p-ISSN 1410-5659 e-ISSN 2621-5144 **Jurnal Ilmu Ternak Universitas Padjadjaran, December 2024, 24(2):172-178**
Published by: DOI: 10.24198/jit.v24i2.55024
Unpad Press Available online at http://jurnal.unpad.ac.id/jurnalilmuternak

ESTIMATION OF EQUATIONS COST MODEL FOR REARING REPLACEMENT DAIRY COW

Melinda Aulia Arifin[1, a], Muhammad Hasan Hadiana[2, b], Cecep Firmansyah[2], Andre Rivianda Daud[2]

[1]*Undergraduate Student, Animal Husbandry Study Program, Padjadjaran University, 45363., West Java*
[2]*Staff at the Department of Socio-economic in Livestock Development. Faculty of Animal Husbandry, Padjadjaran University, 45363, West Java.*
[a,b]*email : melinda20001@mail.unpad.ac.id, hadiana.hasan@gmail.com*

Abstract
a Research was conducted to generate a mathematical model for estimating the rearing cost of replacement dairy cattle. This research uses a survey method to collect data regarding farmer expenditures in raising replacement dairy cattle. Data collection involved 67 farmers who kept 231 replacement dairy cows at various ages, from birth up to two years of age. Data analysis used multiple regression to estimate an equation model to describe a causal relationship between the partial total cost (TCp) with the period of rearing the cattle (q). The analysis performs two model equations: quadratic and cubic cost functions. The second model performs a goodness of fit better with a S-shaped curve (cubic function). The estimated equation model is $TCp = 2{,}5991 - 0{,}9617q + 0{,}1494\,q^2 - 0{,}0062\,q^3$, with the coefficient of determination (R^2) of 0.67. Based on the estimated cost equation model above, total cash expense for two-year-old pregnant heifers reached IDR 15,565,800. If the opportunity cost of a calf is included in the cost calculation, the cost will increase to IDR 19,102,800. Compared to the local price for two-year-old heifers, farmers still have a price margin of IDR 6,211,200.
Keywords: replacement cows, partial total cost, cubic function.

ESTIMASI MODEL PEMBIAYAAN PEMELIHARAAN SAPI PERAH CALON INDUK

Abstrak
Penelitian ini telah dilakukan untuk menghasilkan suatu model matematis yang dapat menduga biaya pemeliharaan sapi muda calon pengganti sapi perah. Penelitian ini menggunakan data survey mengenai pengeluaran peternak untuk pemeliharaan sapi perah muda. Pengumpulan data melibatkan 67 peternak sapi perah yang memelihara 231 ekor sapi pengganti dengan beragam umur, dari sejak lahir hingga umur dua tahun. Analisis data menggunakan regresi berganda menghasilkan persamaan yang menghubungkan biaya total per fase pemeliharaan (TCp) dengan fase pemeliharaan (q). Hasil analisis menghasilkan dua persamaan yaitu fungsi biaya kuadratik dan kubik, fungsi biaya kubik memiliki goodness of fit yang lebih baik, secara geometri berupa kurva-S: $TCp = 2{,}5991 - 0{,}9617q + 0{,}1494\,q^2 - 0{,}0062\,q^3$., dengan koefisien determinasi (R^2) sebesar 0,67. Berdasarkan model hasil estimasi biaya diatas, nilai dugaan pengeluaran petani untuk sapi dara buntiing berumur dua bulan adalah Rp 15,565,800. Jika biaya oportunitas pedet ke dalam perhitungan, maka biaya meningkat menjadi Rp 19.102.800. Dibandingkan dengan harga sapi dara bunting umur dua tahun yang berlaku di pasar lokal, peternak masih memperoleh margin harga sebesar Rp 6.211.200.
Kata kunci: sapi calon induk, biaya total parsial, fungsi kubik.

INTRODUCTION

On-farm activities are the primary sector of dairy agribusiness, where farmers raise dairy cows to produce raw milk and calves intended for replacement cows. Productive dairy cattle are the main asset that sustains the farm business (Amelia et al., 2015).

The success of this sector in producing replacement dairy cows determines the increase of cattle population and domestic milk supply in the future. However, the dairy cattle population in Indonesia has shown relatively small growth from year to year (Ifani et al., 2022).

Breeding activities, including the preparation of replacement cattle, have a positive impact on cattle population and dairy farming sustainability (Ammam and Harsita, 2019. Farmers who raise calves as replacement dairy cows must pay close attention to their condition at each phase of growth (Englan et al., 2021). Despite this, rearing heifers in the field has not attracted widespread interest among dairy farmers, due to relatively high production costs because of the duration of cattle maintenance. Farmers need 24 months more to benefit the replacement cows (Firman et al., 2010).

Farmers require various inputs such as labor, calf milk, forage, land, and non-cash expenses such as family labor, depreciation costs of farm buildings, and equipment. Although many farmers are raising replacement dairy cattle, they do not have clear information about the complete input cost record, due to the length of cattle rearing time. Many farmers also sell heifers in the middle of the rearing period, so they do not have complete records.

Many studies show low willingness among small farmers to record and keep farm records, due to their literacy levels and the perception that record keeping is a mundane task (Chagunda et al., 2024). Most farmers also do not track records of their agricultural and financial practices because they do not benefit from recording their farming (Tham-Agyekum, 2010)

This study provides a solution by producing a complete financing model for rearing replacement dairy cattle. Using data sourced from a large sample of reared cattle across several dairy farms, this study generated representative cost equation models with regression analysis. Also, this model allows one to estimate or calculate costs for each maintenance period or monthly age of the cattle.

This study aims, first, to estimate a total cost equation model for maintaining replacement dairy cows up to 24 months of age in a smallholder dairy farm. Second, estimate the price margin calculated from the difference between the market price and the total production costs of the heifers at the various age phases.

MATERIALS AND METHODS

The study is a survey research conducted in Margamukti village, Sub district of Pangalengan, West Java, in January 2024. The object of this study is a cost function model for dairy replacement cattle maintenance, which describes the relationship between total costs and the monthly maintenance period. The research subjects were dairy farmers who are members of a milk cooperative and are currently raising replacement cows.

Sampling Method

The sampling was conducted using a multistage random sampling method. In the first step, we randomly selected three areas of the cooperatives' milk collecting point (MCP): Pangkalan, Cipanas, and Los Cimaung. In the second step, we selected farmers currently raising replacement cows as samples.

Based on the official data sources reported by the local dairy cooperative, there are 1,305 cows and 994 replacement cows in the population (KPBS, 2023). The selected samples included 231 cattle raised by 67 farmers. The Slovin method was used to determine the sample size (n), using the following calculation:

$n = N/(N(e)^2 + 1)$;

While N = 994 (population); and margin of error (e) of 10%; resulting in 91 samples. However, the reliable equation model for further analysis (to estimate total costs) requires larger samples.

Cost Estimation Model

Total Cost (TC) represents all expenses incurred during the production process (Darmawan, 2019). At least two years of farm records are required to cover the total cost of rearing replacement of dairy cows. However, in this study, the data only represented two months of livestock maintenance or partial total cost *(TCp)*, considering farmers' limitations in recalling the records of all observed cattle maintenance costs.

With a large sample size (231 cattle), all partial costs can be combined to estimate the total cost covering 24 months of maintenance. In addition, the problem of variation in maintenance costs among samples, due to differences in animal age, can be minimized.

A nonlinear cost function model is a curve that connects economic variables in a

nonlinear form. The nonlinear and non-straight-line form of the cost function model depicts that as output increases, costs do not increase constantly. The nonlinear form of the cost function used is cubic. The vertical axis of the cost function model indicates the total maintenance cost of replacement dairy cattle over two months, while the horizontal axis represents the age of the cattle.

The cost function model that reflects the relationship between total partial costs and the monthly maintenance period can be represented by the two hypothetical equations, namely quadratic and cubic cost function as follows:

$$TC_{p1} = a + bq_i + cq_i^2 + u_i$$

$$TC_{p2} = a + bq_i + cq_i^2 + dq_i^3 + u_i$$

Where $TCpi$ is the total partial cost of raising the observed cattle for two months or one analysis period, q represents a rearing period, $q = 1, \ldots 12$ is the rearig period; coefficient of $b, c, d,$ are the slope of q^1, q^2, dan q^3 respectively, a is intercept, and u_i is a statistical error.

The suitability of the regression model and TCp variations were tested with F-statistics with a confidence level of 5%. The price margin is the difference between the current price of replacement cow and the total costs incurred to maintain the cattle.

The estimated mathematical model of total cost is used to predict either the total cost for 24 months of maintenance of replacement dairy cow. We calculate the total cost using integral analysis to determine the estimated area of the curve, as follows:

$$M_i = P_i - TC$$

$$M_i = P_i - \int_a^b (aq^3 - bq^2 + cq + d)dq$$

Notes:

M_i = Profit margin of the observed cattle
P_i = Price of cattle of i months of age
TC = Total cost for cattle maintenance
q = Cattle rearing period (2 months)
a, b = Lower and upper limit of q

RESULTS AND DISCUSSION

Regression Equation Model of Cost

The initial step of data processing was plotting the data graphically (Figure-1) to get an overview of the relationship between dairy cattle maintenance costs and rearing duration. The scatter plot can ensure that the data fits the hypothesized model.

Data analysis to estimate the regression model resulted in the following two equations:

$$TCp_1 = 1.9494 - 0.3474q + 0.0309q^2$$

$$TCp_2 = 2{,}5991 - 0{,}9617q + 0{,}1494 - 0{,}0062\,q^3$$

The regression equation states a causal relationship between production costs and the cattle-rearing period, each with a coefficient of determination (R^2) of 0.67 and 0,52. The first equation has better goodness of fit, meaning that the regression model explained 67% of the variation in TCp. Analysis of variance results in F-value of 150,3. It is higher than F-statistic at a 1% significance level. Therefore, we reject Ho, or accept the hypothesis that the equation model above represents the cost of rearing replacement dairy cows.

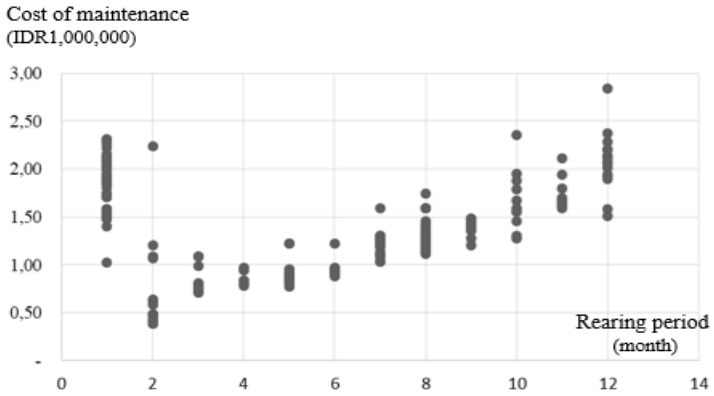

Figure 1.
A Scatter Plot of the Relationship Between Maintenance Costs and Cattle Rearing Periods.

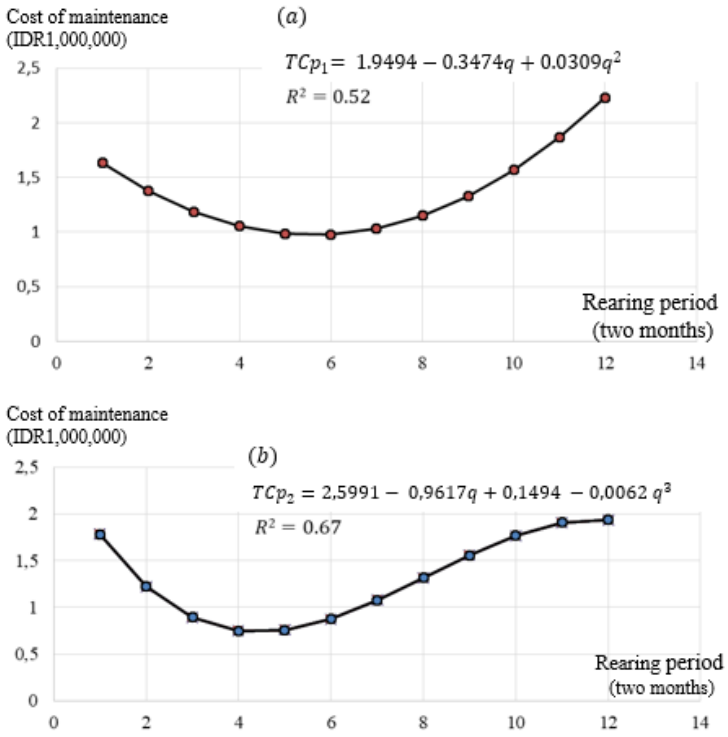

Figure 2.
Two Models of Rearing Dairy Cattle Cost Curves: Quadratic and Cubic Function.

Rearing Total Costs Estimation

The management of financing for the maintenance of prospective dairy cattle involves the selection of superior breeds, the provision of quality feed, and careful economic analysis (Anindyasari, et al., 2015). The rearing costs from the pre-breeding heifer phase to the first calving range from IDR 10,000,000 to IDR 15,000,000 in Pangalengan.

The costs listed in Table 1 include components such as milk, forage, grain, labor, barn, and farm equipment depreciation, except for the value or price of the calves raised (this issue will be discussed in the next section). Figure 2 illustrates the cost pattern of calf rearing. In the early stages of rearing, costs per two months tend to be high due to the cost of milk for the calf, while after weaning, the costs tend to decrease. Milk for calf is required ranging from 6-8 liters per day, provided daily until the calf reaches 3 months of age (Ardiyanto, et al., 2021). The majority of farmers rear calves by providing around 4.5-6.5 L/head/day of milk (Anggraini et al., 2016).

The lowest costs occur during the weaning phase. Calves past 3.5 months are no longer provided milk, as they are being gradually introduced to forage and concentrate with increasing volume (Riski et al., 2017). Cattle weaning can save feed costs for replacement animals (Kusumawati, et al., 2018). Economically, with weaning, farmers can save on rearing costs and increase the parent cow's milk production (Sagala et al., 2022). The highest costs occur during the 12th rearing period when the cows are 23-24 months old. During this period, the cows will consume more feed and additional feed in preparation for the first birth and milk production after giving birth.

Price Margin

The profit margin between the market price of replacement dairy cattle and self-rearing costs indicates the comparison between the two expenses. The margin during the calf-rearing phase is negative, while in other phases is positive, indicating that self-rearing costs tend to be lower than the market price.

Rearing calves until weaning significantly contributes to the overall total maintenance costs of replacement cattle. Milk for calf and initial calf feed are contributing inputs to its maintenance (Hawkins et al., 2019).

Table 1. Maintenance Costs for the Various Rearing Period

Age Status (monthly) of Cattle	Rearing Period	Rearing Cost (IDR/Head)
Calf, 2 months of age (postpartum)	Phase 1	1.780.000
Weaned Calf, 6 months	Phase 3	3.895.500
Heifer, 12 months	Phase 6	6.260.100
Pregnant Heifer, 18 months	Phase 9	10.139.400
Lactating Cow. 24 months	Phase 12	15.565.800

Table 2. The Price Margin of Replacement Dairy Cattle

Age Status of Dairy Cattle	Total Rearing Cost	Market Price	Margin of Price
	…….. (IDR) ……..…		
Calf at 2 Months	5.317.000	3.537.000	-1.780.000
Weaned Calf at 6 Months	7.432.500	7.201.291	567.500
Heifer at 12 Months	9.797.100	11.597.857	2.202.900
Pregnant Heifer at 18 Months	13.676.400	15.994.423	3.323.600
Lactating Cow at 24 Months	19.102.800	20.390.989	1.897.200

Description:
Margin of Cattle Price : Market Price – Total Rearing Cost
Total Rearing Cost : Rearing Cost in Cash + Calf's Value (Rp 3.537.000)

The sale of pregnant heifers provides the largest profit, as these cattle have high productivity. The high market price of pregnant heifers may also be due to their high productivity, as they can produce milk and calves (Latipah et al., 2015).

The farmer's decision to purchase or rear replacement cattle involves economic considerations, including feed costs, labor, and barn expenses. In addition to being more economical, self-reared replacement cattle have production advantages and their reproductive characteristics due to more controlled genetic selection and familiarity with specific farm environments (Suriasih et al., 2015). Self-rearing is considered more economically advantageous, with the total margin indicating a profit of IDR6,211,200. This emphasizes the importance of self-rearing to ensure the quality and economic viability of dairy cows.

CONCLUSIONS

The cost of raising replacement dairy cows increases with increasing length of rearing. The relationship is geometrically non-linear with an S-curve, mathematically it is a cubic function as follows:

$$TCp = 2{,}5991 - 0{,}9617q + 0{,}1494\,q^2 - 0{,}0062\,q^3$$

This equation model is statistically reliable to explain the rearing dairy cattle costs function. The coefficient of determination (R^2) is 0.67 with a significance level for the F-test of <0.01.

With integral solution, this model can predict total costs and calculate the price margin obtained by farmers for various stages of maintenance. The total cost of raising two-years-old heifers is IDR 15,565,800. Referring to the prevailing local prices, farmers can have a margin of IDR 6,210,200.

REFERENCES

Amelia, S. (2015). Analisis Manfaat Finansial dan Faktor Penentu (Pendorong dan Penghambat) Pembesaran Pedet Sapi Perah Sebagai Calon Induk (Kasus pada Peternakan Sapi Perah Rakyat di TPK Sukamenak Wilayah Kerja di KPBS Pangalengan). Skripsi. Bandung: Universitas Padjadjaran.

Ammam, & Harsita, P. A. (2019). Tiga Pilar Usaha Ternak: Breeding, Feeding, and Management. *Jurnal Sain Peternakan Indonesia*, 14 (4): 431- 439.

Ardiyanto, Utami, N.P, & Yuliananda, D. (2021). Managemen Pakan Sapi Perah di

Balai Besar Pembibitan Ternak Unggul Hijauan Pakan Ternak Baturraden. *Jurnal Peternakan Kandang*. 8 (2): 21-28.

Chagunda M G G, Msiska A C M, Wollny C B A, Tchale H and Banda J W 2006: An analysis of smallholder farmers' willingness to adopt dairy performance recording in Malawi. *Livestock Research for Rural Development. Volume 18, Article #66.* Retrieved December 23, 2024. http://www.lrrd.org/lrrd18/5/chag18066.htm.

Anggraini, S., Sulastri, & Sri, S. 2016. Status Reproduksi dan Estimasi Output Berbagai Bangsa Sapi di Desa Sriwedari, Kecamatan Tegineneng, Kabupaten Pesawaran. Jurnal Ilmiah Peternakan Terpadu 4(1) : 47-54.

Anindyasari, D., A. Setiadi, & T. Ekowati. (2015). Analisis Pendapatan Peternak Sapi Perah Kecamatan Banyumanik, Kecamatan Getasan, dan Kecamatan Cepogo. *Jurnal Ilmu Pertanian*, 11(2): 22-23.

Ratnasari, D., A. Atabany, B.P., Purwanto, & L.B., Salma. (2019). Model Pertumbuhan Sapi Perah Friesian Holstein (FH) dari Lahir sampai Beranak Pertama di BBPTU-HPT Sapi Perah Baturraden Menggunakan Model Matematik Logistic. *Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan*, 7 (1): 18-21

Darmawan, Deni. (2019). *Metode Penelitian Kuantitatif. Bandung*. Indonesia: PT. Remaja Rosdakarya.

Englan, F.F., Salman, L.B., & Christi, R.F. (2021). Pengaruh Pejantan Terhadap Bobot Lahir dan Bobot Badan Umur 11 Bulan Pada Sapi Perah Betina Friesian Holstein Di PT. Ultra Peternakan Bandung Selatan. *Jurnal Ilmiah Peternakan Terpadu*, 9(3): 362-371.

Firman, A., P.,Sri, dan Hermawan. (2010). Peran Usaha Perbibitan dalam Pengembangan Ternak Sapi Perah di Indonesia. *Jurnal Ilmu Ternak*, 10(1):7-13.

Hawkins, A., Burdine, K., Philips, D.A., & Costa, J.H.C. (2019). *An Economic of the Costs Associated with Pre-Weaning Management Strategies for Dairy Heifers. Animals (Basel)*, 9(7) :471

Ifani, M., Cahyo, D. N., Syamsi, A. N., Widodo, H.S., & Subagyo, Y. (2022). Pengaruh Produktivitas Sapi Perah Terhadap Produksi Susu Sapi Nasional. *Prosiding Seminar Teknologi dan Agribisnis Peternakan IX: 112-117. Banyumas, 14-15 Juni 2022*: Fakultas Peternakan Universitas Jenderal Soedirman "Peluang dan Tantangan Pengembangan Peternakan Berbasis Sumberdaya Lokal untuk Mewujudkan Kedaulatan Pangan"

Jaki, M. M. R., Nawawi, M.K., & Yono. (2023). Peran Industri Ternak Sapi Perah Dalam Upaya Meningkatkan Kesejahteraan Ekonomi Masyarakat Dalam Perspektif Ekonomi Islam di Kelurahan Kebon Pedes Kota Bogor. *Jurnal Kajian Ekonomi dan Bisnis Islam*, 4(3): 569-595.

KPBS, 2023. Laporan Rapat Anggota Tahunan. Koperasi Peternak Bandung Selatan. Bandung

Kusumawati, E.D., Rahadi, S., Peso, J., & Krisnaningsih, A.T.N. (2018). Pengaruh Umur Lepas Sapih Dan Umur Induk Terhadap Produksi Susu Sapi Perah Peranakan Friesian Holstein (PFH). *Jurnal Ilmu dan Teknologi Peternakan Tropis*, 5(1): 62-68.

Latipah, I., Rahayu, S., dan Firmansyah, C. (2015). Analisis Pembiayaan Pengadaaan Calon Induk Sapi Perah Antar Wilayah Sentra Pengembangan Sapi Perah. *Students E-Journal Universitas Padjadjaran*.

Riski, P., B.P. Purwanto, and A. Atabany. (2017). Produksi dan Kualitas Susu Sapi FH Laktasi yang Diberi Pakan Daun Pelepah Sawit. *Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan*. 4(3): 345-349.

Sagala, Y., Dakhlan, A., Hamdani, D.I., & Adhianto,K. (2022). Estimasi Nilai Most Probable Producing Ability (Mppa) Bobot Sapih Pada Sapi Brahman Cross Betina Di Kecamatan Tanjung Sari, Kabupaten Lampung Selatan. *Jurnal Riset dan Inovasi Peternakan*, 6(4): 328-335.

Salman, L.B., Sumantri,C., Noor, R.R., Saefuddin, A. & Talib, C. (2014). Kurva Pertumbuhan Sapi Perah Fries Holland dari Lahir Sampai Umur Kawin Pertama dengan Model Matematika Logistic. Informatika Pertanian, 23(1): 75-84.

Suriasih, K., Subagiana, W., & Saribu, L.D. (2015). Ilmu Produksi Ternak Perah. Bali: Fakultas Peternakan, Universitas Udayana.

Wulandari, S. & Bowo, P.A. (2019). Pengaruh Produksi, Konsumsi, dan Harga Susu Sapi Nasional Terhadap Impor Susu Sapi. *Economic Education Analysis Journal*, 8 (3): 1130-1146.

Tham-Agyekum, E. K. (2010). Assessing farm record keeping behaviour among small-scale poultry farmers in the Ga East Municipality.