An Empirical Study of Convergence in Japan and Taiwan Agriculture

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Abstract

Keywords: variation coefficient, absolute convergence, conditional convergence, β-convergence, σ-convergence, farm family income, agricultural income, degree of agricultural dependency

A modified Barro & Sala-i-Martin's neoclassical growth model was applied to Japan and Taiwan datasets over the period 1970-1996 to study the problems of farm family and agricultural income differences. The empirical results show that there were trends in convergence in the Taiwan farm family and agricultural income differences, but this trend became slower after the middle 1980s, and the agricultural income difference even began to expand. In the regression of Taiwan agricultural income growth, all of the initial agricultural income, degree of agricultural dependency, agricultural expenditure, and cultivated land area were important factors influencing Taiwan agricultural income growth. In contrast, because of more varied agricultural conditions in the Japanese prefectures, there were no absolute convergence in Japanese farm family and agricultural income. In the regression equation of agricultural income growth, the initial agricultural income, degree of agricultural dependency and cultivated land area in some periods were important factors influencing Japan's agricultural income growth, but the agricultural expenditure was not significant. Under the framework of the World Trade Organization (WTO), the intention to quicken agricultural growth in the short run by increasing agricultural expenditure is an impossible mission. Because Japan and Taiwan share the features of scarce land relative to the mass population, the effect of increasing farm sizes on agricultural growth is limited. Therefore, the emphasis on professional farming might play an important role to increase agricultural income growth and to balance the distribution of prefecture (county) income.

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I. Introduction

In the early stages of Japan and Taiwan economic development, agriculture played an important role in offering resources and markets for the industrial and commercial sectors. In those years, farm family income was composed mostly of agricultural income (For simplicity, the agricultural income of a farm family will be referred to as "agricultural income" in the following text.). Accompanied with economic development, the industrial structure changed and agricultural production as percentage of GNP went down. Agriculture is becoming relatively less important. Even more, the internal structure of agriculture changed. Part-time farming became dominant and the percentage of agricultural income to farm family income became smaller and smaller. Most of the previous studies on Japan and Taiwan agricultural income emphasized the analysis of income changes in aggregate farm families, or the analysis of high- and low- farm income classes in terms of their economic characteristics, or the factors influencing the income differences, or analyses of comparable living standards between farm and non-farm families. However, there were not many studies that touched the issues of growth convergence in farm family and agricultural income across prefectures (counties). Although the agricultural population share in the total population has become less, the agricultural population was 11 million with 3.8 million in agricultural employment in 1999 in Japan, and 3.74 million with 0.77 million in agricultural employment in 1999 in Taiwan. These numbers revealed the importance of farm family and agricultural income issues. In the past, Japan and Taiwan were areas with fast growth in agriculture. Their productivity in

farmland used to rank the highest in the world. Moreover, their natural conditions and farming styles are quite similar. This paper is therefore intended to offer a systematic analysis of Japan and Taiwan farm family and agricultural income growth to determine the critical problems of post-war agricultural development in Japan and Taiwan. For example, did the farm family and agricultural income in different prefectures (counties) diverge or converge? Is it possible for farm family and agricultural incomes across prefectures (counties) to move toward equilibrium? Or will the difference among prefectures (counties) become wider? What were the factors influencing farm family and agricultural income growth? A neo-classic growth theory viewpoint is used to study these issues. Finally, several suggestions for balancing agricultural development among prefectures (counties) are made.

II. Literature Review

The studies on economic growth have emphasized the following two problems: (1) the possibility of per capita income sustainable growth, (2) whether a country's income converges or not. The simplest neo-classical model assumes that marginal return on capital decreases and the prevailing technology and knowledge is fully shared by all countries. Under these assumptions, sustainable growth is impossible and the income growth of all countries is destined to converge. Assuming no technical progress, because marginal product of the capital decreases, more capital stock reduces the incentive to save and the investment contribution to income growth must decrease. Similarly, poorer countries will have a higher incentive to save and a higher economic growth rate in the end. The divergence between income of various countries will disappear sooner and later. Factor mobility and commodity trade equalize the prices in an open economy such that the convergence in the income of various countries can be accelerated.

An empirical work by Baumol (1986) analyzed the development of 16 industrialized countries for almost a century and the results showed that the income growths of these countries converged and the income growth rate was negatively correlated with their initial

income level. Later De Long (1988) criticized that the convergence in Baumol (1986) came from the entire sample composed of industrialized countries. These conclusions may not be true for other samples. More studies were conducted on the per capita real income convergence problem across countries. Among those studies were Grier & Tullock (1989), Barro (1991), Mankiw, Romer & Weil (1992), Button & Pentecost (1995), Islam (1995), Andres, Domenech & Molinas (1996), Caselli, Esquivel & Lefort (1996), Dowrick & Quiggin (1997), Fuente (1997), Murthy and Ukpolo (1999), etc. Generally speaking, studies using OECD or EU countries revealed the phenomena of convergence in real per capita income, but those using samples other than OECD or EU countries usually did not. However, if exogenous variables such as human capital were controlled, there still existed conditional convergence, which will be discussed in the following section.

As one of the researches on convergence in real per capita income in different districts, Barro & Sala-i-Martin (1992) applied their model to a data set of state personal income in the United States making a conclusion that convergence occurred. Johnson and Takeyama (2001) examined the role of initial conditions in the economic development of U.S. states since 1950. Their results showed that the initial conditions were very important factors. Coulombe & Lee (1995) used a data set of personal income in Canadian provinces. Other studies were Barro & Sala-i-Martin (1995), Cardenas & Ponton(1995), Cashin (1995), Koo, Kim & Kim (1998) and Funke & Strulik (1999) which investigated the domestic convergence experiences in Japan, Columbia, Australia, South Korea and West Germany, respectively. Most empirical results tended to support the convergence hypothesis. A sample with higher variance, such as a data set across countries, seldom indicates significant convergence, while a sample with lower variance, such as a data set of states or prefectures in one country, will show both absolute and conditional convergence. Studies on the differences and convergence problems in farm or agricultural income in various districts have seldom been done. From investigating the facts on agricultural labor productivity in 101 countries, Bairam and McRae (1999) concluded that there was no absolute convergence in these countries. If the degree of return to scale and capital expansion were controlled then convergence existed. Gutierrez (2000) found strong and robust evidence of convergence in labor productivity in agriculture across all US states and

11 EU countries during 1970-1992. McCunn and Huffman (2000) examined aggregate agricultural total factor productivity (TFP) data from 1950 to1982 and the results did not support σ-convergence but did support β-convergence, where σ-convergence is convergence to a single TFP level and β-convergence to a steady state rate of growth. This paper therefore attempts to determine whether convergence in per capita income exists in the agricultural sector of Japan and Taiwan .

III. Theoretical Model

"Convergence" is an important concept in the neo-classical economic development theory. Solow (1956) proved that per capita capital stock is adjusting toward the steady state regardless of the initial level of per capita capital stock. Therefore, as long as the growth rate of the population, propensity to save, production technology of each country is generally comparable, the per capita national income of each country will converge in the end. In other words, the countries with lower initial income, according Solow's model, will catch up with those with higher initial income in the long run and have the same living standard.

Therefore, if there are some low initial income countries in a period of time with higher rates of economic growth than those with high-initial-income countries and there is a trend for the former to catch up with the latter, this is called "β-convergence". If the β-convergence holds without any conditions or each country's growth rate converges to the same steady state, this is called "absolute β-convergence" or "unconditional convergence". If every country's growth rate converges but not toward the same steady state, this is called "conditional convergence". According the research by Barro (1991), and Mankiw, Romer & Weil (1992), the OECD countries did have an absolute β-convergence. This was because the differences between the OECD countries were quite small. In contrast, if the sample also included less developed countries, then the hypotheses of absolute convergence was rejected. On the other

hand, if the variation coefficient of per-capita national income across countries or regions is decreasing with the passage of time, then this is "σ -convergence".

In order to explain the concept of convergence of agricultural production via the neo-classical economic theory. We use the Barro & Sala-i-Martin (1995) model. The growth equation of agricultural production is specified as:

$$\frac{1}{t}\cdot\ln\frac{y_L}{y_{L0}} = a - \frac{1}{t}(1-e^{-\beta t})\cdot\ln(y_{L0}) \tag{1}$$

where y_L = per capita agricultural production

L_{L0} = initial per capita agricultural production

a = constant term

t = the observation period

β in equation (1) stands for the speed of convergence for per capita agricultural production to steady state agricultural production per capita. For example, if $\beta = 0.05$ per year, then 5 percent of the gap between per capita agricultural production and steady state agricultural production per capita vanishes in 1 year. The half-life of convergence — the time that it takes for half the initial gap to be eliminated — is thus about 14 years. It would take about 28 years for three-quarters of the gap to vanish.

The left-hand side of equation (1) is the average growth rate of the per capita agricultural production from the initial period to period t. If the i β is positive, then equation (1) shows that the lower the per capita agricultural production in the initial period, the faster the per capita agricultural production will grow.

IV. Agricultural Situations in Japan and Taiwan and Data Sources

A. Agricultural Situations in Japan and Taiwan

Before analyzing the differences in farm family and agricultural income across the prefectures (counties) of Japan and Taiwan, we present some basic statistics about the areas in table 1 for introductory knowledge. Table 1 shows that, in Japan in 1970, agricultural employment accounted for 13% of total employment; agricultural production accounted for 5.9% of GDP; the degree of agricultural dependence was 36.46%. The associated numbers decreased and became 5.1%, 1.88%, and 20.25% in 1996. The cultivated land area per farm family increased from 1.09 to 1.70 acres. Compared with Japan, the industrialization of Taiwan occurred later. Therefore, in Taiwan in 1970, agricultural employment was 36.74% of total employment; agricultural production was 15.47% of GDP; the degree of agricultural dependence was 48.69%. However, accompanied with economic development, the associated numbers decreased and became 10.12%, 3.19%, and 19.97% in 1996. The cultivated land area per farm family increased from 1.03 to 1.12 acres. From the above, we can see that the percentage of total economy that agriculture accounted for gradually declined while industry and commerce developed. The major reason is that farming was becoming unprofitable and its earnings were shrinking relative to the non-agricultural sectors. The decrease in the degree of agricultural dependence between 1970 and 1996 shows that non-agricultural income had increased by a significant amount due to the development of the non-agricultural sector, and agricultural income thus accounted for a smaller share of farm family income.

Table 1 Comparison of Agricultural Situations between 1970 and 1996 for Japan and Taiwan

	Year	Population (10,000 persons)	Total Employment (10,000 persons)	Agricultural Employment (10,000 persons)	Agricultural Employment/Total Employment (%)	Farm Population (10,000 persons)
Japan	1970	10372	5094	842	13.00	2628
	1996	12586	6486	330	5.10	1176
Taiwan	1970	1468	458	168	36.74	600
	1996	2147	907	92	10.12	372
	Year	Land Area (10,000 acres)	Cultivated Land Area (10,000 acres)	Cultivated Land Area per Farm Family (acres)	Degree of Agricultural Dependence (%)	Agricultural Production/GDP (%)
Japan	1970	3775	579.6	1.09	36.46	5.90
	1996	3778	499.4	1.70	20.25	1.88
Taiwan	1970	359.6	90.5	1.03	48.69	15.47
	1996	360.2	87.2	1.12	19.97	3.19

Source: *Japan Statistics Yearbook, and Agricultural Statistics Yearbook of the Republic of China*

B. Data Descriptions and Sources

For data consistence , Taipei City, Kaohsung City, Hsinchu City, and Chiayi City were not included in the Taiwan sample because these cities faced administrative re-division during the sampling period such that their data are discontinuous. The Taiwanese data set is therefore composed of 19 counties. In the data set for Japan, Okinawa was excluded because there was no data for it until its recovery to Japan in 1972. The sample was composed of the 46 prefectures of Japan.

The data sources are as follows:

1. Farm family income per worker is farm family current income divided by the number of agricultural workers employed and then deflated by the consumer price index(with 1991 as

the base year. The agricultural income for farm families per worker is the agricultural net income manipulated in the same way. The degree of agricultural dependence is a share of the farm families' current income that the agricultural net income accounts for. The source of Taiwanese data is the *Report on the Survey of Family Income and Expenditure, Taiwan Province*; the Japanese data is from the *Report of Farm Household Economy Survey, Report of Farm Economy, Japan Statistics Yearbook.*

2. Cultivated land area per worker is the total cultivated land area in various prefectures (counties) divided by the prefecture's (county's) total farm employment. The data sources are the *Japan Statistics Yearbook*, and the *Taiwan Agricultural Yearbook.*
3. Governmental agricultural expenditure per worker is the agricultural expenditure divided by the agricultural employment and then deflated by the consumer price index with base year of 1991. The Taiwanese data sources are: the *Satistical Abstract of Taiwan Province, Statistical Yearbook of Taiwan Province*; the source of Japanese data is the *Japan Statistics Yearbook.*

For reading ease, the words, "per worker" in the variable names, such as farm family income per worker, agricultural income per worker, agricultural expenditure per worker and cultivated land area per worker, will be skipped, but the meaning of each variable is the same as that with "per worker".

V. Empirical Results

A. σ-Convergence

Figure 1 presents the changes in the variation coefficients for the prefectures of Japan and counties of Taiwan from 1970 to 1996. We can see that the difference in Taiwan farm family income across counties decreased during the period before about 1985. After 1985, the trend

became flat without a significant trend. However, it is worthwhile to mention that the changes in farm family income for the counties was quite small after the middle of the 1980s. This means that, during this period, the difference in county farm family income had converged to a level that could not be smaller. The trend in the difference in county agricultural income also decreased before 1985. After 1985 the difference in agricultural income gradually expanded, especially after the late 1980s when the economic bubble was broken. In this period, the influence of free trade on Taiwanese agricultural products was also becoming serious. The change in agricultural income depended on farming conditions and the ability to face competition. The variation coefficient for agricultural incomes was increasing. In addition, we found that the variation coefficients for agricultural income was greater than that for farm family income. One of possible reasons was that agricultural

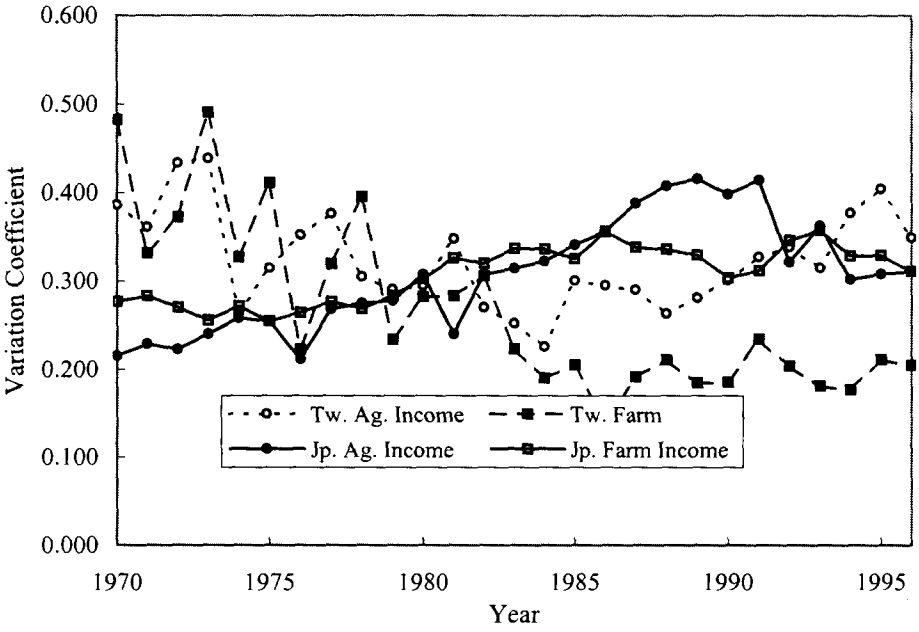

Figure 1. Variation Coefficients for Farm Family and Agricultural Income for Japan and Taiwan

production was affected by the natural conditions in various counties and there was natural variation. The impact of climate change would also contribute to the variation. Consequently, the variation coefficients for agricultural income were greater.

Let's look at the results for Japan. The variation coefficients for farm family income and agricultural income increased at a slow speed, rather than the decreasing trend in Taiwan. Since the period of high growth in the Japanese economy ended after the 1970s, the fluctuation range in farm family income decreased. However, during the period 1985-1990, the yen was overvalued, which resulted in a jump in agricultural imports and a big change in agricultural income. Therefore, the variation coefficients for agricultural income were greater than those for farm family income.

B. β -Convergence

The various-period β values in equation (1) for Japan and Taiwan were estimated using the Nonlinear Least Squares method and are presented in table 2. This table shows that there was absolute convergence in both farm family and agricultural income for Taiwan. In other words, the counties with a lower initial farm family income or agricultural income would have a higher growth rate. The results were clear especially for farm family income because the β estimates for various periods were all very statistically significant. This means that the farm family income across counties had a converging trend. The β estimates for agricultural income in all periods before the mid 1980s, except for1981-82, were statistically significant. The positive signs of β estimates indicate convergence. However, after the mid 1980s, Taiwanese agriculture faced the problems of farmland un-cultivation due to land arbitrage during the bubble economy period and a continuous increase in agricultural imports. The difference in agricultural income across counties became wider and there was again no absolute convergence in the income distribution. Table 2 shows that most of the β estimates for Japan were not statistically significant for both farm family and agricultural income, regardless of the period. Therefore, there was no absolute convergence in Japanese

farm family and agricultural income. The major reason was that the territory of Japan stretches across a great geographical distance and therefore the agricultural conditions across the various prefectures is very different. There were also continuous free trade impacts upon Japanese domestic agricultural products since the 1960s. Different prefectures restricted by their own natural conditions have faced different degrees of import pressure. Consequently, the farm family and agricultural income across the Japanese prefectures did not show trends toward absolute convergence.

Table 2 β-Convergence (Absolute Convergence) of Japanese and Taiwanese Farm Family and Agricultural Incomes for Various Periods

	Taiwanese Farm Family Income			Taiwanese Agricultural Income			Japanese Farm Family Income			Japanese Agricultural Income		
Period	β	t-value	Half-life	β	t-value	Half-life	β	t-value	Half-life	β	t-value	Half-life
71-72	0.249	5.458	2.78	0.306	2.455	2.27	−0.047	−2.656	–	0.243	9.440	2.85
73-74	0.085	3.950	8.18	0.144	2.267	4.81	0.019	1.586	35.93	0.039	1.654	17.57
75-76	0.115	5.303	6.04	0.129	1.838	5.37	0.019	2.260	35.62	0.018	1.126	39.23
77-78	0.052	2.898	13.35	0.146	2.072	4.76	0.016	2.083	44.48	0.016	1.216	42.52
79-80	0.060	3.835	11.56	0.163	2.359	4.25	0.006	0.820	117.82	0.004	0.278	166.86
81-82	0.037	3.300	18.91	0.375	0.659	1.85	0.000	0.083	1453.2	0.009	0.838	78.83
83-84	0.059	4.637	11.83	0.122	2.238	5.69	0.001	0.135	944.16	−0.007	−0.820	–
85-86	0.057	5.539	12.06	0.216	0.792	3.21	0.001	0.285	498.24	−0.011	−1.572	–
87-88	0.054	4.206	12.85	0.163	0.982	4.25	0.001	0.269	594.08	−0.013	−1.822	–
89-90	0.046	3.216	14.97	0.059	1.514	11.69	0.005	1.288	130.38	−0.014	−2.505	–
91-92	0.036	2.638	19.03	0.116	0.949	5.99	0.007	1.654	94.55	−0.011	−1.939	–
93-94	0.039	2.269	17.78	0.141	0.585	4.90	0.005	1.292	127.48	0.016	1.439	44.71
95-96	0.032	2.910	21.83	0.134	0.604	5.19	0.009	2.239	76.72	0.002	0.465	292.37

* The number of observations for these periods was 38 for Taiwan and 92 for Japan. The critical t-value is 2.0 at the 5% level of significance and 1.7 at the 10% level of significance.

** The formula of the half-life is: $(-1/\beta) \times \ln(1/2)$.

The β values and half-life along different periods will now be compared. The half-life is the time that it takes for half the gap between (the natural logarithm values of) the initial and steady-state income to be eliminated. The formula for the half-life show that the larger the β value, the faster the speed of β-convergence will be, and the shorter the half-life will be. In table 2, the βs for Taiwanese agricultural income for these periods were all greater than those for farm family income. Alternatively, the half-life for farm family income were longer than those for agricultural income. Although the variation coefficients for agricultural income in figure 1 were greater than those for farm family income, table 2 shows that the convergence speed of agricultural income was faster than that for farm family income. This means that the steady state to which the agricultural income converged was a lower level of income with a larger variance, although the convergence speed was quicker. In contrast, even if the farm family income converged at a slower speed, the steady state was at a higher level of farm family income with a smaller variance. These results can be used to explain the dilemma faced by Taiwanese agriculture. Because of less mobility of factors in agricultural production, the constraints of natural conditions, and pressures from non-agricultural sector development and agricultural imports, it was difficult to increase agricultural income, even if there was a trend of convergence. In Japan, nearly all of the β estimates were statistically insignificant and therefore there is no need to discuss the half-life for the Japanese results.

The β estimates for Taiwanese agricultural income were insignificant after the mid 1980s. However, when the exogenous variables of agricultural dependence, agricultural expenditure, and cultivated land area were included into equation (1), it was still possible for Taiwan counties to have conditional convergence. The regression results are presented in table 3. Basically, the county agricultural incomes had a trend toward conditional convergence because most of the βs were statistically significant. Therefore, before the mid 1980s, in spite of being different in the degree of agricultural dependence, agricultural expenditure, and cultivated land area, it was possible for county agricultural incomes to converge to a steady state level. After the mid 1980s, absolute convergence did not exist any

longer because the agricultural production conditions degenerated. However, after controlling the degree of agricultural dependence, agricultural expenditure, and cultivated land area effects, the βs became statistically significant. The results also imply that the exogenous variable effects on reducing the difference in county agricultural income after the mid 1980s were larger than before. In Japan, although there was no absolute convergence, conditional convergence did exist if the degree of agricultural dependence, agricultural expenditure, and cultivated land area were controlled. The estimated results are presented in table 4. The half-life for Japan were all longer than those for Taiwan. Consider the fact that Japan is tenfold greater in size than Taiwan. The variety in natural conditions for Japan, with a territory stretching from Hokkaido to Okinawa, is very different from that of Taiwan. Therefore, it took more time for Japanese agricultural incomes to converge.

The effects of exogenous variables can be studied through a comparison of the results in tables 3 and 4. Considering the degree of agricultural dependence, either Japan or Taiwan had a significant regressive coefficient in all periods. That is, the extent of professionalization or specialization in farming was important for agricultural growth. More professionalizion produced a higher agricultural income growth rate. However, the degree of agricultural dependence influence on Taiwanese agricultural income became smaller due to the dominant effects of economic development. In other words, the influence of non-agricultural income on agricultural income growth was greater. In Japan, the degree of agricultural dependence was at a stable level of influence since 1970 when the high growth of the Japanese economy came to an end and the non-agricultural income fluctuation decreased.

Table 3 β-Convergence (Conditional Convergence) of Taiwanese Agricultural Income Per Worker for Various Periods

Period	Intercept	*t*-value	β	*t*-value	Degree of Ag. Dep.	*t*-value	Ag. Expenditure	*t*-value	Cultivated Land Area	*t*-value	Adjusted R^2	Half-life
71-72	0.975	3.249	0.354	3.819	0.499	4.281	0.072	2.728	0.286	2.540	0.577	1.96
73-74	0.591	6.005	0.191	3.761	0.232	5.662	0.032	3.447	0.091	2.804	0.627	3.64
75-76	0.391	4.524	0.158	3.156	0.140	6.030	0.008	1.006	0.078	4.310	0.765	4.38
77-78	0.430	8.735	0.216	4.074	0.123	7.673	0.015	3.046	0.041	4.205	0.849	3.21
79-80	0.303	7.732	0.140	4.182	0.067	6.186	0.004	1.474	0.032	3.810	0.839	4.96
81-82	0.281	8.874	0.123	3.272	0.070	9.238	0.004	1.800	0.022	3.469	0.885	5.65
83-84	0.284	12.226	0.130	4.149	0.069	10.332	0.007	4.959	0.010	2.065	0.868	5.34
85-86	0.265	14.113	0.119	4.174	0.061	11.395	0.004	2.035	0.005	1.154	0.934	5.83
87-88	0.249	13.566	0.122	3.132	0.047	10.049	0.002	0.949	0.003	0.897	0.901	5.67
89-90	0.223	13.753	0.092	3.594	0.044	12.638	0.002	1.705	0.001	0.261	0.885	7.50
91-92	0.230	12.690	0.138	1.540	0.041	9.815	0.003	1.621	-0.001	-0.172	0.855	5.03
93-94	0.207	14.094	0.107	2.233	0.041	12.842	0.003	3.422	0.001	0.366	0.897	6.46
95-96	0.195	12.804	0.102	1.943	0.038	8.703	0.003	1.827	0.002	0.898	0.878	6.82

* The number of observations for periods is 38; the critical t-value is 2.0 at the 5% level of significance and 1.7 at the 10% level of significance.

Table 4 β-Convergence (Conditional Convergence) of Japanese Agricultural Income Per Worker for Various Periods

Period	Intercept	*t*-value	β	t-value	Degree of Ag. Dep.	*t*-value	Ag. Expenditure	*t*-value	Cultivated Land Area	t-value	Adjusted R^2	Half-life
71-72	2.452	9.707	0.226	9.141	0.249	6.705	0.130	2.731	-0.164	-3.500	0.498	3.07
73-74	0.540	3.615	0.058	2.436	0.054	3.259	0.017	0.925	-0.002	-0.092	0.161	11.89
75-76	0.285	2.739	0.038	2.134	0.028	2.609	0.001	0.124	0.012	1.104	0.139	18.39
77-78	0.219	3.246	0.049	3.579	0.023	3.408	-0.006	-0.710	0.029	3.333	0.373	14.25
79-80	0.227	2.328	0.029	1.570	0.039	5.284	-0.004	-0.344	0.002	0.208	0.305	24.30
81-82	0.266	4.490	0.037	2.985	0.028	6.222	0.006	0.940	-0.005	-0.775	0.317	18.53
83-84	0.210	4.529	0.047	3.945	0.024	6.677	-0.006	-0.938	0.013	2.349	0.446	14.62
85-86	0.111	2.130	0.026	2.447	0.019	5.245	-0.005	-0.991	0.013	2.780	0.437	26.46
87-88	0.182	3.940	0.037	3.013	0.025	8.168	-0.004	-0.783	0.007	1.583	0.515	18.93
89-90	0.147	4.540	0.029	3.383	0.022	10.698	-0.006	-1.700	0.008	2.846	0.657	24.19
91-92	0.212	7.594	0.053	4.337	0.021	9.726	-0.007	-1.775	0.007	3.105	0.605	12.98
93-94	0.247	8.513	0.059	3.383	0.023	9.155	-0.002	-0.404	0.001	0.328	0.483	11.65
95-96	0.145	6.348	0.026	3.900	0.016	10.262	-0.005	-1.981	0.002	1.393	0.554	26.71

* The number of observations for periods is 92; the critical t-value is 2.0 at the 5% level of significance and 1.7 at the 10% level of significance.

The effect of governmental agricultural expenditures will now be considered. To pursue the goals of sustainable agricultural growth, increasing farm family income and decreasing the income difference between farm and non-farm families, the Taiwan government implemented a variety of programs since 1969, such as the "Agricultural Policy Guidelines" (in 1969), the "Accelerated Rural Development Program" (in 1972), the "Program for Boosting Farm Income and Strengthening Rural Reconstruction" (in 1979), the "Program for Improving Agricultural Structure and Boosting Farm Income" (in 1985) and the "Integrated Agricultural Adjustment Program" (in 1992). Although the performances of these programs was inconsistent, they did

support agricultural growth and farmers income in some way. From table 3, the agricultural expenditures of Taiwan counties produced statistically significant effects on agricultural income growth for most of these periods. This means that governmental agricultural expenditures did make an important contribution, that is, the counties with a higher level of agricultural expenditures did have a higher agricultural income growth rate. However, the effect became smaller as the economy developed forward. In contrast, Japanese government agricultural expenditures did not make a significant contribution to agricultural income growth. In order to reduce the gap between agricultural and industrial income, Japan initiated the "Agricultural Basic Law" in 1961. From then on, the major policies have been: selective expansion of production, price stabilization and agricultural structure improvement. Therefore, the "production strategy expenditure", "expenditures on pricing, marketing and income strategies", have counted for a high agricultural expenditure ratio. Because of the oversupply of rice since 1970, a very high percentage of agricultural budgets have been expended in the disposal of the rice oversupply and on a rice production adjustment program. However, because the production adjustment policy for rice and the set-aside policy for rice production did not consider the production efficiency of the farmers, they brought about new problems such as a decrease in agricultural production efficiency and an increase in the incentive pay for crop conversion. Consequently, governmental agricultural expenditures supported a level of agricultural income but did not make a contribution to agricultural income growth.

Consider the effect of the cultivated land area. Agricultural economists often suggest that "expanding farm size and adopting integrated mechanicalized operations will increase per-acre productivity, reduce costs efficiently, increase agricultural revenues, and raise the level of farm family income." Therefore, the variable of cultivated land area per family farm was put into the regression equation to investigate the effect of scale. The regressive results found that the influence of cultivated land area on Taiwanese agricultural growth was very statistically significant until the mid 1980s. This was insignificant after the mid 1980s due to the impacts of the bubble economy and the free-importation of agricultural products which made farmland use extensive and farm size expansion not conducive to agricultural growth.

In contrast, the expansion of cultivated land area per Japanese farm did significantly help agricultural income grow during the period 1983-1992. Japan established the "Agricultural Land Use Promotion Law" in 1980, and then revised the "Agricultural Land Law". In addition, during that period, stable farmland prices was good for the liquidation of farmland and operating area expansion. Therefore, the effect of cultivated land area was thought as conducive to agricultural growth.

From the above analysis, we know that the Taiwan governmental agricultural expenditures contributed to agricultural income growth. Nevertheless, this government assistance which yields trade-distortion effect on production will be prohibited by the WTO. Therefore, increasing governmental expenditures is not a good method in the short run to increase agricultural growth. Both Japan and Taiwan have large populations living on relatively scarce land and the cultivated land area is limited. Furthermore, Asian farmers think that of much of the land holdings as family property and they are ashamed of selling their land. Hence, it is also difficult to expand farm size as an effective policy instrument. Accordingly, if we want to increase the agricultural income of farm families, agricultural specialization will be an important way. This conclusion is also supported by the facts from tables 3-4 that the coefficient for the degree of agricultural dependency was much larger than the other exogenous variables.

VI. Conclusions

The difference in farm family incomes across Taiwan counties and in agricultural incomes across counties showed trends of convergence until the mid 1980s. Thereafter, the trend of convergence in farm family incomes became unclear, and the difference in agricultural incomes expanded. The possible reasons were: (1) farmland uncultivation that followed the economic bubble in the 1990s, (2) the impact of globalization and liberalization on agricultural production, and (3) the adjustment of agricultural policy which changed the incentive and behavior of agricultural production. The regression results show that expanding farm sizes,

raising the degree of agricultural specialization and increasing governmental agricultural expenditures would all make important contributions to agricultural growth. However, after the mid 1980s, expanding farm size became ineffective. In Japan, because of the influence of gradual agricultural import liberalization since the 1960s and because of the greater variation in prefecture agricultural conditions, there was no trend toward convergence in farm family and agricultural income. Agricultural expenditures composed a large ratio of the strategic price for producing, pricing and marketing,and income supports. However, the agricultural support policy was ineffective for agricultural growth, although it could hold up the agricultural income level. Recently, Japanese agricultural policy has switched the price support policy to one applied to market principles. In addition, the domestic support instruments, which provide production incentives are prohibited under the WTO. Therefore, increasing agricultural growth through increasing agricultural expenditures is no longer possible. Because both Japan and Taiwan are island economies, it is also difficult to expand farm size as an effective policy instrument. Since the degree of agricultural dependency is the most important factor for agricultural growth, increasing the degree of specialization will be the only way to increase agriculture income in the future. Specialization is the groundwork for agricultural modernization. Only specialized and professional farmers can play an appropriate role in the linkage between agricultural biotechnology, agricultural finance and agricultural marketing. In this way, the agriculture of Japan and Taiwan can compete with other countries' in the twenty-first century and reduce the various impacts in the future.

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臺灣與日本農業所得成長收斂之實證分析

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摘 要

關鍵詞：差異係數、絕對收斂、條件收斂、β收斂、σ收斂、農家所得、農業所得、農業依存度

本研究以新古典成長模型分析1970-1996年台灣與日本各縣市(都道府縣)間的農家所得及農業所得差距問題。實證結果顯示：1980年代中期之前，台灣各縣市間農家所得、農業所得差距有逐漸縮小的趨勢。在農業所得成長率迴歸式中，初期農業所得、農業依存度、農業支出、耕地面積的大小均是影響台灣農業所得成長的重要因素。而日本由於各都道府縣之農業條件差異較大，在農家所得及農業所得並無絕對收斂之現象。在農業所得成長率迴歸式中，初期農業所得、農業依存度及部分期間的耕地面積大小是影響日本農業所得成長的重要因素，而農業支出對農業所得成長影響並不顯著。未來在 WTO 體制下，欲透過農業支出以提高農業成長似不可行。而台灣與日本由於地狹人稠，藉由擴大經營規模面積，以提高農業成長的效果有限。故若要提高農業所得的成長與平衡各縣市(都道府縣)農業所得差距，農業專業化程度的提高扮演重要的角色。

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