Cobb Douglas Production Function For Analyzing Dairy Milk

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Cobb-douglas production function for analyzing dairy milk production factors

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ABSTRACT

The development of dairy cattle business by increasing dairy milk production is a supporting effort to the development of food security, especially in the fulfillment of domestic fresh milk availability (SSDN). Boyolali Regency is one of the districts with the largest population of dairy cattle in Indonesia. However, the dairy cattle population has decreased and resulted in the reduction of dairy milk production. This study aims to identify and analyze factors that are influential in the dairy milk production in Boyolali Regency. Multiple linear regression is used in this study to determine the influential factors in the dairy milk production, as a cattle upstream business, using Cobb-Douglas production function model. Research data are primary and secondary data. Primary data are obtained from the results of observations and direct interviews with dairy farmers in Boyolali Regency who are the respondents of this research. While the secondary data needed are collected from relevant Government institutions including the Department of Animal Husbandry of Central Java Province and Central Bureau of Statistics (BPS) of Boyolali Regency. The research results indicate that factors having simultaneous significant influence on milk production of dairy cattle are the number of cattle, the number of lactating cattle, forage, concentrates and manpower. However, only the numbers of cattle, forage, and concentrates which have significant influence, while manpower variable is a unique finding in this study because of its negative coefficient.

Key words: *Dairy cattle, Dairy milk production, Production factor, Cobb-Douglas*

Introduction

The Working Cabinet Government currently has a vision of creating populist agribusiness-based food sovereignty with an expectation to create community independence and prosperity. Increasing purchasing power through increasing cattle business productivity and income will in turn increase people's food security and at the same time is a potential market for cattle products (Sudaryanto, 2000). Indonesia's population in 2015 was more than 250 million people and most of them still involved in the agricultural and rural sectors in a broad sense. Therefore, this approach is the best choice in developing cattle business in Indonesia.

The development of dairy cattle business through increasing dairy milk production is an effort to support the development of food security, especially in the fulfillment of domestic fresh milk (SSDN) availability. Based on milk outlook data of 2017, the availability of domestic milk on average from years 2012 to 2016 was dominated by imported milk (73.84%), while the amount of domestic fresh milk supply was 26.16%. The lack of domestic

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fresh milk supply produced by local farmers was caused by several obstacles and one of them was the local farmers' dairy milk low production. The Director General of Cattle and Animal Health of the Ministry of Agriculture (Kementan), Syukur Iwantoro, explains that the low productivity of local dairy farmers is caused by many factors such as lack of feed nutrition for local dairy cattle, lack of forage, less concentrates and poor quality feed additives, farmers insufficient knowledge, and some others. In addition, the number of dairy cattle in Indonesia is not sufficient and it tends to decrease (rrd / hen, 2013).

Boyolali Regency is one of the largest cattle producing centers in Central Java. The Boyolali Regency Animal Husbandry and Fisheries Service recorded that there are 92.619 dairy cattle and 96.066 beef cattle available in 2017. However, based on the results of digital data collection conducted by the local government, the dairy cattle population declined in 2018. It is suspected the decline is caused by farmers who tend to switch from dairy cattle to fattening beef cattle business. The reduction in the dairy cattle population once resulted in a decline in milk production in Boyolali Regency. The decline in milk production of dairy is also influenced by feed factors and management, environmental factors, age factors and parity, breeding factors, and some others. The study aimed to identify and analyze the factors that influence the milk production in Boyolali Regency.

Materials and Methods

The study was conducted by survey method, namely research that takes samples from a population and uses questionnaires as a means of main data collection. The study was conducted in Boyolali Regency because it is one of the districts with the largest number of dairy cattle in Indonesia and is one of the dairy cattle suppliers for the Capital City of Jakarta. Research data were primary data and secondary data. Primary data were obtained from the results of observations and direct interviews with dairy farmers in Boyolali Regency as the respondents, while the secondary data needed were collected from relevant government institutions including the Department of Animal Husbandry of Central Java Province and Central Bureau of Statistics (BPS) of Boyolali Regency.

The Cobb Douglas production function model was used to analyze data related to factors that affect milk production in Boyolali Regency. The mathematical equation of the Cobb Douglas function in general is as follows (Gujarati, 2006):

$$Y = b^0 X^{b1}, X^{b2}, X^{b3}, \ldots .., Xbieu \quad .. (1)$$

Transformations in linear form using natural logarithms (ln) are performed in estimating parameters Cobb-Douglas function equation written as follows (Gujarati, 2006):

$$Ln\ Y = \ln\beta 0 + \beta 1 \ln X1 + \beta 2 \ln X2 + \beta 3 \ln X3 + \beta 4 \ln X4 + \beta 5 \ln X5 + \sigma \quad .. (2)$$

Where:

Y = Dairy Cattle Milk Production (liters/day) other number of dairy cattle (X1), number of lactating cattle (X2), forage (X3), concentrate (X4), and manpower (X5) β0 = Constants β1, β2, β3 , ..., β7 = parameter coefficients of estimated parameter with β1, β2, β3, ..., β7> 0

The explanation of production factors coefficients is as follows:

1. β1> 0 means that if the number of dairy cattle increases by one percent, it will increase milk production by one percent.
2. β2> 0 means that if the number of lactating cattle increases by one percent, it will increase milk production by one percent
3. β3> 0 means that if the amount of forage is added by one percent it will increase milk production by one percent.
4. β4> 0 means that if the amount of concentrate is added by one percent, it will increase milk production by one percent.
5. β5> 0 means that if the workforce is added by one percent, it will increase milk production by one percent.

It is necessary to perform hypotheses test to see the properness of the model used in the research (Gujarati, 1978) such as:

1. OLS (Ordinary Least Square) assumption Test

Used to see whether there is multicollinearity in the independent variable, namely by looking at if there is a VIF value > 10, it can be concluded that there is multi-collinearity in the predictive model.

2. Model Parameter Test (F-test)

The statistical test used is the F-test:

$$F\text{-}calculate = R2 / (k\text{-}1) (1\text{-}R2) / (n\text{-}k) \quad .. (3)$$

Where:

R2 = Coefficient of determination K = Number of

independent variables N = Number of respondents

Test criteria

If *F-calculate* > *F-table* (k-1, n-k), at the real level α then reject H0. If *F-calculate* <*F-table* (k-1, n-k), at the real level á then accept H0.

3. Testing of Variable Parameters (T-test)

The statistical test used is the t test as follows:

t-calculate = βi-0 Sβi (4), where:

βi = i-regression coefficient which is assumed to be Sβi = Standard deviation of βi

Test Criteria

T-calculate > T-table (α/2; n – k), then H0 is rejected, meaning that there is an influence of the free variables to the dependent variables.

T-calculate < T-table (α/2; n - k), then H0 is accepted, meaning that there is no influence of the independent variables to the dependent variables.

Where :

n: Number of respondents k: Number of variables

Results

General Characteristics of the Respondents

The age of respondents in this study ranged from 25 to 70 years. The highest percentage of age is 40% in the age group of 51-60 years (24 respondents). In addition, there was also the lowest percentage of age (3.33%) in the age group of <25 years (2 respondents). This result showed that regeneration was a problem for dairy farmers in Boyolali Regency that needed to be considered.

The level of education of dairy farmers in Boyolali Regency was varied and most of them were only Elementary School (SD)/equivalent graduates (43.3%) as many as 26 respondents. This percentage was greater when compared with other levels of education such as junior high school / equivalent (23.33%), high school / equivalent (15.00%) and those who achieved college education which were 5 respondents only. Based on these results, it could be inferred that most farmers received formal education which meant that farmers were able to read and write so that in carrying out their business they did not rely on others. In addition to the formal education obtained by respondents, there was a need for additional education to improve their knowledge and skills in farming. Therefore, the Farmers Group should ideally hold regular meetings once in a month at the member's house carried out in turns.

Based on the experience in dairy cattle business, many of the respondents, 14 of them, were quite experienced with an average of 26-30 years (23.33%). This experience showed the length of time the respondents played an active role in the dairy cattle business. The longer the experience of dairy cattle farming meant that respondents already understood the farming techniques in the cattle business activities they ran.

Based on the number of cattle owned, as many as 80 % of farmers owned cattle about 1-5 heads. This shows that most of the dairy farmers in Boyolali district are small-scale business owners. The low level of cattle ownership is caused by the lack of capital owned by farmers so that it will affect the farmers' income.

Factors Affecting Dairy Cow Milk Production

The main purpose of doing an economic activity or running a business is to earn profit. Effort to gain profit from dairy farming is to increase the production of dairy cattle bred. Therefore, sufficient knowledge on factors that affect dairy cattle milk production is necessary. Factors that influence dairy cattle milk production at farmers' level in Boyolali Regency were analyzed using the Cobb-Douglas function model showing the mathematical relationship between milk production and the production factors used. Production factors that are assumed to be influential in dairy cattle business in Boyolali Regency include the number of dairy cattle (X1), the number of lactating cattle (X2), forage (X3), concentrate (X4), and manpower (X5). These 5 factors will be examined to find out their influence towards dairy cattle milk production.

Data related to several factors that influence dairy cattle milk production were first converted into a natural double logarithm (ln) form in estimating parameters in the Cobb-Douglas function equation. Based on the results of data processing using Eviews 9 software, the production function model is obtained:

$$Y = 2{,}465\ X1^{0{,}88}\ X2^{0{,}103}\ X3^{0{,}126}\ X4^{0{,}102} X5^{-0{,}11} \quad .. (5)$$

If it is linearized, the function becomes:

Ln Y = 2.46 + 0.88*LnX1 + 0.103*LnX2 + 0.126*LnX3 + 0.102*LnX4 - 0.11*LnX5

From the results of model estimation using the

Cobb-Douglas function model (shown in table 2), the results shows that the determination coefficient (R2) was 90.7% with the value of corrected determination (R2 adjusted) was 88.2%. The determination value (R2) shows that 90.7% of the production variation could be explained together by the factors of dairy cattle number, the number of lactating cattle, forage, concentrates, and manpower. Meanwhile, 8.3% was explained by other factors beyond the model. Other factors beyond the model which were thought to have influence on fresh milk production are age, environment, weather and climate influences, administration of drugs and vitamins, cattle environment and disease.

The coefficient value in Cobb-Douglas function model is the production elasticity value of the production variables. The results of the F-calculate on the production function estimator model reached 31.00 and the probability value was 0.000 in which the probability value was less than the real level value (0.05). This condition explains that all production factors used in dairy cattle business activities together have a significant influence on milk production. Based on the results of the t-test it is known that the independent variables that have a significant effect on milk production are the number of dairy cattle, forage, and concentrates feed. Meanwhile, the number of lactating cattle and manpower inputs do not have a significant effect on milk production.

The analyzed production function estimator model shows the existence of a feasibility level based on OLS assumptions (Ordinary Least Square). The intended OLS assumptions are model, the absence of multicollinearity among independent variables, homogeneous variety (homoscedasticity) and the absence of autocorrelation.

Multicollinearity testing was performed so that the independent variables used do not influence each other. Based on the testing using VIF (Variance Inflation Factors), it was identified that the model is free from multicollinearity problem. This is based on the results of the VIF test which shows that all variables have a value of less than 10, namely 2.215815; 1.365999; 1.430548; 1.469673 and 1.275011. Autocorrelation test using Breusch-Godfrey Serial Correlation LM Test with the Chi-Square probability value 0.0596 is greater than real level (0.05). Therefore, it can be concluded that the model is free from autocorrelation problem. Heteroscedasticity test was performed by using Breusch-Pagan-Godfrey test resulted a value of 0.0629 which is greater than the real level of 5% (0.05). It means that the equation of the estimation results is free from heteroscedasticity problem. Jarque Bera test was used to perform normality test. The Jarque-Bera probability value from the estimation results in this study is 0.571, in which the value is greater than the real level of 0.05. So, it can be concluded that the estimation results passed normality test.

Discussion

Based on the results of statistical calculations, the analysis of the production function estimator model of dairy farmers in Boyolali Regency has met the OLS (Ordinary Least Square) assumption. This OLS assumption fulfillment indicates that the production function model can be used to estimate the relationship among the independent variables (production inputs) towards the production results (outputs) in dairy cattle business activities. The following are descriptions of each production input:

Number of Dairy Cows (X1)

Based on the results of parameter estimation to-

Table 2. The Results of Cobb-Douglas Model Regression

Variables	Coefficients	Coefficient Standard Deviations	T-calculate	P-value
Constants	2.462.375	0.265832	9.262.897	0.0000
Ln Dairy Cattle Number	0.883248	0.113061	7.812.149	0.0000*
Ln Cow Lactating Number	0.103256	0.120997	0.853382	0.3972
Ln Forage	0.126081	0.082034	2.536.941	0.0301*
Ln Concentrate	0.102147	0.049911	2.046.577	0.0456*
Ln Manpower	-0.112588	0.142290	-0.791258	0.4323
R2	90.7 %		F-calculate	31
R2 adj	88.2 %		F-cal Prob	0.000000

Source: Processed primary data, 2018

wards production factors, it shows that the number of dairy cattle variable (X1) has a P-value of 0.0000. If the 5% level is real, the variable number of dairy cows has a significant influence on milk production. So, if there is a decrease or an increase in the number of dairy cattle, it will have a significant effect on the milk production. Based on parameter coefficient score, the number of dairy cattle has a positive value of 0.883248. This value indicates that if the number of dairy cattle increases by 1%, it will reduce dairy cattle production by 0.883248 percent by assuming that other factors remain the same (cateris paribus). Siregar (1992) explained that the addition of female dairy cattle population is one of the efforts to increase milk production in addition to efforts to improve feeding and management as well as improving the intensification of artificial insemination (IB) implementation.

Number of Lactation Hosts (X2)

Based on the results of parameter estimation towards production factors, it shows that the number of lactating cattle variable (X2) has a P-value of 0.3972. If the 5% level is real, the number of lactating cattle variable has no significant effect on milk production. So, if there is a decrease or increase in the number of lactating cattle, it does not significantly influence the milk production. However, it does not mean that the number of lactating cattle has no effect because simultaneously all variables have a significant effect on the milk production. Based on parameter coefficient score, the number of lactating cattle has a positive value of 0.103256. This value indicates that if the number of dairy cattle increases by 1%, it will reduce dairy cattle production by 0.103256 percent by assuming that other factors remain the same (cateris paribus).

Lactating cattle are cows within the productive period of producing milk. The variable of lactating cattle number does not have a significant effect because most farmers are lack of the cattle lactating period understanding. There is a maximum limit in determining the lactating period, which is a maximum of 10 months (approximately 305 days) after which the cattle must be prepared for the cage drying and enter the next lactating period. However, in reality farmers do not pay attention to the maximum limits of lactating period. The lactating period in productive cattle will greatly affect the quality and quantity of milk produced. According to Sudono *et al.* (2003) explained that milk production per day will begin to decline after reaching a two-month lactating period. This decrease in the amount of milk production will also be followed by a decrease in fat levels. Therefore, the lactating period will affect milk production. In addition, the number of farmers who have more than two heads of lactating cattle are only 7 out of 60 respondents, or the average lactating cattle owned by the respondents is only 1.5 heads, too few to obtain a maximum milk production.

Forage (X3)

Forage is the main feed for dairy cattle. Forage feed (rough feed) is all feed ingredients derived from plants in the form of leaves, twigs, flowers and stems. Forage has relatively low energy content, but is a good source of vitamins and minerals for cattle. Based on the P-value forage factor has a value of 0.0301. If the real level is 5%, forage variable has a significant influence on milk production. If there is a decrease or increase in forage, it will significantly influence milk production. Meanwhile, based on forage factor regression coefficient, it has a value of 0.126081. This regression coefficient means that if there is 1% addition of production factors in the form of forage, it will increase dairy cattle production by 0.126081% with the provision of forage on dairy cattle owned by an average of 42.6 kg/head/day.

Concentrate (X4)

Concentrate is cattle reinforcing food derived from grains and agricultural wastes such as corn, groats, bulgur, and agricultural by-products from factories such as bran, rice siftings, coconut residue, peanut residue and molasses. Based on the value of P-value, the concentrate feeds production factors have a value of 0.0456. If the real level is 5 %, the concentrate variable has a significant effect on dairy milk production, while the regression coefficient value is 0.102147. This regression coefficient means that if there is an addition of production factors in the form of concentrate feeds of 1%, it will cause an increase in dairy cattle production by 0.102147 by assuming that other factors remains the same (cateris paribus). Concentrate is animal feed containing high levels of energy and protein but low crude fiber content. Concentrates feed is a complementary food ingredient for cattle.

The comparison of the use of concentrate feeds with forage will impact the amount of production

and fat content of dairy cattle milk. Mc Cullough in Siregar (1992) explained that high milk production and meeting the quality requirements standards of milk fat content can be achieved by mixing the good quality of forage dry materials with concentrates of 60: 40. The quality of forage dry materials will impact the use of concentrates comparisons in feed. Research by Supriadi *et al.* (2017) also shows that feeding concentrates for lactating dairy cattle Holstein Friesian breed (FH) can increase the average milk production (precisely 18% according to control and feeding treatment in the study).

Manpower (X5)

Manpower is a group of residents within productive working age. Based on the value of the P-value manpower variable has a value of 0.4232. If the real level is 5%, this variable has no significant effect on milk production. Meanwhile, based on the regression coefficient, manpower variable has a negative value of -0.112588. This regression coefficient implies that for every 1% increase in manpower, milk production will decrease by -0.112588 % by assuming other factors remains the same (cateris paribus).

Manpower is an important factor in production because it is related to the maintenance and handling of cattle. In general, respondents employ manpower within the family to conduct routine maintenance activities such as cage cleaning, feeding, cattle bathing, grass collecting and milking. However, there are some respondents who employ workers outside the family if the number of animals owned is large. Manpower has less influence on milk production even though it is related to the milking process. Special treatment is needed the process of milking, for example workers who do milking should not be replaced because it will negatively impact the cattle such as they are easily become stressful and lead to the decreased in milk production. Although partially manpower does not significantly influence milk production, but simultaneously with other variables, manpower has a significant effect.

Dairy farming is considered effective if a worker can handle seven adult cows in one day. If there is an addition of worker for dairy farming, the amount of milk production will decrease because the manpower needed to handle one lactating cattle is only one. If other manpower is added to make it two or more workers to handle one lactating cow, it clearly will reduce cattle productivity because it exceeds the standard of manpower used.

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