 90% level where the R2 increases to 0.699. In addition, the TFP gap, population growth, private investment rate and TFP growth are all significant at the 95% level. Therefore, we find evidence of conditional convergence over the 1975-2008 period.

3.3 Regional Comovement

In this section, we investigate the pattern of correlation between regional and national private consumption. The fact showed in Table 4a that the consumption correlation is lower than the output correlation is puzzling because the risk of income shocks on consumption can be shared through financial transactions. Assume that representative households in each prefecture has access to a common financial asset. The intertemporal optimality condition will tell us that without any frictions the intertemporal marginal rate of substitution should be equal to the rate of return R_t in all regions. For a standard log

[4] We run a Quandt-Andrews unknown breakpoint test and find that the output growth has a trend break in 1974.

utility function

$$U = \sum_{t=0}^{\infty} \beta^t \log pc_{i,t}$$

the intertemporal optimality condition is

$$R_t = \frac{pc_{i,t+1}}{\beta c_{i,t}} = \frac{pc_{t+1}}{\beta c_t},$$

for all regions. Therefore, it is optimal for all regions to smooth consumption at a similar rate, which should lead to high correlation in consumption fluctuation across regions.

One potential explanation of the low inter-regional consumption correlation is that agents smooth total consumption rather than private consumption. Imagine that the preference is

$$U = \sum_{t=0}^{\infty} \beta^t \log c_{i,t}$$

where $c_{i,t} = pc_{i,t} + gc_{i,t}$. In this case, there will be no puzzle if government consumption fluctuates in a way that inter-regional correlation of total consumption is high. However, the average correlation of total consumption between its prefecture and national level is 0.786, which is still lower than the inter-regional correlation of output.

Another potential explanation for the low consumption correlation is the existence of financial frictions that prevent inter-region consumption smoothing. In this case, since idiosyncratic income shocks are not insurable in the financial market, consumption in each region will react to their output making the inter-regional correlation weaker. Therefore, we run the following regression in order to estimate this effect.

$$\rho(pc_i, pc) = \alpha + \beta\rho(y_i, y) + \gamma x_i + \varepsilon_i$$

where $\rho(\bullet)$ is the correlation coefficient between the prefecture level fluctuation and the national aggregate fluctuation. We control for the average population share of each region among total population because we believe that a small region is less likely to have consumption smoothing opportunities. We also control for the correlation of regional labor and capital wedges with their national counterparts respectively for the 1975-2008 period in which these statistics are available. Labor wedges affect the choice between consumption and leisure while capital wedges affect the choice between consumption and investment. Hence, the higher the inter-regional correlation of the wedges, the higher inter-regional consumption correlation we should expect.

The first column in Table 12 shows the results from the regression over the 1955-2008 period. It turns out that output correlation is important in accounting for consumption correlation. The population share has a negative and significant effect on the correlation as expected. The second column shows the result for the 1975-2008 period. The results show that the output correlation again has a positive and 95% significant effect on consumption correlation. However, the population share turns out to be insignificant. Finally, the third column presents the result with labor and capital wedges. The result shows that the capital wedge correlation is important while output correlation also remains to be important in accounting for the consumption correlation pattern.

4 Conclusion

In this paper, we have gone over regional economic data in Japan over the 1955-2008 period. We find that the difference in per capita output levels and growth rates across regions are quite high while inter-regional output inequality decreased dramatically during the 1955-1975 period. In terms of expenditure data, the cross-regional output correlation is higher than cross-regional consumption correlation. In terms of production, labor misallocation has been declining while capital misallocation has been increasing over the 1975-2008 period. In terms of income data, the income share of labor has been declining during the 1975-1990 period, increasing during the 1990s and declining again in the 2000s in all regions while the depreciation rate has declined during the late 1970s and persistently increased after 1980 in all regions.

We have conducted basic growth accounting analysis and find that TFP growth and capital accumulation are equally important in accounting for regional output growth. We also conduct a growth regression and find that unconditional regional convergence exists in the 1955-2008 period but not during the 1975-2008 period. However, conditional regional convergence does exist during the 1975-2008 period controlling for the TFP gap, population growth, private investment rate, and TFP growth. Future studies on post-1975 Japanese growth should attempt to reveal the underlying reasons of regional discrepancies in these control variables. In terms of the output and consumption correlation puzzle, high inter-regional correlation of consumption is associated with high inter-regional correlation of capital market distortions implying a role played by financial frictions on the lack of consumption smoothing across regions. Future studies on Japanese regional business cycles should focus on the role played by capital market distortions.

A Data Appendix

A.1 Net Capital Stock

We consider net private capital stock as a sum of private firm fixed assets (manufacturing firm fixed assets + non-manufacturing firm fixed assets + intangible fixed assets), private inventory stocks and private residential capital. In order to compute the net capital stock series over the 1975-2008 period, we use the perpetual inventory method which is based on the net capital accumulation equation

$$K_{t+1} = K_t + I_t - D_t$$

where K is the net private capital stock, I is the private investment and D is the private depreciation of the capital stock.

The benchmark capital stock level for 1975 is constructed as follows. We use the ESRI Prefecture Private Capital Stock data for the benchmark regional private firm fixed asset. For the benchmark private inventory stock, we use the Private and Public Sector Balance Sheet data. Since only the national private inventory stock data is available, we allocate the stock to each prefecture using the relative size of private firm capital stock to construct the benchmark regional private inventory stock. For the benchmark residential capital we use the National Asset and Liabilities Balance Sheet data. Since only the national residential capital data is available, we use the private and public ratio of total fixed capital stock using Private and Public Sector Balance Sheet data to construct the private residential capital. Then we allocate the stock to each prefecture using the population share to construct the benchmark regional private residential capital. The value of benchmark regional private capital stock is converted into constant 2000 prices using the regional GDP deflator.

Once we pin down the initial capital stock level, we can use the capital accumulation equation and annual flow data to construct the regional net capital stock series. The regional private investment is available directly from the expenditure data. We obtain regional private depreciation as the difference between total depreciation and the depreciation for government service providers using the ESRI Prefecture Gross Domestic Product by Economic Activity and Factor Income data. Both series are converted into constant 2000 price series using the regional GDP deflator. The capital depreciation rate can be computed by dividing the regional private depreciation by the constructed net capital stock.

A.2 Labor Income Share

The labor income share is constructed following Hayashi and Prescott (2002). They define labor income as the sum of compensation of employees, half of indirect business tax, and 80% of mixed income. Part of indirect business taxes paid by the firms is considered as the contribution of labor to production extracted from the government. "For lack of good alternatives" they choose to split the taxes equally between labor and capital income. They define mixed income as the "operating surplus in the nonhousing component of the noncorporate sector" of which 80% is assumed to be labor income.

The compensation of employees and indirect business taxes (‘tax on production and imports’) are available at the prefecture level in the Prefecture Gross Domestic Product by Economic Activity and Factor Income data. However, mixed income is not available independently as it is reported as ‘operating surplus and mixed income’. In order to construct the mixed income series, we first use the Prefecture Residents Income data to compute the ratio of mixed income to the sum of operating surplus and mixed income of the residents:

$$\frac{\text{mixed income}}{\text{mixed income} + \text{operating surplus}} = \frac{\text{proprietors income - imputed rent}}{\text{nonfirm property income} + \text{business income}}.$$

Then we multiply the prefecture domestic operating surplus and mixed income by this ratio to construct the prefecture domestic mixed income series.

Finally, the constructed labor income series is divided by regional GDP to compute the labor income share. In terms of national income accounting, labor income, capital income and depreciation will add up to GDP where capital income is defined as the sum of corporate operating surplus, half of indirect business tax, 20% of mixed income, and imputed rent.

B Tables and Figures

Table 1. Summary Statistics of Regional Output: 1955-2008

	y^i/y		$g(y^i)$		$corr(y^i, y)$		$std(y^i)/std(y)$	
National	1.000		3.85%		1.000		1.000	
Hokkaido	0.932		3.30%		0.875		0.882	
Tohoku	0.792		4.28%		0.826		0.970	
Kanto	1.190		3.61%		0.961		1.047	
Chubu	1.071		4.09%		0.977		0.963	
Kinki	0.966		3.47%		0.975		1.207	
Chugoku	0.920		3.99%		0.960		1.011	
Shikoku	0.824		3.84%		0.899		1.156	
Kyushu	0.799		3.96%		0.821		0.990	
Okinawa	0.626		4.26%		0.299		0.846	
Average	0.887		3.97%		0.831		1.121	
1	Tokyo	1.764	Nagano	4.71%	Chiba	0.964	Kochi	0.820
2	Osaka	1.195	Fukushima	4.65%	Gifu	0.962	Niigata	0.835
3	Aichi	1.140	Yamanashi	4.57%	Kyoto	0.953	Miyagi	0.883
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Kumamoto	0.694	Nara	3.23%	Saga	0.698	Shiga	1.486
46	Kagoshima	0.689	Hyogo	3.17%	Nagasaki	0.618	Saitama	1.549
47	Okinawa	0.626	Wakayama	2.86%	Okinawa	0.299	Chiba	1.582

Table 2. GDP Share of Expenditures (%): 1955-2008

	Private				Government			
	Consumption		Investment		Consumption		Investment	
National	48.6		22.2		15.1		7.5	
Hokkaido	54.2		18.3		21.7		12.9	
Tohoku	53.4		21.6		20.6		10.7	
Kanto	46.7		21.6		12.4		5.9	
Chubu	47.6		23.2		13.6		7.8	
Kinki	49.4		23.2		13.3		6.4	
Chugoku	47.4		23.4		17.1		8.6	
Shikoku	51.4		21.3		19.8		9.4	
Kyushu	49.7		22.3		21.1		8.9	
Okinawa	53.3		25.0		26.7		11.5	
Average	51.4		22.7		18.2		11.5	
1	Nara	68.8	Ibaraki	33.2	Okinawa	26.7	Fukui	15.9
2	Saitama	64.1	Mie	31.4	Nagasaki	25.9	Shimane	14.8
3	Chiba	64.1	Hyogo	27.5	Tottori	25.6	Iwate	14.1
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Tochigi	44.2	Tottori	18.6	Osaka	11.5	Shizuoka	5.5
46	Fukuoka	43.5	Hokkaido	18.3	Kanagawa	11.4	Osaka	5.5
47	Tokyo	37.5	Tokyo	18.1	Aichi	9.6	Tokyo	5.2

Table 3a. Intra-Regional Expenditure Correlation with Output: 1955-2008

	$\text{corr}(pc^i, y^i)$		$\text{corr}(pi^i, y^i)$		$\text{corr}(gc^i, y^i)$		$\text{corr}(gi^i, y^i)$	
National	0.699		0.783		0.147		0.482	
Hokkaido	0.302		0.687		0.446		0.449	
Tohoku	0.822		0.721		0.649		0.411	
Kanto	0.708		0.816		-0.225		0.448	
Chubu	0.649		0.801		-0.022		0.296	
Kinki	0.559		0.783		0.226		0.655	
Chugoku	0.633		0.733		0.185		0.512	
Shikoku	0.716		0.764		0.564		0.633	
Kyushu	0.819		0.640		0.751		0.702	
Okinawa	0.741		0.239		0.666		0.583	
Average	0.646		0.690		0.384		0.409	
1	Yamagata	0.883	Saitama	0.857	Miyazaki	0.798	Saga	0.738
2	Fukui	0.874	Kagawa	0.836	Nagasaki	0.758	Tokushima	0.734
3	Kagawa	0.866	Chiba	0.828	Kagoshima	0.736	Osaka	0.711
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Hokkaido	0.302	Shimane	0.524	Chiba	-0.190	Tochigi	0.149
46	Wakayama	0.258	Nagasaki	0.307	Aichi	-0.319	Aichi	0.139
47	Aichi	0.248	Okinawa	0.239	Kanagawa	-0.391	Kagawa	0.121

Table 3b. Intra-Regional Expenditure Volatility relative to Output: 1955-2008

	$std(pc^i)/std(y^i)$		$std(pi^i)/std(y^i)$		$std(gc^i)/std(y^i)$		$std(gi^i)/std(y^i)$	
National	0.565		2.810		0.842		2.213	
Hokkaido	0.763		2.317		0.932		2.363	
Tohoku	0.823		2.288		0.993		2.557	
Kanto	0.536		2.999		0.945		2.367	
Chubu	0.595		2.849		0.953		2.311	
Kinki	0.465		2.702		0.908		2.422	
Chugoku	0.601		3.166		0.922		2.554	
Shikoku	0.765		2.538		0.796		2.283	
Kyushu	0.822		2.222		1.078		2.387	
Okinawa	1.727		3.242		1.490		4.769	
Average	0.778		2.619		1.076		2.683	
1	Okinawa	1.727	Ibaraki	4.418	Fukui	1.735	Okinawa	4.769
2	Nagasaki	1.125	Kyoto	3.869	Shizuoka	1.637	Tokyo	3.522
3	Akita	1.103	Hiroshima	3.377	Okinawa	1.490	Niigata	3.392
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Chiba	0.501	Tokushima	2.086	Kanagawa	0.667	Aichi	1.905
46	Aichi	0.493	Kagoshima	1.947	Tokushima	0.665	Nara	1.850
47	Hiroshima	0.484	Miyazaki	1.857	Saitama	0.439	Shiga	1.848

Table 4a. Expenditure Correlation with National Aggregate: 1955-2008

	$corr(pc^i, c)$		$corr(pi^i, i)$		$corr(gc^i, gc)$		$corr(gi^i, gi)$	
Hokkaido	0.700		0.752		0.758		0.835	
Tohoku	0.892		0.893		0.881		0.858	
Kanto	0.842		0.980		0.825		0.894	
Chubu	0.962		0.987		0.933		0.966	
Kinki	0.885		0.988		0.912		0.931	
Chugoku	0.883		0.973		0.931		0.853	
Shikoku	0.841		0.921		0.807		0.796	
Kyushu	0.880		0.910		0.818		0.851	
Okinawa	0.434		0.736		0.649		0.153	
Average	0.747		0.867		0.731		0.727	
1	Miyagi	0.921	Osaka	0.972	Yamaguchi	0.901	Aichi	0.930
2	Toyama	0.903	Shizuoka	0.966	Gifu	0.899	Toyama	0.900
3	Gunma	0.900	Saitama	0.963	Wakayama	0.898	Oita	0.891
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Okayama	0.502	Kagoshima	0.722	Shiga	0.478	Fukui	0.502
46	Osaka	0.460	Oita	0.707	Saitama	0.367	Kagawa	0.311
47	Okinawa	0.434	Aomori	0.646	Nagano	0.287	Okinawa	0.153

Table 4b. Expenditure Volatility relative to National Aggregate: 1955-2008

	$std(pc^i)/std(pc)$		$std(pi^i)/std(pi)$		$std(gc^i)/std(gc)$		$std(gi^i)/std(gi)$	
Hokkaido	1.191		0.727		0.976		0.946	
Tohoku	1.412		0.790		1.143		1.121	
Kanto	0.993		1.117		1.175		1.120	
Chubu	1.014		0.977		1.090		1.006	
Kinki	0.994		1.161		1.301		1.322	
Chugoku	1.075		1.139		1.107		1.167	
Shikoku	1.566		1.044		1.092		1.193	
Kyushu	1.440		0.783		1.267		1.068	
Okinawa	2.586		0.976		1.496		1.823	
Average	1.516		1.031		1.397		1.333	
1	Okinawa	2.586	Ibaraki	1.578	Wakayama	2.105	Okinawa	1.823
2	Nagasaki	2.476	Hiroshima	1.377	Fukui	1.980	Kagawa	1.627
3	Akita	2.180	Kyoto	1.372	Nagasaki	1.974	Hyogo	1.624
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Hiroshima	0.982	Yamagata	0.776	Hokkaido	0.976	Nara	1.076
46	Tokyo	0.950	Hokkaido	0.727	Tokushima	0.949	Hokkaido	0.942
47	Aichi	0.942	Kagoshima	0.640	Saitama	0.807	Aichi	0.930

Table 5. Production Factor relative to National Aggregate: 1975-2008

	Labor		Capital		TFP	
Hokkaido	0.979		0.881		0.952	
Tohoku	1.020		0.805		0.901	
Kanto	1.004		1.038		1.137	
Chubu	1.076		1.188		0.980	
Kinki	0.943		0.965		0.962	
Chugoku	1.021		1.058		0.908	
Shikoku	0.994		0.889		0.872	
Kyushu	0.958		0.859		0.893	
Okinawa	0.851		0.691		0.865	
Average	0.992		0.948		0.928	
1	Tokyo	1.374	Mie	1.663	Tokyo	1.335
2	Nagano	1.101	Ibaraki	1.546	Shiga	1.081
3	Fukui	1.097	Hyogo	1.313	Saitama	1.078
⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Chiba	0.740	Kumamoto	0.651	Mie	0.802
46	Saitama	0.738	Nara	0.649	Wakayama	0.798
47	Nara	0.669	Saitama	0.643	Ibaraki	0.794

Table 6a. Intra-Regional Factor Correlation with Output: 1975-2008

	$\text{corr}(l^i, y^i)$		$\text{corr}(k^i, y^i)$		$\text{corr}(z^i, y^i)$	
National	0.643		0.434		0.846	
Hokkaido	0.518		0.519		0.646	
Tohoku	0.605		0.410		0.788	
Kanto	0.504		0.258		0.897	
Chubu	0.684		0.378		0.875	
Kinki	0.725		0.575		0.899	
Chugoku	0.540		0.338		0.828	
Shikoku	0.358		0.577		0.645	
Kyushu	0.747		0.659		0.757	
Okinawa	0.159		0.183		0.827	
Average	0.383		0.305		0.830	
1	Tochigi	0.727	Osaka	0.743	Osaka	0.961
2	Aichi	0.679	Kagawa	0.702	Tochigi	0.943
3	Saitama	0.666	Fukuoka	0.625	Fukushima	0.935
⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Kyoto	0.039	Shizuoka	-0.022	Kochi	0.632
46	Wakayama	-0.012	Fukui	-0.077	Nagasaki	0.572
47	Tokushima	-0.089	Wakayama	-0.103	Kagoshima	0.546

Table 6b. Intra-Regional Factor Volatility relative to Output

	$std(l^i)/std(y^i)$		$std(k^i)/std(y^i)$		$std(z^i)/std(y^i)$	
National	0.527		0.739		0.791	
Hokkaido	1.114		0.730		0.768	
Tohoku	0.691		0.685		0.811	
Kanto	0.433		0.750		0.883	
Chubu	0.512		0.646		0.793	
Kinki	0.463		0.700		0.709	
Chugoku	0.603		0.649		0.868	
Shikoku	0.959		0.824		0.934	
Kyushu	0.728		0.645		0.666	
Okinawa	0.800		0.683		1.057	
Average	0.671		0.642		0.932	
1	Kagoshima	1.328	Ibaraki	0.951	Kagoshima	1.164
2	Nagasaki	1.142	Gifu	0.882	Fukui	1.159
3	Kochi	1.117	Kagoshima	0.878	Tokushima	1.123
⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Fukushima	0.419	Tochigi	0.439	Saga	0.752
46	Nara	0.407	Toyama	0.418	Iwate	0.720
47	Osaka	0.351	Wakayama	0.347	Osaka	0.711

Table 7a. Factor Correlation with National Aggregate: 1975-2008

	$corr(l^i, l)$		$corr(k^i, k)$		$corr(z^i, z)$		$corr(y^i, y)$	
Hokkaido	0.693		0.548		0.396		0.687	
Tohoku	0.906		0.919		0.759		0.816	
Kanto	0.905		0.986		0.953		0.945	
Chubu	0.962		0.970		0.944		0.957	
Kinki	0.944		0.985		0.820		0.907	
Chugoku	0.869		0.945		0.884		0.929	
Shikoku	0.871		0.968		0.480		0.613	
Kyushu	0.831		0.962		0.753		0.777	
Okinawa	0.528		0.787		0.479		0.398	
Average	0.749		0.866		0.577		0.664	
1	Wakayama	0.922	Kanagawa	0.974	Mie	0.872	Mie	0.932
2	Fukushima	0.906	Osaka	0.972	Tokyo	0.851	Hiroshima	0.909
3	Kagawa	0.904	Miyagi	0.966	Shizuoka	0.817	Aichi	0.888
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Okinawa	0.528	Kumamoto	0.670	Saga	0.267	Kagoshima	0.334
46	Saga	0.471	Shimane	0.621	Ibaraki	0.214	Wakayama	0.308
47	Nara	0.395	Hokkaido	0.548	Kochi	-0.089	Kochi	0.086

Table 7b. Factor Volatility relative to National Aggregate: 1975-2008

	$std(l^i)/std(l)$		$std(k^i)/std(k)$		$std(z^i)/std(z)$		$std(y^i)/std(y)$	
Hokkaido	1.643		0.768		0.755		0.777	
Tohoku	1.309		0.924		1.024		0.998	
Kanto	0.994		1.228		1.351		1.209	
Chubu	1.042		0.938		1.076		1.072	
Kinki	1.014		1.094		1.034		1.154	
Chugoku	1.149		0.882		1.102		1.004	
Shikoku	1.513		0.927		0.982		0.831	
Kyushu	1.278		0.807		0.779		0.925	
Okinawa	1.270		0.773		1.119		0.837	
Average	1.409		0.996		1.367		1.170	
1	Nagasaki	2.362	Ibaraki	1.939	Ibaraki	2.060	Fukushima	1.696
2	Kochi	1.984	Hyogo	1.582	Wakayama	1.931	Hyogo	1.626
3	Ehime	1.947	Tokyo	1.531	Fukushima	1.881	Aichi	1.561
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Gunma	0.967	Kagoshima	0.692	Miyazaki	0.902	Fukui	0.816
46	Osaka	0.881	Toyama	0.680	Kagoshima	0.856	Hokkaido	0.777
47	Gifu	0.876	Wakayama	0.650	Hokkaido	0.755	Kagoshima	0.582

Table 8. Income Statistics: 1975-2008

	Labor Income Share				Capital Depreciation	
	Level		Correlation with Output		Rate	
National	0.593		-0.462		7.12	
Hokkaido	0.635		-0.300		6.62	
Tohoku	0.584		-0.127		7.74	
Kanto	0.597		-0.496		7.75	
Chubu	0.586		-0.445		7.36	
Kinki	0.592		-0.488		6.12	
Chugoku	0.588		-0.353		6.45	
Shikoku	0.588		0.099		6.77	
Kyushu	0.591		-0.313		6.95	
Okinawa	0.540		-0.256		7.36	
1	Tokyo	0.645	Kochi	0.216	Saitama	9.42
2	Kochi	0.635	Saga	0.157	Kumamoto	9.40
3	Hokkaido	0.635	Ehime	0.093	Chiba	8.49
⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Chiba	0.537	Saitama	-0.534	Ibaraki	4.50
46	Ehime	0.529	Fukuoka	-0.553	Wakayama	4.46
47	Shiga	0.489	Hyogo	-0.593	Mie	4.29

Table 9. Efficiency relative to National Aggregate: 1975-2008

	MPL		MPK		Labor Wedge		Capital Wedge	
National	0.891		0.995		1.046		1.014	
Hokkaido	0.978		0.914		1.047		1.022	
Tohoku	0.804		1.059		1.103		0.999	
Kanto	1.159		1.105		0.954		0.939	
Chubu	1.008		0.943		1.081		1.113	
Kinki	0.969		0.952		0.991		0.951	
Chugoku	0.913		0.901		1.012		1.066	
Shikoku	0.825		0.944		1.071		1.008	
Kyushu	0.852		0.958		0.959		1.049	
Okinawa	0.720		1.102		0.932		0.881	
1	Tokyo	1.409	Shiga	1.319	Akita	1.238	Ibaraki	1.321
2	Osaka	1.120	Saitama	1.300	Tottori	1.228	Mie	1.297
3	Kanagawa	1.086	Ishikawa	1.291	Niigata	1.200	Wakayama	1.140
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Ehime	0.751	Wakayama	0.671	Nara	0.877	Okinawa	0.881
46	Aomori	0.742	Mie	0.626	Hyogo	0.876	Ishikawa	0.848
47	Okinawa	0.720	Ibaraki	0.619	Fukuoka	0.836	Shiga	0.827

Table 10. Growth Accounting (%): 1975-2008

	Output		Labor		Capital		TFP	
National	1.99		-0.25		1.05		1.19	
Hokkaido	1.68		-0.39		0.71		1.35	
Tohoku	2.12		-0.28		1.16		1.23	
Kanto	1.93		-0.22		0.96		1.19	
Chubu	2.28		-0.23		1.41		1.10	
Kinki	1.72		-0.30		0.85		1.17	
Chugoku	1.89		-0.31		1.00		1.20	
Shikoku	1.75		-0.25		0.98		1.02	
Kyushu	1.96		-0.22		1.12		1.06	
Okinawa	1.84		0.02		1.02		0.79	
1	Fukushima	2.74	Nagasaki	0.05	Mie	1.73	Nagano	1.78
2	Nagano	2.68	Okinawa	0.02	Ibaraki	1.64	Fukushima	1.74
3	Shiga	2.57	Saga	-0.07	Oita	1.40	Iwate	1.60
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Fukuoka	1.53	Hokkaido	-0.39	Hokkaido	0.71	Aomori	0.70
46	Kochi	1.27	Nagano	-0.40	Fukui	0.69	Mie	0.58
47	Wakayama	0.77	Tokushima	-0.41	Chiba	0.56	Wakayama	0.11

Table 11. Growth Regression

	Growth 1955-2008				Growth 1975-2008			
	(1)		(2)		(3)		(4)	
Constant	0.049	**	0.013		0.023	**	-0.010	
	(32.027)		(0.985)		(7.401)		(-0.803)	
Initial	-0.011	**	-0.014	**	-0.004		-0.008	*
Output	(-6.260)		(-5.105)		(-1.152)		(-1.923)	
TFP			0.010	**			0.019	**
Gap			(2.096)				(1.979)	
Labor			0.012				-0.009	
Share			(0.995)				(-0.787)	
Capital			-0.026				-0.031	
Depreciation			(-0.418)				(-0.633)	
Population			-0.302	**			-0.460	**
Growth			(-3.132)				(-2.881)	
Private			0.050	**			0.093	**
Investment			(2.753)				(4.038)	
Government			-0.022				-0.013	
Investment			(-1.182)				(-0.751)	
TFP			0.452	**			0.801	**
Growth			(3.524)				(7.193)	
R^2	0.454		0.722		0.007		0.699	

Table 12. Consumption Comovement Regression

	1955-2008		1975-2008			
Constant	0.418	**	-0.017		-0.363	**
	(3.758)		(-0.147)		(-2.924)	
Output	0.457	**	0.773	**	0.627	**
Correlation	(3.396)		(4.294)		(4.296)	
Population	-2.381	**	0.227		0.623	
Share	(-2.947)		(0.131)		(0.443)	
Labor Wedge					0.233	
Correlation					(1.607)	
Capital Wedge					0.703	**
Correlation					(4.764)	
R2	0.251		0.317		0.568	

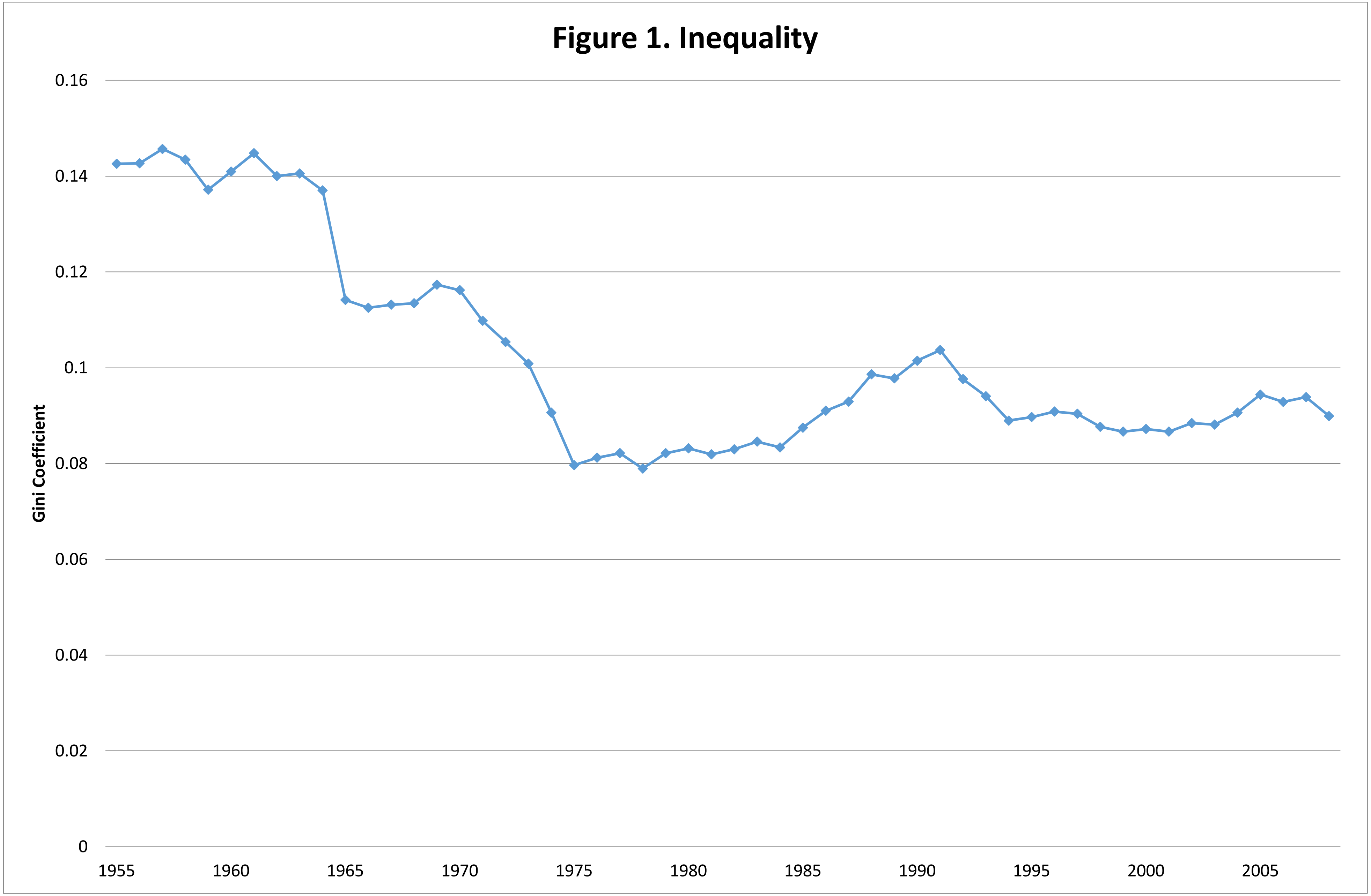
Figure 1. Inequality
Gini Coefficient
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005

Figure 2. Labor Income Share

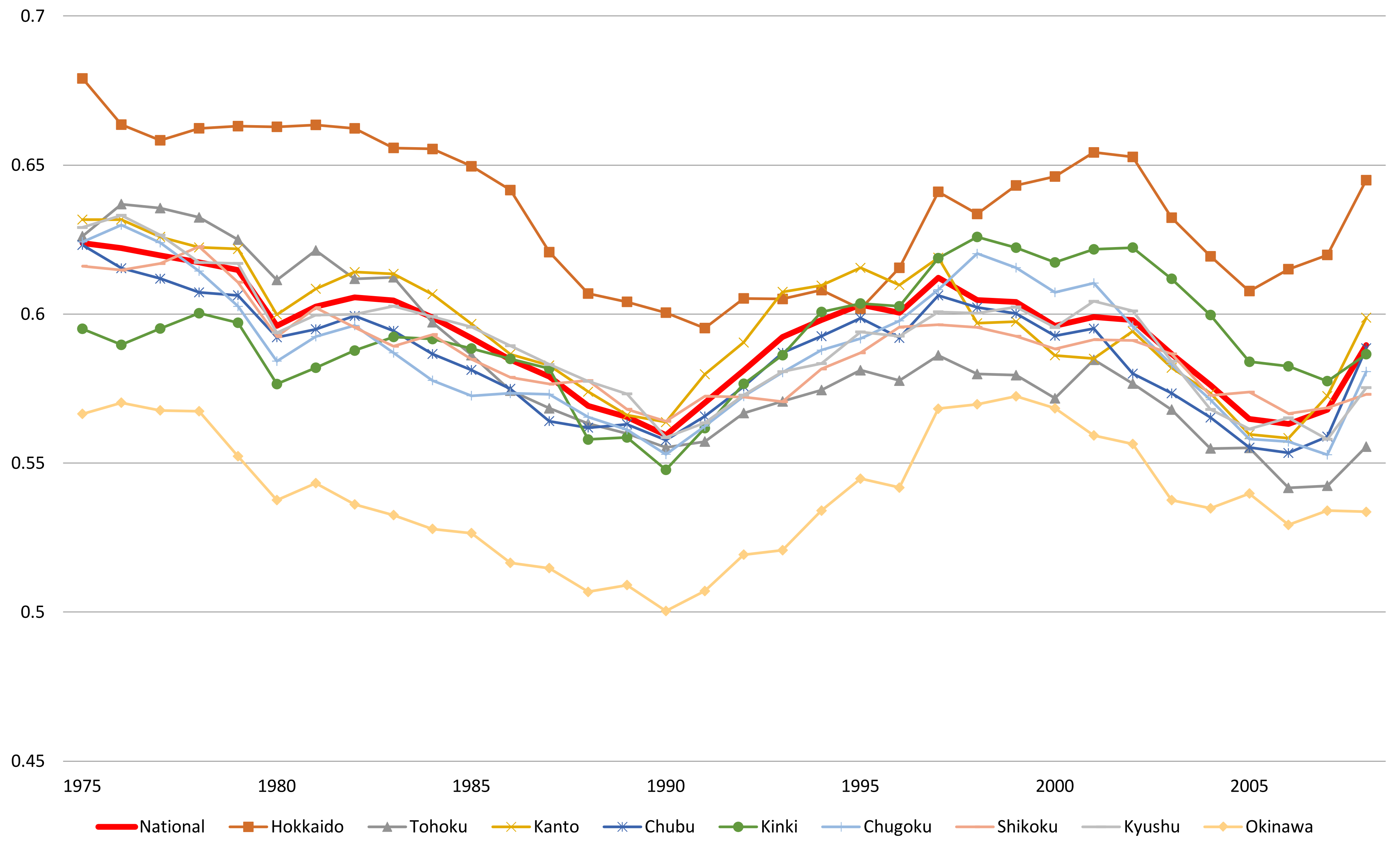

Figure 3. Depreciation Rate

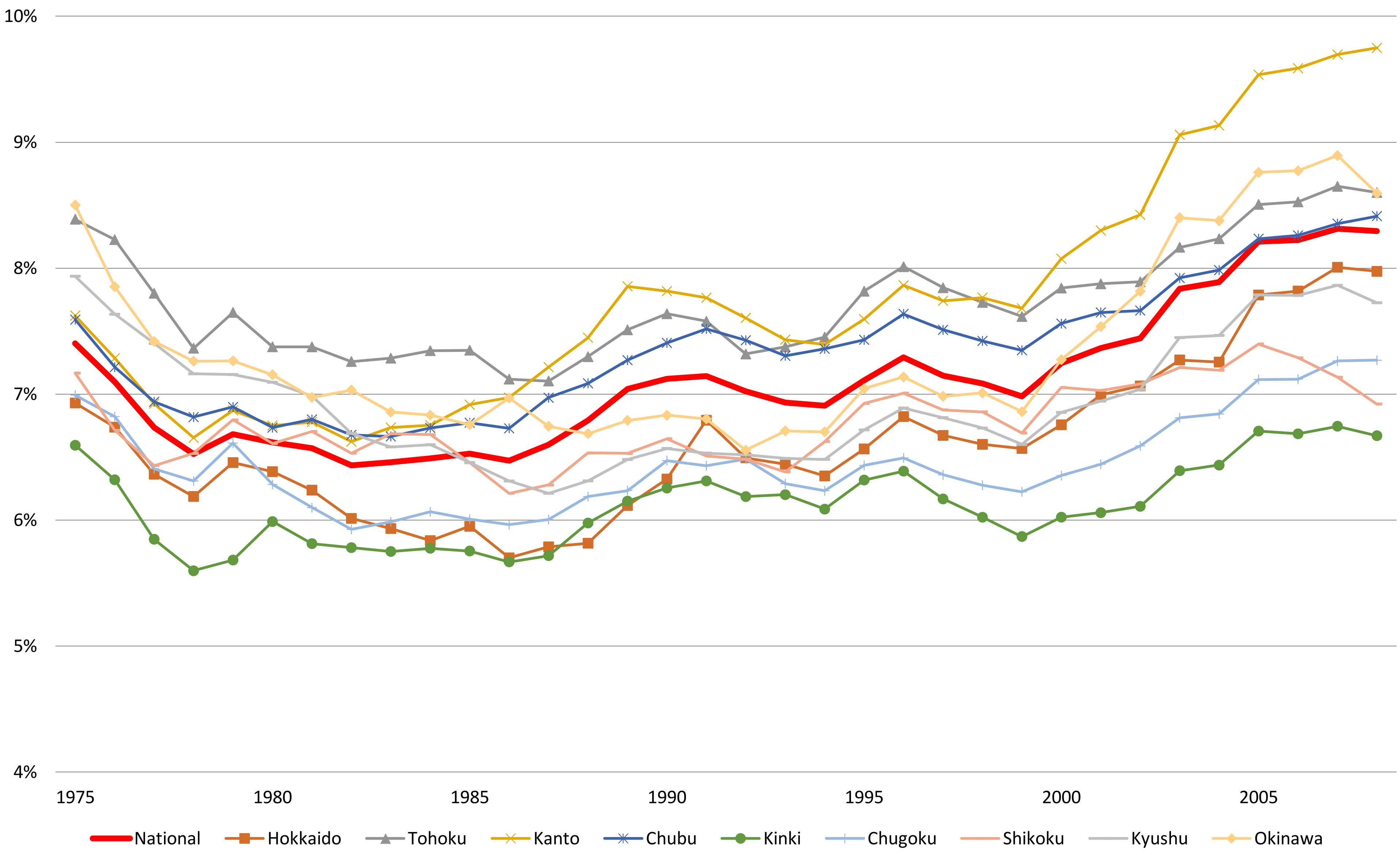

Figure 4. Misallocation

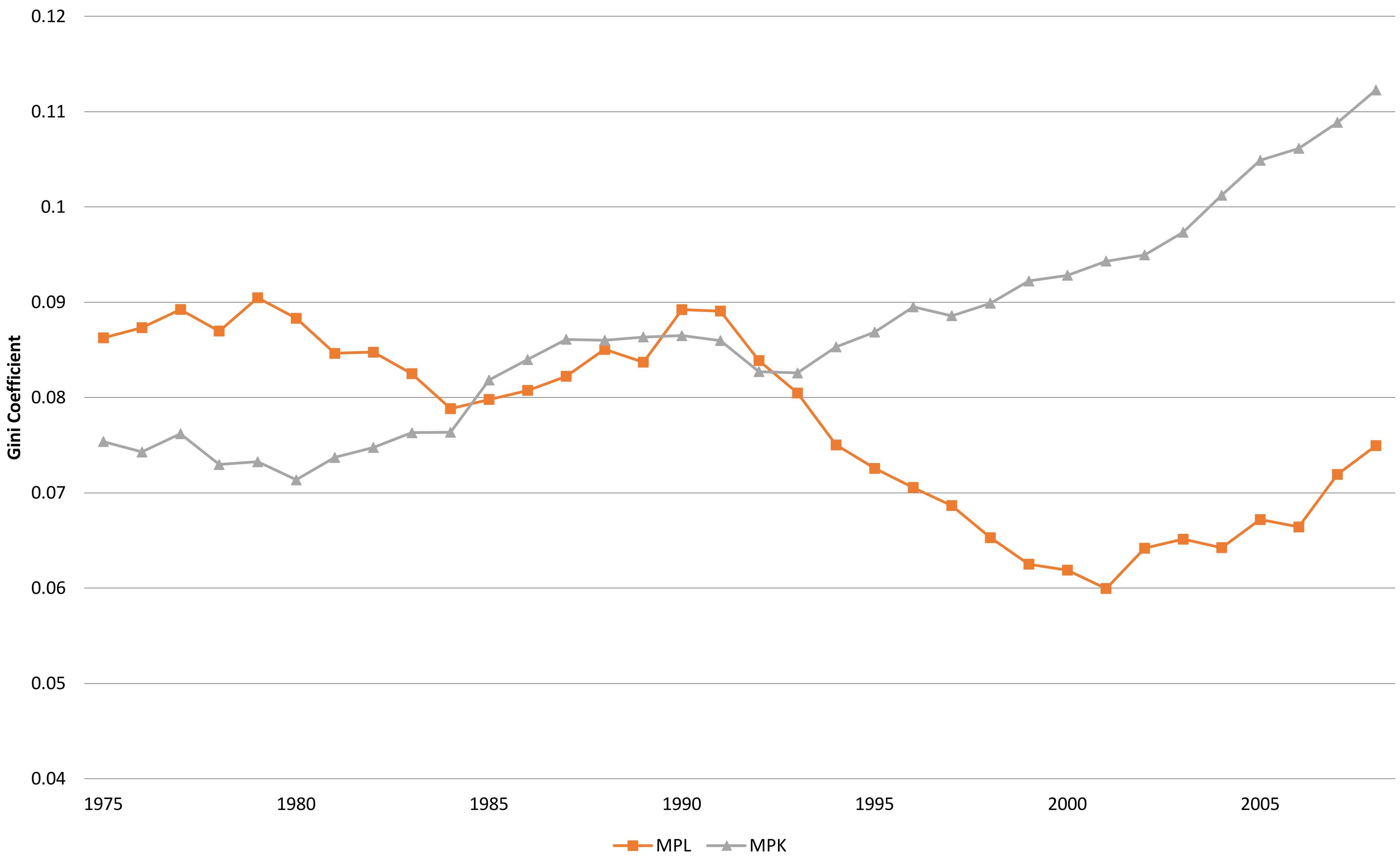

Figure 5. Labor Wedge

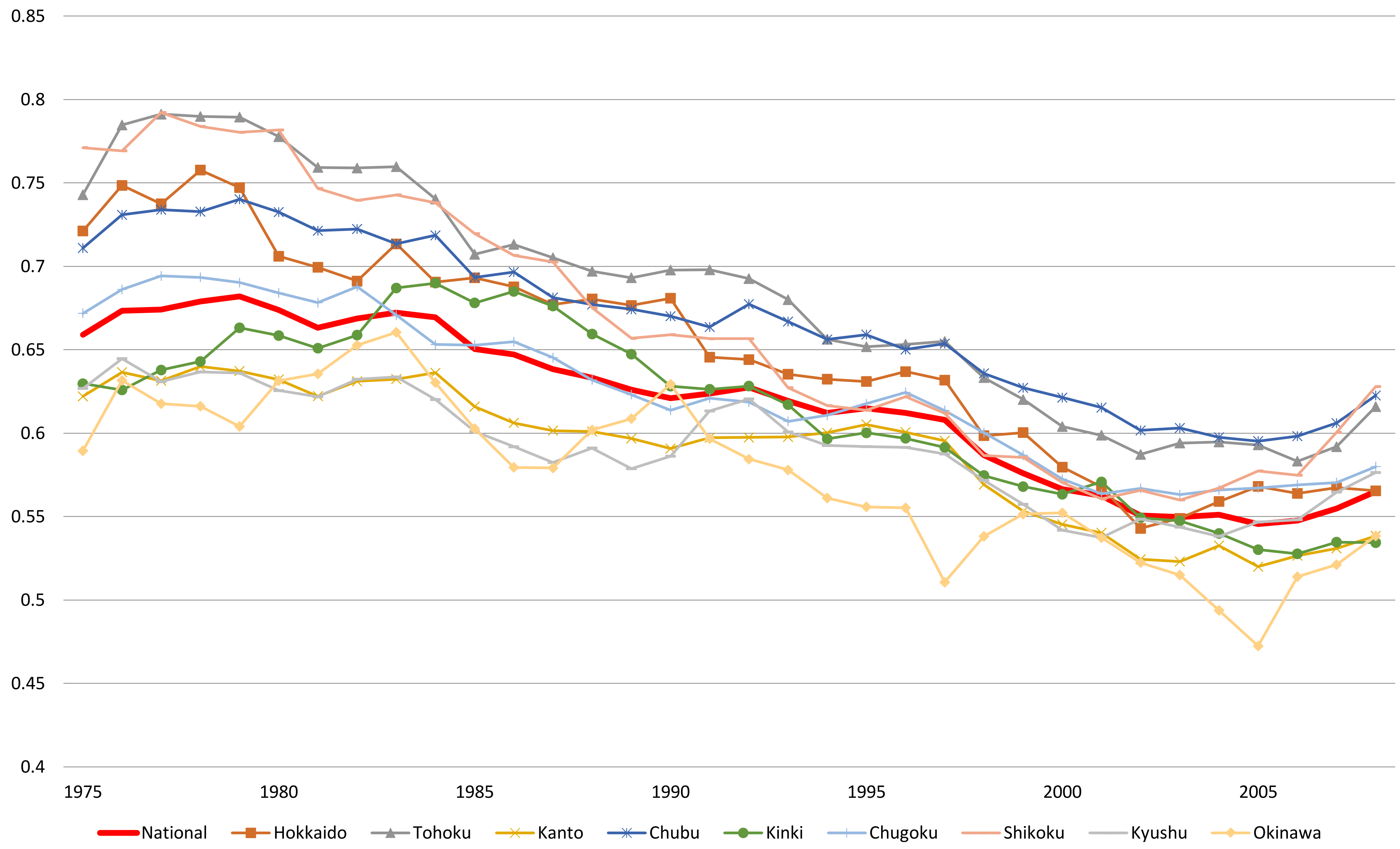

Figure 6. Capital Wedge