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Implementation of the Bisection Method to Determine the Year Predicted Open Unemployment Rate Will Reach 5% Based on Data for 2018 – 2024

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ABSTRACT

This study is motivated by the importance of predictive analysis of the open unemployment rate as an indicator of employment conditions. Most previous studies tend to focus on modeling without determining the time to achieve a certain value. Therefore, this study aims to predict the year when the TPT in Central Java Province will reach 5%, by applying a two-part method based on Microsoft Excel. The methodology used is a quantitative approach with a descriptive-analytical design. The data analyzed is secondary data on the TPT in Central Java Province for the period 2018–2024, sourced from the Central Statistics Agency. Data collection was carried out through documentary studies, while data analysis included descriptive analysis, polynomial regression modeling, and the iterative application of the bisection method using Microsoft Excel. The results showed that the second-order polynomial regression model successfully represented the data with a coefficient of determination of 0.629. The implementation of the bisection method produced an estimated root of 6.524713, in a stable and convergent iteration process until it reached a very small error. These findings indicate that the TPT is predicted to reach 5% between mid-2024 and early 2025. This study implies that the integration of regression and Excel-based numerical methods can be a systematic, practical, and easily replicable approach in the analysis of employment indicator predictions.

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1 INTRODUCTION

The open unemployment rate is a key indicator for evaluating the labor market conditions and economic development of a region. In Indonesia, the issue of unemployment remains a national concern, closely linked to economic growth, social stability, and public welfare [1]. Data from the Central Statistics Agency (BPS) over the past decade show significant fluctuations in the national Open Unemployment Rate, particularly following the COVID-19 pandemic, which has increased overall unemployment [2]. In Central Java Province, based on BPS data, the Open Unemployment Rate changed from 4.51% in 2018 to 4.44% in 2019, surged sharply to 6.48% in 2020, and then gradually declined to reach 4.78% in 2024 [3]. This phenomenon indicates labor market dynamics that require predictive analysis as a basis for more precise policy-making.

Various researchers have addressed the issue of unemployment forecasting using a variety of quantitative approaches. A study by [4] emphasizes the importance of historical data-based modeling in forecasting economic indicators, as it can systematically capture patterns of trends and fluctuations. Research by [5] shows that regression is one of the common approaches used in empirical economic analysis, capable of describing the relationship between variables quantitatively. In the context of nonlinear models, [6] explain that numerical methods such as the bisection method have advantages in terms of stability and ease of implementation when analytical solutions are not available. This perspective underscores the importance of integrating statistical and numerical methods in predictive economic analysis.

A number of previous studies have examined the prediction of unemployment rates using various methods. Some studies have found that polynomial regression is quite effective for modeling non-linear trends in economic data [4]. Additionally, other studies have used time-series approaches such as ARIMA to predict labor market indicators with good accuracy in the short term [4]. In Indonesia, several studies have utilized BPS data to analyze regional unemployment trends using descriptive statistics and regression approaches [7]. However, most of these studies focus more on building predictive models and do not sufficiently address the determination of specific solutions, such as when the unemployment rate reaches a certain value. This highlights a research gap regarding the use of numerical methods to obtain more practical quantitative solutions.

The novelty of this study lies in the combination of polynomial regression modeling with the numerical bisection method to determine when a labor market indicator reaches a specific value. Theoretically, the bisection method is based on the Intermediate Value Theorem, which states that if a continuous function on the interval [a, b] has values of opposite signs at its two endpoints, then there exists at least one root in that interval [6]. By integrating these two approaches, the study produces a quantitative solution that is not only predictive but also operational for estimating the time of reaching a certain value. Furthermore, the implementation of the method in Microsoft Excel adds a practical aspect, as Excel is commonly used for quantitative data processing and simple numerical analysis [8]. Thus, this study contributes to the development of numerical analysis techniques in the field of economics while offering a method that is applicable, systematic, and easy to replicate.

Based on the above description, this study focuses on applying a two-step method using Microsoft Excel to determine the year when the open unemployment rate is predicted to reach 5% in Central Java Province, based on data from the Central Statistics Agency for the period 2018–2024. The objective of this study is to build a predictive model from historical data and apply numerical methods to obtain systematic and accurate estimates of the year, as a basis for analysis in the formulation of labor policies.

2 METHOD

This study adopts a quantitative approach with a descriptive-analytical design, aiming to develop a predictive model for the open unemployment rate and apply numerical methods to determine the year when the open unemployment rate reaches a specific value [9]. This design was chosen because quantitative research allows for the systematic and objective analysis of numerical data through measurable statistical and mathematical procedures [10]. Furthermore, the analytical approach is used not only to describe the data but also to build mathematical models and make predictions based on historical data.

The subject of this study is the open unemployment rate in Central Java Province, using annual data for the 2018–2024 period published by the Central Statistics Agency. This study does not involve human subjects but rather analyzes secondary data. The study population consists of all available data on the open unemployment rate in Central Java Province as published in official BPS publications, while the study sample was drawn from annual open unemployment rate data for the 2018–2024 period, selected purposively due to its relevance to the research objectives and the availability of complete data [3]. The 2018–2024 period was chosen because it provides the most recent, complete, and consistent data from the Central Statistics Agency and is capable of reflecting current labor market changes, including the impact of the COVID-19 pandemic and the economic recovery phase. This time frame was also chosen to maintain the stability of the regression model and reduce the risk of overfitting that might arise from using overly complex long-term data [11].

Data collection was conducted through a literature review of official publications by the Central Statistics Agency and related scientific sources. The documentation technique is considered appropriate for quantitative research because it allows researchers to obtain standardized and verifiable secondary data [10]. Furthermore, the use of secondary data in unemployment studies has been common in various previous studies, given that the data originates from credible official statistics [12].

The research instrument uses a Microsoft Excel worksheet specifically designed to process data and apply the bisection method. This worksheet includes the year variable, the open unemployment rate, regression modeling results, the initial interval for the bisection method, the function value for each iteration, the midpoint of the interval, and the error at each calculation step. The use of simple computational tools such as spreadsheets in predictive research is considered effective because they facilitate systematic and transparent numerical calculations [13].

Data analysis was conducted in several stages. First, descriptive analysis was applied to the Open Unemployment Rate data to identify trends and fluctuations during the study period. Second, regression modeling was performed to obtain a mathematical function representing the relationship between time and the Open Unemployment Rate. Regression has been widely used in unemployment studies because it provides a clear and measurable picture of the quantitative relationship between variables [14]. Mathematically, the regression model is formulated by the equation y=a+bx.

To find the year when the Open Unemployment Rate reaches 5%, the equation is transformed into the function f(x) = a + bx - 5. Next, the value of x that satisfies this function is determined using the bisection method iteratively until a predetermined error limit is reached. Third, the regression function was used as the basis for applying the bisection method, which aims to determine the year when the Open Unemployment Rate is predicted to reach 5%. The bisection method is implemented by setting an initial interval that satisfies the condition for a change in the sign of the function, then calculating the midpoint of the interval iteratively until the termination criteria are met based on an error smaller than the specified tolerance [15]. This procedure follows standard steps in numerical methods to determine the root of the equation gradually and convergently.

Data validity was tested through source triangulation and model accuracy evaluation. Triangulation was performed by comparing the data used with other official publications from the Central Statistics Agency to ensure consistency. Additionally, model accuracy was tested by calculating the coefficient of determination (R^2) and error measures such as the Mean Absolute Percentage Error (MAPE) to ensure the model is sufficiently accurate in representing historical data [16]. A similar model evaluation approach has also been used in various studies on unemployment forecasting in Indonesia to assess model performance quantitatively [17]. With these procedures, the research results are expected to be valid, reliable, and replicable by other researchers.

3 RESULTS AND DISCUSSION

3.1. Result

Presentation of Research Data

This study uses open unemployment rate data for Central Java Province from 2018 to 2024, obtained from the Central Statistics Agency. Analysis of the data reveals fluctuations in the open unemployment rate, with a significant increase occurring in 2020, followed by a gradual decline through 2024. This pattern reflects a nonlinear trend, necessitating mathematical modeling to obtain more accurate estimates.

Table 1. Unemployment Rate Data for Central Java Province

Year	Number
2018	4,51
2019	4,44
2020	6,48
2021	5,95
2022	5,57
2023	5,13
2024	4,78

Regression Modeling Results

Data modeling was performed using second-order polynomial regression, processed in Microsoft Excel. This model was chosen because it better represents the patterns of data fluctuations than a linear model.

The steps for deriving the equation in Microsoft Excel are as follows: First, enter the data into Excel, with the first column (x) containing the number one, and so on. The second column is filled with the annual Open Unemployment Rate. Select the (x) and (TPT) columns, choose the Insert menu, and select the Scatter Plot chart. Click one of the data points, right-click, and select Add Trendline. Choose Polynomial (2nd order) and check Display Equation and Display R^2. The resulting display will appear as shown below.

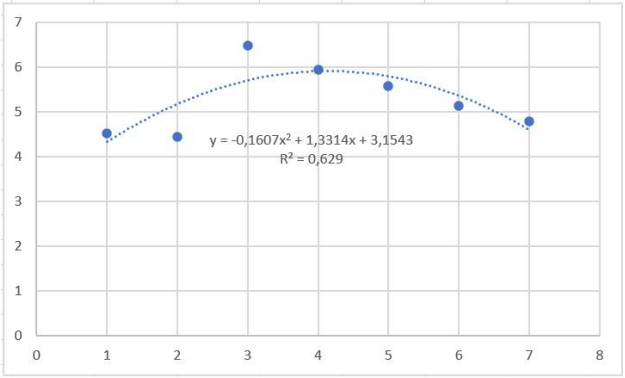

Figure 1. Open Unemployment Rate Chart
Note: The x-axis represents the year, where 1 = 2018, 2 = 2019, 3 = 2020, and so on.

Based on the results of the analysis, the following regression equation was obtained:

$$y = -0{,}1607x^2 + 1{,}3314x + 3{,}1543$$

with a coefficient of determination of:

$$R^2 = 0{,}629$$

The coefficient of determination indicates that the model explains approximately 62.9% of the variation in the open unemployment rate data during the study period. These results suggest that the model is sufficiently representative to serve as a basis for predictions, although there remains variation influenced by factors outside the model.

Implementation of the Bisection Method

1. Determination of function
   To determine the year when the open unemployment rate reached 5%, the regression equation is transformed into:
   $$f(x) = -0{,}1607x^2 + 1{,}3314x + 3{,}1543 - 5$$
   or
   $$f(x) = -0{,}1607x^2 + 1{,}3314x - 1{,}8457$$
2. Determination of the Initial Interval
   The initial interval is determined by finding two numbers that yield different signs. Based on the calculations, it was found that:
   $$f(6) = 0{,}3575 \text{ dan } f(7) = -0{,}4002$$
   Since there is a change in sign, the root of the equation lies in the interval [6,7].
3. Bisection Method Iteration Process
   The bisection method is applied iteratively by determining the midpoint of the interval:
   $$c = \frac{a+b}{2}$$
   The function values are then calculated until the termination criteria are met.
   The work was performed using Microsoft Excel by creating an iteration table as follows:

Table 2. Iteration Table

	A	B	C	D	E	F	G	H
1	iterasi	a	b	C	F(a)	F(b)	F(c)	error
2	1	6	7	6,5	0,3575	-0,4002	0,018825	1
3	2	6,5	7	6,75	0,018825	-0,4002	-0,18064375	0,5
4	3	6,5	7	6,625	0,018825	-0,18064375	-0,078398438	0,25

5	4	6,5	6,75	6,5625	0,018825	-0,078398438	-0,029158984	0,125
6	5	6,5	6,625	6,53125	0,018825	-0,029158984	-0,005010059	0,0625
7	6	6,5	6,5625	6,515625	0,018825	-0,005010059	0,006946704	0,03125
8	7	6,515625	6,53125	6,523438	0,006946704	-0,005010059	0,000978131	0,015625
9	8	6,523438	6,53125	6,527344	0,000977748	-0,005010059	-0,002013703	0,007812
10	9	6,523438	6,527344	6,5255391	0,000977748	-0,002013703	-0,000517364	0,003906
11	10	6,523438	6,525391	6,524415	0,000977748	-0,000517364	0,000230345	0,001953
12	11	6,524415	6,525391	6,524903	0,000229962	-0,000517364	-0,000143663	0,000976
13	12	6,524415	6,524903	6,524659	0,000229962	-0,000143663	0,0000431594	0,000488
14	13	6,524659	6,524903	6,524781	0,0000431594	-0,000143663	-0,000050249	0,000244
15	14	6,524659	6,524781	6,52472	0,0000431594	-0,0000502492	-0,000003544	0,000122
16	15	6,524659	6,52472	6,52469	0,0000431594	-0,0000035443	0,00001981	0,000061
17	16	6,52469	6,52472	6,524705	0,0000198077	-0,0000035443	0,00000794	0,0000305
18	17	6,524705	6,52472	6,524713	0,00000794034	-0,0000035443	0,0000022	0,000015

The iteration column is filled with the numbers 1 and so on. The a and b columns are filled with the initial interval values. The c column is obtained from the formula:

$$= (B2 + C2)/2$$

Column f(a) is obtained from the formula:

$$= -0{,}1607 * (B2^2) + 1{,}3314 * (B2) - 1{,}8457$$

Column f(b) is obtained from the formula:

$$= -0{,}1607 * (C2^2) + 1{,}3314 * (C2) - 1{,}8457$$

Column f(c) is obtained from the formula:

$$= -0{,}1607 * (D2^2) + 1{,}3314 * (D2) - 1{,}8457$$

The error column is calculated using the formula:

$$= ABS(C2 - B2)$$

To proceed to the next iteration step, the value of $f(a) \times f(c)$ must be calculated. If $f(a) \times f(c) < 0$, then for the next iteration step, the value in column a remains unchanged, and the value in column b is replaced with the value from column c in the previous iteration. If the result of $f(a) \times f(c) > 0$, then for the next iteration row, the value in column a is replaced with the value from column c in the previous iteration, and column b remains unchanged. The iteration process continues until the error value approaches 0,00001.

Based on the calculation results (iteration table), the iteration process took 17 steps until the error reached:

$$1{,}5 \times 10^{-5}$$

4. Final Results

The results of the iteration show that the root of the equation is:

$$x \approx 6{,}524713$$

Since the model uses a sequential time index with the base year as the reference point, these values indicate that the open unemployment rate is projected to reach 5% around a specific year:

$$2018 + 6{,}52 \approx 2024{,}52$$

As a result, the open unemployment rate is projected to reach 5% between mid-2024 and early 2025.

3.2. Discussion

The results of the study indicate that a second-order polynomial regression model is capable of effectively representing the patterns of change in the open unemployment rate in Central Java Province during the 2018–2024 period. This is reflected in the coefficient of determination of 0.629, indicating that approximately 62.9% of the variation in the data can be explained by the model. This finding is consistent with previous quantitative research revealing that polynomial regression is effective in modeling economic data that is volatile and does not always follow a linear pattern, including in the analysis of labor market indicators in Indonesia [14][12]. However, the relatively low value of the coefficient of determination (R^2) suggests that the model is not yet capable of explaining the full variation in the unemployment rate. This indicates the presence of other factors outside the model, such as economic growth, labor market structure, and government policy [18].

The regression results were then used as the basis for applying the bisection method to determine the year in which the open unemployment rate is predicted to reach 5%. The application of the bisection method in this study proved to yield stable and convergent results, with the iterative process converging to a very small error. Theoretically, the bisection method is a numerical method known for its high stability, as it systematically narrows the solution interval until it reaches the desired root value [19]. This finding supports that view, as the iterative process consistently yields an estimate of the root of approximately 6.524713.

Based on the calculations, the root value indicates that the open unemployment rate is projected to reach 5% between mid-2024 and early 2025. This result is consistent with trends in data from the Central Statistics Agency, which show a gradual decline in the open unemployment rate in Central Java following a significant increase due to the COVID-19 pandemic. Thus, the model built can capture the general direction of changes in the data, although it does not fully explain all the variations that occur.

Methodologically, this study confirms that the integration of regression modeling and numerical methods provides a more practical approach to predictive analysis than using regression alone. Many previous studies stopped at model formulation without proceeding to the stage of determining specific solutions, such as estimating the time to reach a certain value. Therefore, the application of the two-step method in this study makes a practical contribution to quantitative analysis, yielding estimates that are more operational and easier to interpret.

The use of Microsoft Excel as a tool for implementation also demonstrates that numerical methods can be effectively applied using simple and easily accessible software. [20] research supports this, stating that spreadsheets can be optimally utilized for simple statistical and numerical analysis, as they promote transparency in the calculation process and facilitate replication.

However, this study also has several limitations. First, the model uses only historical data without taking into account other variables that could potentially influence the unemployment rate, such as economic growth, inflation, or education. Second, the relatively limited amount of data means the model has difficulty capturing long-term trends.

Overall, this study shows that a regression-based numerical approach and the divide-by-two method can be used as alternatives in the predictive analysis of employment indicators. This approach not only produces systematic and measurable results, but is also easy to apply practically, particularly in supporting data-based policy analysis.

4 CONCLUSION

Based on the research findings, the second-order polynomial regression model successfully captured the pattern of changes in the open unemployment rate in Central Java Province during the 2018–2024 period, as evidenced by a coefficient of determination of 0.629. This model was then used as the basis for applying the bisection method to determine the year in which the open unemployment rate is predicted to reach 5%. The implementation results show that the bisection method functions stably and converges, yielding an estimated root of 6.524713, indicating that the Open Unemployment Rate is projected to reach 5% between mid-2024 and early 2025. These findings indicate that the integration of regression modeling and numerical methods based on Microsoft Excel can be applied as a systematic, practical, and easily replicable approach in the predictive analysis of labor market indicators. However, this study has limitations because it uses only historical data without considering other variables that may influence the unemployment rate. Therefore, it is recommended that future research develop models by incorporating additional variables or using more complex approaches to improve prediction accuracy.

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The author states that no individual or party made a personal contribution to this research.

AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Niswatun Nikhlah	✓	✓	✓				✓	✓	✓		✓		✓	✓
Dewi Laili	✓	✓	✓				✓	✓		✓	✓		✓	✓
Ari Wibowo				✓	✓	✓						✓		

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing – **O**riginal Draft
E : Writing – Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are openly available in central statistics agency at Tingkat Pengangguran Terbuka Menurut Provinsi - Tabel Statistik - Badan Pusat Statistik Indonesia

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