Empirical Analysis of Regional Differences in Productivity of Manufacturing Industries; the Factors and Changes

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This study measures productivity difference of manufacturing industry among 47 prefectures in Japan and its factors and changes by using the 2-digit industries data of Census of Manufacturers. Especially, in order to grasp interregional difference of economic condition as presented in labor productivity of manufacturing industry, this study puts strong focuses on micro-, that is prefectural level, data observation and analysis.

I approached this theme by shift-share analysis, or its extension as proposed by Esteban (2000). The readers should be careful because the shift-share as proposed by Esteban(2000) is a little bit different from shift-share analysis usually mentioned as by Dunn(1960) etc. as the method to analyze the "growth" of employment or value added etc., interregional difference of growth and its factors. The core of Esteban(2000) is to "extend" shift-share method "to the decomposition of interregional aggregate productivity differentials" at a specific time, as presented $\gamma_i = x_i - x$ in the equation (1), into three components.

$$\gamma_i = x_i - x \quad = \sum_{j=1}^{m}(s_{ij} - s_j)x_j + \sum_{j=1}^{m}(x_{ij} - x_j)s_j + \sum_{j=1}^{m}(s_{ij} - s_j)(x_{ij} - x_j) = \mu_i + \pi_i + \alpha_i \qquad (1)$$

Those three components are ①μ_i, industry-mix component, ②π_i, productivity-differential component, and ③α_i, allocative component. They will be explained in the resume and presentation more.

Calculation outcome of the equation(1) for each prefecture in years to be covered, from 1971 to 2007, πi, shows higher weight in most prefectures and most years. However, by observing individual prefecture outcome, several prefectures with higher weight of μ or even α can be found. In order to treat all prefectures equally, calculation of correlation coefficients of labor productivity, γ_i and other variables was made without giving weights to prefectures by the size of their economic activities such as labor share etc.

In order to observe and follow the situation of individual prefectures, scatter diagrams of the prefecture codes on various variables were drawn for listed years. Figure 1 is on labor share in national total, and labor productivity, where 7 prefectures, Saitama, Tokyo, Kanagawa, Shizuoka, Aichi, Osaka, Hyogo show high labor share. Figure 2, 3, 4 are scatter diagrams to check the relationship between γ and its components, μ, π, and α. Further, in order to follow the changes of individual prefectures, Figure5., diagrams for each individual prefecture present labor share and γi, labor productivity of prefecture i, over the whole period. In Osaka and Tokyo labor share has been decreasing, and labor productivity, though increased in 1980s or 1990s, has decreased to below the national value. Kanagawa and Hyogo have experienced decreasing labor share. Labor productivity has increased in 1990/95, then decreased, but still stays above the national value. Saitama and Chiba have increased labor share until 1985/90. Labor productivity has decreased in Saitama to become below the national value in 1985, while Chiba experienced increase until 2000. On the contrary, Aichi and Shizuoka have been increasing both labor share and labor productivity. Shiga and Yamaguchi, not with high labor share, show high labor productivity. Both prefectures show increasing labor productivity. In Shiga, π, productivity differential component, and in Yamagishi, μ, industry-mix component contribute to the labor productivity increase.

For manufacturing total, "employee basis" labor productivity and working hour show negative relationship, a tendency of not very strong but negative correlation is observed.

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1．Introduction

This study aims at recognizing the factors and changes of regional differences in productivity of manufacturing industries in Japan. This study pays attention to the supply side of economy, manufacturing industries in Japan, and intends to measure and analyze interregional differences of labor productivity of 47 prefectures. Especially, in order to grasp interregional difference of economic condition as presented in labor productivity of manufacturing industry, this study puts strong focuses on micro-, that is prefectural level, data observation and analysis.

2．Method

I approach this theme by extending shift-share analysis as proposed by Esteban (2000).

Shift-share analysis often refers to the method by Dunn (1960) which analyze difference of growth of employment or value added etc. among regions or industries. A hypothetical growth, "share" can be estimated by assuming that growth rate of employment or value added etc. in each region is equal to the national growth rate. Deviation of actual regional growth from "share" is "shift", which is to be classified into "industry-mix component" caused by the difference of industry structures of the region from that of the nation, and other "regional specific components" including difference of productivity.

Esteban(2000) states that the shift-share "was originally conceived as a technique to analyze regional employment dynamics", but "it is straightforward to extend it to the decomposition of interregional aggregate productivity differentials" . This study applies the method proposed by Esteban (2000), therefore naming and economic meaning of key concepts can be different from those in Dunn(1960) or other literatures.

The following is the summary of the method of Esteban (2000) this study applies.

$$\gamma_i = x_i - x = \sum_{j=1}^{m}(s_{ij} - s_j)x_j + \sum_{j=1}^{m}(x_{ij} - x_j)s_j + \sum_{j=1}^{m}(s_{ij} - s_j)(x_{ij} - x_j) = \mu_i + \pi_i + \alpha_i \quad (1)$$

In equation (1), $\gamma_i = x_i - x$ represents the deviation of x_i, labor productivity of manufacturing total in prefecture i from the national value, x. These xi and x, labor productivity of manufacturing total are the weighted sums of 2-digit industries j composing manufacturing total by j's labor share. s_{ij} and s_j are labor share of 2-digit industry j in manufacturing total; the share in prefecture i and the national value. x_{ij} and x_j are labor productivity of 2-digit industry j; the value of prefecture i and the national value.

μ_i, π_i, α_i are three components of shift, the deviation of labor productivity of manufacturing total in prefecture i from the national value. ①μ_i, industry-mix component represents the effect of industry-mix of prefecture i, as represented "s_{ij}- s_j", the deviation of labor share of 2-digit industry j in prefecture i from the national value, to the labor productivity of manufacturing total in prefecture i, assuming the labor productivity of 2-digit industry j is equal to the national value, x_j. ②π_i, productivity-differential component represents the effect of productivity differential of prefecture i, as represented "x_{ij}- x_j", to the labor productivity of manufacturing total in prefecture i, assuming the industry-mix, of 2-digit industry j is equal to the national value s_j. ③α_i, allocative component is a cross term which represents if an efficient allocation of 2-digit industries are made in prefecture i. μ_i, π_i, α_i are sum of overall 2-digit industries in prefecture i, the value of each component for manufacturing total in prefecture i.

By calculating equation (1) for each prefecture i in the year to observe, labor productivity of manufacturing total of prefecture i, exactly speaking, its deviation from the national value, either positive or negative, and the three components μ_i, π_i, α_i can be identified.

3. Data

Data source is "Census of Manufacturers, Report by Industry", statistical tables of establishments with 4 or more employees. 18 2-digit industries covering "Manufacturing Total" is used.

2-digits classification of Census of Manufactures has changed over time by following the change in JISC, Japan Industry Standard Classification. In order to make the data consistent over time, this study excludes from Manufacturing Total the "Publishing, Printing and allied products" which removed Publishing from 2002 to become "Printing and allied products", and adds "Plastic Product, except otherwise classified" which became an independent 2-digit industry from 1985. The coverage of period is from 1971 to 2007, over 37 years. It is because in year 2008, classification of machinery industry was changed completely.

In measuring labor productivity, labor input can be either number of employees or man-hour, the number of employees times working hours. Unfortunately, "Monthly Labor Survey" by the Ministry of Health, Labor and Welfare, offers working hours in each prefecture only for manufacturing total, not for 2-digit industries. Therefore, labor productivity in applying Esteban's method has to be "employee basis", not "man-hour basis". Besides the method of Esteban (2000), working hour is an important component in measuring labor productivity. Therefore, I also double check the relationship between "employee basis" labor productivity and working hour for manufacturing total for which prefecture data of working hour is available.

4. Outcome of Data Observation and Analysis

Table1 shows the calculation outcome of equation (1) for 1995 based upon 2-digits industries data. The numbers in front of prefectures' abbreviated names are prefecture codes to be used in scatter diagrams later.

The result of the analysis shows in most prefectures, and also in other years, higher weight of π, productivity differential component, in the interregional difference of labor productivity of manufacturing total . However, by detailed observation, we can find special features in several prefectures, and also in several years. In 1995, μ, industry-mix component shows higher weight in some prefectures; positive in Saitama(11), Shizuoka(22), Mie(24), Yamaguchi(35), negative in Nara(29) and Kochi(39). Also α, allocative component shows higher weight; Yamanashi(19), Aichi(23), Okayama(33) and Ehime(38) all positive.

Table 2 shows correlation coefficient of labor productivity γ_i, exactly speaking each prefecture i's deviation from the national value of labor productivity, with μ_i, π_i, α_i, and labor share in listed years. In order to treat all prefectures equally, I dare not to give weight to prefectures by the size of their economic activities such as labor share etc. μ_i and π_i show relatively high correlation, while α_i shows low correlation and the correlation coefficient is negative until 2000. Correlation coefficient with labor share has been decreasing.

Figure 1. is a scatter diagram of the prefecture codes on labor share in national total, and labor productivity. 7 prefectures, Saitama(11), Tokyo(13), Kanagawa(14), Shizuoka(22), Aichi(23), Osaka(27), Hyogo(28) show

high labor share. However, Saitama(11), Tokyo(13), Osaka(27) have been decreasing the share, and in recent years, labor productivity has become below the national value. We should be careful in commenting that "Service Economy" or "Post-Industrial Society" is the most current trend in big cities in Japan.

Figure 2, 3, 4 are scatter diagrams to check the relationship between γ and its three components, μ, π, and α. Table 2 of correlation coefficient can be confirmed on the basis of each prefectural level observation.

Further, in order to follow the situation of individual prefectures or types of prefectures, Figure5. presents labor share of manufacturing of prefecture i in national total and γi, deviation of labor productivity of prefecture i from the national value, over years. First of all, in Osaka and Tokyo labor share has been decreasing over the whole period of measurement, and labor productivity, though increased in 1980s or 1990s, has decreased to become negative, below the national value. Kanagawa and Hyogo have experienced decreasing labor share. Labor productivity has increased in 1990/95, then decreased, but stays still positive, above the national value. Saitama and Chiba have increased labor share until 1985/90. Labor productivity has decreased in Saitama to become negative in 1985, while Chiba experienced increase until 2000.

On the contrary, Aichi and Shizuoka have been increasing both labor share and labor productivity. Examples of prefectures with not so high labor share but with high labor productivity are Shiga (25) and Yamaguchi (35). Both prefectures show increasing labor productivity, while labor share has been increasing in Shiga and decreasing in Yamaguchi. In Shiga, π, productivity differential component, and in Yamaguchi, μ, industry-mix component contributes to the labor productivity increase; this can be checked by Figure 1, 2, 3. Most prefectures in local areas show low level of labor share and labor productivity.

For manufacturing total, "employee basis" labor productivity and working hour show negative relationship; a tendency of not very strong but negative correlation is observed. This can be confirmed by scatter diagram and regression. In a regression by taking log of working hours and "employee basis" productivity, the coefficient of ln(value added / employee) to ln(working hour) is negative, -0.058 with high t-statistics for the period 1971～2007; with R-square 0.4429, not so high. It is similar for individual years' regressions. Working hour must be different among 2-digit industries, so if we could measure "man-hour basis" labor productivity for 2-digit industries, it may be possible that both differences of industry-mix and productivity of 2-digit industries contribute to the difference of manufacturing total.

5. Summary

This study applies extension of shift-share analysis proposed by Esteban(2000) to 2-digit and prefectural data of manufacturing industries in Japan to measure the difference and its factors of labor productivity of manufacturing total among prefectures. Especially, the changes of individual prefectures were observed. The outcome is that each prefecture presents its own pattern of change in labor share and labor productivity.

【Reference】

[1] Dunn, Edgar S. Jr., "A statistical and analytical technique for regional analysis", *Papers in Regional Science*, Vol.6, Issue 1, 1960, pp.709-722.

[2] Esteban, J. ,"Regional convergence in Europe and the industry mix: a shit-share analysis", *Regional Science and Urban Economics*, Vol.30, 2000, pp.353-364.

[3] Murano, Kiyofumi, "Analysis of interregional differential of manufacturing industry productivity", mimeo

year	prefecture	γ, ganma	μ, mu	π, pi	α, alpha
1995	_00JPN	0.000	0.000	0.000	0.000
1995	_01HKD	(2.500)	(0.926)	(2.150)	0.577
1995	_02AOM	(5.489)	(1.790)	(3.767)	0.068
1995	_03IWA	(4.220)	(1.301)	(4.132)	1.213
1995	_04MYG	(3.094)	(0.936)	(2.894)	0.736
1995	_05AKI	(4.738)	(2.050)	(3.107)	0.419
1995	_06YGA	(4.525)	(1.155)	(3.905)	0.535
1995	_07FKS	(2.252)	(0.563)	(1.897)	0.208
1995	_08IBA	2.024	0.349	0.997	0.677
1995	_09TCH	1.011	(0.201)	1.919	(0.706)
1995	_10GUN	(0.433)	(0.008)	(0.399)	(0.025)
1995	_11SAI	(0.026)	0.242	(0.176)	(0.092)
1995	_12CHI	3.494	1.159	1.184	1.151
1995	_13TKY	0.103	(0.031)	0.153	(0.019)
1995	_14KAN	3.847	1.280	2.321	0.247
1995	_15NIG	(3.416)	(0.890)	(3.081)	0.556
1995	_16TYA	(0.434)	0.604	(1.924)	0.886
1995	_17ISI	(3.202)	(1.491)	(1.948)	0.236
1995	_18FKI	(3.162)	(1.402)	(2.395)	0.635
1995	_19YNA	(0.617)	(0.714)	(0.996)	1.093
1995	_20NGN	(1.588)	(0.542)	(1.039)	(0.007)
1995	_21GIF	(2.309)	(0.777)	(1.624)	0.093
1995	_22SHZ	1.236	0.650	0.648	(0.061)
1995	_23AIC	1.331	0.311	0.341	0.679
1995	_24MIE	1.345	0.928	0.339	0.078
1995	_25SHG	4.841	(0.084)	5.378	(0.454)
1995	_26KYO	1.010	(0.722)	1.748	(0.016)
1995	_27OSA	(0.457)	0.494	(0.600)	(0.351)
1995	_28HYO	1.790	0.539	1.114	0.137
1995	_29NAR	(0.277)	(1.203)	0.311	0.615
1995	_30WAK	0.960	0.192	(0.636)	1.405
1995	_31TOT	(4.288)	(1.821)	(3.928)	1.461
1995	_32SHM	(4.384)	(1.661)	(3.845)	1.122
1995	_33OKA	1.818	0.299	0.558	0.962
1995	_34HRO	0.028	(0.021)	0.303	(0.253)
1995	_35YGU	3.479	2.910	(0.914)	1.483
1995	_36TOK	(1.875)	(0.197)	(2.311)	0.633
1995	_37KGW	(1.864)	(0.720)	(1.001)	(0.143)
1995	_38EHI	(0.066)	(0.177)	(0.618)	0.729
1995	_39KOC	(2.082)	(1.358)	(0.667)	(0.057)
1995	_40FKO	(0.502)	(0.045)	(0.642)	0.186
1995	_41SAG	(2.208)	(0.906)	(1.636)	0.334
1995	_42NGS	(3.548)	(1.662)	(2.310)	0.423
1995	_43KMA	(2.746)	(0.891)	(2.059)	0.203
1995	_44OIT	3.002	0.041	2.191	0.770
1995	_45MYZ	(4.209)	(0.812)	(4.265)	0.868
1995	_46KGS	(3.909)	(1.205)	(3.968)	1.263
1995	_47OKI	(4.002)	0.118	(4.828)	0.708

Table 1 Labor productivity deviation from the national value, γ and its components; μ industry-mix, π productivity-differential, α allocative (1995)

year	μ (industry-mix)	π (productivity-differential)	α (allocative)	labor share
1972	0.697	0.926	(0.179)	0.604
1975	0.729	0.888	(0.084)	0.444
1980	0.741	0.890	(0.186)	0.478
1985	0.784	0.916	(0.039)	0.488
1990	0.817	0.927	(0.128)	0.522
1995	0.805	0.915	(0.155)	0.431
2000	0.791	0.894	0.029	0.366
2005	0.844	0.914	0.387	0.319
2007	0.835	0.881	0.089	0.389

Table 2 Correlation Coefficient of Labor Productivity (γ_i) with Related Variables

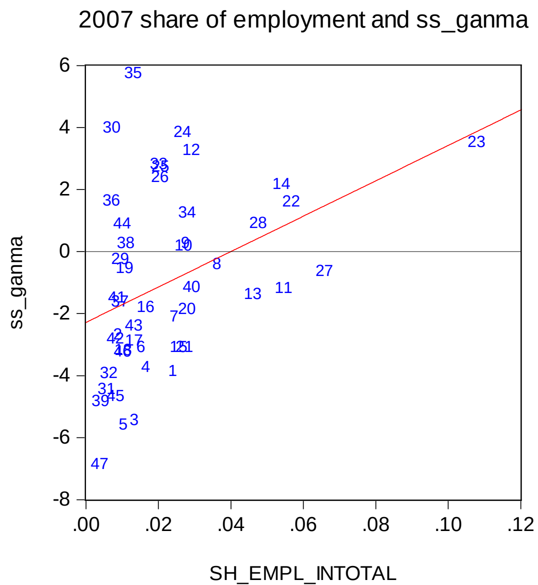

Figure 1. Labor share and labor productivity of each prefecture, deviation from the national value

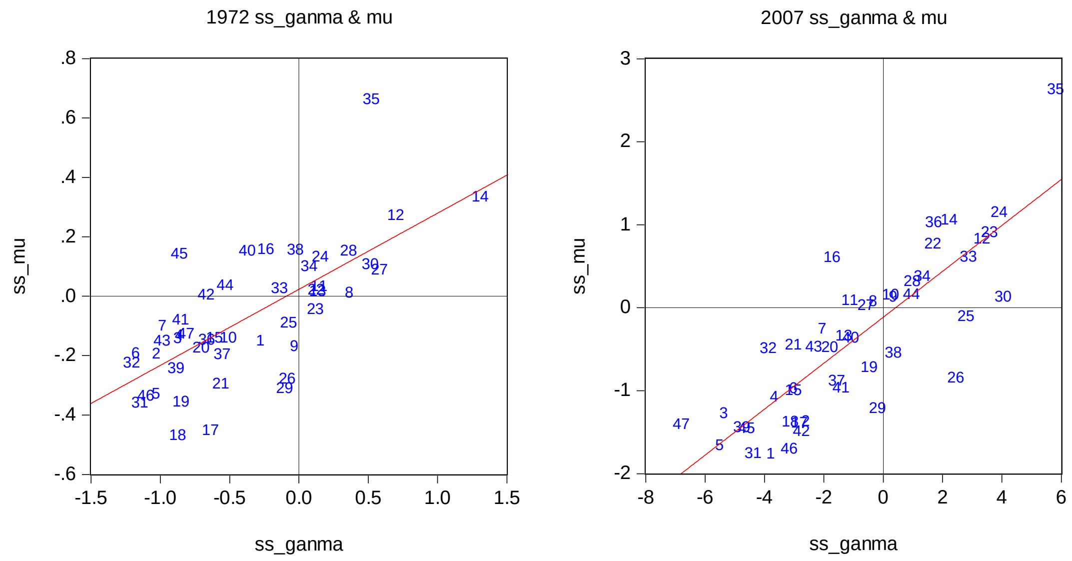

Figure 2. Labor Productivity, γ and Industry-Mix Component, μ

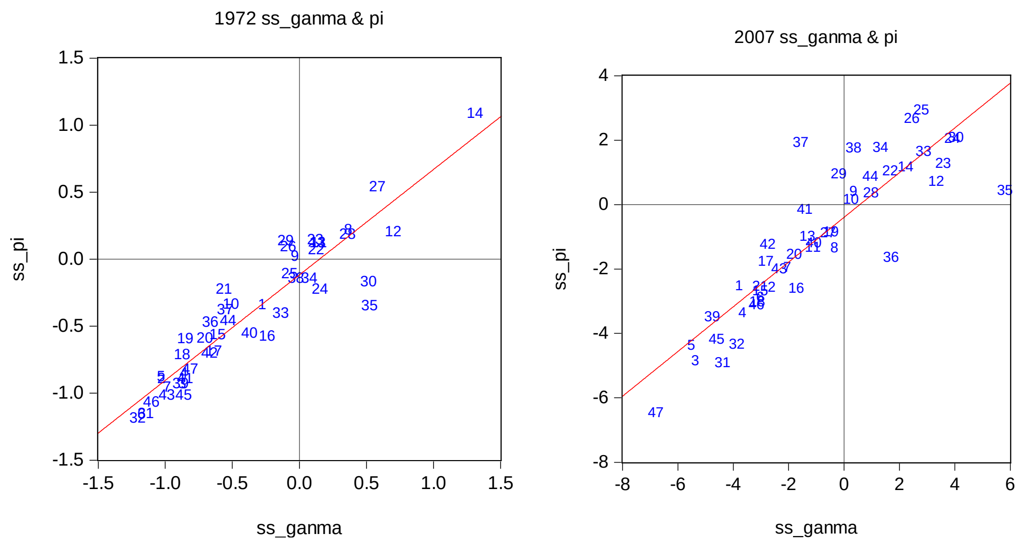

Figure 3. Labor Productivity, γ and Productivity-Differential Component, π

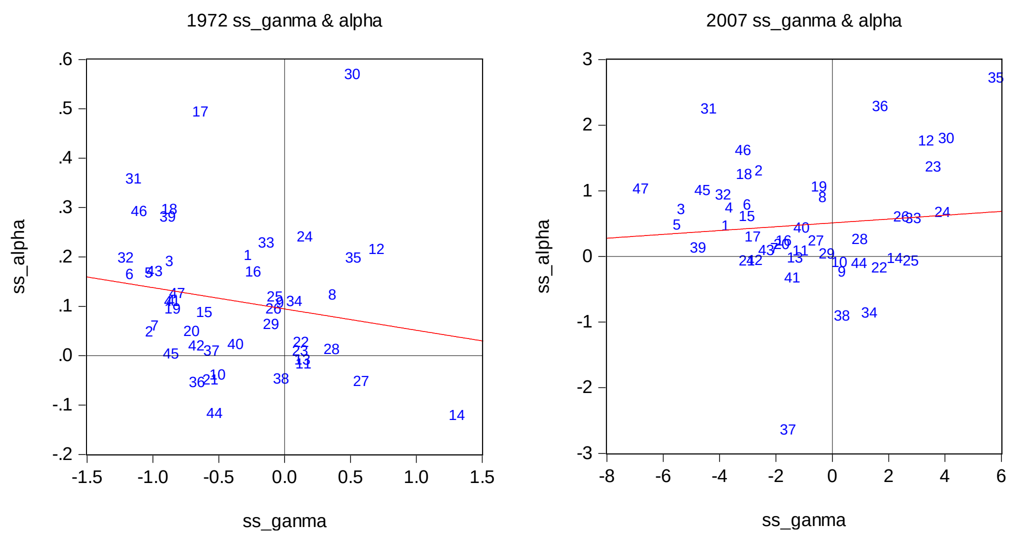

Figure 4. Labor Productivity, γ and Allocative Component, α

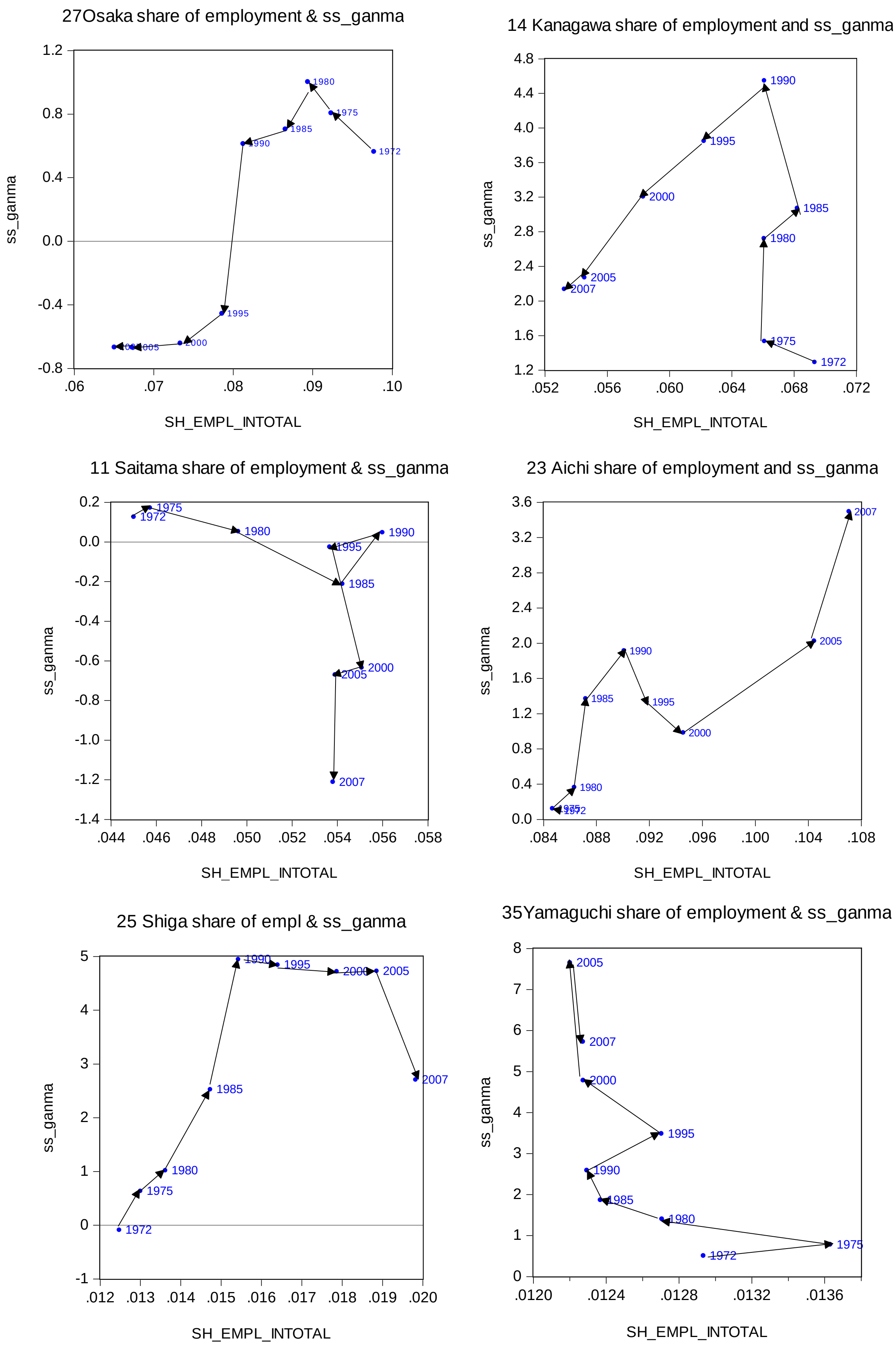

Figure 5. Changes of Labor share and Labor productivity, γ of individual Prefectures