



Analysis Of Technical Efficiency Of Soybean Farming

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Abstract

One of the most widely cultivated agricultural sub-sectors cultivated by farmers in Indonesia is the food crop sub-sector. Based on the topography of tidal swamp land, there are four types of land, namely Type A, B, C, and D. Type C land has the potential to be improved in its land use. One of the most widely cultivated food crop commodities in Indonesia is soybean. One way to cultivate soybeans is by optimizing the land, especially tidal land. Based on the topography of tidal swamp land, there are four types of land, namely Type A, B, C, and D. Type B land has the potential to be improved in its land use. Therefore, it is necessary to analyze the technical efficiency of farming in tidal marshland, especially in Type Bland. This research was conducted with the objectives of: 1) Analyzing the level of technical efficiency of soybean farming in Rantau Rasau sub-district, East Tanjung Jabung Regency, 2) Analyzing the level of technical efficiency of soybean farming in Rantau Rasau sub-district, East Tanjung Jabung Regency, 3) Analyzing the influence of age, education, experience, number of family members and extension workers on the technical inefficiency of soybean farming in Rantau Rasau sub-district, East Tanjung Jabung Regency. The analytical tool used is the analysis of the Stochastic Frontier production function with Cobb-Douglass and calculates the level of efficiency and inefficiency. This research was conducted in the Rantau Rasau sub-district, East Tanjung Jabung Regency. The sampling technique was the census method with a sample of 42 farmers. The data used were secondary and primary. The results showed that: 1) The condition of the land in the study area is tidal land with an average production of 1,039 Kg. 2) The use of production inputs in the study area was technically efficient reaching 0.751. 3) Simultaneously and partially age, education, experience, number of family members and counselling have no significant effect on production.

Keywords: Soybean farming, technical efficiency, technical inefficiency

A. Introduction

Indonesia is a tropical country with vast land and abundant biodiversity. The agricultural sector is one of the main pillars supporting the national economy, this is because the agricultural sector is the livelihood of most Indonesians. One of the most widely cultivated agricultural sub-sectors cultivated by farmers in Indonesia is the food crop sub-sector. One of the food crop commodities that are widely cultivated by farmers in Indonesia is the soybean commodity.

Jambi Province is one of the regions that takes part in the development of increasing soybean production in Indonesia by implementing several programs such as the integrated approach program (PPT). According to data from the Jambi Province Office of Food Crops, Horticulture and Animal Husbandry, it is known that soybean productivity in Jambi Province has fluctuated within the period 2017-2021 along with fluctuations in production and harvest areas. In 2020 there was an increase in harvest area of 32.42% with production of 42.43%. In 2021, there was a significant decrease in the harvest area of 60% with a production of 30.58%.

One of the areas in Jambi Province that cultivates a lot of soybean crops is East Tanjung Jabung Regency. The land condition for soybean cultivation in East Tanjung Jabung Regency is B-type tidal land. According to data from the Food Crops, Horticulture and Livestock Service Office of Tanjung Jabung Regency, Rantau Rasau sub-district is one of the sub-districts with the largest production and harvest area in 2021 compared to other sub-districts followed by Berbak sub-district, where the production was 218 tons and the harvest area was 113 ha. This shows that the Rantau Rasau sub-district has the potential to conduct soybean farming.

Rantau Rasau sub-district is one of the largest soybean cultivation areas in East Tanjung Jabung Regency. Based on the data we obtained from the Agricultural Extension Agency of Rantau Rasau sub-district (BPP) the production, productivity, and soybean land area in 2017-2021 fluctuated. In 2020 there was an increase in the harvest area of 35.39%, namely 226 ha, while in 2021 there was a 100% decrease in the harvest area, namely 113 ha. In the same period in 2020 and 2021, there was an increase and decrease in production by 50.58% and 24.4%, respectively. Based on the initial survey obtained from Agricultural Extension information, the topographic condition of land for soybean farming in the Rantau Rasau sub-district is Type B land. Type B land is wetland but has a dry period so it can be planted with rice and secondary crops. Despite the tidal land condition, the Rantau Rasau sub-district can become the sub-district with the largest soybean production contribution in East Tanjung Jabung Regency. The management of soybean land that is included in the tidal type is technically necessary to achieve efficient production in producing physically better output.

Based on the description above, the problem formulations that will be studied in this study are: 1). Knowing the general description of soybean farming in Rantau Rasau District, East Tanjung Jabung Regency. 2). Analyzing the level of technical efficiency of soybean farming in Rantau Rasau sub-district, East Tanjung Jabung Regency. 3). To analyze the influence of age, education, experience, and the number of family members and extension workers on the technical inefficiency of soybean farming in Rantau Rasau sub-district, East Tanjung Jabung Regency.

B. Methodology

This research was conducted in Rantau Rasau Sub-district, East Tanjung Jabung Regency. The selection of locations was done purposively, namely Bandar Jaya and Marga Mulya villages with the consideration that the area conducts soybean farming and by the research principles. The sample in this study was farmers who cultivated soybean farming. This research was conducted in August-September 2023. The sampling method used in this research is the census method with a total sample of 42 people. The data sources used in this research are primary data obtained through interviews using a list of questions (questionnaires) and secondary data using related literature such as research journals, and related agencies related to the research title. The analysis method used in this research is the analysis of technical efficiency with Frontier regression. Measuring and assessing the level of technical efficiency using the frontier regression formula as follows:

$$\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + V_i - U_i$$

Description:

Y Soybean Production (Tons)

X_1: Land area (Ha)

X_2: Seed (Kg)

X_3: Urea fertilizer (Kg)

X_4: NPK fertilizer (Kg)

X_5 Organic Fertilizer (Ltr)

X_6: Labor (HOK)

β_0 : Constant

$\beta_1 \dots \beta_6$: Elasticity of production input effect on production (E_{xi}/Y_i) V_i : Random error
 U_i Variables that are assumed to be caused by technical inefficiency in the product

Furthermore, according to Pakasi et al, (2011), the method of estimating the stochastic frontier model is carried out in two stages, namely the first stage with the Ordinary Least Square (OLS) method to estimate technology parameters and production inputs. The second stage uses the Maximum Likelihood Estimation (MLE) method to estimate the overall parameters of production factors and the variance of the two error components v_i and u_i . MLE parameters are used to describe the relationship between the maximum production that can be achieved using the available factors of production.

As stated by Nurdiani and Prasetyo (2023) the level of technical efficiency of farming can be measured using the following formula:

$$TE_i = \frac{Y}{Y^*} = \frac{E(Y_i|U_i, X_i)}{E(Y_i|U_i = 0, X_i)} = E[\exp(-U_i)/\varepsilon_i]$$

Description:

TE_i = technical efficiency of farmer i

y_i = actual production from observation

Y_i^* = estimated frontier production obtained from the stochastic frontier production function

Where $0 \leq TE_i \leq 1$

If the value of TE is closer to 1 then the farm can be said to be more technically efficient and if the value of TE is closer to 0 then the farm can be said to be more technically inefficient. To answer the third objective, namely to determine the factors that affect the technical efficiency of soybean farming in the Rantau Rasau sub-district, East Tanjung Jabung Regency, the Maximum Likelihood Estimation (MLE) method was used with the following technical efficiency effect model:

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5$$

where :

u_i = Technical Inefficiency Effect,

δ_0 = Constant,

Z_1 = Farmer Age (Years)

Z_2 = Farmer Education (Years)

Z_3 = Farming Experience (Years)

Z_4 = Number of Family Members (Person)

Z_5 = Dummy for participation in extension activities

$D = 1$; if attending counseling

$D = 0$; does not participate in counseling

C. Findings and Discussion

Production Function Analysis of Soybean Farming

Estimation of technical efficiency can be done by estimating MLE parameters, Estimation of technical efficiency is based on the productivity function of the use of production inputs (Nainggolan S, et al. 2017). The estimation of the MLE production function in the research area can be seen in Table 1.

Table 1. Estimation of Soybean Farming Production Function in the Research Area with the MLE Method in 2023

Variable	Parameter	Coefficient	T-Count
Constant	β_0	5,445	6,649
Seed	β_2	0,065	0,228ns
Urea Fertilizer	β_3	0,076	0,709ns
NPK Fertilizer	β_4	0,502	0,439ns
Organic Fertilizer	β_5	0,048	2,435**
Labour	β_6	0,015	2,130**
Sigma-Squared		0,004	
ΣBi		0,706	
Log-Likelihood Function OLS		53,39	
R ²		0,666	
Tabel α (0.01), df: 30	= 2,750		
Tabel α (0.05), df : 30	= 2,045		
Tabel α (0.10), df : 30	= 1,699		

Source: Frontier Processed Results, (2023)

Notes = *** (significant at 1%)

** (significant at 5%)

* (significant at 10%)

ns (not significant)

Table 1. is the result of processed data using the Frontier 4.1 application used for the use of productivity functions with the Maximum Likelihood Estimation (MLE) method. The table shows the R² value of 0.666, which means that the analysis results obtained the Adjusted R-Square value is 0.666. This shows that the variables of Seed (X1), Urea Fertilizer (X2), NPK Fertilizer (X4), Organic fertilizer (X4), and Labor (X5) together can explain the production of soybean farms by 66.6% while the remaining 33.4% is influenced by other factors outside the model. Based on the estimation results of the Soybean Farm production function with OLS, the Soybean production function model is as follows:

$$\ln Y = 5.445 + 0.065 \ln X_1 + 0.076 \ln X_2 + 0.502 \ln X_3 + 0.048 \ln X_4 + 0.015 \ln X_5 \quad (0.01 - 0.99)$$

The next step is to estimate the production function using OLS. The estimation of the production function using OLS is intended to measure the production response to changes in the use of production inputs (Nainggolan S, et al. 2018). The estimation of the production function of soybean farming in the research area using the OLS method in 2023 can be seen in Table 2.

Table 2. Estimation of Soybean Farming Production Function in the Research Area with OLS Method in 2023

Variable	Parameter	Coefficient	T-Count
Constant	β_0	5,580	6,130
Land Area	β_1	0,036	1,794*
Seed	β_2	0,143	2,058**
Urea Fertilizer	β_3	-0,120	-0,313ns
NPK Fertilizer	β_4	0,004	0,069ns
Organic Fertilizer	β_5	0,801	2,106**
Labour	β_6	0,056	2,644**
Sigma-Squared	0,005		2,012
Gamma	0,999		13,833
$\Sigma\beta_i$	0,920		
Log-Likelihood Function OLS	53,39		
R ²	0,666		
-Tabel α (0.01), df: 30	= 2,750		
-Tabel α (0.05), df: 30	= 2,045		
-Tabel α (0.10), df: 30	= 1,699		

Source: Frontier Processed Results, (2023)

Notes = *** (significant at 1%)

** (significant at 5%)

* (significant at 10%)

ns (not significant)

Table 2 is the result of processed data using the Frontier 4.1 application used for the use of the production function with the Ordinary Least Squares (OLS) method. The table shows the R² value of 0.666, which means that the independent variables (Land Area, Seed, Fertilizer, Organic Fertilizer, and Labor) together can explain the dependent variable (productivity) by 66.6%, while the remaining 33.4% is determined by other factors outside the model.

The value of $\Sigma\beta_i = 0.920 < 1$, meaning that the use of production factors in the study area is in region II of the production curve or the Decreasing Return to Scale area, which means that each addition of the same proportion of production inputs will result in a decreasing increase in output. It can be said that the addition of production inputs in the same proportion of 1% will result in a decreasing increase in output of 0.920. The input variables used in farming will be analyzed in the frontier productivity function model. The results of the frontier productivity function estimation with the following equation:

$$\ln Y = 5,580 + 0,036 \ln X_1 + 0,143 \ln X_2 - 0,120 \ln X_3 + 0,004 \ln X_4 + 0,801 \ln X_5 + 0,056 \ln X_6 \quad (0,01 - 0,99)$$

The effect of the use of production factors on soybean production partially can be seen from the t-ratio value of each independent variable. It can be seen that the variable production factors of NPK fertilizer and urea fertilizer have no significant effect on soybean production. While the production factors of land area, seed, organic fertilizer and labour partially have a significant effect on soybean production and it can also be seen that the parameter u_i is 0,99 and the variable v_i is 0,01 on soybean production in the study area. The effect of each independent variable on the dependent variable in detail can be seen in the description below.

1. Effect of Land Area (X₁) on Production. The results of the analysis in Table 2 show that the elasticity value of land area is positive, namely $\beta_1 = 0,036$ and has a real effect on production, this can be seen from the t-count value of 1,794 > t-table- $\alpha(0,10)$ meaning that the land area variable is one of the factors affecting soybean productivity in the study area. This means

that every 1% increase in the production factor of land area will increase production by 0,036 units. The results of this study are by research conducted by Putri et al. (2015) where the results of their research say that land area has a real and positive effect on soybean production, where each additional land area of 1% will increase soybean production by 0,306%.

2. Effect of Seed (X2) on Production. The results of the analysis in Table 2 show that the elasticity value of the seed is positive, namely $\beta_2 = 0,143$ and has a real effect on production, this can be seen from the t-count value of $2,058 > t\text{-table-} \alpha (0,05)$, meaning that the seed variable has a real effect on soybean production in the study area. The seed production factor is significant at 5% alpha. This means that if all production factors are considered constant then each addition of the seed production factor by 1%, will increase production by 0,143 units. This is to the research of Irsyadi (2011) in Putri et al. (2015) said that seeds have a real and significant effect on soybean production.
3. Effect of Urea Fertilizer (X3) on Production. The results of the analysis in Table 2 show that the elasticity value of urea fertilizer is negative, namely $\beta_4 = -0,120$, and when viewed from the correlation of the table value and the calculated value of the fertilizer variable has no real effect on soybean production in the study area, this is evidenced by the value of the t-count value of $-0,313 < t\text{-table}$. From the results of the analysis, it can be said that the fertilizer variable is not one of the factors affecting soybean production in the Rantau Rasau Subdistrict.

With the assumption that other variables remain (*ceteris paribus*), it can be concluded that every 1% increase in Urea fertilizer production input will result in a decrease in production by 0,120. This is different from the research of Suminartika E, et al. (2019) which says that urea fertilizer significantly affects (at a real level of 1 per cent) soybean production, an increase in the use of urea fertilizer by 1per cent will increase soybean production by 0.554 per cent. This is because the use of urea fertilizer is still below the recommended dose.

4. Effect of NPK Fertilizer (X4) on Production. The results of the analysis in Table 2 show that the elasticity value of urea fertilizer is positive, namely $\beta_4 = 0,004$, and when viewed from the correlation of the table value and the calculated value of the NPK fertilizer variable has no real effect on soybean production in the study area, this is evidenced by the value of the t-count value of $0.069 < t\text{-table}$. From the results of the analysis, it can be said that the NPK fertilizer variable is not one of the factors affecting soybean production in the Rantau Rasau Sub-district.

With the assumption that other variables remain (*ceteris paribus*), it can be concluded that every 1% addition of Urea fertilizer production input will have an impact on increasing production by 0.004 units. However, this contradicts the research of Budiarto E, et al. (2020) said that the use of NPK fertilizer is positive and has a real effect on production. The NPK variable has a parameter coefficient value of 0.0770 which means that if the amount of NPK used increases by 1 percent, soybean farming production will increase by 0.0770 percent assuming other production input variables remain. This NPK variable has a probability value of 0.0380 smaller than the real level of 0.05, meaning that the NPK variable has a very real effect on soybean farm production in the study area.

5. Effect of Organic Fertilizer (X5) on Production. The results of the analysis in Table 2 show that the elasticity value of organic fertilizer is positive, namely $\beta_5 = 0,801$ and when viewed from the correlation of the table value and the calculated value of the organic fertilizer variable has a real effect on soybean production in the study area, this is evidenced by the t-count value of $2.016 > t\text{-table} \alpha (0.10)$. This means that every 1% addition of organic fertilizer with the assumption of *Cateris Paribus* will increase production by 0.801 units. From the results of the analysis, it can be said that the organic fertilizer variable is one of

the factors affecting soybean production in the Rantau Rasau District. Consistent with the research of Amara et al. (2020) the use of organic fertilizer is positive and significant to production. The elasticity value of organic fertilisers is 0.0713, this indicates that the addition of organic fertilizer by 1% of paddy rice production will increase by 0,0713.

6. Effect of Labor (X6) on Production. The results of the analysis in Table 2 show that the elasticity value of Labor is positive, namely $\beta_6 = 0,056$ and has a real effect on production, this can be seen from the t-count value of $2.644 > t\text{-table}\alpha(0.05)$. This means that every 1% increase in labour will increase output by 0,056 units, indicating that the Labor variable affects soybean production in the study area. The results of this study are in line with the research of Nurdiani and Prasetyo (2023) said that the labour variable has a real and positive effect on soybean production. The coefficient value of labour is 0,0116, this indicates that every additional one per cent of labour will increase soybean production by 0,0116 per cent.

Technical Efficiency Analysis of Soybean Farming

Technical efficiency describes the ability of a farm to obtain maximum output from a certain amount of input use. A farm is said to be technically efficient if the efficiency index value is ≥ 0.7 (Nainggolan S., & Yanuar Fitri 2024). The MLE method describes the best practice performance of farmers at the existing technology level.

Table 3. Technical Efficiency of Soybean Farming in the Research Area Year 2023

Technical Efficiency	Frequency (Person)	Per cent (%)
0,586-0,648	6	14
0,649-0,729	9	21
0,730-0,81	15	36
0,811-0,891	12	29
0,892-0,972	0	0
0,973-1,053	0	0
Total	42	100
Lowest Score	0,586	
Highest Score	0,885	
Average	0,751	

Source: Frontier Processed Results, (2023)

Based on Table 3, it can be seen that all soybean farmers in the study area are technically efficient. This can be seen with the range of technical efficiency from 0.586 to the highest value of 0.885 with an average technical efficiency achieved by soybean farmers of 0.751. This shows that the average productivity achieved by farmers in the study area is 75.1%. This means that soybean farmers are quite efficient but there is still an opportunity of 24.9% to achieve maximum production.

Effect of Socioeconomic Factors on Technical Inefficiency of Soybean Farming

Based on the results of Table 3, it is explained that the technical efficiency result is 0.751. It can be said that the problems caused by technical inefficiency in soybean production in the research area are only about 24.9% of the problems caused by inefficiency factors. One factor that influences technical inefficiency is the socioeconomic factors of farmers.

Table 4. Results of Regression Analysis of Factors Affecting Technical Efficiency in Soybean Farming 2023

Variable	Parameter	Coefficient	T-Count
Constant	Delta 0	-0,150	-0.156
Age	Delta 1	0,098	0,434ns
Education	Delta 2	0,039	0,405ns
Experience	Delta 3	-0,005	-0,087, ns
Number of Families Members	Delta 4	-0,015	-1,61ns
Extension	Delta 5	-0,063	-1,62ns
Sigma-Squared	0,003	1,626	
Gamma	0.745	3,197	
LR Test Of The One-Sided Error Log-Likelihood Function MLE Log-Likelihood Function OLS R2	= 0,666	19,56 70,42 53,39	
T-Table α (0.01), df: 30	= 2,750		
T-Table α (0.05), df : 30	= 2,045		
T-Table α (0.10), df : 30	= 1,699		

Source: Frontier Processed Results, (2023)

Notes = *** (significant at 1%)

** (significant at 5%)

* (significant at 10%)

ns (not significant)

Based on the information in Table 4, it is explained that there are no variables that have a real and significant effect or a real effect on the inefficiency of soybean production techniques. According to Putri et al. (2015), a negative sign on the technical inefficiency parameter in the processing results of the frontier 4.1 software indicates that the variable decreases technical inefficiency or increases technical efficiency and conversely a positive sign indicates that an increase in the variable will increase technical inefficiency or decrease technical efficiency. The following is the estimation or estimation of the sources of technical inefficiency in soybean production in the study area as follows:

1. Farmer Age. The results of the analysis in Table 4 show that the elasticity value of farmer age is positive at $\delta_1 = 0.098$, and has no significant effect on technical efficiency where the t-count value is $0.434 < t$ -table. This shows that the increasing age of farmers will increase inefficiency, but it is not significant to production. This is because as the age of farmers increases, farmers try to improve their skills and knowledge, but tend not to want to bear greater risks. This is in line with the research of Putri et al. (2015) which said that the age of farmers is positively correlated and has no significant effect on the level of technical inefficiency of soybean farming.
2. Farmer Education. The results of the analysis in Table 4 show that the elasticity value of farmer education is positive at $\delta_2 = 0.039$, meaning that any increase in farmer education will increase inefficiency or decrease technical efficiency. When viewed from the correlation with the t-count, where the t-count value of $0.405 < t$ -table, it means that the formal education of farmers has no significant effect on soybean production in Rantau Rasau District. The condition of education has no real effect on soybean farming in the research area because the level of education of farmers tends to be the same, namely elementary school graduates. In addition, soybean farming activities do not use difficult or modern

equipment or technology so it is suspected that the education variable does not affect soybean farming activities. This is in line with the research of Kebede (2001) in Putri et al (2015) who found that education has a positive effect on the technical efficiency of rice farmers. However, it is different from the research of Amara et al. (2020) who said that the level of education of farmers was negatively correlated at -0.0079 and was significantly affected by the $\alpha = 1\%$ level. This means that an increase in formal education of farmers will reduce the effect of technical inefficiency in farming. So, the higher the formal education of farmers will increase technical efficiency in rice production.

3. Experience. The results of the analysis in Table 4 show that the elasticity value of the Experience variable is negative at $\delta_3 = 0.005$, and this variable is not significant or has no real effect on the effect of technical inefficiency. This can be seen in the t-count value, where the t-count is $0.008 < t\text{-table}$. This can occur because the condition of soybean cultivation in the study area is a tidal area that makes farmers make innovations to continue to survive in these conditions. Long farmer experience will certainly increase efficiency even though it is not significant because farmers with several years of experience still tend to use the same method. This is consistent with research conducted by Putri et al. (2015) which said that experience is negatively correlated and has no significant effect on the technical inefficiency of soybean farming. This condition is by the initial assumption, that the experience variable will reduce the level of technical inefficiency of soybean farming. The longer the experience of farmers in soybean farming, the lower the technical inefficiency and the higher the efficiency of soybean farming.
4. Number of Family Members. The results of the analysis in Table 4 show that the elasticity value of the variable number of family members is negative at $\delta_4 = -0.159$, but this variable is not significant or has no real effect on the effect of technical inefficiency. This can be seen in the t-count value, where the t-count is $1.618 < t\text{-table}$. It means that the variable of the number of family members resulted in a decrease in inefficiency or an increased level of technical efficiency. The result of this study is in line with the research of Ismail et al. (2017) where it was explained that the variable number of family members (Z4) in soybean farming had a negative but not significant effect on technical inefficiency. This means that the greater number of family dependents of farmers will further reduce the technical inefficiency of soybean farming in Pidie Jaya Regency.
5. Extension. The results of the analysis in Table 4 show that the elasticity value of the extension variable is negative at $\delta_5 = 0.063$, but this variable is not significant or has no real effect on the effect of technical inefficiency. This can be seen in the t-count value, where the t-count is $1.622 < t\text{-table}$. This means that the addition of extension variables resulted in a decrease in inefficiency or an increase in the level of technical efficiency. This is different from the wording of the hypothesis where any addition of extension activity will increase inefficiency. This can occur because the extension program followed by farmers is quite effective and significant to the soybean farming of respondent farmers, this is also supported by the distribution of sufficient extension workers in each research village. The results of this study differ from the research of Putri et al. (2015) where it is explained that extension is positively correlated and has no significant effect on the technical inefficiency of soybean farming. This condition is also not by expectations, where the more often the respondent farmers follow the counselling, the more inefficiency will also increase.

D. Conclusion

Research on Technical Efficiency Analysis of Soybean Farming in Rantau Rasau Sub-district, East Tanjung Jabung Regency concluded: (1) that tidal land conditions have an impact on the disruption of soybean farming production in the study area. Farmers have done several ways, but

have not been able to stem the volume of water that inundates the land when the tide occurs. The productivity or average production produced by farmers in the study area is 1,039 kg/ha (2) farming in the study area is technically efficient with an efficiency of 0.751 or 24.9%. (3) Socioeconomic factors such as age, education, experience, number of family members and counselling simultaneously and partially do not significantly affect soybean production.

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