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Production Structure and Productivity of Japanese Agriculture

Yoshimi Kuroda

Volume 2: Impacts of Policy Measures

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of Japanese Agriculture, Volume 2

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Preface to Volume 2

In Volume 1, we quantitatively analyzed and evaluated the various aspects of the production structure and productivity of postwar Japanese agriculture for, roughly speaking, the second half of the 20th century. In summary, we found that Japanese agriculture during the period, in particular after the mid-1970s toward the end of the 20th century, was basically stagnant in many aspects. This finding may be said to be consistent with the drastic slowdowns, or even stagnancy, of the growth of the non-agricultural sectors after the mid-1970s, in particular since the experiences of the severe ‘food shortage’ in 1972 and the serious ‘oil crises’ in 1973 and 1978. That is, the stagnancy both in the agricultural and non-agricultural sectors must have been intimately correlated during the latter period, 1975–97, of the whole study period, 1957–97, in this book. Accordingly, we would like to specifically investigate the impacts of several representative policy instruments introduced by the MAFF (Ministry of Agriculture, Forestry and Fisheries) on the production structure of Japanese agriculture for the period 1965–97, during which the Agricultural Basic Act was established in 1961 and the set-aside was introduced in 1969 for the first time in Japanese agricultural history. Ever since, the policy measures such as the price-supports and set-asides as well as various subsidies have been persistently executed by the MAFF.

Accordingly, the major objective of Volume 2 is to quantitatively estimate and evaluate the impacts of various agricultural policy measures during the 1965–97 period. In particular, we would like to pursue this objective in order to seek possibilities for changing the inefficient and less productive small-scale farming to a more efficient and productive large-scale farming. For this, we definitely need drastic structural transformation by transfers of farmlands from small- to large-scale farms.

To be more specific, as is well known worldwide, the Japanese economy as a whole experienced an extremely rapid development during the mid-1950s through to the early-1970s with a compound annual average growth rate of more than 10 percent. However, even though the labor productivity of the agricultural sector increased fairly sharply with a compound annual growth rate of around 6 to 7 percent, the non-agricultural sectors enjoyed much higher growth rates of labor productivity during the period under question. This resulted in big income gaps between the agricultural and non-agricultural households. As a result, in order to reduce such income gaps between the two sectors, the MAFF enacted the Agricultural Basic Act in 1961 and started enforcing various policies for agriculture; the representative policy measures have been the output price-supports, in particular rice, the output-mix change, the set-asides, the input subsidies, and the research and extension (R&E) programs.

Therefore in Volume 2, we use the (crops-livestock) multiple-product translog variable *profit* function to quantitatively investigate the impacts of the output price-supports, the set-asides, the input subsidies, and the R&E programs on the important economic indicators such as the output supplies, the factor demands, the maximized profits, the degrees of scale economies, and the shadow prices of lands for different size classes for the period 1965–97. The most important finding based on such quantitative analyses is that the agricultural policy measures introduced by the MAFF, contrary to expectations, played vital roles in general in restricting land transfers from small- to large-scale farms for more efficient and productive farming on larger-scale farms.

Part I
Impacts of Policy Measures on Postwar Japanese Agriculture

1

Impacts of Output Price-Support Programs on Postwar Japanese Agriculture 1965–97: A Variable Profit Function Approach

1.1 Introduction

One of the primary concerns in Japanese agriculture since the Basic Agricultural Act was enacted in 1961 has been the implementation of more efficient and productive large-scale farming. This concern has received even greater attention because of persistent pressure from foreign countries for liberalizing Japanese markets of agricultural commodities. Accordingly, the transition from small- to large- scale farms has been heavily promoted, and various policy measures have been introduced by the government; revisions of the Farmland Act in 1970 and 1980, launching of the Farmland Utilization Promotion Project in 1975, and the passing of the Farmland Utilization Promotion Act in 1980.

To assess the effects of these policies on a shift to more efficient larger-scale farming, Tables 9.1 and Table 10.1 in Volume 1, for Tofuken and for all Japan, offer general information on farmland movements.

Furthermore, Table 10.1 presents the numbers of farm households by size of cultivated land area. We will also review the findings obtained in that table.

By reviewing these tables we have observed that, in spite of the government's efforts to promote land movements, the transition from small- to large-scale farming has not made significant progress against our expectations. One major reason for this limited change has been the rapid increase in the market price of farmland, which has been caused in large part by the strong demand for land for non-agricultural purposes such as construction of highways, railways, factories, and residential areas. This demand for land by the non-agricultural sectors has given farmers strong incentives to keep their lands as profitable assets.

Thus, the point of this chapter is that we will shed a special light on quantitative investigations of an important cause within agriculture for the high farmland prices. As shown in Table 1.1, price-support programs have been an important agricultural policy measure. Furthermore, since production levels of wheat and barley were very low during the study period[1] 1965–97, the budget assigned to price-support policies for rice, wheat, and barley shown in column (iv) in Table 1.1 has in fact been allocated mainly to rice. In this sense, rice price-support programs have been a critical policy instrument in postwar Japanese agriculture from the early-1960s until the current date.

On the other hand, though not as heavily as rice as shown in column (v) in Table 1.1, the prices of livestock products have also been supported either in direct or indirect forms through the Livestock Production Promotion Programs, since livestock products have been most important demand-increasing agricultural products of the 'Selective Product Expansion Programs' of the Basic Agricultural Act.

At this point, we will briefly observe the movements of prices and the amounts of production of crops and livestock in Figures 1.1 and 1.2, respectively. At a glance at Figure 1.1, we observe much sharper increases in the price of crops than livestock, especially from 1975 up to 1997. This may reflect the sharp increases in the budget for rice price-supports during the 1970s and 1980s.

On the other hand, the prices of livestock products were stagnant from the late-1970s. This may reflect the drastic increase in the supply of milk due mainly to the scale enlargement of milk production during the study period 1965–97. As a result, the terms of trade of livestock to crops declined consistently during the entire study period. Conversely, according to Figure 1.2, the total amount of crop production was stagnant or even had a decreasing trend, which seems to have been consistent with the movements of rice production. On the other hand, livestock production increased consistently from 1960 to around 1992, but after that it was stagnant or even slightly decreasing. However, it is noted that the amount of production of livestock has surpassed that of rice since as early as 1980.

Table 1.1 Agricultural budget, 1960–99 (unit: 1 billion yen)

Selected years	National budget (i)	Agricultural budget (ii)	For Price-support policies: total (iii)	rice, wheat, and barley (iv)	livestock (v)
1960	1,765	139	31	29	0
		(7.9)	(22.3)	(93.5)	(0.0)
1965	3,745	346	128	121	0.3
		(9.2)	(37.0)	(94.5)	(0.2)
1970	8,213	885	393	375	15
		(10.8)	(44.8)	(95.4)	(3.8)
1975	20,387	2,000	858	811	30
		(9.8)	(42.9)	(94.5)	(3.5)
1980	43,681	3,108	773	652	16
		(7.1)	(24.9)	(84.3)	(2.1)
1985	53,222	2,717	582	456	10
		(5.1)	(21.4)	(78.4)	(1.7)
1990	69,651	2,519	311	232	9
		(3.6)	(12.3)	(74.6)	(2.9)
1995	78,034	3,423	284	184	6
		(4.4)	(8.3)	(64.4)	(2.1)
1999	81,860	2,549	364	243	5
		(3.1)	(14.3)	(66.8)	(1.4)

Notes: (1) Figures in parentheses in column (ii) are the shares of agricultural budget in the national budget in per cent.
(2) Figures in parentheses in column (iii) are the shares of the budget for price-support policies in the total agricultural budget in per cent.
(3) Figures in parentheses in column (iv) are the shares of the budget for price-support policies for rice, wheat, and barley in per cent.
(4) Figures in parentheses in column (v) are the shares of the budget for price-support policies for livestock in per cent.

Source: Statistics Department, the MAFF. The *Nogyo Hakusho Fuzoku Tokeihyo* [the *Appendix Tables of Agricultural White Paper*], Government Printing Office: Tokyo, 1999, pp.20–1.

Now, we hypothesize in this chapter that price-support programs during the last half of the 20th century gave more advantages to smaller-scale farms than to larger-scale farms in increasing such important economic indicators as the supplies of both crops and livestock, the maximized profits, the shadow price of farmland,

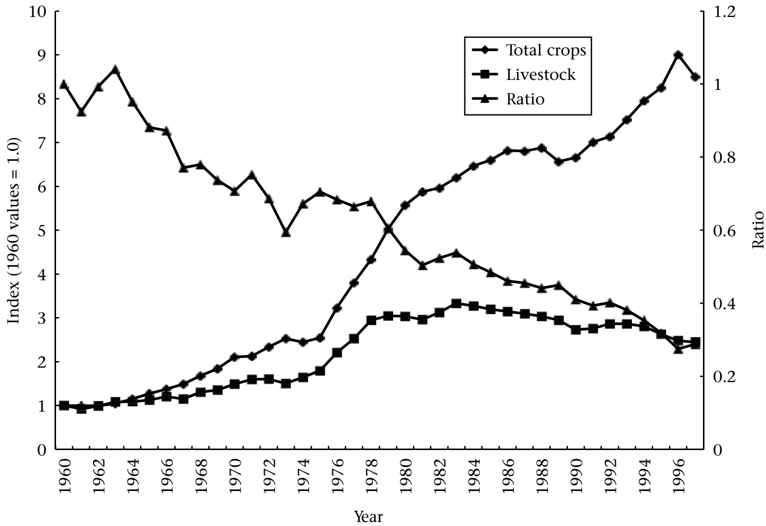

Figure 1.1 Price indexes of crops and livestock and the ratio of the two price indexes for 1960–97 at 1985 prices

Source: *The PWRV*, the Statistical Bureau of the MAFF:Tokyo, various issues. Refer to Appendix of 1.1 in Volume 1 for detail.

and even scale economies, which may have limited the transition of farmland from small- to large-scale farms. To empirically verify this hypothesis, we will introduce a multiple-product variable profit (VP) function framework where labor and land are assumed to be quasi-fixed factor inputs.

We specify the multiple-product VP function as an ordinary translog type and estimate the system of equations composed of the multiple-product ordinary translog VP function, two output revenue-profit share equations, and three variable factor input cost-profit share equations. Based on the estimated parameters, various economic indicators such as the maximized profits, the degrees of RTS, and the shadow value of farmland will be computed for all observations of different size classes for the entire period 1965–97.

In addition, we will estimate the impacts of changes in prices of crops and livestock on (i) the supplies of crops and livestock, (ii) the demands for variable factor inputs, (iii) the maximized profits, (iv) the

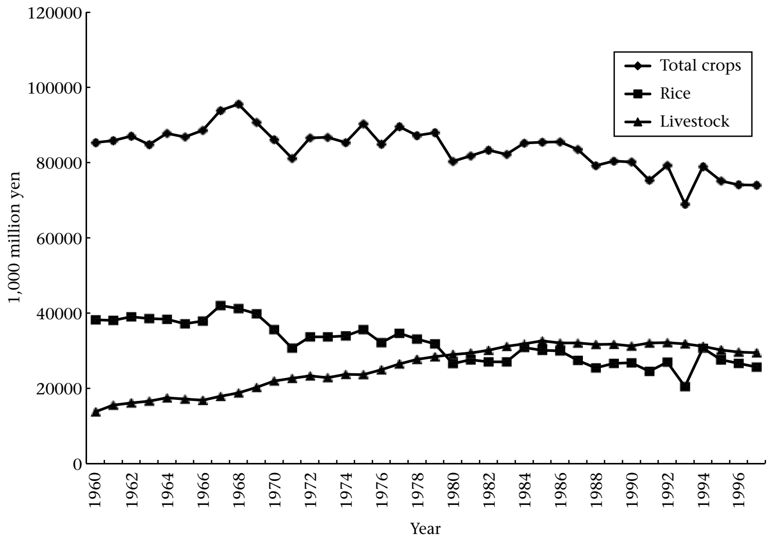

Figure 1.2 Amounts of production of total crops, rice, and livestock for 1960–97 at 2000 fiscal year prices

Source: *The Social Account for Agriculture- and Food-Related Industries*, the MAFF: Tokyo, 2004. Refer to Appendix 1.1 in Volume 1 for detail.

degrees of RTS, and (v) the shadow value of land. The estimation of these economic indicators and the impacts of the price-support programs on them will be carried out for different size classes for the entire study period 1965–97, so that we will be able to examine whether or not these impacts were farm size neutral. To be more specific we will ask a critical question, namely, which were more successful in obtaining gains from the price-support programs during the study period 1965–97; smaller- or larger-scale farms?

Although several researchers have estimated the shadow value of land for Japanese agriculture (e.g., Egaitsu and Shigeno (1983), Shigeno and Egaitsu (1984), Kuroda (1988a, 1988b), Kuroda (1992), Kusakari (1989), Kusakari (1994)), none has empirically documented the impact of price-support programs on the shadow value of farmland. This chapter may be the first attempt to present such influence in quantitative terms and is expected to offer policy makers useful information on how to ease land movements in the agricultural sector.

The rest of this chapter is organized as follows. Section 1.2 presents the analytical framework. Section 1.3 explains the data and estimation procedure. Section 1.4 presents the empirical results. Finally, Section 1.5 provides a brief summary and conclusion.

1.2 Analytical Framework

As mentioned earlier, the major objective of this chapter is to investigate the impacts of output price-support policies on various economic indicators such as the output supplies and factor input demands, the degrees of RTS, the maximized profits, and the shadow price of land.[2] To pursue this objective, the present section develops a framework of the multiple-product VP function model for which the ordinary translog form is specified.[3] However, before going immediately into this subject, it is critical to quantitatively examine the following subjects related to the production technology of postwar Japanese agriculture. More specifically, based on the estimated parameters of the multiple-product ordinary translog VP function, (i) we will test several hypotheses concerning the technology structure of postwar Japanese agriculture, (ii) we will estimate output supply and factor demand elasticities, RTS, and the shadow value of farmland,[4] (iii) based on the estimated shadow value of land, we will investigate the possibilities of land transfers from small- to large-scale farms.[5] Before going further, we will elaborate on the hypothesis and describe the methodology used to assess the impact of price-support programs. More specifically, we will elaborate the hypothesis around the statement that price-support programs in Japanese agriculture during the latter half of the 20th century increased the price of farmland and hence limited the transfer of farmlands from small- to large-scale farms for more efficient larger-scale farming.

Now, the rapid economic growth in Japan during the postwar years, especially since the mid-1950s, has been accompanied by a sizable transfer of labor from the agriculture to the non-agricultural sectors, mainly due to the strong demand for labor in the latter. Because of this sharp demand, labor has become more expensive compared to capital, which in turn has induced a rapid mechanization and resulted in economies of scale in Japanese agriculture because of the 'indivisibility' of machinery input.[6] Theoretically,[7] such 'mechanical' (M) technological change has the following effects on the marginal productivity (or the shadow value) of land. To take full advantage of the new technology and achieve more efficient use of family labor and machinery, farmers who have adopted the new technology want to have more land. This implies that the demand (or, equivalently, marginal productivity) curve of land will shift to the right, which in turn will cause increases in the marginal productivity of farmland, since the supply of farmland is limited in the short run.

If, at the same time, price-support programs are adopted by the government, more farmers will want to add land to their farms to gain more profits. This will increase the demand for land and hence raise the marginal productivity of farmland. On the other hand, if the government does not adopt price-support programs, the result will be totally opposite. By adopting new technology and larger-scale farming, farmers can in general produce more, for example, rice, than before. The inelastic demand for rice would result in a sharp decrease in its price due to the shift to the right of the supply curve of rice. This decrease in rice price would then cause a decline in the derived demand for land, that is, a downward shift in the marginal productivity curve of land and hence a decline in the shadow value of farmland.

This demonstrates the importance of price-supports in the explanation of changes in land prices. From this theoretical explanation, one may say that price-support programs together with M-technological change played an important role in raising the price of farmland during the latter half of the 20th century. To investigate the impact of price-support programs on the shadow value of farmland, the multiple-product ordinary translog normalized VP function system will be estimated where unpaid family labor and land are treated as quasi-fixed inputs.[8] Introduction of the profit function of this specification makes it possible to compute directly the shadow values of both family labor and land and the impacts of changes in output prices on various economic indicators, including the shadow values of labor and land.

Since the primary concern in this chapter is to investigate the possibilities of changes in the production structure from small- to large-scale farming, indicators such as (i) the elasticities of supplies of the two categories of outputs, that is, crops and livestock, (ii) the elasticities of demands for variable factor inputs, (iii) the maximized profits, (iv) the magnitudes of RTS, and (v) the shadow value of land,

and the effects of price-support programs on them will be estimated for the different size classes of farms. In particular, it is intriguing to investigate quantitatively whether the impacts of the price-support programs are neutral or systematically different among the different size classes. As Gardner and Pope (1978) point out, consideration of the neutrality of such impacts among different size classes has important implications in size distribution. If, for example, a price-support program is found to yield higher (or even equal) rates of return to land in small farms than in large farms, the movement of land from small to large farms will be restricted, and vice versa.

1.2.1 The Variable Profit Function Model

Consider the following multiple-product VP function,

$$VP' = G(\mathbf{P}', \mathbf{w}', \mathbf{Z}, t, \mathbf{D}), \tag{1.1}$$

where VP' is a nominal variable profit, $\mathbf{P}'$ is a vector of nominal output prices which are disaggregated into the prices of crops ($P_G{}'$) and livestock ($P_A{}'$), $\mathbf{w}'$ denotes a vector of nominal variable factor input prices which consists of the prices of machinery ($w_M{}'$), intermediate ($w_I{}'$), and other ($w_O{}'$) inputs, $\mathbf{Z}$ is a vector composed of labor (Z_L) and land (Z_B) as quasi-fixed inputs and a stock of technological knowledge (Z_R) which can be regarded as a productivity parameter external to all of the farms. Additionally, t is a time index as a proxy for technological innovations which are not explained by changes in Z_R, and $\mathbf{D}$ consists of dummy variables for period (D_p), farm sizes (D_s, $s = II, III, IV$), and weather condition (D_w).[9] By normalizing nominal VP', $\mathbf{P}'$, and $\mathbf{w}'$ by $P_A{}'$, we rewrite the nominal VP' function in (1.1) as the real VP function:

$$VP = F(P_G, \mathbf{w}, \mathbf{Z}, t, \mathbf{D}), \tag{1.2}$$

where $VP = VP'/P_A{}'$, $P_G = P_G{}'/P_A{}'$, $\mathbf{w} = \mathbf{w}'/P_A{}'$.

Now, for econometric estimation, the following multiple-product ordinary translog form (Diewert, 1974) is postulated for the VP function (1.2):[10]

$$\ln VP = \alpha_0 + \alpha_G \ln P_G + \sum_k \alpha_k \ln w_k + \sum_l \beta_l \ln Z_l$$
$$+ \frac{1}{2}\gamma_{GG} \left(\ln P_G\right)^2 + \sum_k \gamma_{Gk} \ln P_G \ln w_k$$

$$
\begin{aligned}
&+\frac{1}{2}\sum_k\sum_n \gamma_{kn}\ln w_k \ln w_n + \frac{1}{2}\sum_l\sum_h \delta_{lh}\ln Z_l \ln Z_h \\
&+\sum_k \phi_{Gk}\ln P_G \ln w_k + \sum_l \phi_{Gl}\ln P_G \ln Z_l \\
&+\sum_k\sum_l \phi_{kl}\ln w_k \ln Z_l + \mu_{GR}\ln P_G \ln Z_R \\
&+\sum_k \mu_{kR}\ln w_k \ln Z_R + \sum_l \mu_{lR}\ln Z_l \ln Z_R \\
&+\frac{1}{2}\mu_{RR}\left(\ln Z_R\right)^2, \qquad (1.3)
\end{aligned}
$$

$k,n = M,I,O,\ h,l = L,B,$

where $\gamma_{kn} = \gamma_{nk}, \quad \delta_{hl} = \delta_{lh}$.

Applying the Hotelling (1932)–Shephard's (1953) Lemma to the ordinary translog VP function (1.3), we can obtain output revenue-profit share functions as well as variable factor input cost-profit share functions. Assuming that the farm-firm takes the prices of the outputs and the variable factor inputs as given, the following output revenue- and factor input cost-profit share equations are derived.

To begin with, the crop product revenue-profit share equation (R_G) can be written as follows:

$$
\begin{aligned}
R_G &= \frac{\partial VP}{\partial P_G}\frac{P_G}{VP} = \frac{\partial \ln VP}{\partial \ln P_G} \\
&= \alpha_G + \gamma_{GG}\ln P_G + \sum_k \gamma_{Gk}\ln w_k + \sum_l \phi_{Gl}\ln Z_l \\
&\quad + \mu_{GR}\ln Z_R, \qquad (1.4)
\end{aligned}
$$

$k,n = M,I,O,\ l = L,B.$

Note here, however, that the prices of both crop and livestock products have been supported by the government in some form or other, so that the prices of these products (P_G and P_A) are not the equilibrium prices in competitive markets. These prices are instead the sums of subsidies and market-clearing prices. We will call these prices the 'effective prices' of the two products. Thus, we are assuming here that the farm-firm maximizes profits by equating the marginal revenue of each product, that is, the 'effective price', to its marginal cost.

Next, the variable factor input cost-profit share equations can be derived as follows:

$$-R_k = -\frac{\partial VP}{\partial w_k}\frac{w_k}{VP} = \frac{\partial \ln VP}{\partial \ln w_k}$$
$$= \alpha_k + \gamma_{Gk}\ln P_G + \sum_n \gamma_{kn}\ln w_n + \sum_l \phi_{kl}\ln Z_l$$
$$+ \mu_{kR}\ln Z_R, \qquad (1.5)$$
$$k,n = M,I,O, \; l = L,B.$$

Following Fuss and Waverman (1981, pp. 288–9), Ray (1982), and Capalbo (1988), we introduce an analogous assumption as done in the case of the multiple-product ordinary translog VC function that the ordinary translog VP function can be used along with the profit-maximizing condition to derive an additional equation representing the optimal choice of a quasi-fixed input, that is, labor (Z_L).[11] In doing this, we are assuming that the farm-firm attains the optimal allocation of labor input by equating the marginal productivity of labor to the market price of labor represented by the wage rate of temporary-hired labor:[12]

$$R_{Z_L} = \frac{\partial VP}{\partial Z_L}\frac{Z_L}{VP} = \frac{\partial \ln VP}{\partial \ln Z_L}$$
$$= \beta_L + \phi_{GL}\ln P_G + \sum_k \phi_{kL}\ln w_k + \sum_h \delta_{Lh}\ln Z_h$$
$$+ \mu_{BR}\ln Z_R, \qquad (1.6)$$
$$k = M,I,O, \; h = L,B.$$

Introduction of the labor cost-profit share equation (R_{Z_L}) into the estimation of the system of equations will in general lead to a more efficient estimation of the coefficients, in particular of the labor input-associated variables due to the additional information provided by the labor cost-profit share equation.

Now, any sensible profit function must be homogeneous of degree one in output and input prices. In the ordinary translog VP function (1.3) this requires the following restrictions:

$$\sum_i \alpha_i + \sum_k \alpha_k = 1,$$

$$\sum_i \gamma_{Gi} + \sum_k \gamma_{Gk} = 0,$$
$$\sum_i \gamma_{Ai} + \sum_k \gamma_{Ak} = 0,$$
$$\sum_i \gamma_{Mi} + \sum_k \gamma_{Mk} = 0,$$
$$\sum_i \gamma_{Ii} + \sum_k \gamma_{Ik} = 0,$$
$$\sum_i \gamma_{Oi} + \sum_k \gamma_{Ok} = 0,$$
$$\sum_i \phi_{Li} + \sum_k \phi_{Lk} = 0,$$
$$\sum_i \phi_{Bi} + \sum_k \phi_{Bk} = 0,$$
$$\sum_i \mu_{Ri} + \sum_k \mu_{Rk} = 0, \qquad (1.7)$$
$$i = G, A,\ k = M, I, O.$$

The ordinary translog VP function (1.3) has a general form in the sense that the restrictions of input-output separability and Hicks neutrality with respect to Z_R are not imposed *a priori*. Instead, these restrictions will be statistically tested via the estimation process of this function together with other restrictions to be mentioned immediately in the next subsection.

1.2.2 Tests for the Technology Structure of Production

Before going further to estimate various economic indicators such as scale economies and the shadow value of land, it may be critical to test the technology structure of postwar Japanese agriculture. This subsection therefore deals with important concepts representing the technology structure of production, namely, (i) input-output separability, (ii) input non-jointness, (iii) no technological change, (iv) neutral technological change in input space, (v) neutral technological change in output space, (vi) C–D production function, and (vii) CRTS.

The detailed expositions of the tests of similar hypotheses have already been presented in Chapter 8 of Part II, in Volume 1, which employed the multiple-product VC function with land as the quasi-fixed input as in this chapter. Of course, the formulations of these hypotheses are different between the VC and VP function frameworks.[13]

However, we will not expose here the detailed development of the procedures of testing the above seven hypotheses, since we obtained almost the same results for the above hypotheses in the present chapter as in Chapter 8, which utilized the same data set as in this chapter. We will therefore briefly summarize our test results in the section of empirical results later.

1.2.3 Output Supply and Input Demand Elasticities

Following and modifying the procedures presented by Sidhu and Baanante (1981) for the case of the multiple-product ordinary translog VP function in this chapter,[14] we can derive the formulas for output supply and variable factor demand elasticities with respect to two output prices ($P_i{}'$, $i = G, A$), three variable factor prices ($w_k{}'$, $k = M, I, O$), and two quasi-fixed factor inputs (Z_l, $l = L, B$).

We will note here that there are two types of price elasticities which correspond to the total effect and substitution effect of price changes. These are the *Marshallian* (1890) or *uncompensated* elasticities and the *Hicksian* or *compensated* elasticities. The uncompensated elasticities correspond to the total effects of a price change. They measure the effect of price changes, holding other prices constant but allowing inputs and outputs to adjust to their new equilibrium levels under the new set of relative prices (Higgins 1986, p. 480). This is exactly what we try to do in this subsection. As compactly exposed by Yotopoulos and Nugent (1976, p. 52), the output supply and input demand elasticities obtained based on the estimation of the profit function are *mutatis mutandis* elasticities which may be equivalent to Marshallian uncompensated elasticities, that is, the effect upon output (or input) of a change in the price of one factor, with all other factors taking on their optimal values.

1.2.3.1 Output Supply Elasticities

The output supply elasticities with respect to the output prices ($P_i{}'$, $i = G, A$) can be derived using the definition of the output revenue-profit shares as follows.

To begin with, the *i*th output revenue-profit share can be written as,

$$\frac{\partial \ln VP'}{\partial \ln P_i{}'} = \frac{\partial VP'}{\partial P_i{}'}\frac{P_i{}'}{VP'} = \frac{P_i{}' Q_i}{VP'} = R_i, \quad i = G, A. \tag{1.8}$$

Taking the natural logarithms of both sides of the last equation and rearranging gives,

$$\ln Q_i = \ln R_i - \ln P_i{}' + \ln VP', \quad i = G, A. \tag{1.9}$$

Now, using the parameters of the multiple-product ordinary translog VP function (1.3), the *i*th product supply elasticity with respect to the own price $P_i{}'$ (ε_{ii}) can be estimated through a little tedious calculation by,

$$\varepsilon_{ii} = \frac{\partial \ln Q_i}{\partial \ln P_i{}'} = \frac{\gamma_{ii}}{R_i} + R_i - 1, \quad i = G, A. \tag{1.10}$$

At the approximation points of the associated variables, this can be rewritten as,

$$\varepsilon_{ii} = \frac{\gamma_{ii}}{\alpha_i} + \alpha_i - 1, \quad i = G, A. \tag{1.11}$$

Similarly, the *i*th product supply elasticity with respect to the price of the other product $P_j{}'$ (ε_{ij}) can be given by,

$$\varepsilon_{ij} = \frac{\partial \ln Q_i}{\partial \ln P_j'} = \frac{\gamma_{ij}}{R_j} + R_j, \quad i \neq j = G, A. \tag{1.12}$$

At the approximation points, this can be given by,

$$\varepsilon_{ij} = \frac{\gamma_{ij}}{\alpha_j} + \alpha_j, \quad i \neq j = G, A. \tag{1.13}$$

In deriving ε_{ij} ($i, j = G, A$), the following relations from the homogeneous-of-degree-one-in-output-and-input-prices restrictions were utilized:

$$R_j = 1 - \left(R_i + \sum_k R_k \right),$$

$$\gamma_{ij} = -\left(\gamma_{ii} + \sum_k \gamma_{ik} \right),$$

$$\gamma_{jj} = -\left(\gamma_{ij} + \sum_k \gamma_{jk}\right),$$

$$i,j = G,A,\ k = M,I,O.$$

Second, the supply elasticities of crops and livestock with respect to the prices of the variable factor inputs ε_{ik} $(i = G,A,\ k = M,I,O)$ can similarly be derived as:

$$\varepsilon_{ik} = \frac{\gamma_{ik}}{R_i} - R_k,\ i = G,A,\quad k = M,I,O. \tag{1.14}$$

At the approximation points, equation (1.14) can be written as,

$$\varepsilon_{ik} = \frac{\gamma_{ik}}{\alpha_i} - \alpha_k,\quad i = G,A,\ k = M,I,O, \tag{1.15}$$

where

$$\gamma_{jk} = -\left(\gamma_{ik} + \sum_k \gamma_{nk}\right),\quad i,j = G,A,\ k,n = M,I,O.$$

Third, the supply elasticities of crops and livestock with respect to the quantities of the quasi-fixed factor inputs Z_l $(l = L,B)$, that is, ε_{il} $(i = G,A,\ l = L,B)$ can similarly be derived as:

$$\varepsilon_{il} = \frac{\phi_{il}}{R_l} + R_l,\quad i = G,A,\ l = L,B. \tag{1.16}$$

At the approximation points, equation (1.16) can be written as,

$$\varepsilon_{il} = \frac{\phi_{il}}{\alpha_i} + \beta_l,\quad i = G,A,\ l = L,B, \tag{1.17}$$

where

$$\phi_{jl} = -\left(\phi_{il} + \sum_k \phi_{kl}\right),\quad i,j = G,A,\ k = M,I,O,\ l = L,B.$$

1.2.3.2 Variable Factor Input Demand Elasticities

As in the cases of output supply elasticities, we can easily derive the formulas for estimating the demand elasticities for variable factor inputs in a very similar mammer as the former case.

First, variable factor demand elasticities with respect to the prices of crops and livestock ($\eta_{ki},\ k=M,I,O,\ i=G,A$) can be derived by the following equation:

$$\eta_{ki} = -\frac{\gamma_{ik}}{R_k} + R_k, \quad k=M,I,O,\ i=G,A. \tag{1.18}$$

At the approximation points, equation (1.18) can be written as,

$$\eta_{ki} = -\frac{\gamma_{ik}}{\alpha_k} + \alpha_k, \quad k=M,I,O,\ i=G,A, \tag{1.19}$$

where, from the linear-homogeneity-in-prices restrictions, we have,

$$R_j = 1 - \left(R_i + \sum_k R_k\right),$$

$$\alpha_j = 1 - \left(\alpha_i + \sum_k \alpha_k\right),$$

$$\gamma_{jk} = -\left(\gamma_{ik} + \sum_k \gamma_{kn}\right),$$

$$i,j=G,A,\ k,n=M,I,O.$$

Second, variable factor demand elasticities with respect to the prices of crops and livestock ($\eta_{kn},\ k,n=M,I,O$) can be derived as follows. To begin with, the own-price factor demand elasticities are given by,

$$\eta_{kk} = -\frac{\gamma_{kk}}{R_k} - R_k - 1, \quad k=M,I,O. \tag{1.20}$$

At the approximation points, this equation can be written as,

$$\eta_{kk} = -\frac{\gamma_{kk}}{\alpha_k} - \alpha_k - 1, \quad k=M,I,O. \tag{1.21}$$

Third, the cross-price factor demand elasticities are given by,

$$\eta_{kn} = -\frac{\gamma_{kn}}{R_k} - R_k, \quad k \neq n=M,I,O. \tag{1.22}$$

At the approximation points, equation (1.22) can be written as,

$$\eta_{kn} = -\frac{\gamma_{kn}}{\alpha_k} - \alpha_k, \quad k \neq n=M,I,O. \tag{1.23}$$

Fourth, the factor demand elasticities with respect to the quantities of the quasi-fixed inputs ($Z_l,\ l = L, B$) can be derived as follows:

$$\eta_{kl} = -\frac{\phi_{kl}}{R_k} + R_l, \quad k = M, I, O, \ l = L, B, \tag{1.24}$$

which can be rewritten at the approximation points as,

$$\eta_{kl} = -\frac{\phi_{kl}}{\alpha_k} + \alpha_l, \quad k = M, I, O, \ l = L, B. \tag{1.25}$$

1.2.4 Estimation of RTS

In their pioneering work of introducing the profit function for the first time in the production economics, Lau and Yotopoulos (1972) developed a very useful formula of testing CRTS in the profit function framework as a *dual* transformation of a production function which is homogeneous of degree κ. Using the duality theorem, they derived the following very convenient equation for testing the degree of homogeneity of the *dual* profit function (Lau and Yotopoulos, 1972, equation (1.19), p. 14) which can be written as follows using the corresponding variable notations of the present chapter:

$$\frac{(\kappa - 1)}{\kappa} \sum_n \frac{\partial VP'}{\partial w_n{}'} w_n{}' + \frac{1}{\kappa} \sum_l \frac{\partial VP'}{\partial Z_l} Z_l = VP', \tag{1.26}$$

$$n = M, I, O, \ l = L, B.$$

In other words, VP' is an *almost* homogeneous function of degrees $(\kappa - 1)/\kappa$ and $1/\kappa$ in variable factor input prices and quantities of fixed inputs, respectively.[15] Dividing both sides of equation (1.26) by VP', we obtain the following equation,

$$\frac{(\kappa - 1)}{\kappa} \sum_n \frac{\partial VP'}{\partial w_n{}'} \frac{w_n{}'}{VP'} + \frac{1}{\kappa} \sum_l \frac{\partial VP'}{\partial Z_l} \frac{Z_l}{VP'} = 1,$$

or alternatively, the RTS can be captured by,

$$RTS = \sum_l \frac{\partial \ln VP'}{\partial \ln Z_l} = \kappa - (\kappa - 1) \sum_n \frac{\partial \ln VP'}{\partial \ln w_n{}'}, \tag{1.27}$$

$$n = M, I, O, \ l = L, B.$$

Note that $\sum_n \partial \ln VP'/\partial \ln w_n' < 0$ by monotonicity conditions on the profit function. Hence, if $\kappa > 1$ (IRTS), $\sum_l \partial \ln VP'/\partial \ln Z_l > 1$. If $\kappa = 1$ (CRTS), $\sum_l \partial \ln VP'/\partial \ln Z_l = 1$. If $\kappa < 1$ (DRTS), $\sum_l \partial \ln VP'/\partial \ln Z_l < 1$.[16] Thus, the test of the hypothesis of CRTS in the case of the profit function can be carried out by examining if $\sum_l \partial \ln VP'/\partial \ln Z_l = 1$. Alternatively, we can estimate degrees of RTS for each observation by $\sum_l \partial \ln VP'/\partial \ln Z_l$ which are the elasticities of the profit function with respect to the fixed factors of production or the shadow value-profit shares of the quasi-fixed inputs, labor (R_{Z_L}) and land (R_{Z_B}) in this chapter. They are given by the following equation derived easily from the VP function (1.3) of this chapter.

$$\begin{aligned} R_{Z_l} &= \frac{\partial \ln VP'}{\partial \ln Z_l} \\ &= \beta_l + \sum_i \phi_{il} \ln P_i' + \sum_k \phi_{kl} \ln w_k' + \sum_l \delta_{lh} \ln Z_h \\ &\quad + \mu_{lR} \ln Z_R, \end{aligned} \tag{1.28}$$

$$i = G, A,\ k = M, I, O,\ h, l = L, B.$$

1.2.5 Estimation of the Shadow Values of Land

The shadow value of a quasi-fixed input can be obtained by differentiating the profit function (1.1) with respect to the quantity of that quasi-fixed input (Diewert, 1974, p. 140; Nadiri, 1982, p. 452) as:

$$\frac{\partial VP'(\mathbf{P}', \mathbf{w}', \mathbf{Z}, t, \mathbf{D})}{\partial Z_l} = w_l^{S'}(\mathbf{P}', \mathbf{w}', \mathbf{Z}, t, \mathbf{D}), \quad l = L, B, \tag{1.29}$$

where $w_l^{S'}$ is the shadow value of the lth quasi-fixed input. Derivatives of the VP function (1.1) and the *primal* production function (not presented in this chapter) with respect to the lth quasi-fixed input are equivalent due to the *dual* transformation relationships between the two functions (Lau, 1978, p. 146; Nadiri, 1982, p. 452).

These equations give the imputed value of a marginal unit of quasi-fixed input l. As clearly seen in equation (1.29), the shadow value equation is a function of the output prices (P_i', $i = G, A$), the variable factor input prices (w_k', $k = M, I, O$), the quantities of the quasi-fixed inputs (Z_l, $l = L, B$), and the stock of technological knowledge (Z_R).[17]

In terms of parameters of the multiple-product ordinary translog VP function (1.3) of this chapter, $w_l{}'$ is given by,

$$\frac{\partial VP'}{\partial Z_l} = w_l^{S'}$$
$$= \frac{VP'}{Z_l}\frac{\partial \ln VP'}{\partial Z_l}$$
$$= \frac{VP'}{Z_l}\left(\beta_l + \sum_i \phi_{il} \ln P_i{}' + \sum_k \phi_{ik} \ln w_k{}' + \sum_h \delta_{hl} \ln Z_h \right.$$
$$\left. + \mu_{lR} \ln Z_R \right), \tag{1.30}$$

$$i = G, A,\ k = M, I, O,\ h, l = L, B.$$

Given estimates of β_l $(l = L, B)$, ϕ_{il} $(i = G, A)$, ϕ_{ik} $(k = M, I, O)$, the shadow value can be computed for each sample observation of each size class for the study period 1965–97. In order to examine at what level the farm-firm evaluates the productive value of land, the computed shadow value of land will then be compared with the actual land rent, which has been regulated by the government in certain forms based on the Agricultural Land Law.

It is noted here however that the shadow value of labor can be estimated together with the shadow value of land using equation (1.30). However, as mentioned earlier in the section of developing the VP function model, the labor cost-profit share equation is going to be included in the system of estimating equations. This means that we assume the farm-firm maximizes profits with respect to labor input, or, in other words, the farm-firm utilizes the 'optimal' level of labor input with respect to the actual market price of labor. Thus, we will not present the shadow value of labor in the present chapter.[18]

1.2.6 Impacts of Changes in Output Prices on Output Supplies, Variable Factor Demands, Profits, RTS, and the Shadow Value of Land

Needless to say, one can compute the impacts of all the exogenous variables of the VP function $H(\mathbf{P}, \mathbf{w}, \mathbf{Z})$ on the supplies of outputs $(Q_i,\ i = G, A)$, demands for variable factor inputs $(X_k,\ k = M, I, O)$, profits (VP'), RTS, and the shadow values of the quasi-fixed inputs $(w_l^{S'},\ l = L, B)$. However, this chapter will concentrate on evaluating the effects of the government output price-support programs on (i) the farm-firm's profit-maximizing supplies of crop and livestock products, (ii) the profit-maximizing demands for variable factor inputs, (iii) the maximized variable profits, (iv) RTS, and (v) the shadow value of land.

Here, the impacts will be expressed in terms of elasticities which easily capture the relative degrees of importance of the effects of changes in the prices of crops and livestock (P_i, $i = G, A$) on the above-mentioned economic indicators.

At this point, we will briefly mention about price-support programs during the period under question, 1965–97. The price-supports for rice production, in particular, have been substantial since around the early-1960s right after the Agricultural Basic Act was put in force in 1961. Although the levels of rice price-supports have become smaller and smaller over time due to changes in agricultural policies, the price-supporting system has still been fairly active. Furthermore, prices not only of rice but also of other crop products such as wheat, barley, soybeans, other vegetables, fruits, and livestock products have been supported at least in some form or other.

Accordingly, investigating the impacts of changes in the prices of two categories of products (P_G and P_A) on the above-mentioned various economic indicators may be tantamount to examining the effects of price-support programs on the above-mentioned economic indicators in Japanese agriculture during the latter half of the 20th century. It is not only a challenging and intriguing research topic but also an important realistic subject to examine quantitatively the effects of the government price-support policies on agriculture. Thus, we will derive procedures to pursue this objective in the following paragraphs.

Now, the impacts of changes in the prices of crop and livestock products ($P_G{}'$ and $P_A{}'$) on the own and cross supplies of these two products may be given by $\partial Q_i / \partial P_j{}'$ $(i, j = G, A)$. In terms of elasticities, they are given by the output supply elasticities with respect to the prices of crops and livestock as follows.

First, the own-price impacts on the supplies of crops and livestock are given by,

$$\frac{\partial \ln Q_i}{\partial \ln P_i{}'} = \varepsilon_{ii} = \frac{\gamma_{ii}}{R_i} + R_i - 1, \quad i = G, A, \tag{1.31}$$

and the cross-price impacts on the supplies of crops and livestock are given by,

$$\frac{\partial \ln Q_i}{\partial \ln P_j{}'} = \varepsilon_{ij} = \frac{\gamma_{ij}}{R_i} + R_i, \quad i \neq j = G, A, \tag{1.32}$$

where R_i $(i = G, A)$ is the output revenue-profit share derived in equation (1.4). In fact, these elasticities given by ε_{ii} and ε_{ij} are equivalent to the own- and cross-price elasticities of supply of crops and livestock which are already given by equations (1.10) and (1.12), respectively.

Second, the impacts of changes in the output prices $(P_i{}', \; i = G, A)$ on the demands for the variable factor inputs in terms of elasticities can be obtained by,

$$\frac{\partial \ln X_k}{\partial \ln P_i{}'} = \eta_{ki} = -\frac{\gamma_{ik}}{R_k} + R_k, \quad i = G, A, \; k = M, I, O, \tag{1.33}$$

where R_k $(k = M, I, O)$ is the variable factor input cost-profit share given in equation (1.5). In fact, the η_{ki}s are the elasticities of demand for the kth factor input with respect to the ith output price, which is already given by equation (1.18).

Third, the impacts of changes in the output prices $(P_i{}', \; i = G, A)$ on the maximized profits (VP') in terms of elasticities can be obtained by,

$$\frac{\partial \ln VP'}{\partial \ln P_i{}'} = \alpha_i + \sum_j \gamma_{ij} \ln P_j{}' + \sum_k \gamma_{ik} \ln w_k{}' + \sum_l \phi_{il} \ln Z_l + \mu_{iR} \ln Z_R, \tag{1.34}$$

$$i, j = G, A, \; k = M, I, O, \; l = L, B,$$

which is equivalent to the output revenue-profit shares of crop and livestock production $(R_i, \; i = G, A)$. Here, however, we are going to estimate the impacts given by equation (1.34) using the estimated coefficients of the VP function model, which are in general different from the actual output revenue-profit shares of crops and livestock used for the estimation of the system.

Fourth, the impacts of changes in the output prices $(P_i{}', \; i = G, A)$ on RTS in terms of elasticities can be obtained by,

$$\frac{\partial \ln(RTS)}{\partial \ln P_i{}'} = \frac{\sum_l \phi_{il}}{RTS}, \quad i = G, A, \; l = L, B, \tag{1.35}$$

where RTS is given by equation (1.27).

Finally, the impacts of changes in the output prices ($P_i{}'$, $i = G, A$) on the shadow value of land ($w_B^{S'}$) in terms of elasticities can be obtained by,

$$\frac{\partial \ln w_B^{S'}}{\partial \ln P_i{}'} = \frac{\partial \ln VP'}{\partial \ln P_i{}'} + \frac{\partial \left(\frac{\partial \ln VP'}{\partial \ln Z_B} \right)}{\partial \ln P_i{}'} \left(\frac{\partial \ln VP'}{\partial \ln Z_B} \right)^{-1}$$
$$= \frac{\partial \ln VP'}{\partial \ln P_i{}'} + \phi_{iB} \left(\frac{\partial \ln VP'}{\partial \ln Z_B} \right)^{-1}, \tag{1.36}$$

$i = G, A.$

All these impacts caused by changes in the prices of crops and livestock (P_G and P_A) on the profit-maximizing output supplies (Q_i, $i = G, A$) and the variable factor demands (X_k, $k = M, I, O$), the maximized variable profits (VP'), returns to scale (RTS), and the shadow value of land ($w_B^{S'}$) will be estimated for all observations for all four size classes for the entire study period 1965–97 and they will be shown in the form of graphs. In this way, one can visually capture differences in the magnitudes of the impacts among the four size classes and changes in the impacts over time for the four different size classes.

1.3 The Data and Estimation Procedure

The data required for the estimation of the VP function model consist of the variable profit (VP'), the output revenue-profit shares (R_G and R_A) and prices of crops and livestock ($P_G{}'$ and $P_A{}'$), the prices and quantities of the three variable factors of production, machinery ($w_M{}'$ and X_M), intermediate input ($w_I{}'$ and X_I), and other input ($w_O{}'$ and X_O), the variable factor input cost-profit shares (R_M, R_I, R_O), the quantities of labor (Z_L) and land (Z_B) as quasi-fixed inputs, and the stock of technological knowledge (Z_R) as an exogenous input. In addition, dummy variables for period (D_p), farm sizes (D_s, $s = II, III, IV$), and weather (D_w) are introduced. The details of the sources of data and the variable definitions are described in Appendix.

For statistical estimation, the system of equations consists of the ordinary translog VP function (1.3), two of the revenue-profit share equations (1.4), three of the variable factor cost-profit share equations (1.4), and one shadow labor cost-profit share equation (1.6). Note here that in this system of equations, labor is treated as a 'quasi-endogenous' variable. Thus, the estimation model is 'complete' in the sense that it has as many (seven) equations as endogenous variables (seven). Therefore, the full information maximum likelihood (FIML) method is chosen.[19] In this process, the restrictions due to symmetry and linear homogeneity in prices are imposed. Due to the linear-homogeneity-in-prices property of the profit function, one revenue share equation can be omitted from the simultaneous equation system. In this chapter the livestock revenue-profit share equation is omitted. The coefficients of the omitted livestock revenue-profit share equation can easily be obtained after the system is estimated using the imposed linear homogeneity restrictions.

1.4 Empirical Results

1.4.1 Estimates of the VP Function Model

To begin with, the estimated parameters of the VP function system and the associated *P*-values are reported in Table 1.2.[20] According to the *P*-value tests, eleven out of the forty-five coefficients are not statistically significant at the 10 per cent level, which may be considered to be reasonable. Goodness-of-fit statistics are given in the lower part of Table 1.2, and indicate a fairly good fit for the model.

In addition, based on the parameter estimates of the VP function model given in Table 1.2, the monotonicity and convexity conditions with respect to input prices were checked at each observation. Since all the estimated profit shares for both outputs are positive, but were negative for the variable factor inputs, the production technology satisfied the monotonicity condition. Furthermore, all of the eigenvalues of the diagonal elements of the Hessian matrix were positive for all observations, which indicates that the convexity conditions with respect to the variable factor prices were also satisfied at all samples for the entire period 1965–97. This implies that the estimated factor demand elasticities with respect to their own prices are all negative, which is economically meaningful.

As for the concavity conditions with respect to the quasi-fixed inputs, labor (Z_L) and land (Z_B), the eigenvalues given by $[\delta_{hh}+\beta_h(\beta_h-1),\ h=L,B\ ]$ in the present chapter must be smaller than or equal to zero. The estimated eigenvalues for all samples were all negative

Table 1.2 Parameter estimates of the multiple-product ordinary translog VP function: 1965–97

Param.	Coeff.	*P*-value	Param.	Coeff.	*P*-value
α_0	0.032	0.171	γ_{IO}	−0.027	0.532
α_G	1.564	0.000	δ_{LL}	0.694	0.000
α_A	0.392	0.000	δ_{BB}	0.136	0.000
α_M	−0.350	0.000	δ_{LB}	−0.196	0.000
α_I	−0.428	0.000	ϕ_{GL}	−0.436	0.000
α_O	−0.179	0.000	ϕ_{GB}	0.047	0.457
β_L	1.314	0.000	ϕ_{AL}	−0.300	0.000
β_B	0.197	0.000	ϕ_{AB}	0.185	0.000
β_R	0.276	0.000	ϕ_{ML}	0.310	0.000
γ_{GG}	0.750	0.019	ϕ_{MB}	−0.079	0.039
γ_{GA}	−1.040	0.000	ϕ_{IL}	0.277	0.000
γ_{AA}	0.555	0.000	ϕ_{IB}	−0.095	0.003
γ_{GM}	−0.153	0.468	ϕ_{OL}	0.150	0.000
γ_{GI}	0.316	0.002	ϕ_{OB}	−0.058	0.000
γ_{GO}	0.126	0.000	μ_{GR}	−0.002	0.985
γ_{AM}	0.286	0.000	μ_{AR}	0.116	0.057
γ_{AI}	0.056	0.492	μ_{MR}	−0.005	0.938
γ_{AO}	0.144	0.000	μ_{IR}	−0.114	0.002
γ_{MM}	−0.062	0.679	μ_{OR}	0.005	0.774
γ_{II}	0.136	0.000	μ_{LR}	0.373	0.002
γ_{OO}	−0.134	0.000	μ_{BR}	0.034	0.153
γ_{MI}	0.038	0.388	μ_{RR}	−0.538	0.008
γ_{MO}	−0.109	0.002			

Estimating equations	*R*-squared	*SER*
Variable profit function	0.977	0.087
Machinery input cost-profit share equation	0.844	0.065
Intermediate input cost-profit share equation	0.787	0.044
Other input cost-profit share equation	0.869	0.116
Labor input cost-profit share equation	0.627	0.030

Notes: (1) The symmetry and homogeneity-of-degree-one-in-output-input-prices restrictions are imposed in the estimation. The coefficients of the parameters with *A* in this table were obtained from these restrictions; more specifically, through equation (1.7) after the estimation of the whole VP model.
(2) *SER* denotes standard error of regression.
(3) The *P*-value indicates the degree of probability which gives directly the extent of statistical significance of the estimated indicator.

or close to zero. This may imply that the concavity conditions with respect to the quasi-fixed inputs (Z_L and Z_B) were satisfied basically for all observations.[21]

These findings indicate that the estimated VP function (1.3) represents second order approximations to the data that satisfy the curvature conditions. The estimated parameters given in Table 1.2 are therefore reliable and are utilized for further analyses in the following sections.

1.4.2 Results of Tests of Hypotheses

In this subsection, the technology structure of postwar Japanese agriculture is tested using the Wald test procedure in order to examine whether or not our specification of the multiple-product ordinary translog VP function model is valid.

However, as mentioned earlier, we have already carried out similar tests in detail based on the estimated results of the multiple-product ordinary translog VC function (Chapter 8 in Volume 1). Accordingly, we will explain briefly the results of the tested hypotheses. They are (i) input-output separability, (ii) input non-jointness, (iii) no technological change, (iv) neutral technological change in input space, (v) neutral technological change in output space, (vi) C–D production function, and (vii) CRTS.[22]

First, the hypothesis of input-output separability was strongly rejected. It immediately follows that the profit-maximizing variable factor input cost-profit shares depend on changes in the output prices (P_i', $i = G, A$).

Second, the null hypothesis of non-jointness in inputs was also strongly rejected. This result implies the absence of input non-jointness, indicating that a separate production function does not exist for each output. The results of these two tests indicate that the multiple-product profit function is more appropriate than the single-product profit function for the specification of the technology structure of postwar Japanese agricultural production.

Third, the test for no technological change was strongly rejected. This implies that there existed technological change in postwar Japanese agriculture in some form or other.

Fourth, Hicks neutral technological change in input space was strongly rejected. This means that technological change in postwar

Japanese agriculture is biased *toward* or *against* specific factor inputs; that is, machinery, intermediate, and other inputs.

Fifth, Hicks neutral technological change in output space was also strongly rejected, indicating that technological change in postwar Japanese agriculture has been biased in output space as in the case of input space. The estimates of the direction of bias were 0.298 at the approximation points whose *P*-value for the Wald test was 0.154. This implies that the output bias was livestock-production *favoring* during the study period 1965–97, though the level of statistical significance is a little low, around the 15 per cent level.

Thus, it is natural from the results of the tests for the fourth, fifth, and sixth hypotheses above that Hicks neutrality both in input space and in output space was strongly rejected.

Sixth, the null hypothesis of the C–D production function was absolutely rejected. This means that the strict assumption of unitary elasticity of substitution between any pair of factor inputs is not realistic at all in specifying the production structure of postwar Japanese agriculture. Furthermore, since the C–D production function assumes Hicks neutrality of technological change from the beginning, this result of rejection of the C–D production function is consistent with the above results of the tests of the Hicks neutrality of technological change in input space as well as in output space.

Seventh, CRTS in joint production of crops and livestock was strongly rejected in the present VP function model. The estimated degrees of scale economies were 1.341 at the approximation points for the VP function model. This result indicates that there existed IRTS on the average for the VP function model for postwar Japanese agriculture. We will estimate later in this section the degrees of IRTS for all observations of the four different size classes for the entire study period 1965–97.

In sum, we may assert that the most important finding in this subsection is that a multiple-product VP function approach may be more appropriate than a single-product VP function approach to investigating the technology structure of postwar Japanese agriculture. This result is consistent with the one which we obtained in the previous Parts I and II, where we found that the multiple-product TC and VC function models are more appropriate than the single-product TC and VC function models. In addition, the test results tell us that we should employ models which are as flexible as possible in terms of input-output separability, Hicks neutrality of technological change, elasticities of output supplies and input demands, and RTS.

1.4.3 Output Supply and Input Demand Elasticities

Using the appropriate equations (1.10) through (1.25), output supply and input demand elasticities were estimated at the approximation points of the variables employed for the estimation of the VP function (1.3). They are shown in Table 1.3. Recall that the estimated elasticities are the *Marshallian* elasticities instead of the *Hicksian* elasticities. Several intriguing findings emerge from this table.

To begin with, the own-price supply elasticities of both crops and livestock are 1.044 and 0.806, respectively, which are fairly high for agricultural commodities. That is, a 1 per cent increase in the prices of crops and livestock will increase the supplies of crops and livestock by 1.044 and 0.806 per cent, respectively. This in turn implies that the price-support programs for these agricultural products during the study period 1965–97 had fairly strong effects on increasing the supplies of crops and livestock, in particular rice. Turning to the cross-price elasticities, the elasticity of supply of crops with respect to the price of livestock is −0.272 while the elasticity of supply of livestock with respect to the price of crops is −2.257, indicating that increases in the price of crops decreased the supply of livestock rather sharply, while increases in the price of livestock had a weak impact in reducing the supply of crops. From these results, we may infer that the price-support programs for rice, in particular, gave strong effects not only on increasing rice production but also on reducing the supply of livestock products at the same time.

We will compare our results with those in the previous studies. There are only a few studies which estimate output supply elasticities for Japanese agriculture. Kuroda (1979, Table 3–2, p. 115) estimated aggregate single-product C–D profit function for the years 1965, 1966, and 1967 using data from the FHE, and obtained the own-price supply elasticities 0.982, 0.895, and 0.853 for the three years, respectively. The magnitudes of these elasticities are fairly comparable with our results for crops and livestock (1.044 and 0.806, respectively). Chino (1984) applied the linear output supply system proposed by Laitinen and Theil (1978) to Japanese data for the period 1955–81 obtained from the *Seisan Nogyo Shotoku Tokei* [the *Statistics of Agricultural Production Income*] and the PWRV published annually by the MAFF. He

Table 1.3 Elasticity estimates for supply of crop and livestock products and for demand for machinery, intermediate, and other inputs for 1965–97

	Price of crops (P'_G)	**Price of livestock (P'_A)**	**Price of machinery input (w'_M)**	**Price of intermediate input (w'_I)**	**Price of other input (w'_O)**	**Quantity of labor (Z_L)**	**Quantity of land (Z_B)**
Supply of crops (Q_G)	1.044	−0.272	−0.447	−0.226	−0.098	1.035	0.227
	(0.000)	(0.013)	(0.001)	(0.000)	(0.019)	(0.000)	(0.000)
Supply of livestock (Q_A)	−2.257	0.806	0.378	−0.286	0.187	0.549	0.668
	(0.000)	(0.008)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Demand for machinery input (X_M)	2.002	0.575	−1.173	−0.537	0.133	0.428	0.423
	(0.001)	(0.000)	(0.006)	(0.000)	(0.202)	(0.021)	(0.000)
Demand for intermediate input (X_I)	0.825	1.262	−0.439	−0.532	−0.117	0.666	0.418
	(0.001)	(0.000)	(0.000)	(0.016)	(0.239)	(0.000)	(0.000)
Demand for other input (X_O)	0.858	0.590	0.259	−0.279	−0.429	0.479	0.520
	(0.019)	(0.000)	(0.200)	(0.239)	(0.035)	(0.000)	(0.000)

Notes: (1) The elasticities were estimated using equations (1.10) through (1.25) at the approximation points of the associated variables.
(2) Figures in parentheses are the estimated *P*-values which give directly the extents of statistical significance of the estimated indicators.

obtained the long-run own-price supply elasticities 0.245 (rice), 0.794 (wheat), 0.198 (vegetables), 0.128 (fruits), 0.576 (cattle), 0.923 (milk), 0.601 (pigs), and 0.175 (eggs). At first glance, it appears that the supply elasticities of crops are smaller than those of livestock. The simple average supply elasticities of crops and livestock are 0.341 and 0.569 (Chino, 1984, Table 2-5, p. 13) which are smaller than our estimates in this chapter.

Second, the supply elasticities of crops with respect to changes in the prices of the variable factor inputs, that is, machinery, intermediate, and other inputs, are −0.447, −0.226, and −0.098, respectively. Though not that elastically, increases in the prices of the variable factor inputs will reduce the supply of crop products. On the other hand, the supply elasticities of livestock with respect to the prices of machinery, intermediate, and other inputs are respectively 0.378, −0.286, and 0.187. Unlike in the case of crops, we obtained positive elasticities with respect to machinery and other inputs. Recall that other inputs consist of farm structures and buildings, large plants, and large animals. Accordingly, we may interpret the positive elasticities as follows. Increases in the prices of these inputs will definitely reduce the revenue and hence profits from livestock production. In order to try to offset the reduction of the revenue, farmers will increase the supply of livestock products.

Third, the supply elasticities both of crops and of livestock with respect to the quasi-fixed inputs, labor and land, are positive. In particular, the output supply elasticities of crops and livestock with respect to land are respectively 0.227 and 0.668, indicating that increases in land input will increase the supply of both crops and livestock. This in turn implies that set-aside programs will reduce the supplies of both products; the reduction is sharper for livestock than for crops.

1.4.3.1 Variable Factor Demand Elasticities

To begin with, Table 1.3 shows that, on average, increases in the price of crops increase the demand for machinery, intermediate, and other inputs more elastically than in the case of increases in the price of livestock, except for the case of the demand for intermediate input. This indicates that the price-support programs for crops had stronger effects in the demand for variable factor inputs than the price-support programs for livestock, except for intermediate input. For this exception, we may conjecture that increases in the price of livestock products induced increased demand for feed for increased supplies of livestock products.

Second, according to Table 1.3, the Marshallian own-price demand elasticities for machinery, intermediate, and other inputs are −1.173, −0.532, and −0.429, respectively. The absolute numbers of these elasticities were in general greater than those obtained from the corresponding VC function from which we obtained the own-price elasticities for the three variable factor inputs: they are −0.445, −0.205, and −0.741 (Table 8.4 in Chapter 8 of Volume 1). These elasticities may be regarded as the Hicksian elasticities since they were estimated with the output levels being fixed. At least for machinery and intermediate inputs, we may say that the Marshallian elasticities are greater in absolute terms than the Hicksian elasticities. For example, the elasticity of demand for machinery indicates that a one per cent decrease in machinery price will increase the demand for machinery input by 1.17 per cent. This in turn implies that if subsidies for machinery purchases are increased, farmers will considerably increase the demand for machinery input. Though with less extent, subsidies for intermediate and other inputs will also increase the demand for these factor inputs, and hence increase the quantities of crop and livestock production.

Finally, the demand elasticities for the variable factor inputs with respect to the quasi-fixed inputs, labor and land, are all positive, indicating that increases in labor and land will increase the demand for machinery, intermediate, and other inputs. Here, we are more interested in the demand elasticities with respect to land than with respect to labor, since we may infer the magnitudes of impacts of the set-aside programs on the demand for the variable factor inputs. The demand elasticities for machinery, intermediate, and other inputs are respectively 0.423, 0.418, and 0.520, indicating that, for example, a ten per cent reduction of land input due to a set-aside program will reduce the demand for these variable factor inputs by around 4.2 to 5.2 per cent. This may cause a substantial reduction in agricultural production, both crops and livestock.

1.4.3.2 Estimates of Returns to Scale (RTS)

Using equation (1.27), RTS were estimated for all observations for the four size classes for the entire study period 1965–97 and are presented in Figure 1.3. Several important points are noteworthy.

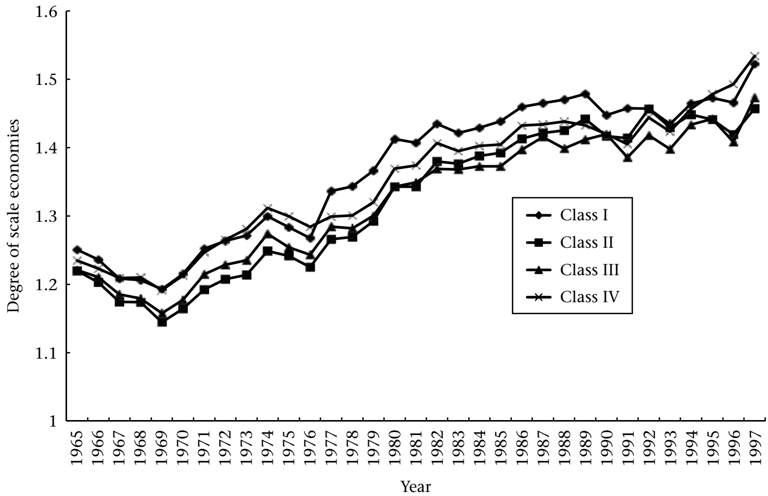

Figure 1.3 Estimates of degrees of returns to scale for 1965–97: all size classes
Note: Returns to scale (RTS) were estimated using equation (1.27).

First, all four size classes enjoyed fairly high IRTS for the period 1965–97. The degrees of scale economies had decreasing trends in all size classes during the 1965–9 period. This may have been because smaller-scale mechanization represented by hand-driven cultivators prevailed all over Japan, even for smaller-scale farms, and hence the degree of 'indivisibility' became smaller and smaller. However, as a medium- and larger-scale mechanization represented by riding-type tractors, cultivators, and rice-transplanters became popular from the late-1960s and early-1970s toward the late-1990s, the degrees of scale economies became much greater than those before the 1970s, and grew consistently over the 1970s through 1990s in all size classes; the degrees of scale economies were around 1.15–1.19 in 1969 and increased to around 1.45–1.53 in 1997.

Second, it is intriguing to observe that the degrees of scale economies of the smallest size, class I, were greatest for the whole study period 1965–97 except for the 1972–76 and 1995–7 periods. Very similar results are presented in Table 8.3 in Chapter 8 of Volume 1, which estimated an multiple-product ordinary translog VC function with only land being a fixed input for the period 1957–97.

This may reflect the fact that even many smaller-scale farms invested in medium- and larger-scale machinery and hence the degrees of 'indivisibility' may have been the greatest among all size classes due to the limited planted areas. We will come back to this intriguing observation in the next section when we evaluate the results of impacts of output price-support programs on the degrees of RTS.[23]

1.4.3.3 Estimates of the Shadow Value of Land

The shadow value of land was estimated using equation (1.30) for all samples of all four size classes for the whole period 1965–97 and is presented in Figure 1.4. For the sake of comparison, we added in this figure the actual land rent of the average farm of Tofuken, which has been regulated by the government in some form or other for the entire study period 1965–97[24] At least two important findings are worth mentioning from Figure 1.4.

First, it is very clear that the larger the farm sizes, the larger the shadow values of land for the entire period 1965–97.

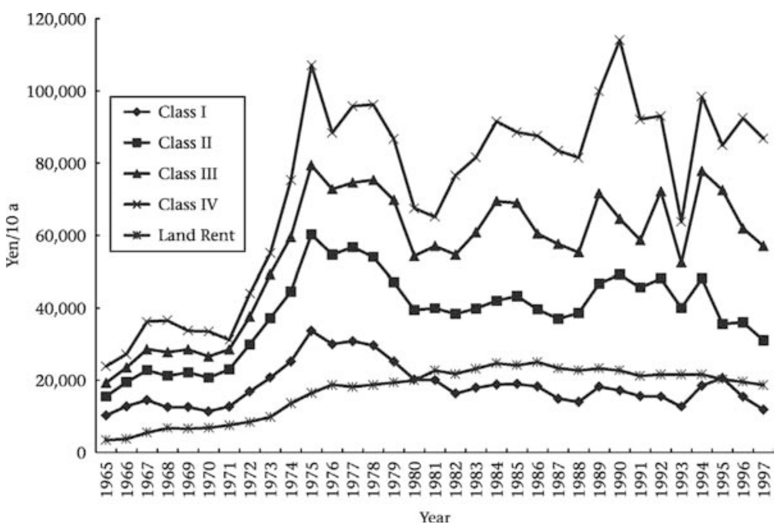

Figure 1.4 Shadow value of land and actual land rent per 10 a for 1965–97: all size classes

Notes: The shadow value of land was estimated using equation (1.30). The actual land rent was obtained from the *FHE*.

Second, but not least important, a most significant finding is that the shadow values of land of the larger three size classes were much greater than the observed land rent. However, in the case of the smallest size, class I, the shadow value of land was smaller than the observed rent of land for the period 1980–97. From this finding, we may conjecture that it is very likely that the shadow value of land of farm-firms with less than 0.5 ha might have been even smaller than the actual land rent of the average farm for a longer period than in the case of size class I in this chapter. This finding implies that farm-firms in all size classes have not been utilizing land input so as to maximize profits. Furthermore, we have already obtained very similar results as the present ones which were estimated based on the parameter estimates of the VC function with only land being a fixed input for the period 1957–97; see Figure 9.1 in Chapter 9 of Volume 1.

1.4.3.4 Possibilities of Land Transfers from Small to Large Farms

We will now try to investigate the possibilities of land movements from small to large farms. For this investigation, we will have to take into account the following small-scale farmers' behavior when it comes to transferring their farmlands to large-scale farms.

To begin with, land movements by selling and buying were limited during the whole study period 1965–97, despite government's continuous efforts for promoting land movements. One of the most important reasons for this limited land movement may be that farmers have had a strong preference to possess their lands as profitable assets. It has been considered that farmers have strong expectations that they could sell their farmlands at much higher prices for either industrial uses such as buildings, plants, highways, railroads, shopping centers, residential purposes, and so on than for purely farming purposes.

Then, what about the possibilities of land movements by renting from small-scale to large-scale farms? What economic conditions should at least be satisfied in order for small-scale farms to rent out their lands to large-scale farms? To simplify the following discussions, we will denote size classes I (0.5–1.0 ha) and IV (2.0 ha or larger) as respectively small- and large-scale farms in this chapter. Since more than 70 per cent of farms are stratified into size classes with less than 1.0 ha in Japanese agriculture, this investigation will have an important implication for the possibility of achieving more efficient and productive larger-scale farming.

With reference to Kajii (1981), Shintani (1983), Kako (1984), Hayami (1986), and Chino (1990), this chapter proposes the following two economic norms for small-scale farms to make a decision of selling or renting out their lands to large-scale farms. We note here that these two norms are basically the same as the ones given in equations (9.5), (9.6), and (9.7) in Chapter 9 (Section 9.2.2) of Volume 1, where the VC function framework was employed, although the variable notations and the expressions and the interpretations of equations are different.

$$NormI : \frac{(w_B^{S'})^{IV}}{(w_B^{S'})^{I}} > 1,$$

and

$$NormII : \frac{(w_B^{S'})^{IV}}{(FI)^{I}} > 1,$$

where *FI* is 'farm income' and defined as,

$$\begin{aligned} FI &= \sum_i P_i{}'Q_i - (w_M{}'X_M + w_I{}'X_I + w_O{}'X_O) \\ &\quad - (w_L{}'X_L^H + w_B{}'Z_B^R) \\ &= VP' - (w_L{}'X_L^H + w_B{}'Z_B^R), \end{aligned} \tag{1.37}$$

where the two terms in the parentheses of the last relation are respectively the paid wage bill to permanent and temporary-hired labor ($w_L{}'$) and the rent paid for the rented land ($w_B{}'Z_B^R$). That is, *FI* is a slightly modified 'farm income' which accrues to the self-employed factor inputs, that is, operator and family labor and own land.[25] It is noted here that both $w_B^{S'}$ and *FI* are estimated in terms of yen per 10 a.

Theoretically speaking, farm income, or, more vigorously, 'profits' of the *farm-firm* may in general be defined as total revenue minus total costs which include the costs for self-employed labor and land. In reality, however, a large number of *farm households* may not always count the costs for self-owned factor inputs as 'costs'. They instead may regard such 'costs' as part of 'farm income' which is in turn regarded as a part of 'farm household income.'

It is noted here that the *NormI* implies that if the shadow value of land (or 'rent-bearing capacity')[26] of the large farm is greater than that requested by the small farm, the small farm will rent out its land to the large farm. This norm may be valid for small farms which can find better-paid off-farm jobs even if they give up farming.

Now, we will turn to investigating the possibilities of land movements from small-scale to large-scale farms based on the two norms exposed above. The *NormI* says that if the shadow value of land (that is, 'rent-bearing capacity') of size class IV farms is greater than that of class I farms, then lands of small-scale (size class I) farms may be rented out to large-scale (size class IV) farms. According to Figure 1.5, the shadow price of land of size class IV farms was clearly much larger than that of size class I farms for the entire study period 1965–97, indicating that the *NormI* was absolutely satisfied for this period.

Next, the *NormII* says that if the shadow value of land (that is, 'rent-bearing capacity') of large (size class IV) farms is greater than the amount of 'farm income' accruing to own family labor and land

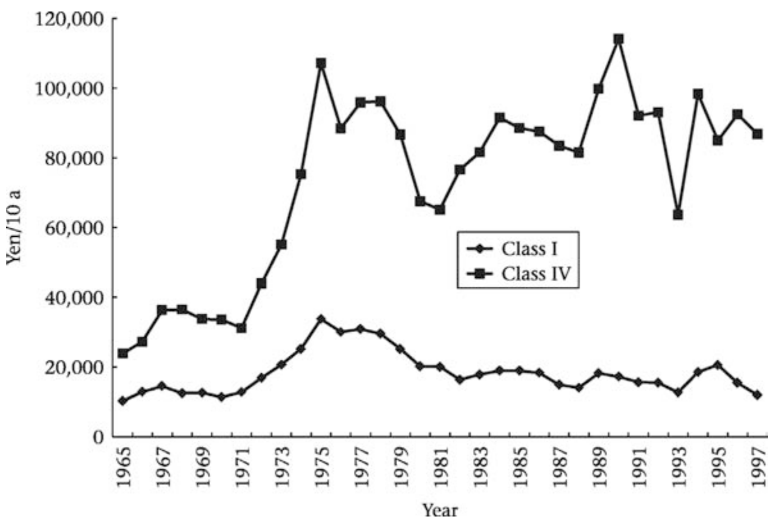

Figure 1.5 Comparison of the shadow values of land between size class I and size class IV for 1965–97 (Yen/10a)

Source: Figure 1.4.

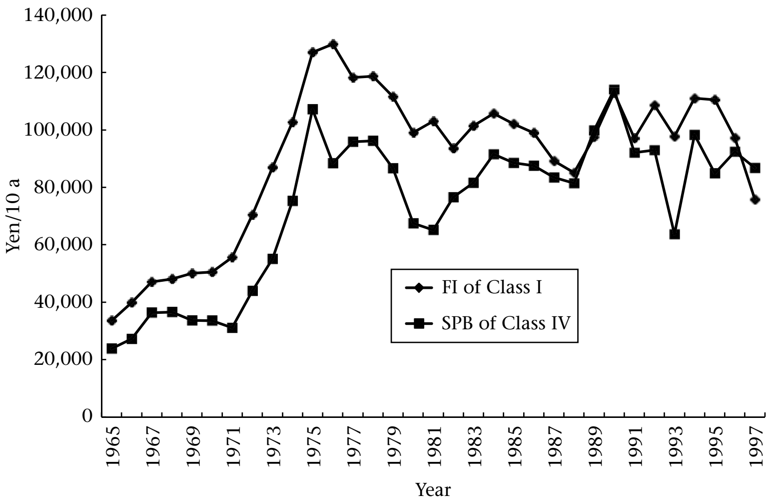

Figure 1.6 Comparison of the farm income of size class I and the shadow value of size class IV for 1965–97 (Yen/10 a);
'SPB' is the shadow price of land.

Source: Figure 1.4.

of small (size class I) farms, then there exist possibilities of land movements by renting out from small- to large-scale farms. If we look at Figure 1.6, this norm was barely satisfied for only three years 1989, 1990, and 1997.

In sum, as long as farmers completely retire from farming by any reasons, applying the *NormII* may be more realistic when it comes to considering land movements by renting out by small farms. If so, we may conclude that small-scale farmers were not ready yet to rent out their lands to large-scale farms for almost the entire study period 1965–97. Recall that very similar findings were obtained in Section 9.4.3 in Chapter 9 of Volume 1, where the VC function model was introduced. Thus, we may say that the findings obtained here based on the VP function model are consistent with those based on the VC function model.

At this point, let us look into the actual movements of land. In Table 10.1 presented in Chapter 10 of Volume 1, areas of land movements by (i) transfers of rights for land holdings and (ii) transfers of rights for lease are reported for selected years from 1960 to 2006 for Tofuken. According to this table, the area rented out increased from 1980 when the Agricultural Management Reinforcement Law was inaugurated. On the other hand, land movements by transfers of rights for land holdings increased from 2000. Due largely to the latter movement, the ratio of total transferred land area to total cultivated area increased sharply from the year 2000; by around 9 per cent.

How does one interpret this figure, large or small? The present author argues that it is still small. However, he claims that there must have been rational economic reasons why land transfers did not proceed smoothly enough against the expectations of many agricultural economists and policy makers. We hypothesize here that the governmental agricultural policies such as output price-supports, input subsidies, production adjustment programs, R&E activities and so on must have been significant influences on the slow and inactive movements of farmlands during the last half of the 20th century in Japanese agriculture. To test this critical hypothesis, we will here shed a special light on evaluating the impacts of output price-support programs on (i) the supplies of crop and livestock products, (ii) the demands for variable factor inputs, (iii) the maximized profits, (iv) the degrees of RTS, and (v) the shadow value of land.

1.4.4 Impacts of Output Price-Support Programs

1.4.4.1 Impacts of Output Price-Support Programs on the Supplies of Outputs

To begin with, we must admit that our procedure may be regarded as an *indirect* method of evaluating the impacts of output price-support programs on various economic indicators since we do not introduce in our profit function model any variable which can capture *directly* the impacts of output price-support programs. However, we believe that we can evaluate at least *indirectly* the impacts of output price-support programs on various economic indicators of agricultural production in postwar Japan by quantitatively investigating the impacts of changes in the prices of crops and livestock on any economic indicators such as output supplies, factor input demands, maximized profits, RTS, and the shadow value of farmland.

Now, we will evaluate the impacts of the price-support programs for crop production by examining the impacts of changes in the prices of crops and livestock on the supplies of these products. Needless to say, the most important price-support program in postwar Japanese agriculture has been the one for rice, as clearly observed in Table 10.1 presented in Chapter 10 of Volume 1. However, there are many other crop products whose prices have been supported in some form or other by the government as mentioned elsewhere. Thus, investigating the impacts of changes in the prices of crops and livestock on the supplies of these two categories of products may give us important information on the effects of price-support programs on the supplies of crop and livestock products during the last three decades of the 20th century in Japanese agriculture.

Figures 1.7 through 1.10 present the impacts of changes in the prices of crops and livestock on the supplies of crops and livestock. As mentioned earlier, these figures in fact present the own- and cross-price elasticities of crops and livestock with respect to their prices. Several intriguing findings are worth mentioning from these figures.

First, we will evaluate the own-price elasticities in Figures 1.7 and 1.10. According to Figure 1.7, it is clear that the smaller the farm

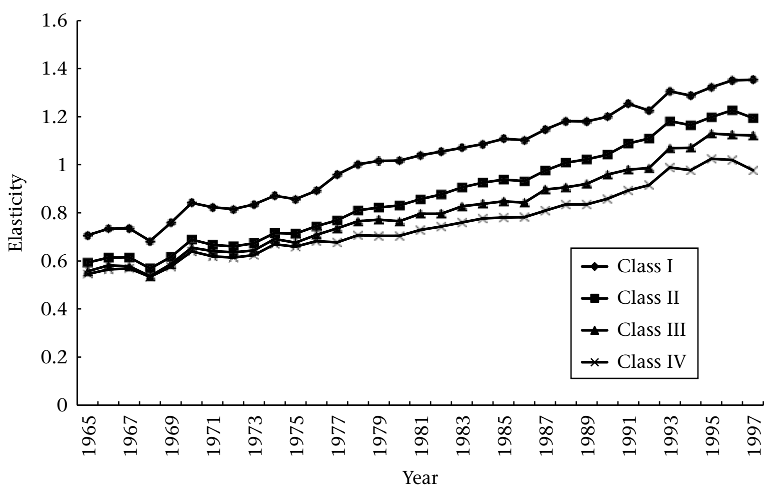

Figure 1.7 Impacts of changes in the price of crops on the supplies of crops for 1965–97: all size classes

Note: The impacts were estimated using equation (1.31).

sizes, the larger the own-price elasticities. In particular, the smallest size class had the largest own-price supply elasticities of crops for the entire period 1965–97. Furthermore, the own-price elasticities in all four size classes increased consistently during the entire study period 1965–97, except for a slow decreasing trend of size class IV for the 1995–7 period. The magnitudes of the own-price elasticities were fairly high: in the smallest size class I, in particular, the elasticity increased from around 0.7 (in 1965) to around 1.35 (in 1997). These findings may indicate that the price-support programs, in particular rice price-support programs, played an important role in giving incentives to smaller-scale farms to stick to crop, especially rice production, for the whole 1965–97 period.

Second, how about the own-price supply elasticities of livestock? The elasticities are shown in Figure 1.10. According to this figure, the supply elasticities of all four size classes show more or less very similar magnitudes (around 0.6–0.7) and movements for the period 1965–89 except for 1970 (around 0.8–0.9). After 1990, the elasticities increased very sharply, even close to 1.8–1.9 with a drop in 1994. However, we could not find a consistent difference in the supply elasticities among different size classes, unlike in the case of the own-price supply elasticities of crops.

Third, we observe in Figure 1.8 that the impact of changes in the price of crops on the supply of livestock were negative in all size classes, although the magnitudes of elasticities were small in terms of absolute number, and that the larger the farm sizes, the larger the impacts in absolute terms. This indicates that larger-scale farms had stronger negative impacts than smaller-scale farms due to the price-supports to crop production when it came to supplying livestock products. This may reflect the fact that smaller-scale farms are more or less specialized in crop farming while livestock producers increased the scale of livestock farming very sharply during the period under question.

Fourth, conversely, changes in the price of livestock products gave very strong negative impacts on the supplies of crop products as shown in Figure 1.9. The elasticities in absolute terms were around 1.5–2.0 for the period 1965–89, except for 1970 (around 2.5–2.8). After 1990, the impacts of livestock price changes became much stronger, as seen in Figure 1.9; the elasticity increased to as much as 5.0 in absolute terms in 1996. However, in this case also, we could not find

Figure 1.8 Impacts of changes in the price of crops on the supplies of livestock products for 1965–97: all size classes

Note: The impacts were estimated using equation (1.32).

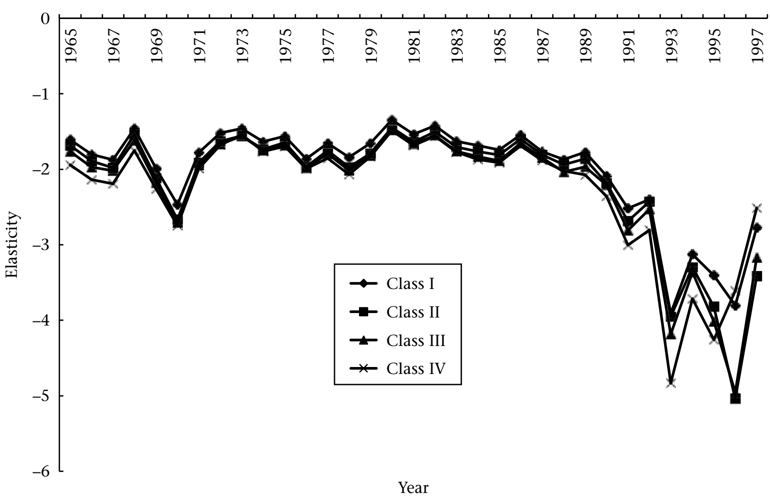

Figure 1.9 Impacts of changes in the price of livestock products on the supplies of crops for 1965–97: all size classes

Note: The impacts were estimated using equation (1.32).

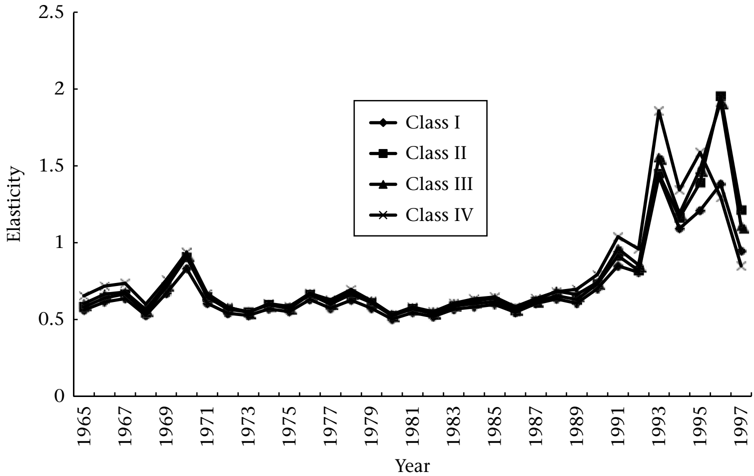

Figure 1.10 Impacts of changes in the price of livestock on the supplies of livestock for 1965–97: all size classes

Note: The impacts were estimated using equation (1.31).

clear tendencies in the differences in the magnitudes and over-time movements of the impacts in the different size classes for the entire period 1965–97.

In sum, the crop price-support programs implemented during the study period 1965–97 seem to have given bigger advantages and stronger incentives to smaller-scale farms than to larger-scale farms in increasing the supplies of or in sticking to the production of crops, especially rice. We may conjecture from this finding that the crop, in particular rice, price-support programs have given small-scale farmers incentives to refrain from transferring farmlands to large-scale farms.

1.4.4.2 Impacts of Output Price-Support Programs on the Demands for Variable Factor Inputs

Impacts of the Price-Support Programs for Crops on the Demands for Variable Factor Inputs To begin with, we will evaluate the impacts of changes in the prices of crops on the demands for the variable factor inputs; machinery, intermediate, and other inputs. Actually, the impacts expressed in terms of elasticities are exactly the same as the demand elasticities of the variable inputs with respect to the prices of crops. We estimated the impacts for all observations of the four size classes for the entire 1965–97 period. The impacts of changes in the price of crops on the demands for the variable factor inputs are shown in Figures 1.11, 1.12, and 1.13, respectively. Several findings are noteworthy from these figures.

First, the impacts of changes in the price of crops on the demand for machinery input were positive and had increasing trends in all four size classes for the study period 1965–97. The elasticities were more than unity in all four size classes, ranging from around 1.1 in 1965 (size class III) to around 2.2 in 1997 (size class I), indicating that farms in all size classes were fairly responsive to changes in the price of crops for the demand for machinery input. This in turn implies that crop price-support programs helped to speed up the M-innovations for all four size classes.

Second, the impacts of changes in the price of crops on the demands for intermediate input were all positive for size classes I and II. For size classes III and IV, there were some periods whose elasticities were negative; 1968–69 for size class III and 1965–71 for class IV. Otherwise,

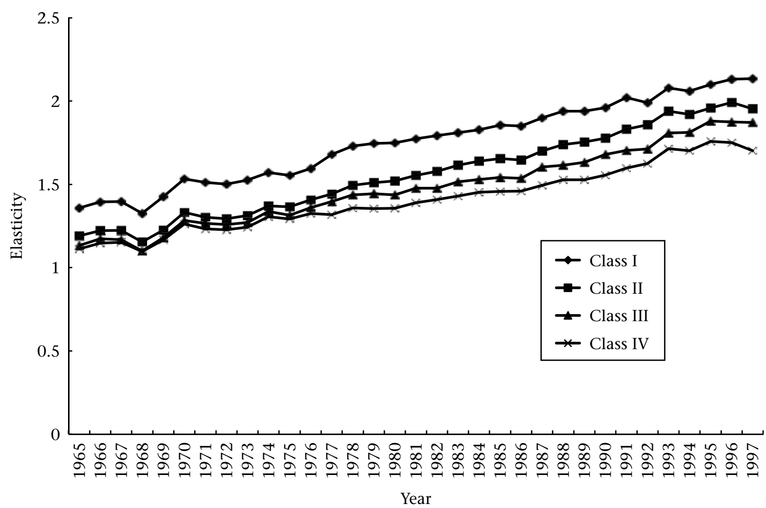

Figure 1.11 Impacts of changes in the price of crops on the demands for machinery input 1965–97: all size classes

Note: The impacts were estimated using equation (1.30).

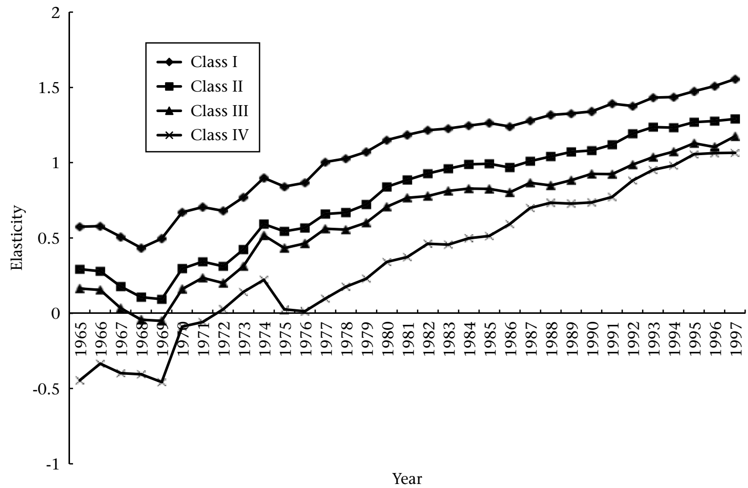

Figure 1.12 Impacts of changes in the price of crops on the demands for intermediate input for 1965–97: all size classes

Note: The impacts were estimated using equation (1.33).

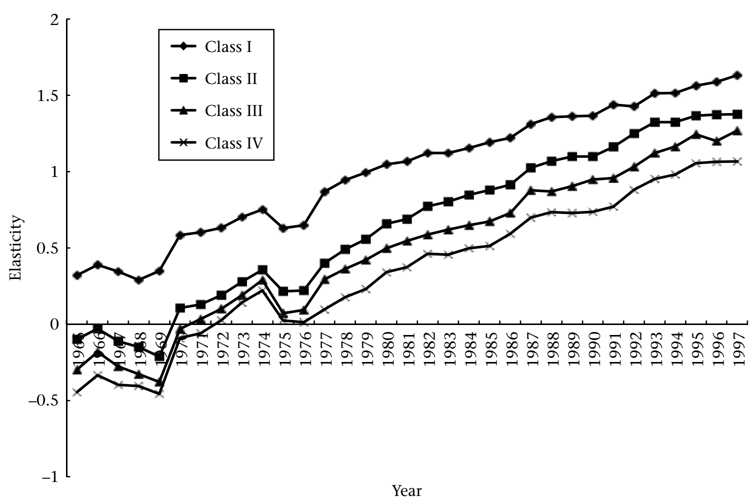

Figure 1.13 Impacts of changes in the price of crops on the demands for other input for 1965–97: all size classes

Note: The impacts were estimated using equation (1.33).

the elasticities were positive and increased consistently over time. The magnitudes of elasticities for size classes I, II, and III were fairly high; ranging from around 0.2 in 1965 (size class III) to around 1.5 in 1997 (size class I). Size class IV farms caught up with the other size classes from the late-1980s. This finding implies that the demand for intermediate input in farms of all size classes was fairly responsive to increases in the price of crops. This in turn implies that the price-support programs for crops encouraged farms to utilize more and more intermediate inputs such as chemical fertilizers, agri-chemicals, and seeds, which strongly induced farmers to introduce advanced BC-innovations.

Third, similarly to the above two cases, the impacts of changes in the price of crops on the demand for other input were positive for the 1970–97 period for all four size classes; actually, for size class I, the impact was positive for the entire period 1965–97. Furthermore, the impacts had increasing trends in all size classes for the entire period, with fairly large elasticities ranging from around 0.3 in 1965 to 1.6 in 1997 (size class I). Recall that other input consists of the expenditures on farm buildings and structures, large plants, and large animals. This may imply that increases in the demand for other input due to increases in the price of crops have helped to promote the so-called 'Selective Product Expansion Programs' based on the Agricultural Basic Act inaugurated in 1961; that is, increased production of livestock, vegetables, and fruits.

Finally, but most important for the present chapter, we observe clearly from Figures 1.11, 1.12, and 1.13 that, for the three variable factor inputs, that is, machinery, intermediate, and other inputs, the smaller the farm sizes, the greater the impacts of increases in the prices of crops. Indeed, the smallest size class (I) enjoyed the most advantageous benefits obtained from increases in the crop prices due to the price-support programs. This in turn implies that the price-support programs for crops, especially rice, strongly encouraged small-scale farms to apply more variable factor inputs to produce more farm products, which may have played an important role in restricting land movements from small- to large-scale farms.

Impacts of the Price-Support Programs for Livestock on the Demands for Variable Factor Inputs The impacts of changes in the price of livestock are presented in Figures 1.14, 1.15, and 1.16.

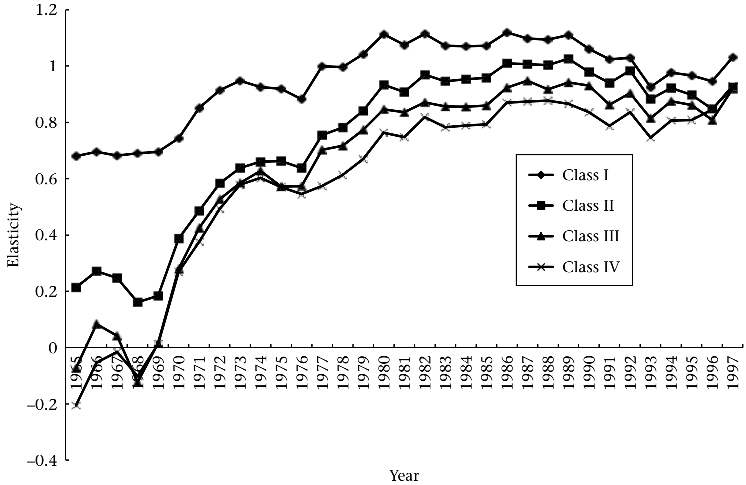

Figure 1.14 Impacts of changes in the price of livestock on the demands for machinery input for 1965–97: all size classes

Note: The impacts were estimated using equation (1.33).

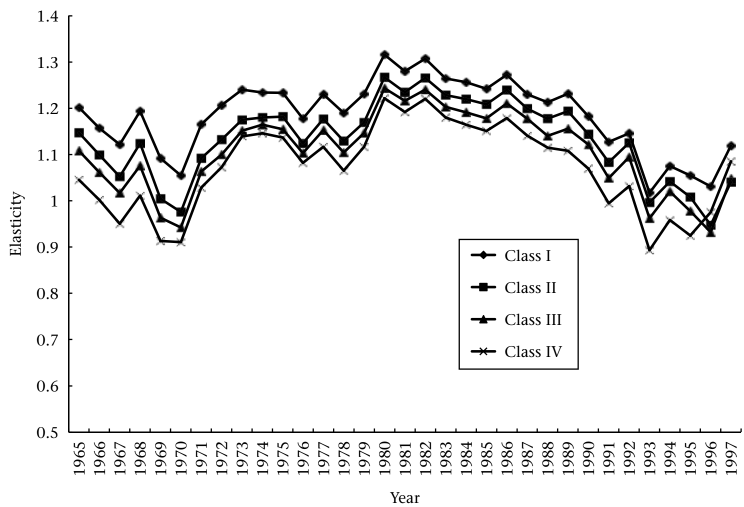

Figure 1.15 Impacts of changes in the price of livestock on the demands for intermediate input for 1965–97: all size classes

Note: The impacts were estimated using equation (1.33).

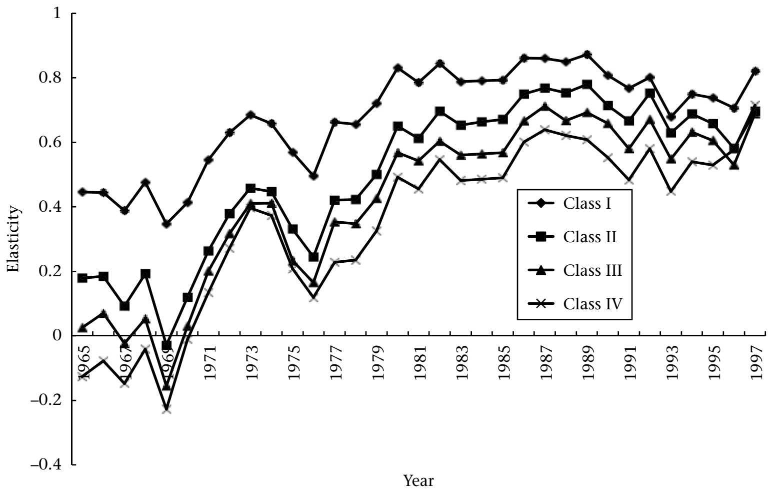

Figure 1.16 Impacts of changes in the price of livestock on the demands for other input for 1965–97: all size classes

Note: The impacts were estimated using equation (1.33).

In this case, we will not present a detailed exposition on the magnitudes and trends of the impacts of changes in the price of livestock on the demands for machinery, intermediate, and other inputs, as done for the case of the impacts of changes in the prices of crops. However, the common most important finding in this case, as in the case of changes in the prices of crops, is that the smaller the farm sizes, the larger the impacts of changes in the price of livestock on the demands for the variable factor input, that is, machinery, intermediate, and other inputs for the entire period 1965–97. However, the magnitudes of impacts were on average slightly smaller compared to those impacts due to changes in the prices of crops.

Again, this finding implies that the price-support programs for livestock encouraged small-scale farms to use more variable factor inputs to produce more farm products, either crops or livestock, which in turn may have limited land movements from small- to large-scale farms.

1.4.4.3 Impacts of Output Price-Support Programs on the Maximized Profits

The impacts of changes of the prices of crops and livestock on the maximized profits were estimated in terms of elasticity using equation (1.34) for all samples of the four size classes for the study period 1965–97, and are presented in Figures 1.17 and 1.18, respectively. As a matter of fact, these impacts are equivalent to the profit-maximizing output revenue-profit shares of crops and livestock. There are several noteworthy findings from Figures 1.17 and 1.18.

First, according to Figure 1.17, the impacts of changes in the prices of crops in terms of elasticity were fairly high in all four size classes; from around 1.2 in 1965 (size classes III and IV) to around 2.15 in 1997 (size class I). Furthermore, the impacts had increasing trends in all size classes for the entire period, which indicates that price-support programs for crop production played an important role in increasing profits of farms in all size classes.

Second, we observe very clearly that the smaller the farm sizes, the greater the effects of increased crop prices on the maximized profits

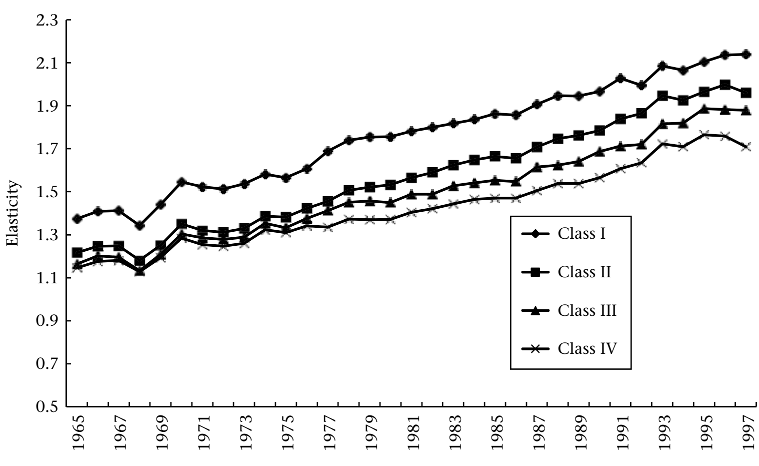

Figure 1.17 Impacts of changes in the price of crops on the maximized profits for 1965–97: all size classes

Note: The impacts were estimated using equation (1.34).

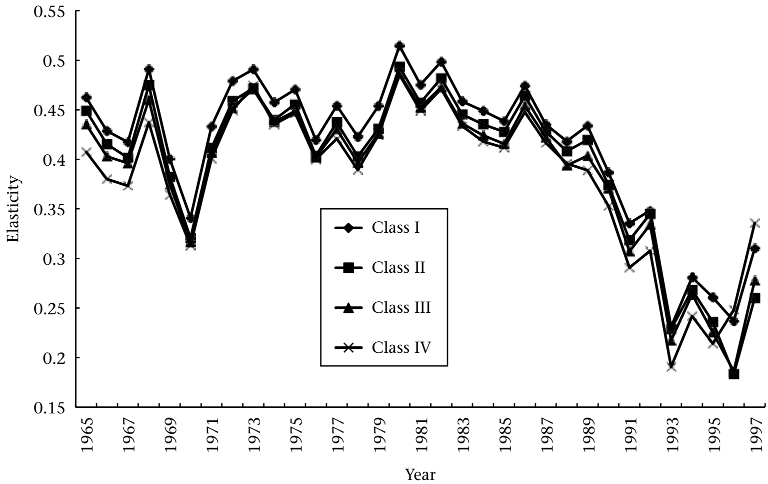

Figure 1.18 Impacts of changes in the price of livestock on the maximized profits for 1965–97: all size classes

Note: The impacts were estimated using equation (1.34).

for the entire period 1965–97; the smallest size class I enjoyed the most advantageous position thanks to increases in the prices of crops, in particular rice. This in turn may have worked in the direction of limiting transfers of farmlands from small- to large-scale farms.

Third, how about the impacts of changes in the prices of livestock? The impacts in terms of elasticity are presented in Figure 1.18. We observe in this figure that the impacts are much smaller compared to those with respect to changes in crop prices given in Figure 1.17. Furthermore, the impacts presented in Figure 1.18 fluctuated heavily during the study period 1965–97. However, we could at least say that the impacts had decreasing trends for the 1980–96 period in all four size classes, which corresponds to decreases in the budget for livestock price-supports since 1980 as observed in Table 10.1 in Volume 1. However, due to the limited data available we could not tell at this point what happened after the increases in impacts in 1997.

Fourth, a more important finding from Figure 1.18 is that, though small, size class I enjoyed the strongest impacts among all size classes with respect to increases in the prices of livestock for the 1965–95 period; it was only for the two years 1996 and 1997 that the impacts in size class IV surpassed the impacts in size class I. Here again we may say that, although the impacts of the price-support programs for livestock became weaker after 1980, the smallest size class farmers enjoyed the most delicious fruits from the price-support programs for livestock during the study period 1965–97, except for the last two years 1996 and 1997. This finding may indicate that the price-support programs for livestock also restricted transfers of farmlands from small- to large-scale farms.

1.4.4.4 Impacts of Output Price-Support Programs on RTS

Using equation (1.35), the impacts of changes in the prices of crops and livestock were estimated. The results are presented in Figures 1.19 and 1.20, respectively. There are several noteworthy findings from these figures.

First, we observe that in for changes in the prices of both crops and livestock, the impacts in terms of elasticity were negative. This can be interpreted as follows. Increases in, say, crop prices will induce

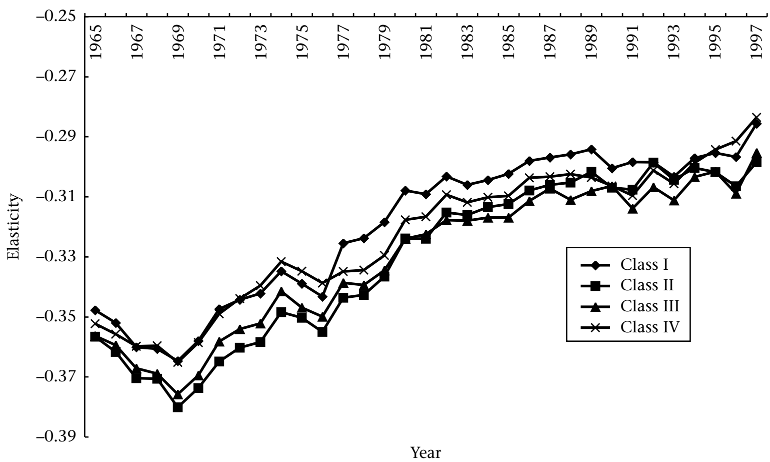

Figure 1.19 Impacts of changes in the price of crops on returns to scale for 1965–97: all size classes (Tofuken)

Note: The impacts of changes in the price of crops on returns to scale were estimated using equation (1.35).

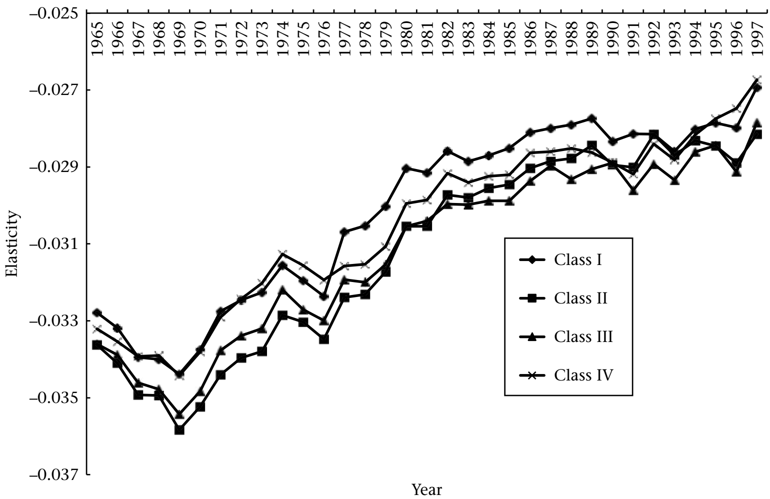

Figure 1.20 Impacts of changes in the price of livestock on returns to scale for 1965–97: all size classes

Note: The impacts were estimated using equation (1.35).

farmers to produce more crops. However, this will lead to reductions in the degrees of RTS in crop production. A similar phenomenon may be observed for livestock in Figure 1.20, though the degrees of the impacts were smaller than in for changes in crop prices.

Furthermore, the effects of changes in the prices of both crops and livestock increased consistently for the entire period in all four size classes except for the 1965–9 period, during which agricultural mechanization was shifting from smaller-scale to medium-scale types. In addition, we observe in Figures 1.19 and 1.20 that the smaller the size classes, the smaller the impacts of changes in the prices of both crops and livestock. In other words, the smallest size class encountered the least impacts on the degrees of RTS due to increases in output prices of either crops or livestock, for the entire study period 1965–97. This in turn implies that the situation where the smallest size classes enjoyed the highest degrees of scale economies observed in Figure 1.3 continued consistently over the study period 1965–97, which may have acted as a strong obstacle to transferring farmlands from small to large farms during this period.

1.4.4.5 Impacts of Output Price-Support Programs on the Shadow Value of Land

The impacts of changes in the prices of crops and livestock on the shadow value of land were estimated using equation (1.36). The results are presented in Figures 1.21 and 1.22, respectively. Several findings emerge from these two figures.

First, according to Figure 1.21, the impacts of changes in the price of crops had considerably strong impacts on increasing the shadow value of land in all four size classes for the entire study period 1965–97. Furthermore, the impacts had clear increasing trends in all size classes for the study period. The degrees of elasticities ranged from around 1.3 in 1965 (size class IV) to around 3.0 in 1992 (size class I). This implies that, for example, a one per cent increase in the crop price increased the level of shadow value of land by almost three per cent in 1992. In addition to this finding, we also observe very clearly that the smaller the size classes, the greater the impacts for the entire period. This finding again indicates that the price-support programs

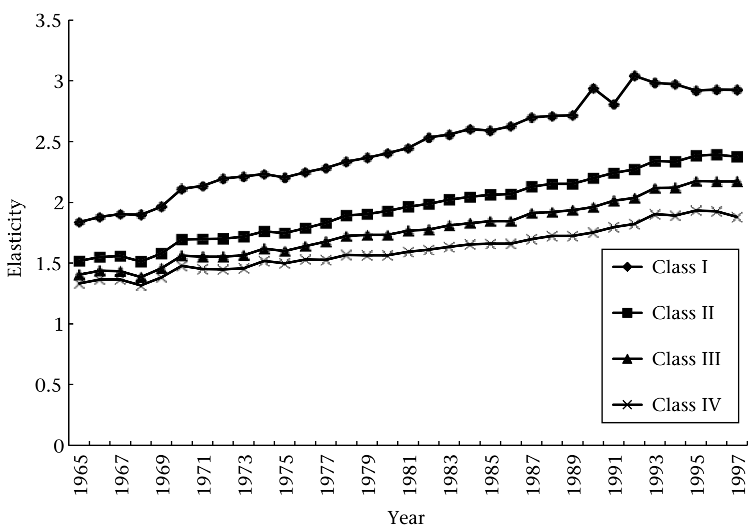

Figure 1.21 Impacts of changes in the price of crops on the shadow values of lands for 1965–97: all size classes

Note: The impacts were estimated using equation (1.36).

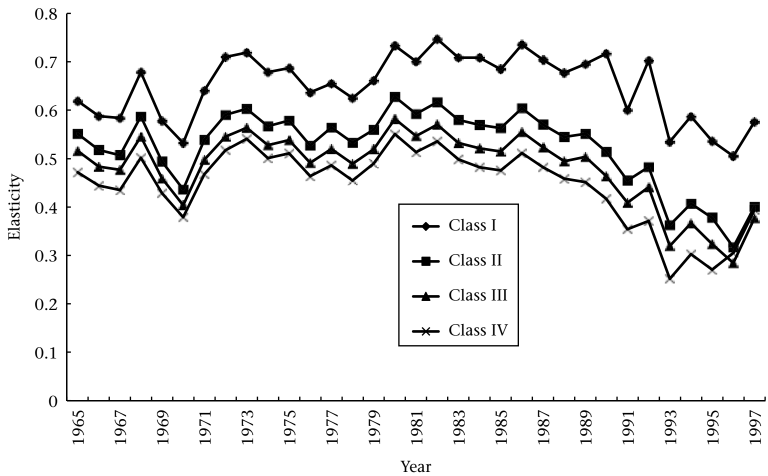

Figure 1.22 Impacts of changes in the price of livestock on the shadow values of lands for 1965–97: all size classes

Note: The impacts were estimated using equation (1.36).

for crops had negative impacts for land transfer from small- to large-scale farms by raising the shadow value of land of small-scale farms relatively more than that of large-scale farms.

Second, how about the impacts of changes in the prices of livestock on the shadow value of land? The results are presented in Figure 1.22. As clearly seen in this figure, the impacts with respect to livestock prices were weaker than those with respect to crop prices for all four size classes for the whole period; in this case, the impacts were ranged between 0.33 and 0.72. Furthermore, the impacts with respect to livestock prices were at fairly consistent levels, though with ups and downs, in all four size classes for the period 1965–86. However, for the 1986–97 period, the impacts had decreasing trends in all size classes.

More importantly, again, we observe very clearly that the smaller the size classes, the greater the impacts of changes in livestock prices on the shadow value of land, indicating that the price-support programs for livestock products helped to raise the rent-bearing capacity of small-scale farms during the entire study period 1965–97. Needless to say, this may have restricted transfers of farmlands from small- to large-scale farms.

1.5 Summary and Concluding Remarks

This chapter has estimated the multiple-product ordinary translog VP function with labor and land being the quasi-fixed factor inputs for the period 1965–97. Based on the estimated parameters, the Marshallian output supply and input demand elasticities, the degrees of RTS, and the shadow value of land were estimated and evaluated. We will not summarize the results here in order to save space.

Instead, we would like to mention only one important finding related to the estimated shadow value of land. We found that it was not ready yet for small-scale farms to transfer their farmlands by renting them out to large-scale farms for the study period 1965–97. Behind this finding, we emphasized treating the farm (more precisely, the 'firm-household complex' [Maruyama, 1984]) as the farm household instead of the 'farm-firm' (Jorgenson and Lau, 2000). The 'costs' of labor and land are basically counted as part of costs for the 'farm-firm'. However, those same 'costs' accruing to the farm-owned family labor and land may be considered to be part of household income for the 'farm household'. Thus, in order to examine the possibilities of land transfers from small- to large-scale farms, this narrowly defined 'farm income' of the small-scale farm should be compared to the shadow value of land (or, 'rent-bearing capacity') of the large-scale farm. When this norm was applied to our case, the 'farm income' of the small-scale farm overwhelmed the shadow value of land of the large-scale farm for almost the entire study period. This indicates that not many small-scale farms were ready to transfer their farmlands to large-scale farms during the study period 1965–97.

We investigated the impacts of the output price-support programs introduced by the government, not only for crops represented by rice but also for livestock products, on (i) the supplies of both crops and livestock, (ii) the demands for the variable factor inputs such as fertilizers, agri-chemicals, feed, seed and other materials, (iii) RTS, (iv) profits, and (v) the shadow value of land. We found in all examinations that the price-support programs yielded the most favorable harvests to small-scale farms. This in turn may have caused the slow transfers of farmlands from small- to large-scale farms during the last three to four decades of the 20th century in Japanese agriculture. Indeed, this statement is perfectly consistent with the finding discussed in the above paragraph.

We may conclude from these findings that, in order to drastically change the existing structure of small-scale inefficient farming to that of much larger-scale efficient and productive farming, the government has to reconsider the applications of the output price-support programs so as to give stronger incentives to larger-scale farms.

Two important caveats are worth mentioning here.

First of all, the follow-up chapters should be written on the impacts of such agricultural policies as input subsidies, set-asides and production adjustments, and R&E activities.

In the process of engaging such research project, it may be necessary to focus only on rice production, since both the price-support and set-aside programs have been most conspicuous for rice.

Appendix: Variable Definitions

It suffices here to expose how the variable profit, variable factor input-profit shares, and output revenue-profit shares were defined. The data sources and the definitions of the other variables have already been fully explained in Appendix 1.1 of Volume 1.

The variable profits (VP') was defined as total revenue minus the sum of the expenditures on these three categories of variable factor inputs (VC), that is, $VC = \sum_i w_k{}'X_k$ $(k = M, I, O)$. The output revenue-profit shares for crop and livestock production (R_G and R_A) were obtained by dividing the total revenue of each category of products ($P_G{}'Q_G$ and $P_A{}'Q_A$) by the variable profits (VP'). The variable factor input cost-profit share ($R_k, k = M, I, O$) was obtained by dividing the expenditure on each category of the variable factor inputs ($w_k{}'X_k, k = M, I, O$) by the variable profits (VP').

As for the definition of the stock of technological knowledge (Z_R), we heavily drew on the procedure developed by Ito (1994).

The stock of technological knowledge (Z_R) was estimated by the perpetual inventory method. The data used for this estimation was public research and extension expenditures. The source of data is the *Norinsuisan Kankei Shiken Kenkyu Yoran* (the *Abstract Yearbook of Research and Experiment on Agriculture, Forestry, and Fisheries*)(AYRE) published annually by the MAFF. The estimation procedures are basically the same as Ito (1992).

It is assumed that the stock of technological knowledge is determined by the annual investments on research activities and appropriate weights. The weights are determined by the lag structure and the speed (or rate) of obsolescence of the stock of technological knowledge.

The *Norinsuisan Shiken-Kenkyu Nenpo* (*Yearbook of Research and Experiments of Agriculture, Forestry, and Fisheries*) (YRE) by the MAFF reports researches on agriculture, forestry, and fisheries in Japan by various national research institutions. It documents the beginning year, the ending year, and the number of years (that is, the research period) of each research topic. Ito (1992) regarded this research period as the development lag of each research topic, and obtained the number of research topics for each development lag for 1967, 1977, and 1987. He then computed the weighted average year of research lag period with the numbers of research topics as weights for each of these three years and obtained roughly six years for these three years. As for the rate of obsolescence of the stock of technological knowledge, we assumed 10 per cent per year following Goto, Honjo, Suzuki, and Tokino (1986).

Now, the stock of technological knowledge was estimated as follows. Suppose that R_t is the stock of technological knowledge at the end of year t. Then, the following equation can be obtained.

$$R_t = G_{t-6} + (1 - \delta_R)R_{t-1} \tag{A.1}$$

where δ_R is the rate of obsolescence of the stock of technological knowledge and G_t is the research expenditure (investment) in year t which is added to the stock of technological knowledge with a six-year lag. Assume at this point that the annual rate of change in this stock is g. Then, (A.1) can be written as

$$R_t = G_{t-6} + (1 - \delta_R)R_{t-1} = (1 + g)R_{t-1}.$$

Thus, the stock at the benchmark year (in this chapter 1957) R_s can be expressed as

$$R_s = G_{s-5}/(\delta_R + g). \tag{A.2}$$

Note that one cannot obtain the value of g before obtaining the stock of technological knowledge. We approximated this rate by 10 per cent of investment in research for the 1955–9 period when the stock of technological knowledge was still small. Using (A.1) and (A.2), we estimated the stock of technological knowledge for the period 1957–97.

Next, Ito (1992) did not introduce any lag structure for extension activities. That is, he added the flow value of expenditures on extension activities to the stock of technological knowledge each year.

However, it appears to be more realistic to assume a certain lag structure for the case of extension activities, since it often takes several years for a new technology to be adopted and materialized in real agricultural production. This study assumes five years as the maximum for extension activities for a particular innovation. This assumption is based on the present author's personal discussions with extension people. Using a procedure similar to that used for the stock of technological knowledge, that is the benchmark year method, the capital stock of extension activities was estimated for a five-year lag. In this case, 10 per cent was assumed for the rate of growth of the capital stocks based on the growth rate of extension expenditures (investment) for the 1955–9 period which was very close to 10 per cent. However, since there is no reliable information for the rate of obsolescence of the capital stock of extension activities, this chapter assumes simply 10 per cent as in the case of the stock of technological knowledge.

This chapter assumes that the two different stocks of technological knowledge based on R&D and extension (R&E) activities together yield the stock of technological knowledge which is materialized on actual farms. Thus, the two capital stocks were added together for each year for the period 1957–97.

For a sensitivity analysis, this chapter assumes 5, 10, and 15 per cent for the rate of obsolescence both for the stock of technological knowledge and for the capital stock of extension investments; five, six, seven, eight, nine, ten and eleven years for research development lag; and three, four and five years for extension lag. Thus, there are altogether $(3 \times 7) \times (3 \times 3) = 189$ different combinations. These 189 combinations of the R&E capital stocks were used for the sensitivity analysis based on the estimating equation system composed of equations (1.3), (1.4), (1.5), and (1.6) given in Section 1.2.1.

As a result, the combination of 15 per cent for the rate of obsolescence both for the stock of technological knowledge and for the capital stock of extension investments, a seven-year lag of research development, and a three-year lag for extension activities gave the best results in terms of the R^2s and the asymptotic t-statistics of the coefficients as well as monotonicity and concavity conditions. Thus, this option was used for the variable Z_R in this chapter[27].

2
The Set-Aside Programs and Land Movements: A VP Function Approach

2.1 Introduction

The major objective of this chapter is to investigate the impacts of the set-aside programs on the same five economic indicators as presented in Chapter 1: that is, (i) the output supplies of crops and livestock, (ii) the variable factor demands, (iii) the maximized profits (or, 'farm income'), (iv) the degrees of RTS, and (v) the shadow value (equivalently, marginal productivity or 'rent-bearing capacity') of farmland.[1]

The set-aside program for rice production was introduced in 1969 for the first time in the history of Japanese agriculture because of the persistent surplus of rice, a problem since 1965. Since then, the set-aside area has an increasing trend with some fluctuations over time as shown in Figure 2.1. The area no longer used for rice production because of the set-aside programs was around 500 thousand ha per year during the early-1970s, then gradually increased to around 800 thousand ha during the late-1980s through to the early-1990s, and then reached almost 1 million ha during the late-1990s through to the early-2000s. This means that the area of paddy fields made inactive by the enforcement of the set-aside programs almost doubled in the 33 year period. Due mainly to the set-aside programs, the total arable land area of paddy fields decreased from around 3.5 million ha in 1970 to around 2.5 million ha in 2003, that is, a decrease of as large as 1 million ha over the 33 years. We will then look at the ratio of the set-aside paddy field to the total area of arable paddy field in Figure 2.2. The ratio was less than 20 per cent for the ten years of the 1970s,

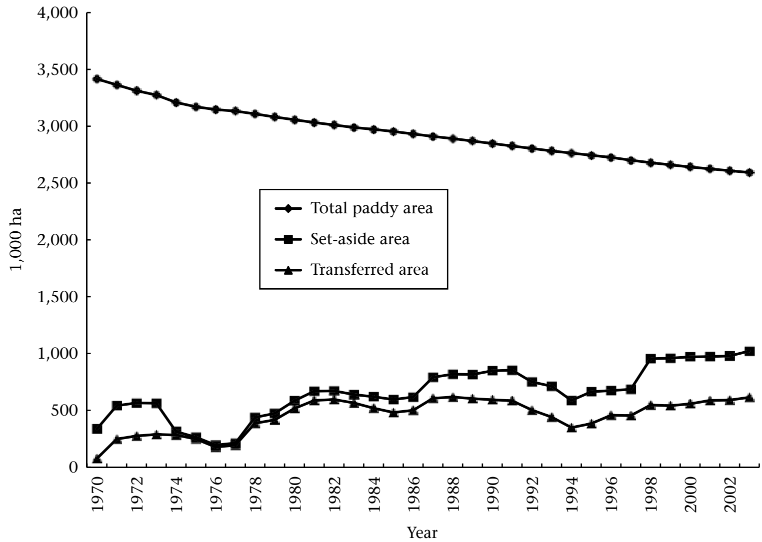

Figure 2.1 Paddy, set-aside, and transferred areas for 1970–2003: all Japan
Source: The MAFF. *The Poketto Bei-Baku Deeta Bukku* [*The Pocket-Size Data Book on Rice and Barleys*]. Tokyo (various issues). Mizuho-Kyokai.

stayed around 20–21 per cent for the period 1980-86, then jumped up to 28–30 per cent for the period 1987–91, decreased somehow for the period 1992–7, but after that increased sharply to 37–40 per cent for the period 1998–2003.

Turning back to Figure 2.1, we observe the area changes in the set-aside paddy fields transferred to production of other crops such as wheat, soybeans, vegetables, and so forth. It appears that, except for the period 1974–8, the gap between the set-aside paddy area and transferred area became larger and larger as time passed. This finding may be confirmed by looking at the ratio of transferred area to the set-aside area drawn in Figure 2.2. The ratio was as high as 90 per cent for the period 1974–83, but after this it consistently decreased from 1984 through 2003 except for the two-year period 1996–7, when some increases were observed. It became as low as 60 per cent for the early-2000s. This may have caused a tremendous expansion of abandoned farmlands all over Japan. It should be noted here that restoring

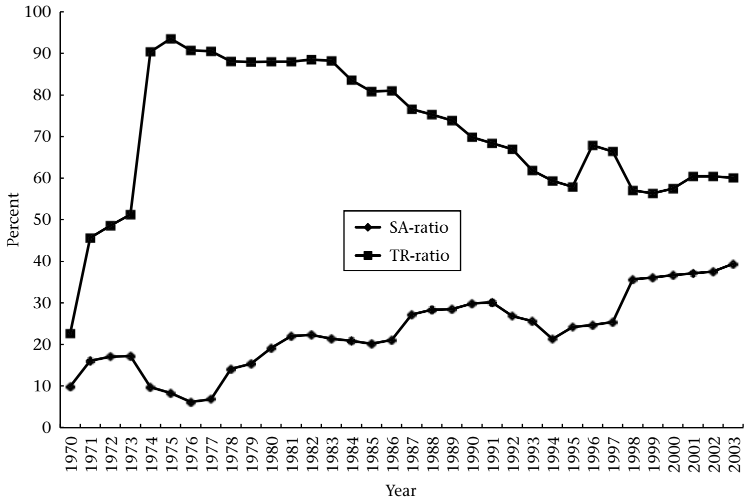

Figure 2.2 The ratio of the set-aside are to total paddy area (SA-ratio) and the ratio of the transferred area to the set-aside area (TR-ratio) for 1970–2003: all Japan

Source: The same as in Figure 2.1.

given-up paddy fields to the original state may require a huge amount of re-investment.

Therefore, we may infer from these observations that the set-aside programs for the most important product in Japanese agriculture, that is, rice, must have exerted great influences not only on rice production but also on production of all other agricultural products. As carried out in Chapter 1, we will in this chapter shed a special light on the quantitative investigations of the impacts of the government set-aside programs on the above-mentioned five economic indicators. To pursue this objective, we will employ the same analytical framework of the multiple-product ordinary translog VP function as used in Chapter 1.

A considerable number of studies have been conducted to examine the impacts of the set-aside programs in Japanese agriculture. Hasebe (1984) investigated the impacts of the set-aside programs on land movements. Kusakari (1989) found that the 'given-up income' due to the set-aside programs was greater on larger farms than on smaller farms. Ito (1993) examined the impacts of the set-aside programs on rice income and demand for rented land. Kondo (1991, 1992, 1998) investigated the impacts of the set-aside programs on rice income and land rent. Furthermore, Kuroda (2009d) analyzed the impacts of the set-aside programs on the degrees of RTS and technological change based on the parameter estimates of the multiple-product ordinary translog VC function for the period 1957–97 using the same data set as used in this chapter.

The rest of this chapter is organized as follows. Section 2.2 presents the formulas for evaluating the impacts of the set-aside programs on the five economic indicators mentioned above. Section 2.3 presents empirical results. Finally, Section 2.4 provides a brief summary and conclusion.

2.2 Analytical Framework

To begin with, we should emphasize that we are going to use the same parameter estimates of the same VP function framework employed in Chapter 1, where we investigated the impacts of the price-support programs on the five economic indicators mentioned above.

In this chapter, then, we will immediately derive the formulas to quantitatively evaluate the impacts of the set-aside programs on those five economic indicators, resorting to the estimates of the multiple-product ordinary translog VP function system given by equations (1.1) through (1.7) in Chapter 1.

2.2.1 Impacts of Changes in Land Input on the Five Economic Indicators

At the outset, we must admit that the following procedure may be regarded as an *indirect* method of evaluating the impacts of the set-aside programs on the five economic indicators, since we do not employ in our VP function any variable which can capture *directly* the impacts of the set-aside programs. We will in this chapter regard a decrease in land input (to be more specific, planted area, as defined in Appendix 1.1 in Volume 1) as a proxy for set-aside. The impacts will be expressed in terms of elasticities which easily capture the relative degrees of importance of the effects of changes in land input (Z_B) on the above-mentioned five economic indicators.

First, the impacts of changes in land input (Z_B) on the supplies of crop and livestock products (Q_G and Q_A) in terms of elasticities can be estimated by,

$$\frac{\partial \ln Q_i}{\partial \ln Z_B} = \varepsilon_{iB} = \frac{\phi_{iB}}{R_i} + \frac{\partial \ln VP'}{\partial \ln Z_B}, \quad i = G, A, \tag{2.1}$$

which is equivalent to the output supply elasticities with respect to land input (Z_B).

Second, the impacts of changes in Z_B on the demands for the variable factor inputs can be given by,

$$\eta_{kB} = -\frac{\mu_{kB}}{R_k} + \frac{\partial \ln VP'}{\partial \ln Z_B}, \quad k = M, I, O, \tag{2.2}$$

which is equivalent to the variable factor demand elasticities with respect to land input (Z_B).

Third, the impacts of changes in Z_B on the maximized profits VP' in terms of elasticity can be given by,

$$\frac{\partial \ln VP'}{\partial \ln Z_B} = \beta_B + \sum_i \phi_{iB} \ln P_i{}' + \sum_k \phi_{kB} \ln w_k{}' + \sum_h \delta_{hB} \ln Z_h + \mu_{BR} \ln Z_R, \tag{2.3}$$

$$k, n = M, I, O, \; h = L, B.$$

The term $\partial \ln VP'/\partial \ln Z_B$ may be called the 'shadow land cost-profit share' of land input (Z_B) which can be computed using the estimated parameters of the VP function system.

Fourth, the impacts of changes in Z_B on $RTS = \sum_l \frac{\partial \ln VP'}{\partial \ln Z_l}$ in terms of elasticities can be obtained by,

$$\frac{\partial \ln(RTS)}{\partial \ln Z_B} = \frac{\sum_l \phi_{kl}}{RTS}, \tag{2.4}$$

$$k = M, I, O, \; l = L, B.$$

Finally, the impacts of changes in Z_B on the shadow value of land ($w_B^{S'}$) in terms of elasticities can be obtained by,

$$\frac{\partial \ln w_B^{S'}}{\partial \ln Z_B} = \frac{\partial \ln VP'}{\partial \ln Z_B} - 1 + \frac{\partial \left(\dfrac{\partial \ln VP'}{\partial \ln Z_B} \right)}{\partial \ln Z_B} \left(\frac{\partial \ln VP'}{\partial \ln Z_B} \right)^{-1}$$

$$= \frac{\partial \ln VP'}{\partial \ln Z_B} - 1 + \delta_{BB}\left(\frac{\partial \ln VP'}{\partial \ln Z_B}\right)^{-1}, \tag{2.5}$$

$i = G, A.$

All these impacts caused by changes in land input (Z_B) on the profit-maximizing output supplies (Q_i, $i = G, A$), the variable factor input demands (X_k, $k = M, I, O$), the maximized profits (VP'), the degrees of RTS, and the shadow value of land ($w_B^{S'}$) will be estimated for all observations for all four size classes for the entire study period 1965–97 and they will be shown in the form of graphs. In this way, one can visually capture differences in the impacts between different size classes and changes in the impacts over time.

2.3 Empirical Results

Using the parameter estimates of the multiple-product ordinary translog VP function presented in Table 1.2 in Chapter 1, we estimated the impacts of changes in land input on the five economic indicators mentioned just above. We will evaluate the estimated results in the following subsections.

2.3.1 Impacts of Set-Aside Programs

2.3.1.1 Impacts of the Set-Aside Programs on the Supplies of Outputs

We will first evaluate the impacts of the set-aside programs for crop production by examining the impacts of changes in the planted area of land (Z_B) on the supplies of these products estimated using equation (2.1). Figures 2.3 and 2.4 present the impacts of changes in the planted area on the supplies of crops and livestock. Several intriguing findings are worth mentioning from these figures.

First, we will evaluate the impact of changes in land input (Z_B) on the supply of crops (Q_G) in Figure 2.3. According to Figure 2.3, it is clear that the larger the farm size, the larger the impact of changes in land input. In particular, the largest size class, IV, had the largest impacts of changes in land input for the entire study period 1965–97; the magnitudes of impacts in terms of elasticity were consistently greater than 0.8. This implies that a 10 per cent increase in the planted area will increase the amount of supplies of crop products by more than 8 per cent. Furthermore, the impacts in the smaller size classes, I, II, and III, decreased consistently though slowly during the entire

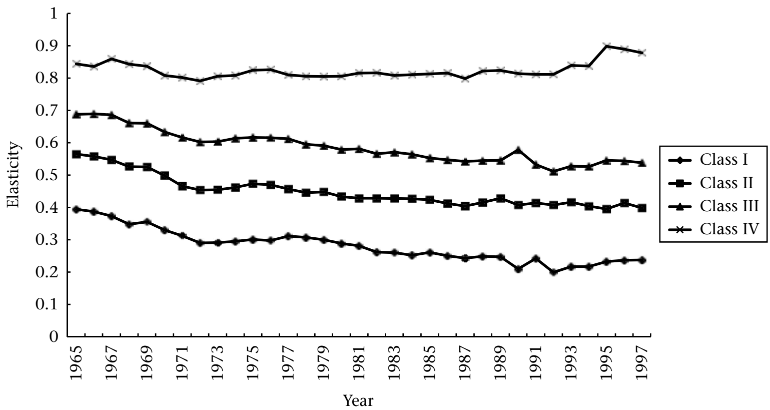

Figure 2.3 Impact of changes in the planted area on the supply of crops for 1965–97: all size classes

Note: The impacts were estimated using equation (2.1).

study period 1965–97. These findings may indicate that the set-aside programs had significant negative impacts on the production of crops, in particular rice, especially on large-scale farms for the entire study period.

Second, how about the impacts of changes in land input (Z_B) on the supplies of livestock products (Q_A)? The magnitudes in terms of elasticity are shown in Figure 2.4. According to this figure, the impacts in all four size classes show more or less similar movements for the study period 1965–97; fairly consistent movements for the period 1965–1992 but increased slightly for the 1993–7 period.

Again, we observe very clearly from Figure 2.4 that the larger the size class, the larger the impact of changes in land input on the supplies of livestock products. In particular, the elasticities of the largest size class, IV, ranged from around 0.85 (in 1965) to 1.05 (in 1995), meaning that a 10 per cent increase in the planted area of land will increase the supplies of livestock products by 8.5 to 10.5 per cent. Conversely, a 10 per cent decrease in land input will reduce the amounts of supplies of livestock products by 8.5 to 10.5 per cent, which may be considered fairly elastic responses. This in turn implies that the set-aside programs decreased the supplies of livestock products in all four size classes, but the damages were the greatest for large-scale farms.

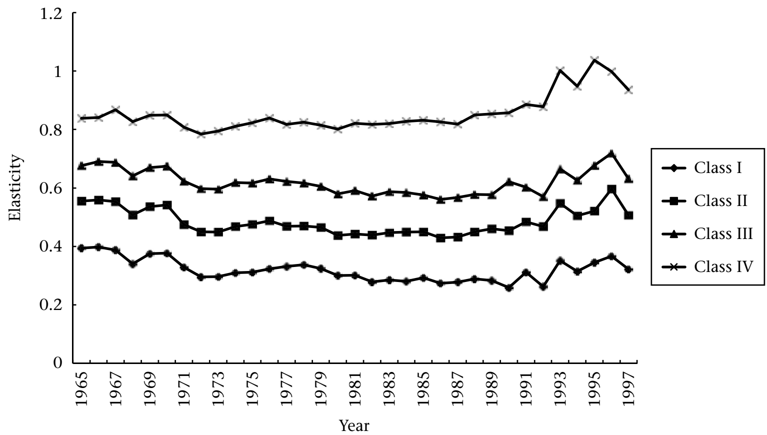

Figure 2.4 Impact of changes in the planted area on the supply of livestock for 1965–97: all size classes

Note: The impacts were estimated using equation (2.1).

In sum, the impacts of increases in land input on the supplies of both crops and livestock estimated in terms of elasticities were all positive in all four size classes for the entire study period 1965–97. Above all, we have found that the larger the size class, the larger the impact. This means that the set-aside programs, which forced farmers to reduce the planted areas of lands, had naturally negative impacts on increasing production of both crops and livestock. In particular, the set-aside programs had the strongest negative impacts on the supplies of these products in large-scale farms, indicating that the set-aside programs may have had strong negative effects against larger-scale more efficient farming on large-scale farms.

2.3.1.2 Impacts of the Set-Aside Programs on the Demands for Variable Factor Inputs

In this subsection, we will evaluate the impacts of changes in planted area of land (Z_B) on the demands for the variable factor inputs ($X_k,\ k = M, I, O$). Actually, the impacts expressed in terms of elasticities are exactly the same as the demand elasticities for the variable inputs with respect to land input. We estimated the impacts for all observations of the four size classes for the entire study period 1965–97. The impacts

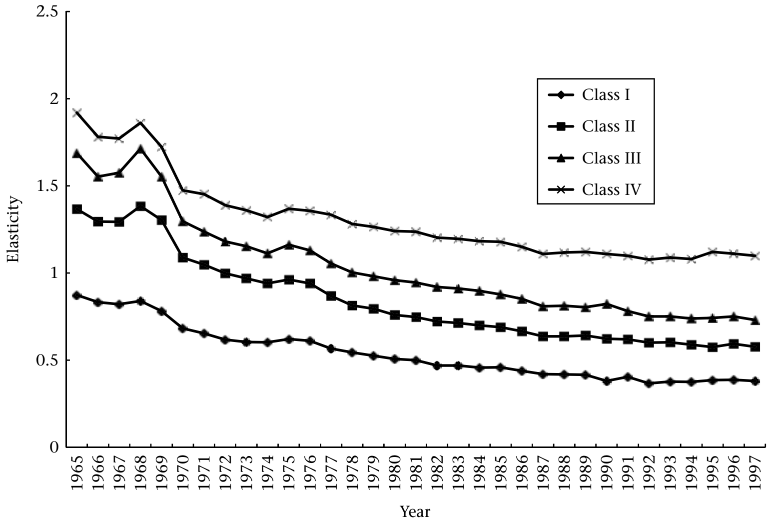

Figure 2.5 Impact of changes in the planted area on the demand for machinery input for 1965–97: all size classes

Note: The impacts were estimated using equation (2.2).

of changes in land input on the demands for the variable factor inputs are shown in Figures 2.5, 2.6, and 2.7, respectively. Several findings are noteworthy from these figures.

First, according to Figure 2.5, the impacts of changes in land input on the demand for machinery input were positive and had consistent decreasing trends in all four size classes for the study period 1965–97. Indeed, as is clear in equation (2.2), the impacts are equivalent to the variable factor input elasticities with respect to land input.

Furthermore, we observe that the larger the farm size, the larger the impact. In particular, the largest size class farm, IV, had fairly high elasticities for the entire study period, ranging from around 1.9 in 1965 to around 1.1 in 1997. The elasticities of the other three size classes were also fairly high, ranging from around 1.7 (in 1965) to around 0.7 (in 1997) for size class III, around 1.4 (in 1965) to around 0.6 (in 1997) for size class II, and around 0.9 (in 1965) to around 0.4 (in 1997) for size class I. This indicates that farms in all size classes were fairly responsive to changes in land input for the demand for

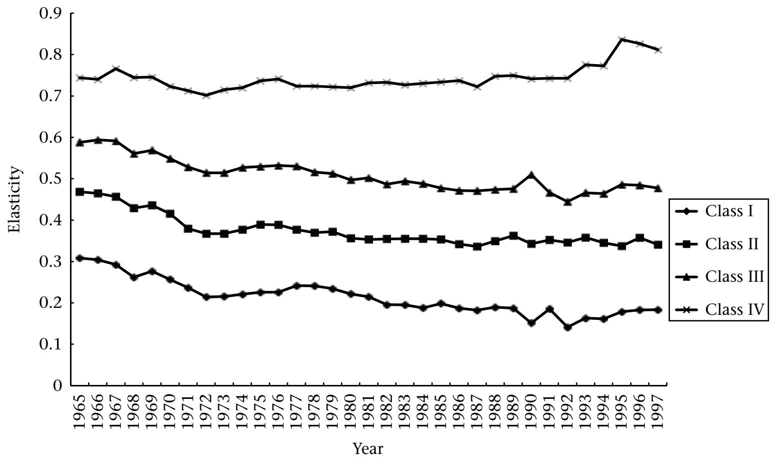

Figure 2.6 Impact of changes in the planted area on the demand for intermediate input for 1965–97: all size classes

Note: The impacts were estimated using equation (2.2).

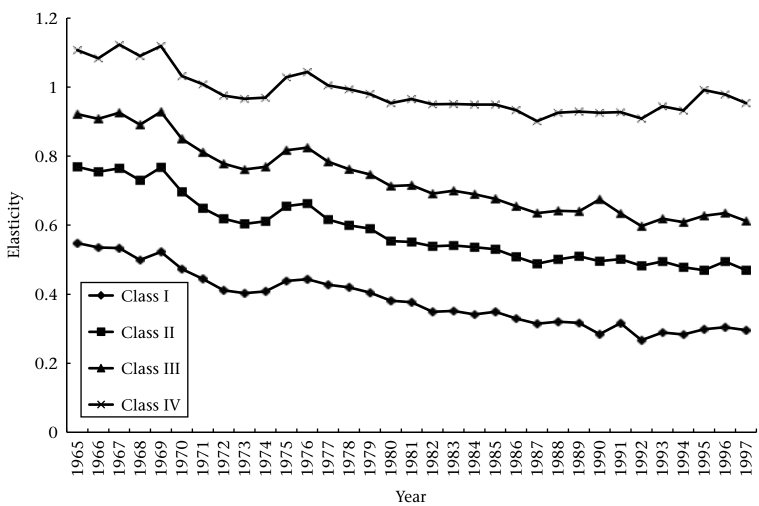

Figure 2.7 Impact of changes in the planted area on the demand for other input for 1965–97: all size classes

Note: The impacts were estimated using equation (2.2).

machinery input. This in turn implies that the set-aside programs may have restricted the speed of introduction of 'M-innovations' (Hayami, 1986) in all four size classes, in particular large-scale farms.

Second, Figure 2.6 shows that the impacts of changes in land input on the demands for intermediate input were all positive for all four size classes. The impacts are equivalent to the variable factor demand elasticities with respect to land input. According to Figure 2.6, the impacts in terms of elasticities were positive in all four size classes. Furthermore, the elasticities in the smaller three size classes had slight decreasing trends; around 0.31 (in 1965) to around 0.19 (in 1997) in size class I; around 0.48 (in 1965) to around 0.35 (in 1997) in size class II; and around 0.59 (in 1965) to around 0.48 (in 1997) in size class III. Conversely, the impacts in size class IV appear to have had an increasing, though weak, trend; ranging from around 0.75 (in 1965) to around 0.81 (in 1997). This finding indicates that farms in all size classes had positive responses to increases in land input in utilizing more intermediate input such as fertilizers, agri-chemicals, feed, and so forth to increase either crops or livestock or both. This in turn implies that the set-aside programs may have limited the development of 'BC-innovations' (Hayami, 1986) in all four size classes, in particular large-scale farms.

Third, Figure 2.7 shows very a similar picture to that of the demand for intermediate input. That is, (i) the impacts were all positive in all four size classes for the entire study period 1965–97; (ii) the impacts had decreasing trends, in this case, in all four size classes including the largest size class, IV; (iii) however, the magnitudes of the impacts in terms of elasticities were in general slightly larger than those for intermediate input; and, (iv) the larger the farm size, the larger the impact for the entire period.

These findings indicate that farms in all size classes had positive responses to increases in land input in using other input such as farm buildings and structures, large plants, and large animals to increase either crops or livestock or both. Increased demands for these factor inputs must have been intimately related to the government policy of the so-called 'Selective Product Expansion Programs' of agricultural products, especially those such as livestock, fruits, and vegetables, as an important policy based on the Agricultural Basic Act inaugurated in 1961. In this sense, these findings in turn imply that the set-aside programs may have restricted the development of 'Selective Product

Expansion Programs' for all four size classes, in particular large-scale farms.

In sum, the impacts of increases in land input on the demand for the variable factor inputs, that is, machinery, intermediate, and other inputs, estimated in terms of elasticities were all positive in all four size classes for the entire study period 1965–97. Above all, we have found that the larger the size class, the larger the impact for all three variable factor inputs. This means that the set-aside programs, which forced farmers to reduce the planted area of lands, had negative impacts on more rapid 'M-innovations', 'BC-innovations', and the 'Selective Product Expansion Programs' of agricultural products. In particular, the set-aside programs had the strongest negative impacts on large-scale farms, meaning strong negative effects against larger-scale, more efficient and productive farming on large-scale farms.

2.3.1.3 Impacts of the Set-Aside Programs on the Maximized Profits

Using equation (2.3), the impact of changes in land input (Z_B) on the maximized profits (VP') in terms of elasticities were estimated for all observations in all four size classes for the study period 1965–97 and presented in Figure 2.8. As is clear from equation (2.3), $\partial \ln VP'/\partial \ln Z_B = (\partial VP'/\partial Z_B) \times (Z_B/VP')$. This may be called the 'shadow land cost-profit share'. Several intriguing findings emerge from Figure 2.8.

First, the impacts of changes in land input on the maximized profits were positive in all four size classes for the entire 1965–97 period. More specifically, however, the impacts had slight decreasing trends in the smaller size classes, I, II, and III; from around 0.58 (in 1965) to around 0.48 (in 1997) in size class III; from around 0.45 (in 1965) to around 0.33 (in 1997) in size class II; and from around 0.29 (in 1965) to 0.18 (in 1997) in size class I. Conversely, the impact in the largest size class, IV, had a slight increasing trend: from around 0.72 (in 1965) to around 0.80 (in 1997).

As clearly seen in these magnitudes and Figure 2.8 itself, the larger the farm size, the larger the impact of increases in land input. Conversely speaking, the larger the farm size, the greater the decrease in profits if the planted area of land was reduced. In other words, we may say that the set-aside programs caused greater damage to large-scale farms than to small-scale farms. These results indicate that the persistent set-aside programs may have had negative effects on transferring

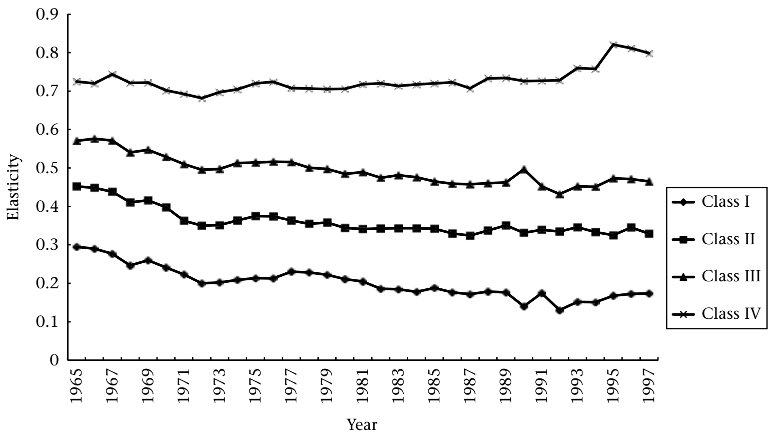

Figure 2.8 Impact of changes in the planted area on the maximized profits for 1965–97: all size classes

Note: The impacts were estimated using equation (2.3).

lands from small-scale to large-scale farms during roughly the last three decades of the 20th century.

2.3.1.4 Impacts of the Set-Aside Programs on Returns to Scale (RTS)

The impact of changes in land input (Z_B) on RTS was estimated using equation (2.4) for all samples of all four size classes for the whole study period 1965–97 and they are presented in Figure 2.9. At first glance, it is clear that the impacts in all four size classes increased from 1965 to 1969. However, from 1969 the impacts in all four size classes had consistent decreasing trends toward the late-1990s. Recall at this point that the first set-aside program was introduced in 1969. This may clearly indicate that the set-aside programs had the impact of reducing the degrees of scale economies, though the impacts became smaller and smaller over time.

The impacts started from around 0.202 (size class I, in 1965), reached the peak of 0.220 (size class II, in 1969), and became around 0.164 (size class IV, in 1997). Though these figures appear to be small, they have important meaning in reality. For example, doubling the planted area, or equivalently, a 100 per cent increase in the planted area, will increase the degree of scale economies by, say, 22 per cent,

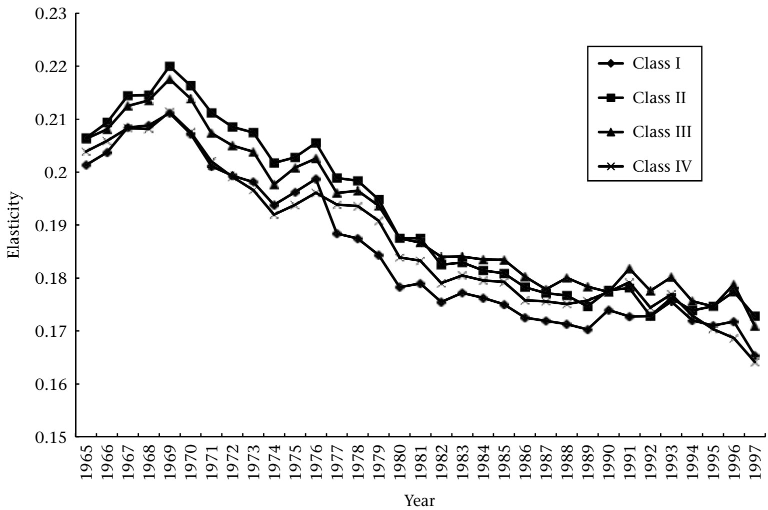

Figure 2.9 Impact of changes in the planted area on returns to scale for 1965–97: all size classes

Note: The impacts were estimated using equation (2.4).

if we take the figure of the impact in 1969. Conversely, the set-aside programs, which forced farmers to reduce the planted paddy area by almost 30 per cent an average during the 1990s, had the effect of reducing the degree of scale economies by, say, around 5.1 per cent in 1997 ($30 percent \times 0.17$).

Although we do not observe any consistent differences in the impacts between different size classes in Figure 2.9, one clear thing is that the set-aside programs restricted the degrees of RTS in all four size class farms during the study period 1965–97.

At this point, we will compare this result obtained from the multiple-product ordinary translog VP function framework to the result obtained from the multiple-product ordinary translog VC function framework based on the same data, although a longer period data set (1957–97) was used for the latter study (Kuroda, 2009c, 2009d, 2009e). According to the latter study, Kuroda obtained positive impacts of changes in land input on scale economies for all four size classes for the whole study period 1957–97 with the elasticities ranging from around 0.14 to 0.23, which are more or less similar to those in this chapter. However, it was found in Kuroda (2009d) that the smaller the size class, the larger the impact. In other words, the set-aside programs gave stronger negative effects of reducing the degrees of scale economies on small farms than on large farms. In any case, what we can conclude from these empirical studies, which tackled the same subject based on different frameworks, is that the set-aside programs had effects of reducing the magnitudes of RTS in Japanese agriculture during the latter half of the 20th century.

2.3.1.5 Impacts of Set-Aside Programs on the Shadow Value of Land

The impacts of changes in land input (Z_B) on the shadow value of land ($w_B^{S'}$) in terms of elasticities were estimated using equation (2.4) for all samples of all four size classes for the entire study period 1965–97 and are presented in Figure 2.10. Before evaluating the impacts in this figure, we will review the estimates of the shadow values of land presented in Figure 1.4 in Chapter 1. We observed in that figure that (i) the larger the size class, the larger the shadow value of lands, (ii) the shadow values of lands of the larger size classes, II, III, and

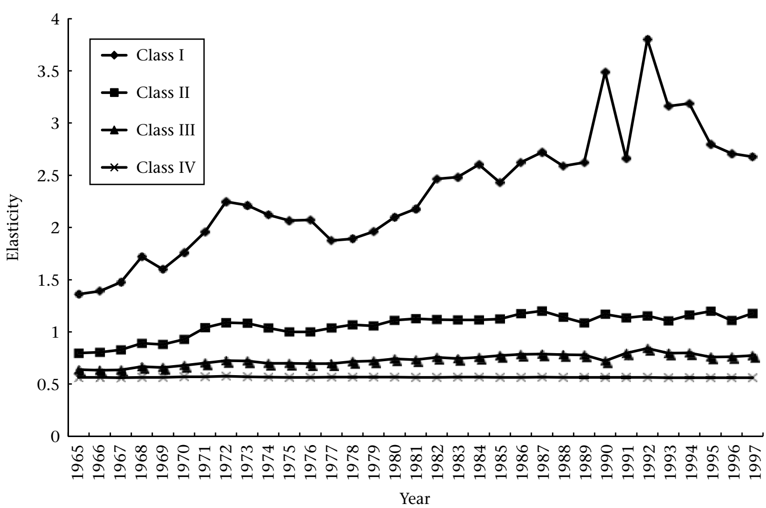

Figure 2.10 Impact of changes in the planted area on the shadow value of land for 1965–97: all size classes

Note: The impacts were estimated using equation (2.10).

IV, were much larger than the (government-regulated) 'market' land rent, and (iii) the shadow value of land of the smallest size class, I, was higher than the 'market' land rent until 1980, but since then it was smaller than the 'market' land rent. Based on these findings, we may conclude that farms in all size classes did not utilize farmlands up to the 'optimal' points to maximize the profits. Keeping this conclusion in mind, we will now turn back to the results in Figure 2.10. Several intriguing findings are noteworthy from this figure.

To begin with, impacts of changes in land input on the shadow value of land in terms of elasticities were positive in all four size classes for the entire study period 1965–97. Furthermore, it is very clear that the smaller the size class, the larger the impact. More specifically, the impacts in terms of elasticities of classes III and IV were consistently around 0.6–0.7 and 0.6, respectively, for the entire period. For size class II, the impacts ranged from around 0.7 to 1.2 for the same period. Common sense tells us that these elasticity values are fairly high. On the other hand, the impact in size class I was surprisingly large; it ranged from around 1.4 in 1965 to around 3.8 in 1992, but then decreased to 2.6 in 1997, which was still high. At any rate, that the impacts of land input on the shadow value (or marginal productivity) of land are positive implies theoretically that increases in land input will increase the shadow value of land. This indicates that all four size class farms did not utilize their farmlands so as to maximize their profits. More specifically, all four size class farms engaged in farming with much smaller scale farmlands to attain profit maximization.

What then can we say from these findings on the impacts of the set-aside programs which forced farmers to reduce the planted area of paddy fields? The above-observed findings indicate that those programs may have had negative effects on the shadow values of land in all size classes for the entire study period 1965–97. In particular, such negative effects were substantial in the smallest size class, I, so that the shadow value of land of this size class became smaller than the 'market' land rent from 1980. This may have had the effect of easing land transfers from small to large farms. However, the same set-aside programs gave much stronger effects of reducing the profits (or 'farm income') on large farms than on small farms. We may infer from these conflicting findings that the latter effects may have overwhelmed the former, which resulted in the limited movements of farmlands from small- to large-scale farms during the entire study period 1965–97, as seen in Figure 1.6 in Chapter 1.

2.4 Summary and Concluding Remarks

This chapter has estimated the impacts of changes in land (planted area) as a fixed input in order to quantitatively investigate the effects of the set-aside programs applied since 1969. For this objective, we estimated the multiple-product ordinary translog VP function with labor and land being the quasi-fixed factor inputs for the period 1965–97. Based on the estimated parameters, the impacts of changes in land input on the supplies of crop and livestock products, the demands for variable factor inputs, the maximized profits, the degrees of RTS, and the shadow value of land were estimated for all observations of four different size classes for the period 1965–97. The impacts are expressed in terms of elasticities and presented in the form of graphs by which the reader can visually capture differences in the estimated impacts between different size classes. The empirical findings are summarized as follows.

First, the set-aside programs decreased the supplies both of crops and of livestock in all four size classes for the entire study period 1969–97 for which the set-aside programs were applied. At the same time, the set-aside programs decreased the demands for the variable factor inputs, that is, machinery, intermediate, and other inputs in all four size classes for the same period, indicating that the levels of production of crops and livestock must have declined in all four size classes. Furthermore, the set-aside programs had negative effects on profits in all four size classes.

However, it should be emphasized that in these findings the larger the size of farm, the greater the damage in all these economic indicators due to the persistent applications of the set-aside programs since 1969.

Next, the set-aside programs reduced the degrees of scale economies in all four size classes. But, we could not find any systematic differences in the negative effects of the set-aside programs on scale economies in different size classes.

Finally, the set-aside programs decreased the shadow values of land in all four size classes. The negative effect was most substantial in size class I, which might have worked as an engine to transfer farmlands from small to large farms. It is here noteworthy that this finding is consistent with the one obtained in Chapter 9 (Subsection 9.4.5.4) of Volume 1, where the VC function approach was employed.

However, this negative effect may have been offset by the weakest negative effect of the set-aside programs on profits, so that the profits (or 'farm income') of small farms were greater than the shadow value (or 'rent-bearing capacity') of land of large farms. This may have been a critical reason why the government policies for promoting land movements from small- to large-scale farms have not been successful, as seen in Tables 9.1 and 10.1 in Chapters 9 and 10, respectively, of Volume 1.

Thus, the conclusion is now clear. The set-aside programs have to be remodeled or thrown away in order to ease transfers of farmlands from small- to large-scale farms for more efficient and profitable agricultural production on large-scale farms.

3
Impacts of R&E Programs on Structural Change

3.1 Introduction

The previous chapters, 1 and 2, have respectively investigated quantitatively the effects of the price-support programs and the set-aside programs on transfers of farmlands by either selling and buying or renting out and renting in from small farms to large farms for more efficient and productive farming on larger-scale farms. To put it one way, we have found that both policies have limited the possibilities of movements of farmlands from small to large farms. To put it another way, the transition of the basic structure of small-scale farming to larger-scale farming has not proceeded smoothly against our expectation.

The point of departure of this chapter is to quantitatively examine the effects of public R&E investments on land transfers from small to large-scale farms. For this objective we will investigate the impacts of public R&E activities on the five economic indicators as exposed in the previous two chapters; that is, (i) the supplies of crops and livestock, (ii) the demands for variable factor inputs such as machinery and intermediate inputs composed of the expenditures on fertilizers, agri-chemicals, feed, and so on, (iii) the maximized profits, (iv) the degrees of RTS, and (v) the shadow value of farmland. As in the cases of Chapters 1 and 2, the parameter estimates of the same multiple-product ordinary translog VP function with labor and land being quasi-fixed factor inputs will be employed to compute quantitatively the impacts on the five economic indicators mentioned above.

Similarly to Chapters 1 and 2, the investigations will be carried out for farms with different size classes based on farm management data. This method will therefore enable us to evaluate the impacts of public R&E activities on the five economic indicators of farm-firms among different size classes, which will hopefully offer important information on evaluating the possibilities of farmland movements from small to large farms.

At this point, we will look at Figures 3.1 and 3.2 which present the annual expenditures on and the accumulated capital stock of R&E investments, respectively.[1] They are deflated by the research expenditure deflator and expressed at 1985 prices. According to Figure 3.2, the R&E capital stock increased fairly sharply from the early-1970s through to the late-1980s, and then the rate of increase started declining. As shown in Figure 3.1, these movements reflect the rather sharp increase in research expenditures in the 1960s and the stagnation in both research and extension expenditures since the early-1970s up to

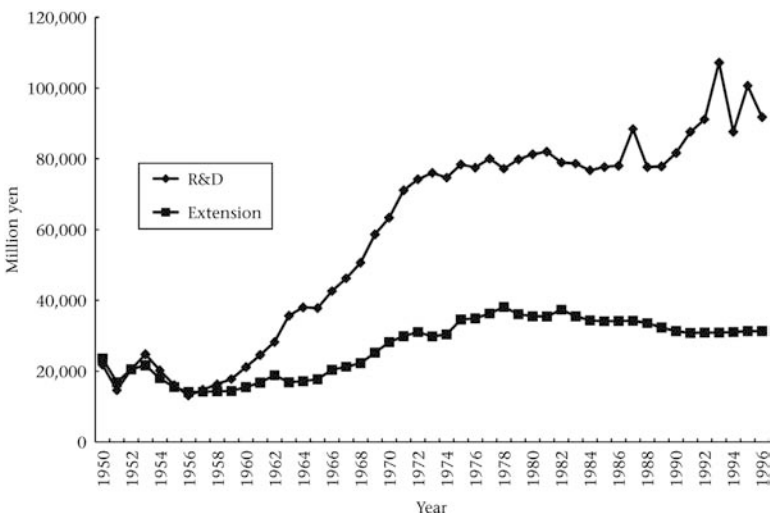

Figure 3.1 Public real agricultural R&D and extension (R&E) expenditures for 1950–96 at 1985 prices: all Japan

Note: For the details of the definitions and data sources of R&E, refer to Appendix 1.1.

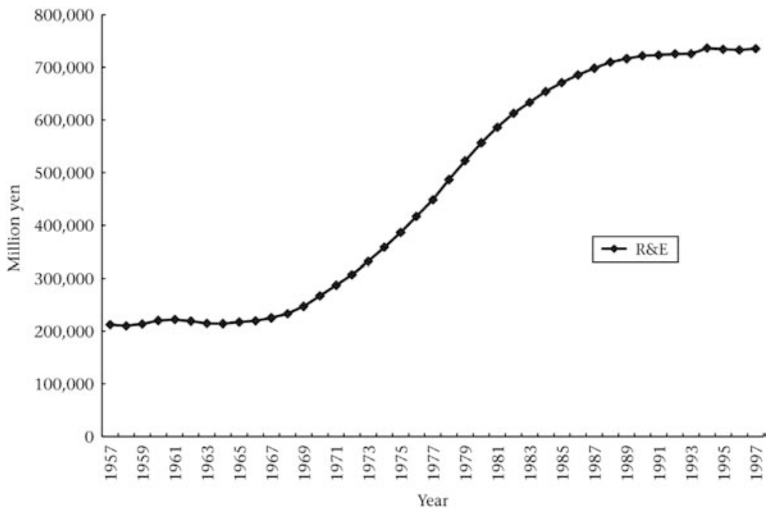

Figure 3.2 Public real R&E capital stock for 1957–97 at 1985 prices: all Japan

Note: For the details of the estimation of the R&E capital stock, refer to Appendix 1.1.

the late-1980s. We have introduced the R&E capital stock as an exogenous variable into the VP function whose details were fully exposed in Chapter 1.

The rest of this chapter is organized as follows. Section 3.2 presents the VP function-based analytical framework. Section 3.3 presents empirical results. Finally, Section 3.4 provides a brief summary and conclusion.

3.2 Analytical Framework

To begin with, we should emphasize that we are going to use the same VP function framework employed in Chapter 1, where we investigated the impacts of the price-support programs on the five economic indicators mentioned above.

In this chapter, then, we will immediately derive the formulas to quantitatively evaluate the impacts of the public stock of technological knowledge on those five economic indicators using the parameter estimates of the VP function system obtained by equations (1.3) through (1.7).

3.2.1 Impacts of Changes in the Stock of Technological Knowledge on the Five Economic Indicators

First, the impacts of changes in the stock of technological knowledge (Z_R) on the supplies of crop and livestock products (Q_G and Q_A) in terms of elasticities can be estimated by,

$$\frac{\partial \ln Q_i}{\partial \ln Z_R} = \varepsilon_{iR} = \frac{\mu_{iR}}{R_i} + \frac{\partial \ln VP'}{\partial \ln Z_R}, \quad i = G, A, \tag{3.1}$$

which is equivalent to the output supply elasticities with respect to the stock of technological knowledge.

Second, the impacts of changes in the Z_R on the demands for the variable factor inputs ($X_k,\ k = M, I, O$) can be given by,

$$\eta_{kR} = -\frac{\mu_{kR}}{R_k} + \frac{\partial \ln VP'}{\partial \ln Z_R}, \quad k = M, I, O, \tag{3.2}$$

which is equivalent to the variable factor demand elasticities with respect to the stock of technological knowledge.

Third, the impacts of changes in Z_R on the maximized profits VP' in terms of elasticity can be given by,

$$\begin{aligned}\frac{\partial \ln VP'}{\partial \ln Z_R} &= \beta_R + \sum_i \mu_{iR} \ln P_i' + \sum_k \mu_{kR} \ln w_k' \\ &\quad + \sum_l \mu_{lR} \ln Z_l + \mu_{RR} \ln Z_R, \end{aligned} \tag{3.3}$$

$$i = G, A,\ k = M, I, O,\ l = L, B.$$

The term $\partial \ln VP' / \partial \ln Z_R$ may be called the 'profit-increasing effect' of the stock of technological knowledge (Z_R) which can be estimated using the estimated parameters of the VP function system.

Fourth, the impacts of changes in the Z_R on $RTS = \sum_l \frac{\partial \ln VP'}{\partial \ln Z_l}$ in terms of elasticities can be obtained by,

$$\frac{\partial \ln(RTS)}{\partial \ln Z_R} = \frac{\sum_l \mu_{lR}}{RTS}, \tag{3.4}$$

$l = L, B.$

Finally, the impacts of changes in the Z_R on the shadow value of land ($w_B^{S'}$) in terms of elasticities can be obtained by,

$$\frac{\partial \ln w_B^{S'}}{\partial \ln Z_R} = \frac{\partial \ln VP'}{\partial \ln Z_R} + \frac{\partial\left(\dfrac{\partial \ln VP'}{\partial \ln Z_B}\right)}{\partial \ln Z_R}\left(\frac{\partial \ln VP'}{\partial \ln Z_B}\right)^{-1}$$

$$= \frac{\partial \ln VP'}{\partial \ln Z_R} + \mu_{RR}\left(\frac{\partial \ln VP'}{\partial \ln Z_B}\right)^{-1}, \qquad (3.5)$$

$i = G, A.$

All these impacts due to changes in the stock of technological knowledge (Z_R) on the profit maximizing output supplies (Q_i, $i = G, A$), variable factor input demands (X_k, $k = M, I, O$), maximized profits (VP'), RTS, and the shadow value of land ($w_B^{S'}$) will be estimated for all observations for all four size classes for the entire study period 1965–97 and they will be presented in the form of graphs. In this way, one can visually capture differences in the impacts among different size classes and changes in the impacts over time.

3.3 Empirical Results

3.3.1 Results of the VP Function

Since the estimated parameters of the multiple-product ordinary translog VP function system and the associated P-values are presented in Table 1.2, and the associated hypothesis testing and output supplies and factor input demands presented in Table 1.3 are fully evaluated in Sections 1.4.2 and 1.4.3, respectively, in Chapter 1, we will not repeat the same explanations here.

Accordingly, we will immediately proceed to evaluate the estimates of the impacts of changes in the stock of technological knowledge Z_R on the five economic indicators.

Recall however that the major objective here is to quantitatively investigate the effects of the stock of technological knowledge on land transfers from small- to large-scale farms, that is, structural transformation, for more efficient rice farming.

3.3.2 Impacts of Public R&E Programs

3.3.2.1 Impacts of Public R&E Programs on the Supplies of Crops and Livestock

To begin with, we will evaluate the impacts of changes in the stock of technological knowledge (Z_R) on the supplies of crops (Q_G) and livestock (Q_A) estimated using equation (3.1) in terms of elasticities. In fact, these impacts can be considered to be equivalent to the supply elasticities of crops and livestock with respect to changes in the stock of technological knowledge (Z_R). Figures 3.3 and 3.4 present the impacts for crops and livestock respectively for all observations of all four size classes for the study period 1965–97. Several intriguing findings are worth mentioning from these figures.

First, we will evaluate the impact of changes in the stock of technological knowledge (Z_R) on the supply of crops (Q_G) in Figure 3.3. According to Figure 3.3, it is clear that the smaller the farm size, the larger the impact of changes in Z_R. In particular, the smallest size class had the largest impact of changes in Z_R for the entire study period 1965–97; the magnitudes of impacts in terms of elasticity ranged from

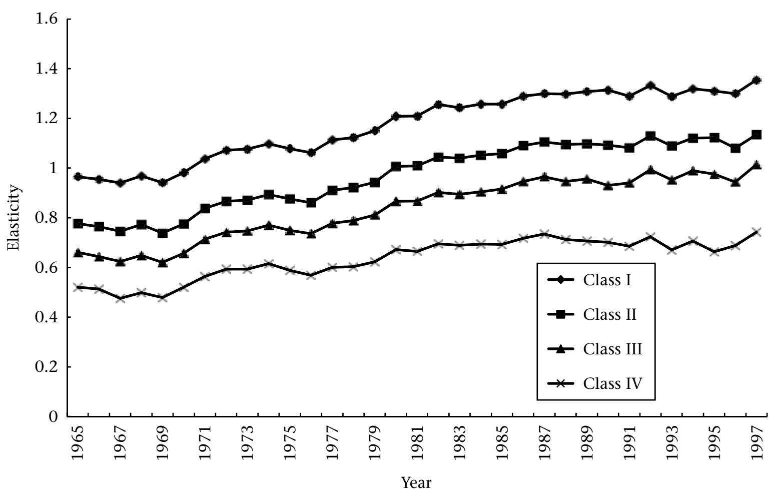

Figure 3.3 Impacts of changes in the stock of technological knowledge on the supplies of crops for 1965–97: all size classes

Note: The impacts were estimated using equation (3.1).

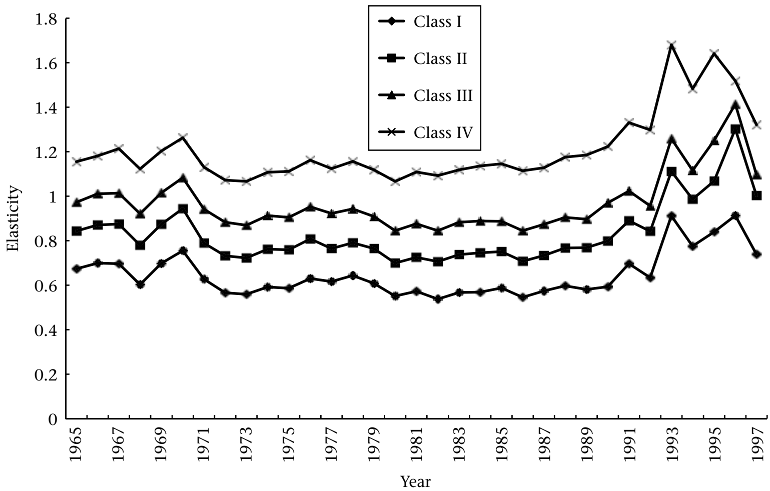

Figure 3.4 Impacts of changes in the stock of technological knowledge on the supplies of livestock for 1965–97: all size classes

Note: The impacts were estimated using equation (3.1).

around 0.95 during the late-1960s to around 1.38 in 1997, indicating that small-scale farms were considerably responsive to improved technologies developed in the public agricultural experiment and extension institutions in the production of crops, for example, rice, vegetables, fruits, and other crop products. Though smaller compared to the impacts in the smallest size class, the impacts in the larger size classes, II, III, and IV, also had fairly high and over-time increasing trends in the elasticities of supply with respect to Z_R.

Based on these findings, however, we may infer that increases in the stock of technological knowledge Z_R might have caused restrictions of transfers of farmlands from small to large farms in the case of crop production. Recall at this point that in Chapter 2 we witnessed that the set-aside programs had significant negative impacts on crop, in particular rice, production, especially on large-scale farms, for the entire study period 1965–97. Unfortunately, the public R&E activities seem to have had similar effects as those due to the set-asides; that is, restricting possibilities for larger-scale, more efficient crop farming on large-scale farmlands.

Second, how about the impacts of changes in the stock of technological knowledge (Z_R) on the supplies of livestock products (Q_A)? The magnitudes in terms of elasticities are presented in Figure 3.4 and they were apparently all positive. According to this figure, the impacts in all four size classes show more or less similar movements for the study period 1965–97; fairly consistent and steady movements for the period 1965–89 but increased sharply since then, though with ups and downs, for the 1989–97 period.

Conversely to the case of crop production, we observe very clearly from Figure 3.4 that the larger the size class, the larger the impact of changes in the stock of technological knowledge on the supplies of livestock products. In particular, the elasticities of the largest size class, IV, ranged from around 1.18 (in 1965) to around 1.68 (in 1993), meaning that a 10 per cent increase in the stock of technological knowledge Z_R will increase the supplies of livestock products by 11.8 to 16.8 per cent. Such strong responses to changes in technological innovations in livestock production on large-scale farms may have played an important role in rapidly increasing the number of larger-scale livestock producers during the study period 1965–97.

On the other hand, though smaller compared to the impacts in the largest size class, the impacts of Z_R in the smaller size classes, I, II, and III, were fairly high; their movements are very similar to that of the largest size class, IV, for the whole period 1965–97. We may conjecture that increases in the stock of technological knowledge Z_R might have caused restrictions of transfers of farmlands from small to large farms in the case of livestock production as in the case of crop production.

In sum, the impacts of increases in the stock of technological knowledge on the supplies of both crops and livestock estimated in terms of elasticities were all positive in all four size classes for the entire study period 1965–97. Above all, we have found that the smaller the size class, the larger the impact in the case of crop production. On the other hand, we have found that the larger the size class, the greater the impact of changes in the stock of technological knowledge on livestock production. These findings imply that the public R&E programs, which tried to improve technologies of production of both crops and livestock, had naturally positive impacts on increasing production and supplies of both crops and livestock in all four size classes. In particular, the R&E programs had the strongest positive impacts on the supplies of crop products in small-scale farms. On the other hand, the

R&E programs had the strongest positive impacts on the supplies of livestock products in large-scale farms, although smaller-scale farms also enjoyed fairly positive effects from the public R&E programs on livestock production. These findings indicate that the R&E programs may have worked in the direction of delaying the speed of transfers of farmlands from small to large farms for more productive and efficient farming on larger-scale farms both for crop and for livestock production.

3.3.2.2 Impacts of Public R&E Programs on the Demands for Variable Factor Inputs

In this subsection, we will evaluate the impacts of changes in the stock of technological knowledge (Z_R) on the demands for the variable factor inputs (X_k, $k = M, I, O$); machinery, intermediate, and other inputs. Actually, the impacts expressed in terms of elasticities are exactly the same as the demand elasticities for the variable factor inputs with respect to Z_R. We estimated the impacts for all observations of the four size classes for the entire study period 1965–97. The impacts of changes in Z_R on the demands for the variable factor inputs are shown in Figures 3.5, 3.6, and 3.7. Needless to say, as is clear in equation (3.2), the impacts presented in Figures 3.5, 3.6, and 3.7 are equivalent to the variable factor input demand elasticities with respect to Z_R. Several findings are noteworthy from these figures.

First, according to Figure 3.5, the impacts of changes in the stock of technological knowledge (Z_R) on the demand for machinery input (X_M) were positive and consistent in all four size classes for the study period 1965–97; the impact in size class I decreased its magnitudes from around 0.25 (in 1965) to 0.16 (in 1997); that in size class II ranged from around 0.38 (in 1965) to 0.31 (in 1997); and that in size class III decreased from around 0.48 (in 1965) to around 0.44 (in 1997). On the other hand, the largest size class, IV, increased the impacts from around 0.62 (in 1965) to around 0.78–0.80 for the 1995–97 period. As is clear from Figure 3.5, the larger the farm size, the larger the impact. In particular, the largest size class IV farms had fairly high elasticities for the entire study period; that is, 0.62 to 0.80. These findings imply that public R&E programs promoted 'M-innovations' for all four size classes; the speed of mechanization in the largest size class was the highest for the entire study period 1965–97.

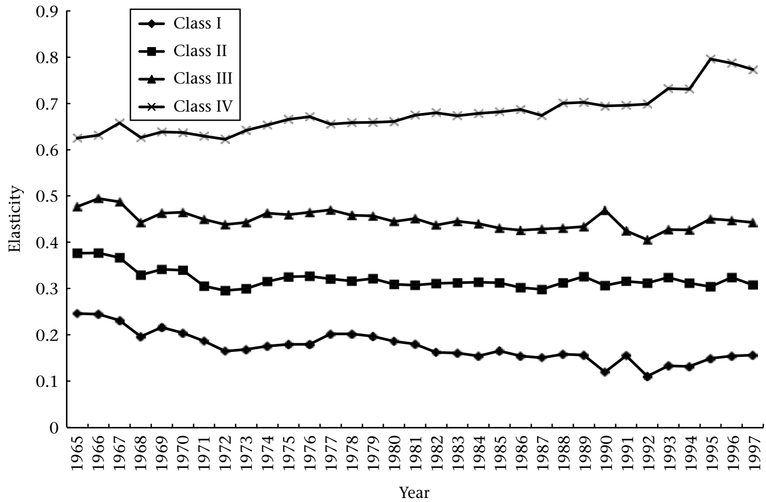

Figure 3.5 Impacts of changes in the stock of technological knowledge on the demands for machinery input for 1965–97: all size classes

Note: The impacts were estimated using equation (3.2).

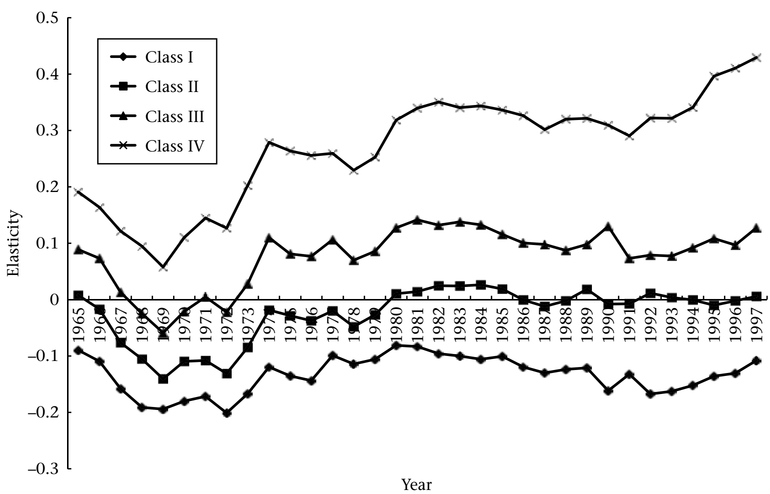

Figure 3.6 Impacts of changes in the stock of technological knowledge on the demands for intermediate input for 1965–97: all size classes

Note: The impacts were estimated using equation (3.2).

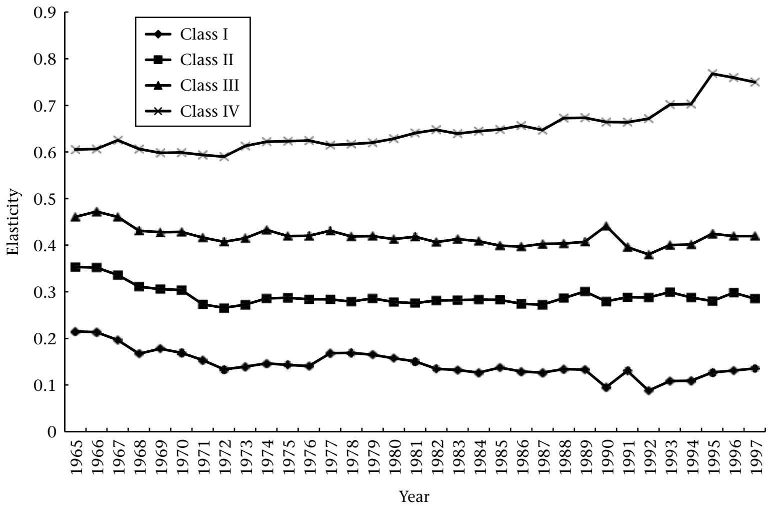

Figure 3.7 Impacts of changes in the stock of technological knowledge on the demands for other input for 1965–97: all size classes

Note: The impacts were estimated using equation (3.2).

Second, Figure 3.6 shows considerably different magnitudes and over-time movements of the impacts of changes in the stock of technological knowledge (Z_R) on intermediate input (X_I) among the four different size classes. As in the case of the impact of Z_R on machinery input, the impacts of changes in the stock of technological knowledge (Z_R) on intermediate input (X_I) are equivalent to the demand elasticities of intermediate input with respect to Z_R. A few intriguing findings emerge from Figure 3.6.

It is very clear that the larger the size class, the larger the impact. The elasticities of the largest size class, IV, for example, decreased for the period 1965–9 from around 0.19 to around 0.06. Then it had an increasing trend for the rest of the study period 1969–97; the elasticity in 1997 was around 0.43, indicating a fairly sharp increase. Conversely, the elasticities in the smaller size classes, I, II, and III, were very low: the elasticity in class I was even negative for the whole period, that in size class II was also negative or close to zero for the entire period, and size class III had several years with negative elasticities, while positive elasticities of this size class were as low as around 0.1.

This finding may indicate that only large farms had fairly elastic positive responses to changes in the stock of technological knowledge in utilizing more intermediate input such as fertilizers, agri-chemicals, feed, and so forth to increase either crops or livestock or both. This in turn implies that smaller-scale farms did not enjoy the fruits of developments of 'BC-innovations' brought about by public R&E investments during the study period 1965–97.

Third, Figure 3.7 presents the impacts of changes in the stock of technological knowledge (Z_R) on the demand for other input (X_O). This figure shows a very similar picture to the one in the case of the demand for machinery input. That is, (i) the impacts were all positive in all four size classes for the entire study period 1965–97, (ii) only the impact of size class IV had an increasing trend, though just slightly, (iii) for the other three smaller size classes, I, II, and III, the impacts were all fairly consistent for the entire period with some weak ups and downs, (iv) the larger the farm size, the larger the impacts for the entire study period 1965–97; the impacts in size class I ranged from around 0.60 (in 1965) to around 0.78–0.75 for the 1995–7 period. Again, the impacts of changes in the stock of technological knowledge (Z_R) on other input (X_O) are equivalent to other input demand elasticities with respect to Z_R. Some intriguing findings are noteworthy from Figure 3.7.

These findings indicate that farms in all size classes had positive responses to increases in the stock of technological knowledge (Z_R) in utilizing more other input, such as farm buildings and structures, large plants, and large animals, to increase either crops or livestock or both. Increased demand for these factor inputs are intimately related to the government policy of the so-called 'Selective Product Expansion Programs' of agricultural products, especially for products such as livestock, fruits, and vegetables, as an important policy of the Agricultural Basic Act inaugurated in 1961. In this sense, these findings in turn imply that the public R&E programs have played an important role in developing the 'Selective Product Expansion Programs' for all four size classes, in particular for large-scale farms.

In sum, the impacts of increases in the stock of technological knowledge on the demand for the variable factor inputs, that is, machinery, intermediate, and other inputs, estimated in terms of elasticities were all positive in all four size classes for the entire study period 1965–97, except for the case of the negative elasticities for intermediate input in size classes I and II. Above all, we have found that the larger the size class, the larger the impact. This means that the public R&E programs had positive impacts on more rapid 'M-innovations', 'BC-innovations', and selective expansion of agricultural products. In particular, the R&E programs had the strongest positive impacts in large-scale farms, meaning strong positive effects for larger-scale, more efficient farming on large-scale farms.

3.3.2.3 Impacts of Public R&E Programs on the Maximized Profits

Using equation (3.3), the impact of changes in the stock of technological knowledge (Z_R) on the maximized profits (VP') in terms of elasticities were estimated for all observations in all four size classes for the study period 1965–97 and are presented in Figure 3.8. Some intriguing findings emerge from Figure 3.8.

First, it is clear that the larger the farm size, the greater the impact of changes in the stock of technological knowledge on profits. Second, the over-time movements of the impacts in all four size classes appear to be very similar; for the first period, 1965–8, the impacts were almost

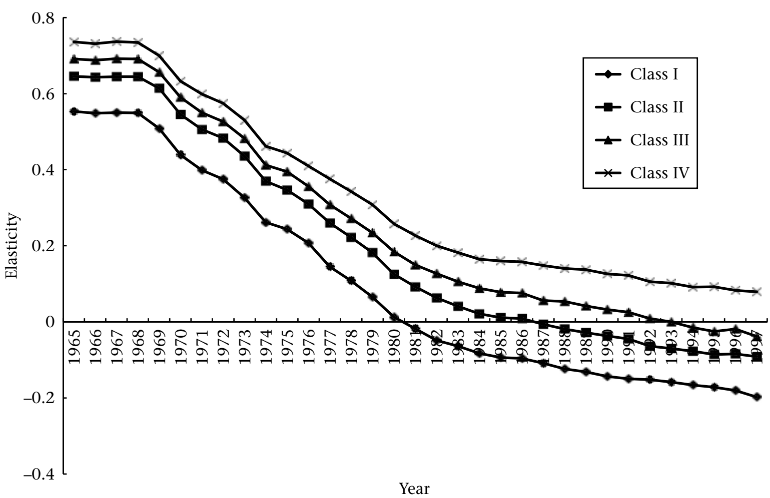

Figure 3.8 Impacts of changes in the stock of technological knowledge on the maximized profits for 1965–97: all size classes

Note: The impacts were estimated using equation (3.3).

constant and fairly high, ranging from 0.55 (size class I) to 0.75 (size class IV); then, the impacts in all size classes started decreasing sharply for the 1968–97 period; the impact in size class I became negative in 1981, that in size class II became negative from 1987, and that in size class III became negative in 1993. Only size class IV had positive effects for the entire study period 1965–97.

This finding may be interpreted as follows. During the period of high growth in the Japanese economy from the mid-1950s until the early-1970s, public agricultural R&E investments were very active, as seen in Figures 3.1 and 3.2. Introductions of newly developed technologies may have brought about large amounts of profits for farmers. However, as 'M-innovations' together with 'BC-innovations' were promoted in all farms in all size classes, the costs of production increased sharply so that the amounts of profits received by farmers became smaller and smaller, which finally pushed them down even to 'negative-profits' farmers. Accordingly, it may be said that, *ceteris paribus*, it is a only matter of time before the largest size class IV farms will also become 'negative-profits' farms if they still stick to conventional technologies.

3.3.2.4 Impacts of public R&E Programs on RTS

The impacts of changes in the stock of technological knowledge (Z_R) on the degrees of RTS were estimated using equation (3.4) for all samples of all four size classes for the whole study period 1965–97, and they are presented in Figure 3.9. At first glance, it is clear that the impacts in all four size classes were positive for the entire study period 1965–97. More specifically, they first increased from 1965 to 1969, but from 1969 the impacts in all four size classes had consistent decreasing trends toward the late-1990s. This finding supports the results obtained by Kuroda (2010a) based on the estimated parameters of the multiple-product VC function with land as a quasi-fixed factor input using the same set of data as used in this chapter.

Recall at this point that the first set-aside program was introduced in 1969. This may indicate that the set-aside programs had intimate associations with changes in the stock of technological knowledge in reducing the degrees of scale economies, that is, synergy impacts, though the impacts became smaller and smaller over time.

The impacts started from around 0.096 (size class I in 1965), reached a peak of 0.105 (size class II in 1969), and became around 0.078 (size

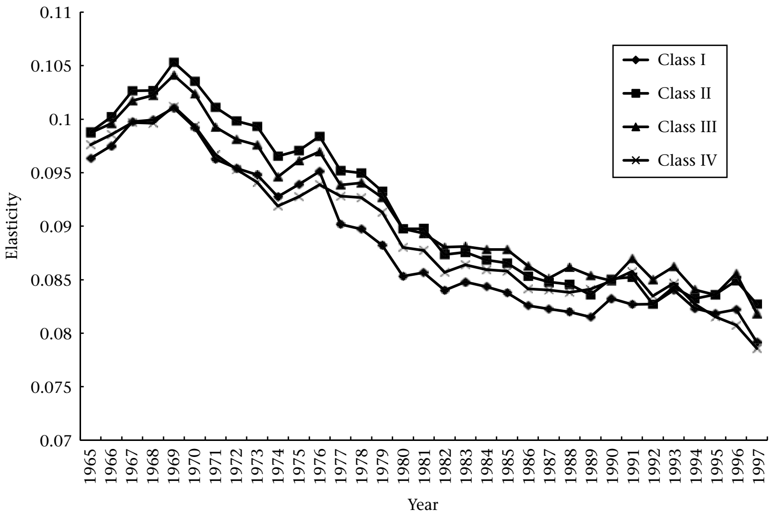

Figure 3.9 Impacts of changes in the stock of technological knowledge on returns to scale for 1965–97: all size classes

Note: The impacts were estimated using equation (3.4).

class IV in 1997). Though these figures appear to be small, they have important meaning in reality. For example, doubling the planted area, or equivalently, a 100 per cent increase in the planted area, will increase the degree of scale economies by, say, 10.5 per cent, if we take the figure of the impact in 1969 as an example.

Although we do not observe any consistent differences in the impacts among different size classes in Figure 3.9, one clear thing is that changes in the stock of technological knowledge increased the degrees of RTS in all four size class farms during the study period 1965–97, though the positive effects had decreasing trends in all size classes.[2]

3.3.2.5 Impacts of Public R&E Programs on the Shadow Value of Land

The impacts of changes in the stock of technological knowledge (Z_R) on the shadow value of farmland ($w_B^{S'}$) in terms of elasticities were estimated using equation (3.5) for all samples of all four size classes for the entire study period 1965–97, and are presented in Figure 3.10.

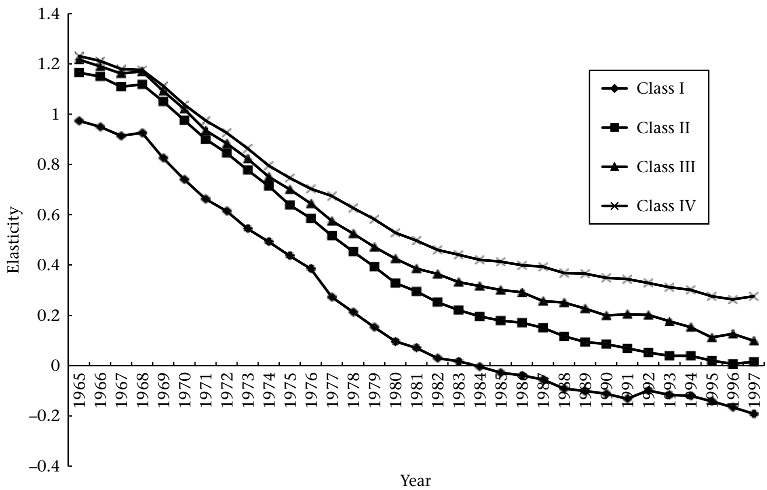

Figure 3.10 Impacts of changes in the stock of technological knowledge on the shadow value of land for 1965–97: all size classes

Note: The impacts were estimated using equation (3.5).

Before evaluating the impacts given in this figure, let us review the estimates of the shadow values of land presented in Figure 1.4, presented in Chapter 1 of this book. We observed that (i) the larger the size class, the larger the shadow value of land, (ii) the shadow values of land of the larger size classes, II, III, and IV, were much larger than the (government-regulated) 'market' land rent, and (iii) the shadow value of land of the smallest size class, I, was higher than the 'market' land rent for the period 1965–80, but from 1981 it was smaller than the 'market' land rent. Based on these findings, we may infer that farms in all size classes did not utilize farmlands up to the 'optimal' points to maximize the profits. Keeping this important finding in mind, we will now turn back to the results in Figure 3.10. Several intriguing findings are noteworthy from this figure.

To begin with, the impacts of changes in the stock of technological knowledge Z_R on the shadow value of land $w_B^{S'}$ were positive in the larger three size classes, II, III, and IV, for the entire study period 1965–97. However, the impact in size class I was positive for the period 1965–83, but it became negative for the period 1984–97. Furthermore, the impacts in all four size classes declined fairly sharply for the entire study period 1965–97. For example, the impact in size class II was around 1.18 in 1965 but it decreased to almost zero in the late-1990s.

This finding may be interpreted in a similar fashion as the interpretation of the similar impacts of Z_R on the maximized profits. During the period of high growth of the Japanese economy from the mid-1950s until the early-1970s, public agricultural R&E investments were very active, as observed in Figures 3.1 and 3.2. Introductions of newly developed 'M- and BC-innovations' may have increased the shadow values of farmlands fairly sharply from the mid-1960s to the late-1970s in all size classes. However, as public agricultural R&E investments became stagnant from the mid-1970s, 'M- and BC-innovations' became much less active than before, which may have caused stagnation in the effects of increasing the shadow values of farmlands in all farms in all size classes. Accordingly, it may be said that, *ceteris paribus*, it is a matter of time before the impact of changes in Z_R on the shadow value of land in the largest size class IV farms may become negative. To avoid such an undesirable result, it is strongly recommended that the government must substantially increase the investments in agricultural R&E activities.

Furthermore, it is very clear from Figure 3.10 that the larger the size class, the larger the impact. More specifically, the impact in size class IV in terms of elasticity was around 1.22 in 1965 and declined to around 0.28 in 1997. On the other hand, the impact in size class I was almost 0.98 in 1965 and decreased much more sharply than in the case of size class IV to around −0.2 in 1997. These findings indicate that large farms were more responsive and eager to employ newly developed agricultural technologies than small farms. This in turn indicates that if such behavioral gaps between small and large farms continue, the differentials in the shadow values of farmlands between small and large farms will be enlarged. This may result in decreases in the amount of the 'farm income' accruing to the own family labor and lands in small farms and hence may result in increases in the differentials between the shadow values of farmlands in large farms and the 'farm income' in small farms,[3] so that the possibilities of land transfers by renting out from small to large farms may increase.

However, as seen in Figure 3.2, the stock of technological knowledge (Z_R) became stagnant during the 1990s due mainly to the stagnant investments in both R&D and extension activities from around the early-1970s as shown in Figure 3.1. This might have caused weaker or even negative effects on enlarging the gaps in the shadow values of lands between small and large farms. As a result, the stagnant R&E activities must have worked in the direction of restricting land transfers from small to large farms.

3.4 Summary and Concluding Remarks

Based on the estimated parameters of the multiple-product ordinary translog VP function, exposed fully in Chapter 1, this chapter has estimated the impacts of changes in the public stock of technological knowledge in order to quantitatively investigate the effects of the public R&E activities on the five economic indicators for the last four decades of the 20th century in Japan. The impacts are expressed in terms of elasticities and presented in the form of graphs by which the reader can visually capture differences in the estimated impacts among different size classes. The empirical findings are summarized as follows.

First, the public R&E programs increased the supplies both of crops and of livestock in all four size classes for the entire period 1965–97. More specifically, smaller-scale farms enjoyed more fruits out of the public R&E programs for crop production than larger-scale farms. We may conjecture from this finding that the public R&E programs had negative effects on transferring lands from small-scale to large-scale farms for more efficient and productive farming on larger-scale farms. On the other hand, the public R&E programs for livestock production resulted in most advantageous benefits on large farms, which reflected a rapid increase in the number of larger-scale livestock farmers during the study period 1965–97.

Second, it was found that the larger the size class, the greater the effect of the public R&E programs on the demands for machinery, intermediate, and other inputs for the entire study period 1965–97. This indicates that larger-scale farms enjoyed more fruits out of 'M-innovations', 'BC-innovations', and the 'Selective Product Expansion Programs' of agricultural products such as livestock, fruits, and vegetables for the last four decades of the 20th century.

Third, the public R&E programs had fairly strong impacts on increasing profits for all size classes during the late-1960s, but the profit-increasing effects had considerably sharp negative trends from the early-1970s toward the late-1990s. These sharp decreases in the impacts of the public R&E programs may have been partly because of the stagnancy in government investments in R&E activities and the nature of 'public goods' of the stock of technological knowledge to which all farmers can approach. However, it should be noted here that the larger the size of farm, the greater the impact of the public R&E programs, which may have worked positively in transferring farmlands from small-scale to large-scale farms during the study period 1965–97.

Fourth, the public R&E programs had the effect of increasing the degrees of scale economies, but the effects themselves had decreasing trends over time for the entire study period 1965–97 in all four size classes. Furthermore, we could not find any systematic differences in the effects of the public R&E programs on scale economies in different size classes.

Finally, the public R&E programs had positive effects on increasing the shadow values of lands in all four size classes except for the negative impacts for the 1984–97 period in size class I. However, the impacts in all four size classes had fairly sharp decreasing trends for the entire period. Again, these sharp decreases in the impacts may have been partly because of the stagnant investments in public R&E activities since the early-1970s and partly because of the nature of public goods of the stock of technological knowledge. However, we note here that the larger the size of farm, the greater the impact of the public R&E programs on increasing the shadow values of farmland, which may have worked positively in transferring farmlands from small to large farms during the study period 1965–97.

We may now conclude that the public R&E programs have to be remodeled and strengthened in such a direction that large farms can obtain the most advantageous fruits from R&E activities in order to attain larger-scale more efficient farming on much larger-scale farms in future Japanese agriculture.

4
The Impacts of Input Subsidies on Structural Change

4.1 Introduction

The major objective of this chapter is to investigate the effects of input subsidies on the urgent policy issue of transforming the small-scale inefficient and low productive farming to more efficient and high productive farming on large-scale farms. In order to pursue this objective, we are going to quantitatively evaluate the impacts of input subsidy programs on the following five important economic indicators of farming. These are exactly the same as in the previous Chapters 1 through 3, that is, (i) the output supplies of crops and livestock, (ii) the demands for variable factor inputs such as machinery, intermediate, and other inputs, (iii) the maximized profits, (iv) the degrees of RTS, and (v) the shadow value of land.

Furthermore, the methodology used for evaluating the impacts of input subsidies is basically the same as employed in the previous three chapters; that is, the multiple-product VP function model with labor and land being quasi-fixed inputs is employed. However, the formulas to estimate the impacts of input subsidies on the above-mentioned economic indicators are naturally different from those used in the previous three chapters, where the impacts of the output price-supports, set-asides, and R&E programs were estimated and evaluated.

At this point, we have to recognize that there have been many kinds of subsidies for agriculture and forestry; about 70 or so subsidies altogether. Thus, it is very difficult to identify which items of subsidies have been applied specifically to, say, machinery input, intermediate input such as fertilizers, agri-chemicals, and other input composed of expenditures on farm buildings and structures, large animals, and large plants. Fortunately, however, it seems to be clear that the Finance for Agriculture, Forestry, and Fisheries has been offered for purchasing machinery input. As for intermediate and other inputs, we have to conjecture that farmers may have used parts of the following subsidies for purchasing fertilizers, agri-chemicals, repairing farm buildings, and so on; that is, Farming Production Promotion, Structural Reform of Paddy Farming, Countermeasure of Agricultural Management, Agricultural Infrastructure Construction and Improvement Programs, Rural Area Improvement Programs, and so on.[1]

Theoretically speaking, such subsidies associated with purchasing factor inputs by farmers may be considered to be equivalent to lowering the prices of factor inputs such as machinery, fertilizers, agri-chemicals, farm equipment, and so on, in real terms. Thus, the major objective of this chapter is to quantitatively estimate and evaluate the impacts of decreases in the prices of factor inputs on the five economic indicators listed above from the viewpoint of the possibility of structural transformation for more productive and efficient farming in postwar Japanese agriculture.

As far as our extensive survey goes, it is found that very few (or no) studies have been executed in Japan for empirical investigations of effects of input subsidies on structural transformation in Japanese agriculture.[2] This chapter may in this sense be claimed to be the first attempt to quantitatively present impacts of input subsidies on structural transformation and may be expected to offer policy makers useful information on how to ease land movements in the agricultural sector in postwar Japanese agriculture.

At this point, it is worth mentioning that a brief conclusion of this chapter is that input subsidy programs, as a whole, have caused most serious disadvantages in postwar Japanese agriculture in the sense that such policies have restricted the possibilities of transferring farmlands from small- to large-scale farms for more efficient farming on large-scale farms.

The rest of this chapter is organized as follows. Section 4.2 presents the procedures to estimate the impacts of input subsidies on the five economic indicators mentioned above based on the VP function framework. Section 4.3 presents empirical results. Finally, Section 4.4 provides a brief summary and conclusion.[3]

4.2 Analytical Framework

To begin with, we should emphasize that we are going to utilize the same VP function framework employed in Chapter 1, where we investigated the impacts of the output price-support on the five economic indicators: that is, they are (i) the output supplies of crops and livestock, (ii) the demands for the variable factor inputs, (iii) the degrees of RTS, (iv) the maximized profits, and (v) the shadow value of land.

In this chapter, then, we will immediately derive the formulas to quantitatively evaluate the impacts of input subsidies on the above-mentioned five economic indicators resorting to the VP function system given by equations (1.1) through (1.7).

4.2.1 Impacts of Changes in the Prices of the Variable Factor Inputs on the Five Economic Indicators

In this subsection, we follow basically the same procedures employed in Chapter 1. Thus, the exposition of the procedures of estimating the various impacts will be carried out as compactly as possible. We will present only the final equation for estimating each impact, since the reader may easily derive the same formulas by following the procedures given in Chapter 1 with simple modifications.

Now, we could unfortunately not obtain the direct effects of decreases in the prices of the variable factor inputs thanks to subsidies on the various economic indicators. This is because it was not always possible to compile all necessary data on the price indexes corresponding to the variable factor inputs defined in the VP function (1.1) given in Chapter 1.[4] Note however that increases in input subsidies by the government may have analogous effects to decreases in the prices of variable factor inputs. Therefore, our procedure will first estimate the impacts of changes in the prices of the variable factor inputs ($w_M{}'$, $w_I{}'$, and $w_O{}'$) on the above-mentioned five economic indicators and then, based on the estimated results, we will try to infer the impacts of decreases in the prices of the variable factor inputs due mainly to subsidy programs.

4.2.1.1 Formulas for the Impacts of Changes in the Prices of the Variable Factor Inputs on the Five Economic Indicators

First, the impacts of changes in the nominal prices of the variable factor inputs ($w_M{}'$, $w_I{}'$, and $w_O{}'$) on the output supplies (Q_i, $i = G, A$)

can be given by,

$$\varepsilon_{Q_{ik}} = \frac{\gamma_{Q_{ik}}}{R_{Qi} - R_k}, \quad i = G, A, k = M, I, O, \tag{4.1}$$

where R_k is the kth variable factor input cost-profit share as given already in equation (1.2) in Chapter 1. Note here that these impacts expressed in terms of elasticities are equivalent to the elasticities of output supplies (Q_i, $i = G, A$) with respect to the nominal prices of the variable factor inputs ($w_k^{'}$, $k = M, I, O$).

Second, the impacts of changes in the nominal prices of the variable factor inputs ($w_M^{'}$, $w_I^{'}$, and $w_O^{'}$) on the demands for the variable factor inputs (X_M, X_I, and X_O) are again equivalent to the variable factor demand elasticities with respect to changes in the nominal prices of the variable factor inputs. Here, however, we will shed a special light on the own-price elasticities. Otherwise, it will be fairly complicated if we try to evaluate the cross-price impacts.

Now, the impact of changes in the kth factor price on the demand for the kth factor input, that is, the own-price elasticity of the kth factor input, can be obtained by,

$$\eta_{kk} = -\frac{\gamma_{kk}}{R_k} - R_k - 1, \quad k = M, I, O, \tag{4.2}$$

where R_k is the kth variable factor input cost-profit share.

Third, the impact of changes in the kth factor price on the maximized profits ($VP^{'}$) in terms of elasticities can be obtained by,

$$\frac{\partial \ln VP^{'}}{\partial \ln w_k^{'}} = \alpha_k + \sum_n \gamma_{kn} \ln w_n^{'} + \sum_l \phi_{kl} \ln Z_l + \mu_{kR} \ln Z_R, \tag{4.3}$$

$$k, n = M, I, O, \; l = L, B,$$

which is equivalent to the kth variable factor input cost-profit share of output (R_k). Here, however, we are going to estimate the impacts given by equation (4.3) using the estimated coefficients of the VP function (1.1) which are presented in Table 1.2 in Chapter 1, which are in general different from the actual kth variable factor input cost-profit share used for the estimation of the system.

Fourth, the impact of changes in the price of the kth variable factor input on the degrees of RTS in terms of elasticities can be obtained by,

$$\frac{\partial \ln RTS}{\partial \ln w_k^{'}} = \frac{\sum_l \phi_{kl}}{RTS}, \; k = M, I, O, \; l = L, B, \tag{4.4}$$

where RTS is given by the following equation (1.37) given in Chapter 1,

$$RTS = \sum_{l} \frac{\partial \ln VP'}{\partial \ln Z_l}, \quad l = L, B. \tag{4.5}$$

Finally, the impact of changes in the price of the kth variable factor input on the shadow value of land ($w_B^{S'}$) in terms of elasticities can be obtained by,

$$\begin{aligned} \frac{\partial \ln w_B^{S'}}{\partial \ln w_k'} &= \frac{\partial \ln VP'}{\partial \ln w_k'} + \frac{\partial \left(\frac{\partial \ln VP'}{\partial \ln Z_B} \right)}{\partial \ln P'} \left(\frac{\partial \ln VP'}{\partial \ln Z_B} \right)^{-1} \\ &= \frac{\partial \ln VP'}{\partial \ln w_k'} + \phi_{kB} \left(\frac{\partial \ln VP'}{\partial \ln Z_B} \right)^{-1}, \end{aligned} \tag{4.6}$$

$k = M, I, O.$

As executed for evaluating the impacts of the output price-support, set-aside, and R&E programs on the five economic indicators in Chapters 1, 2, and 3, respectively, all the impacts caused by changes in the prices of the variable factor inputs on (i) the profit-maximizing output supplies ($Q_i,\ i = G, A$), (ii) the variable factor demands ($X_k,\ k = M, I, O$), (iii) the maximized variable profits (VP'), (iv) the degrees of RTS, and (v) the shadow value of land ($w_B^{S'}$) will be estimated for all observations for all four size classes for the entire study period 1965–97 and they will be shown in the form of graphs.

4.3 Empirical Results

4.3.1 Estimates of the Variable Profit Function System

Since the estimated parameters of the VP function system and the associated P-values are reported and exposed in Table 1.2 in Chapter 1, we will not present the same explanations here in this chapter. Accordingly, we will immediately proceed to evaluate the estimates of the impacts of changes in the prices of the variable factor inputs on the five economic indicators mentioned above.

4.3.2 Impacts of Changes in the Prices of the Variable Factor Inputs on the Five Economic Indicators

4.3.2.1 Impacts on the Supply of Crops

Using equation (4.1), the impacts of changes in the prices of the variable factor inputs ($w'_k, k = M, I, O$) on the supply of crops (Q_G) were estimated for all observations of the four size classes for the entire study period 1965–97 and are presented in Figures 4.1, 4.2, and 4.3, respectively. Several findings are noteworthy from these figures.

To begin with, the impacts of changes in the price of machinery (w'_M) on the supply of crops (Q_G), were all negative in all size classes for the entire study period 1965–97. In addition, the impacts in terms of elasticities increased over time in absolute terms from around 0.12 (size class VI in 1965) to around 0.68 (size class I in 1997). In other words, the supply of crops became more and more responsive to changes in the price of machinery input over time in all size classes. This in turn indicates that decreases in the machinery price due to subsidies for machinery input may have increased the demand for machinery input in all size classes. This may have led to increases in the supplies of crops for increased revenues in all four size classes during the study period 1965–97.

Furthermore, it is clear from Figure 4.1 that the smaller the size class, the greater the impact of changes in the price of machinery input (w'_M) on the supplies of crops (Q_G) in absolute terms for the entire study period 1956-97. This finding may suggest that government subsidies, which may have had effects of reducing the price levels of machinery input, may have given stronger impacts on smaller- than larger-scale farms in increasing the demand for machinery input (X_M) and hence increasing the supplies of crops (Q_G). In other words, this finding suggests that government subsidies for machinery input may have given stronger incentives to smaller-scale farms to stick to producing crops than to larger-scale farms. This may have limited movements of farmlands from small- to large-scale farms. This in turn may have restricted the transition from smaller- to larger-scale and more efficient crop farming during, roughly, the last four decades of the 20th century, 1965–97.

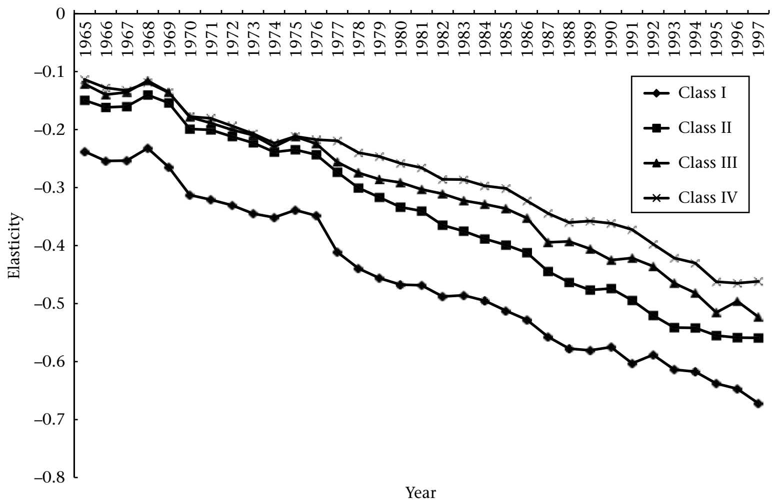

Figure 4.1 Impacts of changes in the price of machinery input on the supplies of crops for 1965–97: all size classes

Note: The impacts were estimated using equation (4.1).

Next, the impacts of changes in the price of intermediate input (w_I') on the supplies of crops (Q_G) for all sample observations of all four size classes for the entire study period 1965–97 are presented in Figure 4.2. Several intriguing findings are worthwhile mentioning from this figure.

First of all, although the impacts expressed in terms of elasticities were very small (under 0.1), we obtained positive elasticities for changes in the price of intermediate input on the supplies of crops for 1967–9 for size class IV and for 1968–9 for size class III. An informal interpretation for this finding may be that in order to cover the increased expenditures on intermediate inputs (X_I) such as fertilizers, agri-chemicals, seeds, and materials, farms in these size classes might have behaved so as to increase the supplies of crops (Q_G) during those years.

Otherwise, the impacts in all size classes were negative for the entire study period, which is theoretically reasonable. As is clear from Figure 4.2, the impacts in all size classes had decreasing trends in absolute terms during the 1965–82 period, but after 1982 it turned

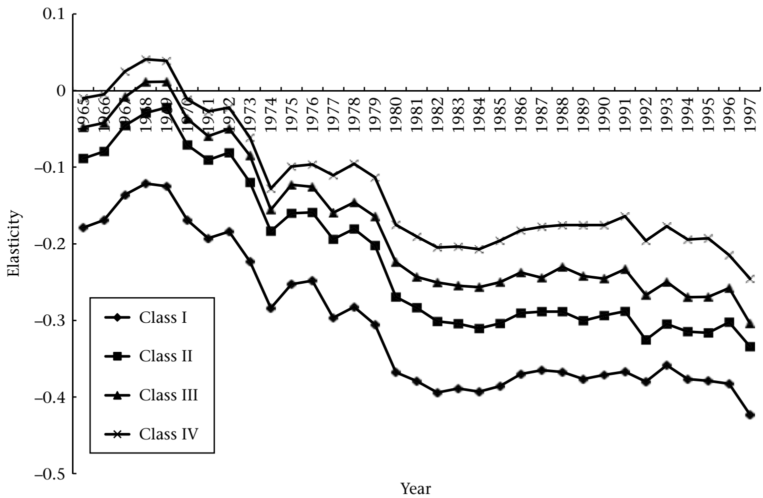

Figure 4.2 Impacts of changes in the price of intermediate input on the supplies of crops for 1965–97: all size classes

Note: The impacts were estimated using equation (4.1).

out that all size classes had increasing trends in absolute terms until around the 1982–4 period, then slightly increasing trends until 1991, and finally slightly decreasing trends for the 1991–7 period.

In addition, as in the case of the impact of changes in the price of machinery input on the supply of crops, it is clear that the smaller the size class, the larger the impact of changes of the price of intermediate input on the supply of crops in absolute terms for the entire study period 1965–97. This indicates that decreases in the price of intermediate input thanks to subsidies increased the supply of crops of smaller farms more than that of larger farms. This mechanism may have worked in the direction of limiting transfers of farmlands from small- to large-scale farms, which may have limited the development of larger-scale and more efficient agricultural production in postwar Japan; more specifically, during the last three or four decades of the 20th century. Note here, however, from Figures 4.1 and 4.2, we may say that the impacts on the supplies of crops with respect to changes in the prices of machinery and intermediate inputs were in absolute terms fairly comparable with each other, although the

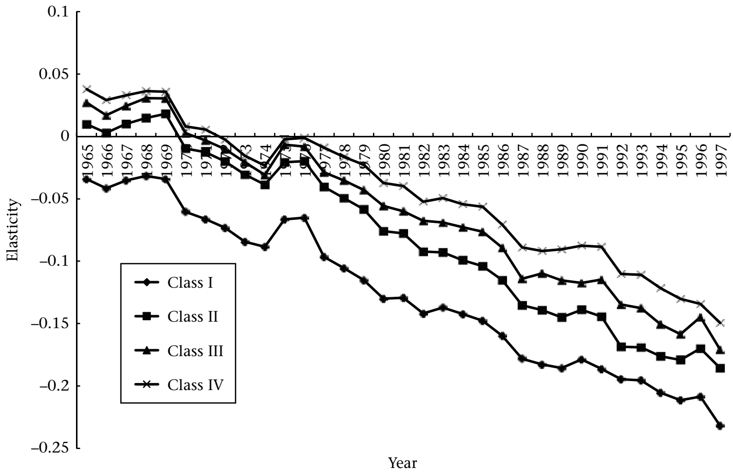

Figure 4.3 Impacts of changes in the price of other input on the supplies of crops for 1965–97: all size classes

Note: The impacts were estimated using equation (4.1).

over-time movements of the two kinds of impacts were considerably different.

Finally, the impact of changes in the price of other input (w'_O) on the supply of crops (Q_G) is shown in Figure 4.3. Recall here that other input is composed of the expenditures on farm buildings and structures, large animals, and large plants.

As in the case of the impacts with respect to intermediate input, we observe that the impacts of changes in the price of other input on the supply of crops in the size classes II, III, and IV were positive, though very small, for different periods during the period 1965–72; 1965–9 for size class II, 1965–70 for size class III, and 1965–72 for size class IV. Again, an informal interpretation is similar to the case of the impacts with respect to changes in the price of intermediate input. That is, it may be interpreted in such a way that in order to cover the increased expenditures on other input (X_O), farms in these three size classes may have tried to increase the supply of crops for more crop revenue during those periods.

After those periods until 1997, the impacts were negative and had increasing trends in absolute terms in all four size classes, though with some ups and downs. In addition, we observe that the smaller the size class, the greater the impact in absolute terms for the entire study period 1965–97. This indicates that decreases in the price of other input due to subsidies may have increased the supply of crops of smaller-scale farms more than that of larger-scale farms. This mechanism may have played a role in limiting transfers of farmlands from small- to large-scale farms, which may have limited the possibilities for larger-scale and more efficient crop production. Note, however, based on a rough observation of the magnitudes of impacts in absolute terms in Figures 4.1, 4.2, and 4.3, we may assert that the extents of the impacts on the supply of crops with respect to changes in machinery were the largest, then those with respect to intermediate input, and finally, those with respect to other input.

At this point, we will recall that we found that the smaller the size class, the larger the impacts of changes in the price of crops on the supply of crops for the entire study period 1965–97 (Figure 1.7 in Chapter 1). This indicates that the crop price-support policies had a negative effect on transferring paddy lands from small- to large-scale farms.

Based on the findings with respect to changes in the prices of the variable factor inputs together with the output price for crop production, we may conclude that policies both for the crop price-support and for factor input subsidies may have played important roles in limiting transfers of farmlands from small- to large-scale farms. This in turn may have restricted the possibilities for larger-scale farming with higher productivity and efficiency in crop production during, roughly, the last four decades of the 20th century, 1965–97.

4.3.2.2 Impacts on the Supply of Livestock

To begin with, using equation (4.1), the impacts of changes in the prices of the variable factor inputs ($w_k^{'}, k = M, I, O$) on the supply of livestock (Q_A) were estimated for all observations of the four size classes for the entire study period 1965–97 and are presented in Figures 4.4, 4.5, and 4.6, respectively. Several findings are worthwhile mentioning based on these figures.

First of all, the impacts of increases in the price of machinery ($w_M^{'}$) on the supply of livestock (Q_A), were almost all positive in all size classes for the entire study period 1965–97; however, for the period 1977–92 and 1986–9 for size classes I, and II, respectively, the impacts

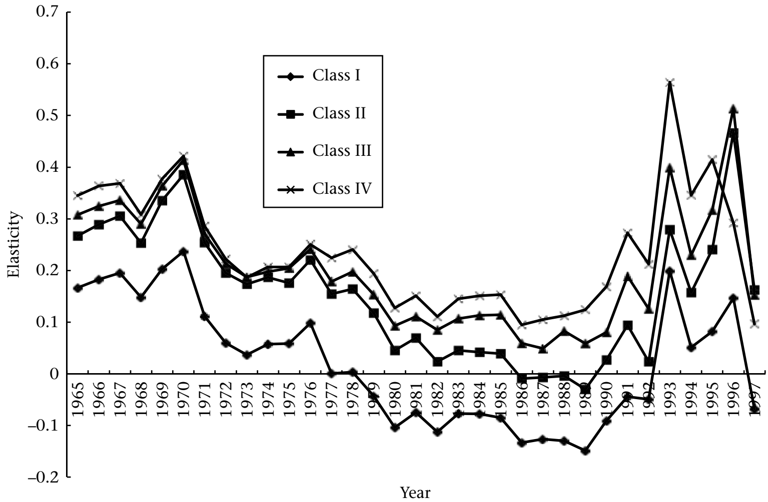

Figure 4.4 Impacts of changes in the price of machinery input on the supplies of livestock for 1965–97: all size classes

Note: The impacts were estimated using equation (4.1).

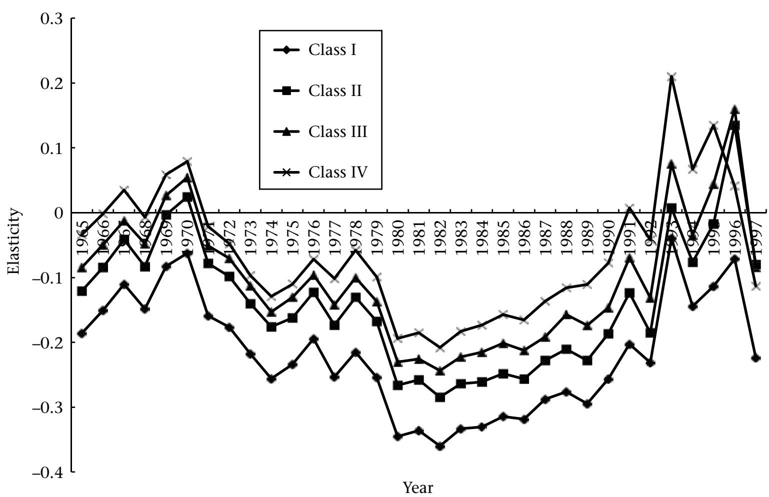

Figure 4.5 Impacts of changes in the price of intermediate input on the supplies of livestock for 1965–97: all size classes

Note: The impacts were estimated using equation (4.1).

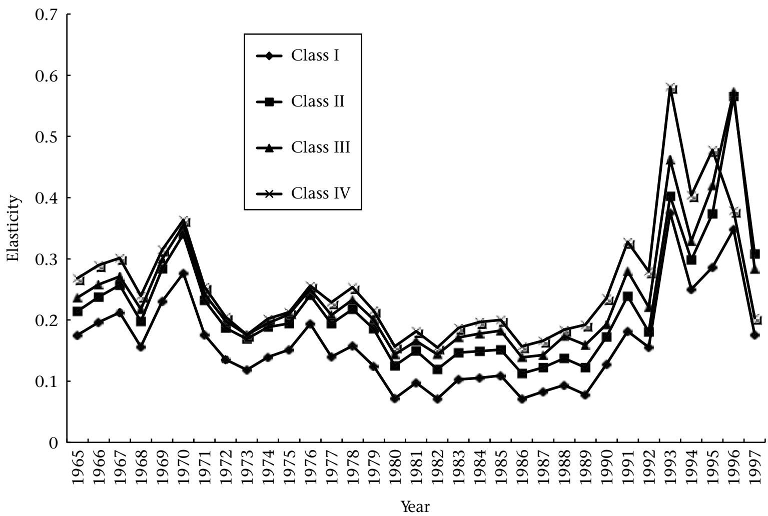

Figure 4.6 Impacts of changes in the price of other input on the supplies of livestock for 1965–97: all size classes

Note: The impacts were estimated using equation (4.1).

were negative, which may have been natural from the economics theory point of view. Then, how can we interpret the peculiar finding in Figure 4.4?

One possible interpretation may be as follows. A rise in the price of machinery will decrease the demand for machinery input. However, it is possible that livestock farmers may have utilized the limited stock of machinery input more efficiently to increase the levels of livestock production, in particular for the 1990s.

Conversely, the governmental subsidies may have decreased the price of machinery, which may have increased the demand for machinery input and hence increased the levels of livestock production. However, the story was opposite; decreases in the price of machinery input may have increased the demand for machinery input, but decreased the supply of livestock. In addition, it is easily recognized that the larger the size class, the greater the extent of the impacts on supply reductions. This may have decreased the differentials of the amounts of livestock supply between small- and large-scale farms, which may have resulted in restrictions against the possibilities of transfers of lands from small- to large-scale farms.

Next, the impacts of increases in the price of intermediate input (w_I') on the supply of livestock (Q_A) for the entire study period 1965–97 are presented in Figure 4.5. Again, we find some peculiar results for larger-scale farms for the periods 1965–70 and 1993–7 during which we found increases in the supply of livestock: for the periods 1966–70 and 1993–6 in size class IV; for the periods 1969–70 and for the years 1993, 1995, and 1996 for size classes III and II. As in the case of the impacts of machinery input, we will interpret these findings for the impacts of intermediate input price changes on the increased supply of livestock in a similar way; that is, more intensive and efficient utilization of intermediate input such as feeds.

On the other hand for the period 1971–92 for the cases of size classes II, III, and IV, but for the entire period 1965–97 for size class I, the impacts of increases in the price of intermediate input were all negative. It is easy and natural to interpret this finding. That is, increases in the price of intermediate input decreased the demand and hence usage of intermediate input for livestock production, which must have caused reductions in the supply of livestock in all size classes.

Furthermore, it is clear from Figure 4.5 that the larger the size class, the greater the impact of increases in the price of intermediate input on the supply of livestock in absolute terms for the entire study period 1965–97.

Now, we will evaluate the effects of subsidies for intermediate input on the supply of livestock. Decreases in the price of intermediate input thanks to input subsidy programs increased the demand for intermediate input, which may have increased the supplies of livestock in all size classes. We may infer that the smaller the size class, the greater the extent of increases in the supply of livestock for the entire study period 1965–97. This may have caused decreases in the differentials of the amounts of supply of livestock between small- and large-scale farms. As a result, the input subsidy programs worked in the direction of restricting land transfers from small- to large-scale farms.

Finally, the impacts of changes in the price of other input (w_O') on the supply of livestock (Q_A) are shown in Figure 4.6.

We observe in Figure 4.6 that the impacts of increases in the price of other input on the supply of livestock in all four size classes were positive and seem to have increased during the 1990s, though with sharp drops in 1994 and 1997. What logic can we use to interpret such a peculiar result?

As in the case of the impacts of increases in the price of machinery presented in Figure 4.4, the following interpretation may be possible. A rise in the price of other input will decrease the demand for other input. However, it is possible that livestock farmers in all four size classes may have utilized the limited stock of other input such as farm buildings and structures and large animals more efficiently to increase the levels of livestock production, in particular for the 1990s.

Conversely, the governmental subsidies may have decreased the price of other input, which may have increased the demand for other input and hence increased the levels of livestock production. However, the story was totally opposite; decreases in the price of other input may have increased the demand for other input, but in reality decreased the supply of livestock. In addition, it is easily recognized that the larger the size class, the greater the extent of the impacts on supply reductions except for 1996–7 period. This may have decreased the differentials of the amounts of livestock supply between small- and large-scale farms, which may have resulted in restrictions against the possibilities of transfers of lands from small- to large-scale farms.

Recall here that we have obtained very similar findings in Chapter 9 (Section 9.4.5.2) of Volume 1 on the impacts of factor input subsidies on the shadow values of farmlands, where we found that factor input subsidy programs may have played significant roles in restricting land transfers from small- to large-scale farms. This further implies that we obtained almost the same results, at least qualitatively, using either the VC function or the VP function approaches.

4.3.2.3 Impacts on the Demands for Variable Factor Inputs

The impacts of changes in the prices of the variable factor inputs ($w_k', k = M, I, O$) on the demands for the variable factor inputs for all observations of the four size classes for the entire study period 1965–97 were estimated using equation (4.2) and are presented in Figures 4.7, 4.8, and 4.9. Several findings are worth noting based on these figures.

To begin with, the impacts of increases in the price of machinery (w_M') on the demand for machinery input (X_M) were all negative in all sample observations in all four size classes. This is consistent with the microeconomic theory.[5] In addition, we found that the own-price

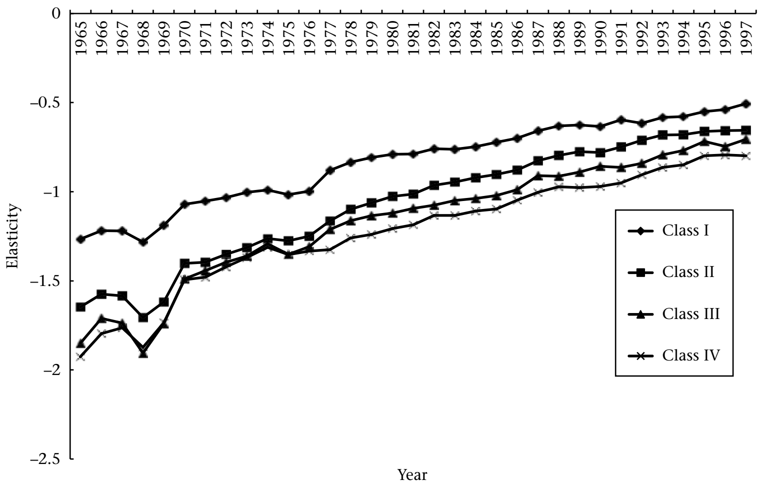

Figure 4.7 Impacts of changes in the price of machinery input on the demands for machinery input for 1965–97: all size classes

Note: The impacts were estimated using equation (4.2).

demand elasticities for machinery in all four size classes had decreasing trends in absolute terms for the entire study period 1965–97. This may imply that the elasticities of demand for machinery input steadily decreased over time in absolute terms because farms in all size classes increased the amounts of machinery inputs, either in the form of physical equipment or in the form of mechanical services, that is, custom works, or both.

More specifically, as clearly seen in Figure 4.7, the impacts, or equivalently, the own-price demand elasticities for machinery input were rather high in absolute terms in the larger three size classes, II, III, and IV, for the 1965–1975 period; ranging from around 1.9 in 1965 (size class IV) to 1.3 in 1975 (size class II) in absolute terms. But, from that period toward the end of 1990s, the elasticities in all four size classes appear to have decreased at more or less similar rates.

Furthermore, we clearly observe that the larger the size class, the greater the magnitude of the own-price demand elasticities for machinery input for the entire study period, 1965–97.

This in turn indicates that decreases in the price of machinery input due to subsidies may have increased the demand for machinery input more on larger-scale farms than on smaller-scale farms, which may have led to greater amounts of farm production of either crops or livestock or both on larger-scale farms than on smaller-scale farms. This indicates that subsidies for machinery input played a role of encouraging transfers of farmlands from small- to large-scale farms for more productive and efficient farming, either crops or livestock.

Next, the impacts of changes in the price of intermediate input (w_I') on the demand for intermediate input (X_I) for all four size classes for the entire study period 1965–97 were estimated using equation (4.2) and the results are presented in Figure 4.8. According to the figure, the impacts in all four size classes were all negative, which is consistent with the convexity condition. In addition, the trends of the impacts (or demands) in absolute terms may be classified into three patterns for the entire study period 1965–97: (i) for the period 1965–9, the demands for intermediate input increased considerably; (ii) however, after 1969, when the first set-aside program was introduced for rice production, the demands for intermediate input decreased fairly sharply until around 1980; (iii) from 1980 through to 1997,

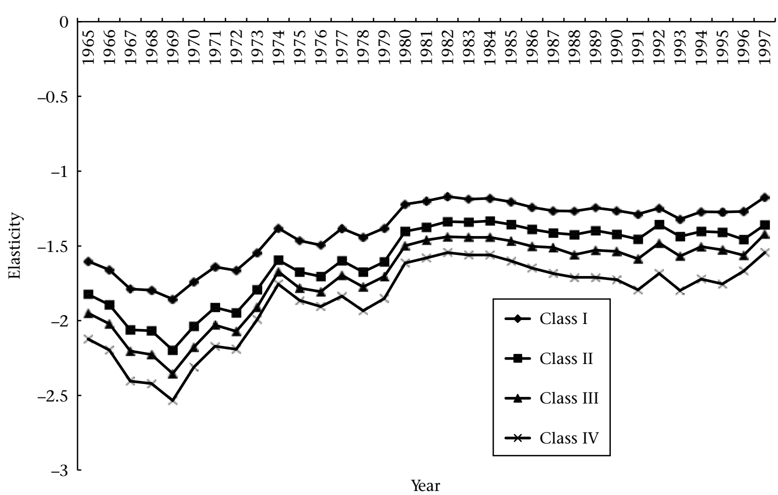

Figure 4.8 Impacts of changes in the price of intermediate input on the demands for intermediate input for 1965–97: all size classes

Note: The impacts were estimated using equation (4.2).

the demands for intermediate input became stagnant. We may infer that these changes in the patterns of demands for intermediate input may have been intimately related to the introduction of the set-aside and production adjustment programs which may have had negative effects on the demands for intermediate input.

Furthermore, we can observe that, in absolute terms, the larger the size class, the larger the demand for intermediate input consistently for the entire study period 1965–97. This in turn indicates that decreases in the price of intermediate input due to subsidies may have increased the demand for intermediate input to greater extents on larger-scale farms than on smaller-scale farms. This may have led to greater amounts of farm production of either crops or livestock or both on larger-scale farms than on smaller-scale farms, which indicates that subsidies for intermediate input played a role in encouraging transfers of farmlands from small- to large-scale farms for more productive and efficient farming, either crops or livestock.

Finally, the impacts of changes in the price of other input (w_O') on the demand for other input (X_O) are equivalent to the own-price elasticity of demand for other input as in the cases of machinery and intermediate inputs interpreted above. They were obtained using equation (4.2) and are presented in Figure 4.9.

To begin with, according to Figure 4.9, it seems to be very clear that, in absolute terms, the impacts of changes in the price of other input on the demands for other input in all four size classes had very similar steady decreasing trends, though with some ups and downs, for the entire study period 1965–97. The elasticities (equivalently the impacts) range from around 2.4 (size class IV in 1965) to around 1.2 (size class I in 1997) in absolute terms, which are, roughly speaking, comparable with those of machinery and intermediate inputs.

Furthermore, it is fairly clear from Figure 4.9 that the larger the size class, the greater the impact of changes in the price of other input on the demands for other input in absolute terms for the period 1965–97. This finding may suggest that subsidies, which may have the effect of reducing the price levels of other input, will give stronger impacts on larger-scale than on smaller-scale farms in increasing the demands for other input and hence increasing the supplies of either crops or livestock or both. It may thus suggest that subsidies for other input may have given stronger incentives to larger-scale farms to produce

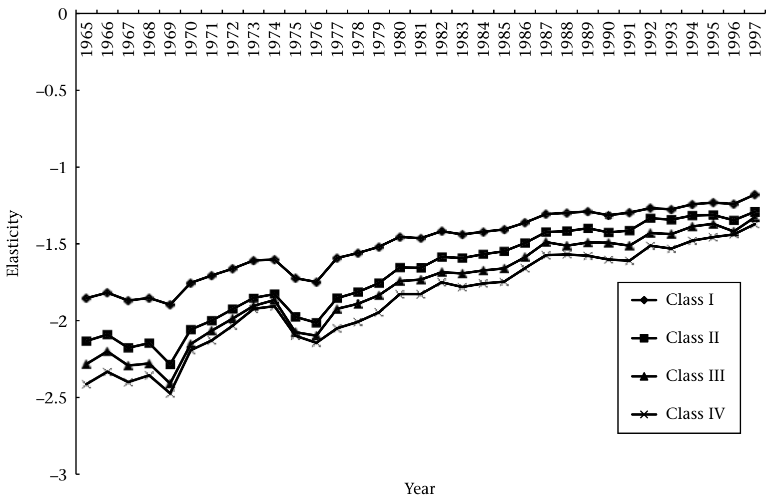

Figure 4.9 Impacts of changes of the price of other input on the demands for other input for 1965–97: all size classes

Note: The impacts were estimated using equation (4.2).

more outputs than smaller-scale farms. This may have encouraged movements of farmlands from small- to large-scale farms.

4.3.2.4 Impacts on the Maximized Profits

The impacts of changes in the prices of the variable factor inputs ($w_k^{'}, k = M, I, O$) on the maximized profits (VP') were estimated using equation (4.3) for all observations of the four size classes for the entire study period 1965–97 and are presented in Figures 4.10, 4.11, and 4.12. As mentioned earlier, they are equivalent to the kth factor input-profit shares ($R_k, k = M, I, O$). Several findings are worth noting from these figures.

To begin with, the impacts of increases in the price of machinery ($w_M{'}$) on the maximized profits (VP') were all negative in all samples in all four size classes.

It is clear that the impacts of increases in the price of machinery on the maximized profits had increasing trends in absolute terms for the entire study period 1965–97 in all size classes; the impacts ranged from 0.12 (size class IV in 1965) to 0.68 (size class I in 1997).

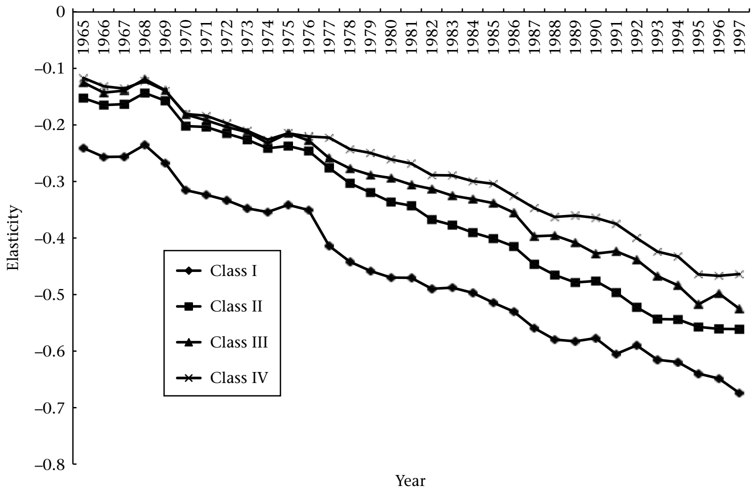

Figure 4.10 Impacts of changes in the price of machinery input on the maximized profits for 1965–97: all size classes

Note: The impacts were estimated using equation (4.3).

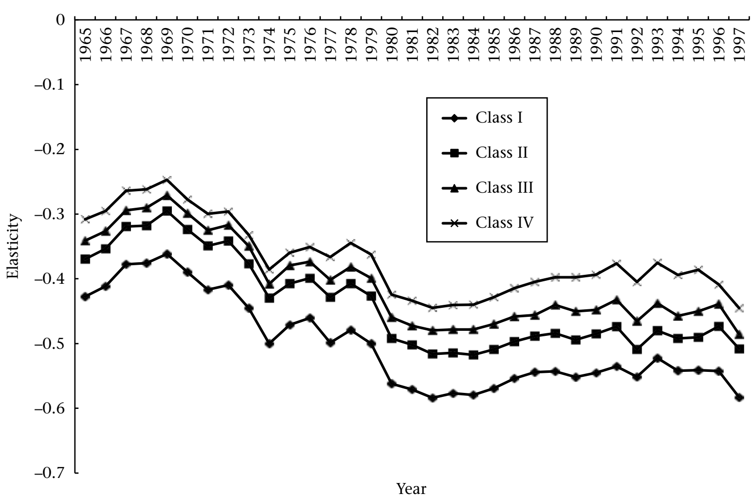

Figure 4.11 Impacts of changes in the price of intermediate input on the maximized profits for 1965–97: all size classes

Note: The impacts were estimated using equation (4.3).

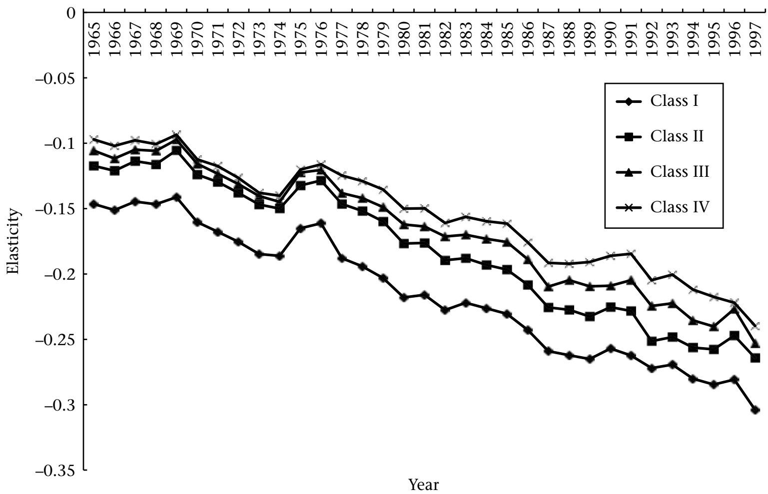

Figure 4.12 Impacts of changes in the price of other input on the maximized profits for 1965–97: all size classes

Note: The impacts were estimated using equation (4.3).

Conversely speaking, decreases in the price of machinery input due to subsidies may have increased the maximized profits in all four size classes during the entire study period 1965–97.

Furthermore, we observe very clearly from Figure 4.10 that the smaller the size class, the greater the impact in absolute terms for the entire period.

This may indicate that decreases in the price of machinery input thanks to subsidies will result in larger amounts of maximized profits in smaller size classes than in larger size classes. This will in turn indicate that smaller-scale farms had stronger incentives to increase profits through farming by increasing demand for machinery input than did larger-scale farms, which may have caused a delay in transfers of farmlands from small- to large-scale farms during the study period 1965–97.

Next, we observe in Figure 4.11 that the impacts of increases in the price of intermediate input (w_I') on the maximized profits (VP') were all negative in all samples in all four size classes for the entire study period 1965–97.

Furthermore, it is clear that the impacts of increases in the price of intermediate input in absolute terms had decreasing trends for the period 1965–9 and then increasing and steady trends for the period 1969–97, except for a decrease in 1974 (due probably to the 'oil crisis') in all four size classes; the impacts ranged from around 0.25 (size class IV in 1965) to 0.58 (size class I in 1997). Conversely speaking, this finding indicates that decreases in the price of intermediate input such as fertilizers and agri-chemicals thanks to subsidies may have increased the maximized profits for all size classes for the entire study period 1965–97, in particular for the period 1968–97, during which a medium- and larger-scale mechanization proceeded with a high speed.

In addition, we observe very clearly from Figure 4.11 that the smaller the size class, the greater the impact in absolute terms for the entire study period 1965–97. This may imply that decreases in the price of intermediate input due to subsidies resulted in larger amounts of maximized profits in smaller size classes than in larger size classes. This may in turn indicate that smaller-scale farms may have had stronger incentives than larger-scale farms to increase profits through increased production of either crops or livestock or both by increasing the demand for intermediate input. This may have limited transfers of farmlands from small to large farms during the study period 1965–97, which may thus have worked in the direction of discouraging structural transformation in agricultural production for postwar Japan.

Finally, Figure 4.12 shows that the impacts of increases in the price of other input (w_O') on the maximized profits (VP') were all negative in all sample observations in all four size classes for the entire study period 1965–97. Again, conversely speaking, this finding indicates that decreases in the price of other input may have increased the maximized profits in all four size classes. At least two more findings from Figure 4.12 are worth noting.

First, it is clear that, roughly speaking, the impacts of increases in the price of other input on the maximized profits had increasing trends in absolute terms for the whole period 1965–97 in all four size classes; the impacts ranged from 0.1 (size class IV in 1965) to 0.31 (size class I in 1997). Conversely speaking, we may infer that decreases in the price of other input may have increased the maximized profits in all four size classes for the entire study period 1965–97.

Furthermore, we observe in Figure 4.12 that the smaller the size class, the greater the impact in absolute terms for the entire study period 1965–97. This indicates that decreases in the price of other input thanks to subsidies may have resulted in relatively larger amounts of maximized profits in smaller size classes than in larger size classes. This may in turn indicate that smaller-scale farms had stronger incentives than larger-scale farms to increase profits through farm production of either crops or livestock or both by increasing demand for other input. We may conjecture here also that this may have limited transfers of farmlands from small to large farms during the study period 1965–97, as in the cases of machinery and intermediate inputs exposed above.

At this point, we recall that we found that the smaller the size class, the larger the impact of changes in the price of crops on the maximized profits for the entire study period 1965–97 (Figure 1.17 in Chapter 1). This indicates that the price-support policies for crops had negative effects on transferring farmlands from small- to large-scale farms.

Based on the findings with respect to changes in the prices of the variable factor inputs together with the price of crops, we may conclude that government policies both for the crop price-supports and for subsidies for factor inputs may have restricted transfers of farmlands from small to large farms. This in turn may have limited the possibilities for larger-scale crop production with higher productivity and efficiency during, roughly speaking, the last four decades of the 20th century.

4.3.2.5 Impacts on the Degrees of RTS

The impacts of changes in the prices of the variable factor inputs ($w_k^{'}, k = M, I, O$) on the degrees of RTS were estimated using equation (4.4) for all sample observations of the four size classes for the entire study period 1965–97. The results are presented in Figures 4.13, 4.14, and 4.15. Several findings are noteworthy from these figures.

First, according to Figures 4.13, 4.14, and 4.15, the impacts of increases in the prices of machinery ($w_M{'}$), intermediate ($w_I{'}$), and other ($w_O{'}$) inputs increased the degrees of RTS in all four size classes for the entire study period 1965–97. Second, the impacts of changes in $w_M{'}$ were greater than those with respect to changes in $w_I{'}$ and $w_O{'}$ for the entire period. Third, we observe from Figures 4.13, 4.14,

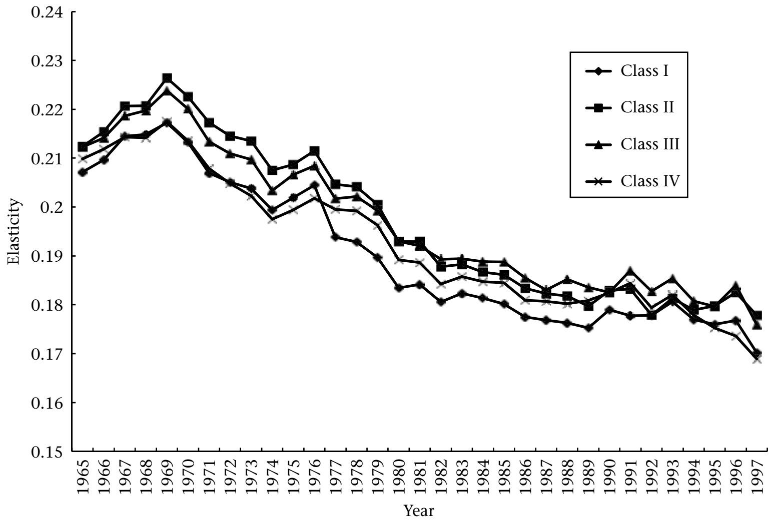

Figure 4.13 Impacts of changes in the price of machinery input on returns to scale for 1965–97: all size classes

Note: The impacts were estimated using equation (4.4).

and 4.15 that in all three cases the impacts had increasing trends for the period 1965–9 and decreasing trends for the period 1969–97 in all four size classes. The movements of the trends with respect to the three factor inputs turned out to be very similar to each other. Fourth, it is difficult to find consistent differences in the impacts between the four different size classes for the entire study period 1965–97.

These findings may be interpreted as follows. Take, for example, increases in the price of machinery ($w_M{}'$). Increases in $w_M{}'$ will induce farmers to reduce the demand for machinery input, which will have a negative impact on the production of either crops or livestock or both. This indicates that the amount of, say, crop production will be further away from the minimum efficient scale (MES), at which the average cost reaches its minimum. This will in turn cause increases in the degrees of RTS in crop production since the ratio of the average to marginal costs ($AC/MC = RTS$) will move further away from the MES toward the vertical axis in the figure of cost curves. According to Figures 4.13, 4.14, and 4.15, the degrees of this movement do

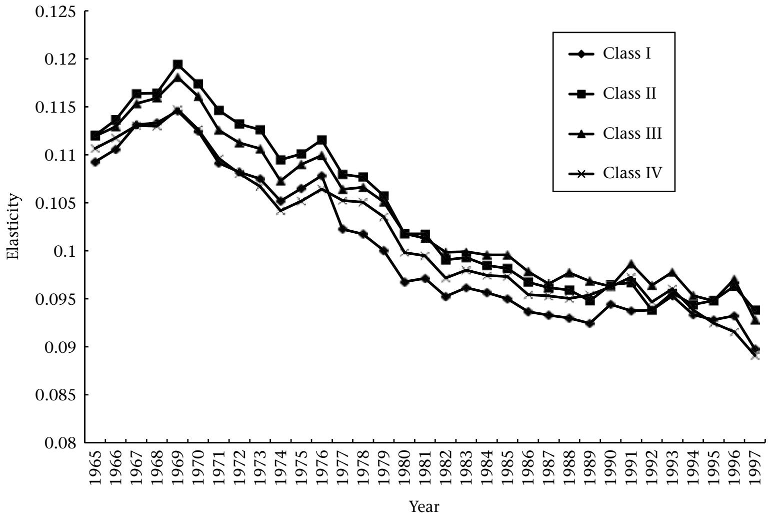

Figure 4.14 Impacts of changes in the price of intermediate input on returns to scale for 1965–97: all size classes

Note: The impacts were estimated using equation (4.4).

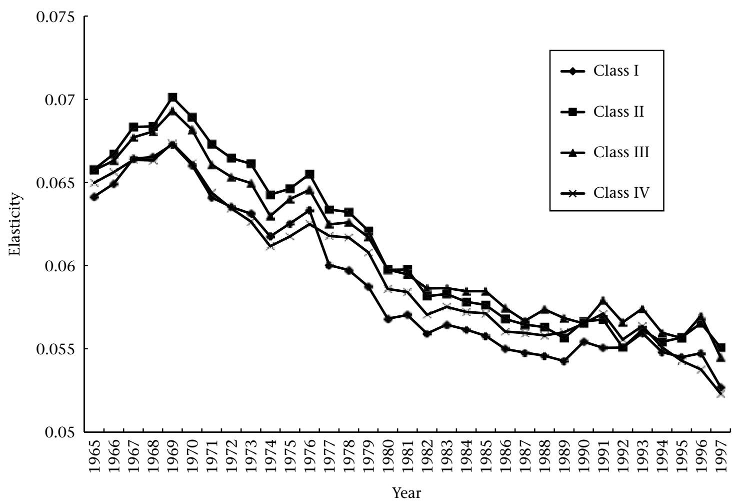

Figure 4.15 Impacts of changes in the price of other input on returns to scale for 1965–97: all size classes

Note: The impacts were estimated using equation (4.4).

not appear to be very different between different size classes. This may indicate that the differentials in the degrees of scale economies between small- and large-scale farms will not shrink that much. This will give little impact on the possibilities of transferring farmlands from small- to large-scale farms. Needless to say, analogous interpretations may be applicable to the cases of increases in the prices of intermediate and other inputs ($w_I{}'$ and $w_O{}'$).

Conversely, input subsidies are in general equivalent to lowering the prices of factor inputs ($w_k{}'$, $k = M,I,O$). This indicates that the converse logic may be applicable if factor prices are reduced thanks to subsidies. In other words, input subsidy programs may not always have enlarged the degrees of RTS between small- and large-scale farms. That is, input subsidy programs may have been rather neutral for farmland transfers with regard to degrees of RTS.

4.3.2.6 Impacts on the Shadow Value of Land

The impacts of changes in the prices of the variable factor inputs ($w_k^{'}, k = M,I,O$) on the shadow value of paddy land ($w_B^{S'}$) were estimated using equation (4.6) for all observations of all four size classes for the entire study period 1965–97 and are presented in Figures 4.16, 4.17, and 4.18. Several findings are worth interpreting based on these figures.

First, the impacts of changes in the price of machinery input ($w_M{}'$) on the shadow value of land ($w_B^{S'}$) in size class I were all negative for the entire study period 1965–97. However, the impacts in size classes II, III, and IV show different pictures from those in size class I. The impacts in these three size classes were negative for the earlier periods, but became positive for the latter periods: the impacts in size class II were negative for the period 1965–85; the impacts in size class III were negative for the period 1965–78; and the impacts in size class IV were negative for the period 1965–72. However, after those periods toward 1997, the impacts turned out to be positive in all three size classes. The following interpretations may be made on such observations.

That is, for size class I, increases in the price of machinery decreased the demand for and usage of machinery input, which may have lowered the marginal productivity (shadow value) of land. Naturally, similar phenomena must have occurred for the respective periods observed above for the other three size classes, II, III, and IV. However, how can we interpret the observations of the positive impacts?

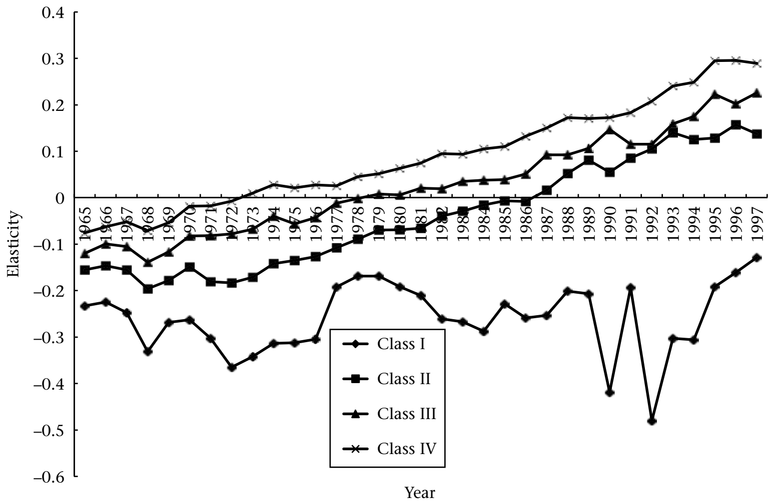

Figure 4.16 Impacts of changes in the price of machinery on the shadow values of lands for 1965–97: all size classes

Note: The impacts were estimated using equation (4.6).

We will interpret such observations as follows. Increases in the price of machinery must have reduced the demand for machinery input. However, we may infer that farms may have utilized the stock of machinery input at hand more intensively and efficiently, which may have resulted in raising the marginal productivity of land.

Furthermore, it is clear from Figure 4.16 that the larger the size class, the smaller the impact in absolute terms. We may infer from this observation that decreases in the price of machinery due to subsidies may have raised the shadow value of land of size class I with a greater degree than that of size class IV, as clearly captured in Figure 4.16. This may have restricted transfers of land from small- to large-scale farms.

Second, according to Figure 4.17, the impacts of changes in the price of intermediate input ($w_I{}'$) on the shadow value of land ($w_B^{S'}$) were all positive in all four size classes for the entire study period 1965–97. In this case, however, the impacts had as a whole slight increasing trends for the entire study period, though with some ups and downs. The logic behind this may be interpreted as follows. A rise in the price of intermediate input will reduce the demand for

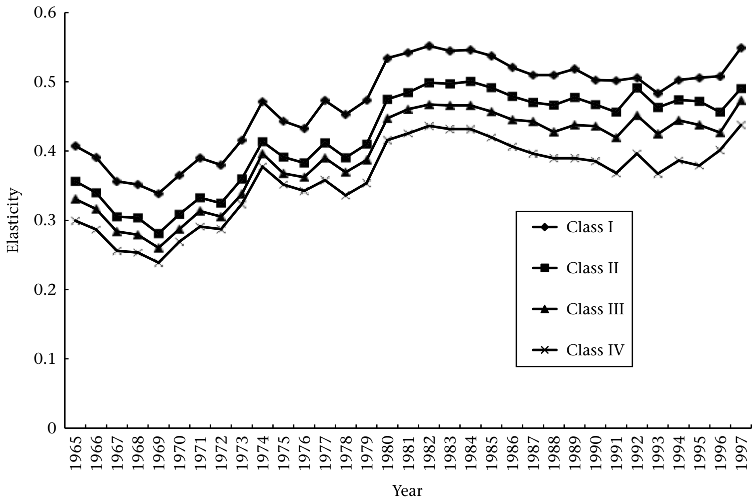

Figure 4.17 Impacts of changes in the price of intermediate input on the shadow values of lands for 1965–97: all size classes

Note: The impacts were estimated using equation (4.6).

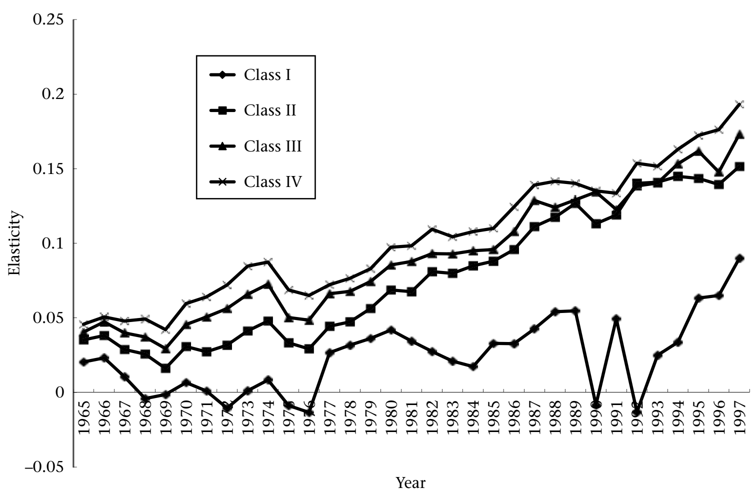

Figure 4.18 Impacts of changes in the price of other input on the shadow values of lands for 1965–97: all size classes

Note: The impacts were estimated using equation (4.6).

intermediate input. This will cause decreases in the amount of output, either crops or livestock or both, and hence decreases in the shadow value of land. However, Figure 4.17 shows the opposite results. We may then infer that decreases in the demand for and thus less utilization of intermediate input may have induced farms to employ both land and intermediate input in more intensive ways, so that the marginal productivity of land increased for all size classes. In addition, it is clear that the smaller the size class, the larger the impact for the entire study period 1965–97.

Now, subsidies for intermediate input under such conditions may have resulted in greater decreases in the shadow values of land in small- than large-scale farms, which may have resulted in greater gaps in the shadow values of lands between large- and small-scale farms. This may have encouraged transfers of land from small- to large-scale farms.

Third, as in the case of the impacts with respect to machinery input, the impacts of changes in the price of other input ($w_O{}'$) on the shadow value of land ($w_B^{S'}$) presented in Figure 4.18 were all positive for all four size classes, including the smallest size class, I, and had increasing trends in absolute terms for the entire study period 1965–97, though with negative impacts in several years in size class I. How can we interpret this rather peculiar finding?

Theoretically, increases in the price of other input will reduce the demand for other input composed of farm buildings and structures, large animals, and large plants. This will decrease the levels of outputs of either crops or livestock or both, which will cause reductions in the shadow value of land for either crops or livestock or both.

However, the finding in Figure 4.18 is totally opposite to our theoretical interpretation. We will then rather forcibly interpret this finding as follows. That is, increases in the price of other input may have forced farms to utilize the stock of other input as well as farmland in more intensive ways. As a result, the shadow values of lands increased in all four size classes.

Furthermore, we clearly find in Figure 4.18 that the larger the size class, the larger the impact of increases in the price of other input for the entire study period 1965–97.

This indicates that decreases in the price of other input due to subsidies may have increased the demands for other input in all size classes. This may have caused decreases in the shadow values of lands in all size classes. However, in this case, the degrees of reduction in the values of shadow prices may have been greater in large- than small-scale farms, which may have played an important role in restricting transfers of lands from small- to large-scale farms.

4.4 Summary and Concluding Remarks

This chapter offers further results based on the estimates of the multiple-product VP function with labor and land being the quasi-fixed factor inputs for the period 1965–97 presented in Chapter 1. In particular, this chapter has focused on evaluating the impacts of input subsidies on (i) the supplies of outputs (crops and livestock), (ii) the demands for the variable factor inputs such as machinery, intermediate, and other inputs, (iii) the degrees of RTS, (iv) the maximized profits, and (v) the shadow value of land.

We have investigated quantitatively the impacts of input subsidizing programs on these five economic indicators. We then found in almost all examinations, except for the cases of the demand for intermediate input with respect to the price of intermediate input, the demands for variable factor inputs such as machinery, intermediate, and other inputs, the RTS, and the shadow value of land with respect to intermediate input, that governmental subsidies yielded most advantageous effects to small-scale farms rather than to large-scale farms. Based on these empirical findings, we may conjecture that input subsidy programs may have more strongly raised incentives for small-scale farms to stick to agricultural production on their own farmlands. This in turn may have restricted transfers of farmlands from small- to large-scale farms during the last three to four decades of the 20th century, 1965–97 in Japanese agriculture.

We may conclude based on these findings that, in order to drastically change the existing structure of small-scale inefficient farming to that of much larger-scale efficient farming both for crops and livestock, the government has to reconsider the applications of various subsidies associated with factor inputs so as to give stronger incentives to larger-scale farms for more productive and efficient agricultural production of both crops and livestock.

5
Summary and Conclusion

At the outset, we would like the reader to recognize here that we are not going to expose the detailed summary of each chapter. The details of methodologies, evaluations of estimated results, summaries, and conclusions are fully explained in each chapter. Instead, we are going to offer in this chapter the whole picture of both volumes of the book, the merits and the demerits, and the qualifications.

To begin with, the major objective of this book has been to offer quantitative investigations of the production structure and productivity of postwar Japanese agriculture for the period 1957–97 which are as *comprehensive*, *consistent*, and *integrated* as possible. Furthermore, another important objective is to assess, based on the estimated economic indicators, the impacts of government policies such as output price-supports, set-asides, factor input subsidies, and R&E activities on various critical economic indicators in order to evaluate the possibilities of land transfers from small- to large-scale farms, so that small-scale, inefficient, and low productive farming may be transformed into much more efficient and highly productive farming on much larger-scale farms.

For this objective, we have introduced new methods such as duality theory, flexible functional forms, and index number theory, developed since the late-1960s.

In particular, in Part I in Volume 1, we employed the *multiple*-product translog TC function, except for Chapter 7, in which crops and livestock are categorized as two outputs and labor, machinery, intermediate input, land, and other input are distinguished as the five variable factor inputs. Furthermore, we found that it is more appropriate to apply the Stevenson–Greene type specification of the multiple-product translog TC function in which each coefficient is assumed to be variable with respect to a time index.

Conversely, we developed a new device in Chapter 7 which is a little more sophisticated: a new growth accounting model departing from the Solow conventional growth accounting model based on the so-called 'residual' technological change method. For this chapter, however, a *single*-product Stevenson–Greene type translog TC function was employed due to the definition of labor productivity.

In reality, however, land price (rent) has been regulated or quasi-regulated by the government, in spite of a few reforms of the Agricultural Land Law during the study period. This may imply that the land market has not been perfectly competitive, so that farms may not use their lands up to the optimal points. Accordingly, in Part II in Volume 1, we modified the specification of the translog cost function. Instead of the TC function, which may be regarded as a *long-run* equilibrium model, we introduced in Part II the ordinary translog VC function with land being a *quasi-fixed* input. Since this model may be regarded as a *short-run* model, we did not employ the Stevenson–Greene type translog TC function, which may be considered to be more appropriate for long-run models. Needless to say, we stuck to the multiple-product ordinary translog VC function for the three chapters in Part II, Chapters 8, 9, and 10.

An application of the translog VC function makes it possible to estimate the shadow value of land, which can be visually compared to the market price of land. By doing this, one can roughly check the optimality of land utilization. Such an informal test was executed and we found that the optimal levels of land utilization were not attained in all four size classes during the study period. This implies that the estimated economic indicators such as elasticities of factor demands and substitutions, rates and biases of technological change, RTS, and so on based on the translog VC function may be more reliable and robust than those based on the translog TC function. Unfortunately, however, we could not obtain important information related to land as a quasi-fixed input as mentioned above, though it is nevertheless intriguing and important to be able to estimate the shadow value of land, unlike in the case of the translog TC function model.

The major objectives in Parts I and II are to obtain more *comprehensive*, *consistent*, and *integrated* understandings of the production structure and productivity of postwar Japanese agriculture based on the estimated results of the multiple-product translog TC and VC functions (except for Chapter 7). We did not mention much about the effects of government agricultural policies.

Conversely, in Part I in Volume 2, we concentrated on assessments on the effects of government agricultural policy measures on various economic indicators intimately related to the ultimate goal of more efficient and productive farming of both crops and livestock on much greater scales.

In Part I in Volume 2, we introduced the multiple-product ordinary translog VP function with labor and land as quasi-fixed inputs, and estimated the model for the period 1965–97. The most important reason for introducing the profit function model in Part I in Volume 2 is that the output prices are entered explicitly in the profit function, so that we are able to assess the impacts of output price-support programs on various economic indicators. In addition, we chose the period 1965–97 instead of the period 1957–97 because when it comes to evaluating the impact of the set-aside programs on various indicators, we may obtain more reliable results of the estimated impacts of the set-asides if we use a data set starting from closer to year 1969, which is when the first set-aside program was introduced in Japanese agricultural history.

We evaluated four government agricultural policy measures. They are (i) output price-supports, (ii) set-asides, (iii) factor input subsidies, and (iv) R&E programs. The economic indicators on which the impacts of these policy instruments were evaluated are (1) the supplies of crops and livestock, (2) the demands for variable factor inputs, (3) the maximized profits, (4) the degrees of RTS, and (5) the shadow values of farmlands. Needless to say, the evaluations were carried out from the point of view of structural transformation from small-scale inefficient and low productive farming to large-scale efficient and high productive farming.

A most important conclusion of this book may be that all public agricultural policies mentioned above have in fact restricted the possibilities of land transfers from small- to large-scale farms, though with a few qualifications. This in turn may have limited the possibilities of transforming the small-scale inefficient and low productive farming to more efficient and productive farming not only of crops but also of livestock.

As an important lesson from the sort of empirical research carried out in this book, the MAFF should be more serious about constructing more competitive agriculture in Japan. For this, not only the MAFF but also the agricultural cooperatives may have to change their philosophy from 'protecting low productive and inefficient farms' to 'fostering competitive, highly productive and efficient farms' as soon as possible.

An important implication of the quantitative investigation carried out in this book for agriculture, especially in Asian countries such as Korea, Taiwan, China, Vietnam, Malaysia, Thailand, Bangladesh, Pakistan, Indonesia, the Philippines, and so forth, may be that agricultural policies should be carefully organized in order to promote competitive agriculture as much and as early as possible to foster efficient and productive farms. Of course, this notion of promoting efficient and productive agriculture may be applicable to countries all over the world, in particular in African countries.

Finally, it may at this point be worth mentioning several qualifications of this book.

To begin with, as already mentioned in the introduction (in Volume 1), the period 1957–97 should be extended by some reliable statistical method in order to increase the degrees of freedom for the estimation of the systems of the TC, VC, and VP functions. Otherwise, it may be recommended that the same analyses as executed in this book should be carried out for the period, say, 1991–2010, since the compilation methods of accounting the depreciations of capital assets such as farm buildings and structures, machinery, large animals, large plants, and so on were drastically changed from 1991. Because of these changes in data compilations, the data continuity has been destroyed.

In reality, however, the movements of the price-supports, the set-asides, the factor input subsidies, and the R&E programs during the late 1990s through to the first decades of the 21st century remained fairly similar, or sometimes turned out to even be worse, to those during the 1980s and 1990s. Furthermore, the quality of labor may have worsened due to the aging of farmers; more than 60 per cent of farms have been managed by farmers older than 65 years old during the 21st century. Considering these facts, the author may conjecture with a fairly strong confidence that the empirical investigations obtained in this book may still have been effective until now.

Second, the Tofuken agricultural district is not always the 'whole Japanese agriculture', since it does not include the Hokkaido district because of the different size classifications from those for the Tofuken district; classified sizes are much larger than those in the Tofuken district, meaning that we could not construct the pooled cross section of time series data combining the Tofuken and Hokkaido districts. As for Okinawa, we could not obtain the necessary data for the periods used in this book and hence we had to omit the Okinawa district. Conversely, as already noted in the introduction, the same analytical procedures could be applied to the database of Hokkaido and be compared to those obtained for Tofuken, which will be an intriguing and challenging research topic.

Third, the methodologies of all three parts of this book are based only on the translog forms for all TC, VC, and VP functions. In fact, we could have employed a quadratic, generalized Cobb–Douglas, generalized Leontief, and so forth, all of which are in general a little more tedious to handle than the translog functional form. Though it was a little more complicated to estimate the system, we estimated various economic indicators based on the parameter estimates of the quadratic function model and found that many of them basically supported a large portion of the estimated results obtained in this book, though the magnitudes were sometimes very different from each other; for example, the rates and the degrees of biases of technological change. In this sense, it is worth estimating other functional forms in order to confirm the results we have obtained.

Fourth, quality adjustments for factor inputs, except for labor, are basically not carried out due to lack of information. As for labor, however, it was possible to aggregate male and female labor into male-equivalent labor hours using the male and female wage rates per day for temporary-hired labor. However, it was impossible to take into account the quality differences resulting from age or experience.

Finally, in reality, totally similar analyses are possible for Tohoku, Hokuriku, Kanto, Tokai, Kinki, and Kita-kyushu for which the necessary data are available for the period 1957–97. We estimated the same models used in this book for these agricultural districts. In general, the results of these districts are similar to those obtained for Tofuken. But, a careful observation of the results will offer differences in various estimates among different districts, though not substantial.

Notes

1 Impacts of Output Price-Support Programs on Postwar Japanese Agriculture 1965–97: A Variable Profit Function Approach

1. We chose the period 1965–97 for this and the following chapters of Part I in Volume 2, since the important policy measures such as price-supports and the set-asides, as well as factor subsidies and public R&E programs, were rather intensively introduced during the 1960s.
2. Of course, it is not only academically intriguing but also important on the side of agricultural policy makers to investigate also the effects of the other important agricultural policies such as input subsidies, set-asides, and R&E programs on these economic indicators. However, the space is limited to discuss all these in one chapter. Individual chapters on the impacts of these important agricultural policies will therefore follow immediately after this chapter.
3. Recall that we found in Part I that the Stevenson (1980)–Greene (1983) (S–G) type translog TC function behaves better than the ordinary translog TC function. However, in the case of the VP function to be specified later, the ordinary translog VP function behaves much better than the S–G type VP function. We may conjecture that the assumption in the S–G model that the coefficients of the VP function change with time may not be appropriate, since the VP function is specified basically for the short-run behavior of the firm.
4. The terms of the 'shadow price', 'shadow value', and 'marginal productivity' of land (or farmland) are used interchangeably in this chapter.
5. A similar investigation has already been done in Part II based on the estimate of the shadow value of farmland which was computed using the parameters of the multiple-product ordinary translog VC function for the period 1957–97.
6. For empirical evidence of the existence of economies of scale in postwar Japanese rice production, for example, see Kako (1983, 1984) and Chino (1984). Many other studies have documented the empirical findings of scale economies in postwar Japanese agriculture.
7. For details on land prices and technological change, see Herdt and Cochrane (1966) and Van Dijk, Smit, and Veerman (1986).
8. Since more than 97 per cent of farm labor in postwar Japanese agriculture comes from family labor, 'family labor' and 'labor' are used as almost equivalent in the present chapter.
9. Details of the variable definitions are presented in Appendix.

10. We specified the *VP′* function (1.1) by adding a time trend t in order to capture the effects of autonomous technological change which occurs independently from public R&E activities such as a new method of marketing agricultural products, an introduction of information technology in farm management, and so on. However, the estimation was not statistically satisfactory because of the multicolinearity between the time trend variable t and the stock of technological knowledge Z_R. In addition, all of the coefficients of the dummy variables (D_P, D_S, $s = II, III, IV$, and D_W) were not statistically significant at any conventional levels. We therefore omitted the time variable (t) and all dummy variables (**D**) in the estimation of the multiple-product ordinary translog VP function (1.3) given below.
11. Instead of introducing this kind of device, the labor cost-profit share equation should ideally be treated as an endogenous equation in the system. However, if we do so, we face a serious problem that many samples, in particular of smaller size classes, have negative profits if labor costs together with the other variable factor costs are subtracted from total revenue. Since the present chapter employs the ordinary translog specification, we have to give up too many observations especially from smaller size classes in the econometric estimation of the system. Of course, we could try to apply a quadratic profit function model under such a situation.
12. As shown clearly in Appendix, we can fortunately obtain the wage rate per male-equivalent hour for all observations for all size classes. Generally speaking, family labor and temporary-hired labor engage in similar work. This may allow us to assume that the shadow price of family labor may be imputed by the wage rate of temporary-hired labor.
13. Refer to Lau (1972, 1976) for the case of joint profit functions and Hall (1973), Denny and Pinto (1978), and Brown, Caves, and Christensen (1979) for the case of joint cost functions.
14. However, one has to be very careful to apply Sidhu and Baanante (1981) formulas because of some minor errors.
15. For a detailed discussion of *almost* homogeneous functions in the economic context, refer to Lau (1978).
16. Note that $\kappa > 0$ for a production function.
17. As mentioned earlier, the time index t as a proxy for technological innovations which are not captured by the stock of technological knowledge (Z_R) is going to be omitted together with the dummy variables **D** from the statistical estimation due to the statistically insignificant nature.
18. Indeed, we did estimate the shadow value of labor for all observations in all size classes for the study period 1965–97. The results were that the estimated shadow value of labor and actual wage rate of temporary-hired labor were fairly close to each other in all four size classes for the entire study period 1965–97, which may be a natural consequence from the assumption with regard to labor input introduced in this chapter.

19. In fact, Iterated Seemingly Unrelated Regressor (ISUR) was also tried for the estimation of the system. But, the estimated results were almost the same as those when the FIML was employed.
20. As exposed in Appendix in detail, some modifications for variable definitions were carried out in order to take care of the discontinuity of data for the period 1991–97, in particular, the depreciations of capital stock such as machinery, large animals and plants, and farm buildings and structures. Due probably to these modifications of the data set, the estimated parameters have somehow changed from those of the previous similar study (Kuroda and Abdullah, 2003). In particular, all of the coefficients of the dummy variables of this chapter were not statistically significant, and hence they were omitted from the final estimation.
21. Refer to Lau (1976) and Hazilla and Kopp (1986) for details on the curvature conditions.
22. Refer to Lau (1972, 1978) for the case of joint profit functions and Hall (1973), Denny and Pinto (1978), and Brown, Caves, and Christensen (1979) for the case of joint cost functions. In addition, Antle and Capalbo (1988) offers very clear and useful expositions for testing various important hypotheses on production technology based on both *primal* and *dual* and single- and multiple-output production, cost, profit, and revenue functions.
23. Kako (1983, Table 1.5, p. 10; for 1969 and 1979) and Chino (1984, Table 3-9, p. 26; for 1977–9) obtained similar results as our case by estimating the translog TC functions using cross section data and a pooled cross section of time series data for rice production, respectively. However, they do not give any explanations on why smaller-scale farms enjoyed higher scale economies than did larger-scale farms.
24. In fact, we can obtain the actual land rent for each size class from the FHE for the study period 1965–97 and there are some differences in the estimated land rents among the four different size classes. However, the differences are very minor and the movements and levels of estimated actual rents are very close to that of the actual land rent of the average farm of Tofuken. Thus, we chose the latter as a representative and present it in Figure 1.4.
25. It has been popular among agricultural economists in Japan to define so-called 'farm income' as

$$FI = \sum_i P_i{}'Q_i - (w_M{}'X_M + w_I{}'X_I + w_O{}'X_O).$$

It may be very clear that the sum of the last two terms in the parentheses of the above equation (1.37), that is, $w_L{}'X_L^H + w_B{}'Z_B^R$, cannot be ignored as the amounts of hired labor and rented land become larger.
26. The term 'rent-bearing capacity' has often been used by Kajii (1981), Shintani (1983), Kako (1984), Chino (1990), and Kondo (1998) to name only a few.

27. We also obtained the stock-of-technological-knowledge variables that are weighted sums of deflated past research and extension expenditures, G_{t-i} and H_{t-i}, respectively, given by

$$R_t = \sum_{i=1}^{m} w_{t-i} G_{t-i}$$

and

$$E_t = \sum_{j=1}^{n} w_{t-j} H_{t-j}$$

where weights are normalized to sum to one as, for example, for $m = 7$, $w_{t-1} = w_{t-7} = 0.05$, $w_{t-2} = w_{t-6} = 0.1$, $w_{t-3} = w_{t-5} = 0.2$, and $w_{t-4} = 0.3$. For a sensitivity analysis, we assumed again five, six, seven, eight, nine, ten and eleven years for research lag years and three, four and five years for extension lag years as in the case of the benchmark year method. Thus, we tried $6 \times 3 = 18$ different combinations of the stocks of technological knowledge for the sensitivity analysis of the estimation of the system of the variable translog cost function and the factor share and revenue share equations. However, the concavity condition with respect to the stock of technological knowledge was not satisfied for any of them.

2 The Set-Aside Programs and Land Movements: A VP Function Approach

1. The terms 'shadow price', 'shadow value', and 'the marginal productivity' of land are used interchangeably in this chapter as in other chapters.

3 Impacts of R&E Programs on Structural Change

1. The details of the sources of data for public R&E expenditures and the procedure to obtain the R&E capital stock (or the stock of technological knowledge) are presented in Appendix 1.1. Incidentally, we use the terms 'the R&E capital stock' and 'the stock of technological knowledge' interchangeably in this chapter.
2. Conversely, Kuroda (2010a), based on the parameter estimates of the VC function, obtained very steady movements of the impacts in the smaller three size classes, I, II, and III, over the entire study period 1965–97. However, only the largest size class had an increasing trend in the impact from the early-1980s through to the late-1990s. We may conjecture that this finding may have reflected a rapid introduction of medium- and larger-scale machinery by large-scale farms.
3. This was defined as Norm II for land transfer from small to large farms in Section 1.4.3.4 of Chapter 1.

4 The Impacts of Input Subsidies on Structural Change

1. The sources of data are the *Hojokin Soran* [the *Conspectus of Subsidies*] published annually by Nihon Densan Kikaku Inc. and the 'Finance for Agriculture, Forestry, and Fisheries' reported in the *Norin Suisan-sho Tokei-hyo* [the *Statistical Yearbook of the Ministry of Agriculture, Forestry, and Fisheries*] published annually by the MAFF. Furthermore, detailed descriptions with statistical data and figures on agricultural budgets are presented in Ishihara (1997).
2. As a matter of fact, the same notion may be applicable on an international basis.
3. The section which explains the data and estimation procedure and an appendix which presents the definitions of the variables used for the VP function model are the same as those in Chapter 1. Thus, they were omitted in this chapter.
4. Indeed, it is far more complicated and awfully time-consuming to compile the necessary price data for the three variable factor inputs defined in the present study ($w_k^{\prime}$, $k = M, I, O$) than in the case of compiling data for output price-supports for outputs.
5. Recall that the test result of the hypothesis of the convexity conditions with respect to the variable factor inputs (X_k, $k = M, I, O$) were satisfactory (refer to Section 1.4.1 of Chapter 1).

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