Prospect of Structural Change in the Japanese Rice Sector

Junichi ITO
National Research Institute of Agricultural Economics

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Introduction

The Japanese farm policy underwent a drastic change when the rice market was partially liberalized by the GATT Uruguay Round agreement. The Diet passed the bill that declared the introduction of market mechanism into the rice price determination and deregulation of the rice distribution system. Due to these institutional changes, rice price is anticipated to be in secular decline in the future. The question then arises how a price cut in rice influences the rice production structure. It is well known that the Japanese rice sector is characterized by small scale producing units. Their average area devoted to rice growing is less than one hectare, and only five percent of them cultivate more than two hectares. This structure has remained unchanged for a long time.

Over the last few decades, it has been subject to controversy whether a decline in rice price induces the structural change of rice production and consequently helps improve the production efficiency. The focal point on this matter is definitely the effects of a price fall on the productivity differences between small- and large-scale rice farms. Provided that the marginal land productivity of the latter is higher than that of the former, farmland will be consolidated by the latter in principle, even if its property rights are retained by the former. Indeed, some authors (e.g., Shintani (1983) and Kako (1984)) verified that this condition is met nationwide. [1]

But it is conceivable that the issues which are practically deep and important in policy terms are not in fact to be found in the above-mentioned land-movement-condition but are to be found in the outcome of the land-lease market. Nevertheless, researches often fail to give a clear image of the expected transactions in farmland and the resulting large-scale tenant farming. [2] In other words, little is known about to what extent paddy fields owned by small-scale farms will be leased in aggregate to large-scale ones and about at what level the equilibrium rent is settled down, when rice price falls. (To the best of my knowledge, Fujiki (1993) is the only work that attempted to answer this empirical question.) Hence, this paper intends to examine the effects of a price cut of rice caused by its import from abroad on its production structure. In addition, the determination of rice price reflecting the quality differences and its effect on rice

* The author is senior researcher of National Research Institute of Agricultural Economics in Tokyo, Japan.

[1] Kajii (1988), contrary to the conclusion of this paper, insists that a decline in rice price will have a negative effect on the improvement of rice production efficiency.

[2] As has been pointed by Ito (1966), the equilibrium rent and the area of rented land are not determined by the land-movement condition alone.

supply will be investigated. The econometric model where both the profit function and the demand function for rice allowing for the quality differences will be employed.

The issue to be considered next relative to the structural change refers to the behavior of farm households that decide to quit farming. In what follows this type of farm households retaining their property over their land will be abbreviated as RF (RF for retired farmers). *The Census of Agriculture* shows that one-tenth on average of paddy fields are cultivated under tenant farming, and more than half of which is leased by RF at present. Furthermore, the governors forecast that the number of RF will increase from 780,000 in 1990 to 1.9 millions at most by the turn of this century. This suggests not only that many farm households are expected to cease their farming in the near future but also that they may play a key role in helping the structural improvement in the rice sector. [3]

The rest of this paper is organized as follows. As a first step of understanding the issues relevant to the structural change, the crucial linkage of the markets for rice and farmland, farmers' retirement decision and the determinants of the equilibrium rent will be preliminarily analyzed in the second section. For the purpose of quantitatively grasping the substitution relations between different rice varieties, the demand function for rice is estimated in the third section. The analytical framework of the profit function and the method used to process the data are explained in the fourth section. The simulation analysis in the fifth section draws some policy implications by assuming equilibrium of the markets both for rice and land to lease. Finally, some concluding remarks are given in the last section.

The Linkage between the Markets for Rice and Land to Lease

Regional Differences in Rice Price and Agricultural Income

Since the middle 1980s, the general trend of rice price has been falling, while its producer price has varied widely over different producing regions. This is partly because many varieties of rice are planted to meet different regional conditions and partly because rice is priced according to its quality. The question then arises how this development will influence the structure of rice production and the farm household economy.

Table 1 shows the correlations both between yield and agricultural income, and between rice price and agricultural income in 1975 and 1994. The source of data is *The Survey Report on Rice Production* published annually by the Ministry, Forestry, and Fisheries (MAFF). The sample consists of rice farms each one of which is selected from all of 47 Japanese prefectures. In 1975, income is not correlated with rice price but it is with yield. These facts suggest that rice price used not to have a regional dispersion and that an increase in yield used to be mainly responsible for an increase in agricultural income. In those days, the government-held rice represented 70 percent of total rice marketed, whose price was uniformly determined by the regulation. However, its semi-controlled marketing program was started in

[3] The economic model developed by Masui (1984), Kondo (1992) and Kusakari (1994) do not give a special consideration of the farm-specific land-lending condition, although they assume the market equilibrium of output and factor inputs. On the ground that then farmland formation has been virtually suspended in Japan, the land is supplied by farm households and those used to be.

Table 1 The Correlations

	1975	1994
yield and income	0.85	0.22
rice price and income	0.02	0.75

1969 in which the supply and demand for it could be reflected on its price to some extent.

As the share of government-held rice declines, or equivalently, that of semi-controlled rice increases in marketing, quality differences among its varieties were started to be reflected on their prices. Furthermore, the quality discrimination system was also introduced into the government-held rice in 1979. Accordingly, its price, instead of its yield, has become responsible for the dispersion of agricultural income over different regions in the recent years. The fact that the correlations between its price and farm income have changed for the past two decades indicates that its price relative to those of intermediate inputs has had regional differences.

Figure 1 endorses this inference. It shows that income deflator to be defined below exhibited no regional differences but a larger rise than the consumer price index (CPI) from 1965 to 1975. However, for a decade after 1975 that of Hokkaido fell, while those of others rose with the regional differences becoming slightly conspicuous. Then the former fell quite abruptly. This figure also shows that the index of "lower-bound income (LBI)" by which farm household can keep the same living standard as employees in other industries. The farm household able to afford this level of income has been referred to as "a viable farm" in the arena of the Japanese farm policy. A farm household classified as a viable farm in 1975 should increase his agricultural income by 80 percent if it intends to remain in the same class in 1994.

The agricultural income deflator (ID) in terms of Laspeyres type is formulated as follows,

$$\mathrm{ID} = \frac{p_1 q_0 - w_1 x_0}{p_0 q_0 - w_0 x_0} = 1 + \frac{\Delta p q_0 - \Delta w x_0}{p_0 q_0 - w_0 x_0} \equiv 1 + \frac{\mathrm{PE}}{y^R},$$

where p, q, w and x respectively denote in this order the output price (rice price), the quantity of output (rice produced), the vector of variable input prices and their quantities. $\Delta p = p_1 - p_0$, $\Delta w = w_1 - w_0$ and agricultural income at the base year is defined as $y^R = p_0 q_0 - w_0 x_0$. Then, Ito (1994) defines the following equation:

$$\dot{y}^N = \dot{y}^R + \mathrm{PE},$$

where $\dot{y} = y_1 - y_0$ and y^N denote agricultural income at current prices. It signifies that the change in nominal income is attributed to the changes in real income and in price (PE for price element). From these two equations, the following relation is obtained,

$$\frac{\dot{y}^R}{y^R} = \frac{y_1}{y_0} - \mathrm{ID}.$$

Here, let us assume that a farm earns just as much income as employees in other industries at the base year and replace y_1/y_0 by LBI, then this equation can be looked upon as an equation whose dependent

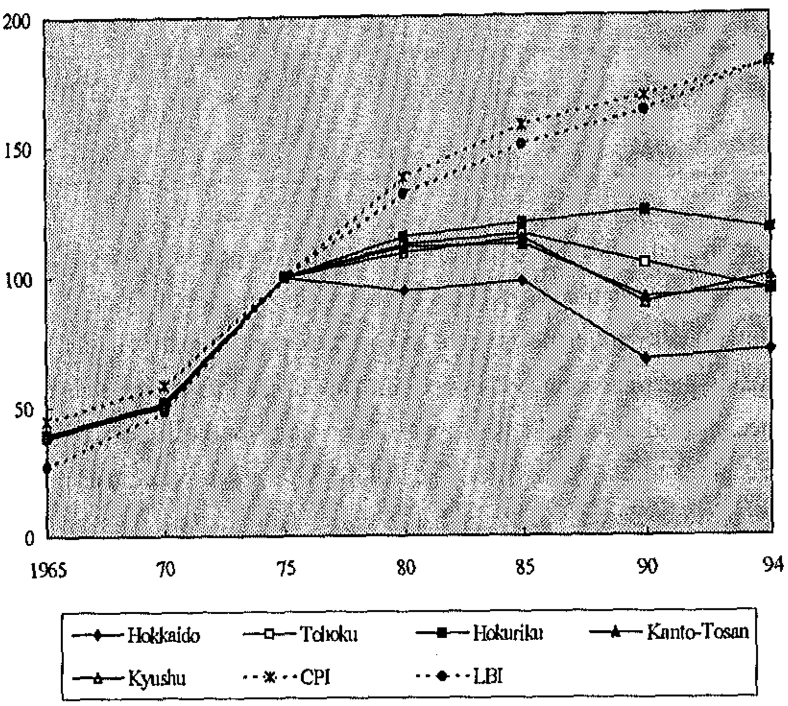

Figure 1 Income Deflator (1975=100)

Source: *The Survey Report on Rice Production*. *The Survey Report on Prices and Wage Rate in Rural Villages*, MAFF. *Economic Statistics Annual*, The Bank of Japan.

variable is $\dot{y}^R/y^R$. $\dot{y}^R/y^R$ gives the rate of change in real income required for a farm to remain as a viable farm. Evidently, the larger the divergence between LBI and the income deflator, the larger the requisite rate of change in real income. The real income should have increased by 150 percent in Hokkaido, 80-90 percent in Tohoku, Kanto-Tosan and Kyushu, and 50 percent in Hokuriku by 1994. Rice farms in Hokuriku are relatively at advantage from the viewpoint of the terms of trade in rice production over those in other regions, while those in Hokkaido are at a severe disadvantage.

Provided that a rice farmer maximizes income (or profit) subject to the production function homogeneous of degree one, the following equations are obtained (Ito, 1994).

$$pA(\partial q/\partial A) = y^R \quad \text{(by Euler's law)},$$

$$\frac{\dot{y}^R}{\dot{A}} = p\frac{\partial q}{\partial A},$$

where A stands for the value of capital (farmland in this case). Hence $\dot{y}^R/y^R = \dot{A}/A$. It is apparent from this equation that the most effective measure to increase real income is to enlarge the farmland. A similar argument is in Egaitsu (1979) which shows empirically that a decline in income deflator obliges farmers to expand their farm size so as to increase the agricultural income. This issue will be discussed again in the fifth section.

A Decline in Rice Price and the Structural Change

A decline as well as a differentiation in the price of rice testifies the fact that rice market works well to induce its supply to keep pace with its demand. However, its price is anticipated to fall down further because the Japanese rice market will be deregulated to a further extent. Now, let us consider the effects of its price decline mainly due to its import from abroad on its production structure, with a special reference to the linkage between the market for rice and for farmland lease.

Figure 2 illustrates the Japanese rice market, where its equilibrium is currently attained at point E(p_0,Q_0). However, import from abroad at price p_1 will reduce the domestic supply down to Q_1. Assuming Japan as a small country, import of rice equal to its excess demand in the domestic market should be perfectly elastic with respect to price.[4] A fall in its price will reduce the demands for factors, but it will have no effect on their equilibrium prices, if their supplies are perfectly elastic with respect to their prices. In fact, the analysis of income deflator in this section indicates that the prices of rice and its production factors did not necessarily fluctuate in the same direction for the past three decades. However, the situations differ greatly for the farmland whose supply is fixed at the level of endorsement. More precisely, a decline in rice price reduces the demand for farmland and the resulting excess supply of it will lower its equilibrium rent. (The Farmland Law of 1952 prohibits farmers from diverting their farmland to other uses.) Thus in case the demand for farmland decreases in small farms and its excess supply is taken over by large farms, the aggregate supply curve of rice will shift to the right. This is because, as several authors have verified, large farms produce rice at a lower cost. Consequently, its domestic supply will be somewhat restored to the level of Q_2.

On the other hand, some farmers may stop their cultivation due to a decline in rice price, then its

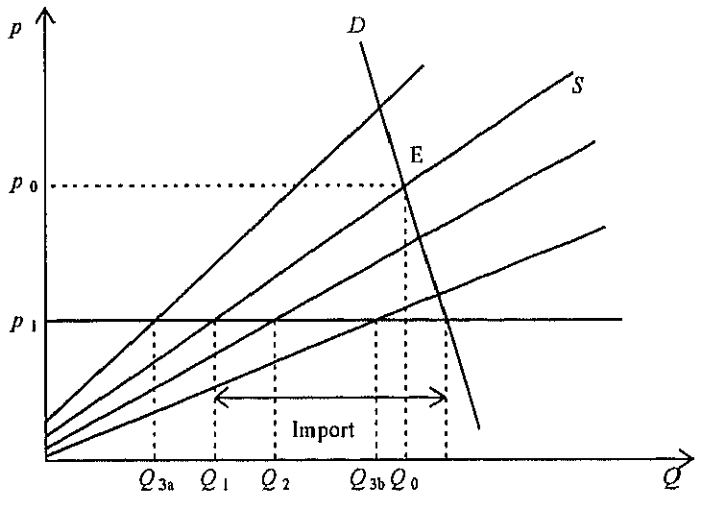

Figure 2 Equilibrium of the Market for Rice

[4] A small country assumption may be too restrictive because the Japanese demand for rice is likely to dictate the world price of Japonica rice. See Cramer *et al.* (1993).

aggregate supply curve will momentarily shifts to the left and its domestic supply will fall down to the level of Q_{3a}. Nonetheless, in case their paddy fields are turned over by lease contract to the farms which continue their cultivation, the aggregate supply curve will shift again to the right and its domestic supply will increase to the level of Q_{3b}.

There remain three points to be discussed. The first pertains to substitutions between different varieties of rice. If rice imported from abroad is a perfect substitute for some varieties planted in some regions and an imperfect substitute for others, rice import would not have a uniform effect over different regions, which will be statistically tested in the following section.

The second pertains to the effect of a fall in rice price on the demand for farmland by farmers of different sizes. A fall in rice price would lower the equilibrium rent since it reduces the aggregate demand for farmland. In case the sign of elasticity of its demand with respect to rice price differs over farms of different sizes, e.g., positive for small while negative for large farms, a fall in rice price will help enhance the efficiency of rice production.

The third pertains to how much its rent will fall in case retired farms release all their paddy fields to the land-lease market. As Shougenji (1994) contends, landowners tend to want for a rent that is enough for paying their incurred cost of land improvement. Hence, the required rent is rigid downward. In case it is excessively high, the land-lease market may possibly shrink. On the other hand, in case it is not high enough to pay their cost of land improvement, they will not make any land-lease contract but keep cultivating their paddy fields for themselves. To sum up, for large farms to consolidate the paddy fields released by small farms, their rents should fall to some extent.

Land-Lease Contract and Land Lending by RF

Table 2 indicates that nearly 10 percent of the paddy field in Tofuken is under the land-lease contract and that more than the half of which is owned by RF (see the ratio of (b)/(a)). In addition, Figure 3 clearly

Table 2 Paddy Field Utilization in Japan (1,000 ha)

Regions	Area of cultivated paddy field	Area of rented paddy field (a)	Area of leased paddy field	Area of paddy field owned by RF (b)
Total	2,373.5	228.7	60.0	139.4
Hokkaido	218.9	13.4	1.2	4.3
Tofuken	2,154.7	215.2	58.8	135.1
Tohoku	605.9	37.2	10.9	19.4
Hokuriku	282.1	36.3	9.3	23.9
Kanto-Tosan	393.4	34.8	13.0	20.7
Tokai	146.0	15.4	5.3	11.7
Kinki	159.6	21.6	6.0	13.8
Chugoku	185.1	20.4	4.8	11.8
Shikoku	84.6	9.3	2.4	6.5
Kyushu	297.4	40.0	7.0	27.2

Table 2 Continued (%)

Regions	(b)/(a)	The share of abandoned farmland by RF	The share of abandoned farmland for operating farms
Total	61.0	30.0	1.40
Hokkaido	32.1	18.8	0.10
Tofuken	62.8	31.0	1.53
Tohoku	52.1	21.6	0.76
Hokuriku	66.0	11.0	1.27
Kanto-Tosan	59.4	33.8	1.83
Tokai	75.6	43.4	2.67
Kinki	64.1	20.7	1.62
Chugoku	58.0	51.3	2.56
Shikoku	69.6	60.1	2.12
Kyushu	67.9	31.6	1.50

Source: *The Census of Agriculture in 1990.*

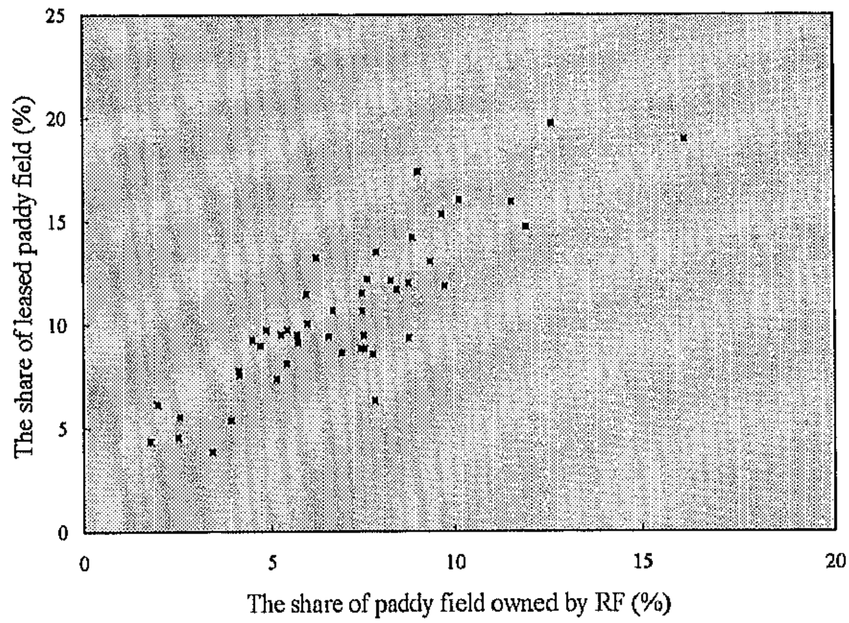

Figure 3 Paddy Field Ownership and Lease Contract

Source: *The Census of Agriculture.*
Note. The correlation coefficient is equal to 0.87.

illustrates that the share of leased land is higher for regions where the share of paddy field owned by RF is larger. These two findings suggest that the development of tenant farming depends heavily on the development of land-lease contract between RF and operating farms rather than between the latter. Tabata (1992) also points out that RF's land supply constitutes a greater part of the recent increase in the farmland lease.

Table 2 also indicates that farmers' retirement from their operation causes a serious abandonment of farmland use. The share of farmland abandoned by RF reaches 30 percent on average. Its share is relatively low for the agricultural regions such as Hokkaido and Hokuriku, while those of Chugoku and Shikoku are more than 50 percent. On the other hand, for operating farms it is not more than 1.4 percent on average. Another important point is the fact that farmland abandonment, irrespective of farm is operated or not, is concentrated on the area where the rent is relatively low. These observations appear to contradict the conventional notion that farmland is in excess demand in regions where rent is low, but the most plausible explanation of this fact is given in Figure 4.

Suppose that farm A's cultivated lands consist of its own (S_0^A) and rented ones. The former is temporarily a fixed input, while the demand for the latter decreases as rent rises. Farm A does not rent any land in so far as the market rent exceeds r_2^A, while it will leases out all its own to the market in so far as $r \geq r_1^A$. Hence, the land supply is rigid downward. As has been previously noted, r_1^A must cover the land improvement cost per area. On the other hand, farm B, smaller in size than A, leases out all its own land in so far as $r \geq r_1^B$. The land-lease contract between farms A and B will realize the equilibrium rent and the leased land at r^* and S_0^B, respectively. In case the number of farm of the farm B type increases up to $n\ (>1)$, the aggregate supply of land by this type is equal to nS_0^B in so far as $r \geq r_1^B$. Then, the area of S^* is leased out at the equilibrium rent of r_1^B, and the rest of area $nS_0^B - S^*$ is left out of cultivation.

Evidently, there are two causes of farmland abandonment. One is the shortage of demand for farmland. An increase in the number of farms of the type A would shift the demand curve to the right, so that the area of uncultivated land might decrease. On the contrary, if the demand for them is short, the released land will remain uncultivated, as this figure shows. The other cause is the downward rigidity of the land supply curve. These two causes will be addressed in the following section.

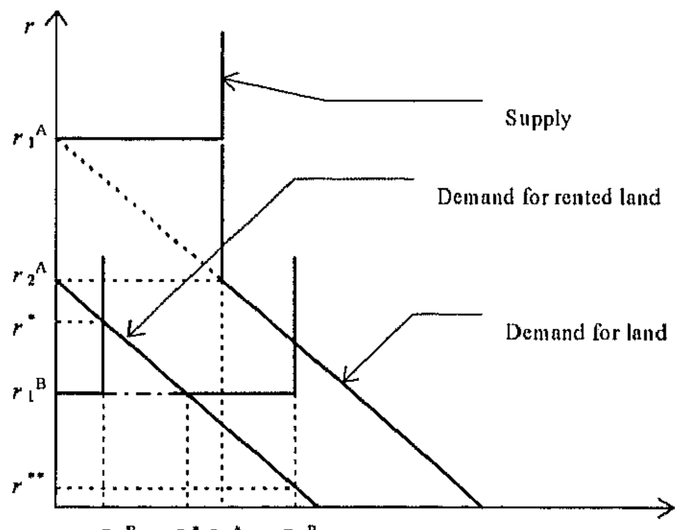

Figure 4 Farmland Abandonment

Farmers' Decision to Retire

As the preceding section shows, a progress in tenant farming depends mainly on RF's behavior in regard to land leasing. Here, a decline in rice price will be associated with the number of farms that cease farming. Two factors seem to affect farmers' decision to retire. One is a demographic factor and the other is an economic one. (As Gale (1993) shows, these two factors also influence the farm's motivation for entry.) As for the latter, many elements can be readily enumerated; the presence of farm's successors, job opportunities in other industries, the self-evaluation of family labor, the development of part-time farming and trust-farming, and so on. Since the dominant factor of them may differ from farm to farm, it seems difficult to generalize on their the retirement decision in this regard. However, farmers at the brink of retirement will seriously consider the opportunity cost of primary factor in agriculture, i.e., farmland.

In this section, the retirement rate (φ) is specified as a function of the ratio of profit from rice-growing to income from off-farm activities (z), $\varphi = g(z)$. In what follows z is simply referred to as the income ratio. Profit from rice-growing is made up of rewards to family labor, rent income from landed property, capital interest and allowances for depreciation. Profit is measured in gross terms on the basis of operation-stop-point argument in production theory. Income from off-farm activities consists only of rent income when the farmer is retired from working completely, while it consists of rent income plus off-farm earnings when he is employed in other industries. Here it is assumed that if the income ratio is less than unity, the farm in question decides to cease farming.

In specifying the retirement rate function, the following two assumptions are made. The first

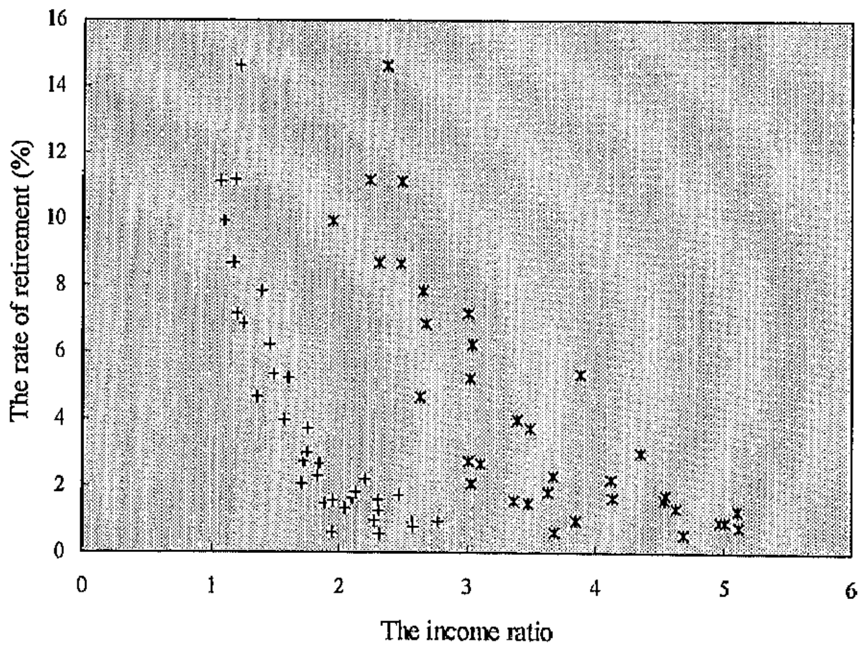

Figure 5 Income Ratio and Rate of Retirement

Source: *The Census of Agriculture*. *The Survey Report on Rice Production*.
Note. "*" indicates the observations whose off-farm income does not include wage income.

pertains the presence of time lag between its retirement decision and its action. It is assumed that a farm whose income ratio falls short of unity ceases farming within five years. Hence, its retirement decision, e.g., during 1985-90 can be related to its income ratio in 1985. The second pertains the statistical distribution of the computed income ratio. It may be natural to consider that the income ratio of some farm groups (classified by farm size and production region) is distributed symmetrically around the sample mean. Hence, when the average income ratio is estimated to be unity for some samples, the corresponding retirement rate is evaluated to be 50 percent, which implies that an equal number of farms are located below and above the mean income ratio respectively.

The observations of income ratio and the retirement rate are plotted in Figure 5 for 1985-90. The data of the retirement ratio is adapted from *The Census of Agriculture*. Profit from rice-growing is estimated by use of *The Survey Report on Rice Production*, while income from off-farm activities is by use of *The Survey Report on Agricultural Wage Rate* (National Chamber of Agriculture) together with *The Survey Report on Rice Production*. Rice-growing farms classified by seven sizes are selected as the sample from five agricultural regions, resulting in 35 observations in each year. As the figure shows, in case wage income is included in off-farm income, the retirement rate is estimated to be 15 percent at the highest, which no doubt contradicts the second assumption. However, the retirement rate can be extrapolated to be 50 percent at the point of $z=1$ in case off-farm income includes only rent income. Judging from these estimates, wage income should be excluded from off-farm income when we specify the retirement rate function. This inference can be supported in another way. *The Census of Agriculture* shows that a large part of farms that ceased its cultivation for the past five years consists of full-time farm households without male member in labor force and those earning main income in other jobs. The former have already lost their chance to be employed in other industries, while the latter are earning enough money in off-farm activities. In short, farming in these two type of households depend on "fringe labor", which tend to undervalue the agricultural wage rate applicable to their own.

The retirement rate function, $\varphi = g(z)$, is specified in the following Logistic form,

(1)
$$\varphi = \frac{50\left\{1+\exp\left(a+bz+cT+\sum_j d_j D_j\right)\right\}}{1+\exp\left(a+bz+cT+\sum_j d_j D_j z\right)}$$

$$z = \frac{\pi^G}{rS} = \frac{\pi + w_k k}{rS}$$

where π^G denotes gross profit (net profit plus depreciation allowances), S the area of paddy field, D_j the regional dummy variables and T the time dummy variable to reflect the effect of demographic factors. (In estimating equation (1), 1980-85 data are added to 1985-90 data). Imposing the restriction of $\varphi(1)=50$ (percent), the maximum likelihood method is employed for estimation. Table 3 summarizes the results of estimation with nearly all parameters being statistically significant. Although the estimated values are not reported, Kanto-Tosan shows the highest rate, while Tohoku and Kyushu lower rates, suggesting that a regional difference in the retirement rate may be attributed to job opportunity in other industries. Hokuriku shows a similar configuration to that of Tofuken average. If this is the case, the regional dummy variable can be regarded as proxies for the wage rates.

Table 3 Estimated Function of Retirement Rate

	Parameters	*t*-value
a	-1.257	-2.21
b	1.459	10.87
c	-0.663	-4.08
D_1	0.315	4.47
D_2	-0.054	-0.86
D_3	-0.363	-5.49
D_4	0.285	4.27

Note. D_i denotes the regional dummy variables. D_1 : Tohoku, D_2 : Hokuriku, D_3 : Kanto-Tosan and D_4 : Kyushu.

Determinants of the Land Rent

We have seen so far that the structural change in rice production depends ultimately on the extent to which the equilibrium rent falls due to a decline in rice price and the RF's land supply. Hence, the rent is regressed on a number of variables for preliminary examination. [5] The main source of data is *The Census of Agriculture*. The result is summarized in Table 4. The parameters represent elasticities because the equation is estimated in a log-linear specification. Although the main attention should be given to the coefficient of rice price and land supply, let us examine others in the first place.

As might be expected, the coefficient of yield is positive, if not significant. A rise in the set-aside subsidy per unit significantly increases the rent, while a rise in the set-aside rate itself decreases it, as shown in the column (c). [6] That is, the instruments employed in the set-aside policy have an adverse effect on the rent. A rise in the set-aside rate, however, reduces the domestic rice supply, which tends to raise the rice price, and consequently increases the rent in the end.

The rent is negatively correlated with the agricultural wage rate and positively correlated with the index of agricultural labor forces measured in terms of the share of households with male regular farm workers. These correlations suggest that the labor and the land-lease markets are closely related. In other words, the rent tends to be high in regions where job opportunities are short, or equivalently, the wage rate is low. This is because the demand for farmland is naturally very strong in regions where there is no key industry other than agriculture. However, other things being equal, if trust-farming develops there, the land-lease market shrinks, so that the land rent tends to decline. This reasoning can be justified by the fact that the ratio of paddy field area under trust-farming to the total area is negatively correlated with the rent.

As has been stated previously, the elasticity of the rent with respect to rice price associated with

[5] If we assume the equilibrium of the lease market, the rent function should have been formulated in a reduced form. In addition, since the rent influences the retirement rate, the rent and retirement rate functions should have been simultaneously estimated.

[6] The per unit set-aside subsidy is defined as the set-aside subsidy granted to farmers divided by the area set aside. As for the estimation method of the per unit subsidy, refer to Ito (1994). See also Ito (1996) as to the reason why a rise in the per unit set-aside subsidy increases the rent.

Table 4 Estimated Function of Rent

Explanatory variables	(a)	(b)	(c)	(d)	(e)
Rice price	1.91*	1.81*	1.25*	2.06*	2.11*
Yield	0.08	0.08	0.06		0.00
Per unit set-aside subsidy	0.28*	0.17	0.26*	0.38*	0.39*
Agricultural wage rate	-0.49*	-0.56*	-0.41*		
Share of farm households with more than 2 male regular farm workers	0.08*	0.06	0.12*		
Share of farm households with male regular farm worker				0.22*	0.23*
Share of paddy field area under trust-farming	-0.08	-0.06	-0.08		-0.11*
Share of paddy fields owned by RF	-0.02	0.04	-0.01	-0.09	-0.01
Share of abandoned paddy fields		-0.07			
Set-aside rate			-0.39*		
R^2	0.65	0.66	0.69	0.54	0.57

Note (1) * indicates that the coefficient is significant at 5% level.

(2) Per unit set-aside subsidy is defined as set-aside subsidy granted for farmers divided by area set aside.

the elasticity of the demand for rented land with respect to rice price is central to the debate in this line of analysis. More specifically, when the demand for rented land (S_1) can be simply expressed as a function of the prices of rice and the rent (r), the following equation results,

$$\frac{d\ln S_1}{d\ln p} = \frac{\partial \ln S_1}{\partial \ln p} + \frac{\partial \ln S_1}{\partial \ln r} \cdot \frac{\partial \ln r}{\partial \ln p} \quad (2)$$

Since $\partial \ln S_1 / \partial \ln p > 0$ and $\partial \ln S_1 / \partial \ln r < 0$, the larger $\partial \ln r / \partial \ln p$, the more likely the left hand side of this equation tends to be negative. If $d\ln S_1 / d\ln p$ is positive for small-scale farms and negative for large-scale ones, then a fall in rice price is expected to help improve the rice production structure. This will be empirically tested in the following section.

On the other hand, as shown in Table 4, the share of paddy fields owned by RF has insignificant coefficients of -0.09 to 0.04. That is, the rent is entirely inelastic with respect to RF's farmland supply. This suggests that RF's farmland supply to the land-lease market does not necessarily induce a progress in tenant farming, which eventually leads to the inefficient rice production. This point will be elaborated in the following section.

Demand Function for Rice
Quality Discrimination and Rice Import

The analysis of income deflators in the second section reveals that the regional difference in the terms of trade in rice production has become significant since 1975. This tendency is exclusively due to the fact that rice has been priced according to its quality in the wake of changes in consumer preference.

In this section, the demand function for rice will be estimated on the assumption that a quality difference is entirely reflected on rice price. The first issue to be addressed is the classification of rice producing regions. Figure 6 shows the dendrogram of cluster analysis. The cluster corresponds to the nine regions, while the variables are the prices of rice of each region in 1980-94. The similarity of cluster between i and j regions is measured by the nearest-neighbor method. The Euclidean distance between two districts are given by

$$d_{ij} = \sqrt{\sum_{k=1980}^{1994} \left(p_{ki} - p_{kj}\right)^2} \qquad (i, j = 1,2,\cdots,9),$$

where p_{ki} denotes rice price of i district in year k. The price data are adapted from *The Survey Report on Rice Production.* The distances between Hokkaido and Tofuken excluding Hokuriku (Tofuken for short from now on), and Hokuriku and Tofuken are relatively long. Hence, it is assumed in the following analysis that domestic rice is classified into three regional groups: Hokkaido rice (low quality), Tofuken rice (medium quality) and Hokuriku rice (high quality), while the equilibrium prices of rice are interdependently determined in each market by the law of demand and supply.

Now suppose that Tofuken rice is a perfect substitute for imported rice and an imperfect substitute for the other two domestic varieties. Accordingly, the argument in the second section will be

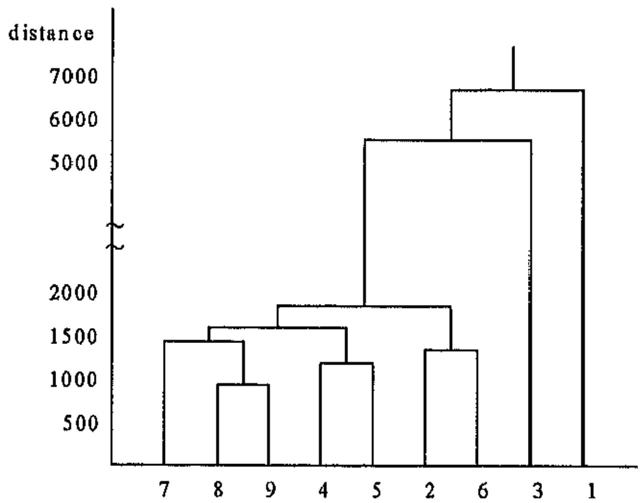

Figure 6 Dendrogram

Note. The number on the horizontal axis represents the region;
1: Hokkaido, 2: Tohoku, 3: Hokuriku, 4: Kanto-Tosan
5: Tokai, 6: Kinki, 7: Chugoku, 8: Shikoku, and 9: Kyushu.

amended in the following way; if rice price of Tofuken is reduced due to imports from abroad, the demand for this variety will increase. If Hokkaido and Hokuriku rice, respectively, are good substitutes for Tofuken rice, demand for the latter will decrease. As a result, their equilibrium prices are anticipated to decline with their supplies being unchanged.

This relationship can be expressed in the following manner. For simplicity, it is assumed that there are two rice varieties produced in Tofuken and elsewhere. The equilibrium condition of rice produced in the latter is described as follows,

$$RD(p, p') = RS(p)$$

where p' and p respectively denote the prices of Tofuken rice and the other. RS denotes the supply of rice produced in regions other than Tofuken, while RD the demand for it. Differentiating this relation by p', the following equation results,

$$\frac{\partial \ln p}{\partial \ln p'} = \frac{\partial \ln RD / \partial \ln p'}{\partial \ln RS / \partial \ln p - \partial \ln RD / \partial \ln p}$$

Its denominator is theoretically positive, while the sign of the numerator is to be empirically determined. If two varieties of rice are good substitutes for each other, that is, $\partial \ln RD / \partial \ln p'$ is positive, the left hand side of this equation proves to be positive. Accordingly, the two equilibrium prices will move in the same direction, as we have seen previously.

Estimation Result of Demand Functions

Prior to the Uruguay Round agreement of GATT, rice import used to be banned in principle, so that the equilibrium of the market for rice is described as follows,

$$\begin{aligned} & RD_j = RD_j(p_1, p_2, p_3, E, t) \\ (3) \qquad & RS_j = RS_j(p_j, F_j, t) \\ & RD_j = RS_j \qquad\qquad (j = 1,2,3) \end{aligned}$$

where E denotes expenditures for consumer goods, while F_j the vector of shift parameters, e.g., the cultivated area of paddy fields and the harvest index which measures basically climatic condition (the index for the average year is 100). In order to allow for the substitution relations between different varieties, prices of competing varieties are included along with its own price. Time trend (t) is also included to reflect the effect of changes in consumer preference, while time trend in the supply function is to reflect the effect of technological change.

Price data are adapted from *The Survey Report on Rice Production*. In particular, rice price of Tofuken is the average price weighted with the relative quantities of rice produced in seven regions (see Figure 9). Due to the data restriction, producer prices are regarded as the equilibrium prices. The data of expenditures for consumer goods are adapted from *Annual Report on the Family Income and Expenditure Survey* published by Management and Coordination Agency. We can utilize *Crop Statistics* (MAFF) to obtain the data of rice production, the cultivated area of paddy fields and the harvest index. The magnitudes of the quantity demanded are obtained by allocating the per capita annual consumption of

Table 5　Estimated Demand and Supply Functions

	Demand functions				Supply functions		
	Hokkaido	Tofuken	Hokuriku		Hokkaido	Tofuken	Hokuriku
p_1	-0.943	0.513	-0.219	p	0.755	0.812	0.879
	(-0.77)	(3.30)	(-1.10)		(3.84)	(3.72)	(4.51)
p_2	0.643	-1.312	1.381	Cultivated	0.018	0.847	1.350
	(0.19)	(-2.87)	(2.74)	area	(0.23)	(4.36)	(12.20)
p_3	2.128	1.458	-1.672	Crop index	0.011	0.008	0.007
	(0.76)	(4.29)	(-3.48)		(60.21)	(11.88)	(16.61)
E	-1.979	-0.771	1.483	t	-0.232	-0.267	-0.185
	(-1.09)	(-3.16)	(5.27)		(-0.11)	(-0.11)	(-0.12)
t	0.213	-0.034	-0.091	R^2	0.87	0.92	0.88
	(0.27)	(-0.07)	(-0.14)				
R^2	0.66	0.89	0.87				

Note. t-value in parentheses.

rice in *Food Balance Sheet* (MAFF) in proportion to the quantities supplied of the three varieties. The period 1980-94 is analyzed, during which rice price is differentiated for different producing regions.

In order to impose on the demand function the restriction of the homogeneity of degree zero in prices and expenditures, all variables are deflated by consumer price index. Rice price in the supply function is also deflated by price index of agricultural input for similar reasons. On the ground that the quantities demanded and supplied, and prices are all endogenous variables, these equations are simultaneously estimated by use of the two stage least squares method. The results of estimation are summarized in Table 5. Since the every equation is specified in the log-linear form, the coefficients represent the corresponding elasticities. Almost all coefficients are consistent with the priori expectations, indicating that the regularity conditions of the demand and supply functions are nearly satisfied.

The own price elasticities of demand is equal to -0.9 -1.3 and -1.7 respectively for Hokkaido, Tofuken and Hokuriku, while the consumption expenditures elasticities -2.0, -0.8 and 1.5 respectively. These elasticities support the proposition that rice variety planted in Hokuriku is a normal good, while others are not. In addition, positive cross elasticities indicate the presence of substitution relations between the two varieties. The price elasticities of supply ranges from 0.7 to 0.9, which are not much different from those to be estimated below by means of the translog profit function (see Table 10).

When we recall the assumption that Tofuken rice is a perfect substitute for imported rice, the market equilibrium conditions (3) can be rewritten as follows,

$$
\begin{aligned}
&RS_1(p_1) = RD_1(p_1, p_2, p_3) \\
(3') \qquad &RS_2(p_2) + M(p_2) = RD_2(p_1, p_2, p_3) \\
&RS_3(p_3) = RD_3(p_1, p_2, p_3)
\end{aligned}
$$

where M denotes rice imports and the subscripts 1,2 and 3 correspond to Hokkaido, Tofuken and

Hokuriku, respectively. Under the small country assumption, the price of Tofuken rice equal to import price is an exogenous variable, while those of Hokkaido and Hokuriku rice, and the imports rice of are endogenous. By differentiating equation (3') by p_2, the following equations result,

$$\frac{\partial \ln RS_1}{\partial \ln p_1}\cdot\frac{\partial \ln p_1}{\partial \ln p_2}=\frac{\partial \ln RD_1}{\partial \ln p_1}\cdot\frac{\partial \ln p_1}{\partial \ln p_2}+\frac{\partial \ln RD_1}{\partial \ln p_2}+\frac{\partial \ln RD_1}{\partial \ln p_3}\cdot\frac{\partial \ln p_3}{\partial \ln p_2}$$

$$\frac{RS_2}{RD_2}\cdot\frac{\partial \ln RS_2}{\partial \ln p_2}+\frac{M}{RD_2}\cdot\frac{\partial \ln M}{\partial \ln p_2}=\frac{\partial \ln RD_2}{\partial \ln p_1}\cdot\frac{\partial \ln p_1}{\partial \ln p_2}+\frac{\partial \ln RD_2}{\partial \ln p_2}+\frac{\partial \ln RD_2}{\partial \ln p_3}\cdot\frac{\partial \ln p_3}{\partial \ln p_2}$$

$$\frac{\partial \ln RS_3}{\partial \ln p_3}\cdot\frac{\partial \ln p_3}{\partial \ln p_2}=\frac{\partial \ln RD_3}{\partial \ln p_1}\cdot\frac{\partial \ln p_1}{\partial \ln p_2}+\frac{\partial \ln RD_3}{\partial \ln p_2}+\frac{\partial \ln RD_3}{\partial \ln p_3}\cdot\frac{\partial \ln p_3}{\partial \ln p_2}$$

The solutions to these simultaneous equations of the third degree, i.e., $\partial \ln p_1/\partial \ln p_2$, $\partial \ln p_3/\partial \ln p_2$ and $\partial \ln M/\partial \ln p_2$, are obtained by use of the estimated parameters of the supply and demand functions. In particular, the substitution relation between rice varieties produced in Hokuriku and Tofuken, expressed in $\partial \ln p_3/\partial \ln p_2$, is of significance in the subsequent analysis. By omitting insignificant parameters such as $\partial \ln RD_3/\partial \ln p_1$, $\partial \ln p_3/\partial \ln p_2$ is readily estimated to be 0.54 without solving all these equations.[7] These results of elasticities will be employed in the simulation analysis in the fifth section.

Profit Function Analysis

The profit function enables us to estimate the supply function of rice and the demand function for variable factor inputs of the individual farm. Let us first suppose that rice-growers (a) regard their labor and their own land as fixed inputs, while the rented land as a variable input; (b) can purchase intermediate and capital inputs in the market at their will; (c) determine the level of factor input so that profit from rice-growing is maximized; (d) act as a price-taker. These assumptions can be implemented in the following way,

$$\max_{x,S_1} \quad \pi = pq - wx - rS_1$$
$$\text{s.t.} \quad q = f(x,L,S) \qquad S = S_0 + S_1,$$

where p and q denote the price and output of rice; w and x the vector of prices and quantities of factor inputs other than labor and farmland; L labor input; r S_0 S_1 and S the rent, the area of his own land, the rented land and total cultivated land respectively.

The solution to this problem gives the maximum profit, $\pi^* = \pi(p,r,w,L,S_0)$. By applying the Hotelling's lemma to it, the supply and factor demand equations are derived as follows,

$$\frac{\partial \pi^*}{\partial p}=q^* \qquad \frac{\partial \pi^*}{\partial r}=-S^*_1 \qquad \frac{\partial \pi^*}{\partial w_j}=-x^*_j \quad (j=1,2,\cdots).$$

Thus the aggregate supply and demand functions are obtained by summing up the individual ones. The profit function used in this analysis is assumed to have the following translog specification,

---

[7] If the simultaneous equations are solved, $\partial \ln p_3/\partial \ln p_2$ proves to be 0.46.

$$\ln\pi^* = \alpha_0 + \alpha '[\ln W] + \frac{1}{2}[\ln W]\beta '[\ln W]$$

$$\alpha = \begin{bmatrix}\alpha_p & \alpha_k & \alpha_m & \alpha_r & \alpha_L & \alpha_S\end{bmatrix} \qquad \beta = \begin{bmatrix} \beta_{pp} & \beta_{pk} & \beta_{pm} & \beta_{pr} & \beta_{pL} & \beta_{pS} \\ \beta_{kp} & \beta_{kk} & \beta_{km} & \beta_{kr} & \beta_{kL} & \beta_{kS} \\ \beta_{mp} & \beta_{mk} & \beta_{mm} & \beta_{mr} & \beta_{mL} & \beta_{mS} \\ \beta_{rp} & \beta_{rk} & \beta_{rm} & \beta_{rr} & \beta_{rL} & \beta_{rS} \\ \beta_{Lp} & \beta_{Lk} & \beta_{Lm} & \beta_{Lr} & \beta_{LL} & \beta_{LS} \\ \beta_{Sp} & \beta_{Sk} & \beta_{Sm} & \beta_{Sr} & \beta_{SL} & \beta_{SS} \end{bmatrix}$$

$$\ln W = \begin{bmatrix}\ln p & \ln w_k & \ln w_m & \ln r & \ln L & \ln S_0\end{bmatrix},$$

where α and β are parameters, w_k and w_m are capital and intermediate input prices, respectively.

The data necessary to estimate this function are the profit, the quantities of fixed inputs, the prices and profit shares of variable factors and of output. The major sources of data are *The Survey Report on Rice Production* and *The Survey Report on Prices and Wages in Rural Villages* (MAFF). In each year of the period 1980-91 a single average farm is selected from each of the seven classes: 0-0.3, 0.3-0.5, 0.5-1.0, 1.0-1.5, 1.5-2.0, 2.0-3.0 and 3.0 hectares and over, from the four major agricultural regions out of nine, i.e., Tohoku, Hokuriku, Kanto-Tosan and Kyushu. The output of rice from these regions accounts for three quarters of the total. Other five regions are omitted because they miss necessary data in some years. The profit is equal to the gross revenue in excess of the costs of intermediate and capital inputs. The gross revenue is the output of rice times its price. The costs of intermediate inputs are defined as the sum of the expenditures on seed, fertilizer, agricultural chemical and others. The costs of capital inputs are defined as the sum of the expenditures on land improvement and water utilization, rent and charge, building and agricultural implement. The quantity and price indexes of intermediate and capital inputs are estimated by the multilateral aggregation method. The labor force is defined as the sum of male equivalent labor hours. The time trend and the dummy variables are included in the translog profit function to capture the effect of technological change and the loss incurred by unusual weather, respectively.

The system of five equations composed of the profit function, the output and factor inputs share functions are jointly estimated by Zellner's iterated seemingly unrelated regression method. [8] Table 6 summarizes the results of estimation. [9] It is noted that the null-hypothesis of homogeneity of degree one in prices which is one of the regularity conditions of the profit function cannot be rejected by Wald Chi-square test at one percent significant level. The other regularity conditions of convexity in prices, nondecreasing in output price and nonincreasing in factor input prices are satisfied for nearly all observations.

[8] The following equation is derived by use of the first-order conditions of profit maximization,

$$\frac{\partial \ln \pi^*}{\partial \ln S_0} = \frac{r' S_0}{\pi^*} + \left(1 - \frac{r'}{r}\right)\left(\beta_{rS} + \frac{\partial \ln \pi^*}{\partial \ln r} \cdot \frac{\partial \ln \pi^*}{\partial \ln S_0}\right),$$

where $p(\partial f / \partial S) \equiv r'$. In estimating the profit function, the above equation is added assuming $r' = r$.

[9] The imputed price of agricultural labor, defined as $\partial \pi^* / \partial L$, is much lower than the market wage rate in the rural area, especially for the small-scale farms, which supports the hypothesis in the second section that the agricultural wage rate is undervalued.

Table 6 Estimated Profit Function

	Parameters	t-value		Parameters	t-value
α_0	-0.406	-14.20	β_{kL}	0.091	1.96
α_p	1.918	36.09	β_{kS}	0.300	8.87
α_k	-0.704	-18.15	β_{kt}	-0.060	-2.77
α_m	-0.276	-19.51	β_{mm}	-0.618	-14.21
α_r	0.062	8.81	β_{mr}	0.002	0.12
α_L	0.990	46.85	β_{mL}	-0.122	-6.38
α_S	0.456	41.09	β_{mS}	0.204	14.00
α_t	0.112	4.71	β_{mt}	-0.051	-6.41
β_{pp}	-1.816	-5.33	β_{rr}	0.021	1.86
β_{pk}	1.155	4.92	β_{rL}	-0.416	-38.58
β_{pm}	0.710	8.17	β_{rS}	0.318	38.97
β_{pr}	-0.049	-1.16	β_{rt}	-0.072	-18.20
β_{pL}	0.447	7.07	β_{LL}	0.616	22.32
β_{pS}	-0.821	-17.56	β_{LS}	-0.353	-22.89
β_{pt}	0.183	6.16	β_{Lt}	0.050	4.93
β_{kk}	-1.087	-6.50	β_{SS}	0.190	16.36
β_{km}	-0.094	-1.54	β_{St}	-0.049	-8.35
β_{kr}	0.026	0.90	β_{tt}	0.039	2.61

Note. Parameters related to the intermediate inputs are estimated by use of the regularity condition of homogeneity of degree one in prices.

Simulation Analysis

The simulation analysis is attempted to answer what would happen to the Japanese markets for rice and farmland if rice is imported at the price lower by 10 or 30 percent than the domestic average price. For the convenience of analysis, the duration of time is divided into the following three phases. In Phase 1 the analysis is focused on the decline in rice price. In Phase 2 the transactions in land between operating farms are analyzed, taking account of the decline in rent caused by a fall in rice price. In Phase 3 some farms quit growing rice. In the simulation analysis the following three assumptions are made. The first is that rice farms that quit farming will never restart farming. The second is that they release all their paddy fields to the land-lease market in retaining their property rights to their fields. The third is that the production technology and all prices of factor inputs other than the rent are fixed at their level in the base year of 1991.

Equilibrium of Land Lease

To begin with, we shall concentrate on the equilibrium of land-lease in Phases 2. The aggregate excess demand for rented land (AED) is defined as follows.

Table 7 **Equilibrium of Land Leas in Phase 2** (1,000 ha)

	Excess demand for rented land				
$\partial \ln r/\partial \ln p$	Tofuken	Tohoku	Hokuriku	Kanto-Tosan	Kyushu
1.4	-27.7 (-92.0)	-6.8 (-23.5)	-1.7 (-6.5)	-3.9 (-11.8)	-3.0 (-10.9)
1.6	-21.0 (-69.2)	-4.7 (-16.2)	-1.1 (-4.6)	-3.1 (-9.1)	-2.2 (-8.5)
1.8	-13.8 (-39.3)	-2.5 (-6.5)	-0.5 (-2.3)	-2.2 (-5.5)	-1.4 (-5.3)
2.0	-6.2 (1.4)	-0.2 (6.7)	0.2 (0.1)	-1.3 (-0.6)	-0.5 (-0.9)
2.2	1.8 (59.3)	2.2 (25.5)	0.8 (2.9)	-0.2 (6.6)	0.4 (5.3)
2.4	10.4 (147.1)	4.8 (53.9)	1.5 (5.9)	0.8 (17.8)	1.3 (14.6)
2.6	19.4 (292.8)	7.6 (101.0)	2.2 (9.4)	2.0 (36.6)	2.3 (30.1)
2.8	29.1 (571.5)	10.5 (191.1)	3.0 (13.4)	3.2 (73.5)	3.4 (59.8)
Rented land in 1990	215.2	37.2	36.3	34.8	40.0

Note (1) The figures signify the excess demands in the case of 10 percent decline in rice price, while in parentheses in the case of 30 percent decline.

(2) Rented land in 1990 signifies the area of paddy fields under the leased contract. The data are adapted from *The Census of Agriculture.*

$$\text{AED} = \sum_{i}^{N} \Delta S_{ii}[(1-\lambda)p,(1-\varepsilon\lambda)r, w, L, S_0]$$

where N denotes the number of farms in a single region, λ is a parameter equal to 0.1 or 0.3 in Tohoku, Kanto-Tosan and Kyushu corresponding to the decline in rice price by 10 or 30 percent and $\varepsilon = \partial \ln r/\partial \ln p$. The estimated demand functions imply that λ is equal to 0.054 or 0.162 in Hokuriku.

Table 7 shows that AED depends heavily on the magnitude of $\partial \ln r/\partial \ln p$. Hence, the larger $\partial \ln r/\partial \ln p$, the more rented land is demanded other things being equal. This is because $d\ln S_1/d\ln p$ in equation (2) above tends to be negative in accordance with a rise in $\partial \ln r/\partial \ln p$. We can see from the table that when $\partial \ln r/\partial \ln p$ is equal to 2.0-2.2, the land-lease market is roughly in balance in every region ($\text{AED} = 0$). This value does not differ much from the value estimated in the second section (Table 4).[10] Moreover, the sign of $d\ln S_1/d\ln p$ is positive for small farms and negative for large ones when the market is in equilibrium, though not shown in Table 7. This suggests that the lease market moves into balance in accordance with a decrease in demand for rented land of small farms and an increase in its demand of large ones. It follows that a decline in rice price in Phase 2 helps improve the resource allocation in the sense that farmland shifts away from less efficient to more efficient producers.

The Structural Change in Phase 3

When the transition advances from Phase 2 to Phase 3, some farms will stop growing rice and reduce themselves to landowners. In the first place, let us estimate the rate of their retirement. If the price of

[10] According to Kusakari (1994), the elasticity of $\partial \ln r/\partial \ln p$ is equal to 1.7 to 2.0, while its value estimated by Kondo (1992) and Saito (1996) is greater than five.

rice falls, some variables such as the equilibrium rent, factor input including rented land and output of rice will change, which necessarily change the income ratio. Hence, the elasticity of income ratio with respect to rice price to be defined below will be of particular importance,

$$\eta=\frac{\mathrm{d}\ln z}{\mathrm{d}\ln p}=\frac{\pi}{\pi^{a}}\cdot\frac{\partial\ln\pi}{\partial\ln p}+\frac{w_{k}k}{\pi^{a}}\cdot\frac{\partial\ln k}{\partial\ln p}-\frac{S_{1}}{S_{0}+S_{1}}\cdot\frac{\partial\ln S_{1}}{\partial\ln p}$$
$$+\frac{\partial\ln r}{\partial\ln p}\left(\frac{\pi}{\pi^{a}}\cdot\frac{\partial\ln\pi}{\partial\ln r}+\frac{w_{k}k}{\pi^{a}}\cdot\frac{\partial\ln k}{\partial\ln r}-\frac{S_{1}}{S_{0}+S_{1}}\cdot\frac{\partial\ln S_{1}}{\partial\ln r}-1\right)$$

The value of elasticities such as $\partial\ln\pi/\partial\ln p$, $\partial\ln K/\partial\ln p$ and others are estimated by use of the parameters of profit function. Substituting the income ratio associated with 10 or 30 percent fall in rice price into the equation (1), the retirement rate is estimated as presented at the top of Table 8.

Irrespective of district, the value of η is positive for small but negative for large farms, which indicates that the further the rice price declines, the larger the retirement rate is for small farms, while the smaller it is for large ones. Table 8 tells us not only that the retirement rate is higher for farms whose operating size is smaller but also that the rate of Kyushu is the highest being followed by Tohoku, Kanto-Tosan and Hokuriku in this order. If rice price of Tofuken falls by 10 (30) percent, 14.5 (17.0) percent of farms in Tofuken are anticipated to quit farming on average. Correspondingly, the total number of RF is 370,000 (430,000). The area of paddy fields that they will release to the land-lease market in aggregate amounts to 154,400 (170,900) ha which constitutes 7.2 (7.9) percent of the total area of Tofuken paddy fields.

Now suppose that Phase 3 is further divided into two subphase in the following manner. We refer to one phase as Phase 3a where the equilibrium rent is perfectly inelastic with respect to RFs' land supply, consequently their paddy field are left uncultivated. On the other hand, we refer to the other phase as Phase 3b where the rent is so adjusted that an increase in demand for rented land is equilibrated with RFs' land supply. The equilibrium rent in Phase 3b is estimated by solving the following equation,

$$\sum_{i}^{n}S_{i}^{RF}=\sum_{i}^{N-n}\Delta S_{1i}^{F}[(1-\lambda)p,r,w,L,S_{0}],$$

where n denotes the number of RF. The left hand side is the sum of the area of paddy fields released by RF, while the right hand side is the sum of an increase in demand for rented land. In order to bring the land-lease market of Phase 3b into balance, the rent has to be reduced by 79 (82) percent in Tofuken when rice price falls by 10 (30) percent, suggesting that the emergence of uncultivated area is unavoidable without a drastic fall in rent. In the face of technological advance, it has to be reduced by 58 (64) percent. As for the regional differences, the rent has to be reduced by the largest margin in Kyushu, being followed by Kanto-Tosan, Tohoku and Hokuriku in this order.

Figure 6 gives a good account of the transition of Phases from 3a to 3b. It is supposed that the total area of paddy fields released by RF is nS_{0}^{B}, while demand for rented land is what the diagram depicts. This results in the area $nS_{0}^{B}-S^{*}$ of uncultivated paddy fields in Phase 3a. Then, there seem to be available at least two measures to turn the uncultivated paddy fields into cultivation. One is the landowners' consent to lease their own land at the rent of r^{**} in disregard of economic rationality (they are unwilling to lease their paddy fields in principle unless $r\geq r_{1}^{B}$), and another is that the measure to cause the demand curve to shift to the right to the extent that it crosses the vertical part of the supply curve. It is too involved a subject to explore which measure we should take in order to get rid of the abandoned farmland. But we can hypothesize that when the requisite rate of decline in rent is extremely large as in the case of Kyushu and Kanto-Tosan (86.6 and 76.5 percent even in the case of 10 percent fall in rice price, respectively), the rent in Phase 3b corresponds to r'' in Figure 6. [11] Therefore, the market mechanism fails to solve the problem of abandoned land in these regions, while the law of demand and supply is

Table 8 Structural Change in Phase 3

	Tofuken		Tohoku		Hokuriku		Kanto-Tosan		Kyushu	
Rate of decline in rice price (%)	10	30	10	30	5.4	16.2	10	30	10	30
	Retirement Rate (%)									
Average	14.5	17.0	11.9	14.8	7.7	7.6	10.9	13.0	16.6	18.8
<0.3ha	26.1	33.9	36.0	48.7	14.0	16.0	15.3	21.4	36.1	41.3
0.3-0.5ha	28.2	19.4	15.2	19.0	14.4	14.9	13.5	16.0	13.0	16.2
0.5-1.0ha	9.0	9.8	7.5	9.5	7.6	6.7	6.8	6.0	6.6	6.1
1.0-1.5ha	3.8	3.2	6.3	5.6	2.8	2.3	6.0	4.1	4.8	4.2
1.5-2.0ha	1.6	1.2	3.6	2.8	1.5	1.1	4.1	3.4	0.7	0.5
2.0-3.0ha	1.0	0.5	2.1	1.1	0.9	0.5	2.2	1.0	0.3	0.2
>3.0ha	0.2	0.1	0.8	0.3	0.1	0.0	0.6	0.3	0.1	0.0
$\sum_i S_i^{R''}$ (1,000 ha)	154.4	170.9	31.3	34.7	10.9	10.1	25.9	27.4	23.5	25.7
Rate of decline in rent (%)	79.1 (58.4)	81.8 (64.2)	66.0 (35.2)	67.2 (38.0)	49.8 (2.0)	47.3 (-2.4)	76.5 (49.0)	74.1 (43.5)	86.6 (75.7)	87.7 (78.1)
	An increase in demand for the rented land in Phase 3b (1,000 ha)									
<0.3ha	6.3	5.0	0.4	0.3	0.4	0.3	2.3	1.9	1.2	1.1
0.3-0.5ha	24.7	24.8	1.6	1.5	1.0	0.9	2.9	2.6	2.8	2.6
0.5-1.0ha	37.6	38.0	4.9	4.6	2.6	2.4	8.2	8.5	6.4	6.7
1.0-1.5ha	29.0	32.4	5.3	5.7	1.9	1.8	5.6	6.4	5.5	6.1
1.5-2.0ha	16.1	18.6	3.9	4.2	1.5	1.4	2.4	2.6	2.5	2.9
2.0-3.0ha	20.7	25.6	6.9	8.2	1.8	1.8	3.1	3.8	4.1	5.2
>3.0ha	20.0	26.4	8.3	10.3	1.7	1.6	1.4	1.7	0.9	1.2
total	154.4	170.9	31.3	34.7	10.9	10.1	25.9	27.4	23.5	25.7
$\Delta S_1/S$ (%)	7.2	7.9	5.2	5.7	3.9	3.6	6.6	7.0	7.9	8.7

Note (1) The rate of decline in rice price in the face of technological advance is shown in parentheses.

(2) $\Delta S_1/S$ signifies the ratio of paddy fields under lease contract to the total.

[11] Chino (1994) verifies that a decline in rice price has little effect on the structural change, while Saito (1996) by use of his general equilibrium model draws the contradictory conclusion. Although the latter takes account of the market mechanism in which a decrease in the derived demand for farmland reduces the equilibrium rent, the former does not. In other words, in the model developed by Saito the rent is so adjusted that the land-lease market attains its equilibrium. Thus, one of major factors underlying the differences in their conclusions is the assumption made with respect to the land market. In other words, Chino preassumes Phase 3a, while Saito preassumes Phase 3b to be relevant, respectively.

expected to work well in Hokuriku where the requisite rate of decline in rent is relatively small.

The manner in which the area of paddy field released by RF is accumulated by operating farms is described at the bottom of Table 8. 40.7 thousand ha paddy fields out of 154.4 thousand ha released by RF will be cultivated by farms of two ha or more in Tofuken. In particular, a large part of these fields are consolidated into large scale farms in Tohoku, while in contrast it is into medium scale ones in Kanto-Tosan and Kyushu. But it is worth noting that the individual farms of large scale have succeeded in increasing rented land to a large extent. For instance, the farms of three ha or more increase rented land by 59 (81) percent on average as compared with the base year in the case of 10 (30) percent decline in rice price, although not shown.

Rice Production and Farm's Profit

Table 9 shows the output of rice in four Phases for each district. The column of "the Rest" represents sub-regions of Tofuken other than the listed four. If rice is imported at the price 10 percent lower than its domestic price, the domestic supply of rice will be reduced to 8.70 million tons in Phase 1 but will be restored to the level of 8.84 million tons in Phase 2. In Phase 3a it will be reduced to 8.09 million tons because of a decrease in the cultivated area, but it will increase to 9.38 million tons in Phase 3b. In sum, if Phase of transition proceeds to Phase 3b, the domestic supply of rice will be reduced only by 0.18 million tons, and therefore the rate of self-sufficiency in rice will decline little.

Table 9 shows what the domestic rice supply looks like if Phase of transition advances from the base year to Phase 3b. Rice supply of the Rest is reduced by the largest margin between the base year and Phase 3a being followed by Kyushu, Kanto-Tosan, Tohoku and Hokuriku in this order. If Phase of transition advances to Phase 3b, rice supply of Tohoku, Hokuriku and Kyushu maintains nearly the current level in the case of 10 percent cut in price. Even in the case of 30 percent cut, rice supply of Hokuriku decreases only by 80,000 tons, while that of the Rest decreases by a little less than one million tons. One

Table 9 Rice Supply (10,000 tons)

		Tofuken	Tohoku	Hokuriku	Kanto-Tosan	Kyushu	Rest
	1991	955	306	127	173	109	240
10% decline in rice price	Phase 1	870	288	125	158	99	200
	2	884	293	126	160	101	205
	3a	809	276	120	148	91	175
	3b	938	305	128	161	114	230
30% decline in rice price	Phase 1	611	218	114	111	64	104
	2	651	233	117	116	69	116
	3a	596	219	112	107	63	94
	3b	704	244	119	117	81	144

Note (1) Rice supply in 1991 is estimated from the profit function.
(2) Rice supply of the Rest does not include that of Hokkaido.

Table 10 Price Elasticity of Supply

Class	Tofuken	Tohoku	Hokuriku	Kanto-Tosan	Kyushu
<0.3ha	1.64	1.73	1.31	1.81	1.41
0.3-0.5ha	1.28	1.23	1.11	1.54	1.58
0.5-1.0ha	1.17	1.08	0.67	0.91	1.26
1.0-1.5ha	0.73	0.65	0.52	0.52	1.21
1.5-2.0ha	0.61	0.57	0.20	0.78	0.70
2.0-3.0ha	0.28	0.16	0.01	0.10	0.90
>3.0ha	0.15	0.08	0.17	0.17	0.52

Note. The elasticity is evaluated at the point of Phase 1.

reason why the reduction of rice supply in Hokuriku is so small is, needless to say, that rice price declines there by a smaller margin than elsewhere. And another is the higher technological level of rice production. As Table 10 indicates, the price elasticity of supply is relatively small in Hokuriku, so that its rice supply decreases less than others do. [12] This result coincides with an economic investigation of Chino (1996) which compares the price elasticity of rice supply between Tohoku and Hokuriku.

The share of rice supply in each region is presented in Table 11. When rice price falls, the shares of Tohoku and Hokuriku rise, while those of Kanto-Tosan, Kyushu and others remain unchanged or decline, which results in the specialization of rice production in some districts. On the other hand, Table 12 shows that large-scale farms (two hectares or over) increase their shares of rice supply as Phase of transition advances, and the trend becomes more conspicuous when rice price declines a lot. For instance, if rice price is reduced by 10 percent, the supply share of large scale farms in Tofuken increases from 17.4

Table 11 The Share of Rice Supply in Each Region (%)

		Tohoku	Hokuriku	Kanto-Tosan	Kyushu	Rest
	1991	32.0	13.3	18.1	11.4	25.1
10% decline in rice price	Phase 1	33.1	14.3	18.1	11.3	23.0
	2	33.2	14.2	18.0	11.4	23.2
	3a	34.1	14.8	18.2	11.2	21.6
	3b	32.5	13.6	17.2	12.2	24.5
30% decline in rice price	Phase 1	35.6	18.6	18.2	10.5	17.1
	2	35.7	18.0	17.8	10.7	17.8
	3a	36.8	18.8	18.1	10.5	15.8
	3b	34.6	16.9	16.6	11.4	20.4

Note. The figures represent the share of each district in the Tofuken total.

[12] Under the condition of producer's profit maximization behavior, the price elasticity of supply is defined as follows:

$$\frac{\partial \ln q}{\partial \ln p} = \frac{\text{the sum of output elasticity of variable factor input}}{1 - \text{the sum of output elasticity of variable factor input}}$$

Table 12 The Share of Rice Supply of Large-scale Farms (%)

		Tofuken	Tohoku	Hokuriku	Kanto-Tosan	Kyushu
	1991	17.4	35.3	22.9	13.6	9.0
10% decline in rice price	Phase 1	19.2	37.3	23.5	14.5	9.5
	2	19.3	37.5	23.7	14.5	9.7
	3a	21.0	39.3	24.8	15.4	10.8
	3b	22.1	40.3	25.8	15.6	13.1
30% decline in rice price	Phase 1	22.4	41.5	24.7	17.3	10.5
	2	23.1	42.4	25.2	17.3	11.6
	3a	25.1	44.6	26.3	18.5	12.8
	3b	26.4	45.7	27.3	18.6	15.6

percent in the base year to 21.0 percent in Phase 3a and to 22.1 percent in Phase 3b, and the latter two figures increases to 25.1 and 26.4 respectively in the case of 30 percent decline in rice price.

From the perspective of the structural change of rice production, we should probe into the change in the farm household economy. More specifically, one might wonder whether farmers have enough incentives to keep farming. In Tables A-1 and A-2 profit from rice-growing is presented for each class in each Phase. Profit decreases from the base year to Phase 1 because of a decline in rice price, while it increases from Phase 1 to 2 and from Phase 2 to 3b because of a decline in rent. Since the terms of trade for rice production do not change between Phases 2 and 3a, profit remains unchanged between the two phases. As is clear from the table, if rice price falls by 10 percent, every farm except the large-scale farm of Hokuriku and Kyushu in Phase 3b registers profit less than in the base year. In the case of 30 percent decline in rice price, every farm household loses a lot. In short, rice-growers are threatened to be put into an economic quandary in the face of a fall in rice price.

One of conceivable methods to get rid of this quandary is to expand its own farmland. Table 13 shows the estimates of its expansion rate that is required for largest farms (three ha and over) to earn a predetermined level of profit. The requisite area of own paddy field is estimated by the following equation,

$$\tilde{\pi} = \pi[(1-\lambda)p, (1-\varepsilon\lambda)r, w, L, \tilde{S}_0]$$

where $\tilde{\pi}$ and $\tilde{S}_0$ denote the target profit and a solution to this equation respectively. The expansion rate is defined as $\tilde{S}_0/S_0$. In this analysis two different target profits are determined tentatively; one is the current

Table 13 The Required Expansion Rate

	Rate of decline in rice price	Tofuken	Tohoku	Hokuriku	Kanto-Tosan	Kyushu
Norm A	10%	1.50	1.59	1.19	1.71	1.46
	30%	4.43	4.30	2.13	5.81	4.20
Norm B	10%	1.50	0.78	1.21	2.67	3.27
	30%	4.43	2.67	2.17	8.13	7.96

profit of its own region (norm A), and the other is the current average profit of Tofuken, 3,098 thousand yen (as norm B). Phase 3a is the base period.

Under the norm A, the required expansion rate is the largest for Kanto-Tosan being followed by Tohoku, Kyushu and Hokuriku in this order, while under the norm B, Kyushu is the largest being followed by Kanto-Tosan, Hokuriku and Tohoku in the case of 10 percent decline in rice price. As rice price a great deal declines, the requisite expansion rate rises as a natural consequence. In any case, these results verify the claim made earlier: a price cut would bring about a severe pressure on farmers to enlarge the cultivated area.

Conclusions

The purpose of this study is to clarify the effect of a decline in rice price on the structure of rice production in Japan. A primary focus is put on the question whether a price reduction facilitates transactions in farmlands and hence helps enhance the efficiency in rice production. The simulation analysis gives the following two propositions in this respect. One is that a price cut accompanied by a decline in rent twice as much as that in rice price will lead the land-lease market to its equilibrium. This result is caused by a decrease in the demand for farmland of small-scale farms and by an increase in it of large-scale farms. This type of land-lease transactions help enhance the efficiency of rice production because larger farms have an advantage in its costs over smaller farms. Another proposition is related to the working of the land-lease market where retired farms release their farmlands. Unless the rent is lowered to such a level that an increase in demand for rented land is equilibrated with its supply on the part of retired farms, the market may fail to perform its expected task, and rice imported from abroad will increase its share of supply in this country.

In reference to the structural change of rice production, a number of policy implications should be given. The simulation analysis indicates that a fall in rice price will improve the production efficiency to the detriment of rice-growing farmers. More concretely, although a decline in price will enable large scale farms to enlarge their cultivated field by lease contract, it is liable to put them into a disadvantage in terms of their income. This issue deserves a close attention of policy makers because it has been widely believed that a major policy goal of fostering "core farms" in the Japanese agriculture should rely on tenant farming.

With respect to the regional difference in the production structure, we have verified that a fall in rice price is expected to increase the share of supply in regions where rice of high quality is grown, which will result in the specialization of rice production in a small number of selected regions. The demand function analysis has made clear that a recent change in consumer preference is the main cause underlying this development.

References

Chino, J., (1994) "A Study on the Structural Change in the Japanese Rice Sector." In Morishima, K., ed.

Table A-1 Profit in the Case of 10% Decline in Rice Price (1,000 yen)

Class	Tohoku				Hokuriku			
	1991	Phase 1	2	3b	1991	Phase 1	2	3b
<0.3ha	130	95	96	103	216	191	193	203
0.3-0.5ha	266	195	197	211	318	272	274	289
0.5-1.0ha	486	361	365	391	589	513	516	538
1.0-1.5ha	952	765	772	819	946	830	834	864
1.5-2.0ha	1,288	997	1,006	1,072	1,414	1,315	1,321	1,364
2.0-3.0ha	2,189	1,828	1,850	1,992	2,187	1,957	1,978	2,119
>3.0ha	4,115	3,303	3,384	3,861	3,078	2,865	2,921	3,305

Class	Kanto-Tosan				Kyushu			
	1991	Phase 1	2	3b	1991	Phase 1	2	3b
<0.3ha	105	76	77	84	122	88	88	96
0.3-0.5ha	171	127	128	138	160	119	120	137
0.5-1.0ha	453	341	343	362	319	244	247	287
1.0-1.5ha	888	689	693	734	543	417	428	566
1.5-2.0ha	869	692	697	747	1,040	833	845	1,004
2.0-3.0ha	1,871	1,499	1,510	1,614	1,328	1,046	1,092	1,654
>3.0ha	2,474	1,972	1,985	2,117	1,943	1,578	1,629	2,241

Table A-2 Profit in the Case of 30% Decline in Rice Price (1,000 yen)

Class	Tohoku				Hokuriku			
	1991	Phase 1	2	3b	1991	Phase 1	2	3b
<0.3ha	130	38	39	42	216	131	134	140
0.3-0.5ha	266	85	89	96	318	190	195	204
0.5-1.0ha	486	163	170	183	589	373	380	395
1.0-1.5ha	952	377	389	415	946	611	621	642
1.5-2.0ha	1,288	498	516	552	1,414	997	1,011	1,041
2.0-3.0ha	2,189	983	1,029	1,114	2,187	1,507	1,560	1,663
>3.0ha	4,115	1,803	1,982	2,277	3,078	2,176	2,324	2,605

Class	Kanto-Tosan				Kyushu			
	1991	Phase 1	2	3b	1991	Phase 1	2	3b
<0.3ha	105	30	31	33	122	37	37	41
0.3-0.5ha	171	52	54	58	160	48	50	58
0.5-1.0ha	453	159	162	171	319	106	111	131
1.0-1.5ha	888	347	354	376	543	183	205	277
1.5-2.0ha	869	332	341	366	1,040	406	430	519
2.0-3.0ha	1,871	815	837	896	1,328	490	585	910
>3.0ha	2,474	1,059	1,085	1,158	1,943	796	906	1,275