# Efficiency of the Tanjung Modang Nagari Tanjung Bonai Weaving Production Process Using the Data Envelopment Analysis Method

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Abstract: The main problem of this research is that the Lintau Weaving Village industry has never conducted an inspection of its production work unit. This research is quantitative. The data collection technique used is observation. The study's findings indicate that DMU 2, 4, and 5 pertain to the VRS model calculations in both 2018 and 2021. In the input variable that is not optimal, namely the total cost of raw materials so that improvements can be made by minimizing the use of raw material costs and planning raw material requirements by analyzing sales records of weaving which have not been done before. The output variable that is not optimal is the number of products. Improvements can be made by increasing resources, expanding marketing, and promoting through various social media platforms.

## 1 INTRODUCTION

Efficiency is a word that describes the success of a person or organization in the work being done, according to how many resources are used to achieve the results of these activities. Efficiency refers to the ratio of input to output. (Liana, 2019) Regarding system theory, efficiency is the ratio of input and output. The output of input processed by a certain process will be based on certain sizes and parameters. Production efficiency in an industry such as the weaving industry is measured by the output in terms of the number of woven products and consumers. The achievement of goals requires competence to do a job in accordance with the planned objectives (Asmarani, 2019).

One way to increase income in the Lintau Weaving Village, Jorong Tanjung Modang, Nagari Tanjung Bonai, Lintau Buo Utara District, Tanah Datar Regency, is to use production inputs as efficiently as possible in order to maximize the profits obtained by the workforce in the Lintau Weaving Village. The efficient utilization of production inputs can result in an increase in weaving production. So far, Lintau Weaving Village has never conducted inspections of production work units and also the amount of production produced is only based on the number of existing workers so it is not yet known whether production output is efficient or not. Therefore, it is necessary to measure efficiency to determine efficiency in the production process.

The DEA method was used to conduct a study in light of these problems. DEA was introduced to the public by Charnes, Cooper, and Rhodes. The DEA method is a method that can be used to measure the efficiency of a company with the advantage of accommodating many inputs and outputs in various dimensions, so that a more accurate efficiency measurement is obtained as a first step in increasing productivity. Data Envelopment Analysis is a productivity multi-factor analysis model to measure the efficiency of a homogeneous Decision Making Unit (DMU) group, so the DEA method can be used because it can accommodate many inputs and outputs in many dimensions and a more accurate efficiency measurement will be obtained as a first step in increase the productivity of a company. Therefore we need measurements that involve multiple inputs. For example, the number of workers, the hours worked, and the total cost of raw materials. The efficiency of the production process in each company is affected by the number of customers and products involved in multi-output.



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# 2 LITERATURE REVIEW

## 2.1 Efficiency

Efficiency is the best ratio between input and output or in other words the optimal results to be achieved by using existing or limited resources (Munthe, 2019). The higher the ratio of output to input, the higher the level of efficiency achieved. Efficiency can also be understood as the achievement of maximum output through the utilization of specific resources. If the resulting output is greater than the resources used, the higher the efficiency achieved. Therefore, this efficiency is related to the value chain, which refers to the linkages between activities carried out in creating goods and services.

## 2.2 Efficiency Measurement

The efficiency of a DMU is measured by its relative efficiency against that of other DMUs in a sample population. Here the condition applies that the DMUs contain the same type of inputs and outputs (Munthe, 2019).

## 2.3 Production

In terminology, the word production means to make an object and add value to it. The value of a product increases when it provides new or more benefits than previously. In general, production is the creation of goods, which means the ability of a product or service to meet certain human needs (Lubis, 2017).

## 2.4 Production Process

Process is a way, method, or technique for implementing a certain thing. While production is an activity designed to add or create benefits, it also considers the form, timing, and location of production factors that are beneficial to satisfying consumers. This can be interpreted that the production process is a step or stage of activity to make an input into an output that has added value.

## 2.5 Data Envelopment Analysis Method

Thanassoulis (2001) stated that DEA is a method for measuring the relative efficiency of homogeneous operating units like schools, hospitals, industrial centers, and so forth. The purpose of DEA is to determine efficiency in production processes and find improvement strategies for inefficient production processes. The advantage of DEA is that it accommodates many inputs and outputs in various dimensions, so that a more accurate measurement of efficiency can be obtained.

# 3 RESEARCH METHODS

This research is a quantitative study aimed at analyzing Data Envelopment Analysis in measuring efficiency. The object of this research is the input and output data from the weaving village. While the subject of this research is weaving or songket from Lintau weaving village as a DMU.

The population used in this study is all woven production in 2018-2021 in Lintau Weaving Village. The sample of this research is the Decision Making Unit (DMU), which consists of 5 DMUs including the Dewi Weaving Unit, Era Weaving Unit, Riza Weaving Unit, Siti Weaving Unit and Triya Weaving Unit because the level of efficiency will be measured.

The instruments in this study were processed by researchers using company data results. In this study, LINDO 6.1 is utilized as the software. The data collection technique that the researchers used was observation, namely the method of collecting data by taking data directly in the field and by direct interviews with the weaving village. In this study, primary and secondary data were used. Primary data is data obtained from direct interviews with the weaving village. Secondary data is data that has been collected and processed by other parties and doesn't need to be measured again.

Data Analysis Techniques is an attempt to create a detailed description for further study. The data that has been obtained is then calculated and analyzed on the results obtained. The data needed for this research are product data, labor data, production working hours data, raw material cost data, and customer data. The data obtained is data related to the weaving production process. The data used is data for 2018-2021. The variables that are employed are both input and output variables in the process of production.

# 4 RESULTS AND DISCUSSION

## 4.1 What Is the Weaving Efficiency Level?

Based on the calculations that have been done, in 2018, the results obtained were less than 1 (inefficient), specifically for the Era Weaving Unit, Siti Weaving Unit, and Triya Weaving Unit. The

efficiency value for the Era Weaving Unit is 0.8250000, Siti's Weaving Unit is 0.6875000, and Triya's Weaving Unit is 0.8491666. The variable that has the highest average weight is the number of customers with a value of 0.0438332. The customer variable is the most influential variable among all other variables. This means that the number of customers is relatively important in the Lintau weaving village. Next is the variable amount of raw material costs, which has an average weight of 0.0000444. Next is the variable amount of working hours, which has an average weight of 0.000081. Whereas the variable number of products has an average weight value of 0 and the variable number of workers has an average weight of 0. This means that relatively the labor and product variables do not affect the value of efficiency in Lintau Weaving Village.

Based on the calculations that have been carried out, in 2019 the results obtained were less than 1 (inefficient), namely the Siti Weaving Unit with an efficiency value of 0.9444444The variable that has the highest average weight is the number of customers with a value of 0.0533336. The customer variable is the most influencing variable compared to other variables. The importance of customers is relative in Kampung Tenun Lintau. Next is the variable amount of raw material costs, which has an average weight value of 0.0002516. Next is the variable amount of working hours, which has an average weight value of 0.000044. Meanwhile, the average weight value of the variable number of products is 0 and the average weight value of the variable number of workers is also 0. This means that relatively the labor and product variables do not affect the value of efficiency in Lintau Weaving Village**.**

Based on the calculations that have been done, in 2020 the results obtained are less than 1 (inefficient), namely the Siti Weaving Unit with an efficiency value of 0.8875740. While the Triya Weaving Unit has an efficiency value of 0.9230769. The variable with the highest average weight is the number of customers, with a value of 0.0809882. The customer variable is the most influencing variable compared to other variables. The number of customers in Kampung Tenun Lintau is a significant factor. Next, namely the variable number of workers who have an average weight with a value of 0.0150474, the variable total cost of raw materials with an average weight of 0.0002744, then the variable number of hours worked with an average weight of 0.000022. The number of products is variable and their average weight is 0. This means that the product variable does not affect the efficiency value in Lintau Weaving Village.

Based on the calculations that have been done, in 2021 the results obtained are less than 1 (inefficient), namely the Era Weaving Unit with an efficiency value of 0.975, Siti Weaving Unit with an efficiency value of 0.9 while the Triya Weaving Unit with an efficiency value of 0.9. The variable with the highest average weight is the number of customers, with a value of 0.063. The customer variable is the most influencing variable compared to other variables. The number of customers in Kampung Tenun Lintau is a significant factor. Next is the variable number of workers who has an average weight with a value of 0.04, then the variable amount of raw material costs with an average weight of 0.0001016. The variable number of products and hours worked has an average weight value of 0. This means that relatively the product variable does not affect the value of efficiency in Lintau Weaving Village.

The CRS Dual model, which was carried out using LINDO 6.1, produces Technical Efficiency (TE) and Slack variables. The dual CRS (constant return to scale) model is a continuation of the primal CRS, but in dual CRS, there is no linear relationship between output and input variables.

The results of CRS Dual in 2018, namely DMU 1 and DMU 3 have a TE value of 1 because the value of z = 1 and are considered efficient, while DMU 2 TE is 1.3872992751 , DMU 4 TE is 1.6647591302 , DMU 5 TE is 1.3868984969. for DMU 2 there is Slack at Y1 of 0.000133 , X3 of 0.000041. DMU 4 has Slack at Y1 of 0.000133, X3 of 0.000041 and DMU 5 has Slack at Y1 of 0.000137, X3 of 0.000063.

The Era Weaving Unit has a CRS Dual efficiency value of 0.7208250, this means that the Era Weaving Unit is not optimal based on technical and scale aspects simultaneously. From the CRS Dual calculation, the slack output value for the number of So1 products is 0.000133, and the slack input value for the total Si3 raw material cost is 0.000041. The Siti Weaving Unit has a CRS Dual efficiency value of 0.6006875, which means that it is not optimal based on technical and scale aspects simultaneously. From the CRS Dual calculation, the slack output value for So1 is 0.000133 and the slack input value for Si3 is 0.000041. The Triya Weaving Unit has a CRS Dual efficiency value of 0.7210333, which means that it is not optimal based on technical and scale aspects simultaneously. The CRS Dual calculation shows that So1 has a slack output value of 0.000137 and Si3 has a slack input value of 0.000063. Meanwhile, the Dewi Weaving Unit and Riza Weaving Unit have a dual CRS value that is already efficient and optimal, namely 1 from a technical and concurrent scale perspective. A DMU that has slack functions to make

improvements, by adding or subtracting the value of each variable in the DMU to achieve an optimal objective function based on the results of CRS Dual.

The results of CRS Dual in 2019, namely DMU 1, DMU 2, DMU 3 and DMU 5 have a TE value of 1 because the z=1 value is considered efficient, while DMU 4 TE is 1.1624054819, for DMU 4 there is Slack at Y1 of 0.000136, X1 of 0.023767. The Siti Weaving Unit has a CRS Dual efficiency value of 0.8602850, this means that the Siti Weaving Unit is not optimal based on technical and scale aspects simultaneously. The CRS Dual calculation results in a slack output value of 0.000136 for the number of So1 products, compared to a slack input value of 0.023767 for Si1. Meanwhile, the Dewi Weaving Unit, Era Weaving Unit, Riza Weaving Unit and Triya Weaving Unit have a dual CRS value which is efficient and optimal, namely 1 from a technical point of view and concurrent scale. A DMU that has slack functions to make improvements, by adding or subtracting the value of each variable in the DMU to achieve an optimal objective function based on the results of CRS Dual.

The results of CRS Dual in 2020, namely DMU 1, DMU 2, and DMU 3 have a TE value of 1 because the z=1 value is considered efficient, while DMU 4 TE is 1.2322274298, for DMU 4 there is Slack at Y1 of 0.000158, X1 of 0.038067 . DMU 5 TE is 1.0833333604, for DMU 5 there is Slack at Y1 of 0.000155, X1 of 0.025541 and X3 of 0.000044. The Siti Weaving Unit is not the optimal choice due to its CRS Dual efficiency value of 0.8115385, which takes into account both technical and scale aspects simultaneously. The CRS Dual calculation yields a slack output value of 0.000158 for So1 products, and an input SI1 value of 0.038067. The Triya Weaving Unit has a CRS Dual efficiency value of 0.9230769, which means that it is not optimal based on technical and scale aspects simultaneously. From the CRS Dual calculation, the slack output value for the number of So1 products is 0.000155, while the slack input Si1 is 0.025541, and Si3 is 0.000044. Meanwhile, the Dewi Weaving Unit, Era Weaving Unit, and Riza Weaving Unit have a dual CRS value which is efficient and optimal, namely 1 from a technical and concurrent scale perspective. A DMU that has slack functions to make improvements, by adding or subtracting the value of each variable in the DMU to achieve an optimal objective function based on the results of CRS Dual.

The results of CRS Dual in 2021 are that DMU 1 and DMU 3 have a TE value of 1 because the value of z=1 is considered efficient, while DMU 2 TE is 1.2091423251, for DMU 2 there is Slack at Y1 of 0.000124, X3 of 0.000041. DMU 4 TE is 1.3666803335, for DMU 4 there is Slack at Y1 of 0.000126, X1 of 0.025700. DMU 5 TE is 1.204456489, for DMU 5 there is Slack at Y1 of 0.000130, X1 of 0.036650. The Era Weaving Unit has a Dual CRS efficiency value of 0.8270325. This means that the Era Weaving Unit is not optimal based on technical and scale aspects simultaneously. From the CRS Dual calculation, the slack output value for the number of So1 products is 0.000124 and the slack input Si3 is 0.000041. The Siti Weaving Unit has a CRS Dual efficiency value of 0.7317, which means that the Siti Weaving Unit is not optimal based on technical and scale aspects simultaneously. The CRS Dual calculation shows that the slack output value for So1 products is 0.000126, compared to the slack input SI1 being 0.025700. The Triya Weaving Unit has a CRS Dual efficiency value of 0.83025, which means that the Triya Weaving Unit is not optimal based on technical and scale aspects simultaneously. From the CRS Dual calculation, the slack output value for the number of So1 products is 0.000130 and the slack input Si1 is 0.036650. Meanwhile, the Dewi Weaving Unit and Riza Weaving Unit have a dual CRS value which is already efficient and optimal, namely 1 from a technical and concurrent scale perspective. A DMU that has slack functions to make improvements, by adding or subtracting the value of each variable in the DMU to achieve an optimal objective function based on the results of CRS Dual.

At this stage, the VRS model is calculated to determine if the DMU efficiency is purely technical efficiency or influenced by other factors outside the DMU. This VRS model is a refinement of the CRS DUAL model by providing a convexity constrain = 1.

In 2018, in the VRS calculation, there was only 1 inefficient DMU, namely DMU 2 Era, where the Era Weaving Unit had a slack output value of So1 of 0.000107 and slack input of Si3 of 0.000041.

In 2019, in the VRS calculation, there were only 2 inefficient DMUs, namely DMU 2 Era and DMU 3 Riza, where the Era Weaving Unit had a slack output value of So1 of 0.000118 and slack input Si1 of 0.023767. Meanwhile, the Riza Weaving Unit has a slack output value of 0.000118 at So1 and 0.000228 at Si2.

In 2020, in the calculation of VRS, all DMUs are efficient.

In 2021, in the VRS calculation, there are only 3 inefficient DMUs, namely DMU 2 Era, DMU 4 Siti, and DMU 5 Triya where the Era Weaving Unit has a slack output value of So1 of 0.000115 and slack input Si3 of 0.000041, Siti's Weaving Unit has a slack value the output at So1 is 0.000117 and the slack input at

Si3 is 0.000057. While the Triya Weaving Unit has a slack output value at So1 of 0.000120 and a slack input at Si3 of 0.000081.

TE values are produced by the calculations of CRS and VRS models that can be used to calculate scale efficiency (SE) values. The TE value is obtained by dividing the optimum efficiency value (1) with the efficiency value of each DMU for both CRS and VRS calculations. To get the SE value for each DMU, the TECRSDUAL value is divided by TEVRS.

## 4.2 How are DMUs Targeted for Improvement?

DMUs that have efficient results can become a reference for improvement for DMUs that have inefficient results by forming a peer group. Formation of peer groups by using hierarchial cluster analysis using SPSS software by looking at the closest squared euclideant distance between DMUs. The smaller the squared euclideant distance between the 2 DMUs, the more similar the DMUs are. The following is the result of forming a peer group using SPSS software.

Tabel 1: Hasil Peer Group 2018.

| Proximity Matrix | | | | | |
|---|---|---|---|---|---|
| | Squared Euclidean Distance | | | | |
| Case | 1 | 2 | 3 | 4 | 5 |
| 1 | ,000 | | ,000 | ,884 | ,299 |
| 2 | ,228 | ,000 | ,228 | ,251 | ,026 |
| 3 | ,000 | ,228 | ,000 | ,884 | ,299 |
| 4 | ,884 | ,251 | ,884 | ,000 | ,154 |
| 5 | ,299 | ,026 | ,299 | ,154 | ,000 |
| This is a dissimilarity matrix | | | | | |

The table shows that DMU 1 has the smallest proximity value to DMU 2 of 228. In DMU 2 it has the closest distance to DMU 3 of 228. Meanwhile, DMU 4 has the smallest proximity value to DMU 5 of 154. At DMU 5 has the smallest closeness value with DMU 2 of 026.

DMUs that have an inefficient score can be considered efficient DMUs, as improvements can be made to one or more DMUs with the help of a peer group. Peer groups can be done using SPSS software using the Hierarchial Cluster Analysis method, namely by looking at the closest squared Euclidean distance between DMUs. Where closeness is done to provide a reference for an inefficient DMU to an efficient DMU.

The results of the SPSS software discuss the value of Squared Euclidean Distance, where the smallest value is between the Triya Weaving Unit and the Era Weaving Unit, which is .026, while the largest value is between the Dewi Weaving Unit, Riza Weaving Unit and Siti Weaving Unit, which is .884.

In 2018, the dual DMU CRS model, which has an inefficient value, is the Era Weaving Unit, Siti Weaving Unit, and Triya Weaving Unit. The DMU VRS model is only inefficient for the Era Weaving Unit. Therefore the Era Weaving Unit becomes an inefficient DMU based on the 2 models CRS dual and VRS. At DMU Era, the variable that experienced target improvement was y1 from a value of 21600 to 21618.000133 with an improvement of 0.083% and the x3 variable from a value of 5000 to 3604.124959 with an improvement of 27.91%. Meanwhile, based on DMU Era's VRS calculations, there were 2 variables that experienced target improvements, namely the number of products from 21600 to 21618.000107 with an improvement of 0.083% and the raw material cost variable from 5000 to 4540.749959 with an improvement of 9.1%.

Sensitivity analysis is conducted to observe changes in efficiency that occur after targeted improvements are made. The optimization reference is obtained from the dual price value, as the given limiting function will bind the target function.

The results of calculations from the dual CRS and VRS models will be subjected to sensitivity analysis to find out which model will be used as a reference in increasing efficiency based on target improvements. In 2018 based on CRS Dual calculations, the Era Weaving Unit has 2 variables that are not optimal, namely the output variable y1 (number of products) and the input variable x3 (raw material costs). Based on the results of calculations using LINDO software, the variable y1 has a dual price value of -0.000100, while the variable x3 has a dual price value of 0.000141. This means that the variable y1 will increase the efficiency of the Era Weaving Unit by 0.0018000133 so that it will change the efficiency value at DMU 2 Era by 0.7226250132. The variable x3 will increase the efficiency of the Era Weaving Unit by 0.1968183808, thereby changing the efficiency value of the Era Weaving Unit by 0.9176433807.

Based on the calculations on the VRS model, the Era Weaving Unit has 2 variables that are not optimal, namely the output variable y1 (number of products) and the input variable x3 (raw material costs). Calculations from the LINDO software produce a dual price value for variable y1 (output) of -0.000100, while for variable x3 it is 0.000141. This means that the variable y1 will increase the efficiency of the DMU by 0.0018000107, which will also increase the efficiency of the Era Weaving Unit by 0.9063499893.

The variable x3 will increase the efficiency of the Era Weaving Unit by 0.0647542558, which will change the efficiency value of DMU 2 by 0.9693042344. Based on the results of the sensitivity analysis, it can be seen that the repair value has not reached its optimal value. The two results indicate that the improvement will be attributed to the VRS model due to its higher efficiency value than the CRS dual efficiency value.

### 4.3 The Right Strategy in Increasing Efficiency?

Based on the results of the calculations that the researcher has performed, the solutions that will be provided only refer to DMUs that have non-optimal or inefficient efficiency values. In 2018, the CRS Dual model has 3 inefficient DMUs, namely the Era, Siti and Triya Weaving Units. Whereas in the DMU VRS model, only the Era Weaving Unit has non-optimal values. The improvements made are 2 solutions, namely by using the CRS Dual or VRS model. Referring to the results of the sensitivity analysis, it was found that VRS's improvement is better than CRS Dual, so the solution to be given should be based on the VRS model. In the calculation of the VRS model, there is an Era Weaving Unit DMU which has a non-optimal value. The Era Weaving Unit's efficiency values are influenced by two variables: y1 (number of products) and x3 (raw material costs). The improvement solution required is for variables y1 (number of products) and x3 (raw material costs). The increase in target improvements from DMU 2 or Era Weaving Units also takes into account the results of peer groups as shown in table 4.27 which shows that Era Weaving Units can perform benchmarking referring to DMUs with the lowest and closest value, namely DMU 1 or Dewi Weaving Unit and DMU 3 or Unit Riza Weaving. In the Era Weaving Unit there are 18 products while in the Dewi Weaving Unit there are 25, therefore DMU Era can refer to DMU Dewi or DMU Riza by increasing sales results in order to increase the value of variable y1 (number of products). Increasing sales can be done by promoting or cooperating with other companies. The raw material costs of the Era Weaving Unit will be raised by 9.1% in relation to the Dewi Weaving Unit. The Dewi Weaving Unit's raw materials cost is the lowest among all DMUs. Therefore, by referring to the Dewi Weaving Unit, the cost of raw materials in the Era Weaving Unit can make improvements by minimizing the use of raw material costs and planning raw material requirements by analyzing records of weaving sales which have not previously been carried out by the Era Weaving Unit.

## 5 CONCLUSIONS

From the results of the study it can be concluded as follows:

1. The results of measuring the efficiency of the weaving production process in Tanjung Modang using Data Envelopment Analysis in 2018 show that the Era Weaving Unit is a DMU that has an inefficient value with an efficiency value of 0.9081500. In 2019 it shows that the Siti Weaving Unit is a DMU that has an inefficient value with a value of 0.8602850. In 2020 it shows that the Siti Weaving Unit and the Triya Weaving Unit have an inefficient value. In 2021 it shows that the Era Weaving Unit, Siti Weaving Unit and Triya Weaving Unit are DMUs that have an inefficient value with values of 0.9250975, 0.8895 and 0.999.
2. The 2018 improvement target for the Era Weaving Unit is because the value obtained is <1 with the variables that are the target for improvement, namely Y1 (number of products) and X3 (raw material costs). In 2019, after improvements were made to the VRS model, the Siti Weaving Unit, which was previously inefficient, became efficient. In 2020, after improvements were made with the VRS DMU model, which was previously inefficient, it will become efficient. The target for improvement in 2021 for the Era Weaving Unit and Siti Weaving Unit is because the values obtained are <1 with the variables that are the target of improvement, namely Y1 (number of products) and X3 (raw material costs). The Triya Weaving Unit is the optimal DMU after target improvement on y1 and x3.
3. Based on the results of data processing and analysis carried out in 2018 and 2021. The Era Weaving Unit, Siti Weaving Unit and Triya Weaving Unit refer to the calculation of the VRS model. In the input variable that does not yet have an optimal value, namely the variable amount of raw material costs so that the three DMUs can make improvements by minimizing use of raw material costs and planning raw material requirements by analyzing records of weaving sales that had not previously been carried out. The output variable that is not optimal is the number of products so that improvements can be made by increasing resources, expanding marketing and promoting from various social media platforms.

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