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# Inseparability Test on Wheat Production in Nepal: A Case Study of Saptari District

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## Introduction

The main objective of this paper is to find out the interrelationship of inputs in wheat production in Nepal using a micro level data. In our country, the production of wheat and area of wheat cultivation are estimated to have increased by 25.6 percent and 20.6 percent respectively in 1982–83 in comparision to the previous year. The share of Saptari district in the total production of wheat in Nepal was 2.36 percent in 1982–83. Keeping in view the share of Saptari district in the total wheat production of Nepal, this study is designed to test the complementarity as well as separability of inputs.

## Methodology

*Data Source*

The present study is based upon primary field survey cross-sectional data collected from *Bisahariya* village panchayat of Saptari district in 1982–83. An appropriate questionnaire was structured covering various aspects of the household economy, and wheat producers were interviewed. The simple random sampling method was used to select about sixteen percent households. Altogether the sample consists of ninety five households.

*Separability Test*

Log–quadratic production model has been used to express the local approximation. The linear production can be expressed as $Y = f(x_1, x_2)$ where Y is the output and $x_1, x_2$ are factors of production. It can be expressed in regression equation as

$$Y = a_0 + a_1 x_1 + a_2 x_2$$

Where $a_0$ is the interecept of Y when factors of production are zero and $a_1$ and $a_2$ are coefficients of $x_1$ and $x_2$ respectively. The same expression can be expressed in log-quadratic equation as

$$\ln Y = \ln a_0 + a_1 \ln x_1 + a_2 \ln x_2 + a_{11} \ln x^2 + a_{12} \ln x_1 x_2 + a_{22} \ln x^2$$

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This type of model with second order terms to a log-linear production function represent the log-quadratic of local approximation. This can be expressed with the help of Taylor expansion:

in the zero order approximation

$$f(x) \qquad f(\bar{x})$$

In the first order approximation

$$f(x) \qquad f(\bar{x}) + df/dx\,(\bar{x})\ 3 < x$$

In the second order approximation

$$f(x) \qquad f(\bar{x}) + df/dx\,(\bar{x}) < x + d^2f/dx^2\,(\bar{x}) < x$$

The above expression is for a single input-output space. In our production model. however, it can be shown in the co-efficient form as

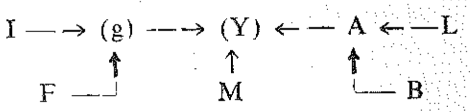
$$Y = a_0 + (a_1 a_2)\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + (x_1 x_2)\begin{pmatrix} a_{11} & a_{12} \\ a_{12} & a_{22} \end{pmatrix}\begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

Where $a_0$ is the intercept of y, $a_1$ and $a_2$ are the first order co-efficients of $x_1$ and $x_2$ respectively whereas $a_{11}, a_{12}, a_{22}$ are the second order coefficients of $x^2, x_1x_2, x^2$ respectively.

The magnitute of $a_{12}$ represents the degree of complementarity of substitutability(*Berndt and Christensen, 1973)*. In a log-quadratic model, a zero value of $a_{12}$ implies a Cobb-Douglas production structure with unit elasticity of substitution between $x_1$ and $x_2$ *(Bhadra, 1982)*. If the sign of the coefficient term $a_{12}$ is positive then $x_1$ and $x_2$ are complementary and if the sign of it is negative then these are substitutes. In log-quartic production model, if the sign of the coefficient of $x_1^2$, $x_2^2$ term is negative then $x_1$ and $x_2$ are inseparable otherwise they are separable.

*Production Process*

The use of labour, and buliock are increased proportionately according to the size of land. The relationship of these inputs with output is not direct but indirect through land variable. Irrigation and chemical fertilizer are used simulteneously, hence they are complementary of each other and functions of 'g' where 'g' is functional notation.




Here, Y is output, I is irrigation, F is chemical fertilizer, L is labour, B is bullock M is manure, A is wheat cultivated land and g stands to denote functional relation with output.

*Regression Equation*

Using the Cobb-Donglas Production function, our regression equation is

$$\ln Y = \ln b_0 + b_1 \ln L + b_2 \ln B + b_3 \ln M + b_4 \ln F + b_5 I + u$$

where,

Y = Output of wheat in Kgs/ha.

L = Labour in mandays/ha.

B = Bullock in bullockdays/ha

M = Manure in dokos/ha.

F = Chemical fertilizer in Kgs/ha.

I = Percentage of irrigated land of the wheat cultivated land.

u = Error term.

Our hypothesis are (a) there is statistical significant relationship between output and inputs of wheat.

(b) There is complementarity between chemical fertilizer and irrigation, and (c) there is inseparable relationship between chemical fertilizer and irrigation.

**Results and Interpretations**

*Production Process*

The use of labour and bullock are proportionate to land. In this study the total wheat cropped land (A) in hectare, total labour in labour-days and total bullock in bullock-days have been considered to estimate the production process as:

$$L = -0.5459 + 109.1644^{*} A \qquad R^2 = 0.8561$$
$$\quad (1.9031) \qquad (4.6914)$$

$$B = -0.7 + 147.7333^{*} A \qquad R^2 = 0.8201$$
$$\quad (2.9687) \qquad (7.3799)$$

Here standard error are paranthesized. It should be noted that the correlation of labour, bullock with land are 93 and 90 percent respectively. As shown above, the coefficient of land is positive and highly significant even at 99 percent confidence level. In both the equations the regression lines are passing through origin, indicated by the insignificant t-value of intercept. From the coefficient values the inference can be drawn that the relation of land with labour and bullock is direct.

*Cobb-Douglas Prodnction Function*

Cobb-Douglas Production Function has been estimated on the assumption that the agriculture production functions are linearly homogeneous of degree one in land and the elasticity of substitution is unity.

In model (1) Cobb - Douglas production function has been estimated. Here intercept and the coefficients of manure, chemical fertilizer and percentage of irrigated land of wheat cultivated land are positive and significant at 95 percent confidence level showing the positive and significant effects of these inputs on output. The coefficient of labour is positive and insignificant and the coefficient of bullock is negative and insignificant at 95 percent confidence level showing that there are not significant effects of labour and bullock on output of wheat. It shows that these inputs are over employed on wheat cultivation. $R^2$ is 0.9935, which explains 99.35 percent of total variation in output by the variation in inputs considered.

**Table–1**

**Estimated Production Functions**

| Model No. | $R^2$ | Intercept | ln L | ln B | ln M | ln F | % I | FI | $F^2I^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Coefficient of | | | | |
| (1) | 0.9935 | 0.6013* | 0.1858 | −0.2280 | 0.1424* | 0.0441* | 0.0456* | | |
| | | (0.0615) | (0.1866) | (0.1748) | (0.0456) | (0.0172) | (0.0089) | | |
| (2) | 0.9938 | 0.6133* | 0.1829 | −0.2359 | 0.1366* | 0.0343* | −0.0298 | 0.1684* | |
| | | (0.0611) | (0.1844) | (0.1728) | (0.0513) | (0.0179) | (0.0431) | (0.0941) | |
| (3) | 0.9941 | 0.5928* | 0.2067 | −0.2171 | 0.1335* | 0.0287 | −0.0359 | 0.3018* | −0.0282* |
| | | (0.0609) | (0.1816) | (0.1701) | (0.0444) | (0.0178) | (0.0424) | (0.1136) | (0.0139) |

* Significant at 95 percent confidence level. Standard errors are bracketed under respective coefficients.

**Table–2**

**Sums of Elasticities**

| Model No. | ln L | ln B | ln F | % I | F I | $F^2 I^2$ | Sums |
|---|---|---|---|---|---|---|---|
| | Co-efficient of | | | | | | |
| (1) | 0.1858 | −0.2280 | 0.0441 | 0.0456 | | | 0.1898 |
| (2) | 0.1829 | −0.2359 | 0.0343 | −0.0298 | 0.1684 | | 0.2565 |
| (3) | 0.2067 | −0.2171 | 0.0287 | −0.0359 | 0.3018 | −0.0282 | 0.4459 |

**Table–3**

**Correlation Matrix**

| | | | | | | |
|---|---|---|---|---|---|---|
| ln Y | × | | | | | |
| ln L | 0.0638 | × | | | | |
| ln B | 0.0865 | 0.8119 | × | | | |
| ln M | 0.2750 | 0.2042 | 0.3480 | × | | |
| ln F | 0.4961 | 0.0517 | 0.0532 | 0.0867 | × | |
| % I | 0.5125 | 0.0660 | 0.0485 | 0.0197 | 0.3878 | × |
| | ln Y | ln L | ln B | ln F | ln F | % I |

*Log–Quadratic and Log–Quartic Production Function*

Translog or log-quadratic production function has been estimated to test the complementarityor substitutability between chemical fertilizerand irrigation. In model (2) log-quadratic production function has been estimated with only one secondorder interaction terms of chemical fertilizer and irrigation. Intercept and the coefficient of manure, chemical fertilizer and F I are positive and significant at 95 percent confidance level. The sign of second order interaction term F I is positiveand significant.This clearly indicates that chemical fertilizer and irrigation are not substitute but comlemepntary to each other. Therefore, they are not independent to each other. $R^2$ is 0.9938, which explains 99.38 percent of total variation in output by inputs considered here.

The estimation of the log–quartic production function adding fourth order interaction term of chemical fertilizer and irrigation ($F^2 I^2$) in model no. (2) will definitely increase the values of the sums of elasticities and $R^2$. In model no. (3) $F^2 I^2$ term has been included. The model in this case clearly assumes that there exists inseparability between chemical fertilizer and irrigation. Therefore, a log–quartic model has been estimated to test that if the log–quadratic explanation of complementarity between chemical fertilizer and irrigation is correct then the coefficient of quartic term must be negative in sign. Intercept and the coefficients of manure, second order F I term are positive and fourth order $F^2 I^2$ term is negative and significant at 95 percent confidence level.The coefficients of bullock and irrigation are negative and insignificant and 95 percent confidence level. Obviously, the sign of quartic $F^2 I^2$ term is negative and significant,which explains that chemical fertilizer and irrigation are not separable but completely inseparable.,$R^2$ value has increased as compared to $R^2$ of model no. (2). was it increased after taking into account the number of variables also ? isc. is $R^2$ really increased ? I$^t$ should be however, noted that these two inputs,chemical fertilizer and irrigation are the function of 'g' as shown in the producion process, affecting the output simultaneously and these are not separable.

**Major Findings**

On the basis of the interpretation and analysis of the data presented in the preceding sections of this paper the following inferences have been drawn:

In production process the output of wheat is related with inputs like labour and bullock via land. The farmer generally uses labour and bullock to prepare land for cultivation. Therefore, they are highly related with land. If there exist multicollinearity problem, it not only affects the cofficients of the variables causing multicollinearities but also affects the coefficients of other variables as well. In such a situation effect of multicollinearity has to be removed in any way. Otherwise the whole model will be of no value for interpretation. In almost all the models analysed above, labour and bullock are not significant at 95 confidence level owing to multicollinearity problem, because they are highly collinear as shown in table 3. It should however, noted that chemical fertilizer irrigation are the functions of 'g' which simultaneously affect the production of wheat.

The analysis of the data also shows that the sums of the elasticities in modelsno.(1)(2) and (3) are 0.1898,0.2565and0.4459 respectively which are less than unity, providing decreasing returns to scale in wheat cultivation in the study area.

From model No. (2),it can be noted that chemical fertilizer and irrigation arenot independent. From model No.(3),it is explicit that chemical fertilizer and irrigation are inseparable factors. Therefore, when farmers use irrigation they must use chemical fertilizer simultaneously to promote the agricultural productivity. Therefore,the government should invest on irrigation as well as chemical fertilizer to develop agriculture. If irrigation facilities are improved,the demand for chemical fertilizer would naturally increase in the case of wheat growers. And, then investment in chemical fertilizer factory arises to fulfil the demand of farmers. The establishment of new factory of chemical fertilizer raises the demand for power. Therefore, government should invest on irrigation, chemical fertilizer factory and power resources simultaneously to develop its agriculture.

In all models the explanatory power ( F–statistics ) is highly significant at 95 percent confidence level. Hence, it provides us the evidence for accepting the alternative hypothesis, viz., $b_1 \neq 0$ (where $s = 0, 1, 2, 3, 4, 5, 6, 7$). To sum up, it is found that there is statistically significant relationship between the production of wheat and its inputs as considered above.

**Recommendations**

It is obvious from the nature and analysis of data that such a study can be enormously usesful for framing agricultural policies in Nepal, where the bulk of the population have to rely on agriculture which is the source of their livelihood. On the basis of the major findings in this study, the following suggestions have been made:

1. The models estimated above for wheat production may also be applicable to other agricultural production and production areas like industry, etc.
2. Chemical fertilizer and irrigation are complementary to each other. Hence, the farmers are suggested to use chemical fertilizer and irrigation inputs together. And, the departments and agencies concerned are also suggested to provide the facilities of these inputs in the area concerned, at proper time.
3. It is clear in all models that the coefficients of labour and bullock are insignificant at 35 percent confidence level. It shows the over employed on wheat cultivation. Therefore these inputs should be transferred to other uses.
4. From the fourth order term, it is obvious the chemical fertilizer and irrigation are inseparable ingredients in the field of agricultural production. So it is also suggested that the government should invest on chemical fertilizer and irrigation together which will eventually increase the agricultural productivity.
5. As a matter of fact, increment in agricultural production has two effects; Frist,it maintains the growing demand of food-grains by people without increasing cultivated land

from forest and other areas. Secondly, it also increases the extra crop residues for growing cattle population, which has positive effect on forest by reducing the fodder demand. So that, the problem of deforestation can be checked through agricultural progression.

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