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Analysis of factors affecting profitability of crystal coconut sugar business in Banyumas Regency, Central Java, Indonesia

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Abstract

Crystal coconut sugar has become one of Indonesia's most valuable agricultural commodities, playing a crucial role in enhancing rural economies and improving smallholder livelihoods. In Banyumas Regency Central Java, the coconut sugar industry has evolved into a significant agroindustrial cluster, where household-scale producers transform locally sourced coconut sap (*neera*) into crystalline sugar products with strong domestic and international market potential. Small and Medium-sized Industries (SMIs) in this sector contribute not only to agribusiness revenues but also to regional economic growth by creating employment opportunities and developing complementary industries. This study aims to analyze the factors influencing the profitability of crystal coconut sugar enterprises in Banyumas Regency, Central Java. Primary data were collected from household-scale producers through structured interviews and analyzed using multiple regression methods to identify key determinants of business performance. The findings reveal that production cost components, particularly expenditures for coconut sap, mangosteen rind (used as a natural preservative), cooking oil, and firewood, significantly affect business profitability. These results highlight the importance of cost efficiency, technological adoption, and sustainable resource utilization in maintaining competitiveness and ensuring the long-term resilience of the rural coconut sugar industry. Strengthening access to innovation, market information, and renewable energy inputs can further enhance profitability and support the transformation of crystal coconut sugar into a globally competitive agribusiness product.

Keywords: Central Java; Indonesia; Profitability; Regression; Crystal Coconut Sugar.

1. Introduction

Coconut sugar represents a vital local commodity in Indonesia, with substantial implications for rural economies and the livelihoods of small-scale agribusiness operators [1]. Among the different forms of coconut sugar, crystal coconut sugar has increasingly attracted attention owing to its higher unit value, extended shelf-life, and growing demand in domestic and international markets [2]. The adoption of value-added processing from raw material to refined product offers important opportunities for income generation beyond primary farming activities [3].

According to national data from BPS and the Ministry of Agriculture, the combined production of coconut sugar in Indonesia reached approximately 1.8 million tons in 2023 [4]. This underscores the scale of upstream supply available for value-added processing enterprises in regions such as Banyumas Regency. At the regional level, BPS data for Banyumas indicate a rising trend in coconut sugar production (from 56.447 tons in 2021 to around 63.000 tons in 2022) [5]. Moreover, BPS classification lists 'crystal sugar' under the category of plantation based smallholder crops, suggesting official recognition of the product category but limited disaggregation by product form.

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Despite this favourable context, the profitability of crystal coconut sugar business in Banyumas exhibits wide variation across producers. Variations stem from differences in production scale, technology adoption, raw material quality, labour efficiency, market access, and selling price strategies [6]. External factors such as fluctuating demand, supply chain limitations, and quality inconsistency further influence business performance, while technological and processing aspects also affect product quality and competitiveness [7].

Given these dynamics, understanding the key factors influencing the profitability of crystal coconut sugar business is essential. Studies related to sustainability and eco-efficiency show that crystal coconut sugar production requires balanced economic, social, environmental, and technological considerations to ensure long-term viability [8]. Therefore, this study aims to analyze the factors affecting the profitability of crystal coconut sugar business in Banyumas Regency, Central Java, to identify the production, managerial, and market attributes that most significantly determine business success in this sector.

2. Materials and methods

The analysis tool used to identify factors affecting profits is *the Cobb-Douglas* profit function, T*he Cobb-Douglas profit function* is used to determine the effect of input prices on the earnings of the crystal coconut sugar business, using output prices and input prices. The profit function is a function of the output price. Input price. As well as fixed inputs with the following models [9]:

$$\pi = A\, X_1^{\alpha 1}\, A\, X_2^{\alpha 2}\, A\, X_3^{\alpha 3}\, A\, X_4^{\alpha 4}\, A\, X_5^{\alpha 5}\, A\, X_6^{\alpha 6}\, A\, X_7^{\alpha 7}\, A\, X_8^{\alpha 8}$$

The profit function is transformed into a *Natural Double Logarithm* (ln) to facilitate the guesswork. So that it becomes a double linear shape. The model of the equation of the profit function of the crystal coconut sugar business is:

$$\text{Ln}\ \pi^* = \text{Ln}a_o + \alpha_1 \text{Ln}X_1 + \alpha_2\, \text{Ln}X_2 + \alpha_3 \text{Ln}X_3 + \alpha_4 \text{Ln}X_4 + \alpha_5 \text{Ln}X_5 + \alpha_6 \text{Ln}X_6 + \alpha_7 \text{Ln}X_7 + \alpha_8 \text{Ln}X_8 \mu$$

Information:

π^* : crystal coconut sugar business profits normalized with production prices
Ao : intersep
X_1 : normalized equipment depreciation cost
X_2 : normalized building depreciation cost
X_3 : normalized labor cost
X_4 : normalized sap cost
X_5 : normalized lime cost
X_6 : normalized mangosteen peel cost
X_7 : normalized cooking oil cost
X_8 : normalized firewood cost
αi : the input parameter of the expected variable, where i = 1,2....,8
μ : error

2.1. Classical Assumption Test

The classical assumption test is used to test the regression coefficient of each variable to determine its significance. The classic assumption test is as follows:

2.1.1. Normality Test

Normality tests are carried out to test whether in a regression model, an independent variable and a dependent variable or both have a normal or abnormal distribution. If a variable is not distributed normally, the results of statistical tests will decrease. In the data normality test, it can be done using the *One Sample KolmogorovSmirnov test*, which is provided that if the significance value is above 5 percent or 0.05, the data has a normal distribution. Meanwhile, if the results *of the One Sample Kolmogorov Smirnov* test produce a significant value below 5 percent or 0.05, then the data does not have a normal distribution [11].

2.1.2. Multicollinearity Test

Multicollinearity occurs due to the relationship between some or all of the variables described in the regression model. If there is multicollinearity in the model, then the model has a large standard error so that the coefficient cannot be

estimated at high speed. The symptoms of multicollinearity can be seen from the magnitude of the value *Tolerance* and VIF (*Variance Inflation Factor*) through the SPSS program. *Tolerance* can measure the variability of selected variables that are not explained by independent variables. The commonly used values are the *Tolerance>1* or the VIF value < 5, then there is no other multicollinearity [12].

2.1.3. Heteroscedasticity Test

The heteroscedasticity test aims to test whether there is an inequality in the regression model *variance* from the residual of one observation to another. This study uses a *Glejser* to test the presence or absence of heteroscedatisity. If the probability of significance > 0.05, it means that heteroscedasticity does not occur. If the probability of significance < 0.05, it means heteroscedasticity occurs[12].

2.1.4. Autocorrelation Test

The purpose of the autocorrelation test is to find out whether in a linear regression model there is a correlation between the disruptive error in period t and the error in the period t-1 (previous). If there is a correlation. So it is called there is an autocorrelation problem. Autocorrelation in most cases is found in regression where the data is a time series or based on periodic time. such as monthly, yearly, and so on, therefore the special feature of this test is time. To detect symptoms of autocorrelation can be used the Durbin-Watson (D-W) test. Decision making on whether or not there is autocorrelation can be seen from the following conditions [13]. The test criteria are shown in Table 1.

Table 1 The value and meaning of Durbin Watson's statistics

DW Value	**Meaning/Result**
-2 < DW	Positive autocorrelation
-2 < DW < 2	No autocorrelation
2 > DW	No serial correlation

Source: Santoso, (2012).

Autocorrelation tests can also be done through the *Run Test*. This test is part of a non-parametric statistic that can be used to test whether there is a high correlation between residuals. Decision making is done by looking at Asymp values. Sig (2-tailed) Run Test. If the value of Asymp.Sig (2-tailed) is greater than the significance level of 0.05, then it can be concluded that there is no autocorrelation.

2.2. Hypothesis Testing

2.2.1. F test

The F test was performed to determine the influence of all independent variables contained in the model together (simultaneously) on the bound (*dependent*) variables. The test criterion was to compare the probability of F-calculation with an alpha of 5 percent. If the value of F calculates > F table at level α: 0.05 otherwise if F calculates ≤ F table, then H_0 is accepted and rejects H_a which means the second independent variable. together there is no real effect on dependent variables [14].

2.2.2. Decision criteria:

If F calculates ≤ F table with a confidence level of 95 percent, then H_0 is accepted and H_a is rejected, meaning that the cost of production factors together has no real effect on the profits of the crystal coconut sugar business.

If F calculates > F table with a confidence level of 95 percent, then H_0 is rejected and H_a is accepted, meaning that the cost of production factors together has a real effect on the profits of the crystal coconut sugar business.

2.2.3. T test

The t-test is used to determine the influence of each independent variable on the bound variable of a model. The criterion for testing the results is that if t value > t table then H_0 rejected and accepted H_a which means independent variables to-*i,* partially has no real effect on the dependent variable, whereas if t calculates ≤ t table, cast H_0 accepted and rejected H_a which means the independent variable to-*i.* by individuals have a real effect on dependent variables [14].

2.2.4. Decision criteria:

If t calculates the t value > t table of the table at a confidence level of 95 percent, then H_0 is rejected, meaning that the cost of the production factor partially has a real effect on the profitability of the crystal coconut sugar business.

If t calculates the t value ≤ t table of the table at a confidence level of 95 percent, then H_0 is accepted, meaning that the cost of the production factor partially does not affect the profitability of the crystal coconut sugar business.

2.2.5. Coefficient of Determination (R2)

The determination coefficient is used to assess the ability of the regression model, namely the proportion of the diversity of bound variables that the regression model can explain through its independent variables. This coefficient shows how much of the percentage of bound variables can be explained by their independent variables. The value of the determination coefficient is on a scale of 0 to 1, so that if the value is closer to 1, the better the free variables will be in explaining the bound variables. The measurement of the accuracy or suitability of the model (*goodness of fit*) is calculated through R^2 and *Adjusted* R^2. In R^2 it is defined as the percentage contribution of the free variable (X) to the variation (up and down) of the non-free variable (Y) while the other is the contribution of other factors that are not included in the model, or to measure the proportion (part) or percentage of total variation in Y that can be explained by X in the regression model. R value always increases with the addition of independent variables of a model, this becomes the weakness of R^2. To overcome this, R^2 is customized (*adjusted* R^2) so as to avoid bias towards independent variables included in the model [14].

3. Results and discussion

3.1. Classical Assumption Test

Before the multiple linear regression analysis was carried out, a classical assumption test was carried out. The classical assumption test is a requirement for multiple linear regression analysis. This test is carried out so that the assessment of parameters and regression coefficients is not biased. Classical assumption testing includes normality test, multicollinearity test, autocorrelation test and heteroscedasticity test. The results of the classical assumption test in this study can be explained as follows:

3.1.1. Normality Test

The normality test is used to verify whether the residuals follow a normal distribution. This procedure is critical to ensure valid regression inference, as highlighted in empirical studies of coconut sugar agribusiness profitability in Indonesia [15]. The normality test is used to test whether in the regression model used, the residual variable has a normal distribution or not. The results of the normality test of the printed coconut sugar and crystal coconut sugar businesses are presented in Table 2.

Table 2 Results of the normality test of crystal coconut sugar business

	Unstandardized Residual
Kolmogorov-Smirnov Z	0.117
Asymp. Sig. (2-tailed)	0.195

Source: Author's calculation using SPSS

Based on Table 2, the normality test uses the Kolmogorov-Smirnov test as the basis for decision-making, namely if the asymptotic significance value > 0.05, it is declared to be normally distributed. The results of the normality test produced an *Asymptotic Significance* (*2-tailed*) value in the printed coconut sugar business of 0.195, which means more than 0.05 or 0.195 > 0.05, so that the data is declared to be normally distributed. Similar findings were reported in agribusiness analyses involving SMEs and agroindustry performance [15].

3.1.2. Heteroscedasticity Test

Heteroscedasticity occurs when the variance of residuals differs across observations. A good regression model should be free from heteroscedasticity. Studies on the coconut sugar agroindustry also emphasize this requirement to ensure reliable model estimation [16].

The heteroscedasticity test aims to test whether in the regression model there is variance disparity from the residual of one observation to another. If the variance from the residual of one observation to another observation is fixed, then it is called homoscedasticity and if it is different it will be called heteroscedasticity. A good regression model is a model that does not have heteroscedasticity . The heteroscedasticity test uses the Glejser test. A good regression model should not have heteroscedasticity. The results of the heteroscedasticity test are presented in Table 3.

Table 3 Results of the heteroscedasticity test of crystal coconut sugar business

Independent Variables	**Sig.**	**Information**
Equipment Depreciation Cost (X_1)	0.050	No Heteroscedasticity
Building Depreciation Cost (x_2)	0.263	No Heteroscedasticity
Labor Cost (X_3)	0.367	No Heteroscedasticity
Sap Cost (X_4)	0.311	No Heteroscedasticity
Lime Cost (x_5)	0.096	No Heteroscedasticity
Mangosteen Peel Cost (X_6)	0.948	No Heteroscedasticity
Cooking Oil Cost (X_7)	0.081	No Heteroscedasticity
Firewood Cost (X_8)	0.383	No Heteroscedasticity

Source: Author's calculation using SPSS

The assumption that heteroscedasticity does not occur is if the *Significance* value > 0.05. Based on Table 3 the *significance value* on the independent variables of equipment depreciation cost (X_1), building depreciation cost (X_2), labor cost (X_3), sap cost (X_4), lime cost (X_5), mangosteen peel cost (X_6), oil cost (X_7) and firewood cost (X_8) each greater than 0.05, it can be concluded that there is no heteroscedasticity in the regression model. The significance values of all independent variables are above 0.05, indicating that the model is free from heteroscedasticity. This is consistent with previous research coconut sugar business analysis, which also reported homoscedastic residual patterns [17].

3.1.3. Multicollinearity Test

The multicollinearity test evaluates the correlation among independent variables. Consistent with earlier studies in the coconut sugar sector, multicollinearity must be avoided to ensure the accuracy of cost profit relationship estimation. The multicollinearity test aims to test whether the regression model finds a correlation between independent variables . A good regression model should not exhibit multicollinearity. The results of the multicollinearity test of the printed coconut sugar and crystal coconut sugar business are presented in Table 4.

Table 4 Results of the crystal coconut sugar multicollinearity test

Independent Variables	**Tolerance**	**VIF**
Equipment Depreciation Cost (X_1)	0.696	1.437
Building Depreciation Cost (x_2)	0.833	1.200
Labor Costs (X_3)	0.757	1.321
Cost of Sap (Nira) (X_4)	0.220	4.545
Lime Cost (x_5)	0.174	5.746
Cost of Mangosteen Peel (X_6)	0.174	5.731
Cooking Oil Cost (X_7)	0.214	4.673
Firewood Cost (X_8)	0.535	1.868

Source: Author's calculation using SPSS

The multicollinearity test is seen from the values of *the* Tolerance (TOL) and Variance Inflation Factor (VIF) of the independent variable against its dependent variable. If the TOL value ≥ 0.10 and VIF ≤ 10, then it can be said that there are no symptoms of multicollinearity or free of multicollinearity. Based on Table 4, the values of Tolerance and VIF on

the independent variables of the crystal coconut sugar business are the cost of equipment depreciation cost (X_1), building depreciation cost (X_2), labor cost (X_3), sap cost (X_4), lime cost (X_5), mangosteen peel cost (X_6), oil cost (X_7) and firewood cost (X_8) for *a tolerance* greater than 0.10 and a VIF of less than 10, respectively, it can be concluded that there is no multicollinearity in the regression model. Statistical patterns were observed in studies analyzing the structure, efficiency, and sustainability of coconut sugar production [15,16].

3.1.4. Autocorrelation Test

The autocorrelation test aims to test whether in the linear regression model there is a correlation between the interference error in the t period with the interference error in the t-1 period (previously). Autocorrelation arises because the observations that are sequential over time are related to each other. To detect the presence or absence of autocorrelation, the Durbin-Watson test (DW test) is used. The Durbin-Watson test is only used for *first-order autocorrelation* and requires that there be an intercept (constant) in the regression model and that there are no more variables among the independent variables. The results of the autocorrelation test of the crystal coconut sugar business are presented in Table 5.

Table 5 Results of the crystal coconut sugar business autocorrelation test

	Unstandardized Residual
Test Value[a]	0.04932
Cases < Test Value	19
Cases >= Test Value	20
Total Cases	39
Number of Runs	21
Z	0.004
Run Test	0.997

Source: Author's calculation using SPSS

Based on Table 5, it is known that *the value of Asymp. Sig. (2-tailed)* is 0.997, or greater than 0.05, so it can be concluded that in the regression model there are no symptoms or autocorrelation problems. Autocorrelation problems that cannot be solved with the *Durbin-Watson Test* can be solved with the *Run Test*, so that linear regression analysis can be continued. This aligns with prior profitability and performance studies on the coconut sugar agroindustry, where similar diagnostic criteria were applied [15,16].

3.2. Hypothesis Testing

In this study, hypothesis testing was carried out with statistical analysis of the data that had been obtained. The statistical analysis used in the study is multiple linear regression analysis. In multiple linear regression testing, the F test, the T test, and the Coefficient of Determination (R^2) were performed. This analytical approach is widely used in agribusiness and production economics studies to identify cost structures that significantly influence business profitability [17].

3.2.1. F test

Testing the significance of the effect of equipment depreciation costs, building depreciation costs, labor costs, sap costs, lime costs, mangosteen peel costs, cooking oil costs and firewood costs on the profits of crystal coconut sugar in this study was carried out using multiple linear regression analysis. Similar analytical methods were also used in prior studies on coconut sugar MSMEs profitability [15,16]. The F test was conducted to determine whether the effect of the regression coefficient used together had a real or no effect on the dependent variable. The full results of the F test are presented in Table 7.

Table 6 Results of the F test of crystal coconut sugar business

Type		*Sum of Squares*	*Df*	*Mean Square*	*F*	*Sig.*
1	Regression	9.858	8	1.232	11.570	0.000
	Residual	3.195	30	0.107		
	Total	13.053	38			
	F_{Table}				2.27	

Source: Author's calculation using **S**PSS

Based on Table 6, the results of the F test show that the F value is greater than the F_{table}, which is 11.570 > 2.27 with Df = (9-1) (39-9) and *the Sig*. value of 0.000 < 0.05. Therefore, it can be concluded that the independent variables of equipment depreciation cost (X_1), building depreciation cost (X_2), labor cost (X_3), sap cost (X_4), lime cost (X_5), mangosteen peel cost (X_6), oil cost (X_7) and firewood cost (X_8) together affect the dependent variable, namely the profit of the crystal coconut sugar business (π*).

3.2.2. T test

After the F test is carried out, the next hypothesis test is the t-test, which aims to test the influence of each independent variable on the dependent variable.

Table 7 Test results of multiple linear regression analysis of crystal coconut sugar business

Variable Independent	**Coefficient Regression**	**Value T_{Count}**	**Sig.**
Equipment Depreciation Cost (X_1)	0.070	0.646	0.523
Building Depreciation Cost (X_2)	- 0.143	-1.442	0.160
Labor Cost (X_3)	0.102	0.982	0.334
Sap Cost (X_4)	- 0.533*	-2.769	0.010
Lime Cost (X_5)	-0.044	-0.203	0.841
Mangosteen Peel Cost (X_6)	0.640*	2.958	0.006
Cooking Oil Cost(X_7)	0.525*	2.687	0.012
Firewood Cost (X_8)	0.276*	2.237	0.033
Constant	6.215		
T_{Table}		2.021	

Source: Author's calculation using SPSS

Information:

*) has a real effect on the confidence level of 95%

Based on the data in Table 7, the following multiple regression equations can be made:

$$\pi^* = 6.215 + 0.070X_1 - 0.143X_2 + 0.102X_3 - 0.533X_4 - 0.044X_5 + 0.640X_6 + 0.525X_7 + 0.276X_8 + e$$

Based on Table 7 of the results of the multiple regression analysis test, t_{table} with *degree of freedom* (Df) = (N – k = 39 – 9) 95% confidence level, then the test results of each variable will be explained as follows.

Equipment Depreciation Cost

The test results in Table 7 have a significant value of 0.523 and $t_{is\ calculated}$ as 0.646 which means that $t_{calculates}$ 0.646 < t_{table} 2.021 and a significance value of 0.523 > 0.05, based on the results of the multiple linear regression analysis, it can be concluded that the independent variable of equipment depreciation costs does not have a real effect on the dependent variable of the profits of the crystal coconut sugar business produced by craftsmen, which means that the increase in

equipment depreciation costs will reduce the profits of the crystal coconut sugar business, because the higher the purchase value of the equipment, the profits of the crystal coconut sugar business will also decrease. Equipment utilization improves performance [16].

Building Depreciation Cost

The test results in Table 7 have a significant value of 0.160 and $t_{is\ calculated}$ as -1.442 which means that $t_{calculates}$ -1.442 < t_{table} 2.021 and a significance value of 0.160 > 0.05 based on the results of the multiple linear regression analysis, it can be concluded that the independent variable of building depreciation costs has no real effect on the dependent variable of the profits of the crystal coconut sugar business produced by craftsmen, which means that the increased cost of building depreciation will decrease the profits of crystal coconut sugar. Previous studies show that high fixed costs can suppress profit margins in small agroindustries [15].

Labor Cost

The test results in Table 7 have a significant value of 0.334 and $t_{is\ calculated}$ as 0.982 which means that $t_{calculates}$ 0.982 < t_{table} 2.021 and a significance value of 0.334 > 0.05, based on the results of the multiple linear regression analysis, it can be concluded that the independent variable of labor costs does not have a real effect on the dependent variable of the profits of the crystal coconut sugar business produced by craftsmen, which means that the increase in labor costs will decrease the profits of the crystal coconut sugar business. This is because the labor used comes from within the family. Labor affects profits because the costs given to labor are assessed based on working hours and not based on labor expertise in the production of crystal coconut sugar. This aligns with findings that increased skilled labor allocation improves production efficiency and value-added processes [17]

Sap Cost

The test results in Table 7 have a significant value of 0.010 and $t_{is\ calculated}$ as -2.769 which means that t_{counts} -2.769 > t_{table} 2.021 and a significance value of 0.010 < 0.05, based on the results of the multiple linear regression analysis, it can be concluded that the independent variable of sap cost has a negative effect on the dependent variable of the profit of the crystal coconut sugar business. This shows that the cost of sap has a real effect on the profits of the crystal coconut sugar business. The negative influence of the sap cost coefficient shows that if there is an increase in costs, the profits received by artisans will decrease. The quality of sap is affected by the season. In the rainy season the quality of sap is not good but the amount of sap obtained is quite large because there is a mixture of water, while in the dry season the quality of sap is good but the amount produced is less compared to the rainy season. The quality of sap produced in the crystal coconut sugar business is different from that of printed coconut sugar. In the coconut sugar business, nira crystals that are of poor quality do not produce crystal granules and will then be printed. This affects the profits that will be received by crystal coconut sugar artisans, because the cost of sap is calculated from the result of multiplying the amount of sap produced by crystal coconut sugar artisans at the price per liter.), The cost of sap has no effect on profits. Previous studies emphasize that nira accounts for the largest share of production cost so increases directly reduce profitability [16,20]

Lime Cost

The test results in Table 7 have a significant value of 0.841 and t_{count} of -0.203 which means that t_{counts} -0.203 < t_{table} 2.021 and a significance value of 0.841 > 0.05, based on the results of the multiple linear regression analysis, it can be concluded that the independent variable of lime cost has no real effect on the dependent variable of the profits of the crystal coconut sugar business produced by artisans, which means that the increase in the cost of lime will decrease the profits of the crystal coconut sugar business. Similar findings occur in studies where clarifying materials minimally influence profit [6].

Mangosteen Peel Cost

The test results in Table 7 have a significant value of 0.006 and t_{count} of 2.958 which means that $t_{calculates}$ 2.958 > t_{table} 2.021 and a significance value of 0.006 < 0.05, based on the results of the multiple linear regression analysis, it can be concluded that the independent variable of mangosteen peel cost has a positive effect on the dependent variable of crystal coconut sugar business profits. This shows that the cost of mangosteen peel has a real effect on the profits of the crystal coconut sugar business. The cost of mangosteen peel is obtained from the result of multiplying the amount of mangosteen peel used multiplied by the purchase price. The appearance of crystal coconut sugar products is important because there is standardization in the quality of the products that will be produced by artisans. In the crystal coconut sugar business, artisans pay more attention to the color of the product to be marketed. Mangosteen peel as a natural

dye material will affect the appearance and selling price so that it will affect the profits received. This supports local findings that natural color enhancers improve product quality and selling value [14].

Cooking Oil Cost

The test results in Table 7 have a significant value of 0.012 and $t_{is\ calculated}$ as 2.687 which means that $t_{calculates}$ 2.687 > t_{table} 2.021 and a significance value of 0.012 < 0.05, based on the results of the multiple linear regression analysis, it can be concluded that the independent variable of cooking oil cost has a positive effect on the dependent variable of the profit of the crystal coconut sugar business. This shows that the cost of cooking oil has a real effect on the profits of the crystal coconut sugar business. The cost of cooking oil is obtained from the result of multiplying the amount of cooking oil used and the purchase price. The use of cooking oil in the crystal coconut sugar business aims to remove foam and foam when the sap is boiling. The cooking process in the crystal coconut sugar business is different from printed coconut sugar, when the sap boils and then let it sit for 10 minutes. Then the artisan adds cooking oil according to the cooked sap. If the artisan does not add cooking oil, the sap will overflow and spill from the pan. This will reduce the amount of sap cooked and the crystal coconut sugar that will be produced to less, thus affecting the profits of crystal coconut sugar artisans. Prior research also indicates that oil stabilizes crystallization, leading to higher product grades and selling prices [6].

Firewood Cost

The test results in Table 7 have a significant value of 0.033 and $t_{is\ calculated}$ as 2.237 which means that $t_{calculates}$ 2.237 > t_{table} 2.021 and a significance value of 0.033 < 0.05, based on the results of the multiple linear regression analysis, it can be concluded that the independent variable of firewood cost has a positive effect on the dependent variable of the profit of the crystal coconut sugar business. This shows that the cost of firewood has a real effect on the profits of the crystal coconut sugar business. The cost of firewood is the result of multiplying the amount of firewood used each month and the purchase price. The use of firewood is very important in the process of cooking crystal coconut sugar. The cooking process of crystalline coconut sugar takes longer compared to printed coconut sugar. Stirring and crystallization will certainly require a large amount of firewood so that the cost of firewood will affect the profits that will be received by crystal coconut sugar artisans. Artisans continue to buy firewood at high prices and sufficient quantities for fuel needs in producing crystal coconut sugar. Several studies affirm that fuel type and availability improve processing duration, affecting daily production volume [18].

The results of the t-test analysis on the multiple linear regression equation of the crystal coconut sugar business show that the cost of production factors that have a real effect on profits, namely the cost of nira, the cost of mangosteen peel, the cost of cooking oil and the cost of firewood. Meanwhile, equipment depreciation costs, building depreciation costs, labor costs and lime costs have no real effect on profits.

Coefficient of Determination (R^2)

The determination coefficient is the amount of contribution independent variables to dependent variables [6]. The result of the determination coefficient (R^2) are presented in Table 8.

Table 8 Results of the determination coefficient (R^2) of the crystal coconut sugar business

Type	R	R Square	Adjusted R Square	Std. Error of The Estimate
1	0.869	0.755	0.690	0.326

Source: Author's calculation using SPSS

Based on Table 8, the coefficient of determination (R^2) with R Square is 0.755. The coefficient shows that 75.5 percent variation in the variable changes of factors affecting the profitability of the crystal coconut sugar in this study can be explained by changes in the variables of equipment depreciation costs (X_1), building depreciation costs (X_2), labor costs (X_3), sap costs (X_4), lime costs (X_5), mangosteen peel costs (X_6), the cost of cooking oil (X_7) and the cost of firewood (X_8) while 24.5 percent can be explained by other variables that are not included in the regression model of this study.

These findings are consistent with the results of national studies indicating that raw material and processing input variables are dominant contributors to profit variation [15,16]. This suggests that earlier studies found even stronger explanatory power, likely due to fewer external market fluctuations compared to more recent conditions [23], The studies also reveal similar patterns where input costs particularly raw material and energy account for large portions of profitability variation in coconut sugar production systems [24].

4. Conclusion

The study concludes that the profitability of crystal coconut sugar enterprises in Banyumas Regency is primarily influenced by several key production cost components. Among these, the costs of coconut sap, mangosteen rind (used as a natural preservative), cooking oil, and firewood exhibit a significant and measurable effect on business profits. These inputs represent the most critical determinants of operational efficiency and cost management within the small-scale crystal sugar industry. The findings emphasize that profitability is closely linked to the producer's ability to optimize input utilization, reduce waste, and improve process efficiency. Strengthening access to affordable and high quality raw materials, adopting energy saving technologies, and enhancing managerial skills can therefore play a crucial role in sustaining competitiveness and income stability. In a broader perspective, supporting micro and small-scale enterprises through targeted policy interventions such as capacity building, market facilitation, and technology transfer will not only improve the economic viability of crystal coconut sugar production but also contribute to inclusive rural industrial development and regional economic growth in Central Java.

Compliance with ethical standards

Disclosure of Conflict of interest

The author(s) declare no conflict of interest.

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