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Influence of Total Cattle, Milk Production, and Age of Cattle on Income of Dairy Farmers

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Abstract

This study aims to analyze the factors that influence the income of dairy farmers in Boyolali Regency. Boyolali Regency is known as one of the largest milk-producing areas in Indonesia, so understanding the factors that influence farmers' income is crucial for improving the welfare of local farmers. The method used in this study is a quantitative approach with the SMART PLS analysis tool, which allows researchers to measure the relationships between variables in greater depth. Primary data were collected through questionnaires distributed to dairy farmers who participated in this study, while secondary data were obtained from relevant agencies such as the Central Statistics Agency (*Badan Pusat Statistik*/BPS) and the Ministry of Agriculture to support data validity. The variables studied include the number of livestock, milk production, and the age of livestock that produce milk. The results of the analysis show that these three variables have a positive and significant effect on farmers' income. With an R-squared value of 0.575, this research model explains 57.5% of the variance in farmers' income. These findings provide valuable insights for farmers and policymakers in designing the right strategies to increase income through more optimal livestock management, such as increasing the number of productive livestock and utilizing technology that supports milk productivity.

Keywords

Age of Livestock, Dairy Cows, Income, Milk Production, Number of Livestock.

1. Introduction

The role of the agricultural sector in the economy is very significant, considering that 87.31% of Indonesia's population depends on this sector for their livelihood (BPS, 2024). The development of the agricultural sector is often evaluated through several factors such as land area, production, livestock, and farmer exchange rates (BPS, 2023). Cattle farming is one of the agricultural activities widely carried out by people in rural areas. This sector not only provides food for the community but also creates jobs and becomes a source of income. In addition, this sector has the potential to contribute to regional income, so it is important for local governments to optimize this potential (Rarasati & Faridatussalam, 2022). This potential can encourage farmers to increase their income through supporting activities such as livestock, which has various advantages, including as a source of income, utilization of livestock waste through reprocessing, and production of milk and meat. The livestock sector, especially dairy cattle, has the potential to become a new growth engine in the agricultural industry to meet the increasing demand for animal protein in the form of milk. In 2024, the population of dairy cattle in Indonesia was recorded at 485,809. Milk production in 2023 reached 20%; however, in 2024 it decreased by 6.19% compared to the same period the previous year (BPS, 2024). This decrease was caused by the high volume of milk imports carried out by the government.

One area that is an example of the importance of dairy farming is Boyolali Regency, Central Java, which is known as the "Milk City". This nickname was given because Boyolali is one of the largest centers of fresh cow's milk production in Central Java (Alfianto & Lambelanova, 2021). This district has an area of around 101,510.10 hectares (*Pejabat Pengelola Informasi dan Dokumentasi/*PPID Boyolali) with a population of 1.09 million people. The largest milk producing areas are in five sub-districts: Musuk, Cepogo, Tamansari, Singosaren, and Mojosongo. Among the five sub-districts, Mojosongo Sub-district is the largest milk producer with a production of 12.02 million liters (BPS, 2024). In total, milk production in Boyolali reached 13.1 million liters in 2023 (BPS, 2023).

Although the majority of Boyolali residents work in the agricultural sector, many also raise livestock as an effort to earn additional income. One of the commonly raised livestock is dairy cattle, which has a number of advantages: high adaptability to the local environment, able to consume low-quality feed, and has good reproductive ability. The development of dairy farming in rural areas has significantly improved the local economy, especially for farmers involved in milk production. This has increased the economic value and income of many small-scale farmers. To expand the scale of dairy cattle farming and stabilize milk prices, strong government support is needed (Rusdiana & Soeharsono, 2019). One strategy to increase the cattle population is to increase the reproduction rate through an artificial insemination program. Programs such as Upsus Siwab (Special Efforts for Mandatory Pregnant Cows) launched in 2017 have succeeded in increasing the pregnancy rate of cows by 5% per year (Rusdiana, 2017). The purpose of this study was to identify the main factors that influence the income of dairy farmers in Boyolali Regency. This study is useful in helping farmers and other stakeholders to design more effective strategies in increasing the income of dairy farmers. In addition to providing practical benefits, this study also contributes to the development of previous studies. The main difference lies in the use of current data and research results, because this study uses the latest data and presents different findings compared to previous studies.

2. Literature Review

From an economic perspective, production is the process of transforming inputs into outputs. Naturally, increasing output will benefit livestock farmers. Given that some economic activities are still agrarian in nature, this is evident from the significant contribution of the agricultural sector to national income (Eka, 2013). Development efforts emphasize economic growth supported by increased productivity and efficiency in the livestock sector. According to Suaib and Zulhijjah (2024), the ultimate goal of development is the welfare of society. Humans are not only objects of development but are also expected to be active subjects who significantly contribute to regional progress. Therefore, agricultural development must be improved and directed to become the main driver of an efficient and highly competitive economy, as well as a reliable source of income for the community. Several methods can be used to increase the income sources of the community in the agricultural sector, one of which is by increasing food production or trade through higher selling prices—such as processing milk or converting waste into various types of fertilizer. In general, income is influenced by several factors of production used to produce goods or services, including natural resources, capital, and technology (Ridha, 2017; Putra & Faridatussalam, 2022). In line with the Theory of Production in economics, the relationship between inputs and outputs is governed by the principle of diminishing returns, which states that an increase in one input (while keeping other inputs constant) will initially increase output, but the rate of output increase will decrease (Viner, 2024). To maintain and increase productivity, it is essential to implement innovations, adopt modern technologies, and improve the quality of human resources. Furthermore, according to Schultz (1961), investments in education, skill development, and health can significantly improve productivity and income levels, particularly in the agricultural and livestock sectors. Therefore, human capital development, in addition to optimizing natural resources and technology, is crucial for sustainable agricultural progress and regional economic growth.

Several studies have explored the factors affecting dairy farmers' income. Isnaini (2024) found that increasing the number of dairy cows significantly contributes to higher farmers' income. This is due to the increased volume of milk production that can be sold, thereby adding to the farmer's daily or monthly income. Additionally, a larger number of cows opens opportunities for product diversification, such as selling calves or organic fertilizer from livestock waste. Therefore, the author formulates the following hypothesis:

H1: The number of dairy cows has a significant positive effect on farmers' income.

Research by Mustofa et al. (2022) indicates that the socio-economic conditions and managerial competencies of farmers significantly influence their income. Moreover, a study by Warangkiran et al. (2021) found that the number of livestock owned impacts farmers' income, with milk production being the primary factor contributing to this income. Labor costs also have a significant impact on income, as the more labor required, the greater the costs incurred by farmers. Another finding from Ramadhan et al. (2022) reveals that the number of cows, livestock selling prices, labor costs, and drug prices significantly affect the income of dairy farming businesses. Therefore, these factors play an essential role in determining dairy farmers' income. The author thus formulates the following hypothesis:

H2: The volume of milk production has a significant positive effect on farmers' income.

Research by Indrayani and Andri (2018) shows that the age of livestock and business experience significantly affect farmers' income. However, the number of livestock and the educational level of farmers do not have a significant impact on their income. On the other hand, a study by Basriwijaya and Balqies (2024) found that the number of livestock, feed costs, and drug costs partially influence the income of farmers in Aceh. These factors contribute to determining the level of income from dairy farming. Therefore, even though some variables, such as the number of livestock, may not always have a significant impact, other factors such as feed and drug costs still play an important role in farmers' income. Hence, the author formulates the following hypothesis:

H3: The age of the cows has a significant negative effect on farmers' income.

3. Methods

This study uses a quantitative approach to analyze the factors influencing the income of dairy farmers in Boyolali Regency (Sugiyono, 2016). This approach was chosen because it allows for the measurement and analysis of numerical data, thereby providing an objective picture of the relationships between the variables studied. To gain a more comprehensive understanding of the dairy farming sector in the area, the study utilized both primary and secondary data. Primary data were collected through questionnaires distributed to farmers, while secondary data were obtained from various official sources, such as the Central Statistics Agency (BPS) 2024, annual reports from relevant ministries, and other references including books and scientific journal articles. The study was conducted in two main stages: testing the measurement model (outer model) and testing the structural model (inner model). The outer model test aims to assess the validity and reliability of the indicators used to measure the research constructs, while the inner model test is conducted to determine the causal relationships between the predetermined constructs. For data analysis, this study used SMART PLS software, which is considered appropriate for processing data in research involving structural models. With this approach and methodology, the study is expected to contribute to a better understanding of the factors that play a significant role in determining the income of dairy farmers in Boyolali Regency.

4. Results

Outer model assessment is conducted to test the validity and reliability of the research instrument. Validity is tested by looking at the outer loading value, where the indicator is considered valid if it has a value above a certain predetermined limit. Meanwhile, reliability is tested through the Composite Reliability value, which shows the internal consistency of the indicators that form a construct. If the Composite Reliability value exceeds the recommended threshold, then the instrument is considered reliable. Thus, through this validity and reliability testing, it can be ensured that the measuring instrument used in the study has good accuracy and consistency.

Table 1. Validity Test

Construct	Items	Outer loading	VIF
Number of Livestock	NL.1	0.847	1.670
	NL.2	0.799	1.395
	NL.3	0.820	1.664
Cow Milk Production	CMP.1	0.780	1.771
	CMP.2	0.726	1.414
	CMP.3	0.783	1.558

Construct	Items	Outer loading	VIF
	CMP.4	0.763	1.668
Age of Cattle That Produce Milk	ACPM.1	0.833	1.805
	ACPM.2	0.831	1.426
	ACPM.3	0.812	1.573
Income	I.1	0.787	1.766
	I.2	0.760	1.660
	I.3	0.783	1.518
	I.4	0.819	1.534

The results of the construct validity analysis in Table 1 show that all indicators have an outer loading value above 0.70, which means they can be considered valid in measuring the intended construct. Additionally, the VIF value for each indicator is below the threshold of 5, indicating that there is no multicollinearity problem. In the livestock number construct, indicators NL.1, JK.2, and JK.3 have outer loading values ranging from 0.799 to 0.847, with a VIF below 2. For the cow's milk production construct, indicators CMP.1 to CMP.4 have outer loading values between 0.726 and 0.783, with a VIF ranging from 1.414 to 1.771. In the age of livestock that produce milk construct, indicators ACPM.1, ACPM.2, and ACPM.3 have outer loading values between 0.812 and 0.833, with VIFs ranging from 1.426 to 1.805. Meanwhile, the income construct, consisting of indicators I.1 to I.4, has outer loading values between 0.760 and 0.819, with VIFs ranging from 1.518 to 1.766. Based on these results, all indicators are declared valid and reliable for use in research.

Table 2. Reliability Test

Variable	Cronbach's Alpha	Composite Reliability	AVE
Number of Livestock	0.761	0.862	0.676
Cow Milk Production	0.796	0.867	0.620
Age of Cattle That Produce Milk	0.767	0.865	0.682
Income	0.761	0.848	0.583

The results of the reliability and construct validity analysis in Table 2 show that all constructs in this study meet very good criteria, indicating high data quality and the relevance of well-measured constructs. The Cronbach's Alpha value for all constructs is above 0.70, indicating high internal consistency and that this research instrument can produce stable and reliable results. In addition, the Composite Reliability (CR) value, which is also above 0.70, further strengthens the evidence of construct reliability, indicating that the constructs have a good level of reliability in measuring the intended phenomenon. In terms of convergent validity, the Average Variance Extracted (AVE) value for all constructs is greater than 0.50, meaning that the measured latent variables are able to explain more than 50% of the variance in their indicators, indicating that the constructs have high validity in measuring the concepts to be studied. Specifically, the Number of Livestock construct has a Cronbach's Alpha value of 0.761, CR of 0.862, and AVE of 0.676; the Cow Milk Production construct has a Cronbach's Alpha value of 0.796, CR of 0.867, and AVE of 0.620; the Age of Livestock Producing Milk construct has a Cronbach's Alpha value of 0.767, CR of 0.865, and AVE of 0.682; and the Income construct has a Cronbach's Alpha value of 0.761, CR of 0.848, and AVE of 0.583. All of these results indicate that each construct used in this study is reliable and has excellent convergent validity, making it suitable for further analysis.

Table 3. Discriminant validity with heterotrait-monotrait ratio (HTMT)

Variable	Number of Livestock	Cow Milk Production	Age of Cattle That Produce Milk	Income
Number of Livestock				
Cow Milk Production	0.833			
Age of Cattle That Produce Milk	0.637			0.795
Income	0.773	0.790		0.851

The results of the correlation analysis between variables in Table 3 show a significant and positive relationship between all the variables studied. The number of livestock has a very strong correlation with cow milk production (0.833), indicating that the more livestock a farmer owns, the higher the level of milk production. This highlights the importance of managing the number of livestock to increase productivity. In addition, the number of livestock also has a moderate correlation with the age of livestock producing milk (0.637), meaning that the age of the livestock plays a role in determining the quality and quantity of milk production. The strong correlation between the number of livestock and income (0.773) shows that the more livestock a farmer owns, the greater the potential income they can generate. On the other hand, cow milk production has a very strong relationship with income (0.790), emphasizing that an increase in milk production directly impacts income growth. The age of livestock producing milk also has a very strong correlation with income (0.851), indicating that livestock of productive age significantly influences the increase in farmer income. Overall, these results confirm the importance of the combination of livestock numbers, productive age, and milk production levels in improving farmer welfare and income.

The inner model assessment is used to test the hypothesis. The bootstrapping approach utilizes 500 subsamples to analyze the hypothesis test. A sample size of 500 was chosen to make the hypothesis testing more focused and to require a one-sided test. Additionally, the tests conducted on the inner model are R^2 and T statistics. R^2 is a measure commonly used to test the inner model, known as the coefficient of determination. This test is a predictive power model obtained from the squared correlation between the actual value and the predicted construct. R^2 values are interpreted as follows: 0.75 = strong, 0.50 = moderate, and 0.25 = weak. The R^2 value for the Income variable is 0.575. This indicates that 57.5% of the variance in the Income variable can be explained by the independent variables in the research model, such as the Number of Livestock, Cow Milk Production, and Age of Livestock Producing Milk. The remaining 42.5% is explained by other factors not included in this research model. This value suggests that the model has a fairly good predictive ability in explaining the factors that influence income.

Table 4. Hypothesis Testing

	Hypothesis	Original Sample	Sample Mean	STDEV	T-Statistics	P Values
H1	Number of Livestock -> Income	0.326	0.326	0.084	3.898	0.000
H2	Cow Milk Production -> Income	0.291	0.299	0.101	2.868	0.004
H3	Age of Cattle That Produce Milk -> Income	0.280	0.268	0.091	3.077	0.002

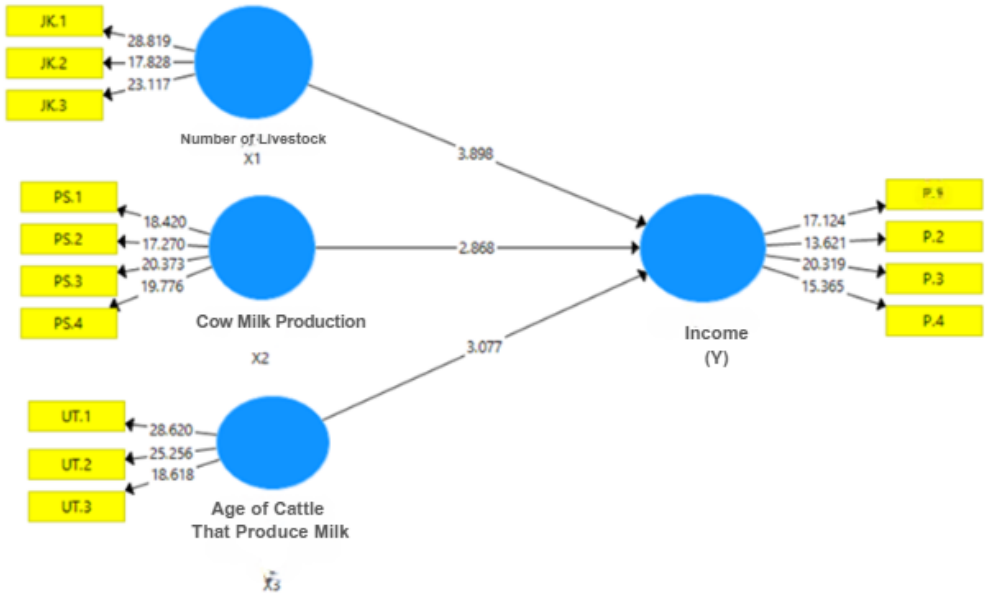

Figure 1. Bootstrapping

The results of the hypothesis test in this study Table 4 and Figure 1 show that all the proposed hypotheses are accepted because they have T-statistic values greater than 1.96 and P-values smaller than 0.05, indicating a significant relationship between the independent and dependent variables. The first hypothesis (H1), which states that the number of livestock affects income, is accepted with a T-statistic value of 3.898 and a P-value of 0.000, indicating a significant positive effect of 0.326. This means that the more livestock farmers own, the greater the potential income they can obtain. The second hypothesis (H2), which states that cow milk production affects income, is also accepted with a T-statistic value of 2.868 and a P-value of 0.004, indicating a positive effect of 0.291. This suggests that increasing cow milk production can significantly contribute to increasing farmers' income. Similarly, the third hypothesis (H3), which states that the age of livestock producing milk affects income, is accepted. The test results show a T-statistic value of 3.077 and a P-value of 0.002, indicating a positive effect of 0.280. This suggests that livestock of productive age produce optimal amounts of milk, contributing to increased income. Overall, these results confirm that the three factors—number of livestock, cow milk production, and the age of livestock producing milk—have a significant effect on farmers' income in this study, providing an important understanding of the factors that affect farmer welfare.

5. Discussion

The results of the study showed that the number of livestock owned by farmers directly affects their income. The more livestock they own, the greater the potential for meat and milk production. This study revealed a positive relationship between the number of livestock and income, with farmers who own more livestock tending to have higher incomes. However, increasing the number of livestock also requires good management to ensure optimal productivity. Aspects such as providing sufficient feed, maintaining livestock health, and proper care are crucial to ensuring that livestock can grow and develop well (Scialabba, 2021; Judijanto et al., 2025). With efficient management, farmers can maximize production from the number of livestock they own. Additionally, a larger business scale provides another advantage: cost efficiency. Farmers with more livestock can take advantage of bulk feed

purchases or use technology for automation, which in turn increases profit margins and reduces operational costs (Warangkiran et al., 2021). This study is also consistent with the research by Gultom & Wahyuni (2022), which shows that the number of livestock raised has a significant effect on the income of beef cattle farming businesses. The more livestock raised, the greater the income that can be generated by beef cattle farmers, as more production can be obtained from the livestock. Therefore, increasing the number of livestock, accompanied by good management, can improve the overall welfare of farmers.

The results of the study showed that cow's milk production has a significant effect on the income of farmers because cow's milk is one of the livestock commodities with high and stable market demand. The higher the amount of cow's milk production, the greater the income that farmers can obtain, both from direct sales of fresh milk and from processing derivative products such as cheese, yogurt, or butter. Optimal milk production is greatly influenced by factors such as feed quality, livestock health, good maintenance management, and the application of modern technology in the milking process. Farmers who are able to increase milk production through effective and efficient management tend to have higher incomes compared to farmers with low production (Ramadhan et al., 2022). In addition, this study is in line with the findings of Munawaroh (2024), which stated that cow's milk production has a significant and positive effect on the income of cattle farmers in Tengaran District. However, farmers' income is also influenced by fluctuations in milk prices in the market, high production costs, and competition with imported products, which can affect the competitiveness of local dairy products. Therefore, in addition to focusing on increasing milk production, farmers also need to consider cost efficiency and adopt the right marketing strategies to maximize income. One way to do this is by introducing processed dairy products that have higher added value, as well as improving the distribution network to reach a wider market (Purnamasari et al., 2023; Saputra & Ariani, 2024).

The results of the study showed that the age of the livestock that produces milk affects the income of farmers. This is because the productivity of cow's milk is greatly influenced by the age of the livestock. Dairy cows generally reach peak milk production at a productive age, which is between 3 and 7 years, during which the quality and quantity of milk produced are at their highest levels (Asyraf et al., 2023). At this age, farmers' income tends to increase due to optimal production and relatively efficient maintenance costs. Conversely, cows that are too young or too old typically produce less milk, which can reduce income (Simamora & Zebua, 2022). Farmers who are able to maintain a balance in the livestock population at a productive age have the potential for a more stable income than those who have a proportion of livestock outside of the productive age range (Adriani, 2021).

6. Conclusion

Based on the results of the analysis and discussion, it can be concluded that the number of livestock, milk production, and the age of livestock that produce milk have a positive and significant effect on the income of farmers in Boyolali Regency. The more livestock owned and the higher the milk production, the greater the potential income that can be obtained. Additionally, livestock that are of productive age are able to produce milk in optimal quantities, which has a positive impact on increasing income. Together, these three variables explain 57.5% of the variation in farmer income. Based on these findings, it is recommended that farmers increase the number of livestock and maintain the proportion of livestock that are of productive age to optimize production results. The local government is also encouraged to provide support in the form of livestock management training, feed subsidies, and milking technology to enhance livestock productivity. Meanwhile, for future researchers, it is recommended to include other variables such as production costs, market access,

and farmer education levels to gain a more comprehensive understanding of the factors influencing income. This study has several limitations, including the fact that it was conducted only in the Boyolali Regency area, so the results may not necessarily be generalizable to other regions. Furthermore, the variables used are limited and do not account for other factors that may also have an effect. The use of a quantitative approach alone is also insufficient to capture the complexity of the socio-economic conditions of livestock farmers. Therefore, future research should consider using a mixed-method approach to provide more in-depth and comprehensive results

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