

Impacts of Paddy-Field Consolidation Projects on Farmland Rental Transactions: Application of Discrete Choice Model

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In order to reallocate farmland to efficient farmers, improvement in Farmland Rental Transactions (FRT) cooperating with public investment, Paddy-field Consolidation (PC) projects, is one of the most important policy issues in Asian monsoon regions as well as in Japan. Unfortunately, there are few empirical studies on FRT due to a lack of flexible data under regulated markets. This study aims to analyze FRT and to evaluate the effect of PC projects by modeling both supply and demand sides of farmland renting with micro-data from a discrete choice type questionnaire. Empirical results show that (i) effects of PC project appear as a remarkable increase in the rental rate and a moderate increase in the rental agreement level, (ii) there is an economic inefficiency in the Japanese rental market, but such an inefficiency can be reduced by PC project implementation, and (iii) regional differences in project effects are caused by differences in agricultural and social situations.

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1. Introduction¹⁾

Improvement of rice productivity is a critical issue in Asian monsoon regions as well as in Japan, where the average area managed by each farmer is less than one hectare (ha) and has hardly increased in many years. To encourage a good farm management situation, agricultural policy is now focusing on an acceleration of farmland rental transactions (FRT) along with paddy-field consolidation (PC) projects. More than 15% of the agricultural budget has been spent on PC projects in Japan. Consequently, 60% of all paddy-fields have been consolidated from small fields of irregular shape to efficient fields endowed

with standardized large parcels of farmland (over 0.3 ha), irrigation and drainage canals and branch roads.²⁾ It is now necessary to evaluate the effects of this cumulative investment capital in view of policy accountability.

Ideally, PC projects have two effects. The first effect is improvement of agricultural productivity by modernization of agriculture with large agricultural machinery, high flexibility of water management and improvement of less fertile soil. This effect is revealed by a high rental rate as a shadow price of farmland through the process of increasing farmland quality. The second effect is realized as economies of scale in rice production from accelerating intensive farmland use by efficient large-scale farmers. Because PC projects break old farmland ownership structures and establish new ownership or usage rights, implementation of these projects stimulates FRT even though ownership of paddy-fields belongs to small-scale farmers. Empirical studies are needed to show not only

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a rise in the rental rate related to the improvement of productivity, but also an increase in the area managed by efficient farmers through FRT.

In previous studies, a hedonic price approach was used to show relations between farmland value and several factors such as soil characteristics (Elad, Clifton and Epperson [3]), urbanization (Plantinga and Miller [14]) and site characteristics (Xu, Mittelhammer and Barkley [18]; Boisvert, Schmit Regmi [1]). Unfortunately, there are few hedonic analyses of Japanese farmland because of limited availability of data. Japanese farmland purchase and FRT have been restricted by local governments to protect the property rights of farmers, so data with enough variance for empirical analysis cannot be obtained from agricultural statistics. There are also few economic data classified by consolidation situations or supply and demand (S-D) conditions for renting. Estimation from S-D equilibria data would cause identification problems. Even if distinct data were available, the data of the restricted market would distort estimation results.

Another option is to estimate the farmland production function. In fact, several previous studies estimated aggregate production functions showing a low elasticity of farmland with regard to the rental rate (Nakashima [13], Godo [4], Ito [7], Kuroda and Abdullah [12]). However, the aggregate production function can hardly represent individual farmer reactions as seen in FRT and can hardly treat differences between farmers, such as technological gaps.³⁾ Since different types of decision making are the driving force of renting, even if other management situations are the same, consideration of technological gaps is important for the analysis of FRT. Moreover, there is no room to include PC projects into estimation of production function because of the multi-co-linearity and data limitation.

The purpose of this study is to analyze FRT and evaluate the effects of PC projects by modeling both supply and demand sides of farmland renting with micro-data. The central concern of this study is whether large-scale farmers, supposed to be the demand side, increase their farmland through FRT with PC projects to achieve economies of

scale in rice production. To overcome restricted market conditions in data, the discrete choice model was employed to estimate the S-D functions in FRT, and effects of PC projects on ideal S-D equilibria were simulated. Unlike the common discrete choice model, the basic equation of this model was derived from the stochastic production function (not a speculative utility function) involving the technological gaps between farmers.

In the following sections, the model and data are explained in detail and then the estimation and simulation results are presented. The final section contains a summary of our findings and the implications of stimulating FRT.

2. Methodology

1) Survey design

To obtain micro data with enough variance, a discrete choice type questionnaire was administered to individual farmers. The question to supply side farmers was :

"If you had a chance to rent one parcel of paddy field (dA) to another farmer, would you accept the rental rate B^s yen/ha/year?"

Demand side farmers were asked the following question :

"If you had a chance to rent one parcel of paddy field (dA) from another farmer, would you pay the rental rate B_1^d yen/ha/year? Assume that you could use other agricultural machinery in addition to your own and employ help to cultivate the field, if needed. Also, assume that the obligation rate of the set-aside program is equal to the average rate for your town."

In Japanese rice production, the number of demand side farmers is far fewer than supply side farmers, although areas rented by a demand side farmer are larger than areas of a supply side farmer. Hence, the estimation error of the demand function is larger due to a smaller amount of data. To improve statistical efficiency, a double bounded question was employed (Hanemann, Loomis and Kanninen [5]). A second question that depended on the response to the first question was as follows :

"If you accept the above situation, will you pay a higher rental rate (B_{2H}^d yen/ha/year) for the rental field?" or, "If you reject the

above situation, will you pay a lower rental rate (B_{2L}^d yen/ha/year) for the rental field?"

In these questions, one parcel of paddy-field for rent (dA) was assumed to be 0.1 ha for Non-Consolidated Fields (N-CF) and 0.3 ha for Consolidated Fields (CF). These parcel areas are common in Japanese paddy-fields.

Five rental rates were used in the questionnaire for the first rates B^s and B_1^d , i.e. 50, 100, 200, 400 and 700 thousand yen/ha/year, and for the second rate, B_{2H}^d (or B_{2L}^d), which was higher (or lower) by one rank than the first bidding rate according to the above rate order including 10 and 1,000 thousand yen/ha/year. Each value was proposed to each group of farmers randomly assigned to one of five equal groups. Questions to the S-D farmers were about both N-CF, paddy-fields in poor condition before the PC project, and CF, paddy fields in improved condition after the project. Thus, four kinds of data were collected, i.e. (supply or demand side) \times (N-CF or CF).

A simple "yes-no" answer was requested of the S-D farmers to duplicate the actual FRT. It would have been possible to let the respondents write the acceptable price numerically or to select their preference from prelisted values. If the respondents had been allowed to answer in these ways, they would not have indicated the border value that they actually wanted to pay or receive. Instead, they would have most likely answered in accordance with the value that the local governments proposed as the standard rental rate, causing a lack of variance in data.

2) Empirical model

The empirical model employed here consists of i) the S-D functions that show farmer decisions about renting based on individual differences in production conditions and ii) the specification of the S-D equilibria as ideal rental agreements. In previous analyses, a stochastic production function was proposed to take account of individual differences between farmers (Kumbhakar [10]; Chambers and Quiggin [2]). These analyses required a convergence process, which sometimes failed, in function estimation to identify intangible differences. In this study, the S-D rental functions were directly estimated to duplicate farmer responses for FRT after de-

riving these functions from the stochastic production function and modifying them to the discrete choice model in order to use hypothetical questionnaire data.

Godo [4] derived the restricted profit function from the assumption that each farmer decides their production level under given farmland area. In addition to his assumption, the total factor productivity is assumed to be increased in accordance with an increase of management scale, because large scale farmers can use effective production methods embodied with agricultural machines and agricultural chemicals. Then, rice production (Q) of each farmer is defined by the production, $Q=F(A, \mathbf{V}, \mathbf{E}, u)$, with predetermined farmland (A), other input factors (\mathbf{V}) and social and geographical influences (\mathbf{E}). Here and subsequently, bold characters show the vector. Variable u is the stochastic element that represents technological gaps between farmers, relating to differences in skills and knowledge of individual farmers, quality of inherited farmland and ability to analyze information from consumers. The existence of technological gaps yields different profits even if farmers have the same management resources. Given that they try to maximize profit $R=PQ-P_A A-P_V \mathbf{V}$ under the technical constraints of the production function, the first order condition with regard to \mathbf{V} is, $\mathbf{P}_V=P(\partial Q/\partial \mathbf{V})$, where \mathbf{P}_V is the price of \mathbf{V} and P is the price of rice.

Because A is uncontrollable for farmers, the optimum rental rate $P_{A(WTP)}$ differs between farmers with different production situations. Assuming that this optimum rental rate, $P_{A(WTP)}$, willingly paid by individual farmers, is decided as satisfying $\partial R/\partial A=0$ and \mathbf{V} is replaced by \mathbf{P}_V according to the first order condition, $P_{A(WTP)}$ can be defined as $P_{A(WTP)}=P(\partial Q/\partial A)=f(A, P, \mathbf{P}_V, \mathbf{E}, \epsilon)$.

In the case of the Cobb-Douglas production function, $Q=aA^b \mathbf{V}^c \mathbf{E}^d \exp(u)$, ($b+c<1$). Small characters a , b , c and d are production parameters. The first order condition with regard to \mathbf{V} is defined as $\mathbf{P}_V=\mathbf{P}(\partial Q/\partial \mathbf{V})=PacA^b \mathbf{V}^{c-1} \mathbf{E}^d \exp(u)$. Then, the optimum value of rental rate $P_{A(WTP)}$ is,

$$\begin{aligned} \ln(P_{A(WTP)}) &= a' + b' \ln(A) + c' \ln(\mathbf{P}_V) \\ &\quad + d' \ln(\mathbf{E}) + e \ln(P) + \epsilon \\ &= f(\mathbf{X}) + \epsilon. \end{aligned} \quad (1)$$

Here, $\alpha' = \frac{1}{1-c} \ln(a) + \ln(b) + \frac{c}{1-c} \ln(c)$,
 $b' = -\frac{1-b-c}{1-c}$, $c' = -\frac{c}{1-c}$, $d' = \frac{d}{1-c}$, $e' = \frac{1}{1-c}$,
 $\varepsilon = \frac{u}{1-c}$. Consequently, the rental rate can be

decomposed into two parts ; a systematic element which is a linear index of the variable matrix \mathbf{X} and a stochastic element ε which represents intangible influences on the rental rate relating to the technological gaps between farmers.

When a farmer cultivates farmland A_0 initially and rents one parcel of farmland dA^s to a demand side farmer or rents additional farmland dA^d from a supply side farmer, the farmland area after renting is $A^s = A_0^s - dA^s$ for the supply side and is $A^d = A_0^d + dA^d$ for the demand side. The superscripts s and d stand for the supply and demand sides, respectively. Thus, the willingly paid rental rate $P_{A(WTP)}$ for dA^s or dA^d are defined as follows.
 Supply side :

$$\begin{aligned} \ln(P_{A(WTP)}^s) &= f(A_0^s - dA^s, P, \mathbf{P}_v, \mathbf{E}^s, \varepsilon^s) \\ &= f(\mathbf{X}^s) + \varepsilon^s, \end{aligned} \quad (2)$$

Demand side :

$$\begin{aligned} \ln(P_{A(WTP)}^d) &= f(A_0^d + dA^d, P, \mathbf{P}_v, \mathbf{E}^d, \varepsilon^d) \\ &= f(\mathbf{X}^d) + \varepsilon^d. \end{aligned} \quad (3)$$

To use questionnaire data on FRT, these equations should be modified to the discrete choice type function. It is reasonable to presume that supply side farmers would agree with the rental rate (B^s) proposed in the questionnaire, if the proposed rate is higher than $P_{A(WTP)}^s$ in Eq.(2). Given that the distribution of technological gaps shown by ε is i. i. d. with zero-mean, the acceptance probability is defined as follows by the cumulative density function G .

Supply side acceptance probability π^s :

$$\begin{aligned} \Pr(B^s > P_{A(WTP)}^s) &= \Pr\left[\frac{\ln(B^s) - f(\mathbf{X}^s)}{\sigma^s} > \frac{\varepsilon^s}{\sigma^s}\right] \\ &= G[\gamma^s \ln(B^s) - \mathbf{X}^s \boldsymbol{\beta}^s]. \end{aligned} \quad (4)$$

Here, σ indicates the standard deviation of ε . γ and $\boldsymbol{\beta}$ are parameters.

Demand side farmers would accept the proposed rental rate (B_1^d for first offer, B_{2H}^d and B_{2L}^d for second offers), if the rate is lower than $P_{A(WTP)}^d$ in Eq.(3). The demand probability functions are defined as follows.

Probability of 'yes' in both answers, π_{yy}^d :

$$\begin{aligned} \Pr(B_{2H}^d \leq P_{A(WTP)}^d) &= \Pr\left[\frac{\ln(B_{2H}^d) - f(\mathbf{X}^d)}{\sigma^d} \leq \frac{\varepsilon^d}{\sigma^d}\right] \\ &= 1 - G[\gamma^d \ln(B_{2H}^d) - \mathbf{X}^d \boldsymbol{\beta}^d]; \end{aligned}$$

Probability of 'yes' followed by 'no,' π_{yn}^d :

$$\begin{aligned} \Pr(B_1^d \leq P_{A(WTP)}^d \leq B_{2H}^d) &= G[\gamma^d \ln(B_{2H}^d) - \mathbf{X}^d \boldsymbol{\beta}^d] \\ &\quad - G[\gamma^d \ln(B_1^d) - \mathbf{X}^d \boldsymbol{\beta}^d]; \end{aligned}$$

Probability of 'no' followed by 'yes,' π_{ny}^d :

$$\begin{aligned} \Pr(B_{2L}^d \leq P_{A(WTP)}^d \leq B_1^d) &= G[\gamma^d \ln(B_1^d) - \mathbf{X}^d \boldsymbol{\beta}^d] \\ &\quad - G[\gamma^d \ln(B_{2L}^d) - \mathbf{X}^d \boldsymbol{\beta}^d]; \end{aligned}$$

Probability of 'no' in both answers, π_{nn}^d :

$$\Pr(P_{A(WTP)}^d \leq B_{2L}^d) = G[\gamma^d \ln(B_{2L}^d) - \mathbf{X}^d \boldsymbol{\beta}^d]. \quad (5)$$

Parameters can be estimated by the maximum likelihood estimation method with the log sum of the likelihood composed by Eq. (4) or (5) as follows.

Supply side :

$$\begin{aligned} \ln(L) &= \sum_{i=1}^{Samples} \langle d_{yi} \ln[G\{\gamma^s \ln(B^s) - \mathbf{X}^s \boldsymbol{\beta}^s\}] \\ &\quad + (1 - d_{yi}) \ln[1 - G\{\gamma^s \ln(B^s) - \mathbf{X}^s \boldsymbol{\beta}^s\}] \rangle, \end{aligned}$$

Demand side :

$$\begin{aligned} \ln(L) &= \sum_{i=1}^{Samples} \langle d_{yyi} \ln[1 - G\{\gamma^d \ln(B_{2H}^d) - \mathbf{X}^d \boldsymbol{\beta}^d\}] \\ &\quad + d_{yni} \ln[G\{\gamma^d \ln(B_{2H}^d) - \mathbf{X}^d \boldsymbol{\beta}^d\} \\ &\quad \quad - G\{\gamma^d \ln(B_1^d) - \mathbf{X}^d \boldsymbol{\beta}^d\}] \\ &\quad + d_{nyi} \ln[G\{\gamma^d \ln(B_1^d) - \mathbf{X}^d \boldsymbol{\beta}^d\} \\ &\quad \quad - G\{\gamma^d \ln(B_{2L}^d) - \mathbf{X}^d \boldsymbol{\beta}^d\}] \\ &\quad + d_{nni} \ln[G\{\gamma^d \ln(B_{2L}^d) - \mathbf{X}^d \boldsymbol{\beta}^d\}] \rangle, \end{aligned}$$

where d_y is the binary-valued indicator variable, and equal to 1, if the i th supply side farmer answered 'yes', and 0 otherwise. The d_{yy} , d_{yn} , d_{ny} and d_{nn} are also binary-valued indicator variables for demand side farmers, and each variable equals 1, if the i th individual gives the response 'yes-yes,' 'yes-no,' 'no-yes,' or 'no-no' for the first and second steps, respectively ; otherwise, these variables are equal to 0.

Expected signs of coefficients are as follows. Rational farmers lead the acceptance probability to $\partial \pi^s / \partial B^s > 0$ and $\partial \pi^d / \partial B^d < 0$. $\partial \pi^s / \partial P = \{\partial \pi^s / \partial G(\cdot)\} \{\partial G(\cdot) / \partial P\}$ is less than zero, because the first differential on the right hand of the equation is positive and the second differential is negative due to the neg-

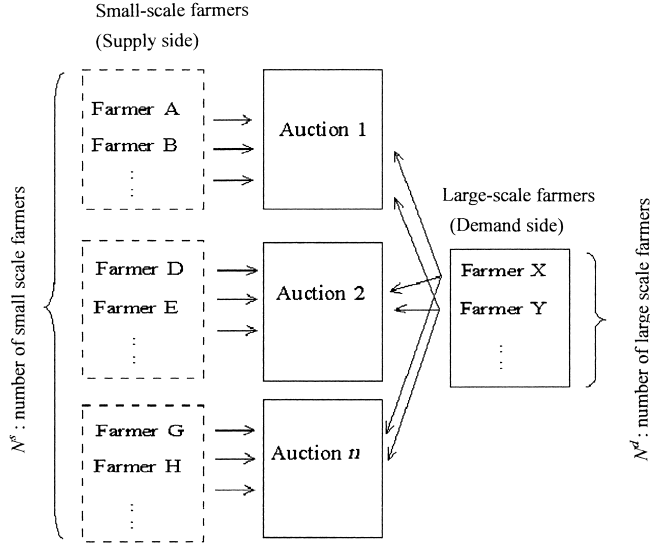


Figure 1. Hypothetical market for the S-D farmers

active sign in the function $G(\cdot)$ in Eq. (4) and $e > 0$ in Eq. (1). $\partial\pi^d/\partial P > 0$ due to $\partial\pi^d/\partial G(\cdot) < 0$ in Eq. (5). Similarly, the negative sign of c' brings about $\partial\pi^s/\partial P_V > 0$ and $\partial\pi^d/\partial P_V < 0$. The signs of $\partial\pi/\partial A = (\partial\pi/\partial P_A)(\partial P_A/\partial A)$ in both S-D sides cannot be determined in advance, because the sign of $\partial P_A/\partial A$ relates not only to the parameter (b') of diminishing returns but also to the total factor productivity (a') in Eq. (1). If total factor productivity changes in proportion to A , the effect of diminishing returns may be overwhelmed ($\partial P_A/\partial A > 0$) and the sign of $\partial\pi/\partial A$ probably corresponds to the sign of $\partial\pi/\partial P_A$.

The acceptance probabilities in Eqs. (4) and (5) correspond to the percentage (in numbers) of farmers who accept the proposed rental rate regarding one farm parcel of dA (ha) in FRT. Since all parcels of farmland are assumed to be the same standard size, an acceptance probability corresponds to the percentage of rented farmland parcels and consequently the percentage of rented farmland areas in the current transactions.

The ideal equilibrium of the S-D sides is defined at the intersection of the S-D functions. At this point, the equilibrium rental rate (B^*) and area rented ($N^* \times dA$) are decided as $N^* \times dA = \Pr(B^* > P_{A(WTP)}^s) \times N^s \times dA = \Pr(B^* \leq P_{A(WTP)}^d) \times n \times N^d \times dA$. Here, N^* shows the number of rented parcels of farmland within a project site. N^s and N^d are the total

number of farmers corresponding to the total number of farmland parcels offered and demanded by the S-D sides, respectively. In detail, transactions at one project site are assumed to be divided into ' n -auctions,' and large-scale farmers can bid on every auction, but small-scale farmers can bid only once on one auction due to the small area of farmland available to rent (Fig. 1). In other words, small-scale farmers can make only one bid to rent a field while large-scale farmers can make n -bids at the same price. From this assumption, the ratio n corresponds to the ratio $(N^s/N^d)^{4)}$. Then, the rental agreement level can be defined as,

$$\begin{aligned} N^*/N^s &= G[\gamma^s \ln(B^*) - \bar{\mathbf{X}}^s \boldsymbol{\beta}^s] \\ &= 1 - G[\gamma^d \ln(B^*) - \bar{\mathbf{X}}^d \boldsymbol{\beta}^d]. \end{aligned} \quad (6)$$

Here, $\bar{\mathbf{X}}$ shows the average value of the explanatory variables and the probability terms are replaced with the acceptance probability functions, assuming that the distribution of all related farmers on each side is consistent.

3) Data sources

In order to simplify and clarify the achievement of large-scale farmers in FRT with PC projects, both S-D sides were a-priori classified according to their management scale. The supply side was assumed to be small-scale farmers who managed farms of less than 3.0 ha and the demand side was assumed to be large-scale farmers who managed farms

Table 1. Outlines of research sites

Regions	Number of project sites	Average project area (ha/site)	Average management scale	
			Supply side (Small-scale) (ha/household)	Demand side (Large-scale) (ha/household)
Tohoku	29	137	1.7	6.1
Kanto	28	184	1.6	6.7
Hokuriku	10	187	1.4	5.7
Tokai	6	248	0.9	20.5
Kinki	11	127	1.0	7.7
Chu-Shikoku	17	105	1.1	5.4
Kyushu	17	92	1.1	7.1
Whole	118	146	1.3	6.4

Table 2. Questionnaire results

	Supply side (Small-scale)	Demand Side (Large-scale)
Distributed questionnaire(household)	7,920 (100%)	925 (100%)
Collection rate (%)	78.0%	75.4%
Effective responses (household)	3,651 (46.1%)	426 (46.1%)
Effective responses (% ; to collected res.)	60.0%	61.1%
Effec. res. for non-consolidated fields	3,335 (42.1%)	409 (44.2%)
Effective responses (% ; to collected res.)	54.0%	58.6%

Note : 1. Farmers who answered only for consolidated fields were excluded for non-consolidated simulations.

2. Questionnaires were distributed to all farmers on site, when the total site area was less than 100 ha. In the case of more than 100 ha, one gathered area of about 100 ha were selected for survey within the project site and questionnaires were distributed to all farmers in this area.

of 3.0 ha or more. These divisions of 3.0 ha were based on an official notice from the Ministry of Agriculture, Forestry and Fishery (MAFF) to the farmers as a necessary condition for project implementation. If farmers were to be subsidized for the PC project, they had to list representative large-scale farmers who satisfied the necessary condition of over 3.0 ha under their management. In fact, the survey result on consolidated paddy-fields (JIID [9]) shows that 54% of large-scale farmers classified by 3.0 ha have already rented fields from other farmers whereas only 12% of small-scale farmers have rented from others. Considering these figures, it can be supposed that small-scale farmers are mostly the supply side and large-scale farmers are the demand side in general.

The cross-sectional data came from the sur-

vey of farmers conducted by JIID with assistance from MAFF in December 1999 (JIID [8]). A total of 118 research sites were selected throughout Japan, excluding Hokkaido and Okinawa where management styles and rice varieties are different from those of other regions. The average project area was over 100 ha of paddy-fields and all projects were implemented by local governments according to a standard design showing almost the same physical paddy-field situations (Table 1).

The questionnaires were distributed to farmers who owned paddy-fields consolidated by PC projects two years before the survey. The results of the survey are shown in Table 2. In terms of effective answers, average values of measurement variables, such as farmland area under single farmer management

Table 3. Candidates of variables for estimation in Eqs. (4) and (5)

Explanatory variables			Unit	Supply		Demand		Data source
				Mean	St. Dev.	Mean	St. Dev.	
Price of rice	(by prefecture)	P	1,000 yen/60kg	16.29	1.12	16.38	1.17	SRPC
Wage	(by prefecture)	P_L	1,000 yen/hr	1.61	0.21	1.54	0.17	SRPC
Attribute	(by farmer)							
Management scale		A_0	ha	1.30	2.25	6.40	6.11	JIID
Enlargement of A_0 ($\geq 20\%$)		A_{gress}	1 or 0	—		0.35	0.48	JIID
Steepness of the site ($>1\%$)		$Steep$	1 or 0	0.36	0.48	0.19	0.39	JIID
Age of farmer (<50)		Age	1 or 0	0.20	0.40	0.47	0.50	JIID
Geographical classification (by town)								
Suburban area		D_{SUA}	1 or 0	0.16	0.37	0.10	0.30	AC
Less favored area		D_{LFA}	1 or 0	0.37	0.48	0.44	0.50	AC
Flat farming area	Except for the above regions							
Regional dummy (by prefecture)								
Hokuriku (including 4 pref.)		D_{Hokuriku}	1 or 0	0.06	0.24	0.05	0.22	AC
Tokai (3 pref.)		D_{Tokai}	1 or 0	0.07	0.25	0.01	0.10	AC
Kinki (3 pref.)		D_{Kinki}	1 or 0	0.09	0.29	0.04	0.19	AC
Chu-Shikoku (8 pref.)		$D_{\text{Chu-Shikoku}}$	1 or 0	0.19	0.39	0.08	0.27	AC
Other regions (19 pref.)	Except for the above regions							

Data : SRPC ; *Survey of Rice Production Cost* by MAFF, AC ; *Agricultural Census* by MAFF, JIID ; Research of JIID [8].

Note : 1. "Agress" becomes 1 in the case of a farmer who enlarges his or her farmland to more than 20% after consolidation, or 0 otherwise.

2. "Other regions" consist of Tohoku (6 pref.), Kanto (7 pref.) and Kyushu (6 pref.).

and age, corresponded to the average figures of mainland Japan (*Agricultural Census in 2000*, MAFF). Hence effective data represent the actual situations of farmers, although some of questionnaire sheets were ineffective.

3. Results and Discussion

1) Estimation results of S-D functions

Table 3 shows candidates for the explanatory variables of Eqs. (4) and (5). The prices of agricultural machinery, fertilizers and pesticides were not included as candidates, because these prices corresponded to nationwide market prices and varied little between farmers (unified by the constant of the equation).

Table 4 shows estimations of the S-D functions in both N-CF and CF, respectively. The t-statistic at the 15% level was used to exclude insignificant variables. Coefficients of the proposed rental rate in both tables were significant and indicated theoretically expected signs. A comparison of N-CF and CF shows that coefficients of rental rate in CF were greater than N-CF in both S-D sides. Clearly,

both S-D farmers reacted to rental rates more sharply after the PC projects indicating lower σ in Eqs. (4) and (5). These changes are shown more concretely by the rental rate elasticity of acceptance probability at the indifferent point where acceptance probability corresponds to 0.5. The elasticity values for N-CF were 0.34 (supply) and -0.39 (demand), and those for CF were 0.44 (supply) and -0.63 (demand). Both S-D elasticity values for CF were higher than for N-CF, but all values were less than 1.0, indicating inelasticity. An inelastic structure in derived demand for farmland was also shown in previous studies on the estimated aggregate cost function or production function.⁵⁾

A positive estimated coefficient of each variable, except the price variable (the proposed rate in our case), will shift both S and D functions to the right in the price-quantity graph, increasing acceptance probabilities. If the probability is held constant, this shift tends to decrease (or increase) the price in supply (or demand), because the inclination of the probability function is positive (or

Table 4. Estimations of the supply and demand functions for FRT

Explanatory variables		Non-consolidated fields		Consolidated fields	
		Est. Coeff.	(t-statistics)	Est. Coeff.	(t-statistics)
Supply function for FRT (π^s)					
C	Constant	-4.561	(-2.4 **)	-3.635	(-1.9 *)
$\ln(B)$	Proposed rate	0.689	(16.6 **)	0.883	(19.9 **)
$\ln(P)$	Price of rice	-1.278	(-1.9 *)	-2.481	(-3.5 **)
$\ln(P_L)$	Wage	1.163	(3.4 **)	1.048	(2.5 **)
$\ln(A_0-dA)$	Management scale	—	—	-0.090	(-2.0 **)
<i>Steep</i>	Steepness	0.598	(7.3 **)	0.408	(4.7 **)
D_{SUA}	Suburban area	-0.232	(-2.0 **)	-0.264	(-2.1 **)
D_{LFA}	Less favored area	0.343	(3.9 **)	0.320	(3.3 **)
$D_{Hokuriku}$	Hokuriku	0.684	(3.6 **)	0.687	(3.7 **)
D_{Tokai}	Tokai	0.912	(6.0 **)	1.184	(7.5 **)
D_{kinki}	Kinki	—	—	0.362	(2.1 **)
$D_{Chu-Shikoku}$	Chu-Shikoku	—	—	0.383	(3.4 **)
Number of data		3,335		3,651	
Log likelihood		-2,046		-1,984	
Fraction of correct prediction		0.660		0.715	
Demand function for FRT (π^d)					
C	Constant	-4.284	(-0.7)	-12.783	(-3.1 **)
$\ln(B)$	Proposed rate	-0.885	(-6.8 **)	-1.287	(-14.5 **)
$\ln(P)$	Price of rice	4.628	(1.9 *)	8.937	(5.9 **)
$\ln(P_L)$	Wage	-7.105	(-3.9 **)	-3.772	(-3.5 **)
$\ln(A_0+dA)$	Management scale	0.670	(2.6 **)	0.825	(4.4 **)
<i>Agress</i>	Enlargement of A_0	0.502	(1.8 *)	0.692	(2.9 **)
<i>Age</i>	Age of farmer	-0.396	(-1.5)	-0.468	(-2.3 **)
D_{LFA}	Less favored area	-0.790	(-2.6 **)	—	—
Number of data		414		426	
Log likelihood		-276		-457	
Fraction of correct prediction		0.460		0.519	

Note : 1. Significant at 5% level ("***"), at 10% level ("**").

2. The probability function G was assumed to obey the logistic distribution in this case. The same tendency was found in the case of normal distribution function.

negative). A negative coefficient has reverse effects. From the signs in Table 4, the higher price of rice and lower wages encouraged both S-D farmers to easily accept a high rental rate in spite of different signs of coefficients for the estimated equations. Farmland area A had a negative effect on supply and a positive effect on demand. As discussed in the earlier section, the coefficient of this variable can take a positive or negative sign, but should take opposite signs for supply and demand. Therefore, the estimation results corresponded to the theoretical framework.

Estimated coefficients of geographical classification show that supply side farmers in suburban areas (SUA) tended to rent their paddy-fields at a high rental rate. This was because the rental rate was raised by farmers hoping the land would soon be bought by developers (Shogenji [16]). However, the situation was the reverse in less favored areas (LFA), showing that farmers are easily willing to accept a low rental rate for their land.

2) Simulation

Figure 2 shows the S-D curves calculated from Eqs. (4) and (5) in N-CF (S0, D0) and

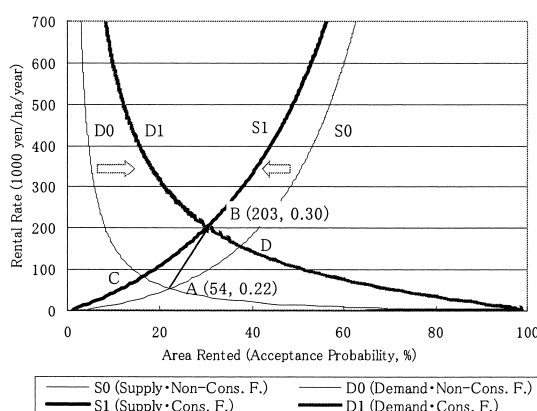


Figure 2. Changes of supply and demand in FRT by the PC projects

CF (S1, D1). Points A and B show the ideal equilibria of FRT in N-CF and CF, respectively. Comparing points A and B reveals that the rental rate increased by four times and the rental agreement level increased by 40% due to the PC projects. Point C shows the supply effect in which the demand function was stable while the supply function shifted after the projects. A comparison of points C and A clearly shows that PC projects raised the rental rate and decreased the rental agreement level on the supply side. This was because of the increased incentive to small-scale farmers restarting cultivation of their own paddy-fields when productivity of their paddy-fields was increased by the projects (JIID [8]). Furthermore, the burden of PC project costs made it impossible to rent paddy-fields to others at a low rental rate (Tanada [17]). Meanwhile, a comparison of points A and D, showing the demand effect only, indicates a large increase in both rental rate and rental agreement level. This was because large-scale farmers could attain efficient production after the projects. Consequently, the projects greatly increased the rental rate due to the interaction of S-D effects, and moderately increased the rental agreement level as the positive demand effect more than offset the negative supply effect.

Table 5, calculated from the mean value of the explanatory variables in each region, reveals that the order of simulated rental rates almost corresponded to the order of actual values. Most of the agreement levels simulated were almost the same as the actual values,

except for Tokai.⁶⁾ These results indicate that our model conforms well to the evidence. Interestingly, all rental rates increased strongly after the projects, especially in Tohoku, Kanto and Hokuriku, and all agreement levels increased moderately, especially in Tokai, Kinki, Chu-Shikoku and Hokuriku. On the whole, the eastern part of Japan, including Tohoku, Kanto and Hokuriku, showed strong project effects on rental rates rather than rental agreement levels, while the western part of Japan tended to show strong project effects on rental agreement levels rather than rental rates.

In Table 5, all simulated rental rates, i.e. ideal equilibrium values, were lower than the actual values in both cases, especially in N-CF, while in five out of seven regions the rental agreement level in the CF simulation was higher than the rate of actual level. These disparities indicate economic inefficiency caused by regulation of the government and mutual maladjustment of farmers in actual renting.⁷⁾ However, the disparity between the ideal value and actual value was far lower in CF than in N-CF. It can be said that PC projects reduced economic inefficiency in the rental market.

Table 6 shows the influences of low rice price, high wages and geographical situation on project effects. The low price of rice and the high wage rate caused low rental rates and low agreement levels in both CF and N-CF, remarkably so in CF. As a result, the effects of PC projects, shown by the difference between N-CF and CF in rental rate, were lower than the status quo, in the case of a decrease in profit of rice production relating to the price of rice and wage, especially in a lower price of rice. In terms of geographical situation, project effects on the rental rate in SUA were higher, but effects on rental agreement levels in SUA were lower than other areas. Meanwhile, the effects in LFA appeared as a rise in the rental agreement level rather than in the rental rate.

4. Summaries and Conclusions

In order to reallocate farmland to efficient farmers, improvement in Farmland Rental Transactions (FRT) cooperating with Paddy-field Consolidation (PC) projects, is one of the most important policy issues in Asian

Table 5. Regional effects of the PC project (at equilibrium)

(1,000 yen/ha/year, %)

Regions	Simulation rental rate			Simulation agreement level (%)			Actual value		
	Non Cons. fields (N-CF)	Consolidated fields (CF)	CF— NCF	Non Cons. fields (N-CF)	Consolidated fields (CF)	CF— NCF	Rental rate		Agreement level (CF, %)
							N-CF	CF	
Tohoku	81	261	180	22.2	27.0	4.8	195	288	31.2
Kanto	49	212	163	19.0	24.7	5.7	188	220	22.2
Hokuriku	41	251	210	28.0	41.3	13.3	169	258	40.7
Tokai	44	169	125	33.0	47.1	14.1	137	210	10.7
Kinki	23	157	134	14.0	29.8	15.8	97	170	43.1
Chu-Shikoku	33	142	109	20.0	33.0	13.0	102	190	18.4
Kyushu	69	191	122	20.0	25.0	5.0	146	238	20.6
Whole	54	204	150	22.0	30.0	8.0	148	225	26.7

Note : 1. Actual values of agreement level were calculated as follows with research data (JIID [8] and [9]).

- Number of parcels owned by small farmers \hat{M}^s = (possession areas of small farmers) ÷ (one parcel area of paddy-field), taking it as total parcels for rental transactions.
- Number of parcels rented by large farmers \hat{M}^d = (area rented by large farmers) ÷ (one parcel area of paddy-field).
- Agreement level in actual market = \hat{M}^d / \hat{M}^s .

2. The estimation values are calculated by using the average values of explanatory variables in each region.

Table 6. Influence of outside factors on effects of the PC project

Outside factors	Rental rate (1,000 yen/ha/year)			Rental agreement level (%)		
	N-CF	CF	CF—NCF	N-CF	CF	CF—NCF
Decrease in rice price (−5%)	44	156	112	21.0	28.0	7.0
Increase in wages (+5%)	42	183	141	20.0	29.0	9.0
Suburban areas	82	239	157	21.0	26.0	5.0
Less favored areas	35	182	147	21.0	33.0	12.0
Whole (correspond to the status quo.)	54	204	150	22.0	30.0	8.0

monsoon regions as well as in Japan. This study analyzed FRT under a regulated market and evaluated the effect of PC projects by modeling both supply and demand sides of farmland renting with micro-data from a discrete choice type questionnaire.

One remarkable result is that PC projects appeared to cause a marked increase in the rental rate due to the interaction of S-D effects, and caused a moderate increase in the rental agreement level due to a negative effect on the supply side overwhelmed by a stronger positive effect on the demand side. A second result is evidence of economic inefficiency that was caused by regulation of the

government and maladjustment of farmers. This may have increased transaction costs in the actual rental market. However, inefficiency can be reduced by the PC project stimulating major changes in farmland conditions and providing incentive to farmers to rent their farmland from others. The third result is that regional differences in agricultural and social situations led to regional differences in project effects. Effects in the eastern part of Japan tended to appear as high rental rates, because both S-D farmers had a strong desire to continue their cultivation supported by the high price and monoculture of rice. Meanwhile, the project effects in the

western part of Japan appeared through an increase in the rental agreement level, because the small average farmland area and large varieties of crops made it easy for farmers to rent their paddy-fields to other farmers. Finally, a decrease in the price of rice reduced project effects. This may be a dilemma because PC projects are needed to improve rice productivity whereas a decrease in rice price due to high rice productivity results in negative effects of the PC projects. Furthermore, a change in the project site from suburban areas to less favored areas makes the project effect appear in the rental agreement level rather than the rental rate. This suggests that PC projects can effectively prevent farmland abandonment caused by a lack of demand for rental farmland in less favored areas.

From above findings, we can conclude that applying the discrete choice model to a regulated market is useful for analyzing the capitalization mechanisms of PC projects and evaluating causative factors in FRT. Given that the agricultural sector is subject to regulations in many dimensions, this model may be applicable to other analyses, such as the price of water which has not been evaluated empirically but constitutes an important factor in agricultural production, effects of public investment in dry fields, and FRT in other countries. Nevertheless, there is a need for further investigation, such as the application of other distribution functions to the model, improvement of questionnaire items and a test for homogeneity in the regional market structure.

- 1) This paper draws heavily on Kunimitsu [11].
- 2) Farmland areas consolidated by PC projects were shown by *Wagakuni Nochi no Genjyo* (Situations of Recent Consolidated Farmland, MAFF, 1993).
- 3) Estimations for the production functions ignored technological gaps between farmers and assumed the same production structure of each farmer, because technological gaps were rarely measured in the actual statistics. However, the estimations without consideration of technological gaps differed from production frontiers and included biases as mentioned by Kumbhakar [10].
- 4) According to the data on site, the rate, n , is approximately eight on average. That is, one

large-scale (demand side) rented from eight small-scale farmers (supply side). This rate differs between sites in the project, but appears stable for many years due to little entry or exit of farmers. Therefore, rate n rarely affects equilibrium values even in actual transactions. The actual rental market may be too small to ensure market equilibrium, but Rustichini, Satterthwaite and Williams [15] showed that the indeterminacy or inefficiency caused by trader bargaining behavior in a small market vanishes rapidly under a uniform price double auction with more than six or three traders per side.

- 5) Elasticity in this paper is different from that in the conventional production function, but the following features were found if this point was ignored for the comparison. That is, the elasticity for factor demand for paddy-fields estimated by Ito [7] during the period 1988-90 was 0.06-0.69 for small-scale farmers and 0.72-0.84 for large-scale farmers. These values are similar to the estimation values calculated in this study for 1999. Godo [4] also showed that the value of elasticity for large-scale farmers was larger than that for small-scale farmers.
- 6) Many cooperative agricultural production groups were established in the Tokai region, and their management area exceeded the project site. The large area under cultivation makes the number of data lower than in other regions. Therefore, the actual value of the area rented in Table 5 has some limitations.
- 7) Many researchers pointed out the probability of obstacle for rental transactions which relate to the institutional regulation in notification of rental transactions to the local committee, and costs of searching for lenders (Hayami and Godo [6]).

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