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Estimating the Shadow Price of Family Labor in Japanese Agriculture, 1958-85

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It is a world-wide phenomenon that agricultural production is done mainly by family labor including operators for which a market does not exist. However, in analyzing agricultural labor market or estimating the labor share and hence the total factor productivity in agricultural production, the traditional procedure of evaluating family labor by the market price of agricultural hired labor has been widely adopted (e.g., Heady and Tweeten; Bauer; Tyrchniewiez and Schuh; Lianos; Kuroda 1979 ; and Shintani). Even in a new area of research where the duality theory, flexible functional forms, and modern theories of index numbers are applied, the traditional method has been commonly used (e.g., Binswanger; Kako; Le Thanh Nghiep; Antle; Weaver; and Kuroda 1987). However, if farm-firms are not behaving so as to evaluate their family labor by the market wage rate of agricultural hired labor, analyses based on such an assumption may cause biases in the results.

Thus, the major objective of this study is to estimate the shadow price of family labor based on the theory of the firm in order to test the validity of the traditional procedure of treating family labor. The estimation is carried out for Japanese agriculture for the 1958-85 period based on aggregate farm data. Considering the fact that more than 95% of total agricultural labor is composed of family labor in postwar Japanese agriculture, it is essential for various areas of research to examine the level of evaluation of family labor by farm-firms.

Similar studies for postwar Japanese agriculture were made by Egaitsu and Shigeno(1983, 1984) for rice production and for livestock production. However, the procedure they introduced was to estimate the shadow prices of factors of production based on estimates of a particular Cobb-Douglas production function.[1/] They failed to incorporate a priori a specific behavioral assumption such as cost minimization or profit maximization of the farm-firm into their framework. Unlike their approach, profit-maximizing behavior of the farm-firm is explicitly assumed a priori in this study and a normalized restricted translog profit function with family labor and land being quasi-fixed factor inputs is specified. Using estimated parameters of the translog profit function, the shadow price of family labor is then estimated.

Results of this study will have important implications on the following two research areas.

First, according to Minami and Ohkawa, and Minami, the Japanese economy passed the "turning point"(Lewis) around the late 1950s through the early 1960s. This implies that the farm-firm has been following the marginal principles after that period in employing factors of production including family labor and in supplying output. Following this Minami and Ohkawa's proposition, the period of investigation in this study, 1958-85, falls on an after-the-turning-point period. Therefore, if Minami and Ohkawa are correct in their finding of the turning point in the Japanese economy, the estimated shadow price of family labor in this study must be equal to or must at least move in parallel with the market price of hired labor (Minami, pp.69-85). In this sense, the present study may offer at least a partial test to the Minami-Ohkawa hypothesis of proposing that the Japanese economy has entered on after-the-turning-point stage.[2/]

Another important implication, which is intimately related to the first one, is associated with specifications of the agricultural household model. Sasaki and Maruyama originally showed that if a competitive market exists for agricultural labor, the economic behavior of the agricultural household can be decomposed into the production decisions and the consumption decisions. Under such a situation, the theory of the firm can be directly applied to the farm-firm. However, if a competitive agricultural labor market does not exist or is limited, decomposition of the production and consumption behavior is not possible. In such a case, the production and consumption behavior of the agricultural household has to be analyzed simultaneously.

Although the latter case is very intriguing in a theoretical analysis based on comparative statics (Maruyama), empirical implementations become rather complex (Lopez). It is much easier to analyze the production behavior separately from the consumption behavior of the farm household as having been done in almost all empirical production studies of agriculture. Rigorously speaking, however, in order to adopt this rather simpler method, a justification is necessary for the assumption of the existence of a competitive agricultural labor market.

Estimating the shadow price of family labor in this study may offer an information on this issue. If it is found that the estimated shadow price is equal to or moves in parallel with the market price of hired labor, one may regard such a finding as an evidence that the farm-firm employs family labor as if a competitive agricultural labor market existed.

The organization of this study is as follows. The methodology is given in section two. The sources of data and processings of variables are discussed in section three. Empirical results are analyzed in section four. Finally, section five offers a summary of empirical results and some concluding remarks.

Methodology

It is assumed that the farm-firm has the following production function which satisfies the usual regularity conditions,

(1) $Q = F(X_M , X_I , X_O , Z_L , Z_B , t)$

where Q is output; X_M , X_I , and X_O refer to machinery, intermediate inputs, and other inputs which are assumed to be variable inputs; Z_L and Z_B are family labor and land which are regarded as quasi-fixed inputs(fixed inputs hereafter); and t is an index of time.

A word needs to be mentioned about the treatment of family labor and land as fixed inputs. Generally speaking, it is often difficult in agricultural production to adjust land stock to the optimal level within the observation period of one year in response to changes in exogenous variables such as prices of output and variable inputs and changing technology. It has a property more like a fixed input rather than a variable input in a short run. On the other hand, family labor is more like a variable input than a fixed input, since its stock appears to be more easily adjusted to changes in exogenous variables than land. But, its shadow price is usually unobservable. Indeed, as mentioned earlier, the major objective of this study is to estimate the shadow price of family labor. And, as shown immediately later in this section, treating family labor as a fixed input is most convenient to compute its shadow price.

Assuming competitive behavior of the farm-firm, the normalized restricted profit function (hereafter profit function in short) can be derived as a dual transformation of the production function(1) (Diewert 1973, Lau). A major advantage in adopting the profit function rather than the primal production function as a means of representing the production technology is that output supply and input demand equations are easily derived as the partial derivatives of the profit function with respect to prices by using Hotelling's Lemma (Lau). The profit function is written as,

(2) $\Pi = G(P_M, P_I, P_O, Z_L, Z_B, t)$

where Π is restricted profit (i,e., gross revenue less variable costs) normalized by output price (P); and P_M, P_I, and P_O are the prices of machinery, intermediate inputs, and other inputs normalized by output price.[3/]

For econometrical estimation, the following translog form (Diewert 1974) is postulated for the profit function (1):

$$(3)\quad \ell n\, \Pi = \alpha + \sum_{i=1}^{3} \alpha_i\, \ell nP_i + \sum_{j=1}^{2} \beta_j\, \ell nZ_j + \beta_t\, \ell nt$$
$$+ \frac{1}{2} \sum_{i=1}^{3} \sum_{k=1}^{3} \gamma_{ik}\, \ell nP_i\, \ell nP_k + \frac{1}{2} \sum_{j=1}^{2} \sum_{\ell=1}^{2} \delta_{j\ell}\, \ell nZ_j\, \ell nZ_\ell$$
$$+ \sum_{i=1}^{3} \sum_{j=1}^{2} \phi_{ij}\, \ell nP_i\, \ell nZ_j + \sum_{i=1}^{3} \varepsilon_{it}\, \ell nP_i\, \ell nt$$
$$+ \sum_{j=1}^{2} \mu_{jt}\, \ell nZ_j\, \ell nt + \frac{1}{2} \beta_{tt} (\ell nt)^2$$

where $\gamma_{ik} = \gamma_{ki}$ and $\delta_{j\ell} = \delta_{\ell j}$; $i = k = M, I, O$; and $j = k = L, B$.

Applying Hotelling's lemma yields the following factor profit share equations:

$$(4)\quad -R_i = -\frac{P_i X_i}{\Pi} = \frac{\partial \ell n \Pi}{\partial \ell n P_i}$$
$$= \alpha_i + \sum_{k=1}^{3} \gamma_{ik}\, \ell n\, P_k + \sum_{j=1}^{2} \phi_{ij}\, \ell nZ_j + \varepsilon_{it}\, \ell nt.$$
$$i = k = M, I, O; \quad j = L, B.$$

The output supply function can easily be derived as

$$(5)\quad Q = \Pi + \sum_{i=1}^{3} P_i X_i$$

$$= \Pi(1 - \sum_{i=1}^{3} R_i)$$

Provided that the normalized restricted profit function is increasing and concave in the quantities of the fixed inputs(Z) and the vector of the fixed inputs available to the farm-firm is the same as that which would be chosen to minimize the cost of producing the given amount of normalized restricted profits, the shadow price of a fixed input is obtained by differentiating the restricted profit by the quantity of the fixed input as $\partial\Pi/\partial Z_j = P_j$ (Diewert 1974, p.140). In terms of parameters of the translog profit function in this study, it is given by,

$$(6)\quad \frac{\partial\Pi}{\partial Z_j} = P_j = \frac{\Pi}{Z_j}(\beta_j + \sum_{j=1}^{2} \delta_{j\ell}\, \ell n Z_\ell + \sum_{i=1}^{3} \phi_{ij}\, \ell n P_i + \mu_{jt}\, \ell n t)$$

i = M, I, O; $j = \ell$ = L, B.

These equations give the imputed value of a marginal unit of fixed input j. Given estimates of β_j , $\delta_{j\ell}$, ϕ_{ij} , and μ_{jt} , the shadow price can be computed for each sample observation. In order to examine at what level the farm-firm evaluates the productive value of family labor, the computed shadow price of family labor will then be compared with appropriate market wage rates in agriculture and nonagriculture.

For statistical estimation, the most efficient estimators of the profit function are obtained by a joint estimation of equations (3) and (4) with parameter restrictions, if any. Since profit maximizing behavior of the farm-firm is maintained in this study, across-equations equality restrictions together with symmetry restrictions are imposed (Christensen, Jorgenson, and Lau). The system of the translog profit function (3) and the three profit share equations (4) is estimated by the iterative seemingly unrelated regression (ISUR) method. These estimates are consistent, asymptotically normal and equal to maximum likelihood estimates (Magnus).

The Data

The data required to estimate the model are the restricted profit, the price of output, the prices and profit shares of the variable factors of production (machinery, intermediate inputs, and other inputs), and the quantities of the fixed factors of production (family labor and land). The major sources of data are the Survey Report on Farm Household Economy (FHE) and the Survey Report on Prices and Wages in Rural Villages (PWRV) published annually by the Ministry of Agriculture, Forestry, and Fisheries. In each year of the 1958-85 period one average farm was taken from each of the four size classes, 0.5-1.0 (I), 1.0-1.5 (II), 1.5-2.0 (III), and 2.0 hectares or over (IV), from all Japan excluding the Hokkaido district because of the different size classification. Thus, the sample size is 28 (years) × 4 (classes) = 112.

The restricted profit (Π') was obtained by subtracting the variable costs ($\sum_{i=1}^{3} P'_i X_i$, i = M, I, O) from gross revenue (PQ) where primes indicate nominal term expressions.. The quantity and price indexes of output (Q and P) were computed by the Tornqvist approximation method of the Divisia index. For this computation eleven different categories of crop and livestock products were distinguished. The base of all indexes is set at 1958 values taken from class I.

The quantity and nominal price indexes of intermediate inputs (X_I and P'_I) and other inputs (X_O and P'_O) were also constructed by the Tornqvist method. In these computations, the cost of intermediate inputs ($P'_I X_I$) was defined as the sum of the expenditures on fertilizer, feed, agri-chemicals, materials,clothes, and others; and the costs of other inputs ($P'_O X_O$) as the sum of the expenditures on animals, plants, and farm buildings and structures. The necessary data were taken from the FHE. In addition, the price data necessary for computing the Tørnqvist indexes were obtained from the PWRV.

The quantity of machinery input (X_M) was defined as the number of machinery hours. The price of machinery input (P'_M) was obtained by dividing the sum of the expenditures on machinery, energy, and rentals ($P'_M X_M$) by the number of hours of machinery usage (X_M).

The quantity of family labor (Z_L) was defined as the total number of male-equivalent labor hours of operators and family workers. The number of male-equivalent labor hours by female workers was estimated by multiplying the number of female labor hours by the ratio of female daily wage rate to male daily wage rate of agricultural temporary-hired labor which can be obtained annually from the PWRV. The quantity of land (Z_B) was defined as the total planted area.

The profit shares (R_M , R_I , and R_O) were obtained by dividing the expenditures, $P'_M X_M$, $P'_I X_I$, and $P'_O X_O$, by the restricted profit (Π').

Finally, the restricted profit (Π') and the prices of the three variable factor inputs (P'_M , P'_I , and P'_O) were normalized by output price (P). These normalized variables are denominated as Π, P_M , P_I , and P_O .

Empirical Results

The translog profit function (3) and the three profit share equations (4) were estimated first by ordinary least squares method in order to check the goodness of fit. For the translog profit function and the profit share equations for machinery, intermediate inputs, and other inputs, the R^2's adjusted for degrees of freedom were 0.993, 0.852, 0.862, and 0.807 respectively, indicating a fairly good fit for the model.

Next, the system of the translog profit function (3) and the three profit share equations (4) were estimated by imposing the across-equations equality and symmetry restrictions. The result is presented in table 1. The regularity conditions of monotonicity and convexity were satisfied for each observation, indicating that the empirical results based on the parameter estimates will be economically meaningful. Thus, the set of estimates in table 1 is referred to as the final specification of the model and will be used for further analyses.

Output Supply and Factor Demand Elasticities.

Before estimating the shadow price of family labor, first elasticities of output supply and factor demands were computed by using the formulas derived in Sidhu and Baanante[4/], in order to gain a general picture of the production technology of Japanese agriculture for the period 1958-85. The results are given in table 2.[5/] However, it should be noted here that these are Marshallian elasticities since they include both expansion and pure substitution effects. Several important findings emerge from this table.

First, the elasticity of output supply with respect to output price is 1.3, indicating a fairly elastic response by farmers to changes in output price. This result supports Kuroda's (1979) estimate of the own-price supply elasticity, 0.91, for 1965-67 based on the parameter estimates of a Cobb-Douglas profit function (Table 3-2, p.115). The output supply elasticities with respect to the prices of the variable factor inputs are all negative, though the absolute values are small. On the other hand, increases in the fixed inputs, family labor and land increase output supply.

Second, it is found that an increase in output price will increase the demand for machinery, intermediate inputs, and other inputs. This indicates that price support programs of farm products will increase the demand for these variable factor inputs.

Third, the own-price demand elasticities for machinery, intermediate inputs, and other inputs are -0.30, -0.60, and -0.97, respectively. These values of elasticities are almost equal or similar to the corresponding estimates, -0.25, -0.59, and -1.96, respectively, obtained by Kuroda (1987) based on the estimates of the translog total cost function for the national average farm for the 1952-82 period (Table 3, p.334).

Finally, the demand elasticities of the variable inputs with respect to the quantities of the fixed inputs are all positive. In particular, a fairly large demand elasticity of intermediate inputs with respect to the quantity of land (0.67) may indicate rather elastic response in the utilization levels of intermediate inputs to an expansion of land. This may reflect that Japanese farming was fertilizer-agrichemicals-intensive during the postwar years.

The Shadow Price of Family Labor

The shadow price of family labor (P_L) was estimated by using equation (6) for the average farm of the four size classes for each year of the 1958-85 period.[6/] In order to compare this shadow price with market wage rates, the following four market wage rates were obtained from the FHE for the same period.

First, the wage rate of agricultural temporary-hired labor (W_A) was obtained by dividing the wage bill for temporary-hired labor by the number of male-equivalent labor hours of temporary-hired labor and is expressed in yen per hour. Next, three categories of nonagricultural employment can be distinguished in the FHE: temporary-hired wage labor, permanent wage labor, and permanent clerical labor. The wage rate for each category of nonagricultural employment was computed by dividing the wage bill by the corresponding male-equivalent labor hours. In this computation, the equivalence ratio used for converting female labor to male-equivalent labor was 0.5, since the ratio of female to male wage rates in nonagricultural firms with more than 30 employees was almost consistently around 0.5 for the period under question.[7/] The three nonagricultulral wage rates so obtained are designated as W_{N1}, W_{N2}, and W_{N3} and are expressed in yen per hour. The shadow price and the four market wage rates are presented in figure 1 and the detailed statistical estimates are reported in table 3.

A casual observation of figure 1 tells us that the time series of the shadow price of family labor (P_L) seem to be very close to those of the wage rate of agricultural temporary-hired labor (W_A) but clearly smaller than any nonagricultural wage rates. In order to gain a rigorous answer to the questions of differences between the shadow price and the market wage rates, a simple statistical test was introduced.

If the time series of the shadow price and the four market wage rates are normally distributed with population mean zero, then the sample mean difference $\bar{D}$ of, say, the shadow price and the agricultural hired labor wage rate, is normally distributed about μ_D with standard deviation of the population of differences. Hence, the quantity $t=(\bar{D}-\mu_D)/s_{\bar{D}}$ follows Students t-distribution with (n-1) degrees of freedom where $s_{\bar{D}} = s_{\bar{D}}/\sqrt{n}$ and n is the number of pairs. The t-distribution may be used to test the null hypothesis that $\mu_D = 0$. (Snedecar and Cochran, pp.91-100).[8/]

The test was carried out for the following four pairs of differences: (1) between the shadow price (P_L) and the agricultural temporary-hired labor wage rate (W_A); (2) between P_L and the wage rate of nonagricultural temporary-hired wage labor (W_{N1}); (3) between P_L and the wage rate of nonagricultural permanent wage labor (W_{N2}); and (4) between P_L and the wage rate of nonagricultural permanent clerical labor (W_{N3}). It should be noted here that, since 22 out of the 28 pairs of the observed differences between P_L and W_A are positive and all pairs between the remaining three comparisons (P_L and W_{N1}; P_L and W_{N2}; and P_L and W_{N3}) are negative, the alternative hypotheses may be set as $\mu_{D(P_L - W_A)} > 0$, $\mu_{D(P_L - W_{N1})} < 0$, $\mu_{D(P_L - W_{N2})} < 0$, and $\mu_{D(P_L - W_{N3})} < 0$, respectively. Hence, a one-tail test was made for each comparison.

The corresponding t-statistics computed are 3.76, -5.23, -5.62, and -6.07 with d.f. = 27. The critical t-values are $\pm$ 1.703 and $\pm$ 2.506 at the 1 % level of significance. Thus, all the null hypotheses are rejected, indicating that $P_L > W_A$, $P_L < W_{N1}$, $P_L < W_{N2}$, and $P_L < W_{N3}$. That is, the shadow price of family labor was larger than the wage rate of agricultural temporary-hired labor during the 1958-85 period, although it was smaller than nonagricultural wage rates.

This finding as such casts a doubt on the validity of the traditional assumption that the shadow price of family labor is equal to the wage rate of agricultural hired labor. For example, imputing the shadow value of family labor by the market wage rate of agricultural temporary-hired labor will cause an underestimation in the labor share and hence a bias when, for example, it comes to estimating total factor productivity in agricultural production.

However, judging from the very similar over-time movements of the shadow price (P_L) and the agricultural wage rate (W_A) as shown in figure 1, analyses based on estimations of, say, structural demand and supply equations of labor or migration functions by imputing the shadow price of family labor by the market wage rate of agricultural hired labor may not suffer from substantial biases in the estimated coefficients as long as the intercepts are carefully interpreted.

Related to this point, in particular, let us evaluate the Minami-Ohkawa hypothesis of dating the turning point in the Japanese economy and the possibility of decomposing the agricultural household behavior into the production and consumption decisions.

As mentioned earlier, according to the Minami-Ohkawa hypothesis, the period 1958-85 chosen in this study falls on an after-the-turning-point stage in the Japanese economy. The most important characteristic of the farm-firm during such an economic phase is that it behaves in the neoclassical world. That is, the farm-firm employs factor inputs in such a manner that it maximizes its profits.

It has been assumed in this study that the farm-firm maximizes profits with respect to machinery, intermediate inputs, and other inputs given the prices of output and these variable factor inputs and the quantities of family labor and land. As done in this study, it may be reasonable to assume land as a fixed input and therefore as an exogenous variable within one year sample period. Unlike land, however, family labor has a strong endogenous variable characteristic, considering the fact that the farm-firm may vary fairly easily the quantity of family labor in response to changes in exogenous variables even within a one year period. Thus, in order to test the above hypothesis, it may be sufficient to test the hypothesis that the marginal principle with respect to labor is valid.

Rigorously speaking, however, the rejections of the equality tests between the shadow price of family labor and market wage rates may lead to rejection of this hypothesis. Indeed, judging from a glance at figure 1 and the results of the equality tests, it may be quite safe to say that the farm-firm does not follow the marginal principle in employing family labor in terms of nonagricultural wage rates. This may be natural since the levels of skills used are different between farming and nonagricultural jobs, even in the case of nonagricultural temporary-hired wage jobs.

However, the skill levels may be considered to be almost equivalent between family labor and hired labor in agricultural production. Then, one may still consider a possibility that the farm-firm follows the marginal principle in employing family labor in terms of agricultural wage rate, once the condition of the marginal principle is slightly relaxed.

It is proposed in this study that the marginal principle with respect to labor is satisfied if the shadow price of family labor changes proportionally to the market wage rate of agricultural hired labor. In order to implement this test, a regression analysis was employed. That is, in the estimation of $P_L = a + bW_A$, if the coefficient b is equal or close to unity, the marginal principle may be regarded as valid.[9/]

The estimated result of the regression equation is,

$$P_L = 8.05 + 1.02W_A \ , \ \bar{R}^2 = 0.993$$
$$(1.2) \quad (62.4)$$

where the figures in parentheses are estimated t-values. The estimated t-value for the null hypothesis H_o: $\hat{b} = 1$ is 1.22. Since the critical t-value with 26 degrees of freedom is 2.06 and 2.78 at the 1% and 5% significance levels, respectively, the null hypothesis cannot be rejected at either significance level. This implies that the shadow price of family labor (P_L) varied almost completely in proportion to the market wage rate of agricultural temporary-hired labor (W_A).[10/]

Consequently, it may be concluded that the farm-firm followed the marginal principle in employing family labor during the 1958-85 period by varying the shadow price of family labor in proportion to the market wage rate of agricultural temporary-hired labor. Therefore, this result may be said to support partially the Minami-Ohkawa hypothesis in that the Japanese economy passed its turning point around the late 1950s through the early 1960s.[11/]

Furthermore, the finding of the proportional variation in the shadow price of family labor and the agricultural market wage rate may imply that the farm-firm evaluates family labor by responding very closely to changes in the agricultural market wage rate. This may indicate that the farm-firm behaves in employing family labor as if it faced a competitive labor market.

This has an important implication in specifications of the agricultural household model. As mentioned in section one, if there exists a competitive labor market, the economic behavior of the agricultural household can be decomposed into the production decisions and consumption decisions. That is, the production behavior can be analyzed with no reference to the consumption behavior, and hence the theory of the firm can directly be applied (Sasaki and Maruyama; Maruyama). Thus, the above finding may give an empirical support to analyses of the production decisions of the agricultural household independently of consumption decisions in Japanese agriculture, at least, after the late 1950s, in spite of the fact that agricultural labor market is apparently imperfect.

Finally, the finding that the shadow price of family labor was smaller than the three categories of nonagricultural wage rates has an important implication in the postwar development of Japanese agriculture. This finding implies that the farm-firm evaluated family labor at less than nonagricultural wage rates. Or, putting it in another way, the marginal productivity of family labor in agricultural production was smaller than the marginal productivity of labor in the nonagricultural sectors. This wage differential, in turn, must have played an important role in the massive exodus of labor from agriculture to the nonagricultural sectors during the postwar years.

On the other hand, the existence of wage differentials between agriculture and nonagriculture may imply that there exists a substantial amount of "surplus" labor in agriculture if farmers aim at achieving higher marginal productivity of labor which are comparable with the wage rate of, say, nonagricultural permanent wage labor.

Concluding Remarks

This study has estimated the shadow price of family labor of the average farm-firm in Japanese agriculture for the 1958-85 period. The findings may be summarized as follows.

(1) The shadow price of family labor was greater than the wage rate of agricultural temporary-hired labor. However, it was smaller than the wage rates of three categories of nonagricultural employment; temporary-hired wage labor, permanent wage labor, and permanent clerical labor. This implies that analyses based on estimation of the labor share with the traditional assumption of evaluating family labor at the market wage rate of agricultural hired labor may cause biases in the results.

(2) Although there existed differences between the shadow price and the agricultural market wage rate as a result of a statistical test, the over-time variations of these two variables were found to be almost completely proportional, and the difference itself was not substantial. This may indicate that estimations of structural demand and supply equations of agricultural labor market and /or migration functions including family labor are safe as far as the coefficients with respect to wages are concerned.

(3) This finding has also an important implication for the dating of the turning point in the Japanese economy by Minami and Ohkawa as well as for the specifications of the agricultural household models. This finding may be used as an evidence that the farm-firm has followed the marginal principle with respect to labor. Or, the farm-firm may be said to have behaved in the use of family labor as if a competitive labor market existed in agriculture. In this context, the period 1958-85 studied in this paper may be said to fall on an after-the-turning-point stage of the Japanese

economy, giving a partial support to the Minami-Ohkawa hypothesis. Furthermore, this finding may offer a guarantee to analyses in which the production decisions of the agricultural household are treated independently of the consumption decisions.

(4) The finding that the shadow price of family labor was smaller than any nonagricultural wage rates implies that there exists substantial "surplus" labor in agriculture if farmers aim at achieving higher marginal productivity of labor in agricultural production.

An important limitation of this study is that machinery and , in particular, other inputs (animals, plants, and farm buildings and structures) used as variable inputs have a strong characteristic as fixed inputs within a one-year sample period. However, they were treated as variable factor inputs in this study in order to increase the efficiency of estimation through increasing the number of parameter restrictions of symmetry and across-equations equality. Therefore, if these factor inputs are treated as exogenous variables, the conclusions obtained in this study might have to be modified.

Table 1. Parameter Estimates of the Translog Restricted Profit Function (1958-85)

α	5.201*	δ_{BB}	0.002
α_M	-0.152*	δ_{LB}	0.114
α_I	-0.244*	ϕ_{ML}	0.078**
α_O	-0.113*	ϕ_{MB}	0.018
β_L	0.672*	ϕ_{IL}	0.181*
β_B	0.753*	ϕ_{IB}	-0.018
β_t	-0.093**	ϕ_{OL}	0.041*
γ_{MM}	-0.216*	ϕ_{OB}	0.015
γ_{II}	-0.295*	ε_{Mt}	-0.047*
γ_{OO}	-0.024**	ε_{It}	-0.097*
γ_{MI}	-0.093*	ε_{Ot}	-0.018*
γ_{MO}	-0.065*	μ_{Lt}	0.073
γ_{IO}	-0.042*	μ_{Bt}	-0.050
δ_{LL}	-0.180	β_{tt}	0.199*

Note: * and ** indicate that the coefficients are statistically significant at the 5 and 10 % levels, respectively.

Table 2. Estimates of Partial Elasticities of Output Supply and Factor Demands (1958-85)

Independent variable / Dependent variable	Price of output (P)	Price of machinery (P_M)	Price of intermediate inputs (P_I)	Price of other inputs (P_O)	Quantity of family labor (Z_L)	Quantity of land (Z_B)
Quantity of output (Q)	1.314 (0.140)	-0.039 (0.105)	-0.148 (0.110)	-0.071 (0.037)	0.693 (0.106)	0.608 (0.063)
Quantity of machinery (X_M)	0.139 (0.688)	-0.298 (0.368)	0.018 (0.206)	0.140 (0.115)	0.519 (0.191)	0.536 (0.043)
Quantity of intermediate inputs (X_I)	0.633 (0.455)	0.001 (0.137)	-0.598 (0.266)	-0.034 (0.054)	0.377 (0.199)	0.665 (0.075)
Quantity of other inputs (X_O)	0.853 (0.371)	0.213 (0.170)	-0.094 (0.140)	-0.972 (0.062)	0.567 (0.144)	0.510 (0.046)

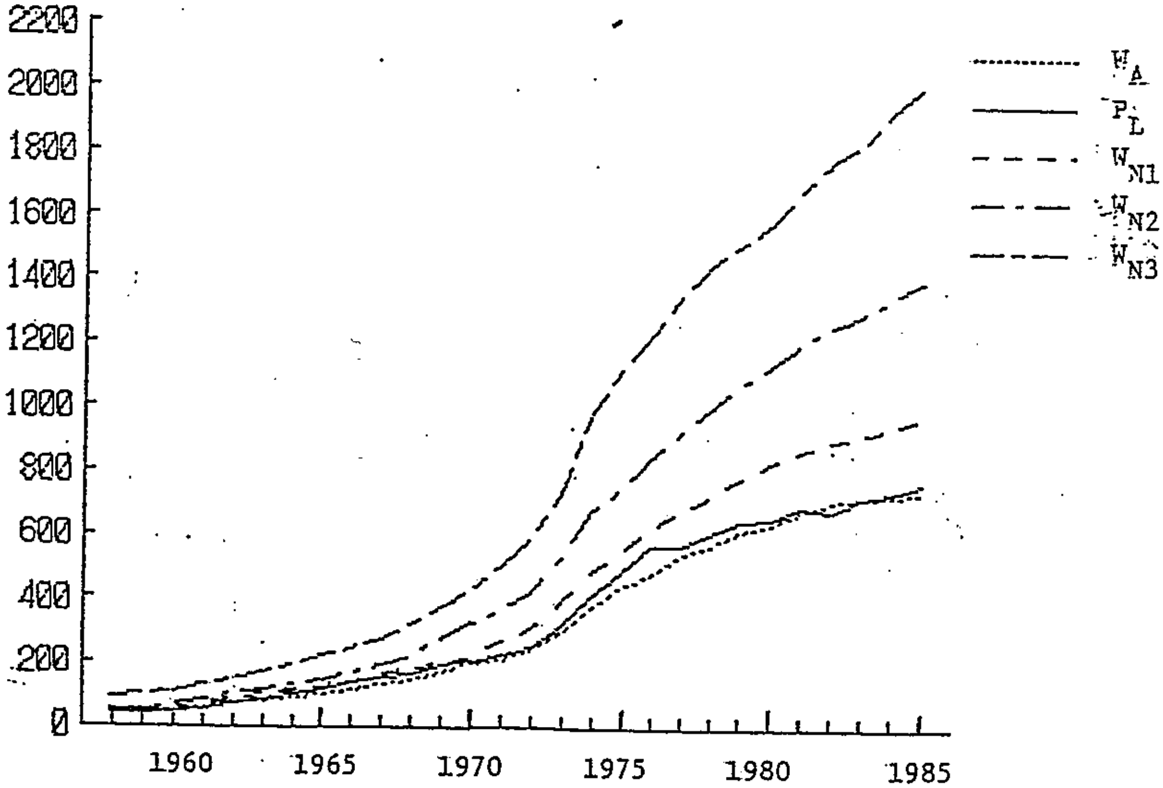
Note: Averages for the 1958-85 period. Figures in parentheses are the standard deviations.

Table 3. Shadow Price of Labor and Market Wage Rates (1958-85)

	Shadow price (SPL)[a]	Agricultural[b] hired labor wage rate (W_A)	Nonagricultural wage rate[b] Temporary hired labor (W_{N1})	Permanent wage labor (W_{N2})	permanent clerical labor (W_{N3})
					(Unit: yen/hour)
1958	39	49	51	56	96
1959	41	49	54	60	102
1960	48	52	61	70	112
1961	58	62	73	84	134
1962	75	78	90	101	148
1963	88	81	102	116	171
1964	99	94	114	133	196
1965	118	105	127	151	222
1966	137	117	141	167	249
1967	158	134	162	193	280
1968	164	151	185	224	323
1969	190	167	191	275	372
1970	212	202	220	327	439
1971	233	219	279	373	509
1972	254	250	315	426	599
1973	325	302	397	536	733
1974	410	376	493	677	973
1975	492	441	560	751	1,119
1976	569	479	624	843	1,226
1977	569	541	676	923	1,346
1978	614	572	725	996	1,444
1979	649	622	784	1,071	1,511
1980	659	638	834	1,136	1,583
1981	692	679	868	1,201	1,686
1982	682	712	896	1,254	1,780
1983	725	722	917	1,293	1,832
1984	740	734	945	1,350	1,939
1985	767	736	976	1,399	2,012

Note: a. Equation (6) was used for the computation.
b. See text for the estimating procedures.

Figure 1. Shadow Price of Family Labor and Market Wage Rates (1958-85)



Footnotes

1/ A very similar specification of the production function was used by Kislev and Peterson

2/ It is only a partial test, since a full test of the turning point hypothesis requires the estimation of the shadow prices as well as the elasticities of labor supply before and after the turning point (Minami, pp.69-85).

3/ Note that, since treating family labor as a fixed input implies that family leisure in the utility function is also treated as fixed and hence as a shifter of the utility function in the underlying agricultural householdbold model, the production decisions are decomposable from the consumption decisions and hence the profit function can be specified with no reference to the consumption decisions.

4/ However, as Antle already pointed out, S_i in equation (2) in their study must read $-S_i$. Furthermore, the formulas for the elasticities with respect to fixed inputs, equations (13) and (23), must also be corrected.

5/ These elastiaties are the weighted averages averages of the fours size classes. The estimations were made by the following procedure. First, the weighted averages of the necessary variables for estimating these elasticities were obtained where the weights are the shares of the numbers of farm households of the four size classes in the total number of farm households. These variables were then employed in the elasticity formulas.

6/ The weighted averages of the shadow price of family labor and the following market wages were computed using similar procedures to the one exposed in footnote 5.

7/ Egaitsu and Shigeno (1983) used 0.8 as the equivalence ratio for the conversion of female to male-equivalent labor. However, the ratio 0.8 was obtained for the case of agricultural temporary-hired labor. Therefore, the nonagricultural wage rates estimated in Egaitsu and Shigeno (1983) may be said to be underestimated.

8/ More rigorous but computationally fairly time-consuming test procedures have been shown by Kulatilaka, and Schankerman and Nadiri.

9/ Minami used this procedure as a criterion for finding the turning point in the Japanese economy.

10/ The same procedure was also applied to the cases of the three nonagricultural wage rates (W_{N1}, W_{N2}, and W_{N3}). The estimated coefficients of b were 0.79, 0.55, and 0.39, respectively. The estimated t-values for testing the null hypothesis of H_o: $\hat{b} = 1$ were -17.2, -42.3, and -85.0, respectively, indicating strong rejections of the null hypotheses.

11/ It should be noted however that, as mentioned in footnote 2, this result may be used only as a partial test of finding the turning point in the Japanese economy.

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