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Tsuchiya, Keizo
Laboratory of Quantitative Analysis of Agricultural Economics, Faculty of Agriculture, Kyushu University

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Land Class and Scale Economy in Agriculture

Keizo Tsuchiya

Laboratory of Quantitative Analysis of Agricultural Economics,
Faculty of Agriculture, Kyushu University, Fukuoka

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In this paper, I tried to make an economic analysis on the relationship between the farm house-hold class dissolution and technological progress in agriculture, by using production function analysis for two rural districts, Chikugo in Fukuoka Prefecture and Saga in Saga Prefecture.

The results of analysis show that the sums of parameters in Cobb=Douglas production functions are constant one and production functions follow the low of constant return to scale, which mean that there are no differences in prodoction efficiency among different size of farms.

In Chikugo and Saga districts, the farm house-hold dissolution does not appear in stable pattern, but rather unstable. Fundamentally, this is due to the fact that the technology of rice production does not stay at the equilibrium point because there is no difference in the production efficiency between various size of farms. Scale economic advantage does not exist under the present situation where the farm size is less than 3.0 hectares of land. And the complete system of large-scale mechanization such as combines and large tractors can not be established without scale advantage.

I. FARM HOUSE-HOLD CLASS DISSOLUTION

The number of farm house-holds in Japan has remained almost constant for along time. From Table 1 we notice, it was 5,408,000 in 1908, and 5,176,000 in 1970. A decrease of *232,000* has occurred within these sixty-two years. About the area of farm land, within the total of 5,408,000 farm house-holds in 1908, the numbers with less than *0.5* hectares and 0.5 to 1.0 hectare of lands are 2,016,000 and 1,764,000 respectively. This makes 37.3 percent and 32.6 percent respectively. In 1970, after a lapse of sixty-two years the number did not

Table 1. The number of farm house-holds according to farm size*.

Farm size	1908	Ratio	1970	Ratio
hectare	1,000 houses	%	1,000 houses	%
Total	5,408	100.0	5,176	100.0
Less than 0.5	2,016	37.3	1,999	38.5
0.5 — 1.0	1,764	32.6	1,604	31.0
1.0 — 2.0	1,055	16.4	1,274	24.6
2.0 — 3.0	348		241	4.7
More than 3.0	225	4.2	60	1.2

* The Ministry of Agriculture and Forestry (1955), and The Ministry of Agriculture and Forestry (1972).

change very much. Within the total of 5,176,000 the numbers of farm house-holds owning less than 0.5 hectares and 0.5 to 1.0 hectare of lands are 1,999,000 and 1,604,000 respectively, making up 38.5 percent and 31.0 percent respectively. Table 1 also shows that the number of farm house-holds with more than 2.0 hectares has decreased and that conversely the number of farm house-holds with less than 2.0 hectares has increased.

A farm house-hold with 1.0 to 2.0 hectares depending on their family labors can maintain a minimum living standard and is called middle class farm house-hold in Japan. Kurihara (1948) found that in Japan, middle class farm house-holds increased in number and that the number of farm house-holds with less than 0.5 hectares or more than 2.0 hectares decreased. He named this tendency "the standardization of middle class farm house-holds." Many Marxian economists have conducted research on the standardization of middle class farm house-holds. According to Ouchi (1969) the research on the farm house-hold class dissolution is one of the most important problems in the agricultural economics.

In this paper, I will try to make an economic analysis on the relationship between the farm house-hold class dissolution and technological progress in agriculture by using my findings of two rural districts of Chikugo in Fukuoka Prefecture and those of Saga in Saga Prefecture (for simplicity they will be called the Chikugo Plain and the Saga Plain).

At first let us examine Table 2 which shows the comparative productivity of rice production. This will make clear the characteristics of both Chikugo Plain and Saga Plain. These plains are typical rice producing areas in Japan and in these plains the yeild per 10 ares, labor return per 10 ares and labor return per day are higher than not only the national average level but also the level of those in Tohoku District where is other typical rice producing areas in Japan.

Table 2. Productivity of rice (1968)*.

Region	Yield per 10 ares	Labor return per 10 ares	Labor return per day
	kilogram	1,000 *yen*	*yen*
All Japan	448	**40.8**	**2,770**
Tohoku	510	**48.4**	**3,335**
Kyushu	415	**36.6**	**2,629**
Chikugo Plain	516	**49.3**	**3,540**
Saga Plain	517	**50.3**	**4,035**

* Kyushu Agricultural Policy Bureau (1970).

The changes in the number of farm house-holds by size in both of these plains during the years 1965-1968 are shown in Table 3. There was an increase in the number of farm house-holds with 0.5 to 1.0 hectare of land and more than 2.0 hectares in the Chikugo Plain and that of farm house-holds with more than 2.0 hectares in the Saga Plain, and a decrease was seen in the number of farm house-holds with other classes. Did such a phenomenon occur because of the technological and structural differences existing between the farm house-holds with more than 2.0 hectares and those with less than 2.0 hectares? Let us

Table 3. The number of farmhouse-holds bv size in the Chikugo and the Saga Plains.

Farm size	Chikugo Plain*		Saga Plain**	
	1965	1968	1965	1968
hectare				
Total	47,430	46,860	30,680	29,770
Less than 0.5	19,590	17,700	9,060	8.380
0.5 — 1.0	14,060	18,360	7,440	6: 830
1.0 — 1.5	8,610	3,320	6,120	6,030
1.5 — 2.0	4,010	3,320	5,530	4,790
More than 2.0	1,160	1,780	2,530	3,740

* Fukuoka Prefecture (1967, 1970).
** Saga Prefecture (1967, 1970).

analyze this point through comparison of net returns from these farm lands.

Table 4 shows the net returns from these two plains in 1959 and 1968. In 1959, in each category there were little differences in the net returns between these plains. In 1968 the farm house-hold of more than 1.5 hectares received a greater increase in returns compared with the farm house-hold with less than 1.5 hectares of land.

Table 4. Net returns from land in the Chikugo and the Saga Plains*.
(unit : 1,000yen)

Farm size	Chikugo Plain		Saga Plain	
	1959	1968	1959	1968
hectare	12		15	
Less than 0.5	11	28 (2)	18	35 (2)
		33 (1)		30 (2)
0.5 — 1.0	12	34 (1)	16	34 (2)
1.5 — 2.0	8	39 (3)	15	41 (2)
More than 2.0			18	43 (2)

Note: Figures in parentheses are standard error.
* Figures are calculated by using Individual Cost Survey of Rice Production which was carried out by the Ministry of Agriculture and Forestry in 1961 and 1970.

If these net returns were capitalized by an interest rate of 8 percent, the capitalized land price for the farm house-hold with more than 1.5 hectares in 1968 would be approximately 500,000 yen for each of these two plains. The land price on which the actual dealings were based in 1968 was 600,000 yen in the Chikugo Plain and 620,000 yen in the Saga Plain according to the survey made by National Agricultural Council (1970). Therefore, the purchase of land will not bring the expected return. But if the return was capitalized by an interest rate of 6 percent, the land price would increase to 650,000 yen for the farm house-hold with more than 1.5 hectares in the Chikugo Plain and 700,000 yen in the Saga Plain and as a result it would exceed the actual land price. Furthermore there might be possibilities for size expansion. With this, the increase in the number of farm house-holds with more than 1.5 hectares in the

Chikugo Plain and more than 2.0 hectares in the Saga Plain is seemingly explicable. But since these interest rates were used arbitrarily, one should not conclude that this explains everything.

In this connection Miyajima (1970) conducted a distinguished research. According to him, in the Saga Plain, the farm house-holds, with more than 2.0 hectares take two directions, one in size enlargement and the other in size reduction. If large size farms are advantageous, there should be an increase in number of large size farms. However this is not always the case. The farm house-holds actually took the opposite direction as mentioned above. Then why is it so? This seemingly shows that net return from land is inappropriate to explain farm house-hold class dissolution.

In the calculation of net return from land, production factors which are difficult to be evaluated, such as family labor wages and self capital, are taken into account. The net return differs depending upon how these production factors are evaluated. For example, whether the farm size is 0.5 hectares or 2.0 hectares, family labor wage is calculated under the assumption that it equals daily wages in ordinary farming. But there is doubt about this assumption. If the family labor wage of the farm house-hold of 2.0 hectares is more highly evaluated than that of the farm house-hold with 0.5 hectares, the net return from the farm house-hold with more than 2.0 hectares becomes less than the estimate reached by normal calculation. In the same way the net return from land easily changes, depending upon the evaluation method of capital and the interest rate. Therefore instead of the net return, we use production function in order to analyse farm house-hold class dissolution and scaled economy.

II. LAND CLASS AND SCALE ECONOMY

We will apply the following Cobb=Douglas model of production function to the farms in the Chikugo and the Saga Plains which were surveyed by the Ministry of Agriculture and Forestry (1970) on their rice production cost.

$$(1) \qquad P = AT^{\alpha}L^{\beta}K_1^{\gamma}K_2^{\delta}u$$

where P is quantity of rice produced, T: Planted area of paddy field, L: Labor input, K_1: Variable capital, K_2: Fixed capital, u: Random disturbance, and A, α, β, γ and δ are parameters to be estimated.

The calculation of the production function is not so easy and it has a few problems. Before performing the calculation, let us take account some problems.

The first one is the heterogeneity of the production factors. The quality of land, labor and capital is not necessarily homogeneous. Some paddy fields can be of good quality, and others are not suitable for rice production. For example if labor input, or technology of rice production and others are the same, A, 10 ares of paddy field produces ***600*** kilograms of rice, while B, an another 10 ares of paddy field produces only 300 kilograms, then input of land in the production function could not be considered 20 ares simply by adding up the above two. If the average yield is 300 kilograms per 10 ares in that region, then paddy field A is 2 times as efficient as an ordinary paddy field and the total of A and B would be, therefore, 30 ares instead of 20.

Likewise the qualities of labor and capital are heterogeneous and it is not reasonable to simply add them up. If this is done, the estimate of the parameters in the production function would be very biased. This has been already pointed out by Griliches (1957).

Griliches regards labor as a heterogeneous production factor. It is true that labor is an important production factor for the quality of human resources influence the result of management to a considerable extent. This is the case especially in the management of dairy and mandarin orange farming. With no exception, the enlargement of farm size accompanies good management. On the other hand, the possibility of enlargement in rice farming is comparatively limited even if it is performed by superior management.

In such regions as the Ishikari Basin in Hokkaido, where the average farm size is more than 5 hectares and Tohoku, where land reclamation is going on, the size of paddy field is enlarging. However, such regions make up a small shave in the whole Japan. After all it is the quality of the land possessed by rice producers which decides the relative merit of their management.

Now, let us see Griliches' view as to what extent the estimate of the parameter will be biased by the heterogeneity of land. To consider this, the report of research conducted by Iwakata (1961) will be very helpful. First let us consider from Sugiyama's research (1961) which was based on the survey of Daijugarami on Ariake coast. His concluding statistics are shown in Table 5.

Table 5. Ratio of farm size and land class in Saga Plain (1959)*.

Land class \ Farm size	Small	Medium	Large
Upper	17.5%	5.3%	34.1%
Middle	19.1	50.4	33.5
Lower	63.4	44.3	32.4
Total	100.0	100.0	100.0

* Sugiyama (1961)

According to Table 5, the small farm size with lower class paddy field covers 63.4 percent, the medium farm size with middle class field covers 50.4 percent, and large farm size wih upper class field covers 34.1 percent. Thus the lower class paddy field makes up the highest ratio of possession in the small farm size, middle paddy field in the medium farm size, and upper paddy field in the large farm size. Also according to Takimoto's research (1961) the input of labor into paddy field on 10 ares average is 97 hours and 47 minutes for upper paddy field, 105 hours and 3 minutes for middle paddy field, and 113 hours and 15 minutes for lower paddy field. If the transportation time is included, it would be 99 hours and 50 minutes, 111 hours and 13 minutes, and 123 hours and 38 minutes, respectively. The required labor hour per 10 ares becomes less with the improvement of paddy fields. Statistical testing was not performed in Takimoto's research, so it is not certain if there is any significant difference among the ratio of upper, middle and lower paddy fields. However as a general trend, it may be not wrong to say that as the farm size becomes larger farmers use land of better quality and the hour of labor input per **10** ares become shorter.

To express this in a mathematical formula, we take the index representing land class as Q and assume that if the land is better, the Q is larger. Also, it is expressed that acreage of land is T, total hour of labor input is L, and parameters to be estimated are a' and β'. Now the research of Takimoto is expressed as follows :

$$Q=T^{\alpha'}\left(\frac{L}{T}\right)^{\beta'} \tag{2}$$

This formula mathematically represents the research of Takimoto in the following manner. If we assume that α' is greater than zero then Q becomes larger, as T becomes larger. If we assume that β' is less than zero, then Q becomes larger, as the required labor input per 10 ares, or $\left(\frac{L}{T}\right)$ becomes less.

Again we apply the Cobb=Douglas production function here as before.

$$P=\underline{A}\,(QT)^{\underline{\alpha}}\,LB\text{-}\ C_1^{\underline{\gamma}}C_2^{\underline{\delta}}u \tag{3}$$

where P is quantity of rice produced, Q is land class, T is acreage of land, L is labor input, C_1 is variable capital, C_2 is fixed capital, u is random disturbance and $\underline{A}, \underline{\alpha}, \underline{\beta}, \underline{\gamma}$ and $\underline{\delta}$ are parameters to be estimated. Bars are put underneath each parameter in (3), because the value of each parameter here will be different from that in (1)

Now we obtain the following formulas by substituting (2) for Q in (3).

$$P=\underline{A}\left\{T^{\alpha'}\left(\frac{L}{T}\right)^{\beta'}\right\}^{\underline{\alpha}}T^{\underline{\alpha}}L^{\underline{\beta}}C_1^{\underline{\gamma}}C_2^{\underline{\delta}}u \tag{4}$$

$$P=\underline{A}T^{(\alpha'-\beta')\underline{\alpha}}T^{\underline{\alpha}}L^{\beta'\underline{\alpha}}L^{\underline{\beta}}C_1^{\underline{\gamma}}C_2^{\underline{\delta}}u \tag{5}$$

$$=\underline{A}T^{\underline{\alpha}(1+\alpha'-\beta')}L^{\underline{\beta}+\beta'\underline{\alpha}}C_1^{\underline{\gamma}}C_2^{\underline{\delta}}u$$

The equation (3) becomes more complicated as equation (5). If we pay no attention to the fact that there is such difference in land class, the parameters are estimated by the original production function.

$$P= AT^{\alpha}L^{\beta}C_1^{\gamma}C_2^{\delta}u \tag{6}$$

the estimate of parameter α is equivalent to the estimate of $\underline{\alpha}(1+\alpha'-\beta')$ in (5). That is,

$$\mathrm{E}(\alpha)=\underline{\alpha}(1+\alpha'-\beta')$$

here $\mathrm{E}(\alpha)$ is the estimate of parameter α.

In the same taken,

$$\mathrm{E}\ (8)=\underline{\beta}+\beta'\underline{\alpha}$$

here E (β) is the estimate of parameter β.

Concerning γ and δ,

$$E(\gamma)=\underline{\gamma}$$
$$E(\delta)=\underline{\delta}$$

here E(7), E(6) is the estimate of parameter γ and δ respectively.

Here since $\alpha'>0$ and $\beta'<0$, the production elasticity of land, $\underline{\alpha}$ (taking into consideration the difference in land class) is larger by $\underline{\alpha}(\alpha'-\beta')$ than α, if attention is not paid to the difference and the production elasticity of labor, β becomes smaller by $|\beta'\underline{\alpha}|$ than β. Accordingly if no attention is given to the fact that there is a difference in land class, the production elasticity of land is overestimated and that of labor is underestimated. Hence the heterogeneity of land should be considered in the estimate of a production function.

III. HOMOGENEITY IN TECHNOLOGICAL PROGRESS

The second problem is the multi-collinearity problem in measuring the production function. The problem of multi-collinearity lies in the fact that the estimation of the parameters become unstable when there is a high correlation among the land, variable capital, fixed capital and labor which are considered as independent variables in the production function.

Now, let us consider the change in the correlation coefficient among the production factors in rice production. Table 6 shows that the correlation coefficient becomes larger and the level of rice production technology becomes more homogeneous as years pass.

Table 6. Correlation coefficients among rice production factors*.

Year	Region	r_{12}	r_{13}	r_{23}
1937	Kyushu	0.69	0.60	0.76
1959	Saga	0.91	0.79	0.89
1968	Saga Plain	0.97	0.95	0.93
1968	Chikugo Plain	0.59	0.41	0.67

Note: The subscripts 1, 2 and 3 represent labor, acreage of paddy field and variable capital (fertilizer), respectively.

* Ohkawa (1945).

The correlation coefficient which Ohkawa (1945) measured as to Kyushu in 1937 was, 0.69 for labor and acreage of paddy field, 0.60 for labor and fertilizer and 0.76 for acreage of paddy field and fertilizer. In 1959 the correlation coefficients as to rice production in Saga Prefecture were 0.91, 0.79 and 0.89 and in 1968 were 0.97, 0.91 and 0.93 in the same order as above. As years go by, the coefficients become higher and the correlation approximates to unity. This shows that the rice production technology has been homogenized.

These things may be due to the following fact ; 1) The agricultural extension work started in 1949, has shown its steady effect. 2) The cooperative works such as cooperative protection work have been often performed. 3) The level of rice production technology has been homogenized in every farm house-hold. Especially, in Saga Prefecture such works as collective cultivation play an important role in such homogeneity.

IV. CONSTANT RETURN TO SCALE

In the foregoing sections, two problems such as land class and multi-collinearity were mentioned. They come up in the estimation of the production. These problems will be discussed more in detail by taking up the Chikugo and the Saga Plains in this section.

Table 7 shows the yield and labor input hour of rice production in 1968 which were measured by the use of rice production cost survey by the Ministry of Agriculture and Forestry (1968). Concerning both plains slight variation were seen in the yield and the labor hours by farm size but they were almost within the range of error and significant difference cannot exist in both the yield and the labor hour. As for the first problem of land class the simplest index to represent land calss is the yield per 10 ares and the labor hours. (As seen in the research by Takimoto, the labor hours per 10 ares are less in upper paddy field.) Such findings may show that the Chikugo and the Saga Plain farm house-holds surveyed about rice production cost have almost the same class of land.

Table 7. Yield and labor hour of rice production on the Chikugo and the Saga Plains (per 10 ares).

Region / Farm size	Chikugo Plain		Saga Plain	
	Yield	Labor hour	Yield	Labour hour
hectare	kilogram	hour	kilogram	hour
Average	568	127	567	110
Less than 0.5	560	135	563	111
0.5 — 1. 0	574	129	562	114
1.0 1.5				
1.5 — 2.0	560	124	560 574	118 100
More than 2. 0	582	115	584	105

The second problem of multi-collinearity comes up in the Saga Plain, because the correlation among production factors is high. However, in the Chikugo Plain, the correlation coefficient is low and this problem is not so serious. Therefore the production function of rice on the Chikugo Plain will be quite easily measured.

Table 8 shows the findings of the above-mentioned measurement. Concerning the Chikugo Plain, the parameters of the production function reach the level of significance and the sum of all parameters becomes almost constant one.

As for the Saga Plain, the estimates of the parameters (except the estimate of the production elasticity of land being 1) are all zero and do not reach the level of significance because of multi-collinearity and the production function becomes $P=AT$. Accordingly the total yield of rice production will be determined only by the size of paddy field. That is, the structure of rice production in the Saga Plain embodies the fixed proportional relationship among the

Table 8. Elasticity of rice production on the Chikugo and the Saga Plains (1968)*.

Region	Constant ((A)	Land (α)	Labor (β)	Current capital (γ)	Fixed capital (δ)	Sum	Multiple regression coefficient
Chikugo	3.11	0.48**	0.32**	0.20**	0.04**	1.04	0.98
Saga	3.84	1.00**	−0.04	0.08	−0.01	1.01	0.99

* The Ministry of Agriculture and Forestry (1970).
** Significance level of 1 percent.

production factors such as 1,000 hours of labor for 1.0 hectare and 2,000 hours for 2.0 hectares. (The same is true with other production factors.)

The fact that sum of parameters in Cobb=Douglas production function is constant one follows the law of "Constant return to scale." This means a farm house-hold with 2.0 hectares will have two times as much yield as a farm house-hold with only 1.0 hectare and that there is no difference in production efficiency between them. According to the research made by Miyajima, the farm house-hold class dissolution does not appear in such a stable pattern that the farm house-holds owning more than 2.0 hectares always increase. Rather the reduction and expansion in the size are seen and thus the dissolution pattern is unstable. Fundamentally, this is due to the fact that the technology of rice production does not stay at the equilibrium point because there is no difference in the produciton efficiency between large farm size and small farm size.

Scale advantage does not exist under the present situation where the farm size is less than 3.0 hectares of land. And the complete system of large-scale mechanization such as combines and large tractors can not be established without scale advantage.

Imamura (1970) conducted a comparative study on farm house-hold class dissolution in the principal rice producing ***areas,*** such as the Shonai Plain in Yamagata Prefecture, the Kanbara Plain in Niigata Prefecture and the Saga Plain in Saga Prefecture. In his comparative study it was made clear that the discrepancy among the classes is the most discernible in the Kanbara Plain, secondly in the Shonai Plain and thirdly in the Saga Plain.

Imamura gives the following exlanation of the fact that in the Saga Plain the discrepancy is not very noticeable. The high rice price in the late Showa 30's brought capital accumulation and induced investment to the upper farmers in the principal rice production. In the districts where land conditions are being improved, the investment is made by the individual farmers, with this background, the farm size expansion progressed among the upper class farmers and management curtailment and the separation from farming among the lower class farmers. In the districts where the arable land condition was unsatisfactory, technological innovation is not easily introduced by the individual farmers in accordance with rapid outflow of labor force and the labor orgnization is reorganized in the form of co-operative groups for cultivation. As a result, in these regions the yield per 10 ares increases for all the classes of farmers and as the leveling is progressing, the discrepancy among the classes is being minimized.

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