PRODUCTION EFFICIENCY OF CAULIFLOWER (*BRASSICA OLERACEA* var. *BOTRYTIS*) AT CIRATEUN, WEST JAVA, INDONESIA[1]

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Introduction

A. Background of Research

The major objectives set forth in the fourth Five-year Development Plan (1984/85 - 1988/89) are mainly aimed at increasing agricultural production, including the production of vegetables. In addition to meeting food requirements, increasing production should be aimed at enlarging the farmer's income. At present, the production of certain kinds of vegetables already exceeds domestic consumption requirements, while exporting surpluses faces various difficulties (Sunarjono, 1971). Therefore, efforts to increase production should be focused on those crops which presently yield a low product, are technically improvable, and have a sound economic and nutritional value. Cauliflower (*Brassica oleracea* var. *botrytis*) meets all these conditions (Research Institute on Nutrition, 1964-1967).

In order to produce a certain amount of product, input factors may be combined in varying proportions. According to the least cost combination principle, maximal profit is attained when the marginal value product equals the marginal factor cost for all input factors used. The problem arises whether or not the combination of input factors presently applied by the farmers is efficient*. If this is not the case, how are these input factors to be combined to yield maximal profit?

B. Objectives and Benefits

The objectives of this study are to evaluate:

1. The efficiency of input factors in the production of cauliflower, and
2. The possibilities of reorganizing production to increase profit.

The results of this research may be used by the farmer as well as by the government as a basis for planning reorganization to increase production and the farmer's

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* Efficiency in this paper is defined as the combination of input factors based on the least cost combination principle.

net income. If the production process is taking place at the stage of decreasing returns to scale and diminishing returns prevail with respect to each input factor, an increase in profit may be achieved by reorganizing the input factors if not already optimal. As such, the results of this research may be used by the government as a guide in extension efforts on the efficient use of input factors in the production of cauliflower.

C. Data Collection

The data collection was carried out at Cirateun which is located approximately eight kilometers north of Bandung and is crossed by the highway connecting the cities of Bandung and Sumedang. This area comprises the villages of Cirateun, Cihideung, and Cigugurgirang.

To obtain, as completely as possible, the data on the entire process of cauliflower production, which requires approximately four and a half months, the actual data collection was conducted from July 1971 to February 1972. Since there were only 66 cauliflower farmers, all of them were interviewed using the census method.

Primary data collection was conducted every week from each farmer by interviewing the farmer with the aid of a questionnaire and by direct observation of the cauliflower crop in the field. Besides the primary data, secondary data concerning the general conditions of the study area were collected from the local village and county authorities, research institutions, literature, and other sources.

Methodology

A. Theoretical Framework

In this study the logarithm of the Cobb Douglas production is used.

$$\log Y = \log a + \sum_{i=1}^{7} b_i \log X_i + \log \mu \qquad (1)$$

where: Y is the output (quintal)
a is a constant
X_1 is the area planted with cauliflower (are[1])
X_2 is the amount of fertilizer used (kg)
X_3 is the amount of manure used (quintal)
X_4 is the amount of pesticide used (gram of active ingredient)

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[1] One are equals 100 m^2.

X_5 is the number of plants
X_6 is the depreciation value of equipment in that season (Rupiah or Rp)
X_7 is labor (manhour)
μ is the error term
$b_1, b_2, b_3, b_4, b_5, b_6, b_7$ are the respective estimated elasticities of output for each input factor.

The sum of the elasticities of output for each input factor ($\sum_{i=1}^{7} b_i$) indicates the level of returns to scale. If $\sum_{i=1}^{7} b_i$ is greater than one, production is taking place at the stage of increasing returns to scale. If $\sum_{i=1}^{7} b_i$ is equal to one, production is at the stage of constant returns to scale, while if $\sum_{i=1}^{7} b_i$ is less than one, production is at the stage of decreasing returns to scale.

To measure efficiency of production, the Cobb Douglas production function must meet the assumptions of diminishing returns with respect to each input factor ($0 < b_i < 1$) and decreasing returns to scale ($0 < \sum_{i=1}^{7} b_i < 1$).

One of the weaknesses of this function when estimated by Ordinary Least Squares (OLS) is the existence of multi-collinearity (Doll, 1974). In this condition, the test is not very helpful in discriminating between a true and a false hypothesis. In addition, Scott indicated that in case of multicollinearity, the signs of the regression coefficients are often inconsistent with economic theory (Econometrica, 1966). To overcome multicollinearity, Scott has suggested the use of factor analysis and combining it with classical regression, naming this model Classical Factor Analysis Regression (CFAR) (S.J.A.E., 1976).

To assess the efficiency of a production process, the following comparisons are made[1].

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[1] Equation (2) is derived by maximizing the profit function, while equation (3) may also be derived by minimizing the cost function.

$$\frac{MVP_1}{Px_1} = \frac{MVP_2}{Px_2} = \ldots\ldots \qquad = \frac{MVP_7}{Px_7} = k \tag{2}$$

Dividing equation (2) by the price of output yields:

$$\frac{MP_1}{Px_1} = \frac{MP_2}{Px_2} = \ldots\ldots \qquad = \frac{MP_7}{Px_7} = \frac{k}{Py} \tag{3}$$

where MVP is the marginal value product, P_X is the price of input or marginal factor cost, k is the ratio of the marginal value product to the marginal factor cost, MP is the marginal product, and P_y is the price of output.

Profit will reach a maximum when k is equal to one for all inputs used. At this point the production process is considered efficient. In other words, the optimal combination in the use of input factors has been met. If the ratio is greater than one, profit can be increased by adding more of the input used. If, on the other hand, the ratio is less than one, profit may be increased by reducing the input used.

According to the least cost criterion, the ratio of the marginal product to the price of input does not need to be equal to any particular value but should be positive and equal to each other. When this ratio is equal to zero, the level of input would produce the maximal output. When this ratio is equal to $\frac{1}{Py}$, the profit will be maximum. As such, the profit maximizing combination of inputs is always a least cost combination of inputs, but the converse is not necessarily true.

To determine the efficient combination of input factors, equation (2) or (3) may be used to yield:

$$Xj = Cj \,.\, X_1 \tag{4}$$

where $Cj = \frac{Px_1 \,.\, bj}{Pxj \,.\, b_1}$

Substitution of equation (4) into equation (2) yields:

$$\log Y = \log a + \sum_{i=1}^{7} bi \log X_1 + \sum_{j=2}^{7} bj \log Cj \tag{5}$$

In optimal conditions, $\frac{MVP_1}{Px_1} = 1$ or

$$X_1 = b_1 \frac{Py}{Px_1} \,.\, Y = dY \tag{6}$$

By substituting equation (6) into equation (5) the optimal combination of input factors is obtained which generates maximal profit.

Equation (5) may also be used to determine the least cost combination of inputs when input factors are scarce or when decision makers establish production targets.

B. Hypothesis

This study is based on the hypothesis that the cauliflower production at Cirateun is not efficient. This means that the marginal value product is not equal to the marginal factor cost for all inputs used.

To test the hypothesis, we use the formula given by Theil (1971). Let the hypothesis be:

$$H_0 : \frac{MVP_i}{P_{x_i}} = 1 \text{ or } \frac{b_i^* \cdot \frac{Y}{X_i} \cdot P_y}{P_{x_i}} = 1 \qquad (7)$$

H_1 : at least one input has a $\frac{MVP_i}{P_{x_i}}$ ratio which is not equal to one.

Before we test this hypothesis, we have to calculate the values of b_i^*. From this hypothesis we derive the following:

$$b_i^* = \frac{X_i \cdot P_{x_i}}{Y \cdot P_y}, i = 1, 2, \ldots \quad , 7$$

where: X_i is the i-th input, Y is output, P_{x_i} is the price per unit of the i-th input, and P_y is the price per unit of output.

After we calculate the value of b_i, we use the formula:

$$F = \frac{(b-b^*)^1 X^1 X (b-b^*)}{K s^2}$$

where: F has the F-distribution with K and (n-K) degrees of freedom, b is the regression coefficient, K is the number of independent variables, s^2 is the residual sum of squares, and b* is as defined above.

We reject H_0 if $F > F_{\alpha}$, K, n-K. This means that the production process is not at the point of maximal profit.

The procedure of testing the hypothesis for maximal profit may also be used to test the least cost criterion by modifying the hypothesis, setting up the ratio of

$\frac{MP_i}{P_{x_i}}$ to be greater than or equal to zero.

We will come to the value of b_i^{**} as:

$$b_i^{**} = \frac{d\, P_{x_i} \quad X_i}{Y}$$

where d is a number greater than or equal to zero.

Results and Discussion

Out of the 66 surveyed farmers, 65 farmers owned land that was equal to or less than 0.5 hectare, while only one farmer owned 1 hectare of land. This farmer was also the one using a hand tractor. Because of these differences, this farmer was excluded from the analysis.

The data were processed using Ordinary Least Squares (OLS) and Classical Factor Analysis Regression (CFAR). The results are given in Table 1.

The results of OLS indicate that the coefficient of determination is 0.85, which means that 85 percent of the variation in production can be explained by the variation in the independent variables. The computational F is 44.92021 and is significant at $\alpha = 0.01$. But only coefficients b_1 and b_5 are significant at $\alpha = 0.10$ and $\alpha = 0.01$ respectively. The computational t values for manure, pesticide, equipment, and labor are each less than one. This clearly shows the presence of multicollinearity (Gujarati, 1978) which explains the negative coefficient for land. The coefficient for land is -0.21276, which means that each additional 1 percent of land will decrease the product by 0.21 percent. This also means that land as an input factor in the production process is already being used excessively, so that its marginal product is negative. This is totally in conflict with reality. In the case of cauliflower, the average area of land used by the farmer is 8.41 are and varies between 1.43 are and 50 are. Obviously, the area of land used in cauliflower production is very small, rendering it impossible to state that the use of land in cauliflower production is excessive.

By applying the CFAR method with one factor extracted, the estimated parameters of the Cobb Douglas production function can be seen in Table 1.

Table 1 shows that the estimated parameters and the sum of parameters obtained by CFAR for all input factors are consistent with the assumptions underlying the production function. It should also be noted that the estimated parameters obtained by OLS for land and labor do not agree with these assumptions.

Table 1. Comparison between the Results of OLS and CFAR and the Assumption Underlying the Production Function.

Input factor	Assumption underlying production function	Parameters OLS	Parameters CFAR
Constant	— — —	-2.01591	-0.70765
X_1 (land)	$0 < b_1 < 1$	-0.21276* (1.70317)	0.14909
X_2 (fertilizer)	$0 < b_2 < 1$	0.11626 (1.53621)	0.06753
X_3 (manure)	$0 < b_3 < 1$	0.04990 (0.56422)	0.08751
X_4 (pesticide)	$0 < b_4 < 1$	0.02215 (0.55278)	0.02701
X_5 (plant)	$0 < b_5 < 1$	0.94866** (5.64477)	0.31062
X_6 (equipment)	$0 < b_6 < 1$	0.01169 (0.23833)	0.01243
X_7 (labor)	$0 < b_7 < 1$	-0.04340 (0.42383)	0.15142
Sum of parameters	$0 < \sum_{i=1}^{7} b_i < 1$	0.8925	0.80561
R^2	— — —	0.85	0.80
F	— — —	44.92	31.96
Estimated output (Y)	— — —	12.10	12.10

Figures in parentheses are computational t values.

* Significant at $\alpha = 0.10$

** Significant at $\alpha = 0.01$.

The sum of the estimated parameters indicates decreasing returns to scale for OLS as well as for CFAR. For CFAR, the sum of the estimated parameters is 0.80561, which is less than 0.8925, the corresponding sum obtained by OLS. In addition, the intercept from OLS is much smaller than that from CFAR. The coefficient of determination, R^2, and the F value obtained by CFAR are also smaller than the respective R^2 and F values obtained by OLS. However, both F values are significant at $\alpha = 0.01$. In spite of the difference in parameters yielded by the two methods, the estimated outputs are the same.

According to Scott (1978), the sampling distribution of the CFAR coefficients has not been derived. It was suggested to those who were interested in finding out the test of significance for independent variables to use the multiple "F" test in estimating the approximate significance levels and standard errors for estimated parameters of CFAR.

This investigation was aimed at evaluating the efficiency in inputs used by the farmer. The least cost combination principle was used to measure efficiency. In using this method, it is important that all input factors can be identified. The test of significance is only needed to test the efficiency for all input factors as a whole. So in this research no test was conducted on the significance of each variable. In these circumstances, tests of significance are superfluous and may or may not indicate meaningful factors; even the "exact" tests are arbitrary (Danford, 1960).

To determine economic efficiency, the estimated marginal value product has to be computed and then compared to the marginal factor cost. The marginal value product of each input factor is computed as follows:

$$MVP_i = b_i \cdot \frac{Y}{X_i} \cdot P_y, \quad i = 1, 2, \ldots \quad , 7$$

where:

b_i	is the elasticity of the i-th input factor
Y	is the geometric mean of the product
X_i	is the geometric mean of the i-th input factor
P_y	is the price of product per quintal
$b_i \cdot \frac{Y}{X_i}$	is the marginal productivity at the geometric mean

The marginal factor cost of each input factor is equal to the price per unit of each input. Because the least cost combination principle implies perfect competition in both input-and product-markets, the prices of inputs and output are taken as given. The comparison between marginal value product and marginal factor cost for each input is given in Table 2.

Table 2. The Comparison Between Marginal Value Product and Marginal Factor Cost for Each Input, in Present Conditions, West Java, 1971-1972.

Input	Geometric Mean	Regression Coefficient	MP_i	MVP_i	MFC_i	$\frac{MVP_i}{MFC_i}$
X_1 (land)	8.41	0.14909	0.2145	306.80	88.64	3.46
X_2 (fertilizer)	32.90	0.06753	0.0248	35.52	75.13	0.47
X_3 (manure)	31.70	0.08751	0.0334	47.78	91.24	0.52
X_4 (pesticide)	202.22	0.02701	0.0016	2.31	8.69	0.27
X_5 (plants)	1656.65	0.31062	0.0023	3.24	0.66	4.91
X_6 (equipment)	520.57	0.01243	0.0003	0.41	0.32	1.28
X_7 (labor)	135.58	0.15142	0.0135	19.33	21.81	0.89

The estimated output at the geometric mean is 12.10 quintals. The price of product per quintal is Rp 1,430.29. As such, the revenue of the farmer is Rp 17,307. The total cost is Rp 12,084, so that the farmer's profit amounts to Rp 5,223, which is 43 percent of his total cost.

The results of the efficiency tests based on the maximum profit criterion as well as on the least cost principle show that cauliflower production at the study area is not efficient (Sugianto, 1979). This indicates the opportunity to maximize profit by reorganizing the input factors.

The optimal combination of input factors is computed by using equations (5) and (6). The results are shown in Table 3.

Table 3. The Optimal Combination of Input Factors.

Input	Geometric Mean	Regression Coefficient	MP_i	MVP_i	MFC_i	$\frac{MVP_i}{MFC_i}$
X_1 (land)	426.39	0.14909	0.06197	88.64	88.64	1.00
X_2 (fertilizer)	227.86	0.06753	0.05258	75.13	75.13	1.00
X_3 (manure)	243.14	0.08751	0.06379	91.24	91.24	1.00
X_4 (pesticide)	787.93	0.02701	0.00608	0.69	0.69	1.00
X_5 (plants)	119,308.00	0.31062	0.00046	0.66	0.66	1.00
X_6 (equipment)	9,847.00	0.01243	0.00022	0.32	0.32	1.00
X_7 (labor)	1,760.00	0.15142	0.01525	21.81	21.81	1.00

The results snow that the optimal levels of input factors by far exceed their average values. In order to obtain maximal profit, the farmer has to utilize the input factors in much greater amounts. For land, the farmer on the average has to increase the area by more than fifty times its present area. At present, vegetables are grown in regions close to cities to facilitate its marketing since there are no storage facilities for vegetables. Population growth and city expansion will decrease the total area of land that is available for vegetable growing. In addition, the amount of capital available to the farmer is also limited. Therefore it would be impossible to apply this result in Indonesia.

Even though the optimal combination of input factors is not applicable, the calculation of revenue, total cost, and profit yield interesting results for discussion. At the optimal combination of input factors, the yield produced is 177 quintals. The revenue is Rp 253,504 while the total cost is Rp 204,225. The profit received by the farmer is Rp 49,279.

The ratio of the total cost over revenue is 0.80561 which is equal to the sum of the elasticity coefficients of the input factors. This will be achieved only when the input factors utilized in the production process are in optimal combination, or when the marginal value product is equal to the marginal factor cost for all input factors. In other words, the ratio of total cost over revenue will be equal to the sum of the elasticity coefficients of the input factors only when production takes place at the point of maximal profit. With any deviation of the point of maximal profit, either by increasing or reducing the input factors, the ratio of total cost over revenue will always be less than the sum of the elasticity coefficients of the input factors, even if the least cost criterion is still being met.

Of all the input factors utilized by the farmer, the area of land is the most difficult to be altered. Although land renting is available, the percentage is low. In this study only 11 percent of the farmers obtained their land by renting. Based on land as the most difficult modifiable input factor, the combination of input factors that meets the least cost criterion is computed. The results are given in Table 4.

The area of land utilized by the farmers in this research ranges from 1.43 to 50 are. In fact, the various combinations of input factors that meet the least cost

Table 4. Combination of Input Factors Using the Least Cost Criterion for Various Levels of Farm Size.

Input factors	Geometric mean					
Land (are)	5.00	10.00	20.00	30.00	40.00	50.00
Fertilizer (kg. of element)	2.67	5.34	10.69	16.03	21.38	26.72
Manure (quintal)	2.85	5.70	11.40	17.11	22.81	18.51
Pesticide (gram of active ingredient)	9.24	18.48	36.96	55.44	73.92	92.40
Plants (number)	1399.00	2798.00	5596.00	8394.00	11193.00	13991.00
Equipment (Rupiah)	115.47	230.94	461.89	692.83	923.77	1154.71
Labor (manhour)	20.64	41.28	82.55	123.83	165.11	206.39
Estimated output (quintal)	4.93	8.62	15.07	20.89	26.34	31.53
MVP_i/MFC_i	2.37	2.07	1.81	1.68	1.58	1.52
Revenue (Rupiah)	7055.00	12331.00	21553.00	29879.00	37672.00	45091.00
Total cost (Rupiah)	2395.00	4790.00	9580.00	14369.00	19159.00	23948.00
Profit (Rupiah)	4660.00	7541.00	11973.00	15510.00	18513.00	21143.00
Profit/Total cost (%)	195.00	157.00	125.00	108.00	97.00	88.00
Total cost/ Revenue (%)	34.00	39.00	44.00	48.00	51.00	53.00
Profit/Revenue (%)	66.00	61.00	56.00	52.00	49.00	47.00

criterion for any level of farm size used in the production of cauliflower can be computed. In this thesis, as shown in Table 4, the combinations of input factors are only computed for the farm size levels of 5, 10, 20, 30, 40, and 50 are. These figures have been chosen to facilitate agricultural extension in disseminating these results to the farmers.

If the farmer operates in accordance with the least cost criterion, the yield produced by a farm of 10 are is 8.62 quintals, generating a revenue of Rp 12,331. The total cost of operation is Rp 4,790, so that the profit obtained is Rp 7,541, which is equivalent to 157 percent of the total cost.

Alternative combinations of input factors that also meet the least cost principle may be computed for any level of target output. In this study, combinations of input factors were computed for the target output of 5, 10, 20, and 30 quintals respectively, to facilitate the government in determining the target product and to aid the agricultural extension worker in conveying the results of this research to the farmers. The outcome of the computation is shown in Table 5.

Table 5. Combinations of Input Factors Using the Least Cost Criterion for Various Levels of Target Output.

Output level (quintal)	5.00	10.00	20.00	30.00
Revenue (Rupiah)	7151.00	14303.00	28606.00	42909.00
Input factor				
Land (are)	5.09	12.02	28.42	47.01
Fertilizer (kg. of element)	2.72	6.42	15.19	25.12
Manure (quintal)	2.90	6.85	16.21	26.81
Pesticide (gram of active ingredient)	9.41	22.21	52.52	86.87
Plants (number)	1424.00	3363.00	7952.00	13154.00
Equipment (Rupiah)	117.55	277.59	656.34	1085.66
Labor (manhour)	21.01	49.62	117.31	194.04
Minimal cost (Rupiah)	2438.00	5757.00	13613.00	22516.00
Profit (Rupiah)	4714.00	8546.00	14993.00	20392.00
MP_i/P_{x_i}	0.00165	0.00140	0.00118	0.00107
Profit/Cost (%)	193.00	148.00	110.00	91.00
Cost/Revenue (%)	34.00	40.00	48.00	52.00
Profit/Revenue (%)	66.00	60.00	52.00	48.00

The profit received by the farmer for producing 5, 10, 20, and 30 quintals of output are Rp 4,714; Rp 8,546; Rp 14,993; and Rp 20,392, respectively. However, the ratios of profit over revenue and profit over cost will diminish as the output produced increases. This may be explained by the fact that the production process is taking place at the stage of decreasing returns to scale. The more output produced, the more input factors have to be used and the lower the marginal product for each input will be. The ratio between marginal product and the price of input for all inputs used will also decrease, as shown in Table 5.

Up to the output level of 30 quintals, the implementation of these results by the farmers will not constitute problems because at that level of product, the area of land is still within the range of land owned by the farmer; and the cash inputs like fertilizer, manure, and pesticide are lower than the average amounts currently used.

In utilizing the results of this research, it should be noted that these findings apply to the average farm. This means that if the government sets production at a target of 1,000 quintals, this goal may be achieved by taking 200 farms, each of which produces 5 quintals using the combination of input factors appropriate for producing that level; or by taking 100 farms each of which produces 10 quintals using the appropriate combination of inputs; or by taking any number of farms each of which in total make up the target product by using the appropriate combination of inputs. The important condition is that for any level of output produced by a farm, the appropriate combination of inputs is applied.

Conclusions

1. The results of this study show that at the time of the study, the process of cauliflower production was not efficient. In such conditions, the estimated output at the geometric mean was 12.10 quintals yielding a revenue of Rp 17,347. The total cost spent was Rp 12,084 leaving the farmer with a profit of Rp 5,223.

   As long as the least cost criterion is not met, the level of efficiency in the use of input factors may still be raised by adjusting the use of such inputs toward that principle to increase the farmer's profit. This study computed the optimal combination of input factors which yielded maximal profit and combinations of input factors using the least cost criterion for various levels of farm size and target output, as shown respectively in Tables 3, 4, and 5.
2. CFAR can be used as one of the methods to overcome the problem of multicollinearity which is frequently encountered in Cobb Douglas production functions.
3. This study emphasizes the methodology to evaluate production efficiency at the farm level. The data used were collected in 1971-1972. At present, the prices of inputs and output have obviously changed. In addition, the technology used in cauliflower production may also have undergone changes. Consequently, to extend recommendations which are relevant to 1986 conditions, it is suggested that the study be reconducted using up-to-date data.

4. In optimal conditions, the amounts of inputs recommended by far exceed the maximum amounts of inputs actually used by the farmer. This raises the question whether or not in such conditions the elasticity of production remains unchanged. The high levels of inputs in optimal conditions are caused not only by the constant production elasticity of the Cobb Douglas function, but also by the fact that $\sum_{i=1}^{7} b_i$ almost equals one. In addition to the assumptions of diminishing returns with respect to each input factor and decreasing returns to scale, is it also necessary for the production elasticity to approach zero, in determining the optimal combination of input factors using the Cobb Douglas model? What are the limits of this production elasticity in order that the optimal combination of inputs may still prevail within the range of data used? These questions need to be answered so that research on production efficiency using the Cobb Douglas model may yield better results.

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