



The Effect of Electricity Supply Interruptions on Small Business Productivity in West Sumatra

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A B S T R A C T

This research examines the impact of interruptions in electricity supply on the production of small and medium enterprises in West Sumatra from 2014 to 2021. The data used in the research was obtained from the Ministry of Trade and Industry of West Sumatra, including the production variables, employment, investment, and other variables that influence the production activities. A regression equation connecting production factors and production levels is formulated. Furthermore, another regression equation is also formulated by considering the electricity interruption factor, namely the SAIDI index on production levels. The effect of electrical power interruptions is then evaluated by comparing the two equations. The research results show that the most significant production loss occurred in 2019, 16.07 hours/year, while the most negligible loss occurred in 2015, 6.53 hours/year. Trend data collected during the research period regarding loss conditions and interruption parameters shows that electricity disturbances do not have a linear impact on production losses. The research also shows that electric power does not significantly impact the production activities of small and medium enterprises in West Sumatra.

INTRODUCTION

Electrical energy is beneficial and valuable as a support for various activities [1]–[4]. Small and medium-sized businesses and large corporations use electrical energy as one of the main components of the production process [5], [6]. The lack of supply of electrical energy and the interruption of electrical energy has resulted in severe losses for both business actors who use electricity and for the electricity providers themselves. When conducting electric power system planning, it is common practice to evaluate the economical and dependable functioning of the system by taking into account the losses incurred due to power outages [7]–[12]. The interruption of electrical energy significantly impacts the productivity results of small and medium enterprises. The dependence on the availability of electrical power in small and medium enterprises is because replacement electrical energy-supplying equipment is not available or adequate [13]. Meanwhile, large businesses have replacement equipment for the supply of electrical energy so that they are not affected by interruptions.

The costs associated with such losses may include expenses related to production cessation, raw materials, equipment damage, and the restarting of production machines [14]. Businesses must assess the potential costs of such losses and implement measures that address

them, such as implementing electrical energy reserves, protecting equipment from interruptions, and keeping spare parts on hand. Calculating the cost of losses is crucial to determining a business's compensation. Compensation is typically offered when the electricity service provider fails to provide service to the customer [15]. The regulations governing compensation vary by jurisdiction.

Various approaches calculate the monetary losses incurred due to power outages. When it comes to individual businesses, calculating losses involves determining the value of the disrupted production factors [16]. Larger groups of organizations require more comprehensive data-collecting methods, such as surveys [17], case studies, and indirect surveys [18]. Examples of these methods include. These techniques produce more thorough data that can be utilized for assessing the impact of electricity outages on businesses.

The direct survey method uses letters, e-mail, telephone, and engaging directly with consumers. This method was developed using a questionnaire sheet. The questionnaire is designed to get the desired information, guide respondents, and help them understand the factors in the electric power supply system, such as reliability and interruptions. The questionnaire will also obtain data for qualitative and quantitative evaluation purposes. The questionnaire contains questions covering reliability, convenience, disturbances, changes in service levels, consumer anticipation to avoid

disturbances, and willingness to receive compensation from electrical disturbances [19]– [21]. The survey method offers more precise and accurate client details. Nonetheless, conducting comprehensive surveys requires considerable time, resources, and effort. For this reason, the direct survey method can only be carried out in small areas, certain agencies or groups, and within a limited scope.

Power outages can result in significant consumer costs, often evaluated through studies [22]. Researchers typically rely on real-life incidents to analyze the secondary economic implications of a noteworthy power outage. While this methodology is considered reliable and accurate, it is essential to note that it has a limitation: it may not be able to identify consequential damages resulting from a power disruption. So, the actual cost of a power outage may need to be considered when relying solely on this approach.

An interruption in the distribution of electrical energy occurs when the supply voltage is lost or faults occur at specific connection points in the power system [23]. Interruptions can be either short or long in duration. Unintentional factors like weather conditions, such as rain and lightning, strong winds and a fallen tree, or distribution equipment nearing the end of its useful life can result in short-duration interruptions [24]. Accidental interruptions are unavoidable and will occur suddenly. These interruptions are unavoidable and will occur suddenly and have a damaging impact on electrical energy equipment and customer electrical equipment. However, deliberate actions like turning off a circuit breaker to prevent permanent damage to electrical equipment or performing routine maintenance on electrical equipment cause long-duration interruptions [25]. Although these interruptions are necessary for maintaining electrical energy equipment, they result in customer losses.

Interruptions damaged electrical energy equipment and businesses. The impact of losses on business can be seen in the desired targets not being achieved [26]. Power interruption impact is based on direct and indirect impact. The direct impact is an interruption of electrical energy felt during the interruption [27]. In contrast, the indirect impact is an unexpected event resulting from the interruption of electrical energy. Direct impacts encompass both economic and social effects. The economic impacts of a disaster include the loss of industrial production, unused resources, the need to restart processes, damage to materials or food, damage to equipment, risks to human health and safety, and the cost of utility outages. Social impacts include losing household free time, public transportation delays, heating and lift disruptions, injuries, and fear. Power outages can lead to civil unrest, forced evacuations, and political or economic implications.

One effective way to enhance the system's performance in terms of electricity is by minimizing power interruptions [28]. The reliability of the electric power system is a critical factor that measures the quality of the service provided to the consumers [29]. The blackout frequency determines the level of reliability, the duration of each blackout, and the time required to restore power [30]. A high level of reliability ensures an uninterrupted power supply, while a low level of reliability causes frequent power interruptions that can lead to numerous problems for consumers [31]–[33]. Power interruptions can cause significant financial losses, disrupt daily activities, and threaten public safety. Therefore, it is essential to maintain a high

level of reliability in the electric power system to ensure the smooth operation of various industries and the general public's well-being.

Measuring the electrical power system's dependability is possible using the reliability index presented on a probability scale [34]. Several parameters have been developed to analyze and evaluate the reliability of electrical systems. IEEE P1366 is a standard document that outlines some of these parameters [35], including supply interruption (blackout), exit/outage, outage duration, extended blackout/interruption duration, number of customers served in total, and report period (assumed to be one year). An interruption of supply occurs when one or more protection components disrupt the supply of electrical energy to a customer. Exit/outage refers to a component that cannot function correctly due to various related events. Outage duration is the time it takes for the protection component to resume operation after a disruption. Long blackout/interruption duration is when an electric power component resumes operation following an intentional perturbation or component failure [36]. The total amount of clients serviced is reported for the most recent reporting period.

The reliability index makes it easier to evaluate and improve the reliability of the electric power system as follows: SAIFI and SAIDI [37]. The SAIFI (System Average Interruption Frequency Index) measures a system's average power outages [38]. It is calculated by dividing the overall quantity of client blackouts throughout a year by the entire number of customers served by the system,

$$SAIFI = \frac{\sum_{i=1}^m Ci}{N} \text{ blackouts/year} \tag{1}$$

SAIDI (System Average Interruption Duration Index) is an index value of the average duration or length of interruption in the system [39], which is the total length of blackout failure experienced by customers in one year divided by the number of consumers served by the equation;

$$SAIDI = \frac{\sum_{i=1}^m Ci ti}{N} \text{ hours/year} \tag{2}$$

Where m is the number of blackouts in one year, Ci is the number of customers who experienced blackouts, ti is the duration of each outage, and N is the number of customers served.

SAIDI is an indicator for electric power service providers to find out the average level of blackout duration for one year [40]. The blackout duration level consists of a protection component when the fault has a duration to recover. Intentional outages for repairs, diversions, and replacements are included in the average duration values calculated by SAIDI. With the calculation of the average blackout duration by SAIDI, it is the average interruption duration for small and medium businesses for a year.

The value limits of the two reliability parameters, which differ from one another, are determined by the electricity supply actors. In Indonesia, where the supply of electric power is carried out by the PLN, the value of this parameter is determined based on the reliability index standard in SPLN (PLN company standard) SPLN 68-2, Level of Guarantee of Electric Power Systems, p.11 (1986) as shown in Table 1 below:

Table 1. Standard Reliability Index

Reliability Index	Value Standard	Unit
SAIFI	3.2	times/customers
SAIDI	21.9	hours/customers

This paper describes the effect of electrical energy interruptions on SME production in West Sumatra. The indirect survey method utilizes primary data in the form of production parameters, labor, investment, and other factors that influence business production activities to collect and analyze the effect of electrical energy disturbances on the production of small and medium enterprises using the regression method [41], [42]. Then, the power interruption factor is included in the calculation and how it affects SMEs' production.

METHODS

This study's method determines how much electrical energy is disrupting the production of small and medium enterprises in West

Sumatra. The steps to realize the research objectives are shown in the flowchart in Figure 1 below.

West Sumatra Small and Medium Enterprises Profile Data

Two primary sources provided the data. The West Sumatra Trade and Industry Office provided West Sumatra SMEs with production volume, investment value, workforce, and raw material profiles. The disturbance metrics were collected from PT PLN data for West Sumatra. Each data is a one-year parameter value. Data for eight years is gathered from available sources.

The esteemed Ministry of Trade and Industry provides primary statistics on West Sumatra firms, from small to large. The data is organized by Ministerial Regulation No. 64 of 2016's SMEs criteria, which include a maximum workforce of 20 people and an investment value of IDR 15 billion, to distinguish business groupings from SMEs. According to the data selection method, several parameter data clusters have been identified for research. These classifications encompass many significant characteristics and circumstances.

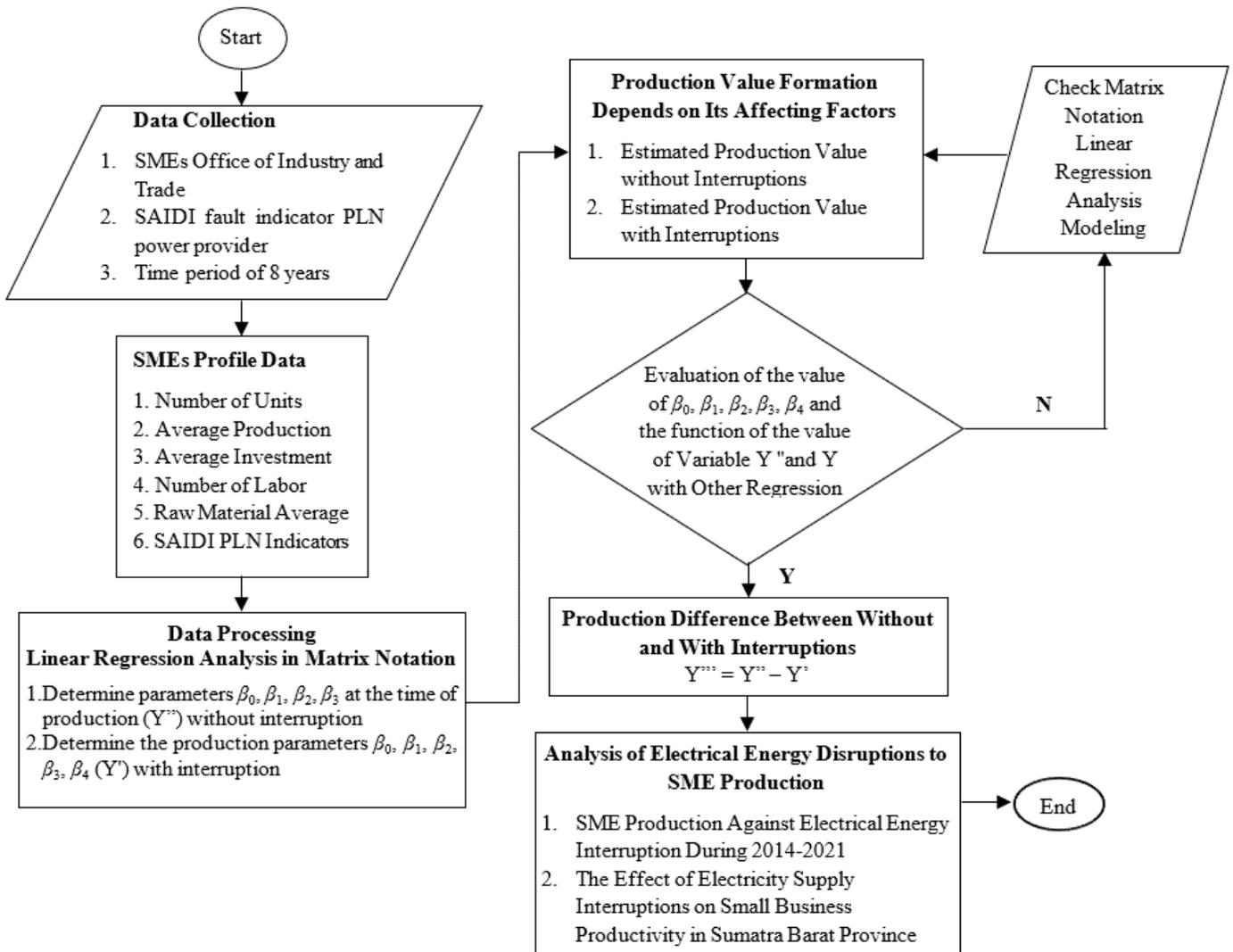


Figure 1. Analysis of Electrical Energy Interruptions to SME Production Flowchart

This report offers a comprehensive quantitative analysis of SMEs in West Sumatra, covering the period from 2014 to 2021. The study encompasses SMEs in 19 urban cities and administrative divisions, with a notable concentration of businesses in Padang Pariaman, West Pasaman, Pesisir Selatan, and Padang City. For a detailed list of these locations, it can be seen in Appendix 1. Furthermore, Appendix 2 provides insight into the average output of West Sumatra's SMEs over the same period. Finally, Appendix 3 contains information on the average capital investment of SMEs in West Sumatra, which refers to the initial value needed to acquire machinery, buildings, transportation means, administrative equipment, and production activities necessary to produce goods and services [43], [44].

Information regarding the labor force and raw materials utilized by small and medium-sized businesses in West Sumatra between 2014 and 2021 is available in Appendix 4 and 5. These businesses prioritize a skilled workforce that efficiently operates machinery to achieve superior product quality during production [45], [46]. The manufacturing process relies heavily on raw materials, as the quality of materials employed directly affects product grade, and the quantity utilized determines output [47], [48].

The indicator that shows the SAIDI index value represents the interrupt condition. Table 6 shows a summary of the SAIDI index values for the PT. PLN (Persero) for the West Sumatra region taken from the PLN Statistics Book published by PT PLN (Persero) for the 2014 to 2021 editions.

Table 2. SAIDI and SAIFI Reliability System Statistics

Year	SAIDI (hours/customers)	SAIFI (times/customers)
2014	9.43	9.51
2015	6.53	8.54
2016	5.48	7.05
2017	19.91	14.55
2018	13.21	9.52
2019	16.07	10.59
2020	9.18	6.54
2021	8.95	5.75

Table 2 shows the SAIDI index value, which varies yearly from 2014 to 2021. The highest SAIDI value indicates the highest power interruption duration in 2017, with 19.91 hours/year. Meanwhile, the lowest level of power interruption duration was in 2016, with a duration of 5.48 hours/per year.

The parameter to indicate the condition of the electric power interruption in a power system is represented by the index of the duration of the system's average interruption (SAIDI, hours/year) [49]– [51]. This index is usually used to describe the reliability index by electric power companies, calculated as the average duration of power outages for each customer served in a year.

Data Processing: Production Value Formation Depends on Its Affecting Factors

Data on production, investment, number of labor and raw materials, as well as SAIDI disruption indicators, are processed to calculate estimated production values. The formation of the function and estimation of production value is carried out using two scenarios,

namely the formation of a production function with the independent variables of production factors (investment, the number of labor and raw materials) alone and the formation of a production function with the independent variables of production factors plus interrupt factors, in this case, is the SAIDI index value.

Estimated Production Value without Interruptions

To calculate this study's estimated uninterrupted production value, the factors considered as production variables are the investment value, the number of laborers, and raw materials. The following equation is proposed to derive the regression equation for estimating production value without interruption[52].

$$Y'' = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \tag{3}$$

Where Y'' is the estimated annual uninterrupted production value (IDR/year), X₁ is the investment value (IDR/year), X₂ is the number of labor (person/year), X₃ is the raw material value (IDR/year), β₀ is constant, and β₁, β₂, and β₃ are regression coefficients (slope) with predictive values.

Following is the matrix equation corresponding to equation 3:

$$\begin{bmatrix} n & \sum X_1 & \sum X_2 & \sum X_3 \\ \sum X_1 & \sum X_1^2 & \sum X_1 X_2 & \sum X_1 X_3 \\ \sum X_2 & \sum X_2 X_1 & \sum X_2^2 & \sum X_2 X_3 \\ \sum X_3 & \sum X_3 X_1 & \sum X_3 X_2 & \sum X_3^2 \end{bmatrix} \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} = \begin{bmatrix} \sum Y \\ \sum Y X_1 \\ \sum Y X_2 \\ \sum Y X_3 \end{bmatrix} \tag{4}$$

Coefficients β₀, β₁, β₂, and β₃ in equation (3) can be calculated using the *Least Square Method*, and the solution can be obtained through matrix operation. In matrix operations, the following stages are required to determine coefficient values. Equation (4) is first translated into a matrix X, β, and Y as follows;

- 1) X matrix consisting of X variables;

$$X = \text{matrix} \begin{bmatrix} n & \sum X_1 & \sum X_2 & \sum X_3 \\ \sum X_1 & \sum X_1^2 & \sum X_1 X_2 & \sum X_1 X_3 \\ \sum X_2 & \sum X_2 X_1 & \sum X_2^2 & \sum X_2 X_3 \\ \sum X_3 & \sum X_3 X_1 & \sum X_3 X_2 & \sum X_3^2 \end{bmatrix} \tag{5}$$

- 2) Y matrix consisting of Y variables;

$$Y = \text{matrix} \begin{bmatrix} \sum Y \\ \sum Y X_1 \\ \sum Y X_2 \\ \sum Y X_3 \end{bmatrix} \tag{6}$$

- 3) β matrix is the parameters β₀, β₁, β₂, β₃;

$$\beta \text{ matrix} = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} \tag{7}$$

Then, create a supporting table to calculate the values of the X, Y, and β matrix elements. Then, Appendix 6 determines the determinant matrices X, X₁, X₂, and X₃. Next, determine the parameter values β₀, β₁, β₂, β₃, with the following equation (12) :

$$\beta_0 = \frac{\det(X_1)}{\det(X)}, \beta_1 = \frac{\det(X_2)}{\det(X)}, \beta_2 = \frac{\det(X_3)}{\det(X)}, \beta_3 = \frac{\det(X_4)}{\det(X)} \tag{12}$$

The values of the parameters $\beta_0, \beta_1, \beta_2,$ and β_3 are obtained using these steps. These values are then used as estimates for the average production (Y') without interruption in equation (3).

Estimated Production Value with Interruptions

A regression equation model has been updated to include a variable for power supply disruptions to improve production value calculations and estimations. This variable is derived from SAIDI values and considers electrical disturbances. The regression equation for estimating production value during interruptions is:

$$Y' = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \tag{13}$$

Y' is the estimated production value without interruption per year (IDR/year), X_4 is the SAIDI fault indicator representing interrupt (hours/year), and e is the term error.

The matrix equation for equation (13) is shown below.

$$\begin{bmatrix} n & \sum X_1 & \sum X_2 & \sum X_3 & \sum X_4 \\ \sum X_1 & \sum X_1^2 & \sum X_1 X_2 & \sum X_1 X_3 & \sum X_1 X_4 \\ \sum X_2 & \sum X_2 X_1 & \sum X_2^2 & \sum X_2 X_3 & \sum X_2 X_4 \\ \sum X_3 & \sum X_3 X_1 & \sum X_3 X_2 & \sum X_3^2 & \sum X_3 X_4 \\ \sum X_4 & \sum X_4 X_1 & \sum X_4 X_2 & \sum X_4 X_3 & \sum X_4^2 \end{bmatrix} \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \beta_3 \\ \beta_4 \end{bmatrix} = \begin{bmatrix} \sum Y \\ \sum YX_1 \\ \sum YX_2 \\ \sum YX_3 \\ \sum YX_4 \end{bmatrix} \tag{14}$$

With the same steps to solve equation (13) in finding the parameter value of the coefficient $\beta_0, \beta_1, \beta_2, \beta_3,$ and β_4 , Equation (12) is converted into the following matrix $X, \beta,$ and Y ,

$$X \text{ matrix} = \begin{bmatrix} n & \sum X_1 & \sum X_2 & \sum X_3 & \sum X_4 \\ \sum X_1 & \sum X_1^2 & \sum X_1 X_2 & \sum X_1 X_3 & \sum X_1 X_4 \\ \sum X_2 & \sum X_2 X_1 & \sum X_2^2 & \sum X_2 X_3 & \sum X_2 X_4 \\ \sum X_3 & \sum X_3 X_1 & \sum X_3 X_2 & \sum X_3^2 & \sum X_3 X_4 \\ \sum X_4 & \sum X_4 X_1 & \sum X_4 X_2 & \sum X_4 X_3 & \sum X_4^2 \end{bmatrix} \tag{15}$$

$$Y \text{ matrix} = \begin{bmatrix} \sum Y \\ \sum YX_1 \\ \sum YX_2 \\ \sum YX_3 \\ \sum YX_4 \end{bmatrix} \tag{16}$$

$$\beta \text{ matrix} = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \beta_3 \\ \beta_4 \end{bmatrix} \tag{17}$$

Then, create a supporting table to find the values of the parameters in the matrix, followed by finding the determinant matrix $X, X_1, X_2, X_3,$ and X_4 , as shown in Appendix 7

Lastly, determine parameter values $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$ with equation (15),

$$\beta_0 = \frac{\det(X_1)}{\det(X)}, \beta_1 = \frac{\det(X_2)}{\det(X)}, \beta_2 = \frac{\det(X_3)}{\det(X)}, \beta_3 = \frac{\det(X_4)}{\det(X)} \text{ and } \beta_4 = \frac{\det(X_5)}{\det(X)} \tag{23}$$

The parameters $\beta_0, \beta_1, \beta_2,$ and β_3 are estimated in equation (13) for production (Y') with interruptions.

It is possible to see the relationship of production in these two conditions by understanding the function of production value to its supporting elements, both with and without interruption (Y'). The difference in the number of productions can also be calculated.

$$\text{Difference in the number of productions } (Y''') = Y'' - Y' \tag{24}$$

The discrepancy in the number of productions in equation (24) can be computed for each year within the available data range. This study examines the relationship between the number of interruptions in small and medium business production and the equation of estimated production value with and without interruption.

RESULTS AND DISCUSSION

The production value of SMEs in West Sumatra was determined using data from the Department of Industry and Trade. These businesses are located in eleven regencies, seven cities, and one island. Table 3 presents the computed factors from 2014 to 2021, which will serve as the primary data for this study.

Table 3. Average Production, Investment, Labor, and Raw Materials for SMEs in West Sumatra for 2014-2021

Year	Production and Support Factors				SAIDI Indicator (Hour/Year)
	Production (IDR x 10 ³ /Year)	Investment (IDR x 10 ³ /Year)	Labor (Person/Year)	Raw Materials (IDR x 10 ³ /Year)	
2014	6,833,252	620,347	50,504	2,207,693	9.43
2015	3,534,024	586,760	60,435	1,690,606	6.53
2016	2,641,849	614,322	69,088	1,661,607	5.48
2017	4,567,71	5,178,147	78,709	8,714,993	19.91
2018	14,658,14	5,178,181	78,744	8,791,081	13.21
2019	9	164,730	104,757	1,551,284	16.07
2020	2,847,901	123,042	96,552	1,526,246	9.18
2021	3,124,311	123,028	96,559	1,525,774	8.95

SME productivity is affected by interruptions in production factors. Interruptions of electrical energy modify production and its components in this study. Regression equations (3) and (13) use SAIDI disruption indicators to estimate productivity with and without interruption.

Production factors affected by disturbances will affect SME productivity. This study uses electrical energy disturbances called interruptions to change production and its components. Productivity estimation with and without interruption uses regression equations (3) and (13) using SAIDI disturbance indicators.

Regression Calculation without Electrical Energy Interruption

Regression analysis determines the average production value and influencing parameters while ensuring an uninterrupted electricity supply. The coefficients $[\beta_0], [\beta_1], [\beta_2], [\beta_3]$ will be determined using multiple phases with this method. The results are outlined in Table 4.

Table 4. Coefficient Values $\alpha, \beta_0, \beta_1, \beta_2, \beta_3$ without Interruption

Variable	Regression Data Matrix Notation	Coefficient
Interception (α)	1,108,313	β_0
Investment (IDR x 10^3 / Year) (X_1)	-5.9106	β_1
Labor (Person) (X_2)	-58.3714	β_2
Raw Materials (IDR. x 10^3 /Year) (X_3)	5.5647	β_3

The coefficient of equation (3) estimates the production difference (Y'') from 2014 to 2021 using the following stages.

$$Y'' = 1,108,313 + (-5.9106) X_1 + (-58.3714) X_2 + 5.5647 X_3 \quad (25)$$

To determine the average production rate of small and medium-sized enterprises (SMEs) in West Sumatra, refer to Equation (25) applicable for 2014 to 2021. For convenience, this information is thoroughly presented in Appendix 8.

Regression Calculation with Electrical Energy Interruption

The regression method calculates the average production and its determinants during electrical energy outages. The calculation of coefficients $[\beta_0], [\beta_1], [\beta_2], [\beta_3],$ and $[\beta_4]$ involved multiple steps, as presented in Table 5.

Table 5. Coefficient values $\alpha, \beta_0, \beta_1, \beta_2, \beta_3, \beta_4$ for SME with Interruption

Variable	Regression Data Matrix Notation	Coefficient
Interception (α)	1,303,823	β_0
Investment (IDR x 10^3 /year) (X_1)	-5.5837	β_1
Labor (Person) (X_2)	-61.9660	β_2
Raw Materials (IDR x 10^3 /Year) (X_3)	5.2935	β_3
SAIDI indicator (Hours/Year) (X_4)	46,264.5037	β_4

The coefficient value of equation (13) provides an estimated production for interruptions between 2014 and 2021. The estimation is determined by utilizing the following calculation,

$$Y'' = 1,303,823 + (-5.5837)X_1 + (-61.9660)X_2 + 5.2935X_3 + 46,264.5037X_4 \quad (26)$$

In order to gain a comprehensive understanding of the production value of SMEs in West Sumatra from 2014 to 2021, it is strongly advised to refer to Equation (26) provided in Appendix 9.

The number of productions at Equation (22) can be calculated for each year within the available data range using the stages above. The Equation for estimating production value with and without interruption can be compared to determine the difference in production, which is shown in Table 6 below, and the details can be seen in Appendix 10

Table 6. Average Interruptions Production Difference

Year	Production Forecast		Production Difference (IDR x 10^3)
	Without Interruption (IDR x 10^3)	With Interruption (IDR x 10^3)	
2014	6,778,800	6,833,252	-54,452
2015	3,520,210	3,534,024	-13,813
2016	2,690,843	2,641,849	48,994
2017	14,404,093	14,567,714	-163,621
2018	14,825,246	14,658,149	167,096
2019	2,652,246	2,847,901	-195,655
2020	3,238,256	3,137,802	100,454
2021	3,235,308	3,124,311	110,997

From 2014 to 2021, disruptions in electrical supply had an impact on the production of small and medium enterprises in West Sumatra. In the year 2019 alone, SME businesses experienced a significant loss in production, amounting to IDR 195,655,000 per year, due to an interruption duration of 16.07 hours. On the other hand, the least significant loss was recorded in 2015, with a value of IDR 13,813,000 per year, resulting from an interruption duration of 6.53 hours per year. However, the data showed no clear correlation between power outages and SME production losses. This finding suggests that electricity does not have a substantial influence on the production activities of SMEs in West Sumatra. Figure 2 provides a visual representation of this concept..

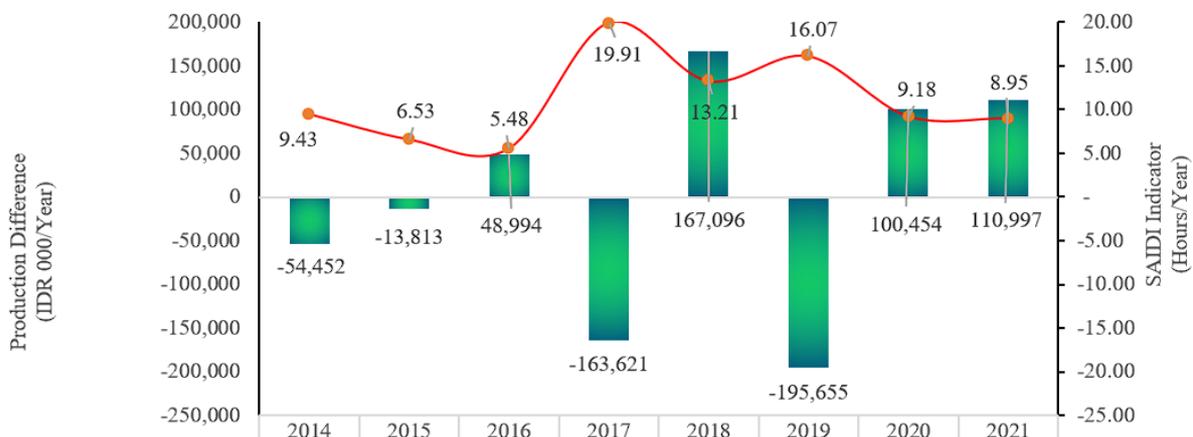


Figure 2. SME Production Against Electrical Energy Interruption during 2014-2021

This study shows that electricity disturbances do not significantly affect production. This study shows that production is influenced by supporting factors such as investment, labor, and raw materials. Previous researchers used the multiple linear regression method to examine the relationship between production and the factors that influence it. The multiple regression method produces factors that influence investment, labor, and raw materials, which have a significant linear relationship to production. The results of previous studies are presented in Table 7 below.

Table 7. Previous researches

Work	Factors that Influence Production	Influence Production	Relationship
M. Y. Saputra and K. Anwar [43]	Invest and Labor	Influence	Linear
L. R. Indrawati, L. Togarlaut, and C. Sundari [45]	Labor	Influence	Linear
H. Sibarani and L. Alhazami [48]	Raw Materials	Influence	Linear

This study combines factors influencing production and SAIDI indicators using multiple regression methods [41]. This research carries out modeling analysis using the relationship between factors that influence production and the relationship between factors that influence production and SAIDI indicators [42]. The study results show the relationship between factors that influence production and the SAIDI indicators, which are presented in Table 8 below;

Table 8. The Relationship Matrix of Factors that Influence Production

Factors that Influence Production	Production Influence	Relationship
Investment		
Labor	Influence is not Significant	Non-Linear
Raw Materials		
SAIDI indicator		

This study shows that the factors influencing production are non-linear regarding SME losses.

CONCLUSIONS

The study found that using the multiple linear regression method can help analyze the relationship between production parameters, power disturbance parameters, and business losses for small and medium-sized enterprise (SME) production in West Sumatra. Two scenarios were considered: uninterrupted production and production with interruptions. The regression analysis showed that the power interruption did not significantly affect business performance.

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APPENDICES

Appendix 1

Number of District/City Small and Medium Enterprises Units in West Sumatra in 2014-2021

No	District/City	Number of units							
		2014	2015	2016	2017	2018	2019	2020	2021
1	Agam	142	1,268	1,269	4,018	4,013	4,078	4,058	4,058
2	Dharmasraya	573	591	630	640	640	681	679	679
3	Padang Pariaman	1,016	1,013	2,156	2,162	2,165	2,251	2,251	2,251
4	Pasaman	354	653	1,215	1,394	1,394	1,487	1,483	1,483
5	Pasaman Barat	1,256	1,289	1,273	1,304	1,304	1,385	1,350	1,350
6	Pesisir Selatan	1,163	1,585	1,634	2,233	2,232	2,366	2,366	2,366
7	Solok	507	507	568	611	611	1,340	1,338	1,338
8	Solok Selatan	518	543	553	580	580	597	597	597
9	Tanah Datar	1,812	2,308	2,331	2,382	2,382	2,422	230	233
10	Mentawai	146	191	213	330	328	382	381	381
11	Lima puluh Kota	467	483	496	526	526	7,174	7,155	7,155
12	Sijunjung	900	675	724	981	981	590	93	93
13	Bukittinggi	395	1,154	2,114	1,939	1,939	2,493	2,481	2,481
14	Padang	1,744	1,980	2,074	2,114	2,114	1,752	1,403	1,403
15	Padang Panjang	660	660	1,041	117	117	547	1,081	1,081
16	Pariaman	691	689	720	1,003	1,003	1,669	1,669	1,669
17	Payakumbuh	876	874	882	1,633	1,645	1,665	1,642	1,642
18	Sawahlunto	378	402	1,068	1,245	1,245	1,316	1,307	1,307
19	Kota Solok	388	388	406	499	499	557	557	557
		13,986	17,253	21,367	25,711	25,718	34,752	32,121	32,124

Appendix 2

Average Production of District/City Small and Medium Enterprises in West Sumatra in 2014-2021

No	District/City	Average Production (IDR x 10 ³ /Year)							
		2014	2015	2016	2017	2018	2019	2020	2021
1	Agam	391,092	153,564	153,685	8,945	8,941	9,416	8,954	9,002
2	Dharmasraya	189,843	137,639	136,124	136,701	136,564	134,753	128,026	128,700
3	Padang Pariaman	132,320	114,890	93,381	79,254	79,065	88,175	83,850	84,291
4	Pasaman	171,195	70,013	115,139	110,717	110,606	106,557	101,539	102,073
5	Pasaman Barat	226,945	224,067	224,742	153,454	153,300	155,853	151,481	152,278
6	Pesisir Selatan	121,476	104,415	112,127	168,643	168,529	166,970	144,141	144,900
7	Solok	229,213	229,213	214,996	201,837	201,635	47,865	45,570	45,810
8	Solok Selatan	96,086	100,297	115,340	129,048	128,919	128,711	122,398	123,042
9	Tanah Datar	46,585	40,364	64,941	71,170	71,099	81,919	143,708	144,803
10	Mentawai	182,894	169,353	154,530	111,595	111,980	95,780	91,276	91,756
11	Lima puluh Kota	288,285	263,855	261,288	297,363	297,066	49,350	47,025	47,272
12	Sijunjung	217,943	50,447	75,970	262,021	261,759	502,000	582,210	585,274
13	Bukittinggi	238,358	110,905	132,657	136,819	136,682	177,187	169,086	169,975
14	Padang	708,348	666,285	636,663	622,042	621,420	503,480	528,302	531,082
15	Padang Panjang	177,576	177,576	157,853	9,349,162	9,339,813	189,835	293,391	294,935
16	Pariaman	130,775	130,557	130,707	2,380,544	2,378,164	52,870	50,277	50,542
17	Payakumbuh	19,005	19,024	19,061	142,233	250,367	240,659	231,881	233,101
18	Sawahlunto	3,174,735	99,709	42,045	13,111	13,098	14,597	13,847	13,920
19	Kota Solok	223,512	223,512	185,733	186,334	186,148	142,522	135,532	136,245
		6,966,187	3,085,686	3,026,983	14,560,994	14,655,156	2,888,501	3,072,493	3,089,003

Appendix 3

Average District/City Small and Medium Enterprises Investment in West Sumatra in 2014-2021

No	District/City	Average Investment (IDR x 10 ³ /Year)							
		2014	2015	2016	2017	2018	2019	2020	2021
1	Agam	48,728	15,397	15,393	10,399	10,402	4,065	4,067	4,067
2	Dharmasraya	20,920	16,821	16,429	16,364	16,364	4,224	4,227	4,227
3	Padang Pariaman	9,610	9,627	7,956	13,999	13,987	6,284	6,284	6,284
4	Pasaman	21,179	20,179	25,632	25,719	25,719	4,515	4,516	4,516
5	Pasaman Barat	27,333	27,032	26,995	26,169	26,169	3,973	3,978	3,978
6	Pesisir Selatan	42,557	70,988	69,801	51,037	51,058	21,176	17,489	17,489
7	Solok	50,946	50,946	46,833	44,019	44,019	6,647	6,650	6,650
8	Solok Selatan	33,655	30,584	30,263	21,100	21,100	3,620	3,620	3,620
9	Tanah Datar	38,791	20,963	32,190	27,036	27,036	5,273	12,729	12,714
10	Mentawai	9,649	23,337	20,897	15,753	15,831	3,894	3,894	3,894
11	Lima puluh Kota	47,068	40,618	49,372	49,416	49,416	18,171	18,201	18,201
12	Sijunjung	47,428	57,650	61,512	70,893	70,893	51,723	4,240	4,240
13	Bukittinggi	40,061	22,293	23,314	1,952,567	1,952,567	4,547	4,548	4,548
14	Padang	52,535	50,631	58,389	66,596	66,596	5,935	3,811	3,811
15	Padang Panjang	11,835	11,835	9,909	2,274,299	2,274,299	4,122	8,222	8,222
16	Pariaman	31,941	31,907	31,699	436,201	436,201	4,136	4,136	4,136
17	Payakumbuh	14,000	14,027	14,863	16,238	16,182	3,948	3,948	3,948
18	Sawahlunto	14,120	13,932	12,598	8,750	8,750	4,138	4,142	4,142
19	Kota Solok	57,992	57,992	60,277	51,592	51,592	4,339	4,339	4,339
		620,347	586,760	614,322	5,178,147	5,178,181	164,730	123,042	123,028

Appendix 4.

Number of District/City Small and Medium Enterprises Workforce in West Sumatra in 2014-2021

No	District/City	Number of Labor							
		2014	2015	2016	2017	2018	2019	2020	2021
1	Agam	782	5,689	5,695	9,827	9,817	9,883	9,840	9,840
2	Dharmasraya	1,862	1,917	2,009	2,041	2,041	2,199	2,189	2,189
3	Padang Pariaman	3,291	3,280	5,710	5,734	5,737	6,147	6,147	6,147
4	Pasaman	1,008	1,810	3,496	4,082	4,082	4,456	4,445	4,445
5	Pasaman Barat	3,656	3,747	3,698	3,812	3,812	4,052	3,880	3,880
6	Pesisir Selatan	4,876	5,948	6,139	8,451	8,448	8,756	8,756	8,756
7	Solok	2,258	2,258	2,477	2,606	2,606	3,133	3,131	3,131
8	Solok Selatan	1,654	1,678	1,708	1,711	1,711	1,781	1,781	1,781
9	Tanah Datar	4,831	6,376	6,493	6,695	6,695	6,736	703	710
10	Mentawai	426	755	791	934	930	969	967	967
11	Lima puluh Kota	2,209	2,254	2,329	2,465	2,465	20,127	20,090	20,090
12	Sijunjung	3,310	1,303	1,446	2,622	2,622	2,156	366	366
13	Bukittinggi	1,942	3,983	6,148	5,862	5,862	8,701	8,667	8,667
14	Padang	6,370	7,311	7,744	8,001	8,001	6,672	5,557	5,557
15	Padang Panjang	2,679	2,679	3,350	128	128	2,279	3,438	3,438
16	Pariaman	3,971	3,955	4,085	4,763	4,763	7,304	7,304	7,304
17	Payakumbuh	2,307	2,302	2,335	5,001	5,050	5,121	5,019	5,019
18	Sawahlunto	1,211	1,329	1,502	1,775	1,775	1,861	1,848	1,848
19	Kota Solok	1,861	1,861	1,933	2,199	2,199	2,424	2,424	2,424
		50,504	60,435	69,088	78,709	78,744	104,757	96,552	96,559

Appendix 5.

Average Raw Materials for District/City Small and Medium Enterprises in West Sumatra in 2014-2021

No	District/City	Raw Material Average (IDR x 10 ³ /Year)							
		2014	2015	2016	2017	2018	2019	2020	2021
1	Agam	276,016	111,812	113,422	5,297	5,299	4,954	4,967	4,967
2	Dharmasraya	220,339	86,264	84,572	84,680	84,680	82,532	82,775	82,775
3	Padang Pariaman	77,217	74,216	56,231	50,864	50,835	53,018	49,805	49,805
4	Pasaman	126,214	40,681	60,759	59,301	59,301	35,432	35,526	35,526
5	Pasaman Barat	144,094	141,494	141,798	78,127	78,127	79,689	81,569	81,569
6	Pesisir Selatan	88,706	79,814	81,196	81,476	81,503	82,289	66,891	66,891
7	Solok	137,452	137,452	128,930	120,071	120,071	17,702	17,727	17,727
8	Solok Selatan	52,138	55,419	57,317	62,985	62,985	64,700	64,700	64,700
9	Tanah Datar	35,386	21,204	37,331	40,579	40,579	29,915	43,181	42,710
10	Mentawai	76,391	73,460	67,955	47,802	48,021	11,101	11,128	11,128
11	Lima puluh Kota	104,450	103,378	109,990	119,146	119,146	15,053	15,092	15,092
12	Sijunjung	92,917	54,535	64,460	128,394	128,394	234,836	86,423	86,423
13	Bukittinggi	136,971	71,463	83,352	89,135	89,135	107,352	107,823	107,823
14	Padang	298,493	299,537	285,914	276,827	276,827	227,859	260,017	260,017
15	Padang Panjang	127,612	127,612	115,122	7,177,316	7,177,316	133,502	225,011	225,011
16	Pariaman	74,708	74,681	73,733	106,960	106,960	140,820	140,820	140,820
17	Payakumbuh	9,502	9,512	9,531	99,699	175,568	169,507	171,786	171,786
18	Sawahlunto	38,968	37,953	16,987	5,114	5,114	5,855	5,838	5,838
19	Kota Solok	90,121	90,121	73,009	81,219	81,219	55,168	55,168	55,168
		2,207,693	1,690,606	1,661,607	8,714,993	8,791,081	1,551,284	1,526,246	1,525,774

Appendix 6

$$\det X_1 = \begin{bmatrix} \sum Y & \sum X_1 & \sum X_2 & \sum X_3 \\ \sum YX_1 & \sum X_1^2 & \sum X_1X_2 & \sum X_1X_3 \\ \sum YX_2 & \sum X_2X_1 & \sum X_2^2 & \sum X_2X_3 \\ \sum YX_3 & \sum X_3X_1 & \sum X_3X_2 & \sum X_3^2 \end{bmatrix} \quad (8)$$

$$\det X_2 = \begin{bmatrix} n & \sum Y & \sum X_2 & \sum X_3 \\ \sum X_1 & \sum YX_1 & \sum X_1X_2 & \sum X_1X_3 \\ \sum X_2 & \sum YX_2 & \sum X_2^2 & \sum X_2X_3 \\ \sum X_3 & \sum YX_3 & \sum X_3X_2 & \sum X_3^2 \end{bmatrix} \quad (9)$$

$$\det X_3 = \begin{bmatrix} n & \sum X_1 & \sum Y & \sum X_3 \\ \sum X_1 & \sum X_1^2 & \sum YX_1 & \sum X_1 X_3 \\ \sum X_2 & \sum X_2 X_1 & \sum YX_2 & \sum X_2 X_3 \\ \sum X_3 & \sum X_3 X_1 & \sum YX_3 & \sum X_3^2 \end{bmatrix} \quad (10)$$

$$\det X_4 = \begin{bmatrix} n & \sum X_1 & \sum X_2 & \sum Y \\ \sum X_1 & \sum X_1^2 & \sum X_1 X_2 & \sum YX_1 \\ \sum X_2 & \sum X_2 X_1 & \sum X_2^2 & \sum YX_2 \\ \sum X_3 & \sum X_3 X_1 & \sum X_3 X_2 & \sum YX_3 \end{bmatrix} \quad (11)$$

Appendix 7

$$\det X_1 = \begin{bmatrix} \sum Y & \sum X_1 & \sum X_2 & \sum X_3 & \sum X_4 \\ \sum YX_1 & \sum X_1^2 & \sum X_1 X_2 & \sum X_1 X_3 & \sum X_1 X_4 \\ \sum YX_2 & \sum X_2 X_1 & \sum X_2^2 & \sum X_2 X_3 & \sum X_2 X_4 \\ \sum YX_3 & \sum X_3 X_1 & \sum X_3 X_2 & \sum X_3^2 & \sum X_3 X_4 \\ \sum YX_4 & \sum X_4 X_1 & \sum X_4 X_2 & \sum X_4 X_3 & \sum X_4^2 \end{bmatrix} \quad (18)$$

$$\det X_2 = \begin{bmatrix} n & \sum Y & \sum X_2 & \sum X_3 & \sum X_4 \\ \sum X_1 & \sum YX_1 & \sum X_1 X_2 & \sum X_1 X_3 & \sum X_1 X_4 \\ \sum X_2 & \sum YX_2 & \sum X_2^2 & \sum X_2 X_3 & \sum X_2 X_4 \\ \sum X_3 & \sum YX_3 & \sum X_3 X_2 & \sum X_3^2 & \sum X_3 X_4 \\ \sum X_4 & \sum YX_4 & \sum X_4 X_2 & \sum X_4 X_3 & \sum X_4^2 \end{bmatrix} \quad (19)$$

$$\det X_3 = \begin{bmatrix} n & \sum X_1 & \sum Y & \sum X_3 & \sum X_4 \\ \sum X_1 & \sum X_1^2 & \sum YX_1 & \sum X_1 X_3 & \sum X_1 X_4 \\ \sum X_2 & \sum X_2 X_1 & \sum YX_2 & \sum X_2 X_3 & \sum X_2 X_4 \\ \sum X_3 & \sum X_3 X_1 & \sum YX_3 & \sum X_3^2 & \sum X_3 X_4 \\ \sum X_4 & \sum X_4 X_1 & \sum YX_4 & \sum X_4 X_3 & \sum X_4^2 \end{bmatrix} \quad (20)$$

$$\det X_4 = \begin{bmatrix} n & \sum X_1 & \sum X_2 & \sum Y & \sum X_4 \\ \sum X_1 & \sum X_1^2 & \sum X_1 X_2 & \sum YX_1 & \sum X_1 X_4 \\ \sum X_2 & \sum X_2 X_1 & \sum X_2^2 & \sum YX_2 & \sum X_2 X_4 \\ \sum X_3 & \sum X_3 X_1 & \sum X_3 X_2 & \sum YX_3 & \sum X_3 X_4 \\ \sum X_4 & \sum X_4 X_1 & \sum X_4 X_2 & \sum YX_4 & \sum X_4^2 \end{bmatrix} \quad (21)$$

$$\det X_5 = \begin{bmatrix} n & \sum X_1 & \sum X_2 & \sum X_3 & \sum Y \\ \sum X_1 & \sum X_1^2 & \sum X_1 X_2 & \sum X_1 X_3 & \sum YX_1 \\ \sum X_2 & \sum X_2 X_1 & \sum X_2^2 & \sum X_2 X_3 & \sum YX_2 \\ \sum X_3 & \sum X_3 X_1 & \sum X_3 X_2 & \sum X_3^2 & \sum YX_3 \\ \sum X_4 & \sum X_4 X_1 & \sum X_4 X_2 & \sum X_4 X_3 & \sum YX_4 \end{bmatrix} \quad (22)$$

Appendix 8

By obtaining equation (25), it is possible to calculate the estimated average production value of Small and Medium Enterprises in West Sumatra from 2014 – 2021.

1. The Estimated production output in 2014 without interruption
 $Y'' = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$
 $= (1,108,313) + (-5.9106) X_1 + (-58.3714) X_2$
 $+ (5.5647) X_3$
 $= (1,108,313) + (-5.9106) (620,347)$
 $+ (-58.3714) (50,504) + (5.5647) (2,207,693)$
 $= \text{IDR } 6,778,800,000/\text{year}$
2. The Estimated production output in 2015 without interruption
 $Y'' = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$
 $= (1,108,313) + (-5.9106) X_1 + (-58.3714) X_2$
 $+ (5.5647) X_3$
 $= (1,108,313) + (-5.9106) (586,760)$
 $+ (-58.3714) (60,435) + (5.5647) (1,690,606)$

- $= \text{IDR } 3,520,210,000/\text{year}$
3. The Estimated production output in 2016 without interruption
 $Y'' = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$
 $= (1,108,313) + (-5.9106) X_1 + (-58.3714) X_2$
 $+ (5.5647) X_3$
 $= (1,108,313) + (-5.9106) (614,322)$
 $+ (-58.3714) (69,088) + (5.5647) (1,661,607)$
 $= \text{IDR } 2,690,843,000/\text{year}$
4. The Estimated production output in 2017 without interruption
 $Y'' = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$
 $= (1,108,313) + (-5.9106) X_1 + (-58.3714) X_2$
 $+ (5.5647) X_3$
 $= (1,108,313) + (-5.9106) (5,178,147)$
 $+ (-58.3714) (78,709) + (5.5647) (8,714,993)$
 $= \text{IDR } 14,404,093,000/\text{year}$
5. The Estimated production output in 2018 without interruption
 $Y'' = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$
 $= (1,108,313) + (-5.9106) X_1 + (-58.3714) X_2$
 $+ (5.5647) X_3$
 $= (1,108,313) + (-5.9106) (5,178,181)$
 $+ (-58.3714) (78,744) + (5.5647) (8,791,081)$
 $= \text{IDR } 14,825,246,000/\text{year}$
6. The Estimated production output in 2019 without interruption
 $Y'' = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$
 $= (1,108,313) + (-5.9106) X_1 + (-58.3714) X_2$
 $+ (5.5647) X_3$
 $= (1,108,313) + (-5.9106) (164,730)$
 $+ (-58.3714) (104,757) + (5.5647) (1,551,284)$
 $= \text{IDR } 2,652,246,000/\text{year}$
7. The Estimated production output in 2020 without interruption
 $Y'' = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$
 $= (1,108,313) + (-5.9106) X_1 + (-58.3714) X_2$
 $+ (5.5647) X_3$
 $= (1,108,313) + (-5.9106) (123,042)$
 $+ (-58.3714) (96,552) + (5.5647) (1,526,246)$
 $= \text{IDR } 3,238,256,000/\text{year}$
8. The Estimated production output in 2021 without interruption
 $Y'' = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$
 $= (1,108,313) + (-5.9106) X_1 + (-58.3714) X_2$
 $+ (5.5647) X_3$
 $= (1,108,313) + (-5.9106) (123,028)$
 $+ (-58.3714) (96,559) + (5.5647) (1,525,774)$
 $= \text{IDR } 3,235,308,000/\text{year}$

Appendix 9

With these several stages, parameter values are obtained so that equation (26) is an estimated production (Y'') for 2014 – 2021 with interruption as follows;

1. The estimated production results in 2014 with interruption
 $Y' = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$
 $= (1,303,823) + (-5.5837) X_1 + (-61,9660) X_2 + (5,2935) X_3$
 $+ (46,264.5037) X_4$
 $= (1,303,823) + (-5.5837) (620,347) + (-61.9660) (50,504)$
 $+ (5.2935) (2,207.693) + (46,264.5037) (9.43)$
 $= \text{IDR } 6,833,252,000/\text{year}$
2. The estimated production results in 2015 with interruption
 $Y' = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$

$$\begin{aligned}
 &= (1,303,823)+(-5,5837)X_1+(-61,9660)X_2+(5,2935)X_3 \\
 &\quad + (46,264.5037)X_4 \\
 &= (1,303,823)+(-5.5837)(586,760)+(-61.9660)(60,435) \\
 &\quad + (5.2935)(1,690,606)+(46,264.5037)(6.53) \\
 &= \text{IDR } 3,534,024,000/\text{year}
 \end{aligned}$$

3. The estimated production results in 2016 with interruption

$$\begin{aligned}
 Y' &= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \\
 &= (1,303,823)+(-5.5837)X_1+(-61.9660)X_2+(5.2935)X_3 \\
 &\quad + (46,264.5037)X_4 \\
 &= (1,303,823)+(-5.5837)(614,322)+(-61.9660)(69,088) \\
 &\quad + (5.2935)(1,661,607)+(46,264.5037)(5.48) \\
 &= \text{IDR } 2,641,849,000/\text{year}
 \end{aligned}$$

4. The estimated production results in 2017 with interruption

$$\begin{aligned}
 Y' &= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \\
 &= (1,303,823)+(-5.5837)X_1+(-61.9660)X_2+(5.2935)X_3 \\
 &\quad + (46,264.5037)X_4 \\
 &= (1,303,823)+(-5.5837)(5,178,147)+(-61.9660)(78,709) \\
 &\quad + (5.2935)(8,714,993)+(46,264.5037)(19.91) \\
 &= \text{IDR } 14,567,714,000/\text{year}
 \end{aligned}$$

5. The estimated production results in 2018 with interruption

$$\begin{aligned}
 Y' &= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \\
 &= (1,303,823)+(-5.5837)X_1+(-61.9660)X_2+(5.2935)X_3 \\
 &\quad + (46,264.5037)X_4 \\
 &= (1,303,823)+(-5.5837)(5,178,181)+(-61.9660)(78,744) \\
 &\quad + (5.2935)(8,791,081)+(46,264.5037)(13.21) \\
 &= \text{IDR } 14,658,149,000/\text{year}
 \end{aligned}$$

6. The estimated production results in 2019 with interruption

$$\begin{aligned}
 Y' &= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \\
 &= (1,303,823)+(-5.5837)X_1+(-61.9660)X_2+(5.2935)X_3 \\
 &\quad + (46,264.5037)X_4 \\
 &= (1,303,823)+(-5.5837)(164,730)+(-61.9660)(104,757) \\
 &\quad + (5.2935)(1,551,284)+(46,264.5037)(16.07) \\
 &= \text{IDR } 2,847,901,000/\text{year}
 \end{aligned}$$

7. The estimated production results in 2020 with interruption

$$\begin{aligned}
 Y' &= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \\
 &= (1,303,823)+(-5.5837)X_1+(-61.9660)X_2+(5.2935)X_3 \\
 &\quad + (46,264.5037)X_4 \\
 &= (1,303,823)+(-5.5837)(123,042)+(-61.9660)(96,552) \\
 &\quad + (5.2935)(1,526,246)+(46,264.5037)(9.18) \\
 &= \text{IDR } 3,137,802,000/\text{year}
 \end{aligned}$$

8. The estimated production results in 2021 with interruption

$$\begin{aligned}
 Y' &= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \\
 &= (1,303,823)+(-5.5837)X_1+(-61.9660)X_2+(5.2935)X_3 \\
 &\quad + (46,264.5037)X_4 \\
 &= (1,303,823)+(-5.5837)(123,028)+(-61.9660)(96,559) \\
 &\quad + (5.2935)(1,525,774)+(46,264.5037)(8.95) \\
 &= \text{IDR } 3,124,311,000/\text{year}
 \end{aligned}$$

2. The estimated difference in production in 2015

$$\begin{aligned}
 Y''' &= Y'' - Y' \\
 &= 3,520,210 - 3,534,024 \\
 &= \text{IDR } -13,813,000/\text{Year}
 \end{aligned}$$

3. The estimated difference in production in 2016

$$\begin{aligned}
 Y''' &= Y'' - Y' \\
 &= 2,690,843 - 2,641,849 \\
 &= \text{IDR } 48,994,000/\text{Year}
 \end{aligned}$$

4. The estimated difference in production in 2017

$$\begin{aligned}
 Y''' &= Y'' - Y' \\
 &= 14,404,093 - 14,567,714 \\
 &= \text{IDR } -163,621,000/\text{Year}
 \end{aligned}$$

5. The estimated difference in production in 2018

$$\begin{aligned}
 Y''' &= Y'' - Y' \\
 &= 14,825,246 - 14,658,149 \\
 &= \text{IDR } 167,096,000/\text{Year}
 \end{aligned}$$

6. The estimated difference in production in 2019

$$\begin{aligned}
 Y''' &= Y'' - Y' \\
 &= 2,652,246 - 2,847,901 \\
 &= \text{IDR } -195,655,000/\text{Year}
 \end{aligned}$$

7. The estimated difference in production in 2020

$$\begin{aligned}
 Y''' &= Y'' - Y' \\
 &= 3,238,256 - 3,137,802 \\
 &= \text{IDR } 100,454,000/\text{Year}
 \end{aligned}$$

8. The estimated difference in production in 2021

$$\begin{aligned}
 Y''' &= Y'' - Y' \\
 &= 3,235,308 - 3,124,311 \\
 &= \text{IDR } 110,997,000/\text{Year}
 \end{aligned}$$

Appendix 10

The equation for estimating production value with and without interruption can be compared to determine the difference in production.

1. The estimated difference in production in 2014

$$\begin{aligned}
 Y''' &= Y'' - Y' \\
 &= 6,778,800 - 6,833,252 \\
 &= \text{IDR } -54,452,000/\text{Year}
 \end{aligned}$$