Farmer's Price Response, A Study on Acreage Determination of Rice in Japan, 1883-1969. *

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Contents

This paper presents some estimates of the short-run and long-run price elasticities of acreage supply of rice derived from time series data of Japan. The regression analysis is applied to the three periods of 1883-1919, 1919-1939 and 1955-1969.

The model used is the Nerlovian adjustment model which allows the adjustment to changes in the price to be spread over more than just one year. In recent years, the same model has been adopted, by many economists, to data of various countries with a common intention: to see whether farm producers behave rationally to changes in

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market price, and from there, to derive arguments for price policies or national economic programs. Although the striking development of agriculture in Japan has attracted attention of the world and here, there are relatively abundant data relevant, very few of such studies can be found in Japan. 1965, Mr. Y. Yuize released a series of his works concerning various agricultural commodities of Japan during the period 1952-1962. However, this series of works done by Mr. Yuize does not provide encouraging results. Most of the parameters are not significantly nonzero at low level.

In most of the regression functions reported in this paper, besides the relative price and the area planted of the previous year of rice, which are automatically included in an adjustment model, the yield per unit of area planted in rice and the total planted area of all agricultural commodities are also included as explanatory variables. The results are encouraging, and all the coefficients seem reasonable for the three periods concerned.

I - The Nerlovian Model

The theory of the firm shows that when price of a product rises, its output increases, and the change in the input of a factor whose price alone rises is of opposite sign [1]. However, it will be recalled that those results are derived from the purely theoretical analysis based upon the assumption that the price vector is already known at the time the producing process takes place. The analysis does not refer to the relation between expected prices and actual prices under uncertainty. Neither does the analysis mention any special relationship between actual output and desired output. Further, the definite statement on the sign to change in output (or input) of the product (or factor) is obtained under assumption that nothing but the price of the product (or factor) in question has changed.

In empirical analysis, to overcome the problems above mentioned, it is desirable to

a) - include important explanatory variables to the supply function,

b) - use the expected price instead of the actual price as the price variable of the initial supply function,

c) - make distinction between the short - run and long - run elasticities.

Now, if we put:

X_t: actual supply quantity at time t,

X_t^*: desired supply quantity at time t,

P_t: actual relative price of the product at time t

P_t^*: expected relative price of the product at time t,

$Z_1, Z_2, \ldots, Z_k$: explanatory variables other than P_t .

U_t: disturbance term,

B : a constant

$b_1, b_2, \ldots, b_k$: constant coefficients,

β : a constant called the coefficient of expectation,

γ : a constant called the coefficient of adjustment,

then, the supply function, the definitive equations of expected price and desired output can be expressed as follows:

(Supply function) $$X^* = BP_t^{*\ b1} Z_2^{b2} Z_3^{b3} \ldots Z_k^{bk} \quad (1)$$

(Expected price) $$\left(\frac{P_t^*}{P_{t-1}^*}\right) = \left(\frac{P_{t-1}}{P_{t-1}^*}\right)^{\beta} \quad (2)$$

(Desired output) $$\left(\frac{X_t}{X_{t-1}}\right) = \left(\frac{X_t^*}{X_{t-1}}\right)^{\gamma} \quad (3)$$

If lower case letters stand for the logarithms,

$$x_t^* = b_0 + b_1 p_t^* + b_2 z_2 + \ldots + b_k z_k + u_t \tag{1'}$$

$$p_t^* - p_{t-1}^* = \beta(p_{t-1} - p_{t-1}^*) \tag{2'}$$

$$x_t - x_{t-1} = \gamma(x_t^* - x_{t-1}) \tag{3'}$$

Now, if we put $\beta = 1$ (consider the previous year price as the subjective normal price of farm producers), some manipulations reduce eqs. (1'), (2)', (3') to a single equation, which includes observable variables only:

$$x_t = \gamma b_0 + \gamma b_1 p_{t-1} + (1-\gamma) x_{t-1} + \gamma b_2 z_2 + \ldots + \gamma b_k z_k + u_t \tag{4}$$

where, b_1 = long-run price elasticity of supply,

γb_1 = short-run price elasticity of supply.

The equation (4) represents the regression equation used in this paper.

II - Variables and Data

X_t : Area planted in rice at time t,

P_{t-1} : Relative price of rice with price index of non-rice agricultural commodities as deflater,

X_{t-1} : Area planted of rice of the previous year,

Y_{t-1} : Yield per unit of area planted of rice in the previous year,

A_t : Total planted area of all agricultural commodities,

D : Dummy variable,

t : Time trend.

This analysis is about the price response on acreage determination. Therefore, the dependent variable must be that of area planted of the the selected crop (in this case, of rice) and price must be included as the main explainatory variable, Further, the model used is that of Nerlove in which, automatically, the area planted in rice of the previous year becomes an independent variable. Thus, it is not necessary for us to stop long with these variables. Problems, if there are, may occur with those variables left, including time trend t, yield Y_{t-1}, dummy variable D and total area planted A_t. We now turn on them.

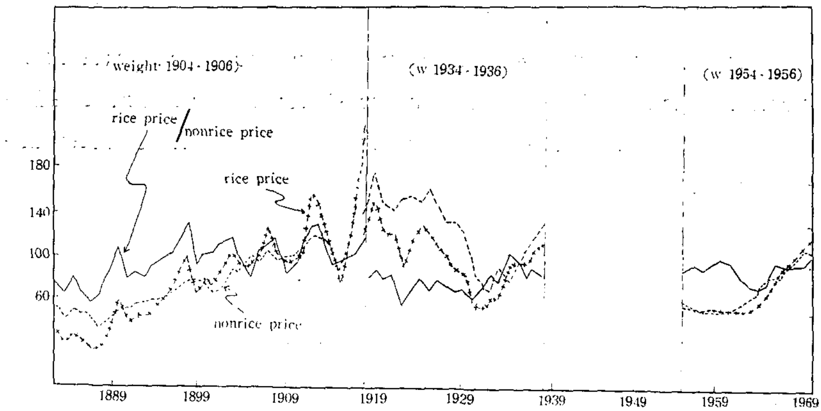


Figure (1) - The rice - nonrice price index
Sources: 1883 - 1939 Choki keizai tokei
1959 - 1969 Noson bukka chingin tokei

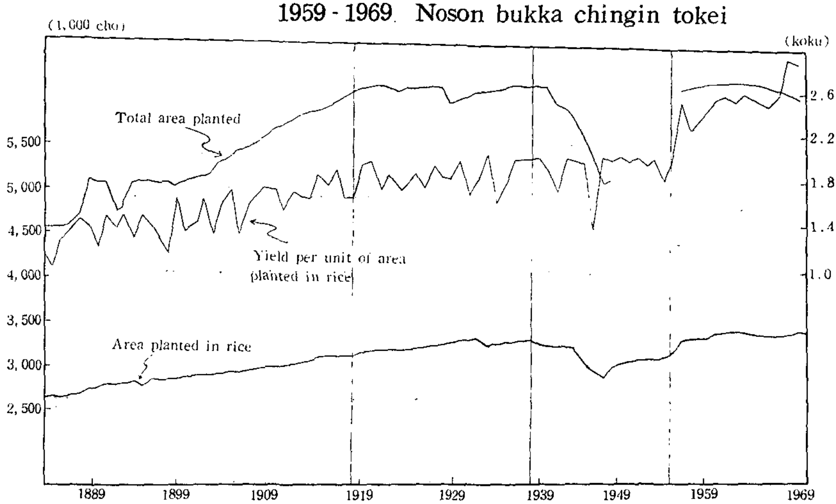


Figure (2) - Area planted and yield
Source: Norinsho tokeihyo

The yield per unit of area planted is introduced due to the belief that a part of the technological changes, which revealed in this variable has substantial influence on the acreage determination of farmers. Even-though the prices are kept constant, farmers can get more profit if they increase the area planted of the crop whose yield rises and decrease that of the crop whose yield falls. Under a price system with serious uncertainty, it is thought that farm-producers rather maximize their profit by altering resources according to the variations of yields of the crops planted.

For some reason, the total area planted increases, even relative price and yield are kept unchanged, the area planted in the selected crop must be increased to maintain the marginal conditions for profit maximum. This may be the case of the period 1883-1919. In the last period, specially from 1960's, the urgent urbanization of the main towns and villages and the industrialization invaded a substantial cultivatable area. The total area planted of all crops narrowed year after year. With the total area planted included as an explanatory variable, we expect to be able to obtain better estimates for most regression parameters. Besides, how the coefficient of adjustment and the parameter of time trend change themselves when the total area planted is included will be of interest too.

In the period II, the area planted in rice rised up smoothly till 1929, where it suddenly increased unusually. After the year 1932, this area inversely decreased in an abnormal way. To exclude this influence of the economic depression, I introduce the dummy variable to the supply function of the second half of the second period (for the years 1929, 1930, 1931, 1932).

Finally, the acreage supply functions with the input price index used as the price deflater are not provided in this paper for one reason. That is, theoretically, variations in this index rather give changes in the productive amount of the selected product. Since a change in the input price index is believed to have equal effects on all agricultural commodities, it must not alter the area planted in any selected crop, assuming other things being constant.

The figures of all data for the three periods concerned are illustrated in Figure (1) and Figure (2).

III - Estimates

The results of the computations performed are presented in Table (1) and Table (2). Table (3) illustrates some estimates of elasticities computed by other authors from data of some other countries for the purpose of inter-regional comparisions. The following main points may be derived from the figures showed in these tables:

(1)-The coefficient of the price variable is significantly positive at 2.5% or 5% level for all selected periods. The short-run price *elasticity of supply is relatively low in the first period and the first* half of the second period. In the post-war period, both the short-run and long-run price elasticities of supply appear substantially high.

(2)-The coefficient of adjustment is approximatly equal to 1 during the period 1928-1939. It is believed that this surprisingly high figure is due to chaos occuring in these years when high mobility of productive factors prevented farmers from planning long-run projects. In the post-war period, the supply function which includes the total area planted of all commodities offers a rather high coefficient of adjustment. However, the coefficient of adjustment obtained from the supply function without the total area planted included as independent variable is low. It seems that the industrialization (in the sense it narrowed the planted area) has lowered this coefficient.

(3)-The coefficient of yield per unit of area planted is significantly positive at low level.

Table 1 - Acreage Response Functions

Periods	Regression Coefficients of p_{t-1} (γb_1)	x_{t-1} $(1-\gamma)$	Y_{t-1} (γb_2)	A_t (γb_3)	t (γb_4)	D (γb_5)	Constant (γb_0)	R^2	d
1883–1919	.0157*** (.0062)	.6813*** (.0637)	.0105 (.0085)	.1535*** (.0345)			.1390	.9929	1.50
1918–1928	.0062*** (.0024)	.4659*** (.1263)	.0220*** (.0047)		.0082*** (.0016)		.4977	.9948	1.64
1919–1939 — 1928–1939	.0506** (.0241)	.0678 (.1395)	.0498* (.0277)	.8268*** (.2221)		.0161*** (.0025)	–.0111	.9381	2.54
1955–1969 (1) a)	.0435*** (.0181)	.8940*** (.1622)	.0202 (.0217)		–.0053** (.0027)		.0476	.8021	1.58
1955–1969 (1) b)	.0597*** (.0177)	.6498*** (.1865)	.0502** (.0240)	.4013** (.2020)	–.0012 (.0031)		.1599	.8685	1.70

***, **, *: t-tests indicate that these estimates are significantly non-zero at respectively 2.5%, 5%, 10% levels.

a) the total area planted is not included.

b) the total area planted is included.

(1) If X stands for the ratio of area planted in rice to the total area planted the response function for the period 1955 - 1969 would be:

$$x_t = .3880 + \underset{(.0147)}{.0607^{***}}\, p_{t-1} + \underset{(.1696)}{.4831^{***}}\, x_{t-1} + \underset{(.0252)}{.0643^{***}}\, Y_{t-1} + \underset{(.0026)}{.0038^{*}}\, t$$

$$R^2 = .9532$$

Table 2 - Short - run and Long - run Elasticities.

Periods	γ	P_{t-1} SR	P_{t-1} LR	Y_{t-1} SR	Y_{t-1} LR	A_t SR	A_t LR	t SR	t LR	D SR	D LR
1883–1919	.3187	.0157	.0492	.0105	.0331	.1535	.4815				
1918–1928	.5341	.0062	.0117	.0220	.0412			.0082	.0153		
1928–1939	1.0000	.0506	.0506	.0498	.0498	.8268	.8268			.0025	.0025
1955–1969	.3502	.0597	.1705	.0502	.1434	.4014	1.1462				

Note - The elasticities of the period 1955 - 1969 are computed from the supply function (b) of Table 1.

SR: Short - run

LR: Long - run

P : Relative price — Y: Yield

A : Total area planted — t : time trend

D : Dummy — γ : coefficient of adjustment

Table 3 - Inter - regional comparisions.

Country and Commodity		Elasticity Short - run	Long - run	Source
Rice				
Punjab	1914 - 1945	.31	.59	Krishna, 1963
Indonesia	1951 - 1962	.30		Mubyarto, 1965
Philippines	1947 - 1963	—	—	Mangahas et al.,
Illocos	1954 - 1964	.22	.51	1965
C. Luzon	1954 - 1964	.13	.62	
S. Tagalog	1954 - 1964	.24	.42	
E. Visayas	1954 - 1964	.13	.15	
Cagayan	1954 - 1964	—	—	
Japan	1883 - 1919	.05	.17	Le Thanh Nghiep,
	1918 - 1928	.10	.18	1972
	1928 - 1939	.97	.97	
	1955 - 1969	.61	2.52	
Wheat				
U. S. A.	1909 - 1932	.48	.93	Nerlove, 1958
United Kingdom	1924 - 1939	.33	.46	Jones, 1962

Notes: Figures about Japan are computed from standardized regression coefficients of the linear function (of original data)

$$X_t = \gamma b_0 + \gamma b_1 P_{t-1} + (1-\gamma) X_{t-1} + \gamma b_2 Z^2_{t-1} + \ldots + \gamma b_k Z^k_{t-1} + U_t$$

-: minus value

(4) - The total area planted proves its great influence upon the level of area planted in rice in most periods. (During 1918 - 1928, since there is no substantial variation in this variable, the relevant coefficient is low and the variable was excluded.) Further, with the addition of the variables of total planted area and yield per unit of area planted, the coefficient of the relative price gets stable.

(5) - The coefficient of the Dummy variable is significantly non-zero at 2.5% level.

IV - General Conclusions

The following 4 points can be derived as conclusions:

First, the results of this work show positive responses of farm producers to price movement for the three selected periods. This evidence of the first two periods supports the recent presumption in favor of the responsiveness of crop supply to prices in low income areas. Again, our results suggest that by appropriate manipulations of the economic environment we can change farmers actions to obtain public goals.

Second, the regressions imply a substantially higher price elasticity in the long - run than in the short - run (except in the period 1928 - 1939). Since the adjustment needs more than one year to be completed, it seems desirable to keep any stabilized price unchanged through an appropriate number of years.

Third, the price elasticity of supply is rather low during the period 1883 - 1919. Farmers in traditional societies usually demonstrate low response to price changes. This is probably due to the low rate of merchandization of the relevant crop, deficiencies in price information and the uncertainty of prices existing in those societies.

Fourth, it is commonly said that the more correctly we are able to specify the relevant non-price variables, the more significant are the regression coefficients of the price variable that we get. We might have been right for using the variables of yield and total area planted instead of the single variable of time trend to present structural and technological changes in the periods of 1883-1919 and 1955-1969.

V-In Connection With Agricultural Price Policies

The short-run and long-run supply elasticities presented in Table (2) were calculated under the assumption that farm-producers act as if the previous year actual price is their subjective normal price for the selected product. In fact, specially when the fluctuations in prices are serious, the coefficient of expectation is believed to be far smaller than 1 and the real price elasticity of supply, assume it is measured by a full nonlinear model [2] , is considered to be greater than that calculated from the adjustment model used in this paper. Thus all estimates of price elasticities illustrated in Table (2) do not tell us, in the strict sense, the response abilities of Japanese farm-producers during the relevant periods. Instead, we rather consider those figures as the manifestations of farmers' response under the periods concerned.

In assuming that the more prices are fluctuated the smaller is the value of the expectation coefficient, we are going to examine the sources of fluctuations in farm incomes.

1)-Price Uncertainty and Farm Income

Assumed perfect market, Figure (3)

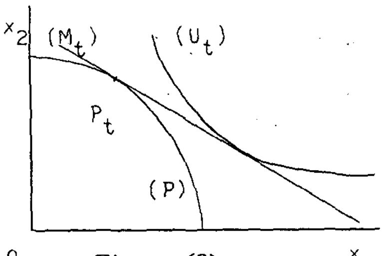


Figure (3)

Figure (3) illustrates

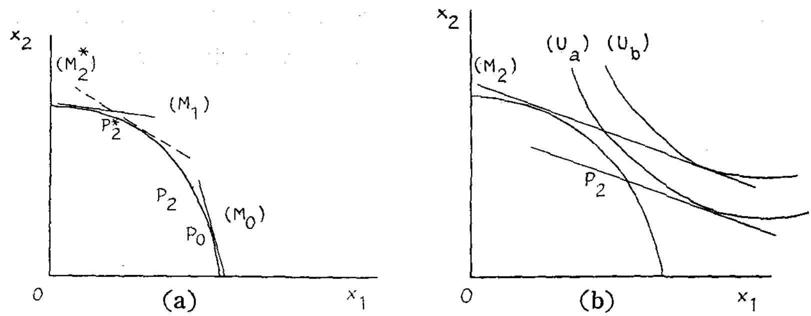
- 2 products, x_1 and x_2,
- P_0, initial endowed wealth,
- (P), the production curve,
- (M), the market line,
- (U), the utility curve

of the individual i.

At time t, under the assumed perfect market, when the market line is at (M_t), the individual i produces the product combination P_t and obtain his optimum utility (U_t)

Actual market, Figures (5-a) and (5-b)

At time t_0, the actual and expected relative prices are consistent each other at (M_0). The actual and desired output are assumed to



(a) (b)

Figure (4)

coincide at P_0. At time t_1, therefore, the expected price and the desired output must rest unchanged. However at time t_1, the actual relative price moves to (M_1). This variation in the actual relative price at time t_1 causes a change in the expected price and the latter comes to (M_2^*) for time t_2. However, since the mobility of input factors is lower than 1, the actual output provided for time t_2 is P_2. If the actual market line at time t_2 is (M_2) the actual income that farmer i obtain at t_2 must be (U_a). Clearly, this level of income is lower than that could be obtained under the perfect market. Further, since farm incomes are always in accord with the actual market prices, fluctuations in market prices lead to permanent fluctuations in farm incomes.

2・Price Stabilizing and Farm Income

In the previous section we have come to such conclusion that under the free market farm incomes are usually lower than those obtained under the assumed perfect market. Farm incomes are also considered to be fluctuated in accord to variations in the prices of agricultural products. It is almost a common belief that those fluctuations of farm incomes could be reduced to some lavel by price stabilizing measures. The situation can be explained, using our words of the Nerlovian model as follows. The policies increase the coefficient of expectation, and from there, make the expected and actual prices coincide with each other. Further, when a price rests fixed for a considerable time, the actual output approaches the desired output.

NOTES

〔1〕- Suppose that the firm's production is always on a production function:

$$f\,(x_1, x_2, \ldots, x_q) = 0 \tag{1}$$

which is at least twice differentiable and on the bounday of the closed convex production set. Now, let

$$X = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_q \end{pmatrix}, \quad P = [p_1 p_2 \ldots p_q]$$

represent respectively commodity vector and price vector of the firm. X is a column vector and P is a row vector. Now, like Hicks, treating input factors as negative products, the profit function can be expressed as follows:

$$V = \sum_{r=1}^{q} p_r x_r = PX \tag{2}$$

The firm is to maximize $V = PX$ subject to $f(X) = 0$. Thus, we obtain the first conditions (necessary conditions) for profit maximum:

$$\begin{aligned} p_r &= \lambda f_r \qquad r = 1, 2, \ldots, q \\ f\,(X) &= 0 \end{aligned} \tag{3}$$

- the sufficient condition for profit maximum:

$$\begin{vmatrix} 0 & f_1 \\ f_1 & f_{11} \end{vmatrix} < 0, \begin{vmatrix} 0 & f_1 & f_2 \\ f_1 & f_{11} & f_{12} \\ f_2 & f_{21} & f_{22} \end{vmatrix} < 0, \ldots, \begin{vmatrix} 0 & f_s \\ f_r & f_{rs} \end{vmatrix} < 0 \qquad (4)$$

If the price vector changes, our assumption imply that the firm will respond by altering its combination of resources in such a way that the marginal conditions continue to be satisfied.

Differentiate (3) totally,

$$dp_r = f_r d\lambda + \lambda \sum_{s=1}^{q} f_{rs} dx_s \qquad (r=1, 2, \ldots, q)$$

$$\sum_{s=1}^{q} f_s dx_s = 0 \qquad (5)$$

(5) can be expressed differently as follows:

$$\begin{pmatrix} 0 & f_s \\ f_r & \lambda f_{rs} \end{pmatrix} \begin{pmatrix} d\lambda \\ dx_s \end{pmatrix} = \begin{pmatrix} 0 \\ dp_r \end{pmatrix} \qquad (6)$$

where r, s=1, 2, . . . , q. Now, let

$$G = \begin{vmatrix} 0 & f_s \\ f_r & \lambda f_{rs} \end{vmatrix} = | g_{ij} |$$

where r, s=1, 2. . . . , q and i, j=1, 2, . . . , q+1. Then by Cramer's rule

$$dx_s = \frac{\sum_{r=1}^{q} dp_r G_{rs}}{G} \qquad (7)$$

where G_{rs} is the cofactor of element $g_{ij} = g_{r+1, s+1}$ in the matrix [gij].

Now, if we put

$$F = \begin{vmatrix} 0 & f_s \\ f_r & f_{rs} \end{vmatrix}$$

and if F_{rs} represents the cofactor of f_{rs}, then equation (7) reduces to

$$dx_s = \frac{\sum_{r=1}^{q} F_{rs} dp_s}{\lambda F} \tag{8}$$

Epuation (8) expresses the change in output or input of the commodity s when price vector P changes and marginal conditions (3) are to be met. In the absence of special knowledge, it is impossible to place a sign upon equation (8). However, if the price of the rth resource alone increases, then if it is a product its supply increases and if it is a factor its input decreases. Let $dp_r = 0$ for all $r \neq s$ and $dp_r \neq 0$ for $r = s$. Then,

$$dx_r = \frac{F_{rr} dp_r}{\lambda F} \tag{9}$$

or.

$$\frac{\partial x_r}{\partial p_r} = \frac{F_{rr}}{F} > 0 \tag{10}$$

Since,

$$F_{rr} < 0$$
$$F < 0$$
$$\lambda > 0$$

(10) implies:

—when price of a product rises, its output increases,

—and since factors are treated as negative products, the change in the input of a factor whose price alone rises is of opposite sign.

As being mentioned in chapter II, it will be recalled that the previous analysis is based upon the assumption that the price vector is already known at the time the producing process takes place. We did not refer to the relation between expected prices and actual prices under uncertainty. Neither did we mention any special relationship between actual output and desired output. Further, the definite statement on the sign of change in output (or input) of the rth product (or factor) expressed in equation (10) has been obtained under the assumption that nothing but the price of the rth product (or factor) has changed.

〔2〕 See, for example, J. R. Behrman, Supply Sesponse in underdeveloped Agriculture (North-Holland, 1968)