CHAPTER V

INPUT DEMAND AND OUTPUT SUPPLY ESTIMATIONS

Several studies on farm-level input demand estimations were made in the past decade. Demand relationships in these studies were typically estimated from a sample of farms in which a common variety of seed was planted. Such studies ignored the possibility that cultivators can respond to price changes not only by adjusting their use of variable inputs but also by switching to different seed varieties (Pitt, 1983). In a situation of rising costs of production and high competition in export market, Thai farmers would require to switch varieties that could bring higher profit. Evidence of switching varieties were also observed in the sample area (Chapter 4).

Therefore, in this study, input demand at farm-level is jointly determined with the possibility of seed switching using Two Stage Switching Regression procedure. The first stage is the Probit Maximum Likelihood Estimation of the reduced-form seed selection equation which will enable us to compute the probability that any farm has missing data on Khao Dawk Mali profit function (regime 1) or the glutinous variety profit function (regime 2). It also shows how prices and fixed factors affect the probability of choosing seed varieties.

The second stage is the joint estimation of the Translog Profit Function and Share Equations for the two separate regimes using the Zellner's Seemingly Unrelated Regression Estimator (SURE).

5.1 Model Specification

The generalized translog profit function model and the ith share equation was developed in Chapter 2. From the general function (9), the normalized restricted translog profit function for the farms can be specified in actual variables as:

$$\begin{aligned}\ln\pi' = {} & \alpha_0 + \alpha_W \ln P'_W + \alpha_F \ln P'_F + \alpha_M \ln P'_M + \frac{1}{2}\gamma_{WW} \ln P'_W \ln P'_W + \frac{1}{2}\gamma_{FF} \ln P'_F \ln P'_F \\ & + \frac{1}{2}\gamma_{MM} \ln P'_M \ln P'_M + \gamma_{WF} \ln P'_W \ln P'_F + \gamma_{WM} \ln p'_W \ln P'_M + \gamma_{FM} \ln P'_F \ln P'_M + \beta_L \ln Z_L \\ & + \beta_A \ln Z_A + \delta_{WL} \ln P'_W \ln Z_L + \delta_{WA} \ln P'_W \ln Z_A + \delta_{FL} \ln P'_F \ln Z_L + \delta_{FA} \ln P'_F \ln Z_A \\ & + \delta_{ML} \ln P'_M \ln Z_L + \delta_{MA} \ln P'_M \ln Z_A + \frac{1}{2} \ln Z_L \ln Z_L + \frac{1}{2} \ln Z_A \ln Z_A + \ln Z_L \ln Z_A \qquad (29)\end{aligned}$$

where π' is the restricted profit from rice production per farm: total revenue less total costs of labor, chemical fertilizer, manures, irrigation, pesticides, and tractor power normalized by the price of rice; P_W' is the money wage rate of labor per day normalized by the price of rice; P_F' is the money price per kg of fertilizer materials normalized by the price of rice; and P_M' is the money price of tractor power per rai normalized by the price of rice.

The definitions of the two fixed inputs included in the specification of the profit function, are, Z_L is the land input measured as rai of rice grown per farm; and Z_A is the quantity of farm equipment and machinery used for rice production per farm measured as baht of total stock value.

The parameters α_0, α, β,γ, δ, and ψ are to be estimated and subscripts W, F, and M stands for the variable inputs of production, labor, chemical fertilizer, and tractor power, respectively.

Following the development of (10), the S_i functions of labor, chemical fertilizer and tractor power is obtained by differentiating the normalized restricted translog profit function (29) as follows:

$$-\frac{P'_W . X_W}{\pi'} = \alpha_W + \gamma_{WW}\ln P'_W + \gamma_{WF}\ln P'_F + \gamma_{WM}\ln P'_M + \delta_{WL}\ln Z_L + \delta_{WA}\ln Z_A \qquad (30)$$

$$-\frac{P'_F . X_F}{\pi'} = \alpha_F + \gamma_{FW}\ln P'_W + \gamma_{FF}\ln P'_F + \gamma_{FM}\ln P'_M + \delta_{FL}\ln Z_L + \delta_{FA}\ln Z_A \qquad (31)$$

$$-\frac{P'_M . X_M}{\pi'} = \alpha_M + \gamma_{MW}\ln P'_W + \gamma_{MF}\ln P'_F + \gamma_{MM}\ln P'_M + \delta_{ML}\ln Z_L + \delta_{MA}\ln Z_A \qquad (32)$$

where X_W, X_F, and X_M are the quantities of variable inputs of labor, chemical fertilizer and tractor power, respectively.

This sets of equations, (29), (30), (31), (32) will be jointly estimated for each regime in the second stage after incorporating the selectivity variable to be obtainable from the first stage probit estimation of the reduced-form seed selection equation.

5.2 The First Stage Estimation: Probit Maximum Likelihood Model

In order to adjust the selectivity bias in the final stage estimation of the profit functions and to see how prices and fixed factors affect the probability of choosing Khao Dawk Mali, we have to estimate the reduced-form seed selection equation

$$I'_1 = \theta_0 + P_1\theta_1 + Z_1\theta_2 - \epsilon'_1$$

as a typical probit equation because this is not directly observable. What we observe is a dummy variable which takes the value of 1 if a plot is planted with Khao Dawk Mali, 0 otherwise: that is

$$\begin{aligned} I_1 &= 1 \ \ if\ I'_1 \geq 0, \\ &= 0 \ \ otherwise. \end{aligned}$$

The maximum likelihood estimates of the probit reduced-form seed selection equation are presented in Table 23. It should be noted that the right-hand side of the reduced form probit equation is the difference in the Khao Dawk Mali and glutinous variety profit functions. Since both profit functions have identical sets of regressors and parametric restrictions, conceptually, the coefficients on the reduced-form regressors can be regarded as the differences between the Khao Dawk Mali and glutinous variety profit function coefficients for the same regressors (Pitt, 1983).

Table 23. Probit reduced-form of seed selection equation

Exogenous Variables	Estimated Coefficients	Standard Error	t-Ratio
Intercept	66.2001	24.1700	2.739***
$\ln P_W'$	-29.9659	10.2897	-2.915***
$\ln P_F'$	2.8074	11.4600	0.245
$\ln P_M'$	-4.9247	4.7950	-1.027
$\frac{1}{2}(\ln P_W')^2$	7.3211	2.9960	2.444**
$\frac{1}{2}(\ln P_F')^2$	-4.6893	5.1180	-0.916
$\frac{1}{2}(\ln P_M')^2$	-0.1631	0.8086	-0.202
$\ln P_W'.\ln P_F'$	-0.7591	3.1770	-0.239
$\ln P_W'.\ln P_M'$	1.0927	1.0250	1.066
$\ln P_F'.\ln P_M'$	0.8733	1.3580	0.643
$\ln Z_L$	-4.0053	3.1200	-1.284
$\ln Z_A$	-1.0981	1.2970	-0.846
$\ln P_W'.\ln Z_L$	1.4900	0.7330	2.033**
$\ln P_W'.\ln Z_A$	0.0115	0.3159	0.036
$\ln P_F'.\ln Z_L$	-1.7091	0.9232	-1.851*
$\ln P_F'.\ln Z_A$	-0.2596	0.4503	-0.577
$\ln P_M'.\ln Z_L$	-0.0864	0.3518	-0.241
$\ln P_M'.\ln Z_A$	0.1546	0.1411	1.096
$\frac{1}{2}(\ln Z_L)^2$	0.2700	0.3129	0.863
$\frac{1}{2}(\ln Z_A)^2$	0.0405	0.0626	0.647
$\ln Z_L .\ln Z_A$	0.0645	0.1105	0.584

Accuracy of Prediction = 83.06 percent

McFadden R^2 = 36.56 percent

*** Significant at 1 percent level
** Significant at 5 percent level
* Significant at 10 percent level

McFadden $R^2 = 1 - \log L_{max}/\log L_0$

Source: Computed

Five of the estimated coefficients are statistically significant at 10 percent level at the least (Table 23). About 83 percent of the observations are accurately predicted and the McFadden's R-squared[1] was 0.366. The coefficients of Table 23 cannot directly reveal the sign or magnitude of the change in the probability of planting Khao Dawk Mali in response to changes in the exogenous variables. The probit estimation is used mainly to obtain the selectivity variable (or Mill's ratio) to be incorporated in the second stage of estimation and to check the accuracy of prediction. The information on the magnitude and direction of the factors affecting seed selection is provided as elasticities in Table 24.

The following procedures were used to obtain the probit elasticities: the derivatives of the probabilities with respect to a particular exogenous variable for the probit model is given by

$$\frac{\partial F(\phi_i)}{\partial X_{ik}} = f(\phi_i)\,\beta_k \qquad (33)$$

where F is the distribution function and f is the density of the standard normal; β_k is the coefficient attached to the exogenous variable X_{ik} (Maddala, 1987). Therefore, the elasticity of the probability of *i*th exogenous variable is:

$$\zeta_q = \frac{\partial F(\phi_i)}{\partial X_{ik}} \cdot \frac{X_{ik}}{p_i} = f(\phi_i)\,\beta_k \cdot \frac{X_{ik}}{p_i} \qquad (34)$$

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[1] McFadden's R^2 is not comparable to the R^2 in the OLS regression. McFadden's R^2 lies in the range of 0.20 to 0.40 in this type of model (Sonka *et al.*, 1989)

where p is the probability.

Two of the five elasticities (at the sample means) are significantly different from zero (P < 0.01, 0.10) suggesting that seed selection is quite responsive to changes in prices (Table 24).

Table 24. Elasticities of the probability of planting Khao Dawk Mali at sample means

Exogenous Variable	Estimates	t-Ratio
Price of Labor	-1.25550	-1.645*
Fertilizer Price	-0.17127	-5.205***
Tractor Power Price	-0.22914	-1.086
Area	0.15250	1.165
Farm Assets	0.13773	0.744

*** Significant at 1 percent level
* Significant at 10 percent level
Source: Computed

The elasticities of fertilizer price and labor price are significantly different from zero (at the sample means) suggesting that seed selection is quite responsive to the input/output price ratio as expected. The elasticity of probability with respect to land area is positive, though small, suggesting that plot size is positively related with Khao Dawk Mali production.

5.3 The Second Stage Estimation: Maximization of the Profit Function

From the first stage probit estimation, we defined the Mill's ratio or selectivity variable which are used as identifiability restriction to adjust the selectivity bias and force the separation of the translog profit function of the two regimes (1) and (2). One of the interesting properties of the Mill's ratio is that, the higher the value of the ratio, the lower is the probability that an observation is having data on $I_i = 1$ (Heckman, 1976).

The final specification of the reduced-form of the translog profit function with the inclusion of the selectivity variable, (equation 13 and 14) are restated as;

$$\pi_{qi} = P_i\beta_q + Z_i\gamma_q + \sigma_{1\epsilon}'\left(\frac{-f(\phi_i)}{F(\phi_i)}\right) + \xi_{qi} \qquad \texttt{for Khao Dawk Mali}$$

$$\pi_{gi} = P_i\beta_g + Z_i\gamma_g + \sigma_{2\epsilon}'\left(\frac{f(\phi_i)}{1-F(\phi_i)}\right) + \xi_{gi} \qquad \texttt{for Glutinous Variety}$$

These translog profit functions and the corresponding three share equations for each regimes were jointly estimated by using Zellner's Seemingly Unrelated Regressions Estimator.

Table 25 and 26 provides the joint restricted parameter estimates of the normalized restricted translog profit function and labor, fertilizer, and tractor power share equations adjusted for selectivity bias for Khao Dawk Mali and glutinous variety, respectively. Two formal statistical tests were conducted to test two sets of hypotheses. The first test was conducted to test the validity of the symmetry and parametric constraints across profit and S_i equations. The null hypothesis is that parameters of the S_i equations (30), (31) and (32) are equal to the corresponding same parameters in equation (29) and that $\gamma_{WF} = \gamma_{FW}$, $\gamma_{WM} = \gamma_{MW}$, and $\gamma_{FM} = \gamma_{MF}$. This is a joint hypothesis on the validity of imposing 18 restrictions (six restrictions for each S_i equations) to estimate jointly equations (29), (30), (31) and (32) for each of the two regimes. An *F*-test statistic with good asymptotic properties was conducted to test this hypothesis. For the seemingly unrelated regression procedure, estimated under the assumption that null-hypothesis $R\beta = r$ is true is

$$F = \frac{(r-R\beta_{seem})'\,[R(X'(\Sigma^{-1}\otimes I)X)^{-1}R']\,(r-R\beta_{seem})}{(y-X\beta)'(\Sigma^{-1}\otimes I)(y-X\beta)}\;\frac{MT-k}{J}$$

where M = number of equations, J is the number of restrictions. *F* is distributed as $(1/J)\,\chi^2_{(J)}$ (Theil, 1971). For the Khao Dawk Mali function, the computed $F_{0.05(18,504)}$ equals 1.905, and the critical $F_{0.05(18,504)}$ equals 1.975. For the glutinous rice function, the computed $F_{0.05(18,492)}$ equals 1.809, and the critical $F_{0.05(18,492)}$ equals 1.975. Thus, the null hypothesis (validity of the constraints) cannot be rejected at the 5 percent level of significance. This implies, among other things, that the sample farms, on an average, maximize profits with respect to normalized prices of the variable inputs, thus supporting empirically the assumption of profit maximization. Evidence of profit maximizing behavior of the Thai farmers were also found by Puapanichya and Panayotou (1985) and Adulavidhaya *et al.* (1979).

The second statistical test was carried out to test for the Cobb-Douglas (C-D) hypothesis. It should be noted that, for the profit function to be Cobb-Douglas, coefficients of all second order terms in (29) should be zero (Sidhu and Baanante, 1981). An *F*-test was conducted to test the null hypothesis that all γ_{ij} equal 0 and all δ_{ik} equal 0. For the Khao Dawk Mali function, the computed $F_{(15,504)}$ equals 2.013, and the critical $F_{0.01(15,504)}$ equals 1.691. Thus, the hypothesis was rejected, and the translog representation appeared to be more suitable than the C-D in this case. On the other hand, for the glutinous rice function the computed $F_{(15,492)}$ equals 1.289 and the critical $F_{0.01(15,492)}$ equals 1.692 and hence the hypothesis cannot be rejected implying that C-D function would not perform worse than translog. However, translog specification was maintained for both functions for our present analysis. This was done in order to maintain comparability between regimes and to avoid the weakness implicit in the C-D profit functional form as noted by Chand and Kaul (1986).

Nineteen and twenty-five coefficients of the total 40 coefficients in each set of functions are statistically significant at 10 percent level at the least (Tables 25 and 26).

At the bottom of the profit function in Tables 25 and 26, the coefficients and standard errors of the selectivity variables appear, $-f(\phi_i)/F(\phi_i)$ for the Khao Dawk Mali function and $f(\phi_i)/[1 - F(\phi_i)]$ for the glutinous variety function. The selection variable is significantly different from zero at the 10 percent level of significance in the Khao Dawk Mali profit function. This is the evidence of pronounced selection bias in estimating equations from a subsample of cultivators (Pitt, 1983). On the other hand, there appears to be no significant selection bias in the estimation of the glutinous variety function. Therefore, single stage estimation of this function from a subsample of glutinous variety cultivators should be unbiased[2].

Table 25. Joint estimation of the normalized profit function and factor share equations for variable inputs in Khao Dawk Mali, adjusted for selectivity bias

Exogenous Variables	Parameters	Estimated Coefficient	Standard Error	t-Ratio
Profit Function				
Intercept	α_0	5.209940	1.50400	3.464***
$\ln P_W'$	α_W	1.185770	0.46370	2.557**
$\ln P_F'$	α_F	0.147314	0.04985	2.955***
$\ln P_M'$	α_M	0.530296	0.28450	1.864*
$\frac{1}{2}(\ln P_W')^2$	γ_{WW}	-0.494342	0.09126	-5.417***
$\frac{1}{2}(\ln P_F')^2$	γ_{FF}	-0.031796	0.01778	-1.789*
$\frac{1}{2}(\ln P_M')^2$	γ_{MM}	-0.169857	0.03568	-4.760***
$\ln P_W' . \ln P_F'$	γ_{WF}	-0.055843	0.01202	-4.648***
$\ln P_W' . \ln P_M'$	γ_{WM}	-0.049073	0.04573	-1.073
$\ln P_F' . \ln P_M'$	γ_{FM}	-0.009452	0.00583	-1.620
$\ln Z_L$	β_L	1.089270	0.32210	3.382***
$\ln Z_A$	β_A	-0.261975	0.17530	-1.503
$\ln P_W' . \ln Z_L$	δ_{WL}	-0.043033	0.05021	-0.857
$\ln P_W' . \ln Z_A$	δ_{WA}	0.011110	0.02204	0.504
$\ln P_F' . \ln Z_L$	δ_{FL}	0.001869	0.00551	0.339
$\ln P_F' . \ln Z_A$	δ_{FA}	-0.001448	0.00255	-0.566
$\ln P_M' . \ln Z_L$	δ_{ML}	-0.040898	0.02979	-1.373
$\ln P_M' . \ln Z_A$	δ_{MA}	0.017678	0.01315	1.344
$\frac{1}{2}(\ln Z_L)^2$	ψ_{LL}	0.044506	0.04281	1.040
$\frac{1}{2}(\ln Z_A)^2$	ψ_{AA}	0.018621	0.01260	1.477
$\ln Z_L . \ln Z_A$	ψ_{LA}	0.004957	0.01790	0.277
Selectivity variable	σ_{1u}	0.100199	0.05931	1.689*

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[2] In general, the selectivity variable may be significant in any or both of the equations (Lee, 1978 and Pitt, 1983).

Table 25. (continued)

Exogenous Variables	Parameters	Estimated Coefficient	Standard Error	t-Ratio
Labor Share Equation				
Intercept	α_W	1.185770	0.46370	2.557^{***}
ln P_W'	γ_{WW}	-0.494342	0.09126	-5.417^{***}
ln P_F'	γ_{WF}	-0.055843	0.01202	-4.648^{***}
ln P_M'	γ_{WM}	-0.049073	0.04573	-1.073
ln Z_L	δ_{WL}	-0.043033	0.05021	-0.857
ln Z_A	δ_{WA}	0.011110	0.02204	0.504
Fertilizer Share Equation				
Intercept	α_F	0.147314	0.04985	2.955^{***}
ln P_W'	γ_{FW}	-0.055843	0.01202	-4.648^{***}
ln P_F'	γ_{FF}	-0.031796	0.01778	-1.789^{*}
ln P_M'	γ_{FM}	-0.009452	0.00583	-1.620
ln Z_L	δ_{FL}	0.001869	0.00551	0.339
ln Z_A	δ_{FA}	-0.001448	0.00256	-0.566
Tractor Power Share Equation				
Intercept	α_M	0.530296	0.28450	1.864^{*}
ln P_W'	γ_{MW}	-0.049073	0.04573	-1.073
ln P_F'	γ_{MF}	-0.009452	0.00583	-1.620
ln P_M'	γ_{MM}	-0.169857	0.03568	-4.760^{***}
ln Z_L	δ_{ML}	-0.040898	0.02979	-1.373
ln Z_A	δ_{MA}	0.017678	0.01315	1.344

***	Significant at 1 percent level
**	Significant at 5 percent level
*	Significant at 10 percent level

Selectivity Variable $= -f(\phi_i)/F(\phi_i)$

Source: Computed

Table 26. Joint estimation of the normalized profit function and factor share equations for variable inputs in glutinous rice, adjusted for selectivity bias

Exogenous Variables	Parameters	Estimated Coefficient	Standard Error	t-Ratio
Profit Function				
Intercept	α_0	-6.885170	4.01100	-1.716^{*}
ln P_W'	α_W	4.451160	1.62600	2.737^{***}
ln P_F'	α_F	0.987797	0.26260	3.762^{***}
ln P_M'	α_M	2.892350	0.57420	5.037^{***}
½(ln P_W')^2	γ_{WW}	-0.925564	0.38770	-2.387^{**}
½(ln P_F')^2	γ_{FF}	-0.169621	0.05755	-2.948^{***}
½(ln P_M')^2	γ_{MM}	-0.486116	0.05686	-8.549^{***}
ln P_W'.ln P_F'	γ_{WF}	-0.244445	0.05931	-4.121^{***}
ln P_W'.ln P_M'	γ_{WM}	-0.319976	0.11520	-2.777^{***}
ln P_F'.ln P_M'	γ_{FM}	-0.079804	0.02766	-2.886^{***}
ln Z_L	β_L	1.734012	0.64270	2.698^{***}
ln Z_A	β_A	0.254821	0.25400	1.003
ln P_W'.ln Z_L	δ_{WL}	-0.375587	0.13230	-2.839^{***}
ln P_W'.ln Z_A	δ_{WA}	-0.040154	0.04832	-0.831
ln P_F'.ln Z_L	δ_{FL}	0.012056	0.02512	0.480
ln P_F'.ln Z_A	δ_{FA}	0.001165	0.00986	0.118
ln P_M'.ln Z_L	δ_{ML}	-0.045749	0.05317	-0.860
ln P_M'.ln Z_A	δ_{MA}	-0.018905	0.02048	-0.923
½(ln Z_L)^2	ψ_{LL}	0.045069	0.10540	0.428
½(ln Z_A)^2	ψ_{AA}	-0.011204	0.01603	-0.699
ln Z_L .ln Z_A	ψ_{LA}	0.027214	0.02648	1.028
Selectivity variable	σ_{2u}	-0.069508	0.09883	-0.703
Labor Share Equation				
Intercept	α_W	4.451160	1.62600	2.737^{***}
ln P_W'	γ_{WW}	-0.925564	0.38770	-2.387^{**}
ln P_F'	γ_{WF}	-0.244445	0.05931	-4.121^{***}
ln P_M'	γ_{WM}	-0.319976	0.11520	-2.777^{***}
ln Z_L	δ_{WL}	-0.375587	0.13230	-2.839^{***}
ln Z_A	δ_{WA}	-0.040154	0.04832	-0.831
Fertilizer Share Equation				
Intercept	α_F	0.987797	0.26260	3.762^{***}
ln P_W'	γ_{FW}	-0.244445	0.05931	-4.121^{***}
ln P_F'	γ_{FF}	-0.169621	0.57550	-2.948^{***}
ln P_M'	γ_{FM}	-0.079805	0.02766	-2.886^{***}
ln Z_L	δ_{FL}	0.012056	0.02512	0.480
ln Z_A	δ_{FA}	0.001165	0.00986	0.118

Table 26. (continued)

Exogenous Variables	Parameters	Estimated Coefficient	Standard Error	t-Ratio
Tractor Power Share Equation				
Intercept	α_M	2.892350	0.57420	5.037^{***}
ln P_W'	γ_{MW}	-0.319976	0.11520	-2.777^{***}
ln P_F'	γ_{MF}	-0.079805	0.02766	-2.886^{***}
ln P_M'	γ_{MM}	-0.486116	0.05686	-8.549^{***}
ln Z_L	δ_{ML}	-0.045749	0.05317	-0.860
ln Z_A	δ_{MA}	-0.018905	0.02048	-0.923

*** Significant at 1 percent level
** Significant at 5 percent level
* Significant at 10 percent level

Selectivity Variable = $f(\phi_i)/[1-F(\phi_i)]$

Source: Computed

All γ_{ij} coefficients are of negative signs in both the regimes as expected. The negative cross-price coefficients imply a complementarity in inputs. Land coefficient (β_L) is positive and highly significant at both the profit functions consistent with the expectation. However, negative farm assets coefficient (β_A) in Khao Dawk Mali profit function implies that increase in capital endowment would reduce profitability. Since the coefficient is not significant, the affect might not be truely negative.

The coefficients are generally found to be larger in magnitude for glutinous function. This is because, the profitability in glutinous variety production is significantly lower as compared to Khao Dawk Mali (see Chapter 4), as such, variations in input prices and exogenous factors would lead to larger decreases in profitability in absolute terms. On the other hand, smaller coefficients in Khao

Dawk Mali function implies that the extent on reduction would be lower, for an equivalent change in input prices and exogenous variable. However, firm conclusions can be drawn only from the elasticities to be computed using these profit function coefficients, factor demand functions and input prices.

5.4 Input Demand and Output Supply Elasticities

The estimates presented in Tables 25 and 26 form the basis for deriving elasticity estimates for rice supply and input demand for the variable inputs of labor, fertilizer, and tractor power. These elasticity estimates for individual varieties were first obtained by using equations (17), (18), (19), (20), (23), (24), and (25). As noted earlier, the elasticities are functions of variable input ratios, variable input prices, level of fixed inputs, and the parameter estimates of the translog profit function presented in Tables 25 and 26. These elasticities are evaluated at simple averages of the S_i, variable input prices and fixed inputs. This provides the basis of using equation (27), which uses these estimates from each regime plus the elasticities of the probabilities presented in Table 24. The elasticity estimates of individual varieties, and total elasticity of demand after allowing for seed switching adjustments (or permitting movements along the meta-response surfaces) are presented in Table 27.

In the translog function, unlike Cobb-Douglas function, the impact across variable input demand functions for labor, fertilizer, and animal power of a given change in any of the exogenous variables is not symmetric. It varies across demand equations, which is consistent with *a priori* theoretical expectations (Sidhu and Baanante, 1981).

Table 27. Derived elasticity estimates for rice supply and demand for variable inputs of rice

	Rice price	Fert. price	Labor price	Tractor price	Farm assets	Land
Elasticity of demand and supply for Khao Dawk Mali rice[a]						
Output supply	0.1942	-0.0108	-0.0773	-0.0386	0.0335	0.9449
Fert. demand	0.2490	-0.7002	-0.0443	-0.0614	0.0410	0.8685
Labor demand	0.2983	-0.0145	-0.2971	-0.0618	0.0436	0.9950
Tractor Demand	0.3705	-0.0239	-0.1538	-0.2028	0.0815	1.1300
Elasticity of demand and supply of glutinous rice[a]						
Output supply	0.6502	-0.0222	-0.2168	-0.1572	0.0591	0.0685
Fert. demand	0.2584	-0.4373	-0.0773	-0.1421	0.0223	0.0379
Labor demand	0.6808	-0.0139	-0.6572	-0.1096	0.0843	0.3728
Tractor demand	0.7814	-0.0610	-0.1743	-0.5472	0.0203	0.0431
Total elasticity of demand and supply (with seed switching adjustments)[b]						
Output supply	0.3128	-0.0146	-0.1160	-0.0678	0.0433	0.8981
Fert. demand	0.2827	-0.8056	-0.0568	-0.0860	0.0423	0.8068
Labor demand	0.4157	-0.0154	-0.6856	-0.0783	0.0510	0.9156
Tractor demand	0.5008	-0.0348	-0.1723	-0.3651	0.0743	0.9733

[a] Using equations (17), (18), (19), (20), (23), (24), (25) and simple averages of input S_i ratios.

[b] Using equations (17), (18), (19), (20), (23), (24), (25), (27) and simple averages of input S_i ratios.

Source: Computed

All the own-price elasticities are less than one indicating an inelastic response of factor utilization. A finding consistent with the estimates for Chiang Mai valley by Sriboonchitta (1983). The total own price elasticities for fertilizer was estimated at -0.73 and the seed switching adjustments increases the elasticity by about nine percent to -0.81. Pitt's (1983) estimates of fertilizer demand elasticity for Javanese rice with seed switching adjustment increased by about 11 percent from -1.042 to -1.155. The total own-price elasticity of tractor power after seed switching adjustments improved by about 17 percent from -0.30 to -0.37. The own-price elasticity of labor was estimated at -0.41 which then increased by about 40 percent to -0.69 after allowing for seed switching.

All the three variable inputs are complements, rather than substitutes, because cross-price elasticities between all these inputs were negative. Complementarity in inputs for Thai agriculture, including rice, were also validated by Puapanichya and Panayotou (1985) and Adulavidhaya *et al.* (1979) and Sriboonchitta (1983). The fixed inputs appear to be important in influencing rice supply. Their influence, however, is not uniform on labor, fertilizer and tractor power demand functions. The exogenous increases in land quantities and expansion in farm capital, in the form of implements and machinery, increase rice supply and demand for all variable inputs of production. The elasticities of output supply with respect to the value of fixed farm assets and land size were 0.04 and 0.90 respectively. This indicates that one percent increase in the value of fixed farm assets would increase output supply by 0.04 percent, while a one percent increase in land size would increase output supply by 0.90 percent.

All price effects are quite reasonable, and nonsymmetric nature of their impact, contrary to the Cobb-Douglas case, is as expected and more natural. The inelastic price elasticity of labor is consistent with the almost zero marginal value product of labor estimated by Abamo (1992), Zhang (1991) and Wiboonpongse (1983).

At an individual variety level, the own-price elasticity of fertilizer is relatively higher (-0.70) for Khao Dawk Mali consistent with the expectation. Also the supply and demand elasticities with respect to land area is much higher in Khao Dawk Mali function. This finding is consistent with the farmers' responses during the interview session, where they mentioned farm size being an important constraint in their plan to expand Khao Dawk Mali area. On the other hand, few farmers expressed interest to expand glutinous rice area as the existing level of production is enough for consumption and market opportunities for glutinous rice is uncertain. Price elasticities of labor and tractor power were higher in glutinous function. In Chapter 4 it was revealed that, relatively less hired labor was used in glutinous rice production implying farmers' responses would be higher to changes in labor price. Also, since the profit margin in glutinous rice was significantly lower as compared to Khao Dawk Mali, farmers tend to response actively to price increases because it would result in larger cuts in aboslute profit as compared to Khao Dawk Mali for an equivalent rise in prices. On the other hand, changes in output price have higher response in glutinous function as compared to Khao Dawk Mali because of its preference for consumption and could be inherent attachment to tradition, culture etc.

The cross-price effects for both regimes are not different from each other, due to the inelastic nature of overall response to price changes. Output supply and input demand elasticities with respect to fixed farm assets were also similar in both functions.

Table 28 presents the comparisons of selected elasticity estimates with other studies. Sriboonchitta (1983), in his cost function study revealed that, all input elasticities were inelastic in Chiang Mai valley. However, over the past decade, the parameters did not seem to be changed much. The labor elasticity however increased to a higher level because of sharp rise in labor price over the past decade.

Table 28. Comparisons of Selected Elasticity Estimates with Other Studies

	Present study (1993)	Sriboon-chitta[a] (1983)	Puapanichya and Panay-otou[b](1985)	Adulavidhaya *et al.*[c] (1979)
Output supply	0.3128	-	0.6496	0.8980
Fertilizer demand	-0.8056	-0.8532	-1.1915	-1.1120
Labor demand	-0.6856	-0.1932	-1.4167	-1.5740
Tractor demand	-0.3651	-0.4819	-	-1.1230
Land[d]	0.8981	-	0.9894	0.5410
Farm assets[d]	0.0433	-	0.0106	0.4590

[a] Estimates for agricultural output in Chiang Mai Valley utilizing translog cost function with six input prices (equipment, animal/tractor, seed fertilizer, labor and land) and crop output.

[b] Estimates for irrigated rice utilizing Cobb-Douglas normalized restricted profit function with three variable inputs (seeds, fertilizer and labor) and two fixed factors (farm assets and land).

[c] Estimates for overall Thai agriculture utilizing Cobb-Douglas normalized restricted profit function with variable inputs (labor,animal,mechanical input, and seed-fertilizer), and two fixed factors (fixed assets and land).

[d] Output supply with respect to fixed inputs, land and farm assets.

It should be noted that, the various estimates presented in Table 28 are not strictly comparable to each other, because of the differences in model specification, location, and time lag between these studies. However, such comparison would assist in providing a picture of the response patterns of Thai farmers to economic incentives introduced over the past years.