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# Panel Data Analysis on Rice (Paddy) Production in Indonesia 2018-2021

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**Abstract**

Rice is the staple food of Indonesian society. Rice (Paddy) as a staple food for Indonesian people is an important commodity for the government in effort to maintain national food security. Food security can be fulfilled if a country has sovereignty over food. Food sovereignty can be realized if domestic production meet its people consumption needs. Therefore, this research pays attention to government policies in effort to increase rice (paddy) production optimally. The policies analyzed included the realization of subsidized fertilizer distribution, the realization of insurance for rice farming, the realization of activities for developing agricultural irrigation units, and farmer exchange rates. Analysis was performed using panel data regression. From this research, it can be concluded that the distribution of subsidized fertilizers, the development of agricultural irrigation units, and the availability of farmer financing in the agricultural financing index positively affect the increase in domestic rice production. Conversely, the occurrence of rice crop insurance claims indicates crop failure in a certain region. This disruption negatively impacts the quantity of domestic rice production. On the other hand, having agricultural insurance provides a guarantee of financing for farmers when they experience crop failure.

*Keywords:* Fixed Effect Model, Panel Data Analysis, Regression, Rice Productions,

## 1. Introduction

Rice production is a crucial factor in maintaining Indonesia's national food security. As a staple food for the society, rice assumes a strategic role in fulfilling the dietary needs of the population. Therefore, the Indonesian government has implemented various policies to optimize rice production. This research aims to analyze the relationship between rice production in Indonesia and several factors, including the realization of subsidized fertilizer distribution, the implementation of rice farmer insurance, the development of agricultural irrigation, and the farmer financing index. These government policies have a significant role in supporting efforts to increase rice production. Fertilizer subsidies enable farmers to obtain affordable fertilizers, which impact agricultural productivity positively (Hedley & Tabor, 1989). On the other hand, rice farmer insurance provides financial protection against the risk of losses that farmers may face due to natural disasters or other unforeseen factors (Dewi, Kusnandar & Rahayu, 2018). Agricultural irrigation development also contributes to increased rice production, as a well-functioning irrigation system ensures an adequate water supply for farming (Bhuiyan, 1992). Additionally, the farmer financing index influences the purchasing power of farmers in obtaining resources and agricultural Supplies (BPS, 2021). This research employs panel data analysis as the method to link these various factors with rice production in Indonesia. Panel data analysis allows the use of data across time and among individuals, providing a more comprehensive overview of the existing relationships. One of the models to be used in the analysis is the Fixed Effect Model, which enables the control of individual variability and separation of time-invariant effects.

## 2. Literature Review

Maryono (2014) in his article examines the government's policy to ensure that rice production meets domestic consumption needs. In his research, he analyzes the government's policy performance based on several determining factors, which underlie the concept of technical efficiency. Panel aggregate data on input-output rice production in 23 provinces during the period 1993-2013 were used to estimate frontier production functions. The research findings indicate that the variation in rice production across different regions of the country is primarily influenced by technical efficiency.

The sources of variation within technical efficiency include intensification, training programs, land fertility, and local culture. Among the regions studied, rice production in Bali has demonstrated the highest level of efficiency. However, overall, the efficiency of rice production remains low and has marginally decreased over time in all regions. As a result, the study concludes that there is significant potential for productivity improvement through increased efficiency.

To enhance rice production, the study suggests several key strategies. Providing training in relevant agricultural methods, developing wetlands, and improving irrigation infrastructure are identified as the most effective ways to increase rice production. This research highlights the importance of government policies in ensuring sustainable and efficient rice production to meet domestic consumption needs.

## 3. Materials and Methods

### 3.1 Materials

In this research, the collected data is analyzed using panel data regression which is based on the general multiple regression equation as follows (Basuki & Yuliadi, 2014):

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots. + \beta_k X_k + \varepsilon \quad (1)$$

The data used in this research explained as follows:
Dependent Variable: The dependent variable data used in this research is rice (paddy) production by province in Indonesia for the years 2018-2021. The rice production data from 2018 to 2021 were obtained from the Rice Land Area and Production Statistics of the Indonesian Central Statistics Agency (Badan Pusat Statistik Indonesia).
Independent Variables:
a. Realization of Subsidized Fertilizer Distribution: Subsidized fertilizer policy has been implemented since 2003 with the aim of alleviating the burden on farmers and ensuring the availability of fertilizer for agricultural activities. It is expected to improve productivity and agricultural commodity production to support national food security. This program is mandated through Law Number 15 of 2017 on the State Budget for Fiscal Year 2018 and Presidential Regulation Number 107 of 2017 on the Details of the State Budget for Fiscal Year 2018. The data on the distribution of subsidized fertilizers were obtained from the Annual Report of the Directorate General of Agricultural Infrastructure and Facilities of the Ministry of Agriculture of the Republic of Indonesia 2018-2021.
b. Agricultural Insurance: The agricultural sector has great potential to contribute to national development. To optimize this potential, financial support from various funding sources is needed to achieve targeted and sustainable agricultural development. One of the main issues faced by farmers is the difficulty in accessing financing sources and limited socio-economic institutions. The data on the agricultural onsurance were obtained from the Annual Report of the Directorate General of Agricultural Infrastructure and Facilities of the Ministry of Agriculture of the Republic of Indonesia 2018-2021.
c. Agricultural Irrigation Development: This includes the development of water sources through pumping and the construction of agricultural embung (small water reservoirs). Agricultural irrigation development is crucial to ensure water availability during the dry season, control floods and drainage, and improve agricultural productivity. The data on agricultural irrigation development were obtained from the Annual Report of the Directorate General of Agricultural Infrastructure and Facilities of the Ministry of Agriculture of the Republic of Indonesia 2018-2021.
d. Farmer Financing Index (IHPP): The Farmer Financing Index is an indicator that measures changes in financing costs or interest rates applied to credits or loans received by farmers. IHPP illustrates how financing costs for farmers change over time. The data on the farmer financing index were obtained from the Agricultural Commodity Price Statistics 2018-2021 of the Indonesian Central Statistics Agency (Badan Pusat Statistika).
The collected data was sorted by province and time series for 2018-2021, and then processed using E-Views 12.

### 3.2 Methods

Panel data is a combination of cross-sectional data and time series data, or a collection of cross-sectional data observed over time. There are several panel data regression models, one of which is the model with a constant slope and varying intercept. Panel regression models influenced by only one unit (cross-sectional unit or time unit) are called one-way component models, while panel regression models influenced by both units (cross-sectional unit and time unit) are called two-way component models (Gujarati, 2013). Generally, there are two approaches used in estimating panel data models: the model without individual effects (Common Effect) and the model with individual effects (Fixed Effect and Random Effect).

### 3.2.1 Regression Model

a. Common Effect Model is a model without individual effects or estimation that combines (pooled) all of time series and cross-sectional data and uses the Ordinary Least Squares (OLS) approach or the method of least squares to estimate its parameters. OLS is one of the popular methods for estimating parameter values in linear regression equations. Generally, the equation of the model is written as follows (Basuki & Yuliadi, 2014):

$$Y_{it} = \alpha + \beta X_{it} + \varepsilon_{it} \tag{2}$$

with,
$Y_{it}$ : Dependent variable for conservation unit i at time t,
$X_{it}$ : Independent variable for observation unit i at time t,
$\beta$ : Slope coefficient or direction coefficient,
$\alpha$ : Intercept of the regression model,
$\varepsilon_{it}$ : Error or residual for observation unit i at time -t.

b. Fixed Effect Model is a method of estimating panel regression parameters using the technique of adding dummy variables, which is often referred to as the Least Square Dummy Variable (LSDV) model. The Fixed Effect model assumes that the slope coefficients are constant, but the intercepts are not constant (Gujrati, 2013). The regression equation for the Fixed Effect model is written as follows (Basuki & Yuliadi, 2014).

$$Y_{it} = \alpha_1 + \sum_{K=2}^{N} a_K D_{ki} + \beta X_{it} + \varepsilon_{it} \tag{3}$$

with,
$Y_{it}$ : Dependent variable for conservation unit i at time t,
$X_{it}$ : Independent variable for observation unit i at time t,
$\beta$ : Slope coefficient or direction coefficient,
$\alpha$ : Intercept of the regression model,
$D_{ki}$ : Dummy variable for parameter k and conservation unit i
$\varepsilon_{it}$ : Error or residual for observation unit i at time -t.

c. Random Effect Model. As it is known, in the Fixed Effect model the individual and time characteristics are accommodated in the intercept, causing the intercept to vary over time. On the other hand, the Random Effect Model (REM) accommodates the differences in individual and time characteristics in the error term of the model. Since there are two components contributing to the formation of the error, namely individual and time, the random error in REM also needs to be decomposed into time-specific error and combined error. The advantage of using the Random Effect model over others is that it can eliminate heteroskedasticity. This model is also known as the Generalized Least Square (GLS) technique. The equation for the Random Effect model is written as follows (Basuki & Yuliadi, 2014):

$$Y_{it} = \alpha + \beta X_{it} + \mu_i + \varepsilon_{it} \tag{4}$$

with,
$Y_{it}$ : Dependent variable for conservation unit i at time t,
$X_{it}$ : Independent variable for observation unit i at time t,
$\beta$ : Slope coefficient or direction coefficient,
$\alpha$ : Intercept of the regression model,
$\mu_i$ : Error or residual for observation unit i,
$\varepsilon_{it}$ : Error or residual for observation unit i at time -t.

### 3.2.2 Selection Model

One of the objectives in regression analysis is to obtain the best model that explains the relationship between the independent variables and the dependent variable. The best model is the one where all regression coefficients are meaningful or significant (Basuki & Yuliadi, 2014).

a. Chow Test This is a test to compare the Common Effect model with the Fixed Effect model. The hypotheses in the Chow Test are as follows:
$H_0$ : Model Common Effect

$H_1$ : Model Fixed Effect
$H_0$ is rejected if *p-value* less than $\alpha$. Otherwise, $H_0$ is accepted if *p-value* greater than significant value $\alpha$.

b. Hausman Test is a test that compares the Fixed Effect model with the Random Effect model to determine the best model to be used as a panel data regression model. The hypotheses formulated in the Hausman Test are as follows:
$H_0$ : Model Random Effect
$H_1$ : Model Fixed Effect
$H_0$ is rejected if *p-value* less than $\alpha$. Otherwise, $H_0$ is accepted if *p-value* greater than significant value $\alpha$.

c. Lagrange Multiplier Test is a test that compares the Common Effect model with the Random Effect model to determine the best model to be used as a panel data regression model. The hypotheses formulated in the Lagrange Multiplier Test are as follows:
$H_0$ : Model Common Effect
$H_1$ : Model Random Effect
$H_0$ is rejected if *p-value* less than $\alpha$. Otherwise, $H_0$ is accepted if *p-value* greater than significant value $\alpha$.

### 3.2.3 Classical Assumption Tests

The classical assumption tests in multiple regression are the foundation of the classical regression method and are prerequisites that must be met for the results of the regression analysis to be considered valid and reliable. In panel data regression, the classical assumption tests include tests for multicollinearity and heteroskedasticity.

a. The normality test aims to examine whether the residuals in the panel data regression model follow a normal distribution or not. As it is known, a good regression model is one that has a normal or close-to-normal distribution. To detect whether the residuals are normally distributed or not, the Jarque-Bera test can be used in Eviews 12. If the Jarque-Bera probability value is less than the significance level α, then the normality assumption test is not satisfied. On the other hand, if the Jarque-Bera value is greater than the significance level α, then the data can be considered normally distributed (Basuki & Yuliadi, 2014).

b. Multicollinearity Test aims to examine whether there is a perfect or near-perfect relationship between independent variables, making it difficult to separate the individual effects of these variables on the dependent variable. This test is conducted to determine if there is no significant correlation among the independent variables in the regression equation. The Variance Inflation Factor (VIF) measures how much the variance of regression coefficients is inflated due to multicollinearity. If the VIF of a variable exceeds a certain threshold (>0.85), it may indicate the presence of multicollinearity (Gujarati, 2013).

c. Heteroskedasticity Test is a statistical test used in regression analysis to examine whether the variance of the errors (residuals) in the regression model changes systematically with changes in the values of the independent variable. If the heteroskedasticity test indicates the presence of heteroskedasticity, it means that the variance of the errors is not constant, and this can affect the validity of the regression analysis results. Glejser Test, this method involves regressing each independent variable individually against the errors (residuals) to evaluate whether there are any patterns or specific trends in the distribution of residuals (Gujarati, 2013).

d. The Individual Parameter Significance Test (t-test) is used to determine whether there is a significant influence of each independent variable individually on the dependent variable being tested at the 0.05 significance level. If the dependent variable being tested has a t-test probability value less than the significance level α, then that dependent variable has a significant influence on the independent variable in the regression model (Basuki & Yuliadi, 2014).

e. The Simultaneous Significance Test (F-test) is used to determine whether all independent variables included in the regression model have a simultaneous significant influence on the dependent variable being tested at the 0.05 significance level. If the probability value (F-statistic) is less than the significance value α, then the independent variables collectively have a significant influence on the dependent variable (Basuki & Yuliadi, 2014).

## 4. Results And Discussion

Based on the results of the regression model selection, the best model is the Fixed Effect Model, as indicated in Table 1 for the Chow Test, Table 2 for the Hausman Test, and Table 3 for the Lagrange Multiplier Test.

**Table 1** Chow Test result

Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section fixed effects

| Effects Test | Statistic | d.f. | Prob. |
|---|---|---|---|
| Cross-section F | 318.534662 | (33,98) | 0.0000 |

From Table 1, the results of the Chow Test, it is found that the probability value of Cross-section F is less than the significance level α (0.05). This indicates that the initial hypothesis that the best regression model is the Common Effect Model is rejected. The best regression model according to the Chow Test is the Fixed Effect Model.

**Table 2** Hausman Test result

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

| Test Summary | Chi-Sq. Statistic | Chi-Sq. d.f. | Prob. |
|---|---|---|---|
| Cross-section random | 158.308748 | 4 | 0.0000 |

From Table 2, the results of the Hausman Test, it is found that the probability value of Cross-section random is less than the significance level α (0.05). Therefore, the initial hypothesis stating that the best regression model is the Random Effect Model is rejected. The best regression model according to the Hausman Test is the Fixed Effect Model.

**Table 3** Lagrange Multiplier Test result

Lagrange Multiplier Tests for Random Effects
Null hypotheses: No effects
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives

| | Test Hypothesis | | |
|---|---|---|---|
| | Cross-section | Time | Both |
| Breusch-Pagan | 96.03895 | 0.088871 | 96.12782 |
| | (0.0000) | (0.7656) | (0.0000) |

From Table 3 the results of the Lagrange Multiplier Test, it is found that the probability value of Both Breusch-Pagan is less than the significance level α (0.05). Therefore, the initial hypothesis stating that the best regression model is the Common Effect Model is rejected. The best regression model according to Lagrange Multiplier Test is the Random Effect Model. Based on the results of the regression model testing, it can be concluded that the best regression model is the Fixed Effect Model.

**Table 4** Fixed Effect Model Regression

Dependent Variable: Y
Method: Panel EGLS (Cross-section weights)
Date: 08/01/23 Time: 05:12
Sample: 2018 2021
Periods included: 4
Cross-sections included: 34
Total panel (balanced) observations: 136
Linear estimation after one-step weighting matrix

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 1249459. | 77616.68 | 16.09782 | 0.0000 |
| X1 | 1.137445 | 0.333784 | 3.407729 | 0.0010 |
| X2 | -0.962070 | 0.355848 | -2.703599 | 0.0081 |
| X3 | 1108.543 | 321.4719 | 3.448336 | 0.0008 |
| X4 | 713.0382 | 192.0034 | 3.713675 | 0.0003 |

Effects Specification

Cross-section fixed (dummy variables)

Weighted Statistics

| | | | |
|---|---|---|---|
| Root MSE | 108707.6 | R-squared | 0.998160 |
| Mean dependent var | 2074435. | Adjusted R-squared | 0.997466 |
| S.D. dependent var | 1795309. | S.E. of regression | 128060.8 |
| Sum squared resid | 1.61E+12 | F-statistic | 1436.954 |
| Durbin-Watson stat | 2.315160 | Prob(F-statistic) | 0.000000 |

Unweighted Statistics

| | | | |
|---|---|---|---|
| R-squared | 0.997896 | Mean dependent var | 1638890. |
| Sum squared resid | 2.08E+12 | Durbin-Watson stat | 2.252860 |

Based on the regression model coefficients, the following equation represents the Fixed Effect Model regression model:

$$Y = 1249459 + 1.137445\, X_1 - 0.96207\, X_2 + 1108.543\, X_3 + 713.0382\, X_4 + \varepsilon_{it.} \quad (5)$$

The representation of the regression model explained as follows:

1) The obtained constant value (model intercept) is 1,249,459, which can be interpreted as: when all independent variables are set to zero, meaning that there is no subsidized fertilizer distribution, no agricultural insurance, no agricultural irrigation development, and farmer's price index remain zero, the constant production of rice will be 1,249,459 tons.
2) The regression for $X_1$ is $1.137445$ which can be interpreted as: when the subsidized fertilizer distribution in province i increases by 1 ton in year t, rice production will increase by 1.137445 tons.
3) The regression for $X_2$ is $-0.96207$ which can be interpreted as: when the number of agricultural insurance claims in province i in year t increases for 1 ha of land, rice production will decrease by 0.96207 tons.
4) The regression for $X_3$ is $1108.543$ which can be interpreted as: when the agricultural irrigation unit development is realized in province i in year t, rice production will increase by 1108.543 tons.
5) The regression for $X_4$ is $713.0382$ which can be interpreted as: when the farmer's price index, covering household consumption of farmers and the needs to support rice productivity in province i in year t, increases by 1 unit, rice production will increase by 713.0382 tons.
6) Based on the Adjusted R-Squared, the independent variables can explain 99.7% of the variation in the dependent variable, while the remaining 0.03% is explained by other factors as residual.

The classical assumption tests on the regression model given the result as follows:

Normality test

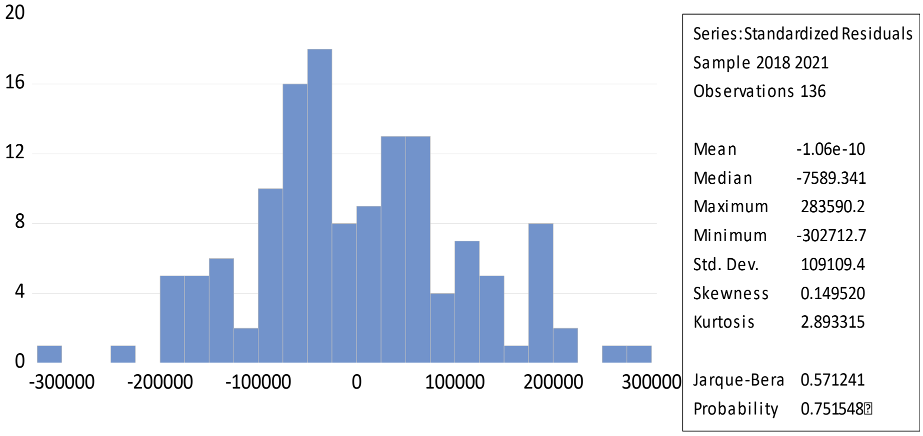


**Figure 1** The results of normality test

Based on the results of the Jarque-Bera normality test, it is found that the Jarque-Bera probability value is greater than the significance level α (0.05), which is the Jarque-Bera probability value 0.75 greater than 0.05 at significance level test. Therefore, it can be concluded that the data is normally distributed.

Multicollinearity test

**Table 5** The results of the multicollinearity test for independent variables

| | X1 | X2 | X3 | X4 |
|---|---|---|---|---|
| X1 | 1.000000 | 0.839841 | 0.760283 | 0.111510 |
| X2 | 0.839841 | 1.000000 | 0.532818 | 0.101706 |
| X3 | 0.760283 | 0.532818 | 1.000000 | 0.124979 |
| X4 | 0.111510 | 0.101706 | 0.124979 | 1.000000 |

From the Table 5, it can be observed that the correlation coefficients between $X_1, X_2, X_3$ and $X_4$ are less than 0.85 Therefore, it can be concluded that the tested variables are free from multicollinearity.

Heteroskedasticity Test

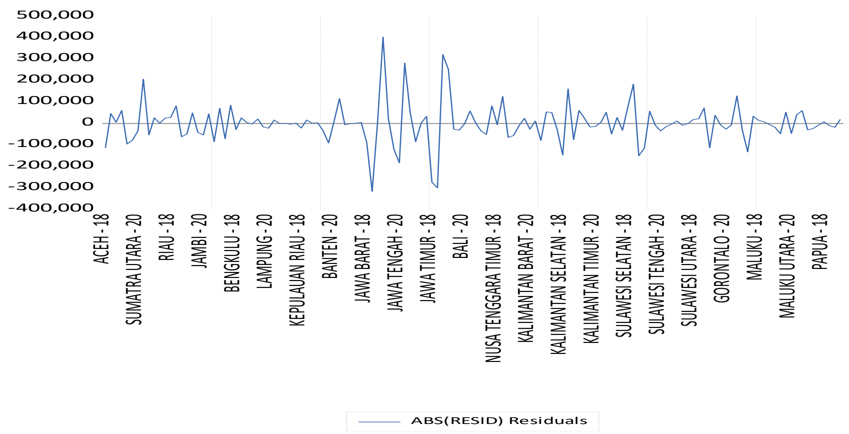

**Figure 2** The results of the heterooskedasticity test

Based on the blue-colored graph, it can be observed that the graph does not exceed the boundaries (-500 and 500), indicating constant residual variance (Napitupulu et al., 2021). Therefore, there is no evidence of heteroskedasticity.

The Individual Parameter Significance Test (t-test)

**Table 6** The results of individual parameter significance test

Dependent Variable: Y
Method: Panel EGLS (Cross-section weights)
Sample: 2018 2021
Periods included: 4
Cross-sections included: 34
Total panel (balanced) observations: 136

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 1249459. | 77616.68 | 16.09782 | 0.0000 |
| X1 | 1.137445 | 0.333784 | 3.407729 | 0.0010 |
| X2 | -0.962070 | 0.355848 | -2.703599 | 0.0081 |
| X3 | 1108.543 | 321.4719 | 3.448336 | 0.0008 |
| X4 | 713.0382 | 192.0034 | 3.713675 | 0.0003 |

From Table 6, on the t-test results, it can be observed that for each variable $X_1$, $X_2$, $X_3$, and $X_4$, the t-test probability value is less than α (0.05). Therefore, individually, all the dependent variables have a significant influence on the regression equation model.

The Simultaneous Significance Test (F-test)

**Table 7** The results of Simultaneous Significance Test

Cross-section fixed (dummy variables)

| Weighted Statistics | | | |
|---|---|---|---|
| Root MSE | 108707.6 | R-squared | 0.998160 |
| Mean dependent var | 2074435. | Adjusted R-squared | 0.997466 |
| S.D. dependent var | 1795309. | S.E. of regression | 128060.8 |
| Sum squared resid | 1.61E+12 | F-statistic | 1436.954 |
| Durbin-Watson stat | 2.315160 | Prob(F-statistic) | 0.000000 |

From Tabel 7, the simultaneous test results, it can be seen that the probability value (F-statistic) is 0.0000, which is less than the significance value α (0.05). Therefore, it can be concluded that all independent variables collectively have a significant influence on the dependent variable in the regression model.

## 5. Conclusion

Based on the conducted research, it can be concluded that the distribution of subsidized fertilizers, agricultural irrigation development activities, and the agricultural financing index have a positive impact on domestic rice production. This means that the increased distribution of subsidized fertilizers to farmers will enhance domestic rice production. The same applies to government-built irrigation units. The more agricultural irrigation units are constructed, the higher the level of rice production will be. Likewise, the agricultural financing index can indicate the farmers ability to obtain capital to fulfill their agricultural needs and financing. A higher agricultural financing index leads to increased domestic rice production. Conversely, the realization of rice crop insurance indicates claims due to failed harvests, which has a negative impact on domestic rice production. On the other hand, having agricultural insurance provides a guarantee of financing for farmers when they experience crop failure.

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