ECONOMICS ANALYSIS OF OPTIMAL MILK PRODUCTION IN SMALL-SCALE DAIRY FARMING IN YOGYAKARTA, INDONESIA

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ABSTRACT

Dairy farm, which produces calf and milk jointly, is expected to raise household's income in rural areas where potential resources are available. This study aims at examing the optimal production of milk and calf by estimating a relationship between both productions. The study was conducted in Sleman, Yogyakarta where dairy farms exist. Theory used in this study is economies scope in joint production. The results of study indicate that the level of joint production is still low such that there is no degree in economies of scope. Consequently, household's income generated from this farm has not been maximised. To increase the income, it can be conducted by two consecutive steps. First, is to increase the production milk and calf jointly until the degree of economies of scope reached. Second, is to produce milk and calf in the best combination after reaching economies of scope. Recently, the best way to maximise income is to produce calf as low as possible, and to increase the period of producing milk.

Keywords: *Economies scope, product transformation curve, and optimal joint production*

INTRODUCTION

One of the potential aspects of Indonesian farm-animal industry that needs a particular attention is dairy farm. One of the reasons is that most of dairy farms are operated with limited capital and traditional/ conventional technology (Djoni 2003). As a consequence, the performance of the dairy production has not been in optimal operation. Thus, no doubt if Indonesia still imports milk to fulfil the domestic demand.

The domestic demand for milk is, on average, 851,300 litres a day, but only 61 per cent of that can be met by domestic production, and the rest is supplied by imported milk (Ditjennak 2000). In 2010, as the demand for milk increases considerably, domestic supply of milk only covers 30 per cent of total demand (Ardiarto, 2010). This implies that dairy farm is economically promising, as predicted by Janvry et al. (2002) that demand for products of livestock in the developing countries is to increase as a consequence of population growth and rising incomes.

Another important aspect is that the dairy farm provides household's income, which is higher than that from rice or secondary food crop farming and the dairy farm has a comparative advantage (Sunandar 2001). But, as studied by Djoni (2003), dairy farm in West Java is still economically inefficient in terms of resource allocation. In Yogyakarta, (Mariyono 2006) finds that dairy farms can be scaled up to improve technical efficiency.

However, it is hypothesized dairy farm still has low economic performance. Improvement in such performance of dairy farm is expected to increase household's income and welfare of people through availability of animal protein. For those reasons, this study is carried out to measure whether the dairy production shows high economic performance or not. The economic performance of dairy production is shown by the measure of economies of scope and optimal production. This indicator is important to study because economies of scope will show how to maximise revenue from the dairy farm that produces milk and calf as joint product. The outcome of this study is expected to be able to provide significant contributions for the producers in order to escalate the farming's performance.

Theoretical Framework

Technically, a cow employed in dairy farm will not able to produce milk well without being pregnant as starter kit. It is therefore inevitable for a dairy farm to produce calf at the first stage. This is, however not really bad because the calf has an economic value.

In an economic point of view, such process is called joint production that yields more than one products with the same resources (Salvatore 1996).

Theoretically, there is a specific relationship between calf and milk production. The relationship can be described as follow. A dairy cow needs to be pregnant in order to produce milk; therefore it is likely that at the initial stage, production of milk and calf increases simultaneously. One after the other however, if the firm keeps on producing milk, the cow will no longer produce calf. Conversely, if the dairy cow is expected to produce calf, the production of milk should be halted. At the further consecutive stage, it seems that there is a trade off between milk and calf production. Diagrammatically, the relationship between calf and milk production is expressed by curved line in Figure-1.

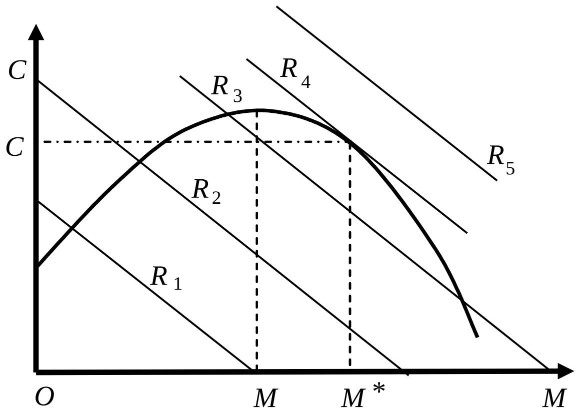

Figure-1. Relationship between calf and milk production

To explain Figure 1, let C and M be production of calf and milk respectively. At initial stage, the production of calf and milk simultaneously increases up to M^*. After reaching a peak, the production of calf starts falling as production of milk increases. Beyond the point of M^*, the curve corresponds to what is called a product transformation curve. The product transformation curve describes 'the different combinations of two outputs that can be produced with a fixed amount of production inputs' (Pindyck and Rubinfeld 1998: 228). The product transformation curve is 'concave to the origin because the firm's production resources are not perfectly adaptable in (i.e., cannot be perfectly transferred between) the production of products …' (Salvatore 1996: 460). If this is the case, the joint productions of milk and calf have an advantage in economies of scope postulating that '…the joint output of a single firm is greater than the output that could be achieved by two different firms each producing a single product…' (Pindyck and Rubinfeld 1998: 227). When the advantage in economies of scope exists, the cost of producing joint outputs is less than that of producing each output separately.

In dairy production, revenue is one of important economic indicators of household income. Therefore, a good performance of dairy farm can be indicated with revenue maximization. Recall Figure 1, and let the straight lines $R=\{R_1, R_2, R_3, R_4, R_5\}$ be revenue generated from the dairy farm. The further R is away from the origin, O, the higher value of R. Thus R_5 is the highest revenue, but it is unattainable. This implies that the maximum attainable revenue generated from the dairy farm is R_4. It can be seen that the maximum revenue is reached when the slope of product transformation curve is equal to the slope of revenue line.

Technically, the slope of product transformation curve is mathematically expressed as $\partial C / \partial M$, which represents a marginal rate of product transformation (*MRPT*), that is, the quantity of product C that must be given up in order to get one unit of product M. The revenue line can be mathematically expressed as:

$$R = P_C \cdot C + P_M \cdot M$$

or

$$C = \frac{R}{P_C} - \frac{P_M}{P_C} M \qquad (1)$$

where P_C is price of calf and P_M is price of milk. The slope of revenue line is represented by $\frac{P_M}{P_C}$. Thus, revenue generated from production of milk and the jointly produced calf will be maximized when the negative *MRPT* is equal to the price ratio. The optimal level of production of milk is M^{**}, combined with jointly produced calf, C^*. Those levels of production milk and calf satisfy revenue maximization.

RESEARCH METHOD

Study Site and Commodities

This analysis is based on a study carried out in November 2003 – January 2004 in a small hamlet, called Kaliadem, in Yogyakarta Province, at which most of households operate dairy farm. The main product is milk, and the joint product is calf.[1] Data on dairy farm was collected by interviewing 32 dairy farm's operators using structured questionnaires. The activities related to the operations of dairy farm during a year were recorded. The definitions and measures of variables used in this study is summarised in Table 1, and summary statistics for those variables is in Table-2.

Procedure of Analysis

The first step is to estimate the production function of milk and calf. The information resulting from the estimation is then used to determine the variables of resource that shift product transformation curve. The production function taken in this study is a Cobb-Douglas technology because is appropriately applied in agricultural production (Soekartawi et al. 1986; Soekartawi 1990). In terms of double logarithms, the function is expressed as:

$$\ln Q = \ln A + \sum_{k=1}^{3} \beta_k \ln X_k + \varepsilon \tag{2}$$

where: Q is quantity of milk and calf; A is total factor productivity; X is variable inputs consisting of k=1 is cows, k=2 is labour, and k=3 is feeding; ε is a disturbance error representing uncontrolled factors excluded from the model; β_k, k=1, 2, 3 is coefficient to be estimated.

The second step is to estimate a curve representing the relationship between production of calf and milk. Since the curve is assumed to be parabolic, a quadratic functional form is one of the suitable approaches (Chiang 1984). The curve reflecting the relationship between calves and milk produced with the same resources is formulated as:

$$C = \alpha_1 X + \alpha_2 M + \alpha_3 M^2 + \omega \tag{3}$$

where X is inputs that have significant impact on either production of calf or milk, α_i, i=1, 2, 3 is coefficient to be estimated, and ω is a disturbance error.

Table-1. Description and measures of variables

Variable	Description
Milk	Production of milk a year (litre)
Calf	Value of calves which is sold a year (000 Rp)
Cow	Number of cows which are owned by farm's operators
Labour	Number of labours which are employed a year (man-day)
Feeding	Value of feeding a year (000 Rp)
Price of milk	Price of milk accepted by producers

Table-2. Summary statistics for key variables

Variable	Average	Standard Deviation	Minimum	Maximum
Milk	8207.09	3601.38	3285	16425
Calves	5314.06	3557.62	1500	19000
Cows	5.03	2.07	2	11
Labour	335.93	93.61	121.59	526.80
Feeding	2047.85	892.93	506.25	3937.50
Price of milk	1100	0	1100	1100

Source: Authors' calculation

[1] Calf is measured in terms of monetary value because there is a variation in the age of the calf sold. Measuring in monetary value is expected to reduce the bias since raising the calf needs additional costs

The concavity of product transformation curve requires some conditions of which $\square_1$ and $\square_2$ are expected to be positive, whereas $\square_3$ is expected to be negative. The *MRPT* derived from the functional form of the product transformation curve is expressed as:

$$\partial C \big/ \partial M = \alpha_2 + 2 \cdot \alpha_3 \cdot M \tag{4}$$

To identify whether the productions provide maximum revenue, the *MRPT* obtained is then tested to show that the value is equal to the price ratio of two products. The test is conducted by the following formulations:

$$-\partial C \big/ \partial M = \psi \cdot P_M \big/ P_C$$

$$\square \; -(\alpha_2 + 2 \cdot \alpha_3 \cdot M) \cdot P_C \big/ P_M = \psi \tag{5}$$

If the negative *MRPT* is equal to the price ratio, the value of $\square$ should be unity.

Calculation of *MRPT* is based on the average value of milk production, $\overline{M}$, and as a consequence, $\square$ is not a fixed number, but it is a random value with certain values of mean and variance. Therefore, assessing on whether $\square$ is equal to one or not can be carried out using a statistical analysis. The procedure of analysis is subject to a property of central tendency theorem stated in Wooldridge (2003) as follow. Suppose $\square$ is a random variable with mean $\overline{\psi}$ and variance σ_ψ^2, and let Λ and Ω be two constant numbers. Related to the variance of the random variable, there is a relation as follows:

$$Var(\Lambda + \Omega \cdot \Psi) = Var(\Lambda) + Var(\Omega \cdot \psi)$$
$$= \Omega^2 \sigma_\psi^2 \tag{6}$$

By following such properties, the average of *MRPT* evaluated at the average level of production of milk, $\overline{M}$, with variance σ_M^2, is expressed as: $\overline{MRPT} = \alpha_2 + 2 \cdot \alpha_3 \cdot \overline{M}$, and the variance of *MRPT* is $\sigma_{MRPT}^2 = \left(4 \cdot \alpha_3^2 \cdot \sigma_M^2\right)$ because $\square_2$ and $\square_3$ are constant. Testing for $\overline{MRPT} = P_M/P_C$ can be carried out by formulating $\overline{\psi} = \overline{MRPT} \cdot P_C/P_M$. If $\overline{\psi}$ is statistically equal to one, the $\overline{MRPT}$ will be statistically equal to P_M/P_C. Testing for $\overline{\psi} = 1$ is carried out using a procedure of one-sample *t*-test suggested by Diekhoff (1992) as:

$$t_{test} = \frac{\overline{\psi} - 1}{\sigma_\psi} \tag{7}$$

where $\square_\square$ is the standard deviation of $\square$, which is square root of variance of $\square$. The variance of $\square$, is $\sigma_\psi^2 = \left(P_C \big/ P_M \cdot 2 \cdot \alpha_3\right)^2 \cdot \sigma_M^2$, since the prices is constant for all producers.

Hypothesis

Related to economies scope, it is hypothesised that joint production of milk and calf has an advantage in economies scope. The formal testing for the economies of scope is formulated below.

Null hypothesis (H_0): $\square_1 = \square_2 = \square_3 = 0$

Alternative hypothesis (H_a): $\square_1$, $\square_2$ >0 and $\square_3$ < 0

If H_0 is rejected, it means that the product transformation curve is concave. The degree of economies of scope will exist if $\overline{MRPT} = \alpha_2 - 2 \cdot \alpha_3 \cdot \overline{M}$ is less than zero.

Related to optimal combination of joint product, it is hypothesised that productions of milk and calves are proportionately optimal. Testing for hypothesis indicating that productions of milk and calves are proportionately optimal is formally formulated as:

Null hypothesis (H_0): $\overline{\psi} - 1 = 0$

Alternative hypothesis (H_a): $\overline{\psi} - 1 \;\square\; 0$

If the H_0 is rejected, this indicates that the combination of two products is not optimal.

The Cobb-Douglas production function and the relationship between calf and milk production will be estimated using STATA 8.0. Decision rule of whether the hypotheses formulated above are rejected or not is determined using critical values of statistical inferences. The critical values are measured at significance levels one per cent, five per cent and ten per cent. If the statistical parameters are greater than the critical values, the null hypotheses are rejected.

RESULTS AND DISCUSSION

Table-3 shows Cobb-Douglas production function for milk and calf. It can be seen that only milk production is significantly estimated, and the number cows is the only variable that has significant impact on milk production. Therefore, the number of cows is then used in estimating a curve that describes the relationship between calf and milk production.

Table-4 shows a relationship between calf and milk produced with the same resource. It can be seen that all coefficients on variables are significant, and as expected before, the sign of □1 and □2 is positive, and the sign of □3 is negative.

Such conditions imply that the relationship between calf and milk production resembles a parabolic curve as drawn in Figure-2.

The curve reaches a peak when level of production milk is 8,781.25 liters a year.[2] After passing point of 8,781, the curve starts declining, and the curve then represents a product transformation curve. This means that an increase in production of milk will reduce production of calf. Related to the number of cows, an increase in number of those will shift the curve upward. This implies that beyond the point of 8,781, one unit increase in number of cows will simultaneously increases in both calf and milk production. The average level of milk production is 8,207 liters, which is less than 8,781. This means that at the average level of milk production, the curve is still increasing. Consequently, a simultaneous increase in calf and milk production is still attainable.

From the estimated functional form, the value of $\partial C / \partial M$ evaluated at the average level of milk production is $0.7025 - 2 \cdot 0.0004 \cdot 8{,}207 = 0.0464 > 0$. Because the value of $\partial C / \partial M$ is still positive,

Table-3. Cobb-Douglas Production Function

Variables		Milk (ln)	Calves (ln)
Constant	□0	8.7187 (5.97**)	6.2244 (2.56*)
ln Cows	□1	0.6452 (3.88**)	0.0787 (0.28ns)
ln Labour	□2	-0.5385 (-0.64ns)	-.13041 (-0.09ns)
ln Feeding	□3	0.3084 (0.59ns)	0.3729 (0.43ns)
	R-squared	0.3648	0.0662
	F(3, 28)	5.36**	0.66ns

Note: figures in the parentheses represent t-ratio; **) significant at □=0.01, *) significant at □=0.05, ns) not significant;

Source: Authors' estimation

Table-4. Relationship between calf and milk production

Variables		Coefficient	t-ratio
Cows (X)	□1	464.8084	1.50*
Milk (M)	□2	0.7025	3.75**
Squared Milk (M^2)	□3	-0.00004	2.33**
R-squared = 0.71			
F(3, 29) = 23.18**			

Note: Dependent variable: calves; ***) significant at □=0.01, **) significant at □=0.05, *) significant at □=0.1, ns) not significant

Source: Authors' estimation

[2] To find out the level of milk production that reaches a peak is done by taking first derivative and equalizing to zero, that is $\partial C / \partial M = 0$, and then solving for M.

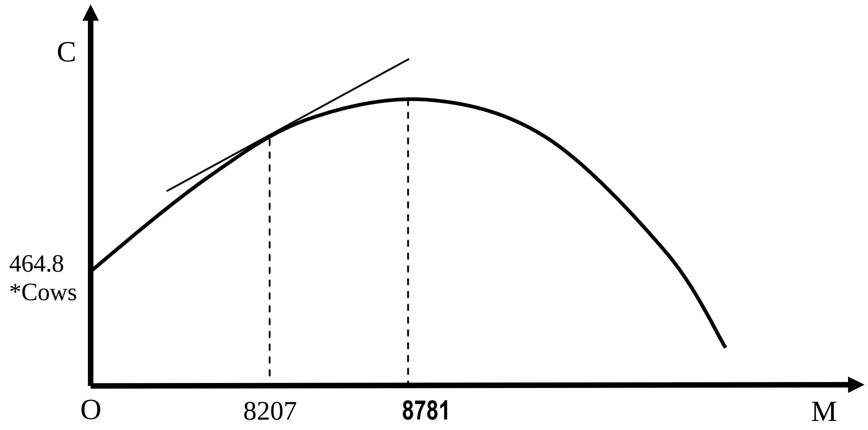

Figure-2. Estimated relation of calf and milk productions

the value does not represent *MRPT*, but it is a marginal effect of one unit increase in production of milk that results in increase in production of calf by such value.[3] This condition implies that the joint production of calf and milk has not been economically optimal. This means that revenue generated from the joint production has not been maximized and can still be increased without need to increase the number of cows. The maximized revenue will be reached after the curve starts declining, with the condition of *MRPT* that is equal to price ratio of calf to price of milk.[4]

Theoretically, when the price of milk is Rp 1,100 per liter, the level of milk production that will provide maximized revenue is 13,758,781 liters a year.[5] But practically, it is impossible to reach such level of production because it would be reached if the value of calf were negative. The second best solution in this case is called a corner solution (Nicholson 2003). Figure-3 describes the unfeasible best solution and the corner solution related to this problem.

If the corner solution were acceptable, the level of milk production that yields maximized revenue would be 20,409 liters a year, and the value of calf is zero.[6] However, the solution is still not sensible, because technically a cow will not produce milk without lactation coming from pregnancy.

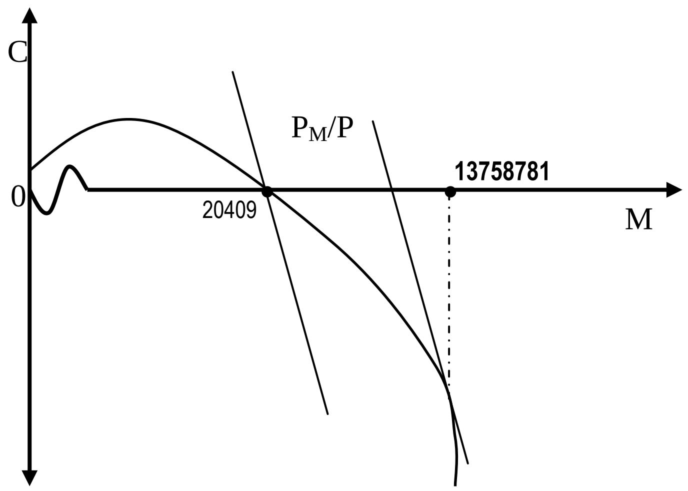

Figure-3. Corner solution

[3] Because the slope at the average level of milk production is still increasing, testing for optimal combination of milk and calf productions is no longer required.

[4] Since the calf is measured in monetary value, thus price of calf in this calculation is one, and therefore the price ratio of P_M/P_C is 1,100.

[5] The number is obtained from -□C/□*M*=1100, that is *M* = (0.7025 + 1100) / (2 * 0.00004)

[6] The number is obtained by setting *C* in the estimated quadratic function in Table 4 equal to zero, and solving for *M*.

The reasonable way to maximize revenue therefore is done by producing calf as minimal as possible. This can be conducted by keeping the cows producing milk in long period; and selling the calf as soon as possible. If the calf is sold soon, there will be greater amount of resources devoted on producing milk, such that the level of milk production is expected to increase.

CONCLUSION AND POLICY IMPLICATION

Conclusion

A dairy farm, which technically produces calf and milk simultaneously, is expected to provide significant contribution in enhancing household's income of rural people. This is because the dairy farm provides higher income than rice and other food crop farming. However, there is a trade off between calf and milk production after certain level of each production. This condition will affect the amount of revenue generated from operating the dairy farm. Searching for the best combination of calf and milk production is needed to increase the revenue.

The dairy farm in Sleman, Yogyakarta has not had an advantage in terms of economies of scope, because the existing levels of calf and milk productions still can be increased simultaneously. Degree in economies of scope will exist after the level of milk production reaches 8,781 litres a year. In fact, the actual level of milk production is 8,207 litres a year. Since both production of calf and milk can still be simultaneously increased, the combination of both production has not been optimal. This means that revenue generated from the actual productions of calf and milk has not been maximised.

Implication

Since production of calf is technically required as starter kit in a dairy production, the reasonable action of increasing income, in this case is to push down the level of calf production as low as possible. Selling the calf as soon as possible and devoting much more resources on milk production are expected to be capable of increasing household's income of farm's operator in Sleman, Yogyakarta.

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