University of Kent

School of Economics Discussion Papers

Regional Business Cycle and Growth Features of Japan

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March 2017

KDPE 1705

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March 13, 2017

Abstract

We study the features of regional business cycles and growth in Japan. We find evidence of unconditional convergence over the 1955-2008 period. For the 1975-2008 period, we find evidence of convergence conditional on TFP gap, population growth, private investment rate and TFP growth. We also find that the consumption-output correlation puzzle exists, which implies that the idiosyncratic income shocks are not shared among prefectures and regions. Our analysis implies that frictions in financial markets are responsible for the low consumption risk-sharing among prefectures.

Keywords: Japanese Economy; Regional Convergence; Regional Business Cycle Synchronization
JEL Codes: E01; E32; O47

*The authors are grateful to Etsuro Shioji for his insightful comments. We thank Steve Ambler and Christian Zimmerman for kindly sharing their source code for empirical analysis. We also thank participants of the 2015 Japanese Economic Association Meeting, 2016 Meeting of Money Macro and Finance Group and workshops at the University of Kent, University of Tokyo, and Development Bank of Japan. Otsu acknowledges the financial support by Grant-in-aid from the Japan Center for Economic Research. Inaba acknowledges the financial support by the Nomura Foundation.

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Non-technical summary

The objective of this paper is to construct a dataset of Japanese prefecture level production, income and expenditure data and analyze the Japanese regional growth and business cycle features. The 47 prefectures are analyzed individually and also as 10 regional groups; Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku, Shikoku, Kyushu and Okinawa.

Our dataset is based on the System of National Accounts (SNA) from the Cabinet Office Economic and Social Research Institute (ESRI). From expenditure data, we construct series of the prefectural per capita GDP, private consumption, private investment, government consumption and government investment in 2000 yen over the 1955-2008 period. From income data we construct series of the prefectural labor income share and depreciation rate over the 1975-2008 period. We construct the prefectural net capital stock series over the 1975-2008 period in 2000 yen from the ESRI Prefecture Private Capital Stock data and Private and Public Sector Balance Sheet data along with the SNA data on investment and depreciation. We construct the prefectural total hours worked series over the 1975-2008 period from the Research Institute of Economy, Trade and Industry (RIETI) R-JIP database and the SNA employment data. Finally, we construct the prefectural total factor productivity (TFP) series from the prefectural output, net capital stock and total hours worked series along with the average prefectural labor share.

In terms of regional growth, we find that over the 1955-2008 period, the Tohoku region and Okinawa region, which had the lowest average income per capita, experienced the highest growth. This is evidence of regional convergence in which poor regions grow faster than rich regions so that the income levels of all regions converge to similar levels over time. We formally test this using the framework introduced by Barro (1991) and find that convergence exists in the prefecture level in Japan over the 1955-2008 period. The convergence during the post oil-shock period 1975-2008 is less obvious but we still find regional convergence after controlling for prefectural characteristics such as TFP level gaps, population growth rates, private investment rates and TFP growth rates.

In terms of business cycles, we focus on the post oil-shock period 1975-2008 and find that the bilateral correlation of per capita output is negatively affected by the distance and the similarity of industrial structure and positively affected by the size of the total output of the pair. We further document that the bilateral correlation of output is higher than that of consumption in 847 out of the total 1081 pairs. This phenomenon frequently documented in open economy macroeconomic literature is puzzling since prefectures should want to smooth their consumption path against income shocks through borrowing and lending among each other. We decompose the consumption risk sharing into 3 steps: i) the net factor payments across prefectures capturing the income risk sharing through the capital market, ii) the government transfer across prefectures capturing the income risk sharing at the personal disposable income level, and iii) the consumption risk sharing of households through the financial market. The results show that the highest contributor to consumption risk-sharing is the government transfer which implies that financial market imperfection might be contributing to the low cross-prefecture correlation of consumption.

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 (1992) and Shioji (2001). Barro and Sala-i-Martin (1992) 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) and van Wincoop (1995). Artis and Okubo (2011) find that prefecture pairs with similar industrial structures and shorter distance tend to have higher business cycle synchronization over the 1955-1995 period. In this paper, we focus on the 1975-2008 period and find similar relationship between distance and business cycle synchronization. Moreover, van Wincoop (1995) finds that the consumption-output puzzle discussed in international macroeconomic literature such as Backus, Kehoe and Kydland (1992) and Baxter and Crucicni (1995) exists in Japanese prefecture level over the 1975-1988 period. We find that this puzzle holds also over the 1975-2008 period. We further decompose consumption risk-sharing into contributions of the inter-prefectural capital market, government transfer and the financial market following Nakakuki and Fujiki (2005) and find that financial market imperfection might be playing a role in the low cross-prefecture consumption risk-sharing.

The remainder of the paper is organized as follows. In section 2 we describe the data facts. In section 3 we conduct quantitative 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 Tohoku area was the highest at 4.28% 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 HP filtered regional output and national output.[1] Kanto area has the highest correlation coefficient at 0.964 while Okinawa area has the lowest at 0.045 which is clearly an outlier. At the prefecture level, Mie has the highest correlation at 0.924 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 2.99% where the Kanto area was the most volatile at 1.135 and the Tohoku area was the least volatile at 0.858 relative to the national volatility respectively. At the prefecture level, Shiga was the most volatile while Kochi was the least volatile where the ratios are 1.705 and 0.842 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, the Gini coefficient temporary rises during the late 1980s and remains thereafter higher relative to the 1975 level.

2.2 Regional Expenditure

The ESRI data set provides annual data of regional expenditure on final consumption and investment of both the household and the government.

[1] Throughout this paper we set the smoothing parameter to 100 for HP filtering.

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 0.489 showing that consumption is procyclical at the national level. At the regional level, the Okinawa area has the highest correlation at 0.633 while the Hokkaido area has the lowest at 0.043. At the prefecture level, the correlation ranges from 0.817 in Gunma to -0.044 in Aichi. The second column shows the intra-regional correlation between output and private investment. The national aggregate correlation is 0.727 showing high procyclicality of investment. At the regional level, the Chubu area has the highest correlation at 0.769 while the Okinawa area has the lowest correlation at 0.072. At the prefecture level, the correlation ranges from 0.806 in Aichi to 0.072 in Okinawa. The third column shows the correlation between output and government consumption. The national aggregate correlation is 0.081. At the regional level, the Kyushu area has the highest correlation at 0.424 while the Kanto area has the lowest correlation at -0.024. At the prefecture level, Miyazaki has the highest at 0.638 and Aichi has the lowest at -0.177. The fourth column shows the intra-regional correlation between output and government investment. The national aggregate correlation is 0.193. At the regional level, the Kyushu area has the highest correlation at 0.552 and Chubu has the lowest at -0.051. At the prefecture level, Tokushima has the highest correlation at 0.606 and Aichi has the lowest at -0.139.

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 1.541 in the Okinawa area and 0.518 in the Kanto area. At the prefecture level, Okinawa has by far the highest ratio while Hiroshima has the lowest correlation at 0.513. 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 3.373. At the regional level, the Chugoku area has the highest ratio at 3.549 while the Hokkaido area has the lowest ratio at 2.692. At the prefecture level, Ibaraki has the highest ratio at 4.235 while Chiba has the lowest ratio at 2.223. 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 0.864 at the national aggregate level. At the regional level, the Okinawa area has the highest ratio at 1.316 while the Hokkaido area has the lowest ratio at 0.762. At the prefecture level, Fukui has the highest ratio at 1.746 while Saitama has the lowest ratio at 0.610. The fourth column shows that the standard deviation of government investment relative to that of output is 2.020 at the national level. At the regional level, the Okinawa area has the highest ratio at 4.044 while the Chubu area has the lowest ratio at 1.929. At the prefecture level, Niigata has the highest ratio at 4.413 while Aichi has the lowest ratio at 1.459.

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 0.919 while the Okinawa area has the lowest at 0.202. At the prefecture level, Fukui has the highest correlation at 0.856 while Okinawa has the lowest. The average of the correlation coefficients of all prefectures is 0.609. The second column presents the correlation between regional and national private investment ranging from 0.986 in the Chubu area to 0.572 in the Okinawa area. At the prefecture level, Osaka has the highest correlation at 0.974 while Aomori has the lowest at 0.539. The average of all prefectures is 0.815. The third column presents the correlation between regional and national government consumption ranging from 0.869 in the Chubu area to 0.206 in the Okinawa area. At the prefecture level, Miyagi has the highest correlation at 0.835 while Shiga has the lowest at 0.108. The average of all prefectures is 0.585. The fourth column presents the correlation between regional and national government investment ranging from 0.918 in the Chubu area to 0.289 in the Okinawa area. At the prefecture level, Oita has the highest correlation at 0.796 while Kagawa has the lowest at 0.210. The average of all prefectures is 0.575.

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 2.861 in the Okinawa area to 1.041 in the Kanto area. At the prefecture level, Okinawa has the highest relative volatility while Tokyo has the lowest at 1.126. The average of all prefectures is 1.677 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 1.149 in the Kanto area to 0.738 in the Tohoku area. At the prefecture level, Ibaraki has the highest at 1.660 while Kagoshima has the lowest at 0.627. The average of all prefectures is 1.043. The third column reports the standard deviation of regional government consumption relative to that of national government consumption which ranges from 1.598 in the Okinawa area to 1.001 in the Chubu area. At the prefecture level, Wakayama has the highest at 2.199 while Saitama has the lowest at 0.849. The average of all prefectures is 1.498. The fourth column reports the standard deviation of regional government investment relative to that of national investment ranging from 2.099 in the Okinawa area to 1.027 in the Chubu area. At the prefecture level, Kagawa has the highest at 2.681 while Aichi has the lowest at 1.039. The average of all prefectures is 1.701.

2.3 Regional Income

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

$$1-\theta = \frac{\text{employees compensation} + 0.5 \times \text{ indirect business tax} + 0.8 \times \text{ mixed income}}{GDP}.$$

following Hayashi and Prescott (2002).[2] The capital depreciation rate is defined as

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

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 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 the HP filtered labor income share and the HP filtered output over the 1975-2008 period. The correlation for the national level is -0.715 where that for regional levels vary from -0.716 for the Kanto area to 0.010 for the Shikoku area. Ehime has the highest positive correlation at 0.115 while Yamanashi has the highest negative correlation at -0.828. The countercyclical labor income share is consistent with the observation in the US by Young (2004) and Hansen and Prescott (2005).

The third column in Table 8 reports the average capital depreciation rate over the 1975-2008 period. The national average is 0.077 ranging from 0.087 in the Tohoku area to 0.066 in the Kinki area. The prefecture level depreciation rates range from 0.109 in Kumamoto to 0.046% 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

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

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.

The fourth column shows the correlation between the HP filtered depreciation rate and the HP filtered output over the 1975-2008 period. The correlation at the national level is 0.489 where the regional correlation ranges from 0.620 in the Kanto area to 0.317 in the Kinki area. At the prefecture level, Saitama has the highest correlation at 0.773 while Hyogo has the lowest at -0.185. The average of the prefecture level correlation is 0.415 indicating procyclical depreciation rate on the average.

2.4 Regional Production

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

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

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.[3]

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.[4] 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

[3] 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.

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

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 second column shows that capital stock is relatively abundant in the Chubu area with a ratio of 1.208 while it is relatively scarce in the Okinawa area with a ratio of 0.661. At the prefecture level, the highest per capita capital is in Mie with a ratio of 1.722 and the lowest is in Kumamoto with a ratio of 0.617. The average of all prefectures is 0.942. 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 1.134 while the Okinawa area has the lowest with a ratio of 0.882. At the prefecture level, Tokyo has the highest relative TFP with a ratio of 1.330 while Ibaraki has the lowest with a ratio of 0.784. The average of all prefectures is 0.933.

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 0.428. At the regional level, the Kyushu area has the highest correlation at 0.660 while the Okinawa area has the lowest correlation at 0.166. At the prefecture level, Osaka has the highest correlation at 0.738 while Wakayama has the lowest correlation at -0.100. The average of all prefectures is 0.298. Finally, the third column shows the intra-regional correlation between output and total factor productivity. The national aggregate correlation is 0.829 showing high procyclicality of TFP. At the regional level, the Kanto area has the highest correlation at 0.887 while the Shikoku area has the lowest correlation at 0.616. At the prefecture level, Osaka has the highest correlation at 0.957 while Kagoshima has the lowest correlation at 0.487. Therefore, TFP is procyclical at the prefecture level as well. The average of all prefectures is 0.813.

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 Hokkaido 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 0.808 at the national level. At the regional level, the Shikoku area has the highest ratio at 0.918 while the Chubu area has the lowest at 0.694. At the prefecture level Kagoshima has the highest at 1.170 while Wakayama has the lowest at 0.380. Finally, the third column shows that the standard deviation of TFP relative to that of output is 0.795 at the national level. At the regional level the Okinawa area has the highest ratio at 1.084 while the Kyushu area has the lowest at 0.662. At the prefecture level Kagoshima has the highest at 1.203 while Osaka has the lowest at 0.701. The average of all prefectures is 0.940.

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 Kinki area to 0.559 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 0.861. 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 0.413. At the prefecture level, Mie has the highest correlation at 0.872 while Kochi has the lowest at -0.092. The average of all prefectures is 0.583. 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, 0.731.

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 1.209 in the Kanto area to 0.860 in the Kyushu area. At the prefecture level, Ibaraki has the highest ratio at 1.891 while Wakayama has the lowest at 0.651. The average of all prefectures is 1.027. The third column reports the standard deviation of regional TFP relative to that of national TFP which ranges from 1.347 in the Kanto area to 0.745 in the Hokkaido area. At the prefecture level, Ibaraki has the highest ratio at 2.071 while Hokkaido has the lowest. The average of all prefectures is 1.371. 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 1955-2008 period.

We can also compare production efficiency across regions by the marginal product of labor and capital which are defined as

$$mpl_{i,t} = (1-\theta_i)\frac{y_{i,t}}{l_{i,t}}, mpk_{i,t} = \theta_i \frac{y_{i,t}}{k_{i,t}}$$

respectively.

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 decreasing while that of capital has been increasing.

3 Regional Growth and Convergence

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 $\beta-$Convergence

In this section we investigate the existence of absolute convergence in output 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.

3.2.1 Solow-Swan Model

Solow-Swan growth model is a dynamic model of capital accumulation. The typical per capita capital law of motion looks like

$$\dot{k}_{i,t} = pi_{i,t} - (\delta_i + \dot{n}_i)k_{i,t},$$

where $\dot{n}_i$ is population growth representing the capital dilution effect. Assume that households save a fixed fraction of their income

$$s_{i,t} = \varphi_i y_{i,t}.$$

Consider a closed economy so that savings is equal to investment:

$$pi_{i,t} = y_{i,t} - c_{i,t} - g_{i,t} = s_{i,t}.$$

Finally, assume production function is (1) so that the capital law of motion is

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

According to the model, when the current capital stock level is low, the marginal product of capital is high. 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.

3.2.2 Growth Regression

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

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

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.[5] 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.

4 Regional Comovement and the Quantity Anomaly

In this section we analyze bilateral business cycle comovement patterns across prefectures. With 47 prefecture, we have 1081 pairs ($47 \times 46 \div 2$) to analyze bilateral comovement patterns. We first focus on the cross-prefectural correlation patterns and find that the so-called quantity anomaly holds in Japanese prefectures as shown in van Wincoop (1995). Second, we investigate sources of the degree of business cycle synchronization following Artis and Okubo (2011). Next, we focus on the components of risk-sharing between prefectures following Nakakuki and Fujiki (2005).

4.1 Cross-Prefectural Correlation Patterns

Table 12 shows the mean bilateral correlation of all pairs for each variable over the 1975-2008 period. The mean output correlation is 0.462. Consumption correlation is lower than output correlation at 0.264 while investment correlation is higher at 0.642. Labor and capital correlation are higher than output correlation at 0.575 and 0.759 respectively. Finally, TFP correlation is lower than output correlation at 0.358. In sum, we find that for private expenditure components

$$\rho(pc_i, pc_j) < \rho(y_i, y_j) < \rho(pi_i, pi_j)$$

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

and for production factors

$$\rho(z_i, z_j) < \rho(y_i, y_j) < \rho(l_i, l_j) < \rho(k_i, k_j).$$

Therefore, the data shows the quantity anomaly a la Backus, Kehoe and Kydland (1994):

$$\rho(pc_i, pc_j) < \rho(z_i, z_j) < \rho(y_i, y_j)$$

which is consistent with the findings of van Wincoop (1995) for the period 1974-1988.

We follow Ambler, Cardia and Zimmermann (2004) and conduct a GMM analysis on the order of correlation. It turns out that, unlike their analysis for 20 OECD countries, we cannot statistically reject the hypothesis that

$$\rho(pc_i, pc_j) > \rho(y_i, y_j),$$

in the 47 prefectures in Japan at a 10 percent confidence level. However, 78.35% of the total 1081 pairs in our sample are consistent with the quantity anomaly:

$$\rho(pc_i, pc_j) < \rho(y_i, y_j).$$

Therefore, we consider that the quantity anomaly does exist within Japan prefectures.

4.2 Cross-Prefectural Business Cycle Synchronization

In this section, we investigate the sources of bilateral business cycle synchronization among Japanese prefectures in a simplified version of Artis and Okubo (2011). Instead of their GMM panel framework, we estimate the following regression for the cross-section correlation of variable v:

$$\rho(v_i, v_j) = \alpha + \beta X_{ij} + \varepsilon_{ij}$$

where X includes the bilateral geographical proximity, industrial similarity, and the size of the combined economy. In addition to their analysis of cross-prefectural output correlation, we investigate the synchronization in the fluctuations of consumption, investment, labor, capital and productivity.

For geographical proximity, we consider the distance which is measured as the straight distance between the capital cities of each prefecture. We expect the pairs to have lower distance and are in the same region should have higher bilateral business cycle synchronization. For industrial similarity, we consider the absolute value of the logged capital income share ratio.[6] We expect this term to have a negative effect on synchronization as it represents the idiosyncrasies in industry composition which leads to idiosyncratic vulnerability to industry level shocks. Finally, the size of the combined economy is defined as the product of the GDP shares of national GDP. We expect this term to be positive as the larger the economy the greater the intraindustry trade we should expect according to the gravity model.

Table 13 presents results to a cross-section regression of several characteristics of the bilateral country pair on the correlation of each variable. The first column shows the result for output. All variables are statistically significant and the coefficients have the expected signs for output correlation. Therefore, the main results of Artis and Okubo (2011) hold in our simplified analysis.[7] The second column shows that for consumption the industry specialization and size affects in the same way of output. This can be considered as an indirect effect of these regressors through their effects on income correlation.[8] Interestingly, the effect of distance is insignificant for consumption correlation. The third column shows that distance and size affect investment correlation in the same direction as they affect output correlation. However, the effect of industry similarity is not significant. The fourth and fifth column show that the effect of industry similarity is not significant for labor and capital correlation as well. The distance negatively affect labor and capital correlation. While size positively affects capital correlation, it negatively affects labor correlation. Finally, distance and size affect TFP in the same direction as they affect output correlation while the effect of industry

[6] Artis and Okubo (2011) consider the per capita output difference as a proxy of industry differences.

[7] Since we have a measure of TFP correlation, we could include it in the regression. In fact, TFP correlation has a significant impact on output correlation in a simplle regression

$$\rho(y_i, y_j) = \underset{(24.58)}{0.206} + \underset{(35.40)}{0.715} \times \rho(z_i, z_j) + \varepsilon_{ij},$$

with $R^2 = 0.537$. However, as we show later, TFP correlation itself is affected by distance and size.

[8] If we simply regress consumption correlation on income correlation we get

$$\rho(c_i, c_j) = \underset{(2.927)}{0.052} + \underset{(13.21)}{0.461} \times \rho(y_i, y_j) + \varepsilon_{ij},$$

with $R^2 = 0.138$.

similarity is insignificant.

4.3 Decomposition of Cross-Prefectural Risk-Sharing

Following Nakakuki and Fujiki (2005) we decompose regional GDP into several components:

$$y_{1it} = \frac{y_{1it}}{y_{2it}} \frac{y_{2it}}{y_{3it}} \frac{y_{3it}}{pc_{it}} pc_{it}, \tag{5}$$

where $y_{1it}, y_{2it}, y_{3it}, pc_{it}$ are per capita GDP, GNP, personal disposable income, and private consumption for prefecture i.[9] The first term $\frac{y_{1it}}{y_{2it}}$ stands for income risk-sharing through the capital market as GNP adjusts for the net factor payment transfers across prefectures. The second term $\frac{y_{2it}}{y_{3it}}$ stands for income risk-sharing through government transfers as personal disposable income adjusts for government transfer across prefectures. The third term $\frac{Y_{3it}}{C_{it}}$ stands for consumption risk-sharing across prefectures.

We estimate the consumption risk-sharing components via panel regressions

$$\begin{aligned} \dot{y_{1it}} - \dot{y_{2it}} &= \nu_{Kt} + \beta_K \dot{y_{1it}} + \epsilon_{Kit}, \\ \dot{y_{1it}} - \dot{y_{3it}} &= \nu_{KTt} + \beta_{KT} \dot{y_{1it}} + \epsilon_{K+Tit}, \\ \dot{y_{1it}} - \dot{pc_{it}} &= \nu_{KTCt} + \beta_{KTC} \dot{y_{1it}} + \epsilon_{K+T+Cit}, \end{aligned}$$

where ν_{jt} correspond to the period fixed effects. Consider the case in which an increase in GDP has no effect on GNP. The the coefficient β_K should be equal to one. Therefore, the interpretation of the coefficients is such that the higher the β the stronger the risk-sharing.

Table 14 summarizes the regression results. We find that over the 1975-2008 period, the income risk-sharing through the capital market β_K is 15.6%, the income risk-sharing through the capital market and government transfer β_{KT} is 46.5% and these income risk-sharing plus the consumption risk-sharing through the financial market β_{KTC} is 69.6%.[10] The marginal effects of each level of risk-sharing are simply the differences in the βs. This shows that most

[9] Regional disposable income is not directly available in the regional SNA database. The detailed method of constructing this data is listed in the appendix.

[10] The total risk-sharing coefficient β_{KTC} is lower than that reported in Nakakuki and Fujiki (2005), 82.2. This is because we have a longer estimation period and that the SNA database recentlt made a significant revision which gave us more access to data that were not available to them.

of the prefectural risk-sharing is done by the government ($\beta_{KT} - \beta_K = 30.9$) and that the financial market plays less of a role ($\beta_{KTC} - \beta_{KT} = 23.1\%$). This implies that the financial market imperfection might be responsible for the low cross-prefectural consumption correlation.

In comparison to the results in Nakakuki and Fujiki (2005) for 1990-2001, our estimate of the total risk-sharing β_{KTC} is lower (69.6% compared to 83.6%).[11] The risk-sharing through capital markets β_K is at a similar level to theirs (15.6% compared to 16.3%), the risk-sharing by the government $\beta_{KT} - \beta_K$ is much higher (30.9% compared to 9.0%) and the risk-sharing through financial markets $\beta_{KTC} - \beta_{KT}$ is much lower (23.1% compared to 58.1%). There are several reasons for this difference. First, we have a different time period. To check whether this has an effect, we estimated the panel regression coefficients with the same period and found that the total risk-sharing is not too different from our original result (71.5% compared to 69.6%). Second, they consider consumption as total final consumption expenditure of the prefecture whereas we only focus on private consumption. We estimated the risk-sharing of total consumption over the 1990-2001 period and found that the coefficient slightly increases from our original result (75.2% compared to 69.6%). However, it is still significantly lower than Nakakuki and Fujiki (2005). Finally, the SNA data has gone through a significant revision over time and we are able to use a more complete data set than what was available for Nakakuki and Fujiki (2005).[12] Most importantly, there is much more SNA income data available today which saved us the need to estimate the prefectural personal disposable income.

5 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

[11] They report results for 68SNA data over the 1975-1999 period and 93SNA data over the 1990-2001 period. Since our data set is predominantly based on 93SNA data, we only compare our resutls with their 93SNA data results.

[12] For instance, the SNA93 data has been extended in the past up to 1980. Furthermore, there are much less missing values in our dataset than theirs. Therefore, we constructed a balanced panel whereas they use an unbalanced panel.

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 regional business cycles, we find that the quantity anomaly holds in Japanese prefectures where on average the cross-prefectural correlation of output is higher than that of consumption. We decompose risk-sharing components and find that government transfers play a more important role in consumption risk-sharing than domestic financial markets. Future studies should investigate sources of financial market imperfections that prevent cross-prefectural consumption risk-sharing.

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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), and private inventory stocks. 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

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

where K is the net private capital stock, PI 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. 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.

A.3 Disposable Income

The definition of the prefectural personal disposable income corresponding to Prefecture Economic Accounts is,

$$\begin{aligned} & \text{prefectural personal disposable income} \\ = \; & \text{prefectural disposable income (household)} \\ & + \text{prefectural disposable income (non-profit institutions serving households)} \\ & - \text{employers' contribution to social security.} \end{aligned}$$

For missing data, we follow Nakakuki and Fujiki (2005) and use Household Survey data to estimate them. The main assumption is that the ratio of "disposable income" to "gross income" net of "social security receipt" in the Household Survey should be equal to the ratio of prefectural income of the household and non-profit institutions serving the households net of employers social security contribution to prefectural disposable income of households and non-profit institutions serving household net of employers' social security contribution in the Prefecture Economic Accounts. Then we can estimate the missing prefectural personal disposable income as

$$\begin{aligned} & \text{prefectural personal disposable income} \\ = & \ [\text{prefectural income (household)} \\ & + \text{prefectural income (non-profit institutions serving households)} \\ & - \text{employers' contribution to social security}] \\ & \times \text{disposable income} \div [\text{gross income} - \text{social security receipt}]. \end{aligned}$$

Further details can be provided by authors upon request.

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%		0.760		0.962	
Tohoku	0.792		4.28%		0.712		0.858	
Kanto	1.190		3.61%		0.964		1.135	
Chubu	1.071		4.09%		0.955		1.075	
Kinki	0.966		3.47%		0.958		1.134	
Chugoku	0.920		3.99%		0.933		1.043	
Shikoku	0.824		3.84%		0.857		1.020	
Kyushu	0.799		3.96%		0.877		0.914	
Okinawa	0.626		4.26%		0.045		1.048	
Average	0.887		3.97%		0.731		1.165	
1	Tokyo	1.764	Nagano	4.71%	Mie	0.924	Shiga	1.705
2	Osaka	1.195	Fukushima	4.65%	Chiba	0.915	Chiba	1.592
3	Aichi	1.140	Yamanashi	4.57%	Saitama	0.902	Mie	1.554
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Kumamoto	0.694	Nara	3.23%	Saga	0.429	Kagoshima	0.892
46	Kagoshima	0.689	Hyogo	3.17%	Aomori	0.387	Niigata	0.844
47	Okinawa	0.626	Wakayama	2.86%	Okinawa	0.045	Kochi	0.842

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

	corr(pc^i, y^i)		corr(pi^i, y^i)		corr(gc^i, y^i)		corr(gi^i, y^i)	
National	0.489		0.727		0.081		0.193	
Hokkaido	0.043		0.540		0.409		0.163	
Tohoku	0.577		0.651		0.298		0.132	
Kanto	0.510		0.765		-0.024		0.126	
Chubu	0.512		0.769		0.037		-0.051	
Kinki	0.334		0.650		0.142		0.426	
Chugoku	0.548		0.670		0.060		0.325	
Shikoku	0.589		0.620		0.244		0.343	
Kyushu	0.496		0.588		0.424		0.552	
Okinawa	0.633		0.072		0.412		0.404	
Average	0.467		0.577		0.234		0.212	
1	Gunma	0.817	Aichi	0.806	Miyazaki	0.638	Tokushima	0.606
2	Mie	0.712	Miyagi	0.749	Nagasaki	0.632	Hyogo	0.606
3	Fukushima	0.699	Kagawa	0.742	Fukui	0.499	Saga	0.557
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Wakayama	00092	Oita	0.260	Kanagawa	-0.102	Kagawa	-0.058
46	Hokkaido	0.043	Nagasaki	0.240	Gifu	-0.118	Shizuoka	-0.075
47	Osaka	-0.044	Okinawa	0.072	Aichi	-0.177	Aichi	-0.139

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		3.373		0.864		2.020	
Hokkaido	0.813		2.692		0.762		2.343	
Tohoku	0.877		2.900		1.061		2.722	
Kanto	0.518		3.413		1.184		2.237	
Chubu	0.592		3.300		0.804		1.929	
Kinki	0.603		3.302		1.138		2.422	
Chugoku	0.615		3.549		0.976		2.794	
Shikoku	0.685		3.245		0.891		2.591	
Kyushu	0.824		2.926		0.985		2.499	
Okinawa	1.541		2.983		1.316		4.044	
Average	0.829		3.041		1.130		3.018	
1	Okinawa	1.541	Ibaraki	4.235	Fukui	1.746	Niigata	4.413
2	Akita	1.174	Fukui	4.187	Gunma	1.731	Kagawa	4.308
3	Kumamoto	1.169	Kochi	3.957	Akita	1.545	Fukui	4.269
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Aichi	0.576	Kagoshima	2.371	Tokushima	0.639	Fukuoka	2.256
46	Tokyo	0.535	Miyazaki	2.271	Mie	0.612	Shiga	1.755
47	Hiroshima	0.513	Chiba	2.223	Saitama	0.610	Aichi	1.459

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	0.619		0.769		0.463		0.659	
Tohoku	0.782		0.859		0.813		0.725	
Kanto	0.848		0.979		0.865		0.860	
Chubu	0.919		0.986		0.869		0.918	
Kinki	0.860		0.985		0.868		0.863	
Chugoku	0.834		0.953		0.859		0.765	
Shikoku	0.760		0.918		0.780		0.659	
Kyushu	0.813		0.922		0.678		0.823	
Okinawa	0.202		0.572		0.206		0.289	
Average	0.609		0.815		0.585		0.575	
1	Fukui	0.856	Osaka	0.974	Miyagi	0.835	Oita	0.796
2	Yamaguchi	0.837	Saitama	0.948	Hyogo	0.825	Aichi	0.777
3	Chiba	0.830	Shizuoka	0.946	Yamaguchi	0.801	Saga	0.769
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Oita	0.389	Akita	0.607	Okinawa	0.206	Fukui	0.329
46	Shiga	0.387	Okinawa	0.572	Nagasaki	0.170	Okinawa	0.289
47	Okinawa	0.202	Aomori	0.539	Shiga	0.108	Kagawa	0.210

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	1.384		0.767		0.849		1.116	
Tohoku	1.332		0.738		1.054		1.157	
Kanto	1.041		1.149		1.557		1.257	
Chubu	1.127		1.051		1.001		1.027	
Kinki	1.212		1.110		1.493		1.360	
Chugoku	1.137		1.098		1.179		1.443	
Shikoku	1.238		0.981		1.052		1.308	
Kyushu	1.334		0.793		1.042		1.131	
Okinawa	2.861		0.927		1.598		2.099	
Average	1.677		1.043		1.498		1.701	
1	Okinawa	2.861	Ibaraki	1.660	Wakayama	2.199	Kagawa	2.681
2	Nagasaki	2.353	Shiga	1.358	Gunma	2.169	Yamanashi	2.189
3	Mie	2.304	Hiroshima	1.338	Tokyo	2.121	Nagasaki	2.120
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Miyagi	1.186	Saga	0.753	Tottori	1.014	Kagoshima	1.363
46	Hiroshima	1.155	Aomori	0.744	Tokushima	0.888	Hokkaido	1.116
47	Tokyo	1.126	Kagoshima	0.627	Hokkaido	0.849	Aichi	1.039

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

	Labor		Capital		TFP	
Hokkaido	0.979		0.861		0.961	
Tohoku	1.020		0.782		0.912	
Kanto	1.004		1.045		1.134	
Chubu	1.076		1.208		0.974	
Kinki	0.943		0.963		0.963	
Chugoku	1.021		1.066		0.905	
Shikoku	0.994		0.872		0.879	
Kyushu	0.958		0.841		0.901	
Okinawa	0.851		0.661		0.882	
Average	0.992		0.942		0.933	
1	Tokyo	1.374	Mie	1.722	Tokyo	1.330
2	Nagano	1.101	Ibaraki	1.596	Saitama	1.096
3	Fukui	1.097	Hyogo	1.339	Shiga	1.074
⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Chiba	0.740	Nara	0.626	Wakayama	0.796
46	Saitama	0.738	Saitama	0.618	Mie	0.790
47	Nara	0.669	Kumamoto	0.617	Ibaraki	0.784

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		0.428		0.829	
Hokkaido	0.518		0.510		0.613	
Tohoku	0.605		0.375		0.756	
Kanto	0.504		0.259		0.887	
Chubu	0.684		0.366		0.863	
Kinki	0.725		0.569		0.884	
Chugoku	0.540		0.335		0.818	
Shikoku	0.358		0.584		0.616	
Kyushu	0.747		0.660		0.718	
Okinawa	0.159		0.166		0.800	
Average	0.383		0.298		0.813	
1	Tochigi	0.727	Osaka	0.738	Osaka	0.957
2	Aichi	0.679	Kagawa	0.698	Tochigi	0.937
3	Saitama	0.666	Fukuoka	0.636	Kanagawa	0.926
⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Kyoto	0.039	Shizuoka	-0.035	Kochi	0.602
46	Wakayama	-0.012	Fukui	-0.090	Nagasaki	0.544
47	Tokushima	-0.089	Wakayama	-0.100	Kagoshima	0.487

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		0.808		0.795	
Hokkaido	1.114		0.898		0.762	
Tohoku	0.691		0.811		0.833	
Kanto	0.433		0.808		0.885	
Chubu	0.512		0.694		0.799	
Kinki	0.463		0.768		0.704	
Chugoku	0.603		0.693		0.872	
Shikoku	0.959		0.918		0.936	
Kyushu	0.728		0.752		0.662	
Okinawa	0.800		0.844		1.084	
Average	0.671		0.729		0.940	
1	Kagoshima	1.328	Kagoshima	1.170	Kagoshima	1.203
2	Nagasaki	1.142	Ibaraki	1.014	Fukui	1.177
3	Kochi	1.117	Gifu	0.961	Yamanashi	1.131
⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Fukushima	0.419	Tochigi	0.479	Saga	0.752
46	Nara	0.407	Toyama	0.453	Iwate	0.723
47	Osaka	0.351	Wakayama	0.380	Osaka	0.701

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		0.559		0.413		0.687	
Tohoku	0.906		0.910		0.764		0.816	
Kanto	0.905		0.985		0.953		0.945	
Chubu	0.962		0.970		0.946		0.957	
Kinki	0.944		0.986		0.820		0.907	
Chugoku	0.869		0.936		0.879		0.929	
Shikoku	0.871		0.967		0.486		0.613	
Kyushu	0.831		0.948		0.765		0.777	
Okinawa	0.528		0.762		0.499		0.398	
Average	0.749		0.861		0.583		0.664	
1	Wakayama	0.922	Kanagawa	0.974	Mie	0.872	Mie	0.932
2	Fukushima	0.906	Osaka	0.972	Tokyo	0.855	Hiroshima	0.909
3	Kagawa	0.904	Kyoto	0.967	Shizuoka	0.826	Aichi	0.888
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Okinawa	0.528	Kumamoto	0.669	Saga	0.288	Kagoshima	0.334
46	Saga	0.471	Shimane	0.623	Ibaraki	0.231	Wakayama	0.308
47	Nara	0.395	Hokkaido	0.559	Kochi	-0.092	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		0.863		0.745		0.777
Tohoku		1.309		1.001		1.046		0.998
Kanto		0.994		1.209		1.347		1.209
Chubu		1.042		0.921		1.079		1.072
Kinki		1.014		1.096		1.023		1.154
Chugoku		1.149		0.861		1.102		1.004
Shikoku		1.513		0.944		0.979		0.831
Kyushu		1.278		0.860		0.771		0.925
Okinawa		1.270		0.874		1.142		0.837
Average		1.409		1.027		1.371		1.170
1	Nagasaki	2.362	Ibaraki	1.891	Ibaraki	2.071	Fukushima	1.696
2	Kochi	1.984	Hyogo	1.567	Wakayama	1.930	Hyogo	1.626
3	Ehime	1.947	Nara	1.540	Fukushima	1.876	Aichi	1.561
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Gunma	0.967	Okayama	0.726	Miyazaki	0.914	Fukui	0.816
46	Osaka	0.881	Toyama	0.673	Kagoshima	0.881	Hokkaido	0.777
47	Gifu	0.876	Wakayama	0.651	Hokkaido	0.745	Kagoshima	0.582

Table 8. Income Statistics: 1975-2008

	Labor Income Share				Capital Depreciation			
	Level		$corr(1-\theta_i, y_i)$		Rate		$corr(\delta_i, y_i)$	
National	0.593		-0.715		0.077		0.489	
Hokkaido	0.635		-0.419		0.073		0.551	
Tohoku	0.584		-0.392		0.087		0.396	
Kanto	0.597		-0.716		0.083		0.620	
Chubu	0.586		-0.694		0.079		0.543	
Kinki	0.592		-0.686		0.066		0.317	
Chugoku	0.588		-0.610		0.069		0.541	
Shikoku	0.588		0.010		0.075		0.338	
Kyushu	0.591		-0.618		0.077		0.334	
Okinawa	0.540		-0.243		0.083		0.438	
1	Tokyo	0.645	Yamanashi	-0.828	Saitama	0.094	Saitama	0.773
2	Kochi	0.635	Saitama	-0.738	Kumamoto	0.094	Yamanashi	0.745
3	Hokkaido	0.635	Shizuoka	-0.732	Chiba	0.085	Chiba	0.718
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Chiba	0.537	Saga	0.022	Ibaraki	0.045	Nagano	0.017
46	Ehime	0.529	Kochi	0.099	Wakayama	0.045	Kagoshima	-0.055
47	Shiga	0.489	Ehime	0.115	Mie	0.043	Hyogo	-0.185

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

	MPL		MPK		Labor Wedge		Capital Wedge	
Hokkaido	0.978		0.935		1.047		1.006	
Tohoku	0.804		1.090		1.103		0.997	
Kanto	1.159		1.098		0.954		0.946	
Chubu	1.008		0.928		1.081		1.132	
Kinki	0.969		0.955		0.991		0.933	
Chugoku	0.913		0.894		1.012		1.062	
Shikoku	0.825		0.963		1.071		0.995	
Kyushu	0.852		0.978		0.959		1.041	
Okinawa	0.720		1.151		0.932		0.873	
National	0.891		1.010		1.046		1.016	
1	Tokyo	1.409	Saitama	1.350	Akita	1.238	Ibaraki	1.311
2	Osaka	1.120	Ishikawa	1.319	Tottori	1.228	Mie	1.284
3	Kanagawa	1.086	Shiga	1.299	Niigata	1.200	Yamaguchi	1.139
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Ehime	0.751	Wakayama	0.667	Nara	0.877	Okinawa	0.873
46	Aomori	0.742	Mie	0.604	Aomori	0.876	Ishikawa	0.858
47	Okinawa	0.720	Ibaraki	0.600	Fukuoka	0.836	Shiga	0.842

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

	Output		Labor		Capital		TFP	
National	1.99		-0.25		1.19		1.05	
Hokkaido	1.68		-0.39		0.83		1.24	
Tohoku	2.12		-0.28		1.34		1.05	
Kanto	1.93		-0.22		1.10		1.06	
Chubu	2.28		-0.23		1.55		0.96	
Kinki	1.72		-0.30		0.96		1.06	
Chugoku	1.89		-0.31		1.10		1.10	
Shikoku	1.75		-0.25		1.11		0.89	
Kyushu	1.96		-0.22		1.30		0.89	
Okinawa	1.84		0.02		1.28		0.53	
1	Fukushima	2.74	Nagasaki	0.05	Mie	1.86	Nagano	1.62
2	Nagano	2.68	Okinawa	0.02	Ibaraki	1.79	Fukushima	1.57
3	Shiga	2.57	Saga	-0.07	Aomori	1.58	Iwate	1.47
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
45	Fukuoka	1.53	Hokkaido	-0.39	Hokkaido	0.83	Aomori	0.46
46	Kochi	1.27	Nagano	-0.40	Fukui	0.77	Mie	0.45
47	Wakayama	0.77	Tokushima	-0.41	Chiba	0.69	Wakayama	0.02

Table 11. Growth Regression

	Growth 1955-2008				Growth 1975-2008			
	(1)		(2)		(3)		(4)	
Constant	0.049	**	0.013		0.023	**	-0.013	
	(32.027)		(1.013)		(7.401)		(-1.052)	
Initial	-0.011	**	-0.014	**	-0.004		-0.009	**
Output	(-6.260)		(-5.217)		(-1.152)		(-2.249)	
TFP			0.023	**			0.023	**
Gap			(2.187)				(2.254)	
Labor			0.012				-0.007	
Share			(0.989)				(-0.617)	
Capital			-0.029				-0.018	
Depreciation			(-0.527)				(-0.396)	
Population			-0.300	**			-0.505	**
Growth			(-3.089)				(-3.032)	
Private			0.051	**			0.104	**
Investment			(2.714)				(4.195)	
Government			-0.022				-0.012	
Investment			(-1.160)				(-0.637)	
TFP			0.428	**			0.709	**
Growth			(3.764)				(6.708)	
R^2	0.454		0.707		0.007		0.650	

Table 12. Average Correlation

Output	0.462
Consumption	0.264
Investment	0.642
Labor	0.575
Capital	0.759
TFP	0.358

Table 13. Comovement Regression

	Output		Consumption		Investment	
Constant	1.051	**	0.601	**	0.924	**
	(23.40)		(10.27)		(27.68)	
Distance	-8E-05	**	-3E-05		-7E-05	**
	(-4.876)		(-1.634)		(-6.214)	
Industry	-0.291	**	-1.017	**	0.052	
Similarity	(-2.350)		(-6.300)		(0.564)	
Output	0.143	**	0.070	**	0.067	**
Size	(12.29)		(4.588)		(7.675)	
R^2	0.146		0.051		0.088	

	Labor		Capital		TFP	
Constant	0.344	**	0.913	**	0.566	**
	(8.951)		(28.74)		(11.53)	
Distance	-9E-05	**	-7E-05	**	-8E-05	**
	(-6.494)		(-5.956)		(-4.364)	
Industry	-0.084		0.094		0.069	
Similarity	(-0.795)		(1.073)		(0.512)	
Output	-0.076	**	0.034	**	0.046	**
Size	(-7.626)		(4.078)		(3.643)	
R^2	0.079		0.049		0.029	

Table 14. Decomposition of Risk-Sharing

	Capital Market	+Government	+Financial Market
Constant	-0.0040**	-0.0056**	-0.0146**
	(-32.61)	(-16.90)	(-46.64)
GDP	0.1557**	0.4649**	0.6956**
Growth	(31.03)	(35.97)	(69.42)
R^2	0.635	0.645	0.801

Figure 1. Inequality

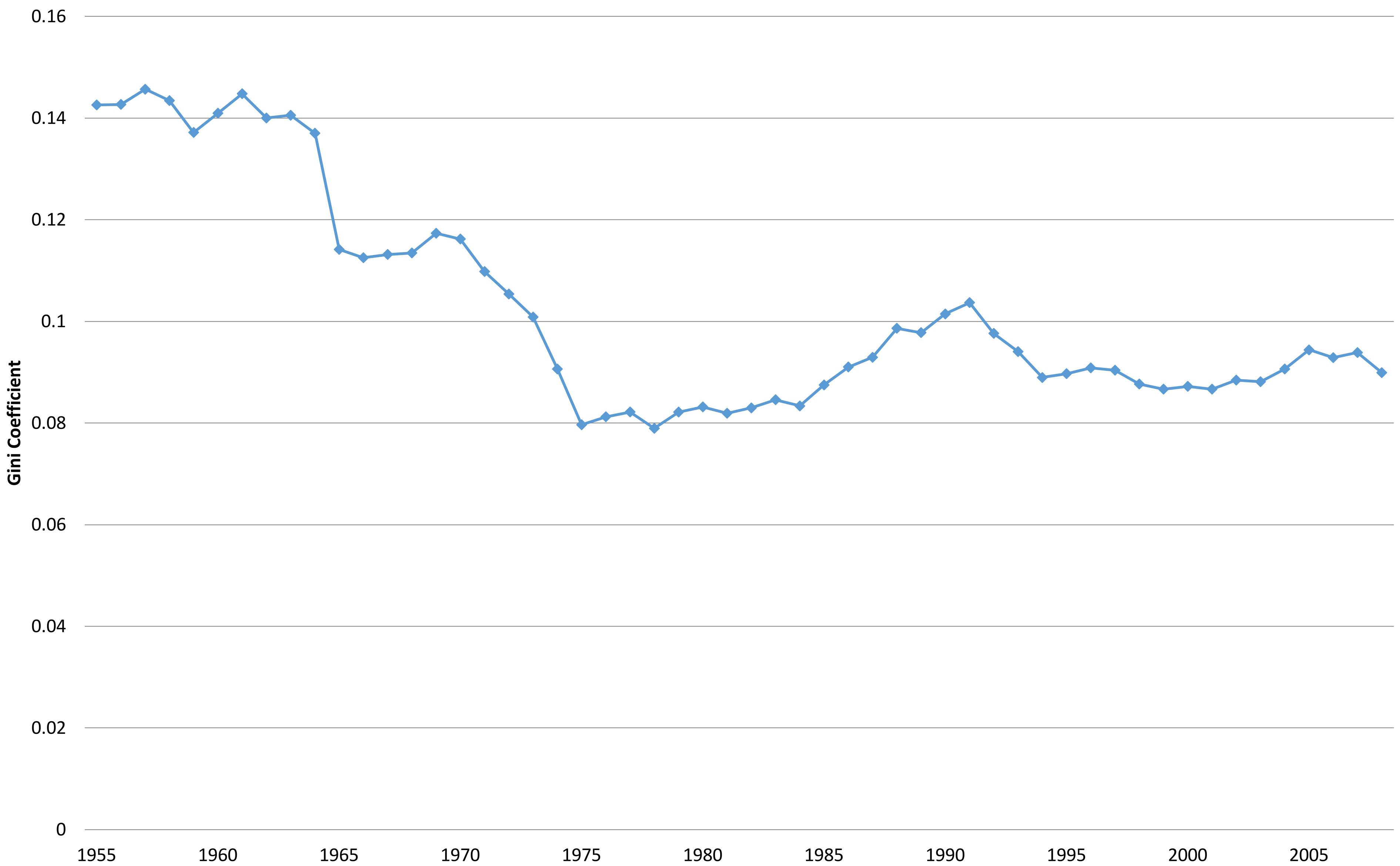


Figure 2. Labor Income Share

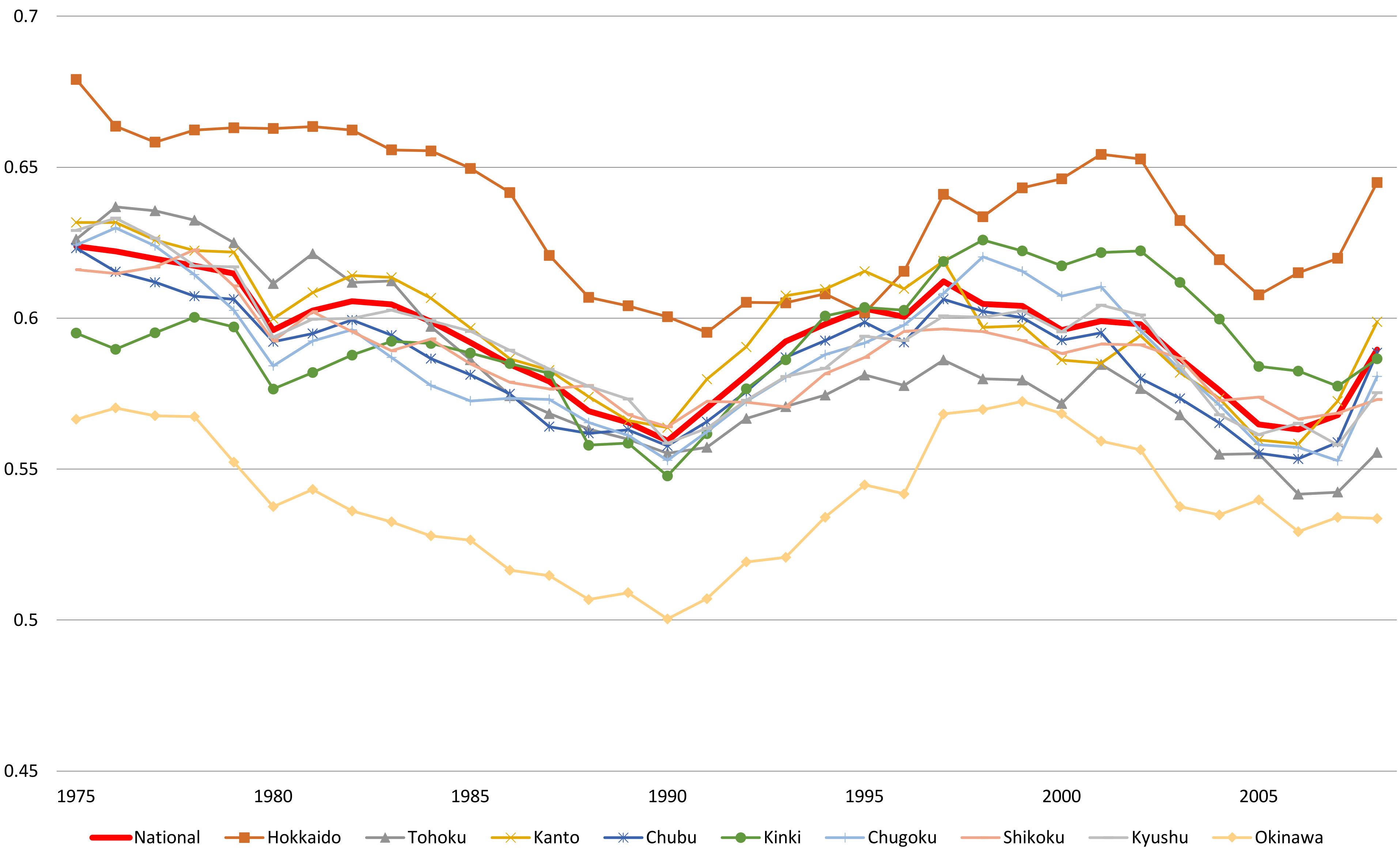


Figure 3. Depreciation Rate

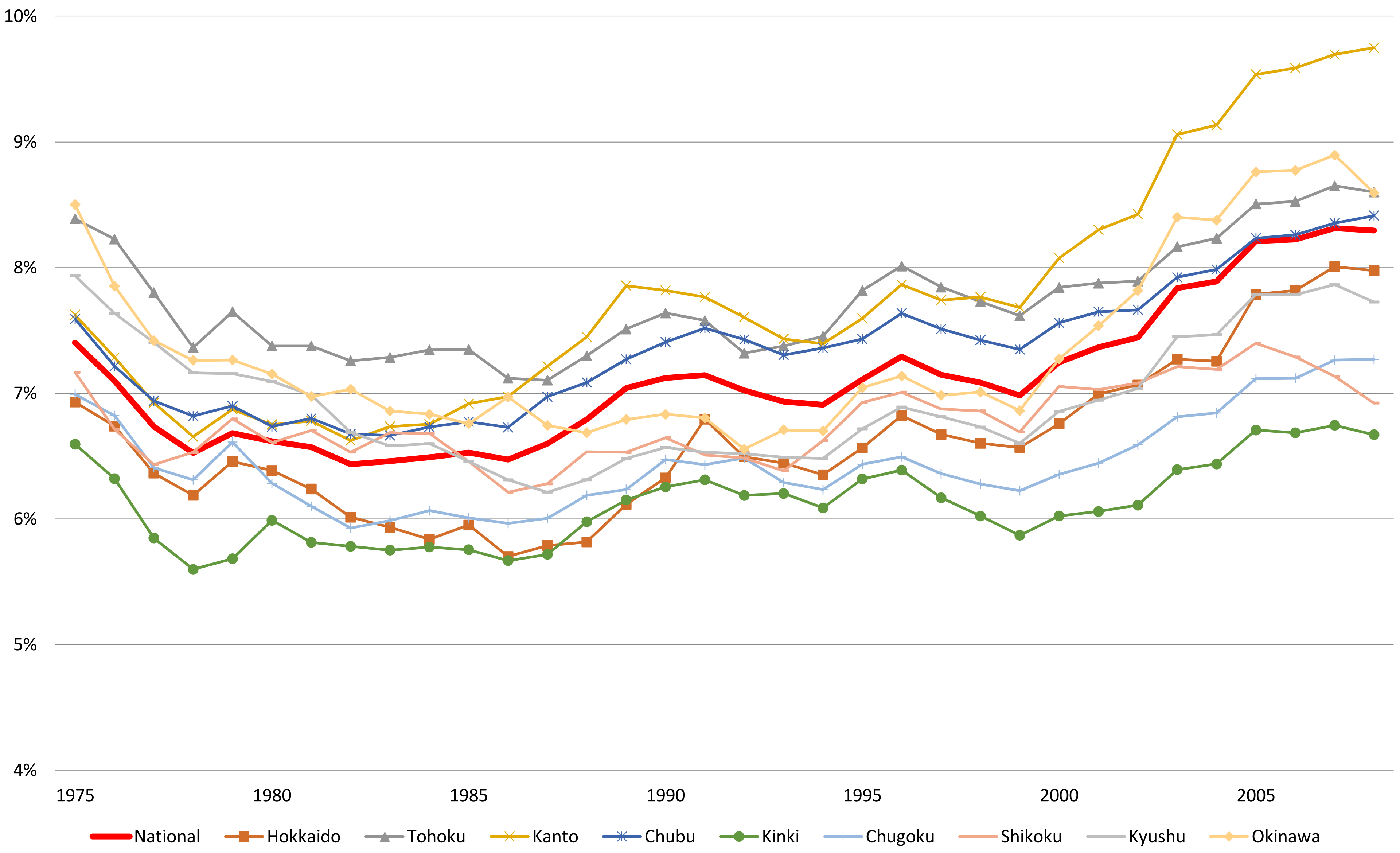
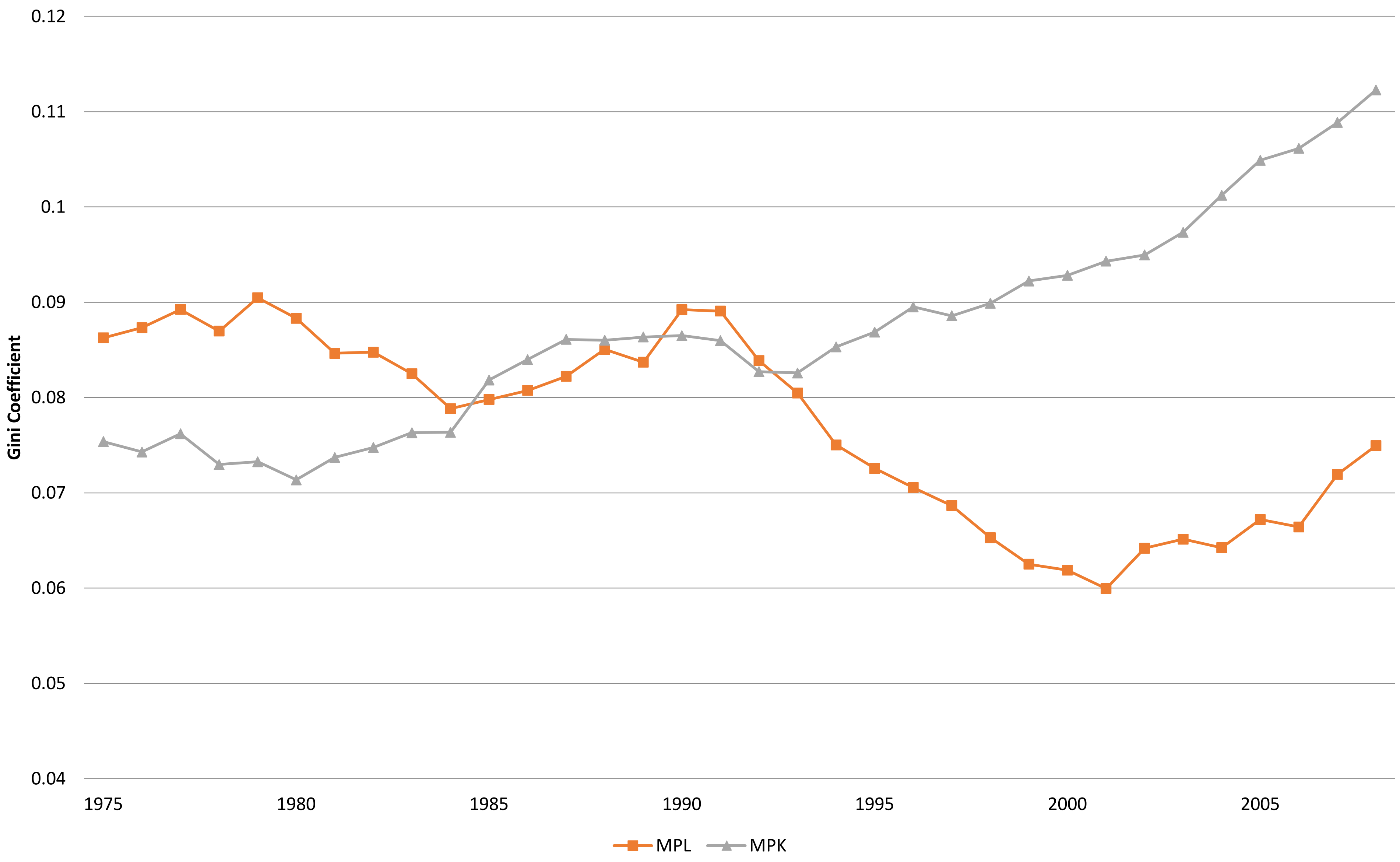


Figure 4. Misallocation



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