# CHAPTER 5. IMPACT OF CREDIT ON FARM PRODUCTIVITY OF RICE AND SOYBEAN CROPPING SYSTEMS

Conventional project assessment assumes that the impact of loans will be analyzed from the changes within a given enterprise of the farmers, as a result of the credit assistance. While this approach could be true, but it is important to point out also, that this type of analysis grossly ignored the changes in consumption and adjustment in all other uses and sources of farm-household liquidity associated with the loan ( Adams and Picsche, 1980 ). In fact, relevant findings of this study revealed that, on the average, about 50 percent of the farmers in the study area are credit constrained and at least 20 percent of the borrowed funds in both soybean and rice cropping systems, is diverted indirectly or directly to non-farm household spending.

Therefore in this study, the impact of credit on farm productivity is jointly determined with the farm-household liquidity management behavior using Two Stage Switching Regression model. The first stage is a Probit Maximum Likelihood Analysis designed to handle the issue of adjustment in farmers sources and uses of household liquidity. This is accomplished by estimating the probability that farmers from either rice or soybean cropping system, are credit constrained ( regime 1 ) or credit unconstrained ( regime 2 ). The second stage is a least squares estimation procedure of the output function for two separate regimes in each crop which will reflect the marginal effect of credit money used by the farmers in the farm operation.

## 5.1 The First Stage Estimation: Probit Maximum Likelihood Model

In order to incorporate the effect of credit utilization behavior into our model, we have to estimate the excess credit demand criterion function ( $C_i = \delta Z_i + U_i$ ) as stated in chapter 2. But as we already noted, $C_i$ is not directly observable. What we observe in practice is a dummy variable $C^*$ defined by :

$$C_i^* = 1 \quad \text{if} \quad \delta Z_i + U_i \leq 0 \qquad \text{( credit unconstrained )}$$

$$C_i^* = 0 \quad \text{if} \quad \delta Z_i + U_i > 0 \qquad \text{( credit constrained )}$$

The econometric intuition of this procedure is that, it allows us to make a Probit transformation of the unobservable dependent variable, such that, we can estimate its probability distribution within the sample space defined by the set of explanatory variables ( $Z_i$ ). This $Z_i$ is an n x k matrix of observations of the key determinants[6] of credit supply and demand suspected to influence the probability that farmers are credit constrained or unconstrained. These are :

(a) Education ( Z1 ) : the number of years in schooling of the farm household head. From the actual survey it was found out that more than 80 percent barely reached grade four.



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6J Most of these variables are based from the actual standard loan requirements of BAAC. Also these are consistent with the study of Tabpan (TDRI, 1991). The signs enclosed in parenthesis indicate expected effect of being credit unconstrained. Those that affect credit supply and demand in the same direction are with no priori sign.

(b) Farm Experience ( Z2 ) : number of years of farmers proven exposure to farming or actual cultivation of the crops.

(c) Owned land ( Z3 ) : total number of rai that the farmer owned. This is expected to influence farmers demand behavior for credit since it is the chief instrument for collateral of loans.

(d) Cultivated land ( Z4 ) : the total area devoted for cultivation of rice or soybean.

(e) Number of adults ( Z5 ) : number of persons in the family between age of 10 to 60 years old who are able to help in the farm operation.

(f) Number of family labor ( Z6 ) : number of person in the family who are not able to help in the farm.

(g) Farm household capital ( Z7 ) : total value of non-liquid farm asset e.g. machinery, equipment, vehicle, buffalo, etc.

(h) Farm income last season ( Z8 ) (+) : amount of income generated by the farm operation in the previous year.

(i) Total initial liquidity ( Z9 ) (+) : consist of the cash, value of product inventory, bank deposit, other sources of income excluding fungible formal loans.

(j) Savings in financial institution ( Z10 ) (+) : amount of money deposited in the bank which are considered as a reasonable reserve fund for farm operation.

(k) Location dummy ( D1-D3 ) : these represented the four districts in Chiang Mai Province where rice and soybean are grown.

(l) Cropping systems ( D4-D5 ) : initially these dummies represented the three cropping systems prevalent in the study area; rice-soybean system, rice and others, soybean and others.

D5 was dropped finally because it was collinear with other dummy variables.

(m) Stable income source (D6) (+) : dummy variable representing as stable source of non-farm income of the household head or the main income earner in the family. Those government employees in the amphur ( district ) and also those regular workers of private enterprise were considered as having stable non-farm work.

(n) Outstanding debt in the formal source (D7) (-) : this is a dummy variable for outstanding loans from the formal sources.

The total initial liquid assets, stable income source are credit demand determinants. Savings in financial institution, loan default, and last season income are supply determinants, while all others affect both credit supply and demand. The estimated parameters at this stage, will be used to calculate the Mills ratios ( $W_i$ ), which will be incorporated in the second stage estimation of the output equations (5) and (6).

### 5.1.1 Relevant Explanatory Variables

In the final specification of the model, 18 variables were included for rice and 19 variables for soybean ( Tables 20 to 21 ). Education of the household head, land holding, number of adults variables and some dummy interactions were dropped after a series of runs because of apparent multicollinearity problem and they were not statistically significant in the estimation. D7 dummy was finally dropped because only 5 farmers from the total respondents have outstanding formal indebtedness.

Table 20. Descriptive statistics of the relevant explanatory variables in the Probit Model ( rice )

| Variable name | Mean | Standard deviation | Minimum value | Maximum value |
|---|---|---|---|---|
| Farm experience | 24.41 | 12.346 | 2 | 50 |
| Owned land | 4.645 | 5.3784 | 0 | 30 |
| Cultivated land | 6.5891 | 4.7169 | 1 | 33 |
| Number of dependents | 3.0559 | 1.3146 | 0 | 7 |
| Farm household capital | 36615 | 25148 | 1065 | 103300 |
| Previous Net Farm Income | 1851.7 | 1403.7 | -850.4* | 8401 |
| Total initial liquidity | 23189 | 13150 | 3000 | 84170 |
| Savings in financial institution | 2491.9 | 7492.2 | 0 | 45000 |
| Dummy variables: | | | | |
| location | | | | |
| D1 ( Hangdong ) | 0.22981 | 0.42203 | 0 | 1 |
| D2 ( San Patong ) | 0.23602 | 0.42596 | 0 | 1 |
| D3 ( Chomtong ) | 0.43478 | 0.49728 | 0 | 1 |
| cropping systems | | | | |
| D4 ( rice-soybean ) | 0.63975 | 0.48157 | 0 | 1 |
| off-farm work | | | | |
| D6 ( stable ) | 0.24224 | 0.42977 | 0 | 1 |
| Interaction variables: | | | | |
| X1 ( D1xCland ) | 2.1404 | 5.1642 | 0 | 33 |
| X2 ( D1xCapital ) | 8381.7 | 19020 | 0 | 103300 |
| X11 ( D3xIncome ) | 743.96 | 1406.7 | -1043 | 12400 |
| X12 ( D3xLiquidity ) | 9124.2 | 13417 | 0 | 74500 |
| X28 ( D6xLiquidity ) | 7033 | 14673 | 0 | 74500 |

number of observations = 161
* = net farm loss

Table 21. Descriptive statistics of the relevant explanatory variables in the Probit Model ( soybean )

| Variable name | Mean | Standard deviation | Minimum value | Maximum value |
|---|---|---|---|---|
| Farm experience | 22.258 | 12.29 | 1 | 52 |
| Owned land | 5.1709 | 6.2808 | 0 | 35 |
| Cultivated land | 7.3396 | 5.9093 | 1 | 35 |
| Number of dependents | 3.0123 | 1.2909 | 0 | 7 |
| Farm household capital | 36742 | 26641 | 850 | 103300 |
| Farm income last season | 1662.8 | 1669.7 | -1043* | 12400 |
| Total initial liquidity | 20591 | 13741 | 420 | 84170 |
| Savings in financial institution | 2035 | 6777.3 | 0 | 45000 |
| Dummy variables: | | | | |
| location | | | | |
| D1 ( Hangdong ) | 0.23926 | 0.42795 | 0 | 1 |
| D2 ( San Patong ) | 0.2454 | 0.43165 | 0 | 1 |
| D3 ( Chomtong ) | 0.34969 | 0.47834 | 0 | 1 |
| cropping systems | | | | |
| D4 ( rice-soybean ) | 0.6319 | 0.48377 | 0 | 1 |
| off-farm work | | | | |
| D6 ( stable ) | 0.2454 | 0.43165 | 0 | 1 |
| Interaction variables: | | | | |
| X1 ( D1xCland ) | 2.2798 | 5.3613 | 0 | 33 |
| X2 ( D1xCapital ) | 9542.5 | 21295 | 0 | 103300 |
| X3 ( D1xIncome ) | 532.22 | 1210.1 | 0 | 6585 |
| X11 ( D3xIncome ) | 591.63 | 1390.1 | -1043 | 12400 |
| X12 ( D3xLiquidity ) | 5785.8 | 10022 | 0 | 44700 |
| X28 ( D6xLiquidity ) | 6127.2 | 12508 | 0 | 67500 |

number of observations = 163
* = net farm loss

### 5.1.2 Factors Influencing the Probability of Being Credit Unconstrained Farm Household

Considering that the farmers across cropping systems were faced with the same credit market situation and since it was also possible for us to separate the observations for each crop under the rice-soybean cropping system, the final Probit model included only two separate estimations. One for rice, and the other for soybean. Hence, the dummy variable D4 for rice-soybean cropping system proved to be important in each estimate, because it captured the effect of the observations from this cropping system.

The results of the Probit estimates [7] for rice and soybean are presented in Tables 22 and 23 respectively. Four estimated coefficients in rice and eight in soybean are statistically significant at 10 percent at the least.

The estimate for rice cropping systems shows that cultivated land and total initial liquidity seem to be an important factors influencing the probability that farmers are credit unconstrained. Both variables have their theoretically predicted signs. The negative sign for cultivated land means that the increase in this variable would decrease the probability that the farmer is credit unconstrained. In other words, the farmer would likely be credit constrained because



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7/The basic model describes the probability of being credit unconstrained for the farmers in Doi Tao under rice-soybean cropping system with stable non-farm work. It should be noted also that the farm households with special farm and economic characterestics e.g. merchant, traders and those with bank deposit more than 50,000 Bht. also those medium and long term borrowers, were excluded in the econometric analysis as their liquidity requirement and borrowing patterns could be quite different.

Table 22. Probability of being credit unconstrained for rice farmers

| Variable name | Estimated coefficient | Standard error | t-ratio |
|---|---|---|---|
| Farm experience | 0.00074070 | 0.0097610 | 0.0760 |
| Owned land | 0.05199160 | 0.0343500 | 1.5020 |
| Cultivated land | -0.11804300 | 0.0549900 | -2.1470 ** |
| Number of dependents | 0.00708600 | 0.0910400 | 0.0780 |
| Farm household capital | 0.00000836 | 0.0000058 | 1.4310 |
| Farm income last season | 0.00023370 | 0.0001584 | 1.4750 |
| Total initial liquidity | 0.00008866 | 0.0000208 | 4.2710 ** |
| Savings in financial institution | 0.00002467 | 0.0000202 | 1.2190 |
| Dummy variables: | | | |
| location | | | |
| D1 ( Hangdong ) | -0.94125800 | 0.9545000 | -0.9860 |
| D2 ( San Patong ) | 0.31446400 | 0.4924000 | 0.6390 |
| D3 ( Chomtong ) | 0.90301100 | 0.7067000 | 1.2780 |
| cropping systems | | | |
| D4 ( rice-soybean ) | 0.00816185 | 0.2816000 | 0.0290 |
| off-farm work | | | |
| D6 ( stable ) | 0.86748900 | 0.6233000 | 1.3920 |
| Interaction variables: | | | |
| X1 ( D1xCland ) | 0.23967200 | 0.1054000 | 2.2730 ** |
| X2 ( D1xCapital ) | -0.00001111 | 0.0000142 | -0.7830 |
| X11 ( D3xIncome ) | -0.00022896 | 0.0001861 | -1.2300 |
| X12 ( D3xLiquidity ) | 0.00000329 | 0.0000241 | 0.1370 |
| X28 ( D6xLiquidity ) | -0.00006613 | 0.0000244 | -2.7160 ** |
| Constant | -2.52318000 | 0.7249000 | -3.4810 *** |
| Accuracy of prediction | 80 percent | | |
| McFadden R-squared | 30.5 percent | | |

* significant at .10
** significant at .05
*** significant at .01

$$\text{McFadden } R^2 = 1 - \frac{\log L_{max}}{\log L_o}$$

Table 23. Probability of being credit unconstrained for soybean farmers

| Variable name | Estimated coefficient | Standard error | t-ratio |
|---|---|---|---|
| Farm experience | -0.01243320 | 0.01078000 | -1.1530 |
| Owned land | 0.05415800 | 0.03595000 | 1.5070 |
| Cultivated land | -0.06213860 | 0.04528000 | -1.3720 |
| Number of dependents | 0.07681700 | 0.10490000 | 0.6830 |
| Farm household capital | 0.00000511 | 0.00000617 | 0.8290 |
| Farm income last season | 0.00048686 | 0.00023350 | 2.0850 *** |
| Total initial liquidity | 0.00003882 | 0.00001399 | 2.7750 *** |
| Savings in financial institution | 0.00006777 | 0.00003094 | 2.1900 *** |
| Dummy variables: | | | |
| location | | | |
| D1 ( Hangdong ) | -0.06299820 | 0.95560000 | -0.0660 |
| D2 ( San Patong ) | -0.07517780 | 0.48600000 | -0.1550 |
| D3 ( Chomtong ) | -0.19448000 | 0.75300000 | -2.5800 |
| cropping systems | | | |
| D4 ( rice-soybean ) | 0.54434900 | 0.33840000 | 1.6090 * |
| off-farm work | | | |
| D6 ( stable ) | 0.96459200 | 0.72830000 | 1.3240 |
| Interaction variables: | | | |
| X1 ( D1xCland ) | 0.11302200 | 0.06800000 | 1.6620 * |
| X2 ( D1xCapital ) | -0.00001581 | 0.00001476 | -1.0710 |
| X3 ( D1xIncome) | -0.00008485 | 0.00031710 | -0.2680 |
| X11 ( D3xIncome ) | -0.00051880 | 0.00025890 | -2.0040 ** |
| X12 ( D3xLiquidity ) | 0.00005716 | 0.00002688 | 2.1270 ** |
| X28 ( D6xLiquidity ) | -0.00004767 | 0.00002815 | -1.6930 * |
| Constant | -2.32260000 | 0.7007000 | -3.3130 *** |
| Accuracy of prediction | 78 percent | | |
| McFadden R-squared | 36.13 percent | | |

* significant at .10
** significant at .05
*** significant at .01

farmers have the tendency to use more inputs when land size increased instead of spending the limited inputs to cover the larger land area.

Total initial liquidity also is positively influencing the likelihood of being credit unconstrained which is understandable since the need for credit decreases as cash and near-cash possession of the farmers increase. The significance of two interaction variables X1 and X28 also portrays an interesting implication. The positive sign for the combined influence of cultivated land and Hangdong ( district dummy ) means that increasing cultivated land size coupled with Hangdong's better-off land type and higher income opportunity, farmers would likely be more credit unconstrained. The negative sign of the estimated coefficient for X28, seems to imply a contrasting influence from the point of view of intuitive expectation. But actually this inverse relationship can be expected since, if a farmer in Doi Tao for example, has a stable source of income it further strengthens his liquidity possession, bolstering his confidence of loan repayment, hence he becomes more likely to avail of credit ( Baker and Sanint, 1981).

About 80 percent of the credit unconstrained observations for rice Probit specification is accurately predicted and the McFadden's R-squared 8_/ was 0.31. This implies a relatively good fit ( Table 22 ).

The soybean Probit model estimate on the other hand, resulted in more variables that are statistically significant, at least, at 10 percent level significance. Three of the variables that are



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8_/ McFadden's $R^2$ is not comparable to the $R^2$ in the OLS regression. McFadden's $R^2$ value in the range of 0.20 to 0.40 is typical for this type of model (Sonka, Hornbaker and Hudson, 1989) statistically significant in rice are also significant in the soybean estimate. The five other significant variables, such as farm income, amount of savings, D4, X11, and X12 are specific to soybean cropping systems. The overall result suggests that rice-soybean farmers in soybean cropping systems are more likely to be credit unconstrained. This is consistent with our earlier contention that given good access to income opportunities and better land types ( as in Hangdong and San Patong districts where many of the rice-soybean respondents came from ), farmers are more flexible in their household-liquidity position. This is further reinforced by the positive coefficient of X1 variable, which is statistically significant at 10 percent level . Farm income last season and amount of savings in financial institution also have their theoretically predicted sign which are both significant statistically at 5 percent level.

The opposing sign of X11 and X12 interaction variables, which are also significant at 5 percent level, is worth noting. The positive sign means that, with increased liquidity and the soybean farmer is from Chomtong, he is more likely to be credit unconstrained as compared to Doi Tao and other areas. This is an indication that total initial liquidity has a greater influence in the probability of being credit unconstrained than location. The reason could be due to some bio-physical constraints existing across districts. Farmers in Chomtong or even in Doi Tao, who are facing a relatively poorer soil type and insufficient water source tend to invest less in their farm operation than the farmers in Hangdong and San Patong. Hence, in order to minimize production risk , they are more inclined to use their household liquidity than avail of credit.

The negative sign for X11 means that, farm income, which varies from season to season, does not provide a more stable source of financial reserve to the farm-household than increase in total liquidity. So, the farmer has the tendency to exhaust his credit or even desires to borrow more than the amount granted in order to reinforced the financial position of the farm-household in a given year or season. Making him more likely constrained with credit (Gustafson, 1989).

About 78 percent of the credit unconstrained observations for soybean were correctly classified and the McFadden's R-squared of 0.36 also shows a very good fit strengthening the reliability of the overall Probit estimation ( Table 23 ).

## 5.2 The Second Stage Estimation: Optimization of the Output Functions

From the first stage estimation using the Probit model, we defined the Mills ratio or separation variable which are used as identifiability restriction to force the separation of the output equations of the two regimes in each crop ( equations 3 and 4 ). One of the properties of the Mills ratio[9/], is that the higher the value of the ratio the lesser is the probability that any given observation is having a data on $C^*_i = 1$ ( Heckman, 1976 ). Since this variable restricts or

9_/The estimation procedure of this variable is done internally by the computer software ( LIMDEP TM version 4.4, 1986 ).

truncates the two output regimes in each crop, then its overall influence to the output function is defined as truncation effect.

Then the final specification of the reduced-form of the output equation, included factors of production, dummy and interaction variables and the separation variable (the term $\sigma_{1i}W_i$ in equations 5 and 6) which are restated here as;

$$Y_{1i} = \beta_1 X_{1i} - \sigma_{1u} W_{1i} + \epsilon_{1i} \qquad \text{for credit unconstrained}$$

and,

$$Y_{2i} = \beta_2 X_{2i} + \sigma_{2u} W_{2i} + \epsilon_{2i} \qquad \text{for credit constrained}$$

These output equations ( credit unconstrained and credit constrained ) of the two crops estimated with the Cobb-Douglas specification, involved the same variables except for some dummy and interaction variables which had been dropped in the final run to obtain the best possible fit of the function ( Tables 24 to 27 ). The basic model in each cropping system describes the output equation of Doi Tao under rice-soybean cropping system with either having deposit in financial institution or stable source of off-farm income.

It should be noted that some variables e.g. D6, D7, or X1, were dropped in the final run of the output function in each regime across crops. The important basis of dropping among others were ; (a) the variable is not theoretically considered as a major determinant of the output function (b) it is highly insignificant statistically, and

(c) dropping such variable would improve the coefficient of determination of the function. Except for those already defined in the first stage estimation, the following variables are redefined and finally included in the output function specification:

a) Total liquidity ( LnLIQ ) (+) [10/] : this is value (Bht.) of product inventory, deposits in financial institution, fungible formal loan and other sources of cash. In other words, this consist of the total initial liquidity variable used in the first stage of the estimation plus the total amount of formal credit intended for the farm operation. It should be noted also, that this variable embodies the cash outlay spent on fertilizer, pesticides and other material cost used in the production process.

b) Labor ( LnLABOR ) : the quantity ( in man day ) of direct non-cash and cash labor used in the farm . The indirect labor expenses such as those spent on food etc., for hired and non-hired labor, is assumed to be absorbed in the total liquidity variable as part of material cost. The reason behind this apportionment, follows the basic assumption of the analysis that production and consumption spending of the farm-household are not totally independent with each other. Actual quantity of hired labor used is estimated from the farmers cash labor



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10/ The enclosed signs indicate the direction of influence of this variable to the output function. Those without any sign means that their priori effect can not be ascertained.

account with relative ease, hence it is separated. Unlike fertilizers, pesticides and other inputs where it is quite difficult to ascertain how much from the intended amount was actually used in the crop under consideration.

c) Land ( LnLAND ) : is the total area ( rai ) devoted to rice or soybean.

d) Capital ( LnCAP ) : value of non-liquid farm assets ( Bht. ) ( as explained in the Probit specification )

e) Seed ( LnSEED ) (+) : quantity of seed ( kg ) used in the farm area. This is identified as a separate variable and not as part of total liquidity, because the actual data showed that most farmers have their own reserved seed.

Table 24. Descriptive statistics of the relevant variables for rice output function ( unconstrained regime )

| Variable name | Mean | Standard deviation | Minimum value | Maximum value |
|---|---|---|---|---|
| Total farm output | 3882.100 | 3087.100 | 750.000 | 18000.000 |
| Cultivated land | 7.863 | 6.815 | 1.750 | 33.000 |
| Farm household capital | 42640.000 | 25604.000 | 1650.000 | 103300.000 |
| Total liquidity | 31324.000 | 13941.000 | 10100.000 | 87170.000 |
| Labor | 73.120 | 47.038 | 17.210 | 279.600 |
| Seed | 55.086 | 41.889 | 9.714 | 215.700 |
| Mills ratio or separation variable | 0.540 | 0.404 | 0.024 | 1.578 |

number of observations = 81

Table 25. Descriptive statistics of the relevant variables for rice output function ( constrained regime )

| Variable name | Mean | Standard deviation | Minimum value | Maximum value |
|---|---|---|---|---|
| Total farm output | 2630.700 | 1979.400 | 500.000 | 12000.000 |
| Cultivated land | 6.061 | 3.143 | 1.000 | 14.000 |
| Farm household capital | 30515.000 | 23283.000 | 1065.000 | 72456.000 |
| Total liquidity | 21141.000 | 12193.000 | 1100.000 | 62420.000 |
| Labor | 76.463 | 29.570 | 9.570 | 251.700 |
| Seed | 49.120 | 29.570 | 11.140 | 142.900 |
| Mills ratio or separation variable | -0.546 | 0.423 | -1.952 | -0.088 |

number of observations = 80

Table 26. Descriptive statistics of the relevant variables for soybean output function ( unconstrained regime )

| Variable name | Mean | Standard deviation | Minimum value | Maximum value |
|---|---|---|---|---|
| Total farm output | 1735.600 | 2173.600 | 205.000 | 16050.000 |
| Cultivated land | 8.486 | 6.222 | 1.750 | 33.000 |
| Farm household capital | 43817.000 | 25329.000 | 1650.000 | 93450.000 |
| Total liquidity | 31809.000 | 13231.000 | 14550.000 | 86170.000 |
| Labor | 48.692 | 37.825 | 9.268 | 183.500 |
| Seed | 86.420 | 66.371 | 10.000 | 345.600 |
| Mills ratio or separation variable | 0.598 | 0.402 | .003 | 1.751 |

number of observations = 66

Table 27. Descriptive statistics of the relevant variables for soybean output function ( constrained regime )

| Variable name | Mean | Standard deviation | Minimum value | Maximum value |
|---|---|---|---|---|
| Total farm output | 1198.400 | 1091.800 | 280.000 | 7000.000 |
| Cultivated land | 6.995 | 5.694 | 1.000 | 35.000 |
| Farm household capital | 31928.000 | 26561.000 | 850.000 | 62100.000 |
| Total liquidity | 19699.000 | 13914.000 | 420.000 | 54400.000 |
| Labor | 55.114 | 42.226 | 6.664 | 209.600 |
| Seed | 76.279 | 65.420 | 11.110 | 388.900 |
| Mills ratio or separation variable | -0.407 | 0.433 | -1.253 | -0.008 |

number of observations = 97

### 5.2.1 Simple Correlation of Explanatory Variables

Simple correlation among the explanatory variables of the reduced-form output equations are presented in Tables 28 to 31. High correlation are observed between land ( lnLAND ) and seed ( lnSEED ), some dummy and interaction variables. This correlation between land and seed is reasonable in the sense that demand for seed vary in the same direction with cultivated land size. Also, seed normally is used at a relatively fixed rate per unit of cultivated land. In fact most farmers especially in soybean used more quantity of seed[11] than what is recommended. Correlation also between the dummy and interaction variables can be expected since one is a function of the other interacting variable.



11_/The recommendation is 7 - 10 kg / rai but from the survey data, farmers used 14 - 16 kg / rai

Table 28. Correlation matrix of exogenous variables for the output function of credit constrained regime ( rice )

| Variable name | Correlation coeficient | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | lnQ | lnLAND | lnCAP | lnLIQ | lnLABOR | lnSEED | D1 | D2 | D3 | D4 | D6 | X1 | X11 | X12 | TRUNCATION |
| lnQ | 1.0000000 | | | | | | | | | | | | | | |
| lnLAND | 0.6502464 | 1.0000000 | | | | | | | | | | | | | |
| lnCAP | 0.3723285 | 0.4829818 | 1.0000000 | | | | | | | | | | | | |
| lnLIQ | 0.4349777 | 0.4576151 | 0.4245173 | 1.0000000 | | | | | | | | | | | |
| lnLABOR | 0.5561563 | 0.6716662 | 0.2957741 | 0.3196178 | 1.0000000 | | | | | | | | | | |
| lnSEED | 0.5467562 | 0.4716634 | 0.2846543 | 0.3126872 | 0.6658712 | 1.0000000 | | | | | | | | | |
| D1 | 0.3142484 | 0.1152832 | 0.0025999 | 0.1866969 | 0.1167495 | 0.1687754 | 1.0000000 | | | | | | | | |
| D2 | 0.1699096 | 0.1903911 | -0.0171369 | 0.1433854 | 0.1691673 | 0.3871645 | -0.2681025 | 1.0000000 | | | | | | | |
| D3 | -0.3748899 | -0.2650665 | -0.0370247 | -0.2716732 | -0.1720708 | -0.2456571 | -0.4236593 | -0.4921978 | 1.0000000 | | | | | | |
| D4 | -0.1026651 | -0.0315484 | 0.1149808 | -0.0485622 | 0.0419421 | 0.0914567 | 0.0413449 | 0.2502803 | -0.2016860 | 1.0000000 | | | | | |
| D6 | -0.2184119 | 0.0341662 | 0.0554203 | 0.2775692 | -0.0440300 | -0.0523789 | -0.0682375 | -0.1326844 | 0.2756065 | -0.2420654 | 1.00000000 | | | | |
| X1 | 0.3828674 | 0.2095515 | 0.0358662 | 0.1293546 | 0.1386817 | 0.1345678 | 0.9187707 | -0.2463247 | -0.3892457 | 0.0883643 | -0.08093310 | 1.0000000 | | | |
| X11 | -0.2782512 | -0.3153556 | -0.2270547 | -0.4510116 | -0.1985009 | -0.3871246 | -0.2137981 | -0.2483858 | 0.5046463 | 0.0853773 | 0.0267418 | -0.1964314 | 1.0000000 | | |
| X12 | -0.1244683 | 0.0172762 | 0.0967113 | 0.2516673 | 0.0048142 | 0.2345671 | -0.3000946 | -0.3486432 | 0.7083396 | -0.2675981 | 0.42206200 | -0.2757182 | 0.2845700 | 1.0000000 | |
| TRUNCATE2 | -0.3432937 | -0.2089305 | 0.4025119 | -0.4744004 | -0.2463665 | 0.3564781 | -0.0815654 | 0.0318512 | -0.0776426 | -0.0334093 | -0.03615430 | -0.1531564 | -0.0370234 | -0.3603053 | 1.00000000 |

Table 29. Correlation matrix of exogenous variables for the output function of credit unconstrained regime ( rice )

| Variable name | Correlation coeficient | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | lnQ | lnLAND | lnCAP | lnLIQ | lnLABOR | lnSEED | D1 | D2 | D3 | D4 | D7 | X11 | X12 | TRUNCATION |
| lnQ | 1.0000000 | | | | | | | | | | | | | |
| lnLAND | 0.7012607 | 1.0000000 | | | | | | | | | | | | |
| lnCAP | 0.0658016 | 0.1987646 | 1.0000000 | | | | | | | | | | | |
| lnLIQ | 0.1999876 | 0.1428017 | 0.0169064 | 1.0000000 | | | | | | | | | | |
| lnLABOR | 0.1154391 | 0.1217080 | 0.0942949 | 0.0776342 | 1.0000000 | | | | | | | | | |
| lnSEED | 0.5277153 | 0.7077846 | 0.0895102 | -0.1038286 | 0.5691789 | 1.0000000 | | | | | | | | |
| D1 | 0.5119910 | 0.4331682 | 0.0176244 | 0.1007805 | 0.2800582 | 0.1784854 | 1.0000000 | | | | | | | |
| D2 | 0.0978927 | 0.1213302 | 0.0951105 | 0.1862856 | 0.0830368 | -0.0070373 | -0.3380386 | 1.0000000 | | | | | | |
| D3 | -0.4735769 | -0.4328262 | -0.1117262 | -0.2291889 | -0.3089831 | -0.1694765 | -0.5326482 | -0.4828765 | 1.0000000 | | | | | |
| D4 | 0.0819745 | 0.1432013 | 0.1014744 | 0.0289064 | 0.0559613 | 0.0512605 | 0.1520296 | 0.2798415 | -0.3616445 | 1.0000000 | | | | |
| D7 | 0.1296764 | 0.0532188 | -0.0499552 | -0.1647282 | -0.0180512 | 0.0227914 | 0.3047085 | -0.0209249 | -0.2237347 | 0.0785676 | 1.0000000 | | | |
| X11 | -0.3097158 | -0.3539093 | -0.1006847 | -0.1265545 | -0.2722941 | -0.1447637 | -0.4145953 | -0.3758547 | 0.7783661 | -0.1317814 | -0.17414750 | 1.00000000 | | |
| X12 | -0.4416324 | -0.3763973 | -0.0650017 | 0.0908069 | -0.3868146 | -0.2410035 | -0.4573125 | -0.4145804 | 0.8585640 | -0.3729434 | -0.19209050 | 0.67331850 | 1.0000000 | |
| TRUNCATE1 | -0.1722197 | -0.0853537 | -0.1959382 | -0.6116471 | 0.0947618 | 0.1287474 | -0.1802634 | -0.0237784 | 0.0950735 | -0.0476289 | 0.15669200 | 0.02652070 | -0.06628730 | 1.0000000 |

Table 30. Correlation matrix of exogenous variables for the output function of credit constrained regime ( soybean )

| Variable name | Correlation coeficient | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | lnQ | lnLAND | lnCAP | lnLIQ | lnLABOR | lnSEED | D1 | D2 | D3 | D4 | D7 | X1 | X11 | X12 | TRUNCATION |
| lnQ | 1.0000000 | | | | | | | | | | | | | | |
| lnLAND | 0.7747069 | 1.0000000 | | | | | | | | | | | | | |
| lnCAP | 0.2776756 | 0.2455783 | 1.0000000 | | | | | | | | | | | | |
| lnLIG | 0.4655014 | 0.4936095 | 0.3412539 | 1.0000000 | | | | | | | | | | | |
| lnLABOR | 0.2678220 | 0.3122738 | 0.1044888 | 0.0480197 | 1.0000000 | | | | | | | | | | |
| lnSEED | 0.7321230 | 0.8007704 | 0.2100314 | 0.3686920 | 0.2346080 | 1.0000000 | | | | | | | | | |
| D1 | 0.1208550 | 0.0785942 | 0.0797206 | 0.0106640 | 0.0825886 | 0.1201597 | 1.0000000 | | | | | | | | |
| D2 | 0.1387680 | 0.1529820 | -0.1283296 | 0.1610063 | 0.1987221 | 0.2114528 | -0.2585255 | 1.0000000 | | | | | | | |
| D3 | -0.3605865 | -0.4930609 | 0.0652099 | -0.2777684 | -0.2391057 | -0.3766579 | -0.3666984 | -0.4160706 | 1.0000000 | | | | | | |
| D4 | -0.1481896 | -0.1028499 | 0.1153539 | 0.1644707 | -0.0589013 | -0.0639483 | 0.0382926 | 0.2295422 | -0.0237708 | 1.0000000 | | | | | |
| D7 | 0.0037827 | 0.0663161 | -0.1935767 | 0.1068659 | 0.1624691 | 0.0058757 | -0.1099409 | 0.2205151 | -0.1142999 | 0.0181031 | 1.00000000 | | | | |
| X1 | 0.3117311 | 0.2445916 | 0.1690343 | 0.0569588 | 0.0980861 | 0.2427467 | 0.8392292 | -0.2169622 | -0.3077440 | 0.0046263 | -0.12581180 | 1.0000000 | | | |
| X11 | -0.1985583 | -0.2954483 | -0.0994672 | -0.2833345 | -0.1296781 | -0.1889295 | -0.1861804 | -0.2112477 | 0.5077207 | 0.1576047 | -0.10676610 | -0.1562480 | 1.00000000 | | |
| X12 | -0.1015955 | -0.1620284 | 0.1402293 | 0.1370791 | -0.1419812 | -0.1435512 | -0.2589768 | -0.2938454 | 0.7062391 | 0.0183979 | 0.07185300 | -0.2173409 | 0.37599190 | 1.00000000 | |
| TRUNCATE2 | -0.1912925 | -0.0353056 | -0.3566585 | -0.4882110 | 0.0091161 | 0.0353500 | -0.1356451 | -0.0495458 | 0.0296785 | -0.3861126 | -0.10437900 | -0.1617943 | -0.00904800 | -0.34394200 | 1.00000000 |

Table 31. Correlation matrix of exogenous variables for the output function of credit unconstrained regime ( soybean )

| Variable name | Correlation coeficient | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | lnQ | lnLAND | lnCAP | lnLIQ | lnLABOR | lnSEED | D1 | D2 | D3 | D4 | D6 | D7 | X1 | X11 | X12 | TRUNCATION |
| lnQ | 1.0000000 | | | | | | | | | | | | | | | |
| lnLAND | 0.7829973 | 1.0000000 | | | | | | | | | | | | | | |
| lnCAP | 0.2012021 | 0.2248291 | 1.0000000 | | | | | | | | | | | | | |
| lnLIQ | 0.1807465 | 0.1452647 | -0.0792084 | 1.0000000 | | | | | | | | | | | | |
| lnLABOR | 0.1300784 | 0.0287421 | -0.0719167 | 0.1499118 | 1.0000000 | | | | | | | | | | | |
| lnSEED | 0.6523886 | 0.8136283 | 0.2086499 | 0.2003509 | 0.1521313 | 1.0000000 | | | | | | | | | | |
| D1 | 0.4634489 | 0.4024688 | 0.0240059 | 0.0618819 | 0.1276176 | 0.2518784 | 1.0000000 | | | | | | | | | |
| D2 | 0.0209549 | 0.0389190 | 0.0946459 | 0.2082978 | 0.1227299 | 0.1243491 | -0.4183300 | 1.0000000 | | | | | | | | |
| D3 | -0.4539032 | -0.3897460 | -0.1097225 | -0.2596337 | -0.1957239 | -0.2949510 | -0.4666667 | -0.4183300 | 1.0000000 | | | | | | | |
| D4 | -0.0692940 | -0.0002721 | 0.0636237 | -0.0925368 | -0.3137895 | -0.0692940 | 0.0111536 | 0.2177423 | -0.0706398 | 1.0000000 | | | | | | |
| D6 | -0.0657985 | -0.1939893 | -0.2710426 | 0.0715020 | 0.2703489 | -0.1225281 | -0.1261630 | 0.0069444 | 0.1660040 | -0.2955074 | 1.00000000 | | | | | |
| D7 | 0.044049 | 0.0637776 | -0.0478859 | -0.1664679 | 0.2106635 | -0.0216355 | 0.2365985 | -0.075308 | -0.2160247 | -0.1084259 | -0.07530800 | 1.0000000 | | | | |
| X1 | 0.6279677 | 0.6404092 | 0.0647423 | 0.1993552 | 0.0799031 | 0.4961450 | 0.7519773 | -0.3145747 | -0.3509228 | -0.0336843 | -0.04253230 | 0.0442180 | 1.0000000 | | | |
| X11 | -0.3010196 | -0.3009003 | -0.0963209 | -0.1143648 | -0.1825278 | -0.2772413 | -0.3546181 | -0.3178872 | 0.7598959 | 0.1381983 | 0.02530900 | -0.1641563 | -0.2666647 | 1.00000000 | | |
| X12 | -0.4190757 | -0.3670653 | -0.1088052 | -0.1230580 | -0.1955078 | -0.2893855 | -0.4405599 | -0.3949274 | 0.9440570 | -0.0734978 | 0.18673920 | -0.2039396 | -0.3312911 | 0.76334680 | 1.0000000 | |
| TRUNCATE1 | -0.2876663 | -0.1974631 | -0.1433572 | -0.4904964 | 0.1206676 | -0.1872675 | -0.2468626 | -0.0801981 | 0.1203326 | -0.3130698 | 0.06806600 | 0.1572276 | -0.3698594 | 0.06047250 | 0.0319938 | 1.00000000 |

High correlation among variables may cause multicollinearity problems. If it is very serious, the independent effect of the correlated variables to the dependent variable is difficult to disentangle, leading us to infer a wrong conclusion about our model. However, judging from the result of the estimated output equations, seemingly the degree of multicollinearity problem is not harmful to the model estimation because the estimated coefficient of one or both correlated variables are statistically significant. Hence, the degree of multicolleniarity problem existing among variables in the model is not serious in this study.

### 5.2.2 Impact of Credit on Farm Productivity of Rice

Estimated coefficients of the reduced-form output equation are presented in Table 32. Both in the credit unconstrained equation ( regime 1 ) and credit constrained equation ( regime 2 ), land, liquidity, labor and D4 ( rice-soybean cropping systems, dummy ) are statistically different from zero ranging from 2.5 percent to 10 percent level of significance. Across regimes, land, labor and liquidity are the dominant output determinants. In the unconstrained regime for example, the positive value of the estimated coefficient for land means that for every 1 percent increase in farm size, total farm output will increase by .31 percent. The marginal change of farm output therefore is reflected in the value of the coefficient and the direction of effect is given by the sign.

Table 32. Estimated coefficients of the output functions of rice in two regimes, adjusted for truncation effect

| Variable name | Regime 1 (credit unconstrained) | | Regime 2 (credit constrained) | |
|---|---|---|---|---|
| | Estimated coefficient (std. error) n = 81 | t-ratio | Estimated coefficient (std. error) n = 80 | t-ratio |
| lnLAND | 0.3134080 | 2.803 *** | 0.377217 | 2.300 *** |
| | (.1118) | | (.1640) | |
| lnCAP | -0.0387517 | -0.846 | 0.0810215 | 1.533 |
| | (.04569) | | (.05285) | |
| lnLIQ | 0.213539 | 1.576 * | 0.298640 | 2.762 *** |
| | (.1335) | | (.1081 ) | |
| lnLABOR | 0.1646520 | 1.746 * | 0.243814 | 1.873 ** |
| | (.09433) | | (.1302 ) | |
| lnSEED | 0.1877190 | 1.855 ** | -0.0976444 | -0.861 |
| | (.1012) | | (.1134) | |
| D1 | 0.567755 | 2.588 ** | -0.381496 | -1.104 |
| | (.2194) | | (.3457) | |
| D2 | 0.348199 | 2.015 ** | 0.316935 | 1.827 ** |
| | (.1728) | | (.1735) | |
| D3 | 0.0815832 | 0.343 | 0.0179393 | 0.100 |
| | (.2377) | | (.1797) | |
| D4 | -0.1823380 | -1.692 | -0.398271 | -3.717 *** |
| | (.1078) | | (.1072) | |
| D6 | --------- | ----- | -0.478368 | -3.429 *** |
| | | | (.1395) | |
| D7 | 0.1459000 | 0.818 | ----- | ----- |
| | (.1783) | | | |
| X1 | --------- | ----- | 0.127470 | 2.625 *** |
| | | | (.04857) | |
| X11 | 0.00011974 | 1.449 | 0.0000651 | 1.939 |
| | (.0000826) | | (.000033) | |
| X12 | -0.0000119 | -1.829 ** | -0.00000679 | -1.241 |
| | (.00000519) | | (.000005476) | |
| Truncation Effect | -0.1332790 | -1.071 | -0.0662263 | -0.509 |
| | (.1244) | | (.1302) | |
| Constant | 4.23161 | 2.633 *** | 2.79339 | 2.186 *** |
| | (1.607) | | (1.278) | |
| R-squared | 0.642 | | 0.700 | |

*** - .01 level of significance
** - .05 level of significance
* - .10 level of significance

The negative sign of rice-soybean cropping systems dummy (D4) seems to contradict with intuitive notion that any crop following soybean (leguminous crop ) will stabilize or even improve its yield performance considering the N-fixing characteristics of the soybean. Actually, this direction of effect could be correct for the following reason. Incidentally, the respondents for rice in this study, are either rice-soybean systems and rice-garlic/onion or rice-tomato system. In the first cropping system ( rice-soybean ), a relatively minimal fertilization is done to soybean before rice comparing with the later two systems where heavy application of chemical fertilizer, manure and pesticides are commonly practiced, making the residual soil fertility before rice, higher than that of soybean. This might be a location specific case, but as a matter of fact, it is a common knowledge in the area that rice after onion, garlic or tomato ( as in Hangdong , San Patong and part of Chomtong ) yields comparably higher than after soybean ( AGS704 , 1991 ). D1 ( Hangdong dummy ) X12 ( Chomtong * liquidity ) interaction variable are statistically different from zero at 10 percent level of significance in the unconstrained but not in the constrained regime.

The positive sign for Hangdong and San Patong dummy variables imply that rice tend to yield more in these areas while in Chomtong it has the tendency to yield lower even with favorable liquidity ( as reflected in X12 variable ). The reasons for this could be that; soil type is much better in Hangdong than in Chomtong and, Hangdong has more predictable water source than in Chomtong.

There are two estimated coefficients that are statistically different from zero at 2.5 percent level which are specific in the credit constrained regime. These are; D6 ( off-farm work dummy ) and X1 ( Hangdong * Land interaction). The significance of D6 dummy with a negative sign, implies that having a stable work outside would reduce the time devoted for farm operation, influencing a decreasing effect to farm output. The reason is that, since the farmers are liquidity (credit) constrained, the fungibility of the extra income is bias toward other pressing farm-household needs instead of using it to hire more labor to compensate for lesser management time. The interaction between cultivated land and Hangdong dummy suggests that cultivated land in Hangdong exerts a greater effect in raising total farm output than land in Doi Tao. The same reason as mentioned earlier, about land type applies to this situation.

Moreover, the truncation variable is found out to be not significant in both regimes. This implies that the two output functions do not exhibit bias toward separation from each other. Hence, we conclude that the two functions can be combined into one to represent both regimes and that credit utilization across regimes are not different. This is also reinforced by the significance of the liquidity variable in both regimes.

Finally, both the F-statistics of the output equation in both regimes are statistically different from zero at 1 percent level of significance. The R-squared at 0.64 and 0.70 for regime 1 and regime 2 respectively suggest that the variations in total farm output are adequately explained by the variations in the exogenous variables.

### 5.2.3 Impact of Credit on Farm Productivity of Soybean

Table 33 shows the estimated coefficients of the credit unconstrained and credit constrained output equations of soybean cropping systems. Only land is found out to be statistically different from zero at 2.5 percent level of significance in both output regimes. The positive signs of the coefficients (ln LAND ) of the two regimes imply the same meaning that soybean yield increases with land size as expected. On the average, 1 percent increase in cultivated land raises total output by about .60 percent.

The total liquidity variable on the other hand, is statistically different from zero at 7.5 percent level of significance, only in the credit constrained regime. This means, the null hypothesis that total liquidity is not an important yield determinant is only rejected in the credit constrained regime. The 0.089 estimated coefficient of the total liquidity ( LnLIQ ) variable suggests a rather small change in total farm output i.e. 0.1 percent, for every 1 percent change in household liquidity. The reason for this could be that there is a significant diversion of credit money for non-productive use in this group as implied by a greater percentage of farmers being credit constrained ( Table 11 ).

Labor and off-farm income (D6) are statistically significant at 10 percent level. The positive value of the estimated coefficient of labor means that in the short-run, output can increase by 0.179 percent from the mean value if we increase labor input by 1 percent. More stable off-farm income also would influence an increasing effect to the total farm output. This is because the tendency of the farmer to spend

Table 33. Estimated coefficients of the output functions of soybean in two regimes, adjusted for truncation effect

| Variable name | Regime 1 (credit unconstrained) | | Regime 2 (credit constrained) | |
|---|---|---|---|---|
| | Estimated coefficient (std. error) n = 66 | t-ratio | Estimated coefficient (std. error) n = 97 | t-ratio |
| lnLAND | 0.590775 (.1542) | 3.832 *** | 0.391543 (.1163) | 3.366 *** |
| lnCAP | 0.005963 (.0739 ) | 0.081 | 0.0057575 (.0311 ) | 0.185 |
| lnLIQ | -0.198505 (.2248) | -0.883 | 0.074138 (.05953) | 1.246 * |
| lnLABOR | 0.1724 (.1050 ) | 1.642 * | 0.109502 (.05829) | 1.879 ** |
| lnSEED | 0.11335 (.1248) | 0.909 | 0.294252 (.1053) | 2.795 *** |
| D1 | -0.031714 (.2627) | -0.05 | -0.201337 (.1954) | -1.03 |
| D2 | -0.22193 (.2185) | -1.061 | 0.143171 (.1262) | 1.232 |
| D3 | -0.65329 (.3962) | -1.649 | 0.187382 (.1618) | 1.158 |
| D4 | 0.170557 (.1638) | 1.047 | -0.291802 (.08355) | -3.492 *** |
| D6 | 0.263249 (.1364) | 1.930 ** | ----- | ----- |
| D7 | -0.11037 (.18432) | -0.599 | -0.063087 (.1132) | -0.557 |
| X1 | 0.0091600 (.01847) | 0.496 | 0.0490072 (.021052) | 2.329 *** |
| X11 | 0.00009336 (.00007653) | 1.206 | 0.00003009 (.00002865) | 1.104 |
| X12 | -0.000000165 (.00001261) | -0.129 | -0.00000954 (.000007994) | -1.193 |
| Truncation Effect | -0.271178 (.1712) | -1.584 * | -0.350138 (.1193) | -2.936 *** |
| Constant | 7.03612 (2.713) | 2.594 *** | 3.69436 (.6794) | 5.441 *** |
| R-square | 0.710 | | 0.724 | |

*** - .01 level of significance
** - .05 level of significance
* - .10 level of significance

the additional income to hire labor and to purchase farm inputs, is also greater being a liquidity ( credit ) unconstrained farm-household.

The result of the estimation in the credit constrained regime suggests that labor, seed and total liquidity are the most important yield determinants in the short run, and that capital ( non-liquid farm assets ) is less likely to contribute to increasing yield. The dummy variable D4 ( rice-soybean, dummy ) and X1 (Hangdong * land interaction) are also found out to be statistically different from zero at 2.5 percent level in the constrained regime.

The significance of rice-soybean cropping systems dummy (D4) with a negative coefficient, suggests a slightly different implication from that of rice as follows: Respondents in soybean systems are either rice-soybean cropping systems or soybean and others ( like garlic, upland rice, and other upland crops commonly practice in Doi Tao and part of Chomtong ). Most of the rice-soybean respondents were from Hangdong and San Patong which are basically lowland rice condition. This differences in location and physical environment of the soil may have caused this negative effect in the total yield because normally soybean performs better in well drained upland condition than in the irrigated lowland ( Pandey, 1987 ).

The positive coefficient of X1 with statistical significance at 7.5 percent level, follows the same line of reasoning with that of rice in that increasing cultivated area on the average would have a greater impact in raising farm output, if it is located in Hangdong than in Doi Tao.

Finally, the truncation effect variables are statistically significant at 7.5 percent and 2.5 percent level in both credit unconstrained ( regime 1 ) and credit constrained ( regime 2 ) respectively. This implies that the two output regimes are statistically bias toward separation. The correctness of the specified model is reflected in the statistical significance of the F-test at 1 percent level and the R-squared are 0.71 and 0.72 for credit unconstrained and credit constrained regime respectively.

## 5.3. Policy Implications

Important policy implications from the result of the output optimization can be drawn from the relationship of the estimated marginal value product ( MVP ) and marginal factor cost ( MFC ) of three important inputs such as labor, total liquidity and seed. At a given price situation, optimum input use is attained when MVP, which is the rate of change in revenue per unit use of any particular input, equals MFC or the unit cost of an input under consideration ( Beattie and Taylor, 1985 ).

Marginal factor costs used in the analysis are; mean wage rate in each district for labor, interest rate of money for total liquidity and price per kilogram of seed. Marginal value product of an input is derived by multiplying the marginal product with the expected price of the output.

The estimated MVP of each input across estimation regimes are presented in Tables 34 and 35. The result shows that the MVPs of labor and total liquidity across cropping systems are generally lower than their corresponding MFCs. This means that there is an over utilization of these inputs in the production of both crops. The reason is that, in the case of labor, given the quantity of farm-household labor available, the farmer has the tendency to over utilize it for a given activity per unit time eventhough its marginal product is almost zero. This is observable under the Thai culture, where farmers feel more comfortable if they work together in the field and share the output as a family. Also, even if any member of the household finds an

Table 34. Estimated marginal value product ( MVP ) of major inputs for rice in each district across output regimes

| Major Inputs | Unconstrained ( Baht ) | | | | Constrained ( Baht ) | | | | MFC (Bht) |
|---|---|---|---|---|---|---|---|---|---|
| | Hangdong | S Patong | Chomtong | Doi Tao | Hangdong | S Patong | Chomtong | Doi Tao | |
| Labor | 3.6700 | 2.6900 | 2.2600 | 2.0800 | 4.0400 | 7.4600 | 5.7900 | 5.4324 | * |
| Total liquidity | 0.0200 | 0.0140 | 0.0110 | 0.0100 | 0.0250 | 0.0400 | 0.0320 | 0.0300 | 0.105 |
| Seed | 8.6100 | 6.9000 | 5.2900 | 4.8800 | 11.3100 | 14.5600 | 10.6100 | 7.8800 | 7.0000 |

Table 35. Estimated marginal value product ( MVP ) of major inputs for soybean in each district across output regimes

| Major Inputs | Unconstrained ( Baht ) | | | | Constrained ( Baht ) | | | | MFC (Bht) |
|---|---|---|---|---|---|---|---|---|---|
| | Hangdong | S Patong | Chomtong | Doi Tao | Hangdong | S Patong | Chomtong | Doi Tao | |
| Labor | 0.7100 | 0.5600 | 0.3640 | 0.7000 | 1.5000 | 1.8000 | 1.7300 | 1.2300 | * |
| Total liquidity | 0.0010 | 0.0010 | 0.0010 | 0.0010 | 0.0020 | 0.0028 | 0.0030 | 0.0024 | 0.105 |
| Seed | 0.2176 | 0.2150 | 0.1720 | 0.1120 | 4.0000 | 5.5900 | 5.8500 | 4.8500 | 15.0000 |

*/ mean wage rate across districts vary; Hangdong and San Patong is 60 Bht./day, Chomtong is 50 Bht/day and Doi Tao is 45 Bht/day

off-farm work , he still has to work in the field after regular hours in order to have the feeling of being part in the family work. In this case the opportunity cost of labor in a family farm is well near zero. This result of near zero marginal product of labor, is consistent with the findings of Zhang ( 1991 ) and Wiboonpongse ( 1983 ).

The estimated MVP for total liquidity on the other hand, implies an excess quantity of liquidity being used and it does not imply that fertilizers, pesticides and other material cost is overapplied to both crops. The major reason is that the total liquidity variable includes also non-farm expenditures. The impact of liquidity on output is thus very small. One possibility is that, from the quantity of fertilizer or pesticides intended for rice or soybean production, not the entire amount was directly applied. Some might have been diverted to other crops resulting in the reduction of effect to the intended crops ( rice or soybean ). This was a common observation for pesticides and fertilizers in rice system where cash crops e.g. garlic, onion, tomato etc. follow after rice. Another possibility is the timing of application. Some farmers might have applied not at the appropriate time of crop growth where optimum effect of inputs can be expected.

Relevant point that should also be emphasized concerning this liquidity variable is that, if we can not separate farm and non-farm expenditures we can not detect the direct impact of chemical inputs on production. This means to say that if liquidity is raised and it is fungible to any purpose, the impact of liquidity ( loan ) on output will be very little. So it is not the case of over utilization of these inputs. However, this does not mean that farmers need less credit . On the contrary credit must be provided for other purpose beside farming.

Reallocation therefore of loan is required, i.e. less hiring of labor and more chemical inputs. This is possible only if no time constraint in land preparation and harvesting. Furthermore, excessive use of family labor during the season should bring about higher productivity if improved technology calls for this additional crop care.

The MVP for seed across regimes in two cropping systems suggest a different implication. On the average, those basically rice growing areas such as Hangdong and San Patong are using seed at just about the recommended rate while in soybean areas e.g. Chomtong and Doi Tao used more seeds than what is recommended. In soybean cropping system, this notional use of seed conform to the biophysical and economic limitation of the farm-household. That is , if the farmer is faced with many constraints e.g. size and quality of arable land, cash to buy inputs and others, he has the tendency to use more of his non-cash inputs such as seed, in order to maximize total return per unit of time. Unlike in rice growing areas with good access to technology, irrigation and better land types, the farmers are more likely to follow optimum seed use.

Drawing from these marginal analyses of inputs of the two crops, we can say that the important issue on productivity across cropping systems is more on how the inputs are used under a given socio-economic constraints. The generally over utilization of inputs particularly labor, to the production process, suggests that at the present volume of credit that the bank is lending to rice or soybean farmers, and the existing price situation in the market, improvement on farm productivity of both crops can be effectively attained by diverting these excess inputs to other uses or by introduction of new technology that can improve the utilization pattern of these inputs.