ECONOMIC EFFECTS OF GOVERNMENT INVESTMENT IN FARM MECHANIZATION

—A Japanese Experience—

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Introduction

The purpose of this analysis is to econometrically clarify how the agricultural policy of Japan, through the government expenditures and government loan, has contributed to the capital formation of farm equipment mechanization. To be more specific, this paper describes a case study, which intends to clarify how the land consolidation and irrigation-drainage projects[1] in a major rice farming area have contributed to the capital formation of mechanized farm equipment. The contribution has been analyzed in relation to the economic circulation process involving agricultural investment, production, consumption, and loans.

This analysis has been conceived to assist the "Green Revolution" in Southeast Asia. We have already learned that variety control of crop and livestock, chemical fertilizer investment, and farm mechanization alone are not enough to achieve increase in the food production. Due to this, it is a prevailing trend in these countries to place more emphasis on investment in land improvements, such as irrigation-drainage and land consolidation projects.

This paper will illustrate Japanese experience on how its farm mechanization has been induced through the irrigation-drainage and the land consolidation projects and should provide Southeast Asian countries with reference data for the mechanization of their rice farming in the future.

Prior to the main part of this report, brief explanations will be given on :

(1) the relation between the farm operations, farm house-hold economy, and the government sector ;

(2) the relation among the capital formation through land improvement

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1. Most of them consists of irrigation projects.

TABLE 1. Social accounts on agriculture

to \ from		Agricultural Production	Farm Household Economy	Capital Formation
Agricultural Production			·Home Consumption 8,513	·Increased Value of Livestock and Plants 2,014 ·Increased Stock of Agricultural Products 270 Subtotal 2,284
Farm Household Economy		·Agricutural Income of Self-employed Farmers 45,102 ·Land Rent 340 Subtotal 45,442	·House Rent 11,414	
Capital Formation		·Capital Consumption Allowance 8,175	·Farm Households Ordinary Surplus 30,111 ·Capital Consumption Allowance 2,881 Subtotal 32,992	
Government		·Indirect Texes 3,974 ·Current Subsidies (deduction) △1,691 Subtotal 2,283	·Direct Taxes and Obligations 9,234 ·Other Transfers from Farm Households to Government 14,044 Subtotal 23,278	
Non-agricultural Sector	Current	·Agricultural Consumption Expenditure 32,861 ·Compensation of Emploees 1,328 ·Corporational Income 2,047 ·Interests 1,498 Subtotal 37,734	·Farm Household Consumption Expenditure 149,646 ·Transfers from Farm Households to Non-farm Households 4,622 Subtotal 154,268	·Agricultural Fixed Capital Formation 24,827 ·Farm Household Fixed Capital Formation 14,246 Subtotal 39,073
	Assets			·Farm Households Fund Surplus 22,036 ·Increased Stock of Agricultural Materials △87 ·Adjustment Items 8,345 Subtotal 30,294
Grand Total		93,634	230,465	71,651

Source: Social accounts of agriculture and households, Ministry of Agriculture, For-

and government (Japan in 1976)

Government	Non-agricultural Sector		Grand Total
	Current	Assets	
	·Value of Agricultural Products Sold 82,837		93,634
·Transfers from Government to Farm Households 21,281	·Wages and Salaries 118,476 ·Non-Agricultural Income from Side Job 8,680 ·Allotted Interests 9,226 ·Rent of Leased Land 1,308 ·Transfers from Non-farm to Farm households 2,511 ·Other Non-agricultural Net Income 3,334 ·Interests on Debt (deduction) △1,207 Subtotal 152,328		230,465
·Subsidies 8,024	·Capital Consumption Allowance (deduction) △335	·Value of Fixed Capital Sold (Exclude Land) 1,460 ·Value of Land Sold 21,355 Subtotal 22,815	71,651
			25,561
			231,075
			30,294
29,305	234,810	22,815	

estry and Fisheries (Unit: 0.1 billion yen).

and purchase of farm machines and equipments, and the government expenditures;

(3) the role of government sector in the whole agricultural loan.

First, the interdependent relationships between the farming and farm household economy and the government policy are shown in Table 1. In 1976, the government expenditures to the agriculture and farm household sector in the forms of transfer payment and the capital formation amounted to 12.9 billion dollars (225 yen to one U. S. dollar) and the tax payment from the farm household to the government was 11.1 billion dollars. Thus, government paid a surplus of 1.8 billion dollars.

The sum of government expenditures (as subsidies) and loan has reached a level as high as 40% of the fixed agricultural capital (Table 2). The ratio of farm machine and equipments to the total fixed capital has increased to 35% (Table 3).

In the national agricultural budget general account, the percentage of the expenditures for the land improvement is 23%, while that for the promotion of mechanization is less than 0.1% (Table 4).

Approximately 90 percent of the land improvement expenditures comes from government investment (Table 5). About 50% of the expenditures is devoted to the land consolidation project (Table 6). The government burden in the investment for equipment mechanization is somewhere around 1%. On the other hand, however, the proportion of the government loan in the farm household loan in Hokkaido is as high as 46%, whereas the national average is 16% (Table 7). The ratio of the national government expenditures for agriculture to the income from agricultural sector is 25%, a level lower than those in West Germany, Britain, and the United States. (See Figure 8).

Thus, whereas the government expenditures occupy only a small fraction in the purchase power of farm machines and equipments, the inducement by land improvement project and the government loan appear to have significant influence. Also notable is the fact that rice accounts for 40% of the agricultural value production in Japan (Table 9). In 1979, the overproduction of rice amounted to as much as 6.5 million tons. The history of rice farming in Hokkaido is only 80 years old, but Hokkaido accounts for 7% of the national rice production and its average cost of rice production is the lowest in the nation.

This case study selected as its survey object Fukagawa area, which now forms a major granary zone as the result of rapid increase in rice production after World War II. The area contains city of Fukagawa and Moseushi

TABLE 2. Agricultural investment and government expenditures (Unit: 0.1 billion yen)

Items \ Year	1960	1965	1970	1973
Agricultural Investment (A)	4,995	9,685	17,755	25,503
Government Subsidies (B)	703	1,650	3,132	6,048
Government Loan (C)	473	1,475	2,896	4,310
B/A (%)	14.1	17.0	17.6	23.7
C/A (%)	9.4	15.3	16.4	16.9
B+C/A (%)	23.5	32.3	34.0	40.6

Source: Same as Table 1.

TABLE 3. Percentage distribution of agricultural fixed capital formation by items

	1965	1970	1976
Agricultural Fixed Capital Formation	100.0	100.0	100.0
Land	34.7	31.2	37.5
Building	28.5	34.2	20.9
Agricultural Machine	24.6	24.6	34.9
Plants	7.2	5.2	2.7
Livestock	5.0	4.8	4.0

Sourco: Same as Table 1.

TABLE 4. Percentage distribution of national budget for agriculture (Unit: %)

	1960	1965	1970	1977
① Production Policies	60.97	46.89	42.52	45.76
Ⓐ Improvement of Agricultural Land	27.97	26.08	20.48	22.80
a Land Improvement Works	17.39	16.70	16.11	19.06
② Agricultural Structure Improvement	2.91	5.82	3.88	5.12
Ⓐ Promotion of Farm Mechanization	0.18	0.21	0.05	0.05
③ Price and Income Policies	26.14	40.36	47.10	39.81
Ⓐ Foodstuff Control	20.92	41.33	42.32	32.49
④ Welfare Policies	0.36	0.39	0.64	1.29
⑤ Others	9.62	6.54	5.86	8.02
Total	100.00	100.00	100.00	100.00

Source: Japanese Agricultural Year Book

TABLE 5. Sources of the burden of land improvement works

	Government	Farmers
1960	83.9%	16.1
1965	85.7	14.3
1970	80.6	19.4
1976	87.6	12.4

Source: Same as Table 1.

TABLE 6. The relative size of land improvement works (%)

	1960	1976
1. Land Improvement (Total)	45.4	67.0
Ⓐ Land Consolidation	14.1 (31.4)	50.4 (75.1)
Ⓑ Irrigation and Drainage	31.3 (68.6)	16.6 (24.9)
2. Agricultural Land Construction	23.4	13.4
3. Prevention of Disasters	6.0	6.8
4. Reconstruction from Disasters	25.2	12.8
Total	100.0	100.0

Source: Same as Table 1.

TABLE 7. Percentage shares of farm debts (1978)

	Government Fund	Fund from Agricultural Cooperatives	Farm Debt
			Farm Deposit & Savings
① Whole Country	15.7	53.9	16.7
② Hokkaido	45.9	42.6	69.5
Ⓐ Rice Farm	38.5	39.5	64.0

Source: Farm Household Economy Survey by the Ministry of Agr., Forestry and Fisheries.

TABLE 8. Government expenditures for agriculture as a proportion of agricultural income

	National Government Expenditures for Agriculture as a Proportion of Agricultural Income						National Government Expenditures for Agriculture as a Proportion of Total National Government Expenditures	
	1965		1968		1971		1971	
U. S. A.	'64	35.5	—		36.9		'71-73	4.5
U. K.	'64	56.4	54.9		48.6		'76	2.0
Australia	'66	6.9	—		22.0		'72	2.0
Netherlands		—	—		29.3			—
Canada	'66	15.5	21.5		23.9		'71	1.9
Sweden		—	—	'70 '71 '72	11.7 15.9 19.3		'72	2.6
West Germany		—	37.9		38.0		'71/'72	2.0
Japan		12.6	'69	17.7	25.3			11.5
France	'65	36.6	—	'73/'72	36.7		'73/'72	11.1

Source: OECD, Agricultural Policies in 1966, OECD, OECD Agricultural Policy Reports 1973-74. Minstry of Agriculture, Forestry and Fisheries, Statistical Yearbook of Ministry of Agriculture, Forestry and Fisheries.

TABLE 9. Percentage distribution of the value of production by major commodities

Items \ Year	1960	1965	1970	1976
Rice	48.4	44.1	37.8	35.2
Wheat and Barley	5.6	3.0	1.0	0.6
Miscellaneous Cereals and Pulses	2.9	1.8	1.3	0.9
Potatoes and Sweet Potatoes	3.1	2.6	1.7	1.5
Vegetables	8.5	12.0	15.8	17.1
Fruit and Nuts	6.2	6.8	8.5	8.2
Industrial Crops	4.5	5.0	4.4	4.8
Sericulture	3.0	2.4	2.7	1.7
Milk	2.6	3.8	5.0	5.9
Eggs	5.3	6.5	6.8	5.5
Others	9.9	12.0	15.0	18.6

Source: Same as Table 1.

TABLE 10. Number of major agricultural implements in 1975

	Under to H. P.	10~20	20 H. P. and Over	Total
Number	1284	729	591	2604

	Rice Power Planter	Combine, Auto Theresher	Truck for Agriculture	Milker
Number	422	938	805	74

	Dryer for Rice	Power Dustry	Reaper and Binder	Power Sprayer
Number	2102	543	888	374

Source: Agricultural Census.

TABLE 11. Farm number by tractor H. P.

		1962	1967	1972
Individual Ownership	Under 30 H. P.	35.7	91.1	82.4
	30 and over	—	0.8	7.2
Organizational Ownership	Under 30 H. P.	7.1	7.2	3.3
	30 and over	57.1	0.8	7.1

Source: Hokkaido Development Bureau, Land Improvement and the Economic Effect in Northern Sorachi Area, 1977, pp. 266–267.

TABLE 12. Unit size of paddy field

	~10 a	10~30 a	30~50 a	50 a~
1960	100%	—	—	—
1963	100	—	—	—
1966	84	—	2	14
1969	42	—	8	50
1971	15	—	12	73
1974	5	—	13	82

Source: Hokkaido Development Bureau.

Town, and can be reached in about two hours' ride north from Sapporo. With the population of 42,626 (1975), the area is genuinely an agrarian district. The land in the area is mostly flat and situated along the Ishikari River, the Uryu River and their tributary streams. The inclination pitch stands at 1/300. The lands are mainly developed as paddy field. The soil is mostly heavy clay made up of sand stones and mud stones, but peat lands are also abundant. The paddy field on soil composition requires construction of adequate drainage ditches. The yearly average temperature is 44.6 deg. F, and the total yearly rainfall 1,200 mm. While the average temperature during July through August is beneficial 70 deg. F, the area has had frequent visits of cold weather damage, as in other districts of Hokkaido. It is therefore an alltime requirement to keep water temperature at high level in the rice pad by sufficient irrigation. The operation of farm households is centered around rice production. According to 1975 survey, 90 percent of 3,194 households are engaged in rice production. The average size of paddy field per farm household is about 4 ha with some big farms operating as large as 20 hectares. Fukagawa area is known as one of the representative rice production districts in Hokkaido. The area has a long postwar history of land improvements. Namely, the food production increase measures started during the last war time, but continued thereafter. Government took responsibility for both open and under drainage, installation of additional soil, rehabilitation of dilapidated irrigation facilities, construction of water supply systems, and promotion of mechanizetion combined with the land consolidation program.

The characteristics of the land improvement investment in Fukagawa area have shifted from the improvement of land productivity to the rehabilitation of the pertinent facilities and preventive measures against setback in production, and to the present emphasis in the increase in labor productivity.

The total investment in the land improvement of this area during 1950 through 1976 turned out to be about 0.18 billion dollars, based on 1975 prices. This amount was appropriated as follows: 4% during 1950 to 1955, 3.6% during 1956 to 1960, 8.4% during 1961 to 1965, 40.7% during 1966 to 1970, and 43.3% during 1971-1976. In the case of the government-operated irrigation-drainage project, the cost was shared as follows: 85% by the national government, 10% by the Hokkaido prefectural government, and 5% by the farm household. The repayments by the farm household are set on a 10-year equalized instalment of principal and interest, made available through the governmental long-term loan policy. The repayment

rates per farm household in 1975 were 133 to 222 dollars per ha.

The number of farm equipments owned by the farm house-hold in the Fukagawa area in 1975 is shown in Table 10. Similarly, the shift of horse power in farm tractors is shown in Table 11, and the transition of padd field size in Figure 12.

In subsequent analysis, we treat only years 1960 to 1969 before the restricted rice production measures start.

Methods of Analysis

The mechanism by which the irrigation-drainage and land consolidation projects bring about mechanization of farming is shown in Figure 1. The first quadrant shows indifference curves on the utility obtained by the land improvement project, namely the field consolidation and the irrgation-drainage projects. The progress from A_1B_1 to A_2B_2 to A_3B_3 is accompanied by some increase in the subsidizing works. The amounts of government expenditure that leads to the largest utility are given by C_1, C_2 and C_3. The fourth quadrant shows the increase in average productivity of land that the irrigation-drainage project mainly brings about. The case of Fukagawa area corresponds to E_1E_5. $E_1'E_5'$ illustrates technological progress that pushes up the land productivity by the irrigation-drainage project. The third quadrant shows that the increased land productivity leads to increased income in peasant farmers, which in turn increases purchasing power of farm machines.

On the other hand, this Figure suggests that the fixed capital formation by farm machines largely depends on the effects gained from the field consolidation shown on the first quadrant and those from the average productivity of land shown on the third quadrant. Based on the experience in the Fukagawa area, G_1G_5 further suggests that the land consolidation project in the initial stage does not significantlly increase the mechanization, but the mechanization spreads rapidly after certain threshold of accumulated consolidation investment is exceeded.

Meanwhile, a purpose of this report is to determine which factor, the drainage-irrigation, or the land consolidation, or the governmentloan, is most responsible for the mechanization of agriculture. This analysis was carried out by using econometric approaches. We adopted a simultaneous equation system model based on the two stage least squares method. Then the effect of exogenous variables such as the land improvement project and government loan on the mechanization of agriculture, for example, rate of increase in the horse-powers of tractors, was subjected to simulation analysis. We tried to quantitatively measure the economic effects of governmental

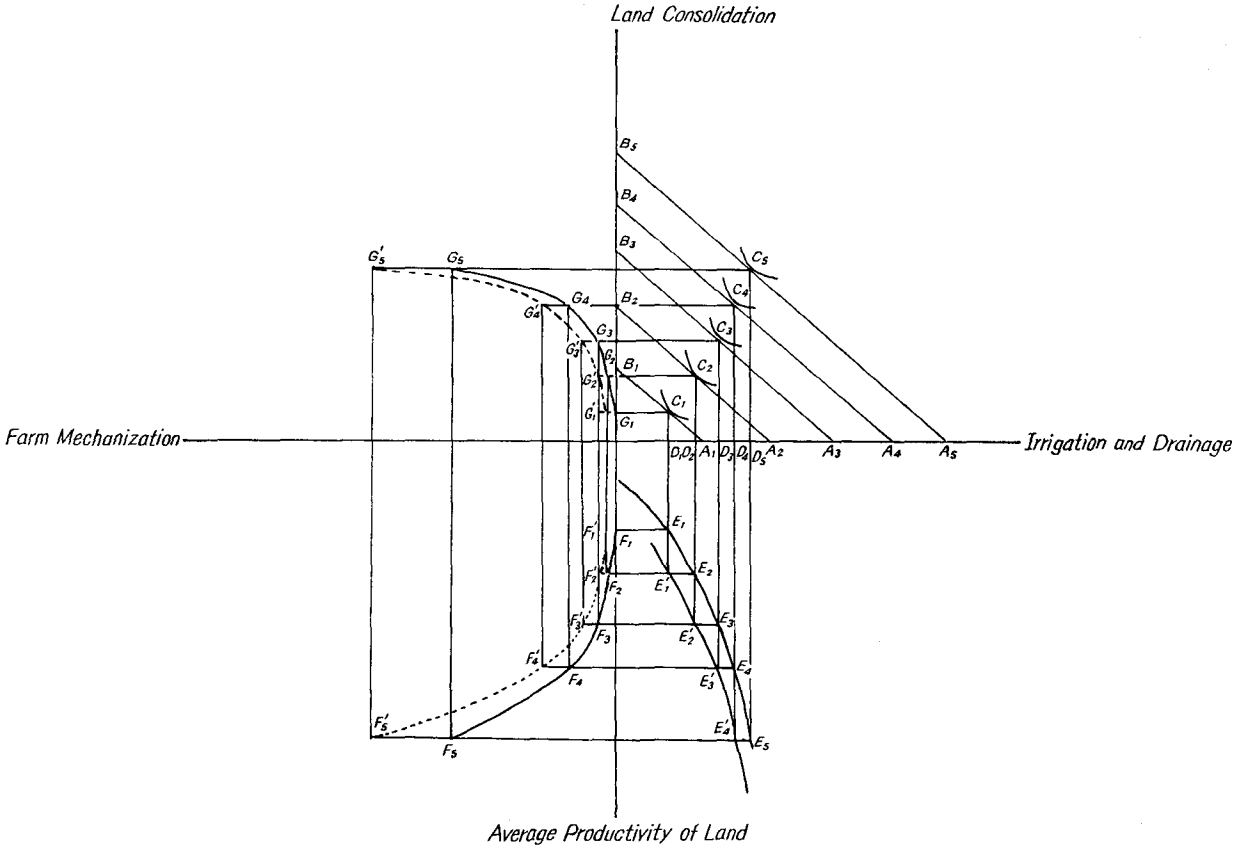


Fig. 1. Relationships between Irrigation and Drainage, Land Consolidation and Farm Mechanization.

plan such as land improvements and loans on the mechanization of agriculture.

The term, economic effects, used in this report, is a shift brought about by financial investment and is defined by a difference between a theoretical volum of the endogenous variables obtained by simulating agriculture, structure in the absence of government expenditures and loans and a final test value obtained by a formulated economic circulation model. The agricultural structure of the area being investigated must be estimated by the use of structural equation.

According to the general economic theory, the investment effect is a marginal productivity on an investment within a given period under the condition of other things being equal. In reality, however, the other conditions constantly change. In the simultaneous equation system employed in this work, all the endogenous variables are simultaneously changed by changing exogenous variables such as government expenditures and loans. Therefore, the economic effect used in this work includes all indirect complex effects as well.

Hence, the contribution of the government expenditures and loans to the farm mechanization to be obtained from the present study is different from what is obtained from the analysis of single equation system, but includes, to considerable extent, indirect and complex effects.

The research methods on the economic effects of governmental agricultural expenditures and loans can be divided into the following three main categories:

(1) production function analysis by the single equation system;

(2) cost-benefit analysis;

(3) propagation of the effects to other industrial fields by the input-output table analysis.

The macro-econometric model analysis used in this report was the merit of giving the overall economic effect taking into account a number of interdependent effects simultaneously for category (1), of making dynamic understanding possible and clarifying economic circulation frame for category (2), and of being able to identify spreading effects of broader sense than industrial structure.

Model Building and Measurements of the Parameter

Designing Theoretical Model.

The regional model of agriculture used in the present study includes investment in agriculture and production structure, agricultural income struc-

ture with consumption, and structure of agricultural finance. The latter is related to agricultural investment. Selected for the exogenous variables are: (1) government expenditures in the land consolidation and road construction in rural areas, (2) government expenditures in underground and open drainage ditches, (3) government loans including "Nogyo Kindaika Shikin" (subsidized agricultural cooperative loan), considered to promote the mechanization of farm equipments, (4) government expenditures on extension services judged to have brought about great economic effect in combination with investments in the land improvements, (5) hired labor wages that act as the medium of substitution relations between farm machines and labors.

The reason for dividing the governmental land improvement projects into two parts, the irrigation-drainage and the land consolidation (including the construction of farm roads), is that we intended to analyze the former as the major element of increasing land productivity and the latter chiefly as the element of increase in labor productivity.

Theoretical Model

(A) Sector of Farm Household Economy

(1)	$C=f(Y)$	Consumption Function
(2)	$S=f(Y)$	Saving Function
(3)	$L=S+L_{t-1}$	Identity Equation of Circulation Asset Holdings
(4)	$PM=f(L)$	Function of Long Term Loan Lent by Agr. Co-op
(5)	$IM=PM+PL$	Identity Equation of Long Term Loan Lent by Agr. Co-op and Government
(6)	$Y=GY-CO$	Identity Equation of Income Determination

(B) Sector of Farm Investment and Production

(7)	$I=f(IM, G_1, W)$	Investment Function of Fixed Capital
(8)	$K=I+K_{t-1}$	Identity Equation of Fixed Capital Equipment
(9)	$NP=f(K)$	Employment Function
(10)	$GY=f(F, K, G_2, SR)$	Production Function
(11)	$F=f(Y)$	Investment Function of Floating Capital
(12)	$CO=f(K)$	Cost Function

Notation

(A) Endogeneous Variables

C: Total Expenditures for Domestic Consumption Acquired from Agr. Co-op
S: Annual Net Increase of Fixed Deposit
L: Fixed Deposit Balance at the End of the Fiscal Year
PM: Long Term Loan by Co-op
IM: Long Term Loan by Agr. Co-op and Government
I: Annual Increase of Total Tractor H. P.
K: Total Amount of Tractor H. P. at the End of the FY.
NP: Workers Engaged in Agriculture
GY: Total Value of Grass Rice Production
F: Total Value of Sales of Fertilizer, Pesticide and Insecticide Sold by Agr. Co-op
CO: Total Cost of Rice Production
Y: Total Net Income from Rice Production

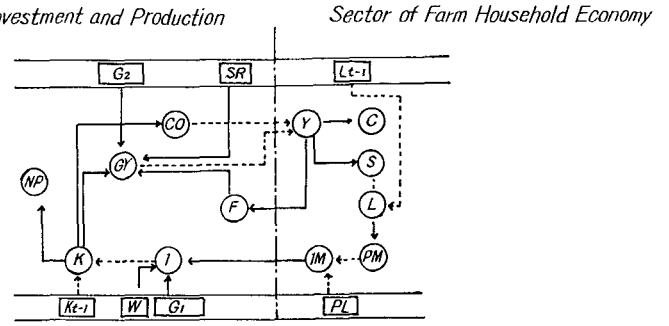
(B) Predetermined Variables
L_{t-1}: Fixed Deposit Balance in the Previous Year
K_{t-1}: Total Amount of Tractor H. P. in the Previous Year

(C) Exogenous Variables
G_1: Government Expenditures for Land Consolidation and Road Construction in Rural Area
G_2: Government Expenditures for Irrigation and Drainage
PL: Government Loan
Ext: Expenditures for Extension Services Paid by Agr. Co-op
W: Hired Labor Wages per Day

After several improvements in the theoretical models, we finally arrived at a system of twelve structural equations consisting of eight measurement equations and four identity equations.[2] Interdependent relationships and sequence of variables are summarized in Figure 2.

A brief explanation is given on the specification of structural equations. The equation (1) is a conventional Keynesian type consumption function and states that the total consumption in an area depends on the net income from rice production in the same period. Y does not include income from part-time jobs. However, the side income is not large, since the majority of the farm households in the area are full-time farm.

2) For the problems which have a small "degree of freedom" in a statistical approach, one independent variable was adopted for each of six out of eight measurement equations in total, whereas each of the values of the parameters of remaining two measurement equations with more than two independent variables was examined on the basis of the results of the t test and using a ridge regression analysis with a view to avoiding multicolinearity.



○ *Endogenous Variable*

□ *Predetermined Variable and Exogenous Variable*

—·—·— *Division of Sectors*

——— *Causal Relation of Functional Formula*

------- *Causal Relation of Identity Equation*

Fig. 2. Flow Diagram and Feedback Loops.

The equation (2) depicts that the income from rice production determines the net increase of fixed deposits for one year during the same period.

The identity equation (3) shows that the sum of net increase in the fixed deposits for the current year with the balance from the previous year is equal to the balance of the fixed deposits at the end of the current year.

The equation (4) indicates a functional relationship between the balance of fixed deposits and the long-term loan from Nokyo (Agricultural Cooperative Association). This suggests that farmers borrow funds for farm sector fixed capital investment by putting their circulating capital as security.

The equation (5) reveals that the fund for farm sector fixed capital investment, excluding the government subsidized projects and the national direct-controlled works, is the sum of the government loan and Nokyo's long-term loan. However, this equation underestimates the fund, since it does not include farmers' own funds.

The identity equation (6) indicates that net income from rice is equal to the gross output of rice minus the average cost of rice production. The cost of production does not include the family labor cost. Hence, the net income involves family labor income.

The equation (7) is an investment function. The increase in tractor

horse power within the current year is a part of the net investment, but preferably should be included in the gross investment. This is because, if one counts the increase as a net investment, the actual investment process involving out-of-service-life through FWT (fair wear and tear), subsequent disposal action and acquisition of new machines will be offset. The reason for putting government expenditures for the land consolidation into the explanatory variables is based on our assumption that agricultural machines are introduced after the irrigation-drainage and other land base preparation have been completed and operational conditions secured. Generally, the land base preparation is started after the harvest of rice and finished as early as within the current year or at the latest before the next planting season. For this reason, the payment of the land consolidation project is assigned to the previous quarter in order to coincide with the timing of tractor introduction. Further, we assumed that the increase in labor wage spurs the mechanization of farm work, and the labor wage was added as an explanatory variable.

The equation (9) assumes that capital may substitute for labor in the process of agricultural growth.

The equation (10) is a production function. Land was not considered here as an explanatory variable, because we assumed that all the reclamable land have been reclaimed by the time of our survey period. Farm labor population was not considered as an explanatory variable, because the farm population decreased during the survey period. If the population was included as one of explanatory variables, an inconsistancy arose, namely the production increase would not be achieved unless the labor population was decreased.

Expenditures for the irrigation-drainage project, accounted in this analysis as an exogenous variable should eventually lead to increased rice productivity of land, as well as improved rice quality. Whereas the expenditures for the project cover a long period of time, the effects will not be evidenced until after the completion. Thus, the total sum of the expenditures are included in this analysis only after the completion of the project in the form of data.

The cost of guidance for farm operations by "Nokyo" is included in this analysis as a substitute variable and consists of human capital for those who engage in various extension services of farm technology involving improvements in fertilizer management practice technology and variety controls in this area.

The equation (11) indicates that income can be taken as an explanatory variable to purchase fertilizer and pesticide during the current year. In general, the farm household purchases fertilizer and pesticide through "Nokyo"

and the purchasing limitations are set below the estimated crop production of the current year, handled by "Nokyo". Thus, income is used as a substitute for estimating crop production quantity, which "Nokyo" expects to handle.

The equation (12) assumes that the capital stock of agriculture at farm level, represented in this study by the horse power of tractor, is a factor contributing to increase production cost. Basically, the increase in production cost is caused by the cost for depreciation. In this study, however, the horse power of tractor is considered as a good indication of the depreciation cost.

We have discussed above on the building of a theoretical model. The final model is based on statistically most significant case in a series of trial and error calculations of limited available data with various ordering of theoretical preferences to the endogenous variables.

2. Measurements of Coefficients of Structural Equations and of Reduced Form Parameters in Equations.

The results of measurements of coefficients of structural equations are as follows:

Sector of Farm Household Economy

(1) Consumption Function

$$C=\triangle 311249.4560167+0.1229912\ Y$$
$$(2.75167)$$

$R^2=0.48625$ $D.\ W=1.187$

(2) Saving Function

$$S=\triangle 95144.3200384+0.0775723\ Y$$
$$(2.62049)$$

$R^2=0.46090$ $D.\ W=1.979$

(3) Identity Equation of Circulating Asset Holdings

$$L=S+L_{t-1}$$

(4) Function of Long Term Loan Lent by Agr. Co-op

$$PM=\triangle 132567.0369792+0.2138099\ L$$
$$(4.59149)$$

$R^2=0.72491$ $D.\ W=1.679$

(5) Identity Equation of Long Term Loan Lent by Agr. Co-op and Government

$$IM=PM+PL$$

(6) Identity Equation of Income Determination

$$Y=GY-CO$$

Sector of Farm Investment and Production

(7) Investment Function of Fixed Capital

$$I=\triangle 930.0764594+0.0004924\,IM+0.0012890\,G_1+1.2676352\,W$$
$$(1.94420)\qquad(3.78007)\qquad(2.82621)$$

$R^2=0.79506$ $D.\ W=0.180$

(8) Identity Equation of Fixed Capital Equipment

$$K=I+K_{t-1}$$

(9) Employment Function

$$NP=12056.4118950-0.1128312\,K$$
$$(3.11580)$$

$R^2=0.54823$ $D.\ W=2.055$

(10) Cost Function

$$CO=1560061.6576468+106.4782883\,\mathrm{K}$$
$$(4.03555)$$

$R^2=0.67059$ $D.\ W=0.689$

(11) Production Function

$$GY=1090692.2441410+34.4374240\,F+77.9458236\,K$$
$$(3.09454)\qquad(1.92625)$$
$$+0.1297581\,G_2+13.1709736\,SR$$
$$(0.35973)\qquad(2.88168)$$

$R^2=0.68853$ $D.\ W=1.290$

(12) Investment Function of Floating Capital

$$F=10664.1747124+0.0080221\,Y$$
$$(3.11424)$$

$R^2=0.54798$ $D.\ W=1.250$

The levels of significance of parameters, the magnitudes of coefficients of determination, and the Durbin-Watson statistics for each structural equation are not necessarily satisfactory, but the plus-minus signs are reasonable. Table 13 presents reduced forms of parameters obtained in the process of approach by the simultaneous equation system.

The magnitudes and signs of reduced form parameters for the exogenous and predetermined variables gave the following observations:

The mechanization of farm equipments by land consolidation project and the investment of the government loan was assisted by increase of hired

TABLE 13. Reduced form parameters

	G_1	G_2	PL	SR	W	L_{t-1}	K_{t-1}	Constant
C	△0.006248	0.022043	△0.002385	2.237520	△6.144440	△0.000510	△4.847170	237905
S	△0.003941	0.013903	△0.001504	1.411230	△3.875380	△0.000322	△3.057170	251214
L	△0.003941	0.013903	△0.001504	1.411230	△3.875380	0.999678	△3.057170	251214
PM	△0.000843	0.002973	△0.000322	0.301736	△0.828595	0.213741	△0.653654	△ 78855
IM	△0.000843	0.002973	0.999678	0.301736	△0.828595	0.213741	△0.653654	△ 78855
I	0.001289	0.000001	0.000492	0.000148	1.267230	0.000105	△0.000322	△ 969
K	0.001289	0.000001	0.000492	0.000148	1.267230	0.000105	0.999678	△ 969
NP	△0.000145	△0.000001	△0.000055	△0.000017	△0.142982	△0.000012	△0.112795	12166
CO	0.137206	0.000155	0.052371	0.015807	134.932000	0.011197	106.444000	1456900
GY	0.086406	0.179385	0.032980	18.208300	84.973700	0.007052	67.033200	5921890
Y	△0.050801	0.179230	△0.019390	18.192600	△49.958500	△0.004146	△39.410800	4465000
F	△0.000408	0.001438	△0.000156	0.145941	△0.400767	△0.000033	△0.316153	142428

labor wages.

The development of mechanization actually pushes up the cost as seen in the flow diagram during the process of K to CO (Figure 2). On the other hand, however, the government expenditures and loans for this project considerably contributed to increase the gross production.

As the result of such decrease in the farm household income, we observed slight decrease in consumption and saving. This result may lead to a negative conclusion regarding the effect of the land consolidation project and the government loan. However, as described previously in III-1, the average production cost CO does not include the family labor cost. In other words, CO is underestimated.

The period of this analysis coincided with the period of high economic growth in Japan. With high job opportunity available in non-agricultural sector, the exodus of large labor force from agricultural to non-agricultural sectors was so grave that the family remained behind would have been unable to continue farm operations without the aid of mechanized farm equipments that could offset increase hired labor force. If the mechanization had not been introduced, the rice production cost would have increased to a prohibitive level and the rice farm operations might have been discontinued.

The land consolidation project is basically a preparation of land base for mechanical equipments and the government loan is the source of fund to purchase the farm machine. The effect of the land consolidation projects and the government loan on promoting farming mechanization is greater

than that of the irrigation-drainage projects. On the other hand, the irrigation-drainage project brings about only slight increase in production cost but large increase in gross production. The increase in gross production leads to higher net income, large consumption, and larger saving. Also notable is the fact that the irrigation-drainage project contributes only slightly to the decrease in labor force and the concomitant increase in mechanization. Thus, the project induces increase in income and saving through the increase in production. Increased saving leads to increased fixed deposits.

These observations suggest that the effect of demand for mechanization from the first to the second quadrant shown in Figure 1 is significant, but the effect of the supply of mechanical equipments from the fourth quadrant is small.

Simulation Analysis

1. Method of Simulation.

We give below quantitative evaluation of our agricultural policy on the farm mechanization. First, we use the land consolidation expenditures, the irrigation-drainage expenditures and the government loan as exogenous variables. Second, we adopt the combination of exgenous variables as shown in Table 14. We assume a case wherein investments are carried out for two variables out of the three, and the remaining variable is not given investment. Thus, substraction of the theoretical value of the case 1 from the value obtained from the final test gives the effect of the land consolidation project. Similarly, substraction of the theoretical value of the case 2 from the final test value leads to the effect of the irrigation-drainage project and substraction of the theoretical value of case 3 from the same gives the effect of the government loan.

TABLE 14. Combination among policy variables for simulation

	Final Test	Case 1	Case 2	Case 3
G_1	1	0*	1	1
G_2	1	1**	0	1
PL	1	1	1	0

* 0 means that the investment was'nt done.
** 1 means that the investment was done.

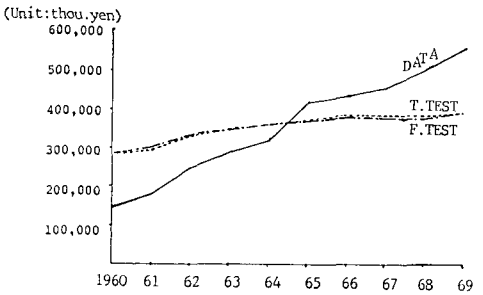


Fig. 3. Total Expenditures of Consumption.

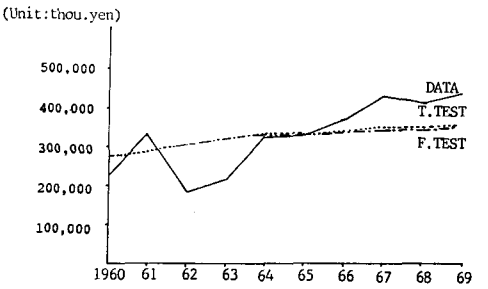


Fig. 4. Annual Net Increase of Fixed Deposit.

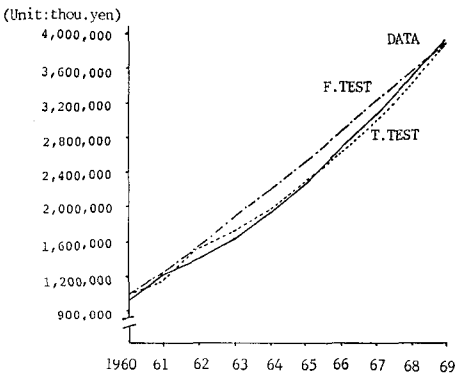


Fig. 5. Fixed Deposit Balance at the End of the Fiscal Year.

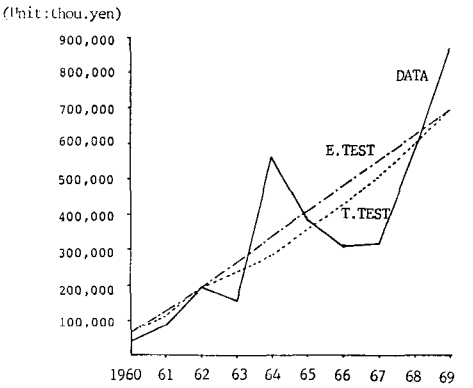


Fig. 6. Long Term Loan Lended by Agricultural Cooparatives.

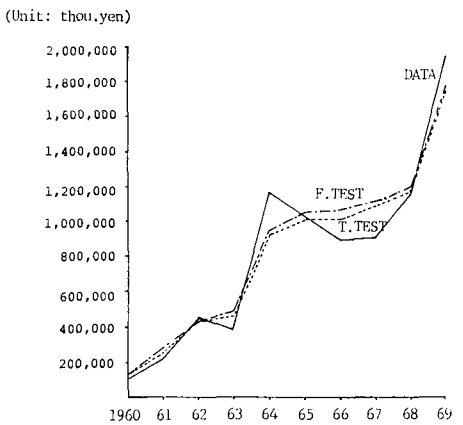


Fig. 7. Long Term Loan Lended by Agr. Co-op and Government.

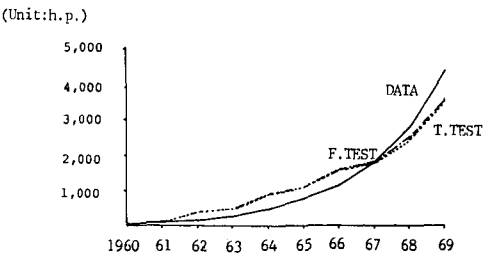


Fig. 8. Annual Increase of Total Tractor H. P.

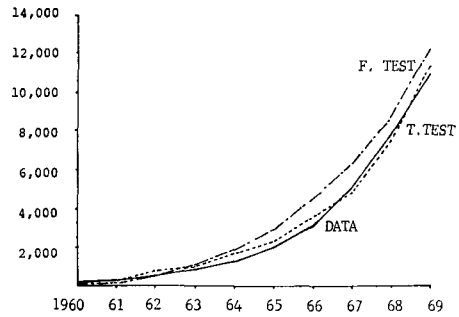


Fig. 9. Total Amount of Tractor H. P. at the End of the Fiscal Year.

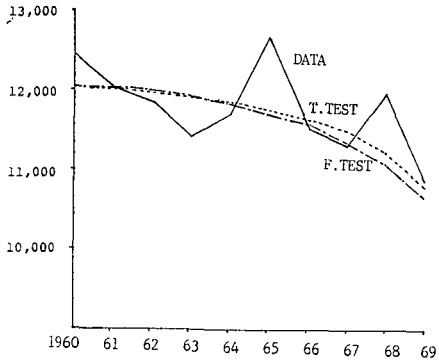


Fig. 10. Workers Engaged in Agriculture

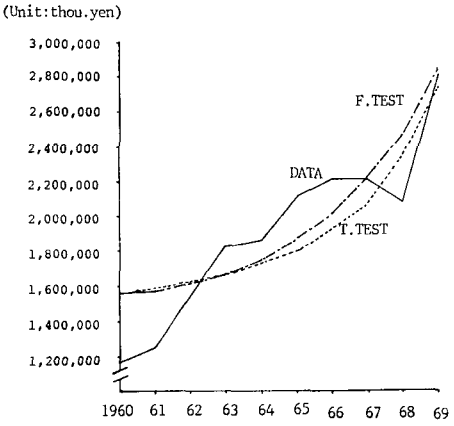


Fig. 11. Total Cost of Rice Production.

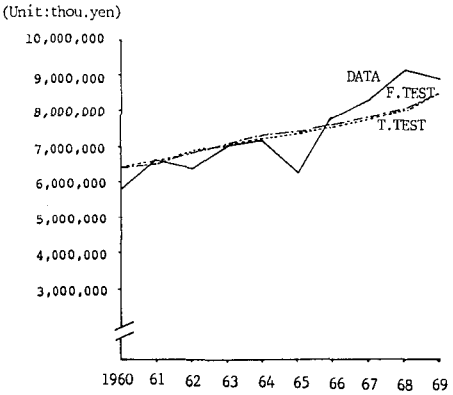


Fig. 12. Total Value of Gross Rice Production.

2. Total Test and Final Test on the Theoretical Model.

The "fitness for realities" test on our theoretical model gives an idea on the extent to which our model fits the realities. We made both the total and final tests. The total test measures predictive ability for a single period by giving real values to the predetermined variables. The final test corresponds to multiple periods and performed by giving real values only to the exogenous variables. The initial values of the predetermined variables were taken from the year 1960.

The results of these tests revealed somewhat unsatisfactory fits between the real and final test values for some variables. However, in view of various limitations such as incomplete exclusion of the instability due to

TABLE 15. Annual increase of tractor H. P. (Unit: h. p.)

I	DATA	TOTAL TEST	FINAL TEST	CASE 1	EFFECT (1)	%	CASE 2	EFFECT (2)	%	CASE 3	EFFECT (3)	%
1960	77											
'61	121	78	84	84	0	0.0	81	3	3.6	21	63	75.0
'62	188	355	956	356	0	0.0	350	6	1.7	235	121	34.0
'63	295	474	488	488	0	0.0	480	8	1.6	378	110	22.5
'64	461	841	866	866	0	0.0	855	11	1.3	557	309	35.7
'65	722	1022	1048	932	116	11.1	1034	14	1.3	725	323	30.8
'66	1129	1520	1547	966	581	37.6	1530	17	1.1	1259	288	18.6
'67	1765	1723	1746	1123	623	35.7	1727	19	1.1	1459	287	16.4
'68	2765	2409	2423	1393	1030	42.5	2401	22	1.0	2144	279	11.5
'69	4321	3481	3488	1830	1658	47.5	3463	25	0.7	2964	524	15.0

EFFECT (1): Effect of land Consolidation works.
EFFECT (2): Effect of irrigation and drainage.
EFFECT (3): Effect of government Loan.

TABLE 16. Total amount of tractor H. P. at the end of the fiscal year (Unit: h. p.)

K	DATA	TOTAL TEST	FINAL TEST	CASE 1	EFFECT (1)	%	CASE 2	EFFECT (2)	%	CASE 3	EFFECT (3)	%
1960	213	71	71	71	0	0.0	69	2	2.8	41	30	42.3
'61	334	291	155	155	0	0.0	150	5	3.2	62	93	60.0
'62	522	689	511	511	0	0.0	500	11	2.2	297	214	41.9
'63	817	996	999	999	0	0.0	980	19	1.9	675	324	32.4
'64	1278	1658	1865	1855	0	0.0	1835	30	1.6	1232	633	33.9
'65	2000	2300	2913	2797	116	4.0	2859	44	1 5	1957	956	32.8
'66	3129	3520	4460	3763	697	15.6	4399	61	1.4	3216	1244	27.9
'67	4894	4852	6206	4886	1320	21.3	6126	80	1.3	4675	1531	24.7
'68	7656	7303	8629	6279	2350	27.2	8527	102	1.2	6819	1810	21.0
'69	10881	11137	12117	8109	4008	33.1	11990	127	1.0	9783	2334	19.3

TABLE 17. Workers engaged in agriculture

NP	DATA	TOTAL TEST	FINAL TEST	CASE 1	EFFECT (1)	%	CASE 2	EFFECT (2)	%	CASE 3	EFFECT (3)	%
1960	12427	12048	12048	12048	0	0.0	12048	0	0.0	12052	△ 4	0.0
'61	12036	12036	12039	12039	0	0.0	12039	0	0.0	12049	△ 10	0.1
'62	11870	11979	11999	11999	0	0.0	12000	△ 1	0.0	12023	△ 24	0.2
'63	11432	11944	11944	11944	0	0.0	11945	△ 2	0.0	11980	△ 36	0.3
'64	11708	11869	11846	11846	0	0.0	11849	△ 3	0.0	11917	△ 71	0.6
'65	12706	11797	11729	11741	△ 13	0.1	11733	△ 5	0.0	11836	△108	0.9
'66	11506	11659	11553	11632	△ 79	0.7	11560	△ 7	0.1	11694	△141	1.2
'67	11320	11509	11356	11505	△149	1.3	11365	△ 9	0.1	11529	△173	1.5
'68	11975	11232	11083	11348	△265	2.4	11094	△11	0.1	11287	△204	1.8
'69	10881	10800	10689	11141	△452	4.2	10704	△15	0.1	10953	△264	2.5

TABLE 18. Total net income from rice production (Unit: thou. yen)

Y	DATA	TOTAL TEST	FINAL TEST	CASE 1	EFFECT (1)	%	CASE 2	EFFECT (2)	%	CASE 3	EFFECT (3)	%
1960	4615862	4820651	4820651	4820651	0	0.0	4641618	179033	3.7	4821827	△ 1170	0.0
'61	5307663	4924449	4929802	4929802	0	0.0	4750906	178896	3.6	4933466	△ 3664	0.1
'62	4776915	5199095	5206119	5206119	0	0.0	4889594	316525	6.1	5214542	△ 8423	0.2
'63	5158375	5354419	5354303	5354303	0	0.0	5038117	316186	5.9	5367073	△12770	0.2
'64	5280374	5484425	5476260	5476260	0	0.0	5140997	335263	6.1	5501213	△24953	0.5
'65	4092556	5560849	5536695	5541279	△ 4584	0.1	5196491	340204	6.1	5574357	△37662	0.7
'66	5612596	5629378	5592352	5619796	△ 27444	0.5	5252809	339543	6.1	5641393	△49041	0.9
'67	6102706	5667784	5614402	5666457	△ 52055	0.9	5275638	338764	6.0	5674760	△60358	1.1
'68	7055188	5671107	5618828	5711498	△ 92670	1.6	5280921	337907	6.0	5690189	△71361	1.3
'69	6081118	5770954	5732328	5890352	△158024	2.8	5303096	429232	7.5	5824339	△92011	1.6

TABLE 19. Average productivity of land (kg/10 a)

	DATA	TOTAL TEST	FINAL TEST	CASE 1	EFFECT (1)	%	CASE 2	EFFECT (2)	%	CASE 3	EFFECT (3)	%
1960	414.5	461.9	461.9	461.9	0.0	0.0	448.9	13.0	2.8	461.7	0.2	0.0
'61	468.3	465.2	464.6	464.6	0.0	0.0	451.7	12.9	2.8	464.1	0.5	0.1
'62	406.5	437.7	436.9	436.9	0.0	0.0	416.6	20.3	4.6	436.0	0.9	0.2
'63	450.7	452.2	452.2	452.2	0.0	0.0	431.7	20.5	4.5	450.8	1.4	0.3
'64	462.4	467.5	468.4	468.4	0.0	0.0	446.5	21.9	4.7	465.7	2.8	0.6
'65	401.6	176.3	479.0	478.5	0.5	0.1	456.7	22.3	4.7	474.8	4.2	0.9
'66	503.2	185.2	489.3	486.3	3.0	0.6	467.1	22.2	4.5	483.9	5.4	1.1
'67	516.5	480.5	486.1	480.6	5.5	1.1	464.5	21.6	4.4	479.7	6.4	1.3
'68	558.5	490.3	495.7	486.1	9.6	1.9	474.4	21.3	4.3	488.3	7.4	1.5
'69	546.1	522.7	526.7	510.2	16.5	3.1	499.6	27.1	5.2	517.1	9.6	1.8

TABLE 20. Average gross productivity of labor (Unit: thou. yen per capita)

	DATA	TOTAL TEST	FINAL TEST	CASE 1	EFFECT (1)	%	CASE 2	EFFECT (2)	%	CASE 3	EFFECT (3)	%
1960	461.3	530.2	530.2	530.2	0.0	0.0	515.4	14.8	2.8	529.9	0.3	0.1
'61	541.9	541.3	540.4	540.4	0.0	0.0	525.5	14.9	2.8	530.5	0.9	0.2
'62	534.6	570.4	568.4	568.4	0.0	0.0	541.9	26.5	4.7	566.1	2.3	0.4
'63	612.1	587.8	587.8	587.8	0.0	0.0	561.1	26.7	4.5	584.2	3.6	0.6
'64	610.0	608.4	610.7	610.7	0.0	0.0	582.0	28.7	4.7	603.5	7.2	1.2
'65	488.8	624.4	631.6	630.2	1.4	0.2	601.9	29.7	4.7	620.4	11.2	1.8
'66	681.8	648.8	660.2	651.7	8.5	1.3	629.9	30.3	4.6	645.1	15.1	2.3
'67	735.5	672.9	690.0	673.3	16.7	2.4	658.9	31.1	4.5	670.7	19.3	2.8
'68	761.8	713.0	730.6	699.7	30.9	4.2	698.5	32.1	4.4	706.7	23.9	3.3
'69	817.8	788.6	802.9	746.2	56.7	7.1	760.4	42.0	5.3	769.3	33.6	4.2

TABLE 21. Tractor H. P. per worker engaged in agriculture

	DATA	TOTAL TEST	FINAL TEST	CASE 1	EFFECT (1)	%	CASE 2	EFFECT (2)	%	CASE 3	EFFECT (3)	%
1960	0.02	0.006	0.006	0.006	0.0	0.0	0.006	0.000	0.0	0.003	0.003	50.0
'61	0.03	0.024	0.013	0.013	0.0	0.0	0.012	0.001	7.7	0.005	0.008	61.5
'62	0.04	0.058	0.043	0.043	0.0	0.0	0.042	0.001	3.3	0.025	0.018	11.9
'63	0.07	0.083	0.084	0.084	0.0	0.0	0.082	0.002	2.4	0.056	0.028	33.3
'64	0.11	0.140	0.157	0.157	0.0	0.0	0.155	0.002	1.4	0.103	0.054	34.2
'65	0.16	0.195	0.248	0.238	0.010	1.0	0.245	0.003	1.2	0.165	0.083	33.3
'66	0.27	0.302	0.386	0.324	0.062	16.1	0.381	0.005	1.3	0.275	0.111	28.8
'67	0.43	0.422	0.546	0.425	0.121	22.2	0.539	0.007	1.3	0.405	0.141	25.8
'68	0.64	0.650	0.779	0.553	0.226	29.0	0.769	0.010	1.3	0.604	0.175	22.5
'69	1.00	1.031	1.134	0.728	0.406	35.8	1.120	0.014	1.2	0.893	0.241	21.2

damage by cool weather, extremely simplified model due to insufficient avalability of data, and adoption of the linear model, we believe the overall results within the range of acceptance.

Figures 3 through 14 show the results of the "fitness measured for the realities" tests on our theoretical model. Figures 15 through 21 illustrate the total test values, the final test values, the theoretical values for each case, and the economic effects of agricultural policy on the main economic indices including equipment mechanization.

3. Economic Effects of Agricultural Policy on the Mechanization of Farming Equipments

Tables 22 and 23 summarize the economic effects of the governmental agricultural expenditures and loans for farm households calculated by the method described in IV-1, for the year 1969, when adjusted rice production policy has not started. The percentage figures in these Figures mean the contribution of the government expenditures and the loan to the theoretical values of the final test, and correspond to the overall spreading effect of investments during the analyzed period. In other words, these are not the

TABLE 22. Economic effects of government investment for farm mechanization including other items (1)

	Effect of Land Consolidation Works	Effect of Irrigation and Drainage	Effect of Government Loan
Total Consumption	△ 4.9	13.4	△ 2.9
Annual Net Increase of Fixed Deposit at Agr. Co-op Level	△ 3.5	9.5	△ 2.0
Total Amount of Fixed Deposit at the End of Fiscal Year	△ 0.7	6.2	△ 0.7
Long Term Loan by Agr. Co-op	△ 0.8	7.4	△ 0.9
Long Term Loan by Agr. Co-op and Government	△ 0.3	2.9	60.3
Annual Increase of Total Tractor H. P.	47.5	0.7	15.0
Total Amount of Tractor H. P. at the End of the Fiscal Year	33.1	1.0	19.3
Workers Engaged in Agriculture	△ 4.2	△ 0.1	△ 2.5
Total Cost of Rice Production	15.0	0.5	8.7
Total Value of Gross Rice Production	3.1	5.1	1.8
Total Net Income from Rice Production	△ 2.8	7.5	△ 1.6
Total Value of Sales of of Fertilizer, Pesticide and Insecticide	△ 0.8	2.3	△ 0.5

TABLE 23. Economic effects of government investment for farm mechanization including other items (2) (%)

	Effect of Land Consolidation Works	Effect of Irrigation and Drainage	Effect of Government Loan
1. Average Productivity of Land	3.1	5.2	1.8
2. Net Income from Rice per Farm	△ 2.8	7.5	△ 1.6
3. Average Productivity of Labor	7.1	5.3	4.2
4. Tractor H. P. per Worker Engaged in Agriculture	35.8	1.2	21.2
5. Tractor H. P. per Farm	33.1	1.0	19.3

results of partial equilibrium approach by the single equation system, but include the interdependence of the internal structures of the model.

Let us first look at the investment in the agricultural equipments from the demand side. In this model, the demend is represented by the land consolidation project, which gave large effect. In this study, we evaluate the extent of the mechanization of farm equipments in terms of both the tractor investment and tractors' property stock. Table 22 suggests that, if the land consolidation project had not been carried out, the tractor investment would have been reduced by 47.5% and the tractor's property stock by 33.1%. Thus, the government loan and the irrigation-drainage project should be regarded as an economic effect for mechanization from the supply side. The government loan is a potential fund source for the purchase of tractors and hence has induced effects on the mechanization. The capital formation effects of the government loan on the tractor investment and the property stock of tractors are not so significant as the land consolidation project. Nevertheless, *the loan accounts for the second most significant factor for* the mechanization with the contributions of 15 and 19.3%, respectively.

Meanwhile, at the time of the model building, we assumed that the irrigation-drainage project pushed up the average productivity of land, thus affecting the farm household income and inducing the mechanization. Namely we presumed that the project has roundabout capital formation effects. Our analysis revealed, however, that the induced effects on the mechanization by the irrigation-drainage project are relatively small with contributions of about 10%. Consequently, the key factor to the mechanization is the land

consolidation project and the government loan. We recognize the former more effective than the latter. At the same time, the agricultural policy has contributed 63% of tractor investment through government expenditures and loans (Table 22).

In addition, the land consolidation project and the government loan have not only contributed to the capital formation for farming mechanization, but also resulted in labor-saving effects in the farm labor population by 4.2 and 2.5%, respectively. On the other hand, the irrigation-drainage project less effective to the capital formation, led to a minuscle decrease of 0.1% in the labor saving.

Therefore, with regard to the substitution of farm labor force with farm machines, the land consolidation project has increased tractor horse power per farm worker as much as 35.8% as shown in Table 23. The contribution of government loan was 21.2%, whereas the irrigation-drainage contributed only 1%. In these calculations, no tractor horse powers per worker was provided in the flow diagram of the Figure 1. Hence, they were estimated by dividing the total tractor horse power by the number of farm workers.

The land consolidation project plays a great role in the man-machine substitution, and increased the average productivity of labor by 7.1%. In contrast, the irrigation-drainage project plays less significant role in the substitution, and increased the labor productivity by only 5.3%. The government loan contributed only 4.2%. The average productivity of labor in these calculations was determined by dividing the value of rice production by the number of workers.

In summary, it can be said that the irrigation-drainage project, which is less effective in promoting the mechanization than the land consolidation project, is also less effective in raising labor productivity. The irrigation-drainage project exerted the greatest effect of 5.2% on the land productivity, as compared with 3.1% by the land consolidation and 1.8% by the government loan (Table 23). Namely, the irrigation-drainage project increased the land productivity by 27.1 kg per ha, while the land consolidation contributed 16.5 kg per ha and the government loan by 9.6 kg per ha. Finally, the irrigation-drainage project showed much smaller effects on pushing up rice production cost, as compared with the land consolidation project and the government loan.

Consequently, whereas the land consolidation project and the government loan have shown negative net income formation effects due to over-investment, the irrigation-drainage project has yielded substantial positive net

income formation effects, by 7.5%. Despite this fact, the irrigation-drainage project proved less effective in promoting the mechanization than the land consolidation project and government loan. On the basis of these observations, the effect of irrigation-drainage project on increasing the income of the farm household through pushing up the land productivity and thus inducing the mechanization does exist but are small. In this respect, the theoretical prediction on the third quadrant in Figure 1 has been varified, but the contribution of the irrigation-drainage project to the mechanization proved minor.

Concluding Remarks

In this paper, we conducted simulation analysis of the effect of agricultural policy on the mechanization of farm equipments (specifically, tractors) in the case of Japan, with the purpose of contributing to the process of increasing rice production in developing countries.

More particularly, the government expenditures and loans are considered as the two major factors of our agricultural policy and the relative contributions of the land consolidation, the irrigation-drainage projects, and the government loan to the mechanization of a rice production area have been determined in Figure 1. The theoretical framework of this analysis is provided in Figure 2.

The results of our case study are as follows:

(1) The land consolidation project proved to be the largest contributor to the mechanization.

(2) The contribution by the government loan ranked next.

(3) The irrigation-drainage project has contributed only marginally.

(4) The combined contribution from the government expenditures and the loans amounted to 50 to 60% of the mechanization trend.

While the land consolidation project and government loan have greatly promoted the mechanization, they also brought about the ill effect of over-investment, namely, some deorease in the net income from rice production. On the other hand, the irrigation-drainage project has significantly increased the land productivity, and thus contributed greatly to the formation of net income. However, the irrigation-drainage project contributed more to the increase in consumption and saving levels, rather than to the increase in the agricultural investment or mechanization. Finally, we admit that the model used in this analysis is very crude and must be supplemented with more data in order to refine the theoretical framework.

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