CHAPTER V
OUTPUT SUPPLY AND VARIABLE INPUT DEMAND

This chapter attempts to analyze the input utilization behavior of rice farmers using the concept of price elasticities of demand and output supply. The analysis is focused on the responses of the small and large farmers in variable input demand and rice supply to change in prices, and economic efficiency. To arrive such analysis, first, the translog profit and input share equations for the small and large farms are estimated simultaneously using Zellner's Seemingly Unrelated Regression Estimator (SURE). Second, based on estimated parameters from the profit and input share equations, elasticities of input demand and output supply, and elasticities of substitution between inputs are derived.

5.1 Model Specification

The normalized restricted translog profit function for each group of farms can be expressed specifically in actual variables as:

$$
\begin{aligned}
(27)\quad Ln\Pi^{*} = {} & \alpha_0 + \lambda_1 D_1 + \lambda_2 D_2 + \lambda_3 D_3 + \alpha_W LnC_W + \alpha_F LnC_F + \alpha_P LnC_P \\
& + \tfrac{1}{2}\gamma_{WW}(LnC_W)^2 + \tfrac{1}{2}\gamma_{FF}(LnC_F)^2 + \tfrac{1}{2}\gamma_{PP}(LnC_P)^2 \\
& + \gamma_{WF} LnC_W . LnC_F + \gamma_{WP} LnC_W . LnC_P + \gamma_{FP} LnC_F . LnC_P \\
& + \beta_L LnZ_L + \beta_E LnZ_E + \delta_{WL} LnC_W . LnZ_L + \delta_{WE} LnC_W . LnZ_E \\
& + \delta_{FL} LnC_F . LnZ_L + \delta_{FE} LnC_F . LnZ_E + \delta_{PL} LnC_P . LnZ_L \\
& + \delta_{PE} LnC_P . LnZ_E + \tfrac{1}{2}\psi_{LL}(LnZ_L)^2 + \tfrac{1}{2}\psi_{EE}(LnZ_E)^2 \\
& + \psi_{LE} LnZ_L . LnZ_E
\end{aligned}
$$

Where:

Π^*: restricted profit defined as total revenue less total cost of labor, chemical fertilizer, pesticide, irrigation fee, land preparation cost, and harvesting cost normalized by output price P_y.

C_W : money wage rate per day normalized by output price P_y. It is expected to have negative effects on profit, demand for inputs and output supply.

C_F : money price of fertilizer nutrient per kilogram normalized by output price P_y. It is expected to have negative effects on profit, demand for inputs and output supply.

C_P : money price of pesticide per kilogram of active ingredient normalized by output price P_y. It is expected to have negative effects on profit, demand for inputs and output supply.

Z_L : land input measured in acres of rice grown. It is expected to have positive effects on profit, demand for inputs and output supply.

Z_E : the average number of years of schooling per family laborers (over fifteen years of age). It is expected to have positive effects on profit, demand for input and output supply.

D_1 : dummy variable taking the value of 1 for farms with land preparation by bullock, and 0 otherwise.

D_2 : dummy variable taking the value of 1 for farms with land preparation by tractor, and 0 otherwise.

D_3 : dummy variable taking the value of 1 for farms with land preparation by both bullock and tractor, and 0 otherwise.

(The fourth method of land preparation is non tillage technique)

The extended model of the profit function used to examine economic efficiency between farm sizes has the same variables as in (27) but it contents a dummy variable represented for farm size. This extented model is also be estimated jointly with the input share equations.

Differentiating the normalized restricted translog profit function one can obtain the following input share equations (S_i) of labor, fertilizer, and pesticide:

Labor Share Equation

(28) $S_L = \alpha_W + \gamma_{WW}LnC_W + \gamma_{WF}LnC_F + \gamma_{WP}LnC_P + \delta_{WL}LnZ_L + \delta_{WE}LnZ_E$

Fertilizer Share Equation

$$(29)\quad S_F = \alpha_F + \gamma_{FW}\mathrm{Ln}C_W + \gamma_{FF}\mathrm{Ln}C_F + \gamma_{FP}\mathrm{Ln}C_P + \delta_{FL}\mathrm{Ln}Z_L + \delta_{FE}\mathrm{Ln}Z_E$$

Pesticide Share Equation

$$(30)\quad S_P = \alpha_P + \gamma_{PW}\mathrm{Ln}C_W + \gamma_{PF}\mathrm{Ln}C_F + \gamma_{PP}\mathrm{Ln}C_P + \delta_{PL}\mathrm{Ln}Z_L + \delta_{PE}\mathrm{Ln}Z_E$$

Where $S_L = -\dfrac{C_W.X_W}{\Pi^*}$ $\quad S_F = -\dfrac{C_F.X_F}{\Pi^*}$ $\quad S_P = -\dfrac{C_P.X_P}{\Pi^*}$

X_W, X_F, and X_P are the quantities of variable inputs of labor, fertilizer, and pesticide, respectively.

This set of equations (27), (28), (29), (30) will be jointly estimated by SURE. Estimation is done separately for the small and large farms in order to examine the elasticities of input substitutions, and responses of farmers in variable inputs demand and rice supply to price changes. By doing this, it is hoped that specific information of each group of farmers and relevant policy recommendations could be obtained.

However, before running 2 separate systems of equations an extended model which pools all data and includes a dummy variable represented for farm size will be run to compare the relative economic efficiency of small and large farms.

5.2 Checking Contemporaneous Correlation of Disturbances across Equations.

It is known that the gain in efficiency yield by SURE over OLS increase directly with the correlation between disturbances of different equations. If contemporaneous correlation does not exist, least squares applied separately to each equation is fully efficient and there is no need to employ the Seemingly Unrelated Regression Estimator (Johnson, 1991). A simple way is to check for the contemporaneous correlation of disturbance correlation matrix. In this study the correlation among disturbances across the profit function and the three input share equations are quite high since most of the coefficients are greater than 0.60 (Tables 34 and 35). Therefore, using SURE to estimate parameters in the system of equations is necessary.

Table 34. Disturbance Correlation Matrix across Equations in Small Farms

	Profit eq.	Lab. Share eq.	Fert. Share eq.	Pest. Share eq.
Profit eq.	0.4976			
Labor Share eq.	0.8609	0.8595		
Fert. Share eq.	0.7580	0.8684	0.6459	
Pest. Share eq.	0.7769	0.7416	0.7846	0.6043

Source: Computed

Table 35. Disturbance Correlation Matrix across Equations in Large Farms

	Profit eq.	Lab. Share eq.	Fert. Share eq.	Pest. Share eq.
Profit eq.	0.5491			
Labor Share eq.	0.8196	0.9302		
Fert. Share eq.	0.8746	0.9621	0.4512	
Pest. Share eq.	0.7428	0.9116	0.9282	0.5946

Source: Computed

The simple correlation coefficients between explanatory variables in the system of equations for each group of farms presented in the appendix tables A1 and A2 are low in absolute value. This indicates that multicollinearity is not a severe problem for regression estimation.

5.3 Joint Estimation of the Restricted Translog Profit Function and Variable Input Demand Equations

Using the extended model, the test of equal relative economic efficiency between small and large farms Was conducted. The null hypothesis is that the parameter of the size dummy variable in the extended model is equal zero. This means that the system of equations is run with only one restriction imposed on the size dummy variable. LR ratio test and Wald test are employed for the purpose. The computed χ^2 values of the Wald test and LR ratio equal 0.998 and 0.994, respectively. Both of these values are smaller than the critical χ^2 values at 1 per cent level of significant. Since the null hypothesis could not be rejected, it is concluded that there is equal relative economic efficiency between small and large farms.

From (27) (28) (29) (30), parameters of normalized restricted translog profit functions and input share equations for labor, fertilizer and pesticide for the small and large farms are estimated and presented in Tables 36 and 37, respectively.

Before discussing the estimated parameters, two formal statistical tests should be presented. The first is for testing the validity of the symmetry and parametric constraints imposed in the system. The null hypothesis is that parameters of the S_1 equations (28) (29) (30) are equal to the corresponding parameters in the profit function (27) and that $\gamma_{WF} = \gamma_{FW}$, $\gamma_{WP} = \gamma_{PW}$, and $\gamma_{PF} = \gamma_{FP}$. This is a joint hypothesis on the validity of imposing 18 restrictions on the system of equations (27) (28) (29) (30). The Wald test and Likelihood ratio (LR) test statistics at the end of the tables 36 and 37 show the validity of the symmetry and parametric constraints across profit and the S_1 equations. The computed χ^2(18 D.F.) of the Wald and the LR tests for the small farms are 27.03 and 25.43 respectively, and for the large farms are 34.5 and 25.96 respectively. The critical χ^2(18 D.F.) at 0.01 level of significance equals 34.8. Thus the null hypothesis can not be rejected. Result of this test implies that both the small and large farmers, on the average maximize profits with respect to normalized prices of the variable inputs. In other words, though the small and large farmers face different input and output prices and have different levels of fixed resources, they both equate the marginal product values of variable inputs to their specific market prices.

The second statistical test is was conducted to test for the Cobb-Douglas hypothesis. It is known that the translog profit function will reduce to the Cobb-Douglas profit function if coefficients of all second-order terms (cross product) in (27) equal zero. To test fôr this null hypothesis, 30 restrictions were imposed in the system of equations. The Wald test was employed to test the null hypothesis that all γ_{ih} and δ_{ik} equal zero. The computed χ^2(30 D.F.) for the small and large farms are 51.27 and 55.13, respectively, and the critical χ^2(30 D.F.) at 0.01 level of significance equals 50.91. Thus the null hypothesis is rejected. This implies that the Cobb-Douglas functional form is not appropriate for the given data of rice production in this study. In addition, at the explanatory state of the study, the Cobb-Douglas profit function was also applied to the data to examine its fitness to the data. The χ^2 (1 D.F.) from the hypothesis test of constant return to scale is 131.1, and the χ^2 (1 D.F.) at 0.01 level of significance equals 6.63. Thus, the hypothesis of constant return to scale is rejected. The Cobb-Douglas profit function is not employed for empirical analysis in this study since it is not helpful in investigating substitution between inputs.

The results of estimation show that 17 and 12 of the total 42 coefficients in each set of equations are statistically significant at 1 percent level or higher. The intercept of the set of equations for the small and large farms are both indifferent from zero at 1 percent level. The dummy variables representing different types of land preparation in the small farms are not statistically significant. This means that land preparation by bullock, tractor, or combination of both do not improve profit for the small farmers. On the other hand, the dummy variables represented for land preparation by bullock and by tractor in the large farms are significantly different from zero at 5 per cent level. This may be because small farmers employed a lot of human labor in place of tractor or bullock power for land preparation.

Table 36. Seemingly Unrelated Estimates of System of the Normalized Translog Profit Function and Variable Input Share Equation for Small Farms

Variables	Parameters	Estimated Coefficient	Standard Error	t-Ratio
Profit Function				
Intercept	α_o	2.6200	2.1380	1.226
D_1	λ_1	-0.0374	0.0699	-0.535
D_2	λ_2	0.0321	0.0707	0.454
D_3	λ_3	-0.0607	0.1038	-0.584
LnC_W	α_W	1.0685	0.6847	1.560
LnC_F	α_F	1.4209	0.5493	2.587***
LnC_P	α_P	0.9544	0.3744	2.549***
$\frac{1}{2}(LnC_W)^2$	γ_{WW}	-0.1732	0.1801	-0.962
$\frac{1}{2}(LnC_F)^2$	γ_{FF}	-0.2121	0.1840	-1.153
$\frac{1}{2}(LnC_P)^2$	γ_{PP}	-0.1004	0.0448	-2.242**
$LnC_W.LnC_F$	γ_{WF}	-0.3492	0.1424	-2.453**
$LnC_W.LnC_P$	γ_{WP}	-0.1667	0.0639	-2.609***
$LnC_F.LnC_P$	γ_{FP}	-0.1049	0.0507	-2.071**
LnZ_L	β_L	-0.8412	0.7909	-1.064
LnZ_E	β_E	0.8739	0.6373	1.371
$LnC_W.LnZ_L$	δ_{WL}	0.1420	0.1397	1.102
$LnC_W.LnZ_E$	δ_{WE}	0.0275	0.1308	0.210
$LnC_F.LnZ_L$	δ_{FL}	-0.0034	0.1086	-0.031
$LnC_F.LnZ_E$	δ_{FE}	-0.0539	0.0974	-0.553
$LnC_P.LnZ_L$	δ_{PL}	0.0212	0.0841	0.252
$LnC_P.LnZ_E$	δ_{PE}	-0.1015	0.0700	-1.449
$\frac{1}{2}(LnZ_L)^2$	ψ_{LL}	0.5187	0.3182	1.630
$\frac{1}{2}(LnZ_E)^2$	ψ_{EE}	-0.3214	0.1496	-2.149**
$LnZ_L.LnZ_E$	ψ_{LE}	-0.0242	0.1465	-0.165
Labor Share Equation				
Intercept	α_W	1.0685	0.6847	1.560
LnC_W	γ_{WW}	-0.1732	0.1801	-0.962
LnC_F	γ_{WF}	-0.3492	0.1424	-2.453**
LnC_P	γ_{WP}	-0.1667	0.0639	-2.609***
LnZ_L	δ_{WL}	-0.1420	0.1397	-1.102
LnZ_E	δ_{WE}	-0.0275	0.1308	-0.210

Table 36 (continued)

Variables	Parameters	Estimated Coefficient	Standard Error	t-Ratio
Fertilizer Share Equation				
Intercept	α_F	1.4208	0.5493	2.587***
LnC_W	γ_{FW}	-0.3492	0.1424	-2.453**
LnC_F	γ_{FF}	-0.2121	0.1840	-1.153
LnC_P	γ_{FP}	-0.1049	0.0507	-2.071**
LnZ_L	δ_{FL}	-0.0034	0.1086	-0.031
LnZ_E	δ_{FE}	-0.5386	0.0973	-0.553
Pesticide Share Equation				
Intercept	α_P	0.9544	0.3744	2.549***
LnC_W	γ_{PW}	-0.1667	0.0639	-2.609***
LnC_F	γ_{PF}	-0.1049	0.0507	-2.071***
LnC_P	γ_{PP}	-0.1004	0.0448	-2.242**
LnZ_L	δ_{PL}	0.0212	0.0841	0.252**
LnZ_E	δ_{PE}	-0.1015	0.0700	-1.449

The Wald test statistic χ^2 (18 D.F.)= 27.03

Likelihood ratio test χ^2 (18 D.F.)= 25.43

*** : Significant at 1 per cent level
** : Significant at 5 per cent level
Source: Computed

Table 37. Seemingly Unrelated Estimates of System of the Normalized Translog Profit Function and Variable Input Share Equation for Large Farms

Variables	Parameters	Estimated Coefficient	Standard Error	t-Ratio
Profit Function				
Intercept	α_o	-0.2079	5.2910	-0.039
D_1	λ_1	0.2132	0.0921	2.314**
D_2	λ_2	0.1887	0.0757	2.493**
D_3	λ_3	0.1216	0.0869	1.399
LnC_W	α_W	0.9465	1.1720	0.808
LnC_F	α_F	0.8765	0.5428	1.614*
LnC_P	α_P	0.2884	0.4753	0.607
$\frac{1}{2}(LnC_W)_2$	γ_{WW}	-0.2928	0.2046	-1.431
$\frac{1}{2}(LnC_F)_2$	γ_{FF}	-0.2502	0.0703	-3.561***
$\frac{1}{2}(LnC_P)_2$	γ_{PP}	-0.0747	0.0358	-2.085**
$LnC_W.LnC_F$	γ_{WF}	-0.2011	0.0888	-2.263**
$LnC_W.LnC_P$	γ_{WP}	-0.0829	0.0726	-1.142
$LnC_F.LnC_P$	γ_{FP}	-0.0533	0.0344	-1.549
LnZ_L	β_L	3.1964	2.024	1.579
LnZ_E	β_E	0.4157	2.098	0.198
$LnC_W.LnZ_L$	δ_{WL}	-0.0126	0.2682	-0.047
$LnC_W.LnZ_E$	δ_{WE}	-0.0149	0.2539	-0.058
$LnC_F.LnZ_L$	δ_{FL}	-0.0156	0.1307	-0.119
$LnC_F.LnZ_E$	δ_{FE}	-0.0313	0.1260	-0.248
$LnC_P.LnZ_L$	δ_{PL}	0.0390	0.1123	0.347
$LnC_P.LnZ_E$	δ_{PE}	0.0366	0.1105	0.332
$\frac{1}{2}(LnZ_L)_2$	ψ_{LL}	-1.3441	0.5987	-2.245**
$\frac{1}{2}(LnZ_E)_2$	ψ_{EE}	-0.3912	0.5620	-0.696
$LnZ_L.LnZ_E$	ψ_{LE}	0.1063	0.3994	0.266
Labor Share Equation				
Intercept	α_W	0.9465	1.172	0.808
LnC_W	γ_{WW}	-0.2928	0.2046	-1.431
LnC_F	γ_{WF}	-0.2011	0.0888	-2.263**
LnC_P	γ_{WP}	-0.0829	0.0726	-1.142
LnZ_L	δ_{WL}	-0.0126	0.2682	-0.047
LnZ_E	δ_{WE}	-0.0149	0.2593	-0.058

Table 37 (continued)

Variables	Parameters	Estimated Coefficient	Standard Error	t-Ratio
Fertilizer Share Equation				
Intercept	α_F	0.8763	0.5428	1.614*
LnC_W	γ_{FW}	-0.2011	0.0888	-2.263**
LnC_F	γ_{FF}	-0.2502	0.0703	-3.561***
LnC_P	γ_{FP}	-0.0533	0.0344	-1.549
LnZ_L	δ_{FL}	-0.0156	0.1037	-0.119
LnZ_E	δ_{FE}	-0.0313	0.1260	-0.248
Pesticide Share Equation				
Intercept	α_P	0.2884	0.4753	0.607
LnC_W	γ_{PW}	-0.0829	0.0726	-1.142
LnC_F	γ_{PF}	-0.0533	0.0344	-1.549
LnC_P	γ_{PP}	-0.0747	0.0358	-2.085
LnZ_L	δ_{PL}	0.0390	0.1123	0.347**
LnZ_E	δ_{PE}	0.0366	0.1105	0.332

The Wald test statistic χ^2 (18 D.F.)= 34.50

Likelihood ratio test χ^2 (18 D.F.)= 25.96

*** : Significant at 1 per cent level
** : Significant at 5 per cent level
* : Significant at 10 percent level
Source: Computed

All γ_{ih} coefficients have negative signs as expected while α_i coefficients are positive in sign. However, the effect of change in one variable input price to change in profit is not determined only by the parameters α_i, but also by other parameters, γ_{ii}, γ_{ih}, δ_{ij}. Provided that the sum of these parameters is negative, profit is negatively related to change in the *ith* input price.

The negative cross-price coefficients imply a complementarily in inputs, and a negative impact on profit. Two fixed input parameters, β_L and β_E are not statistically significant in either the model for the small or large farm. This indicates that at present the level of education and land size may not have positive influences in improving profit from rice production for farmers. However, firm conclusions can be drawn meaningfully from the elasticities to be computed using the estimated parameters, and input and output prices which are discussed below.

5.4 Input Demand and Output Supply Elasticities

The estimates presented in Tables 36 and 37 are utilized to derive elasticity estimates for rice supply and input demand for the variable inputs of labor, fertilizer, and pesticide with respect to their respective prices, and quantities of fixed factors of production namely, land and education. These elasticities are directly related to the ratio of variable expenditures for the *ith* input relative to restricted profit (S_i), variable input prices, level of fixed inputs, and the parameter estimates of the translog profit function through the formulas in section 2.5 and 2.6 of chapter II. The calculated results of price elasticities for variable input demand and output supply are shown in Table 38.

Table 38. Output Supply and Variable Input Demand Elasticities for WS Rice Production, Dry Season 1992.

	Rice Price	Labor Price	Fert. Price	Pest. Price	Land	Education
For Small Farms						
Output supply	0.9748	-0.4165	-0.1658	-0.1371	0.6447	0.6193
Labor demand	1.4457	-1.4527	0.0588	-0.0519	0.5075	0.5276
Fert. demand	0.9159	0.0936	-0.9580	-0.0516	0.7181	0.6881
Pest. demand	1.1486	-0.1252	-0.0783	-0.9542	0.6376	0.9151
For Large Farms						
Output supply	0.7299	-0.3342	-0.1475	-0.0928	3.3885	0.4747
Labor demand	1.2083	-1.1120	-0.0450	-0.0518	3.3444	0.4967
Fert. demand	0.8423	-0.0710	-0.7216	-0.0497	3.4342	0.5540
Pest. demand	1.0600	-0.1637	-0.0995	-0.7968	3.1887	0.2614

Source: Computed. Using equations (16) (17) (18) (19) (21) (22) (23) and simple average of S_i

5.4.1 Input Demand Elasticities

All own-price elasticities (η_{ii}) are negative as expected and relatively higher in absolute value for the small farmer group. This implies that the small farmers' response would be higher to change in variable input prices as compared to the large farmers for an equivalent rise in price. The small farmers use higher levels of labor and material inputs per unit area than the large farmers, therefore, changes in input prices will have greater influences on the input quantity demand for the former than the latter. The own-price elasticities of fertilizer and pesticide for both small and large farms are less than one implying inelastic response of factor utilization. On the other hand, the own price elasticities of demand for human labor are elastic, especially for the small farmer group ($\eta_{WW} = -1.4527$).

It is well known that an increase in price will cause a decrease in quantity demanded and vice versa. However, the net impact of a price on total farm expenditures depends on exactly how much quantity demand changes in response to a given price change. The inelastic demand for fertilizer and pesticide implies that there are increases in farm expenditure on these inputs as their prices increase, given other things being equal .

However, for small farms, the own-price elasticities of demand for fertilizer and pesticide approach one in absolute value. This implies little or no change in farm expenditure on these inputs as their prices increase. The demand elasticities for labor are elastic, but their magnitude is small. The own-price elasticities of labor demand are −1.45 and −1.11 for the small and large farms, respectively. Thus, an increase in labor wage will lead to a decline in total expenditure for labor of farm households, especially for the small farms.

All cross-price elasticities of demand (η_{ih}) for inputs are low, less than 1 in absolute value, and negative, except for the cross-price elasticities of demand for fertilizer and labor, which is positive. These elasticities are quite similar in absolute value between two groups of farmers. The low cross-price elasticities indicate limited price responsiveness across the inputs.

The output supply and input demand elasticities with respect to fixed factors of production indicate the response to exogenous changes in these factors, holding the price of output and variable inputs constant, but allowing output and variable inputs to adjust optimally (Sidhu and Baanantee 1979). The fixed inputs raise rice supply and demand for all variable inputs of production. The influence of education on increasing demand for all variable inputs is higher for the small farmer group as compared to the large farmer group. This indicates that shifts in rice supply and factor demand functions resulting from an expansion in education is greater in small farms than those in large farms. The land input also has strong influences in increasing demand of labor, fertilizer and pesticide, especially in large farms.

Elasticities of demands for labor, fertilizer, and pesticide with respect to land quantities of the large farms are higher than those of the small farms, which are 3.34, 3.43 and 3.18, respectively. The reason for this may be explained as follows: though the amounts of inputs used per acre are greater in the small farms, an increase in land for the small farms would not raise total demand for each input as much as in the large farms since small farmers own fewer land and may have less cash for futher investment.

Elasticities of demand for inputs with respect to the price of rice are all positive in sign consistent with the expectation. These elasticities are slightly greater than one for labor and pesticide input which indicate elastic responses of demand for these two inputs to rice price. The demand elasticities for fertilizer with respect to rice price for the small and large farms are 0.915 and 0.842, respectively. Demand elasticities for labor with respect to rice price are greater than those of fertilizer and pesticide imply that as rice price increases farmers will use more labor in rice production than fertilizer and pesticide. This may be due to the high rate of returns to labor as shown in the chapter 4.

5.4.2 Output Supply Elasticities

The elasticity of output supply with respect to rice price, variable input prices, and fixed inputs also have expected sign for both groups of farmers. The own-price elasticity of rice supply for small and large farms are 0.97 and 0.72, respectively. This indicates that one per cent increase in rice prices would increase output supply in small farms by 0.20 per cent greater than that in large farms. Output supply elasticities with respect to land inputs are higher than those with respect to education. Specifically, the influence of land quantity on output supply of the large farms is quite high (3.38).

5.5 The Elasticities of Substitution (σ_{ih})

The elasticities of substitution between inputs(σ_{ih}) are related to the price elasticities of factor demands (η_{ih}) through the formula (26) in section 2.7 of chapter II. Table 39 shows the calculated partial elasticities of substitution between inputs. All of the cross partial elasticities of substitution have the same sign as their cross-price elasticities of demand for inputs.

Table 39. Elasticities of Substitution between Variable Inputs

Variable	Small farm	Large farm
Labor-Fertilizer	0.1338	-0.1184
Labor-Pesticide	-0.1788	-0.2728
Fertilizer-Pesticide	-0.1780	-0.2618

Source: Computed. Using formula (26).

In small size farms, labor and fertilizer are substitution inputs while labor and pesticide, pesticide and fertilizer are complementary inputs. This means that when relative price of fertilizer to human labor (C_F/C_W) increase, quantity ratio of human labor to fertilizer (X_W/X_F) will increase. However, the change in the (C_F/C_W) ratio will affect the X_W/X_F ratio slightly since the substitution elasticities between labor and fertilizer are quite small (σ_{WF} = 0.133). The substitution between labor and fertilizer in small farms may be because farm household labor is available as compared to the money to pay for fertilizer.

On the other hand, labor and fertilizer seems to be used to complement with the pesticide input due to the negative estimated partial elasticities of substitution between labor and pesticide (σ_{WP}) and between fertilizer and pesticide (σ_{FP}). This is because farmers still need a certain amount of labor in preparing and applying pesticide or fertilizer in the fields, weeding, getting rid of insects, etc.. Moreover, both fertilizer and pesticide are important inputs for productivity of high yielding varieties, and they have impacts on marginal product of each other. Therefore, complementary relationship between fertilizer and pesticide are reasonable. In comparison, σ_{WP} is quite similar to σ_{FP} in absolute value. This implies that responsiveness of quantity ratio of pesticide to labor (X_P/X_W) to relative price of labor to pesticide (C_W/C_P) is about equal to the responsiveness of quantity ratio of fertilizer to pesticide (X_F/X_P) to relative price of pesticide to fertilizer (C_P/C_F).

For large farms, the result of the estimated elasticities of substitution between labor and fertilizer, labor and pesticide, fertilizer and pesticide show complimentary relationships between them. In comparison both σ_{WP} and σ_{FP} are greater than σ_{LF}. However, all of these elasticities are also as low in absolute value as those of the small farmers.

In conclusion, based on the estimated parameters from the system of normalized translog profit function and input share equations, variable input prices and fixed factors of rice production, the variable inputs demand and output supply elasticities are derived. All price elasticities of demand for inputs and output supply have meaningful sign as expected.

First, the cross-price elasticities show that the relationship between labor, fertilizer, and pesticide are complementary in rice production for both the small and large farms except for labor and fertilizer which are substitution inputs in the small farms. Own-price elasticities of demands for labor are greater than those for fertilizer and pesticide, and all cross-price elasticities of demand for variable inputs are also as small in absolute value as their own-price elasticities.

Second, a rise in rice price would cause an increase in demand for variable inputs as well as output supply. However, any variation in rice price would cause larger changes in the utilization of labor and pesticide than in fertilizer since elasticities of demand for labor and pesticide with respect to rice price are elastic while that of fertilizer is inelastic.

Finally, the fixed factors of production, i.e., land and education increase the demand for input and output supply.

It is unfortunate that there is no previous estimates of the elasticities of input demand, output supply and substitution between iuputs in Vietnam rice production to compare with the current results.