Productivity Cost Model in 308 ROSS Chicken Poultry Systems: Case Study of Contract Farming in Rural Development Cooperative

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ABSTRACT

This paper explains the current costs characterization in broiler meat production under the economic conditions of Malaysia using mathematical and statistical techniques. State of the art of econometrical modelling currently used for regulatory decision-develop in the cost productivity model are described. This study examined the effects of the interaction between the main factors. Five variables considered in this study in which it has been divided into two types of variables which are dependent and independent variables. Four independent variables considered are the price of chick, starter fertilizer prices, chicken grower fertilizer prices and prices of chicken medicines. The multiple regression models involve the interaction up to the third level and considering 32 potential models. Each model was tested with multicollinearity test and test coefficient with the objective of removing variables that were not significant. Concluded in this study that mathematical modelling using Eight Selection Criteria (8SC) would improve economic profitability of broiler productivity.

Keywords: multiple regression, eight selection criteria, fourth-order interaction, best model, moisture ratio.

1.   Introduction

In Malaysia, broiler is a commodity which is in great market demand. In order to improve the country's agro-food production and economic growth, as in path of introducing the agriculture sector towards generating economic profitability business, the program Agriculture Contract (AC) has been introduced by the Federal Agricultural Marketing Authority (FAMA) as a paradigm to help entrepreneurs of small and medium scale farmers to market their agricultural products (Ratnawati, 2009). In AC system, company who obtained the contract will be supplied with all the necessary inputs while farmers provide land and labor (Farah et al., 2012). However, the conditions and nature of the contracts vary according to the type of crop or livestock, the agencies involved, the farmers themselves, technology and context of the contract is established.

Generally, farmer participation is limited to the production on the farm (Baumann, 2002). The Malaysian government is also looking at contract farming as imperative to the reconstruction of the country's agricultural sector (Ahmad, 2006), and as such has already taken initial steps to draft legislation regulating the agriculture. According to Tapsir et al. (2011), the improvement in poultry technology besides the management system is a crucial factor of the increasing demand of the broiler in Malaysia. The non-governmental organizations such as the Rural Development Cooperative (KPD) may help boost the involvement of entrepreneurs by allotting them ACs. Figure 1 shows one of the broiler farm constructed through the AC program conferred by the KPD.

Figure 1: KPD broiler house using AC system in Sabah.

Cost of production is one of an important pre-handling process of broiler
productivity. It can extend shelf life of the chicken, improve quality, improve
the bargaining position of the farmer to maintain relatively constant price of
his products and reduces losses. The most important associated cost factors
are the price of chicks, chick starter fertilizer, chicken grower fertilizer and of
chicken medicines. Usually, chicken harvesting occurred after 42 days in which
chicken breeds ROSS 308 are fully mature (Aviagen, 2009).

Recently, there have been few reports on productivity model in poultry
production system (Satir, 2003) and found that the classical method of eco-
nomic optimization in animal production would not be suitable for all kinds of
economic assessments of different approaches is necessary so that the methods
used are most appropriate for the available data and for the economic risk char-
acterization issue. Later, the research suggested that by using the time series
approach will be able to explain more in detail about the poultry produc-
tions. Tegel poultry of New Zealand reported that a model of energy exchange
between the chickens and their shed environment is developed for better un-
derstanding and control the shed climate and hence maximize the growth rate
of broiler. The design model for the heat production and water respiration rate
of a typical chicken was developed based on the physical principles (Ahmad,
2006).

Previous studies suggested that the application of biometrical empirical
models such as Gompertz, Laird and Robertson to model the poultry data as
to determine the growth rate of the broiler which later can estimate the pro-
ductivity. But, according to Ahmad (2006), the poultry growth modeling using
the above mentioned approach is usually done under specific sets of biological
and environmental constraints. These constraints may include, but are not
limited to genetic variations, feeding regimen, climate control, and other farm
management conditions.

Thus, several variables need to be controlled before the method can reason-
ably be determined. Once any of those variables changes, which is often the
case, the response changes too. Thus, ideally one constantly has to perform
empirical experiments to obtain new information. Such an approach is time
and cost prohibitive. Ahmad (2006) later suggested, one alternative approach
is to simulate body growth data by using sensical bounds (biological limits).
Simulation on a variety of poultry growth data can be done using the Monte
Carlo technique or other simulation methodologies.

From the literature, it seems search there has been to no work done in
regards to finding the factors that contribute to the broiler poultry productivity

in Ross 308. The novelty of eight selection criteria (8SC) also not yet revealed in the determination on important factor that associate to 308 ROSS chicken production system cost. The present study was carried out to select the best mathematical model to illustrate the poultry production cost of 308 ROSS chicken broilers and to investigate the effect of the interaction between the factors related to cost productivity Ross 308 poultry breeds.

2. Methodology

2.1 Phase 1 − All Possible Models

Ascertaining all possible models is prerequisite to determining the best model (Khuneswari et al., 2008). Equation 1 below was used in determining the best model.

$$N = \sum_{j=1}^{k} j(^{k}C_{j}) \tag{1}$$

Where,

  (i) N is the number of the possible models

 (ii) k is the total number of independent variables

(iii) j is 1,2, . . . ,k

After obtaining the total number of possible models, the procedure is proceed to the next phase.

2.2 Phase 2 − Selected Models

For this Phase, a total of 4 tests exists which are the Multicollinearity Test, the Coefficient Test, the Global Test and the Wald Test. However, only 2 of them will be carried out, which are the Multicollinearity Test and the Coefficient Test. This is done to be able to obtain the selected models. Only the significant variables is remained in the model while the insignificant variables are removed or eliminated.

2.2.1 Multicollinearity Test

Firstly, the Multicollinearity Test. Multicollinearity is said to exist when the independent variables are correlated with one another. Multicollinearity among predictors in multiple regression creates problems for the validity of the model for the investigation. High correlation will result in highly unstable least-squares estimate of the regression coefficients. That is why before the analysis is continued, one has to identify and remove the source of multicollinearity. Finally, the model is free from multicollinearity and proceed to the next test.

Steps in doing so are as follows:

(i) We first calculated the correlation coefficient for all variables in each model and then verify the high values among independent variables (|correlation coefficient| > 0.95).

(ii) We then removed the most common variable with the high correlation coefficient value and then recalculate the correlation coefficient.

(iii) Steps (i) and (ii) are repeated until the variable(s) of the model has no multicollinearity, where then the smaller value of absolute correlation coefficient between the dependent variable is removed.

(iv) Next, we check for the correlation between the dependent variable and the entire multicollinearity source variables to see whether multicollinearity exists between the dependent variable and the other variables.

(v) Lastly, we removed the independent variable with the smallest correlation coefficient with respect to the dependent variable.

When carrying out the removal of the source of the multicollinearity, there will be three common cases that would happen. All models may exhibit any one of these three, or even a combination of them Noraini et al. (2011). The three common cases are listed as follows:

A. Highest frequency variable found

   −In this case, an independent variable is chosen to be removed because it has the highest frequency. It is also the most common variable.

B. Highest frequency of two or more are found

   −In this case, a tie is found between some of the variables. But the variable which has the weakest correlation coefficient with the dependent variable was removed.

C. Highest frequency of one found

   −In this case, at least one or more pairs of the multicollinearity variable have the same frequency of 1. Up to this stage, every paired variable that has multicollinearity can then be compared at their correlation coefficient and thus removing the one with the weakest correlation coefficient with the dependent variable.

2.2.2 Coefficient Test

Then, the Coefficient Test is performed. When the alternative hypothesis is accepted in the global test, the coefficient test will be carried out by the two-tailed t-test. According to Ramanathan (2002), the coefficient test is to test each of the independent variables for each model whether they are insignificantly different from zero or equal to zero. The value of the estimated parameters and the t-value will be calculated in the coefficient test at significant level, $\alpha = 0.05$.

$$H_0 : \Omega_j = 0$$
$$H_1 : \Omega_j \neq 0$$

In this study, the calculated t-value, $t_{calculate}$ can be obtained by formula:

$$|t_{calculate}| = \frac{\hat{\Omega}_j - \Omega(H_0)}{se(\hat{\Omega}_j)} \tag{2}$$

Where,

(i) j is 1,2,...,k.

(ii) $\hat{\Omega}_j$ is the estimated parameters.

(iii) $\Omega(H_0)$ is the specific value in the null hypothesis.

(iv) $se(\hat{\Omega}_j)$ is the standard error of the parameter.

The null hypothesis will be rejected if the value of the $|t_{calculate}|$ is greater than the critical value, $|t_{critical}| = |t_{\frac{\alpha}{2}, n-k}|$, which can be obtained from the t distribution table and α is at a significant level of 0.05 and $n - k$ is the degree of freedom. If however the null hypothesis is accepted then the parameters are known to be non-zero and therefore, the parameters contribute to the dependent variable. Meanwhile, if the alternative hypothesis is accepted, this means that it is a selected parameter that will be eliminated from the regression. After these two tests are implemented on the models, one can proceed into the next phase.

2.3 Phase 2 – The Best Model

After obtaining the list of selected models, we can now obtain the best model in the midst of the selected model. According to Noraini et al. (2011), it was stated that there are eight selection criterions to assist in choosing the best model from the list of selected models. The formulas are shown in the Table 1.

Table 1: Eight Selection Criteria Table

AIC:	RICE:
$(\frac{SSE}{n})(e)^{\frac{2(k+1)}{n}}$	$(\frac{SSE}{n})[1-(\frac{2(k+1)}{n})]^{-1}$
(Akaike, 1969)	(Rice, 1984)
FPE:	SCHWARZ:
$(\frac{SSE^2}{n})\frac{n+(k+1)}{n-(k+1)}$	$(\frac{SSE}{n})n^{\frac{(k+1)}{n}}$
(Akaike, 1974)	(Schwarz, 1978)
GCV:	SGMASQ:
$(\frac{SSE}{n})[1-\frac{k+1}{n}]^{-2}$	$(\frac{SSE}{n})[1-\frac{k+1}{n}]^{-1}$
(Golub et al., 1979)	(Ramanathan, 2002)
HQ:	SHIBATA:
$(\frac{SSE}{n})(lnn)^{\frac{2(k+1)}{n}}$	$(\frac{SSE}{n})\frac{n+2(k+1)}{n)}$
(Hannan and Quinn, 1979)	(Shibata, 1978)

Where,

(i) n is the number of observations.

(ii) $k+1$ is the number of estimated parameters.

(iii) SSE is sum of square error.

From the mentioned eight selection criterions above, the Best Model is chosen based on the model with the most number of minimum statistics of the listed criterion, as stated by Zainodin et al. (2011).

2.4   Phase 2 − Goodness-of-fit

Ramanathan (2002) stated that, the goodness of fit test is to ensure how well the model fits into the problem or data. In here, we will be using the residual data which collected from the differences between actual and predicted data using the best model in Phase 3. In multiple regression, there is two types of tests that will be used which is the randomness and normality tests. Finally, the residual analysis should be carried out on the best model to verify whether the residuals are randomly and normally distributed. Zainodin et al. (2014) stated that randomness test should be carried out to investigate the randomness of the residuals produced. One of the MR assumptions is that the residuals should follow a normal distribution. Besides that, Shapiro- Wilk test

is used (for $n < 50$) while using Kolmogorov-Smirnou (for $n > 50$) to check the normality assumption of the residuals. Scatter plot, histogram and box-plot of the residuals are to a get a clear picture of distribution of the residual. These plots are used as supporting evidence in addition to the two quantitative tests.

3.   Result & Discussion

The data used in this study was provided by the Sabah Rural Development Cooperative (RDC), who gave permission to freely distribute the data and use them for non-commercial purposes. There were a total of 199 sets of data with no missing values. The dependent variable (Y) chosen for the multiple regression was the cost of poultry production. Four quantitative variables were chosen as the independent variables namely the prices of chicks (X_1), starter feed (X_2), grower feed (X_3), and chicken medications (X_4). The multiple regression modelling involved interaction until the third level and the number of models being considered is shown in Table 2 below. This means the total number of possible models is 32 models. Table 2 illustrates the calculation of the possible models.

Table 2: All possible model calculations

Number of Variables	Single	Interact			Total
		First order	Second order	Third order	
1	4	-	-	-	4
2	6	6	-	-	12
3	4	4	4	-	12
4	1	1	1	1	4
Total Model	15	11	5	1	32
Model ID	M1 - M15	M16 - M26	M27 - M31	M32	

Moving into Phase 2, two tests were carried out on all 32 possible models of this study in order to remove multicollinearity sources and insignificant variables. Equation 3 shows Model M 29 that used to illustrate the both test in Phase 2.

3.1   Multicollinearity Test

Multicollinearity test used to remove multicollinearity sources amongst the four independent variables, since without its removal, the results of the study will be affected. This is because high correlation will result in highly unstable

least-squares estimate of the regression coefficients which would result in it being almost impossible to determine significant variables towards the dependent variable Y.

The procedure of removal must be followed step by step within certain guidelines. Failure to do so can result in removal of the wrong multicollinearity source and could produce inaccurate results. High correlation is defined as those with correlation coefficient of above 0.95. A correlation matrix table is obtained with the use of Microsoft Excel.

There are the 3 cases of removal of high correlation. The 3 cases are case A, B and C. Model M 29 is used to illustrate cases in this study. From Table 3, X_1, X_3, X_4, X_{13}, X_{14}, X_{34}, and X_{134} are all highly correlated. However, X_{14} has the highest frequency and no tie found thus is removed. So, this displays a case A situation on M 29.0, which will then be named M 29.1, signifying a removal of a variable. Table 4 shows variable X_{14} had highest frequency which is 5. Then, the variable X_{14} was removed.

Table 3: Multicolinearity of M 29.0.0

	Y	X_1	X_3	X_4	X_{13}	X_{14}	X_{34}	X_{134}
Y	**1.0000**	0.8868	0.9186	0.8949	0.8867	0.8467	0.8874	0.7856
X_1	0.8868	**1.0000**	0.9147	**0.9907**	0.9433	**0.9647**	0.9345	0.8652
X_3	0.9186	0.9147	**1.0000**	0.9298	**0.9526**	0.8912	**0.9551**	0.8511
X_4	0.8949	**0.9907**	0.9298	**1.0000**	0.9479	**0.9650**	0.9476	0.8709
X_{13}	0.8867	0.9433	**0.9526**	0.9479	**1.0000**	**0.9753**	**0.9977**	**0.9643**
X_{14}	0.8467	**0.9647**	0.8912	**0.9650**	**0.9753**	1.0000	**0.9708**	**0.9588**
X_{34}	0.8874	0.9345	**0.9551**	0.9476	**0.9977**	**0.9708**	**1.0000**	**0.9634**
X_{134}	0.7856	0.8652	0.8511	0.8709	**0.9643**	**0.9588**	**0.9634**	**1.0000**

Table 4: Case A for M 29.0.0

Variable	Frequency	Action
X_1	2	
X_3	2	
X_4	2	
X_{13}	4	
X_{14}	5	Removed
X_{34}	4	
X_{134}	3	

After the removal of a variable, the model named as M 29.1.0 that means 1 variable is remove from the M 29.0.0 model. Then, Multicollinearity Test is rerun again, this process continues until there are no variables with correlation

coefficient higher than 0.95, which means the model is free from correlation. Model M 29.5.0 illustrates the result in Table 5.

Table 5: Multicolinearity test of M 29.5.0

	Y	X_3	X_{134}
Y	**1.0000**	0.92986	0.87091
X_3	0.92986	**1.00000**	0.85119
X_{134}	0.87091	0.85119	**1.00000**

From Table 5, the correlation value of X_3 and X_{134} are less than 0.95. So, X_3 and X_{134} is free from multicolinearity. Then, the selected model from equation 3 is proceed for Coefficient Test.

$$M29.5.0 : Y = \beta_0 + \beta_3 X_3 + \beta_{134} X_{134} \tag{3}$$

3.2 Coefficient Test

In the coefficient test, all variables with no significant influence on the dependent variable were eliminated. The values of the estimated parameters and the t-value was be calculated for this test at significance level, $\alpha = 0.05$. The hypothesis statement for the test is as follows:

$$M29.5.0 : Y = \beta_0 + \beta_3 X_3 + \beta_{134} X_{134} \tag{4}$$

The hypothesis statement is as follows.

$$H_0 : \beta_j = 0$$
$$H_1 : \beta_j \neq 0$$

where $j = X_3$ and X_{134}.

In this study, the Statistical Package for the Social Science (SPSS) was used to obtain the following table, Table 6, which automatically calculates the significant-p value. The hypothesis is tested on each variable. The null

hypothesis is accepted if the significant-p value is larger than 0.05. If the null hypothesis is accepted for any variable, it will be open to elimination. In this case, the null hypothesis for X_{134} are accepted. X_{134} has the highest significant-p value, and therefore eliminated. This would mean that variable X_{134} is not significant to the dependent variable.

Table 6: Output of Coefficient Test for M 29.5.0

Variables	B	S.E	Sig.	Reject or Accept H_0	Action
X_3	0.837222	0.04960	$4.601e^{-40}$	Reject	
X_{134}	0.02137	0.085586	$8.073e^{-1}$	Accept	Removed
Constant	0.0594	0.0144	$1.899e^{-4}$		

After the elimination, the M 29.5.0 was renamed as M 29.5.1, which signifies that a variable is eliminated in the Coefficient Test. Since only one variable is permitted to be eliminated at one time, the procedure of the Coefficient Test is repeated after the elimination till all null hypotheses of the variables are rejected. Table 7 is the SPSS output for M 29.5.1, where all null hypotheses of the variables are rejected. The remaining variables contribute towards the dependent variables, the model was chosen as Selected Model and proceeds to the next phase.

Table 7: Output of Coefficient Test for M 29.5.1

Variables	B	S.E	Sig.	Reject or Accept H_0
X_3	0.84773	0.02597	$2.097e^{-81}$	Reject
Constant	0.05248	0.01050	$1.2680e^{-6}$	

The Selected model for M29.5.1 as in equation 5,

$$M29.5.1 : Y = \beta_0 + \beta_{134}X_{134} \tag{5}$$

Then, models with the same independent variables are identified and grouped together to avoid repetition as in Table 8. Amongst the grouped models, the first model is chosen as the selected model, whereas the remaining ones are excluded. For example, M 1.0.0 and M 5.1.0 contains exactly the same independent variables in the models, we can then conclude that M 1.0.0 = M 5.1.0. Thus, M 1.0.0 is chosen as the selected model to represent that group. In this study the total number of parent models is 32, but the total number of selected models is 9. Therefore, the selected ratio is

$$\frac{\sum SelectedModels}{\sum ParentModels} = \frac{9}{32} = 0.28125 \qquad (6)$$

Table 8: Selected Models with the same independent variables

Selected Models	SSE	k+1
M 1.0.0 = M5.1.0 M 6.1.0 = M 7.1.0	0.98398	2
M 2.0.0	1.26291	2
M 3.0.0 = M 6.1.0 = M 13.2. 0= M 17.2.0 =		
M 21.2.0 = M 27.5.1 = M 29.5.1 = M 31.0.1	0.71891	2
M 4.0.0 = M 9.1.0 = M 10.1.0 = M 20.2.0 =		
M 23.5.0	0.91724	2
M 8.0.0 = M 11.1.0 = M 14.1.0 = M 15.2.0 =		
M 19.1.0 = M 22.4.0 = M 25.4.0 = M 30.4.1	0.64556	3
M 24.4.0	0.70145	3
M 26.8.0	0.69396	3
M 28.5.0	0.89247	3
M 32.10.3	0.63066	4

We then substitute the SSE values from Selected Model into the 8SC formula as in Table 1. Table 9 is a summary of the 8SC for this study. The most number of minimum statistics of the listed criterion is chosen as the Best model. In this study, the model chosen as the Best Model is M 32.10.3 (bold).

Table 9: Summary of the 8SC

MODEL	SSE	n	$k+1$	A	RICE
M 1.0.0	0.98398	199	2	0.00505	0.00505
M 2.0.0	1.26291	199	2	0.00648	0.00648
M 3.0.0	0.84397	199	2	0.00433	0.00433
M 4.0.0	0.80092	199	2	0.00411	0.00411
M 8.0.0	0.85989	199	3	0.00445	0.00446
M 24.4.0	0.84776	199	3	0.00439	0.00439
M 26.8.0	0.84938	199	3	0.00440	0.00440
M 28.5.0	0.80630	199	3	0.00418	0.00418
M 32.10.3	**0.63066**	**199**	**4**	**0.00330**	**0.00330**

FP	SCHWARZ	GCV	SGMASQ	H	SHIBATA
0.00505	0.00521	0.00505	0.00499	0.00511	0.00999
0.00648	0.00669	0.00648	0.00641	0.00656	0.01282
0.00433	0.00447	0.00433	0.00428	0.00439	0.00857
0.00411	0.00424	0.00411	0.00407	0.00416	0.00813
0.00445	0.00468	0.00445	0.00439	0.00454	0.01309
0.00439	0.00461	0.00439	0.00433	0.00448	0.01291
0.00440	0.00462	0.00440	0.00433	0.00449	0.01293
0.00418	0.00439	0.00418	0.00411	0.00426	0.01228
0.00330	**0.00352**	**0.00330**	**0.00323**	**0.00339**	**0.01280**

This model can be written in the form of general expression as in equation 7, with Y is the cost of financing the operation for a round of poultry (Ringgit Malaysia), X_2 is a chick starter fertilizer prices (Ringgit Malaysia), X_3 is the chicken Grower fertilizer prices (Ringgit Malaysia), X_{1234} is the interaction between the chicken, chick starter fertilizer price, chicken Grower fertilizer prices and prices of chicken medicines.

$$\hat{Y} = 0.018 + 0.329X_2 + 0.676X_3 - 0.185X_{1234} \qquad (7)$$

After determining the Best Model, the model is then brought forth into the last test, which is the goodness-of-fit. Residual data from M 32.10.3 were tested for normality and randomness. It was found that all the basic assumptions were satisfied and the residuals plots are shown in Figures 2-3. Both randomness test and residuals scatter plot indicate that the residuals are random, independent and normal. The total sum of residual of the best model, M 32.10.3 is 0.00330 while the sum of square error is 0.63066. The randomness test carried out on residuals shows that resulting error term of best model M 32.10.3 is random and independent. This strengthens the belief which is reflected in the residuals plot of Figure 3 which confirms that no obvious pattern exists. This showed that the best model M 32.10.3 is an appropriate model in determining the cost of financing the operation for a round of poultry.
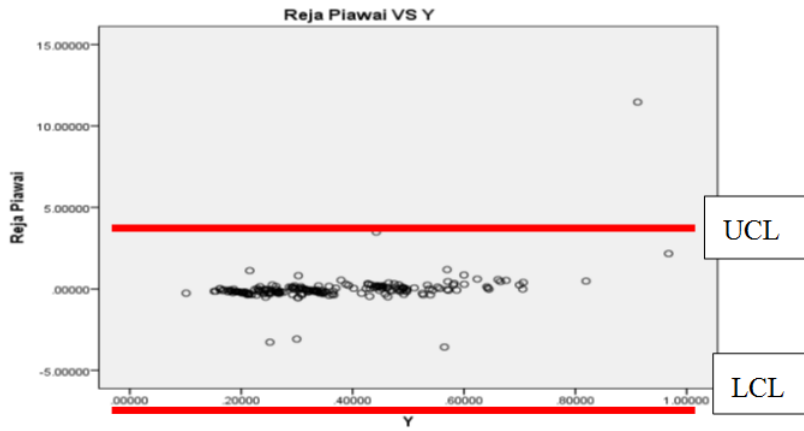
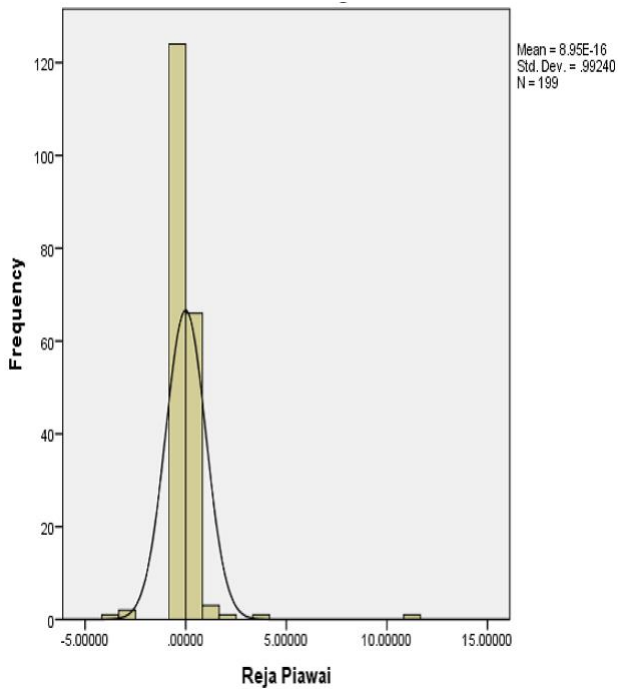Figure 2: Scatter plot of standardized residuals for best model M 32.10.3

Figure 3: Histogram of standardized residuals for best model M 32.10.3

Besides that by taking ± 5 standard deviation for Upper Control Limit (UCL) and Lower Control Limit (LCL) as in Figure 2, the residuals are distributed between the ± 5 standard deviation lines which indicate that there are one outlier data. The Shapiro-Wilk statistics of the normality plot in Figure 3 shows that the residuals of model M 30.10.3 are distributed normally (i.e., $statistics = 0.30444$, $df = 199$ and p-value $= 4.7521e^{-52}$). Thus, the model is ready to be used for further analysis. Now the cost of financing the operation for a round of poultry is ready for use in forecasting.

4. Conclusion

Through the studies that have been conducted, one of the best models of the model under consideration was obtained. There are three factors that contribute to the cost of financing the operation for a round of poultry. This model describes chick starter fertilizer prices, chicken Grower fertilizer prices and interaction between the price of chicks, chick starter fertilizer prices, fertilizer prices Grower chicken and prices of chicken medicines. This model was chosen based on the results of the eight selection criteria best. This study suggested, M 32.10.3 is the best model after multicollinearity and coefficients test. This also indicates the 8SC procedure can be implemented in determining the cost of productivity of broiler.

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