

## Cattle Farming Risk Simulation based on Business Typology

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**Abstract.** Cattle farming in Aceh Province is an important sector contributing to the local economy and food security. However, cattle breeders in this region often face various risks, including production risk and market price fluctuation. Using a quantitative approach, this research identified various typologies of cattle farming businesses in Aceh and developed an integrated risk management model. Data were collected through surveys, interviews and observations of cattle breeders. The research results showed that extensive, intensive and semi-intensive rearing systems in Aceh Province differed significantly in terms of the influence towards livestock number, meat production and livestock price. In extensive system, insemination cost and the risk of livestock disease had a strong influence, while animal feed and livestock price had a less significant influence. In the intensive system, the cost of insemination and animal feed greatly contributed to the parameters, while the risk of disease and animal price did not significantly influence the parameters tested. Medical cost affected livestock price significantly. The semi-intensive system revealed a large contribution to the cost of insemination and animal feed where production risk had a significant effect on livestock production and price. Reducing production and price risk had varying impacts depending on the maintenance system. In addition, semi-intensive system showed the greatest response to changes in risk.

**Keywords:** Risk, cattle farming, business typology, simultaneous equation.

### I. Introduction

Cattle farming in Aceh Province plays a vital role in supporting the local economy and food security because it contributes significantly to farmers' income and the provision of animal protein. However, this sector is faced with various challenges threatening its sustainability, especially those related to risk management. These risks include livestock health problems, extreme climate changes, price fluctuations in cattle feed and products, and natural disasters that frequently hit the region.

Aceh, as a province with diverse geographical and climatic characteristics, has various typologies of cattle farming businesses, ranging from small-scale farms managed traditionally to large farms using modern technology. These differences in scale and type of business mean that the risks faced and mitigation strategies required can vary significantly. Based on this understanding, it is important to develop a risk management model that is not only based on a general approach but is also adapted to various existing business typologies. Current risk management models often do not consider the diversity of business typologies, so their effectiveness is reduced in dealing with risks specific to each type of business. In this context, this research aims to develop a comprehensive and adaptive risk management model, which can be applied specifically based on the typology of cattle farming businesses in Aceh Province. By examining the risks faced by various business typologies and developing appropriate mitigation strategies, it is hoped that this model can help farmers manage risks more effectively and increase the resilience and sustainability of cattle farming businesses in Aceh.

It is hoped that this research can contribute to the literature on risk management in animal husbandry and offer practical recommendations for farmers and policy makers in Aceh Province, so that risk management and the performance of the livestock sector improve overall.

II. Materials and Methods

2.1 Time and Location of Research

This research was carried out from October 2022 to July 2023 in Aceh Province. The choice of Aceh as a research location took into account that Aceh is a potential area for developing large livestock such as cattle (Muyasir, 2010; Samadi et al., 2021) where there are unique local types of cattle (Jamilah, 2017, Hakim et al., 2022) which are maintained with a business pattern prioritizing local wisdom in it (Iskandar et al., 2023; Mukhtasar and Syahputra, 2020). The Aceh regions chosen as research sites were Aceh Besar, Aceh Jaya and North Aceh districts. These three districts were chosen because they represent cattle farming patterns in Aceh Province.

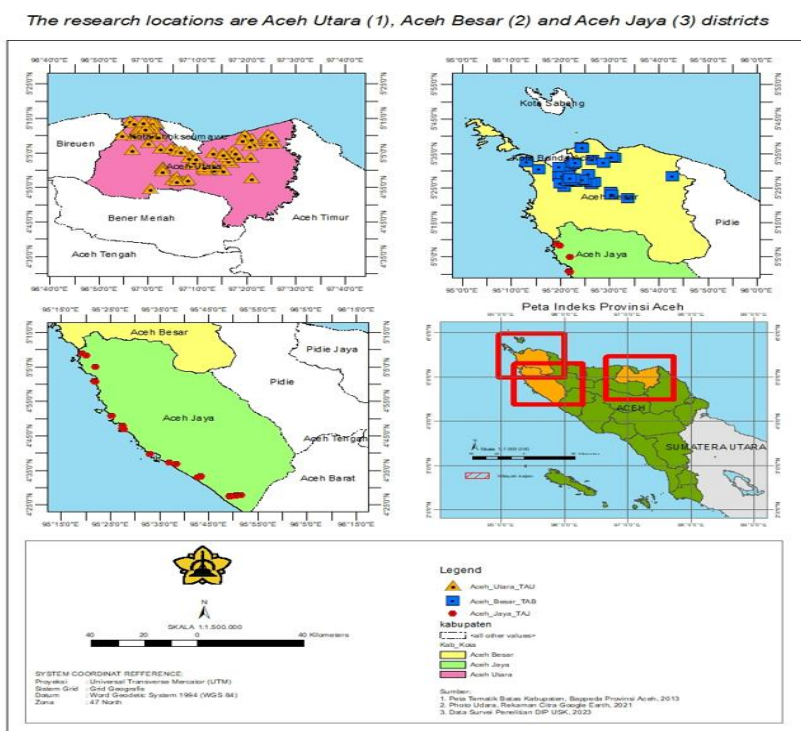


Figure 1. Map of research locations

2.2 Population and Samples

The population of this study were cattle breeders in North Aceh, Aceh Besar and Aceh Jaya Regencies with a total of 35,883 people. Furthermore, the Slovin formula at the value  $e=5\%$  produced a total of 396 respondents, which was then rounded up to 400 people. According to Sugiono (2014), a respondent size of 30-500 people is suitable for use in research.

Table 1. Distribution of Population and Research Respondents

No	Regency	Population (Persons)	Respondent (Persons)
1	North Aceh	20.850	232
2	Aceh Besar	10.282	115
3	Aceh Jaya	4.751	53
	Total	35.883	400

### 2.3. Research Data

This research used primary and secondary data. Primary data were obtained through a survey and interview process using research instruments in the form of questionnaires. Research data were collected to be tabulated and analyzed using econometric models taking into account economic, statistical and econometric criteria.

In the application of this analytical model, several respecifications were carried out first on the model so that the analysis output was more representative, namely by adding or subtracting variables included in the equation. Thus, the results obtained would be in accordance with the expected criteria. The expected equations consisted of 3 identity equations and 3 structural equations.

### 2.3. Research Analysis Method

Simultaneous equation model analysis is composed of several equations that are interrelated and influence each other. *The econometric model is also a statistical and mathematical model that connects economic variables from an economic phenomenon, which includes stochastic elements (Intriligator et al., 1996).* The stages carried out to analyze the model are: model specification, preparation of analysis procedures and application of the model. Model specification is an attempt to study the relationships between variables and then express these relationships in the form of mathematical equations. Econometric model specifications are made based on economic theory and various empirical experiences related to the phenomenon being studied. The equations are as follows:

$$1. JTS_i = a_0 + a_1BI_i + a_2PT_i + a_3HTS_i + a_4RPET_i + e_{1i}$$

Where:

- JTS<sub>i</sub> = number of cattle (head)
- BI<sub>i</sub> = cost of artificial insemination (IDR)
- PT<sub>i</sub> = animal feed (kg)
- HTS<sub>i</sub> = price of cattle (IDR/head)
- RPET<sub>i</sub> = livestock disease risk (squared)
- e<sub>1i</sub> = confounding variable

The signs of the expected parameter: a<sub>1</sub>, a<sub>2</sub> > 0; a<sub>3</sub>, a<sub>4</sub> < 0

$$2. PDS_i = b_0 + b_1JTS_i + b_2BI_i + b_3RP_i + e_{2i}$$

Where:

- PDS<sub>i</sub> = beef production (kg)
- JTS<sub>i</sub> = number of cattle (head)
- BI<sub>i</sub> = insemination cost (IDR/kg)
- RP<sub>i</sub> = beef production risk (squared)
- e<sub>2i</sub> = confounding variable

The signs of the expected parameter: b<sub>1</sub>, b<sub>2</sub>, > 0; b<sub>3</sub> < 0

$$3. HTS_i = c_0 + c_1PDS_i + c_2BI_i + c_3BO_i + c_4RH_i + e_{3i}$$

Where:

- HTS<sub>i</sub> = cattle price (IDR)
- PDS<sub>i</sub> = beef production (kg)
- BI<sub>i</sub> = insemination fee (IDR)
- BO<sub>i</sub> = medical cost (IDR)
- RH<sub>i</sub> = livestock price risk (squared)
- e<sub>3i</sub> = confounding variable

The signs of the expected parameter: c<sub>1</sub>, c<sub>3</sub>, c<sub>4</sub> > 0 ; c<sub>2</sub> < 2

$$4. RPET = JSTP/JTS$$

Where:

RPET = risk of livestock disease

JSTP= number of cows affected by the disease (head)

JTS = number of cattle (head)

5.  $RP = (PDS - RPDS)^2$

Where:

RP = production risk

PDS = Beef production (Kg)

RPDS = average beef production

6.  $RH = (HTS - RHTS)^2$

Where:

RH = livestock price risk

HTS = price of cattle (IDR/head)

RHTS = average price of cattle

This research used a simultaneous equation econometric model that applied the 2SLS method. The model consisted of structural equations and identities. One thing that determined the model estimation method was model identification. According to Koutsoyiannis (1977), capital can be calculated using the formula:  $(K - M) \geq (G - 1)$ ,

where K is the total variables in the model; M is the number of endogenous and exogenous variables included in a particular equation in the model; G is the total equation. An equation is said to be over identified if the model has more information than is needed to estimate the existing parameters. Over identified models can provide several advantages, namely allowing the use of diagnostic tests to evaluate the validity of instruments and models. However, if the instruments are invalid or irrelevant, the model may produce unreliable estimates. Over identification can provide additional flexibility in the model allowing further testing of the reliability and validity of the instruments used.

The purpose of model validation is to find out whether the model is valid enough to be used in simulation. According to Pyndick and Rubinfeld (1998), the statistical criteria used are RMSE (Root Mean Square Error), RMSPE (Root Mean Square Percent Error), and U (U-Theil's inequality coefficient). The bias proportion statistic (UM) indicates a systematic error where the desired value is zero, so a value greater than 0.2 indicates the presence of systematic bias. In this case, the ideal regression proportion (UR) and variance proportion (US) are close to zero. Meanwhile, the ideal distribution proportion (UD) and covariance proportion (UC) are close to one (Sitepu and Sinaga, 2006). Apart from that, the ideal inequality coefficient (U) is close to zero and if the value is one then the model is said to be naive. Model validation in this research was carried out through basic simulations of price risk and production risk.

Model validation of the equations in this research was carried out by considering the business typology (Table 2). In general, the validation stage used the RMSPE (Root Mean Square Prediction Error) values. In this case, the number of endogenous variable equations that had RMSPE values below 100 percent were found in the three cattle rearing systems in all models. This showed that the model had relatively good prediction accuracy for the measured endogenous variables. In other words, if the RMSPE for the endogenous variable was below 100 percent, then the model was able to provide prediction that was quite close to the actual value. In addition, the model's accuracy in predicting these variables was not bad. RMSPE values below 100 percent generally indicated that the model was adequate in terms of prediction accuracy. Although not perfect, the model provided quite good results and could be used as a basis for decision making or further analysis. With an RMSPE below 100 percent, the model could provide a solid basis for decision making and planning. If the RMSPE value for the endogenous variable in the model was below 100 percent, then the model could be said to have relatively good predictive accuracy and could be considered adequate for analytical purposes. The model in this research was able to provide predictions that are quite close to the actual values.

Meanwhile, the results of the U validation test showed that the U-theil value was close to zero, which means the model was valid.

**Table 2.** Model Validation Results Based on Business Typology

Extensive Maintenance System								
Variable	RMSE	RMSPE(%)	Bias (UM)	Reg (UR)	Dist (UD)	Var (US)	Covar (UC)	U
JTS	3.7521	62.0011	0.00	0.00	1.00	0.02	0.98	0.1028
PDS	114.9	26.9636	0.00	0.01	0.99	0.01	0.99	0.0853
HTS	1268796	11.8503	0.00	0.00	1.00	0.21	0.79	0.0551
Intensive Maintenance System								
Variable	RMSE	RMSPE(%)	Bias (UM)	Reg(UR)	Dist (UD)	Var (US)	Covar (UC)	U
JTS	2.7243	51.7424	0.00	0.00	1.00	0.04	0.96	0.1306
PDS	136.5	41.5105	0.00	0.00	1.00	0.05	0.95	0.1317
HTS	2264518	13.5208	0.00	0.00	1.00	0.23	0.77	0.0616
Semi-Intensive Maintenance System								
Variable	RMSE	RMSPE(%)	Bias (UM)	Reg(UR)	Dist (UD)	Var (US)	Covar (UC)	U
JTS	1.5270	24.8092	0.00	0.02	0.98	0.01	0.99	0.1217
PDS	112.0	25.5231	0.00	0.02	0.98	0.02	0.98	0.1201
HTS	3779217	49.9614	0.00	0.02	0.98	0.31	0.69	0.1492

The data analysis carried out in this research used an econometric approach, namely the 2SLS method followed by forecasting simulation analysis.

### III. Results and Discussion

The model analysis in this research was carried out using an Econometric Model which considered economic, statistical and econometric criteria (Koutsoyiannis, 1977). Overall, the simultaneous equation model in this study was stated to be quite good because this model met economic criteria (relatively the same sign), statistical criteria (accurate) and econometric criteria (did not show serious serial correlation).

#### 3.1 Extensive Maintenance System

In the extensive rearing system, the analysis results showed that the determination value ( $R^2$ ) in the equation for the number of cattle (JTS) was 0.9307. In the beef production equation (PDS), the determination value of the equation was 0.819. Meanwhile, in the cattle price equation (HTS), the determination value of the equation was 0.4502. This condition demonstrated that each endogenous variable could be explained by the explanatory variables included in the model with the respective F statistical value in the JTS equation of being 53.74, the PDS equation of being 25.65 and the HTS equation of being 3.27. This showed that together the explanatory variables had a real influence on the endogenous variables. The Durbin-Watson (DW) value in the JTS equation was 1.8754; in the PDS equation was 1.8857; and in the HTS equation was 1.7923. Based on the DW value of each equation, there was no significant serial correlation problem at the validation stage. To test each explanatory variable in each equation, a statistical t test was carried out on the endogenous variables in each equation. The results of estimating the parameters of the equation can be seen in Table 3.

*This is in line with the research by Katsko and Kremyanskaya (2021) and Li et al. (2013), which found that the model has a high level of confidence in explaining the variation in livestock populations. Insemination and feed costs show a positive effect, while disease risk has a significant negative effect. Investment in reproductive technology and quality feed is crucial for increasing cattle populations. At the same time, managing disease risks is essential to maintaining these populations. These findings provide valuable insights for livestock managers aiming to optimize cattle productivity and ensure sustainable growth.*

**Table 3.** Results of parameter estimation and statistical tests of the extensive maintenance system

Equation/Variable	Notation	Estimated Parameters	Pr >  t	Description
<b>Number of Cattle</b>	JTS			
Intercept	-	9.616485	0.0009	R-Square = 0.9307
Insemination cost	BI	1.224E-6	0.0039	Adj R-Sq = 0.91341
Animal feed	PT	0.001090	0.1488	F-Statistics = 53.74
Price of cattle	HTS	7.933E-7	0.2586	DW = 1.8754
Risk of livestock disease	RPET	4.981811	<.0001	
<b>Beef Production</b>	PDS			
Intercept	-	415.9586	<.0001	R-Square = 0.81906
Number of cattle	JTS	24.83501	0.0001	Adj R-Sq = 0.78713
Insemination cost	BI	0.000035	0.4646	F-Statistics = 25.65
Beef Prod. Risk	RP	-0.00175	0.0031	DW = 1.88574
<b>Cattle Prices</b>	HTS			
Intercept	PDS	10540522	<.0001	R-Square = 0.45017
Beef production	BI	-3444.08	0.0960	Adj R-Sq = 0.31271
Insemination cost	BOP	0.616948	0.2376	F-Statistics = 3.27
Medical cost	RH	1.454689	0.0407	DW = 1.792288
Livestock price risk		2.019E-7	0.0377	

*In the research by Tadesse et al. (2022) and Das et al. (2023), investment in reproductive technologies such as artificial insemination can increase beef production due to better genetic selection and improved reproductive efficiency, ultimately resulting in a larger cattle population. Adequate and high-quality feed is crucial for livestock growth and health. Good feed contributes to reproductive health and the growth of adult livestock, which in turn boosts beef production. Livestock mortality, decreased birth rates, and reduced production efficiency can be caused by widespread diseases or increased disease risk. Therefore, to maintain stable beef production, vaccination, proper healthcare, and effective disease risk management are essential to controlling diseases.*

*Schroeder, Coffey, and Tonsor (2021), along with Urak et al. (2022), state that in the beef industry, higher production levels usually lead to greater supply, resulting in lower market prices. Conversely, proper treatment and care are critical for maintaining livestock health. Livestock prices are directly influenced by medical care costs, as healthier herds have a higher market value. Additionally, livestock prices fluctuate due to price volatility and associated risks, reflecting market uncertainty and the dynamic nature of supply and demand.)*

Mean Squared Error (MSE) is a statistical measure used to evaluate the quality of a prediction or estimation model. Mathematically, MSE is the average of the squared differences between the value predicted by the model and the actual value. The smaller the MSE value, the better the model is at predicting the data because the difference between the prediction and the actual value becomes smaller. MSE is sensitive to outliers because the square of the difference is taken into account. The MSE value in the JTS equation was 16.67596. This gives an idea of how good or bad the model is at predicting the target value. A value of 16.67596 meant that the average of the squared differences between the predicted value and the actual value was 16.67596. In this case, the number of observations in the extensive cattle rearing system was twenty-one. The DF (Degree of Freedom) model was a concept often used in statistics and modelling to indicate the number of independent variables estimated in a model. A DF model of 5 meant that the model had a degree of freedom of 5. In the context of regression, degrees of freedom can refer to the number of parameters that can be selected independently. In the context of hypothesis testing or model evaluation, degrees of freedom help in determining statistical distributions and influence the

interpretation of results. Degrees of freedom are also important for calculating various statistical tests such as the F value or t value which are used to test the significance of the model or its coefficients.

The MSE value in the PDS equation was 20154.99. This gives an idea of how good or bad the model is at predicting the target value. A value of 20154.99 meant that the average of the squared differences between the predicted value and the actual value was 20154.99. In this case, the number of observations in the extensive cattle rearing system was twenty-one. The DF (Degree of Freedom) model is a concept that is often used in statistics and modelling to indicate the number of independent variables or parameters that are freely estimated in a model. A DF model of 4 indicated that the equation had a size of 4 degrees of freedom. In the context of regression, degrees of freedom can refer to the number of parameters that can be selected independently. In the context of hypothesis testing or model evaluation, degrees of freedom help in determining statistical distributions and influence the interpretation of results. Degrees of freedom are also important for calculating various statistics such as F values or t values that are used to test the significance of a model or its coefficients.

The MSE value in the HTS equation was  $2.091 \times 10^{12}$ . This gives an idea of how good or bad the model is at predicting the target value. A value of  $2.091 \times 10^{12}$  meant that the average of the squared differences between the predicted value and the actual value was  $2.091 \times 10^{12}$ . In this case, the number of observations in the extensive cattle rearing system was twenty-one. The DF (Degree of Freedom) model is a concept that is often used in statistics and modelling to indicate the number of independent variables or parameters estimated in a model. A DF model of 5 indicated a size of 5 units of degrees of freedom. In the context of regression, degrees of freedom can refer to the number of parameters that can be selected independently. In the context of hypothesis testing or model evaluation, degrees of freedom help in determining statistical distributions and influence the interpretation of results. Degrees of freedom are also important for calculating various statistics such as F values or t values that are used to test the significance of a model or its coefficients. This can be seen in Figure 2.

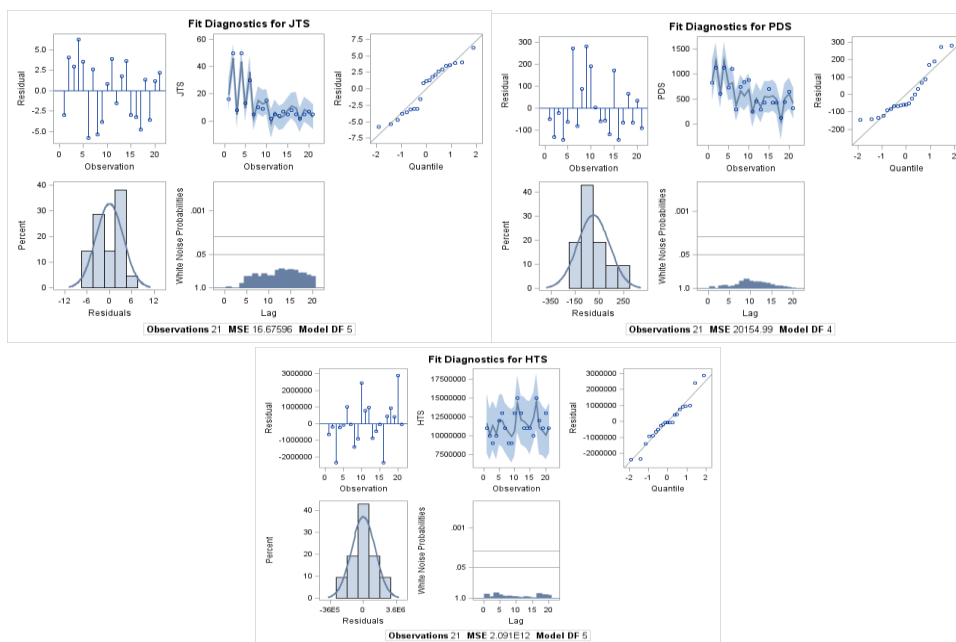


Figure 2. Fit Diagnostics for JTS, PDS and HTS on Extensive Maintenance System

### 3.2 Intensive Maintenance System

The research by Shidqi and Hayati (2023) states that an intensive maintenance system is an effort to increase cattle production. The increase in cattle production can run smoothly with a good maintenance system. A well-implemented intensive maintenance system can prevent a decline in cattle productivity and reduce cattle mortality.

In the intensive rearing system, the analysis results showed that the determination value ( $R^2$ ) in the equation for the number of cattle (JTS) was 0.8584. In the beef production equation (PDS), the determination value of the equation was 0.7045. Meanwhile, in the cattle price equation (HTS), the determination value of the equation was 0.3881. Such conditions indicated that each endogenous variable could be explained by the explanatory variables included in the model. The F statistic values respectively were 109.15 in the JTS equation, 58.00 in the PDS equation, and 11.41 in the HTS equation. This showed that together the explanatory variables had a real influence on the endogenous variables. The Durbin-Watson (DW) values were respectively 1.7495 in the JTS equation, 1.9659 in the PDS equation, and 1.6202 in the HTS equation. Based on the DW value of each equation, there was no significant serial correlation problem in the three equations. To statistically test the real influence of each explanatory variable in each equation on the endogenous variable, a statistical t test was carried out. The results of estimating the parameters of the three equations can be seen in Table 4.

**Table 4.** Results of parameter estimation and statistical tests of intensive maintenance system

Equation/Variable	Notation	Estimated Parameter	Pr >  t	Description
<b>Number of Cattle</b>	JTS			
Intercept	-	1.496262	0.7653	R-Square = 0.8584
Insemination cost	BI	6.917E-6	<.0001	Adj R-Sq = 0.8506
Animal feed	PT	0.009571	<.0001	F-Statistics= 109.15
Price of cattle	HTS	-9.78E-8	0.6207	DW = 1.7495
Risk of livestock disease	RPET	-2.95829	0.1807	
<b>Beef Production</b>	PDS			
Intercept	-	189.5730	<.0001	R-Square = 0.7045
Number of cattle	JTS	29.35610	<.0001	Adj R-Sq = 0.6923
Insemination cost	BI	0.000162	0.0878	F-Statistics = 58.00
Beef Prod. Risk	RP	-0.00070	0.0314	DW = 1.9659
<b>Cattle Price</b>	HTS			
Intercept	PDS	15046679	<.0001	R-Square = 0.3881
Beef production	BI	50.88960	0.9848	Adj R-Sq = 0.3354
Insemination cost	BOP	-2.24362	0.1844	F-Statistics = 11.41
Medical cost	RH	3.412762	<.0001	DW = 1.6202
Livestock price risk		1.02E-8	0.7913	

*According to Tito and Savita (2021), since maintenance is fully conducted in enclosures, intensive maintenance is most commonly used. Cattle raised intensively receive more regular treatment, such as feeding, cleaning of enclosures, and bathing. Cattle farms that aim to produce more meat adopt the intensive maintenance system. The intensive maintenance system for cattle can increase their selling price because the cattle are kept in enclosures from the time they are purchased until they are sold (Agustiyana, 2022).*

Mean Squared Error (MSE) is a statistical measure used to evaluate the quality of a prediction or estimation model. MSE is mathematically the average of the squared differences between the value predicted by the model and the actual value. The smaller the MSE value, the better the model is at predicting the data because the difference between the prediction and the actual value becomes smaller. MSE is sensitive to outliers because the square of the difference in values is taken into account. The MSE value in the JTS equation was 7.6739. This gives an idea of how good or bad the model is at predicting the target value. A value of 7.6739 meant that the average of the squared differences between the predicted value and the actual value was 7.6739. In this case, the number of observations in the intensive cattle rearing system was seventy-seven. The DF (Degree of Freedom) model is a concept that is often used in statistics and modelling to indicate the number of independent variables

estimated in a model. A DF model of 5 indicated that the model had a size of 5 degrees of freedom. In the context of regression, degrees of freedom can refer to the number of parameters that can be selected independently. In the context of hypothesis testing or model evaluation, degrees of freedom help in determining statistical distributions and influence the interpretation of results. Degrees of freedom are also important for calculating various statistics such as F values or t values that are used to test the significance of a model or its coefficients.

The MSE value in the PDS equation was 22107.34. This gives an idea of how good or bad the model is at predicting the target value. The value of 22107.34 showed that the average of the squared differences between the predicted value and the actual value was 22107.34 where the number of observations in the intensive cattle rearing system was seventy-seven. The DF (Degree of Freedom) model is a concept that is often used in statistics and modelling to indicate the number of independent variables or free parameters estimated in a model. A DF model of 4 indicated that the model had a size of 4 degrees of freedom. In the context of regression, degrees of freedom can refer to the number of parameters that can be selected independently. In the context of hypothesis testing or model evaluation, degrees of freedom help in determining statistical distributions and influence the interpretation of results. Degrees of freedom are also important for calculating various statistics such as F values or t values that are used to test the significance of a model or its coefficients.

The MSE value in the HTS equation was  $5.482 \times 10^{12}$ . This gives an idea of how good or bad the model is at predicting the target value. A value of  $5.482 \times 10^{12}$  meant that the average of the squared differences between the predicted value and the actual value was  $5.482 \times 10^{12}$  where the number of observations in the intensive cattle rearing system was seventy-seven. The DF (Degree of Freedom) model is a concept that is often used in statistics and modelling to indicate the number of independent variables or free parameters estimated in a model. A DF model of 5 indicated that the model had a size of 5 degrees of freedom. In the context of regression, degrees of freedom can refer to the number of parameters that can be selected independently. In the context of hypothesis testing or model evaluation, degrees of freedom help in determining statistical distributions and influence the interpretation of results. Degrees of freedom are also important for calculating various statistics such as F values or t values that are used to test the significance of a model or its coefficients. This can be seen in Figure 3.

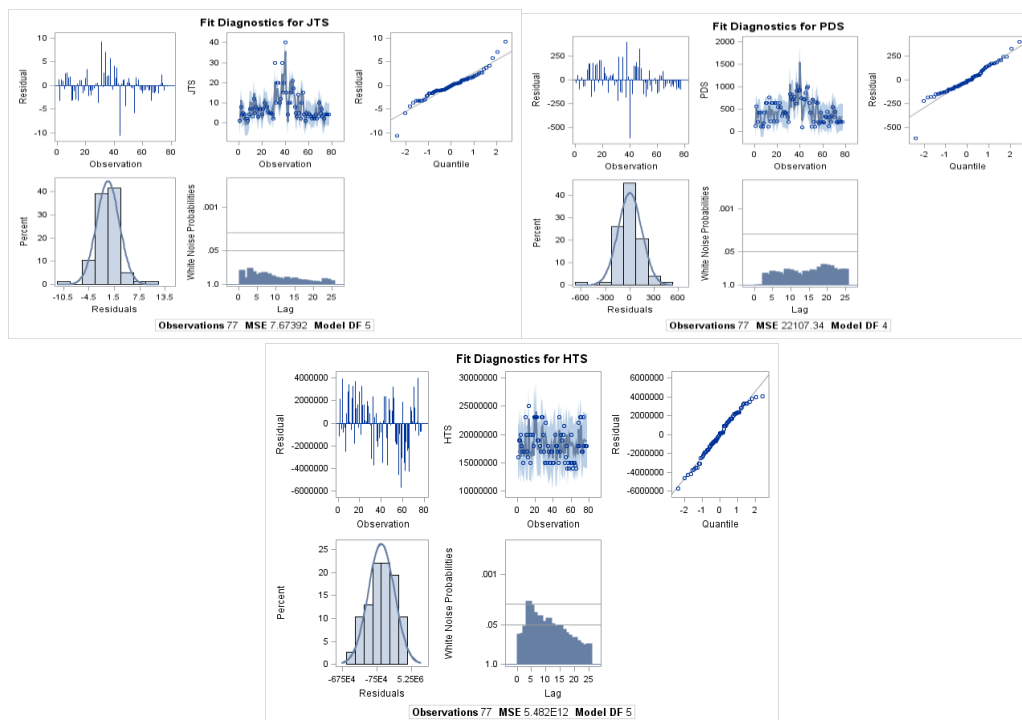


Figure 3. Fit Diagnostics for JTS, PDS and HTS on Intensive Maintenance System

3.3 Semi-intensive Maintenance System

In the semi-intensive rearing system, the analysis results show that the determination value ( $R^2$ ) in the equation for the number of cattle (JTS) was 0.8037. In the beef production equation (PDS), the determination value of the equation was 0.8219. Meanwhile, in the cattle price equation (HTS), the determination value of the equation was 0.1896. Such conditions indicated that each endogenous variable could be explained by the explanatory variables included in the model. In this case, the F statistic values were respectively 303.98 in the JTS equation, 458.49 in the PDS equation, and 17.37 in the HTS equation. This revealed that together the explanatory variables had a real influence on the endogenous variables. The Durbin-Watson (DW) values were respectively 1.5522 in the JTS equation, 1.7810 in the PDS equation, and 1.1852 in the HTS equation. Based on the DW value of each equation, there was no significant serial correlation problem in the three equations. To statistically test the real influence of each explanatory variable in each equation on the endogenous variable, a statistical t test was carried out. The results of estimating the parameters of the three equations can be seen in Table 5.

Table 5. Results of parameter estimation and statistical tests for semi-intensive maintenance system

Equation/Variable	Notation	Estimated Parameter	Pr >  t	Description
<b>Number of Cattle</b>	JTS			
Intercept	-	-2.54681	0.0130	R-Square = 0.8804
Insemination cost	BI	4.294E-6	<.0001	Adj R-Sq = 0.8011
Animal feed	PT	0.005926	<.0001	F-Statistics = 303.98
Price of cattle	HTS	3.37E-7	<.0001	DW = 1.5522
Risk of livestock disease	RPET	-0.91182	0.0971	
<b>Beef Production</b>	PDS			
Intercept	-	167.2735	<.0001	R-Square = 0.8219
Number of cattle	JTS	42.83725	<.0001	Adj R-Sq = 0.8201
Insemination cost	BI	0.000196	<.0001	F-Statistics = 458.49
Beef Prod. Risk	RP	-0.00081	<.0001	DW = 1.7810
<b>Cattle Price</b>	HTS			
Intercept	PDS	8676478	<.0001	R-Square = 0.1896
Beef production	BI	9933.858	0.0212	Adj R-Sq = 0.1786
Insemination cost	BOP	-5.23800	0.0107	F-Statisti = 17.37
Medical cost	RH	0.308888	0.4269	DW = 1.1852
Livestock price risk		4.916E-8	<.0001	

Borithnaban, Tophianong, and Foeh (2022) state that with a good maintenance system, increasing cattle populations can be done easily. The fact that a semi-intensive maintenance system can produce an average of 24 cattle per year suggests that this system is highly recommended for farmers. Research by Lase, Ardiarini, and Habeahan (2021) shows that semi-intensive maintenance can improve cattle growth and weight due to the combination of supplementary feed and natural feed from pastures. Providing supplementary feed such as concentrates and high-quality forage can enhance the cattle’s nutritional intake, allowing them to grow faster and gain more weight. The semi-intensive system offers better supplemental feeding and improved healthcare, which enhances cattle body condition, weight, and beef quality. As a result, body condition, weight, and beef quality all improve, which can in turn increase the cattle’s market price. Farmers can produce consistently high-quality cattle with the semi-intensive system, allowing for better control over livestock growth and reproduction. Although the semi-intensive system requires a higher initial investment in feed and facilities, the efficiency in feed use and improved cattle health can reduce production costs per unit. The stability in the supply of quality livestock

*can keep prices stable or even rising, especially if demand is high. Farmers can sell their livestock at more competitive prices without losing profit (Pratama, 2024).*

Mean Squared Error (MSE) is a statistical measure used to evaluate the quality of a prediction or estimation model. Mathematically, MSE is the average of the squared differences between the value predicted by the model and the actual value. The smaller the MSE value, the better the model is at predicting the data because the difference between the prediction and the actual value is smaller. MSE is sensitive to outliers because the square of the difference in values is taken into account. The MSE value in the JTS equation was 3.02371. This gives an idea of how good or bad the model is at predicting the target value. A value of 3.02371 meant that the average of the squared differences between the predicted value and the actual value was 3.02371 where the number of observations in the semi-intensive cattle rearing system was three hundred and two. The DF (Degree of Freedom) model is a concept that is often used in statistics and modelling to indicate the number of independent variables or free parameters estimated in a model. A DF model of 5 indicated that the model had a size of 5 degrees of freedom. In the context of regression, degrees of freedom can refer to the number of parameters that can be selected independently. In the context of hypothesis testing or model evaluation, degrees of freedom help in determining statistical distributions and influence the interpretation of results. Degrees of freedom are also important for calculating various statistics such as F values or t values that are used to test the significance of a model or its coefficients.

The MSE value in the PDS equation was 6797.646. This gives an idea of how good or bad the model is at predicting the target value. A value of 6797.646 meant that the average of the squared differences between the predicted value and the actual value was 6797.646 where the number of observations in the intensive cattle rearing system was three hundred and two. The DF (Degree of Freedom) model is a concept that is often used in statistics and modelling to indicate the number of independent variables or free parameters estimated in a model. A DF model of 4 indicated that the model had a size of 4 degrees of freedom. In the context of regression, degrees of freedom can refer to the number of parameters that can be selected independently. In the context of hypothesis testing or model evaluation, degrees of freedom help in determining statistical distributions and influence the interpretation of results. Degrees of freedom are also important for calculating various statistics such as F values or t values that are used to test the significance of a model or its coefficients.

The MSE value in the HTS equation was  $1.354 \times 10^{13}$ . This gives an idea of how good or bad the model is at predicting the target value. A value of  $1.354 \times 10^{13}$  meant that the average of the squared differences between the predicted value and the actual value was  $1.354 \times 10^{13}$  where the number of observations in the intensive cattle rearing system was seventy-seven. The DF (Degree of Freedom) model is a concept that is often used in statistics and modelling to indicate the number of independent variables or free parameters estimated in a model. A DF model of 5 indicated that the model had a size of 5 degrees of freedom. In the context of regression, degrees of freedom can refer to the number of parameters that can be selected independently. In the context of hypothesis testing or model evaluation, degrees of freedom help in determining statistical distributions and influence the interpretation of results. Degrees of freedom are also important for calculating various statistics such as F values or t values that are used to test the significance of a model or its coefficients. This can be seen in Figure 4.

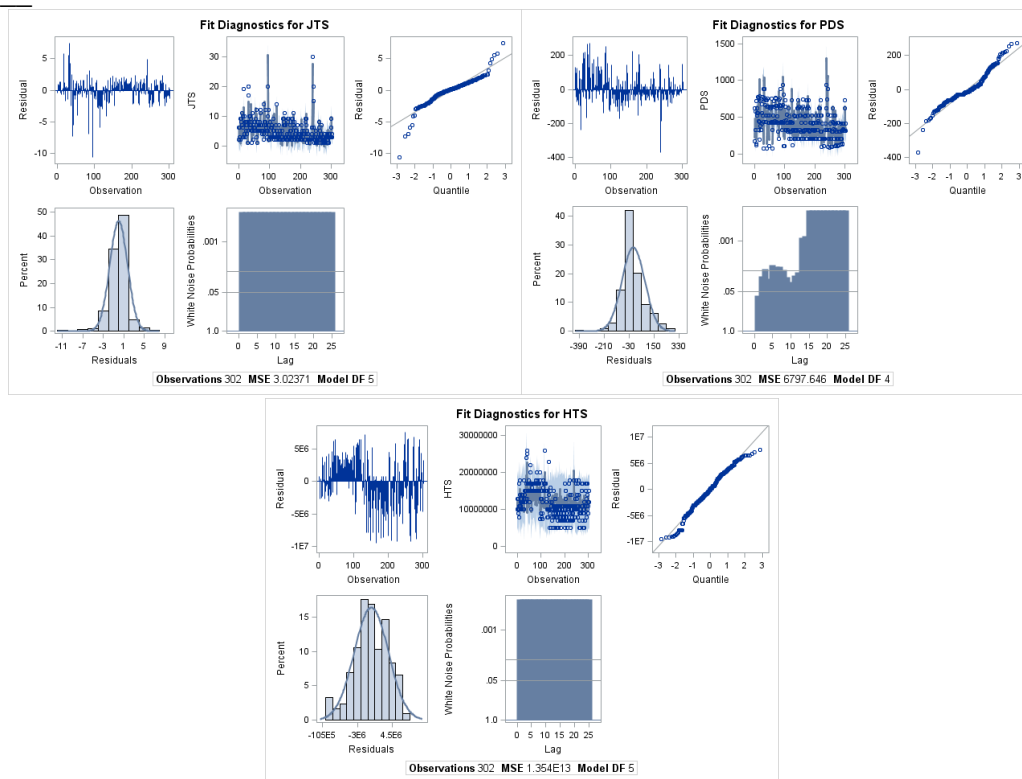


Figure 4. Fit Diagnostics for JTS, PDS and HTS on Semi-intensive Maintenance System

### 3.4 Simulation of Production Risk and Price Risk

Risk simulation with simultaneous equations involves the use of mathematical models consisting of several interconnected equations to understand the impact of risk in a more complex context. The simulation results can be seen in Table 6.

Table 6. Risk Simulation Results

Equation	Simulation	
	Production risk decreases by 10%	Price risk falls 10%
<b>Extensive Maintenance System</b>		
Number of Cattle (head)	0.428	0.478
Beef Production (kg)	2.749	0.247
Price of Cattle (IDR/head)	-0.501	-0.559
<b>Intensive Maintenance System</b>		
Number of Cattle (head)	0.000	0.010
Beef Production (kg)	1.027	0.022
Price of Cattle (IDR/head)	0.001	-0.047
<b>Semi Intensive Maintenance System</b>		
Number of Cattle (head)	0.243	-0.604
Beef Production (kg)	0.868	-0.305
Price of Cattle (IDR/head)	0.299	-0.746

In an extensive rearing system, if production risk decreased by 10 percent, the number of cattle increased by 0.428 percent; beef production increased by 2,749 percent; and cattle prices fell by 0.501 percent. If the price risk fell by 10 percent, then the number of cattle increased by 0.478 percent; beef production raised by 0.247 percent; and cattle prices fell by 0.559 percent. According to Gading, Nurtini, and Ummul (2020), the extensive

*maintenance system tends to be more vulnerable to environmental fluctuations and health risks, which can affect livestock productivity and prices. Reducing disease risk can improve the health of the livestock population and individual animals, but an increase in market supply may also lower livestock prices.*

In an intensive rearing system, if the production risk decreased by 10 percent, then the number of cattle had no impact; Beef production increased by 1.027 percent, and cattle price increased by 0.001 percent. If the price risk fell by 10 percent, then the number of cattle increased by 0.010 percent; beef production increased by 0.022 percent; and cattle price fell by 0.047 percent. *The intensive maintenance system can increase production efficiency but also raises the risk of disease due to the high livestock population density. Good disease control can significantly improve productivity and the number of livestock. However, since an increased market supply may lower selling prices, reducing price risks may not always benefit livestock prices (Muslimah and Nuzaba, 2023).*

In a semi-intensive rearing system, if production risk decreased by 10 percent, the number of cattle increased by 0.243 percent; beef production increased by 0.868 percent; and cattle price increased by 0.299 percent. If the price risk fell by 10 percent, then the number of cattle decreased by 0.604 percent; beef production fell by 0.305 percent; and cattle price fell by 0.746 percent. This is supported by Munadi et al. (2021), who state that the semi-intensive system provides a good balance between production efficiency and livestock welfare; effective disease control can increase livestock numbers and meat production, while the impact of reducing price risks can be more complex, depending on market dynamics. To achieve optimal results, risk management in semi-intensive systems must also consider how economic and environmental factors interact with one another. Based on the findings above, it can be detailed that reducing disease risks in livestock maintenance systems can significantly improve productivity. Intensive systems are generally more prone to disease outbreaks due to high population density, but strict control can help mitigate this risk. Extensive systems, while more resistant to disease outbreaks, often exhibit greater variability in production outcomes due to larger environmental influences (Dijkstra et al., 2007; Uwizeye et al., 2016).

#### **IV. Conclusion**

In an extensive rearing system, insemination cost, livestock disease risk, number of cattle, beef production risk and medical cost had a significant effect on cattle farm productivity, while animal feed, cattle prices and insemination cost and livestock price risk had a less significant effect on cattle farm productivity. In an intensive rearing system, the cost of insemination, animal feed, number of cattle, risk of beef production, and medical cost had a significant effect on the productivity of cattle farming, while the risk of livestock disease, cattle price, beef production, and livestock price risk did not have much influence significantly to the productivity of cattle farming. Meanwhile, in the semi-intensive rearing system, the cost of insemination, animal feed, number of cattle, risk of beef production, price of cattle had a significant effect on the productivity of cattle farming, while the risk of livestock disease, medical cost, risk of livestock price did not have a significant effect on livestock productivity. The model showed a strong impact of price and production risk where the semi-intensive system was more responsive to changes in risk. In general, reducing production risk increased beef production and had a greater impact on cattle price in extensive system. Meanwhile, reducing price risk had a small impact on the productivity of cattle farming in an intensive system. However, reducing price risk had a significant effect on the productivity of cattle farming in extensive system.

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