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Prediction of Unemployment Rates in East Java Region Using Multiple Linear Regression Method

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Abstract
Unemployment is a major problem for developing countries, including Indonesia. The average unemployment rate in East Java is 5.202 percent from 2004 to 2023, according to data from Badan Pusat Statistik (BPS). These figures show that unemployment is still a major problem for local governments, despite changes. The purpose of this study is to create an application that can predict the number of unemployed in the future. The method used is multiple linear regression where this method was chosen because it can show how the year and labor force participation rate, which are two independent variables, correlate with the unemployment rate as the dependent variable. The data used comes from BPS and covers 19 years. This prediction model is integrated into a web-based platform to make the research results easier to access and use. This platform will display data and analysis results interactively, so that it can be used by local governments, academics, and other individuals looking for information about unemployment. The results of the study show that the regression model created is quite accurate. Based on the results of testing that has been carried out on the existing features, the system has displayed the appropriate output.

1. Introduction
Unemployment is a problem often faced by developing countries, one of which is Indonesia. Unemployment is a situation where someone in the workforce wants to get a job but has not been able to obtain one. Unemployment involves people who are not working but are looking for a job, or are preparing to start a business, or are finding it difficult to get a job (desperate) or have been accepted for a job but have not yet started working [1].

According to data from the Badan Pusat Statistik (BPS), East Java has an average unemployment rate of 5.202 over a 19-year period from 2004 to 2023. This figure shows that despite fluctuations from year to year, the unemployment rate in this region remains a challenge that needs to be addressed by the local government.

This research aims to analyze BPS data using the multiple linear regression method to predict the unemployment rate in the East Java region. The multiple linear regression approach method itself is a technique used to obtain a model of the relationship between the dependent variable and one or more independent variables with the aim of describing the data phenomenon or case being studied [2].

By utilizing web-based technology, the analysis results will be displayed on an interactive website, facilitating access to information for all stakeholders. The hope is that this research can serve as a strong foundation for better decision-making in managing employment issues at the local level.

Several recent studies have made significant contributions to understanding and predicting various economic phenomena. [3] In the study titled "Prediksi Jumlah Pengangguran Di Jawa Barat Dengan Menggunakan Algoritma Regresi Linear" (Prediction of Unemployment Rates in West Java Using Linear Regression Algorithm), a consistent error rate (RMSE) of 15,859.070 was achieved. The consistency of the RMSE value indicates that the linear regression model can provide predictions of the unemployment rate with a relatively stable and optimal level of accuracy.

Next, [4] in the study titled "Prediksi Tingkat Pengangguran Di Indonesia Menggunakan Linear Regression Dengan Weka" (Prediction of Unemployment Rate in Indonesia Using Linear Regression with Weka), successfully predicted the open unemployment rate at 99.83% with an error rate of 0.17% on the forecast data using the linear regression algorithm. Meanwhile, [5] explored the study titled " Peramalan Pendapatan dari Penjualan Bawang Merah Menggunakan Metode Regresi Linear Berganda" (Forecasting Revenue from Red Onion Sales Using Multiple Linear Regression Method), with a revenue prediction result of 60% accuracy and an error rate (MAPE) of 13%, indicating that this model is effective in making predictions.

[6] also analyzes the study titled "Peramalan Hasil Padi di Kabupaten Cirebon Menggunakan Algoritma Regresi Linear Bergand" (Forecasting Rice Harvest in Cirebon Regency Using Multiple Linear Regression Algorithm), which aims

to predict rice production in 2023. The predicted results show production of 685,403 tons, a decrease in production compared to previous years. In addition, [7] in the study titled "Prediksi Kuota Pesanan Bahan Bakar di SPBU Menggunakan Metode Regresi Linear Berganda" (Prediction of Fuel Order Quotas at Gas Stations Using Multiple Linear Regression Method), successfully made forecasts with an error rate of 11.0% for Pertalite and 13.2% for diesel through testing with MAPE. The overall research provides valuable insights and can serve as a reference for understanding and decision-making in various sectors.

Thus, this study is present to predict the unemployment rate in East Java using the multiple linear regression method. The results of this study are expected to provide insight into local governments and stakeholders in designing more effective policies to reduce the unemployment rate in East Java. By understanding the factors that play a role in the unemployment rate, strategic steps such as improving the quality of education, investment in the industrial sector, and appropriate employment policies can be more focused and have a positive impact on community welfare.

2. Research Method

2.1 Forecastiong

Forecasting is a method used to systematically predict what will happen in the future using relevant data from the past [8]. Effective planning and good policy-making are greatly influenced by the important role of forecasting. The results of forecasting data analysis can be used as a relevant guide in the process of accurate decision-making, including making sales estimates for the future [9].

2.2 Multiple Linear Regression

The Multiple Linear Regression Method uses two types of variables: independent variables and dependent variables. This method uses regression equations to utilize more than one independent variable [10]. The multiple linear regression equation model can be seen in Equation 1, Equation 2, Equation 3, and Equation 4.

$$b_1 = \frac{(\sum x_2{}^2)(\sum x_1 y)-(\sum x_1 x_2)(\sum x_2 y)}{(\sum x_1{}^2)(\sum x_2{}^2)-(\sum x_1 x_2)^2} \quad (1)$$

$$b_2 = \frac{(\sum x_1{}^2)(\sum x_2 y)-(\sum x_1 x_2)(\sum x_1 y)}{(\sum x_1{}^2)(\sum x_2{}^2)-(\sum x_1 x_2)^2} \quad (2)$$

$$a = \frac{\sum y}{n} - b_1.\left(\frac{\sum x_1}{n}\right) - b_2.\left(\frac{\sum x_2}{n}\right) \quad (3)$$

$$y' = a + b_1.\, x_1 + b_2.\, x_2 \quad (4)$$

The description of equations 1-4 is as follows:
y': Predicted Value
y: Actual Value
x_1: Independent Variable 1
x_2: Independent Variable 2
a: Constant
b_1: Coefficient of indicator x1
b_2: Coefficient of indicator x2
n: Number of data
Σy: Total sum of data for indicator y
Σx_1: Total sum of data for indicator x_1
Σx_2: Total sum of data for indicator x_2
$\Sigma x_1{}^2$: Total sum of data for indicator $x_1{}^2$
$\Sigma x_2{}^2$: Total sum of data for indicator $x_2{}^2$
$\Sigma x_1 x_2$: Total sum of data for indicator $x_1 \times x_2$
$\Sigma x_1 y$: Total sum of data for indicator $x_1 \times y$
$\Sigma x_2 y$: Total sum of data for indicator $x_2 \times y$

2.3 MAPE (Mean Absolute Percentage Error)

Mean Absolute Percentage Error (MAPE) is an error measurement method that measures the percentage deviation between actual data and predicted data. MAPE is calculated by taking the absolute error value for each period, then dividing it by the actual value for that period. After that, the average of the absolute percentage errors is calculated [11]. To calculate the MAPE value, you can use the formula in Equation 5.

$$MAPE = \frac{1}{n}\sum\left|\frac{(y-y')}{y}\right| \times 100\% \quad (5)$$

The description of equation 5 is as follows:
y = Actual value at period *x*
y' = Predicted value at period *x*
n = Number of data points

The range of MAPE values can be seen in Table 1. From Table 1, if the resulting MAPE value is low, the forecasting model's performance is considered good. To assess the accuracy of a forecasting model, the MAPE calculation has a value range. The MAPE value range indicates that the model's prediction is more accurate in projecting actual data if the value is lower [12].

Table 1. MAPE value range

MAPE Value	Interpretation
Less than 10%	Excellent
10% - 20%	Good
20% - 50%	Acceptable
More than 50%	Poor

2.4 Website

A website can be described as a collection of pages that contain digital data, including text, images, animations, sound, and video, or a combination of all of these. Users can access information in the form of images, audio, or text from a system known as the World Wide Web (WWW), also referred to as a website. The data is stored in a location called a web server [13].

2.5 Database

A database is a collection of data that has a logical relationship between them and serves as an explanation of that data. The design of a database is intended to facilitate the discovery of data needed by an organization. In a database, all information is integrated to avoid data duplication. A database can be used by various departments and users, and it is a combination of logically integrated and interconnected data elements [14].

2.6 PHP

PHP stands for Hypertext Preprocessor, a programming language commonly used for managing the creation and development of websites. PHP can be used in conjunction with HTML [16]. The PHP programming language is open source, providing developers the freedom to create websites or develop applications using the documentation provided by php.net without any limitations on code or functions. Currently, the popularity of PHP programming has reached a high level, and in response to this demand, many developers have created various tools to accelerate the process of building websites or applications. Examples of these tools include Codeigniter, Laravel, PHPCake, and several other tools [11].

2.7 Laravel

Laravel is widely used by developers around the world due to its ease of use and comprehensive documentation. These factors have made it a popular choice in recent years. Additionally, great features of Laravel such as the template engine, routing, and modularity help developers maximize the use of PHP when building websites [16].

2.8 Preparing the Data

Table 2 represents the data for Malang City. The Year will be variable x1, the Labor Force Participation Rate will be variable x2, and the Unemployment Rate will be the variable y.

Table 2. Data of Malang City

Year (X_1)	Labor Force Participation Rate (X_2)	Unemployment Rate (Y)
2004	64,22	9,14
2005	58,06	17,83
2006	57,48	13,1
2007	60,47	11,27

Year (X_1)	Labor Force Participation Rate (X_2)	Unemployment Rate (Y)
2008	61,46	11,14
2009	62,51	10,44
2010	63,81	8,68
2011	68,72	9,74
2012	64,16	7,96
2013	65,99	7,73
2014	63,66	7,22
2015	60,56	7,28
2016	62,7	6,91
2017	64,77	7,22
2018	66,25	6,65
2019	66,1	5,88
2020	66,41	9,61
2021	67,59	9,65
2022	63,08	7,66
2023	67,58	6,8

2.9 Creating the sum of the indicator

Table 3 represents the total sum of the indicators that will be used in the calculations. The next step is to input the statistical values into the formula used.

Table 3. Total sum of indicator

Indicator	Sum
ΣX_1	210
ΣX_2	1275,55
ΣY	181,91
$\Sigma X_1 Y$	1705,27
$\Sigma X_2 Y$	11501,5
$\Sigma X_1 X_2$	13606,3
$\Sigma (X_1)^2$	2870
$\Sigma (X_2)^2$	81531,2
ΣY^2	1800,68

2.10 Inputting the statistical values into the formula used

a. $\sum {x_1}^2 = \sum {X_1}^2 - \frac{(\sum x_1)^2}{n}$
$= 2870 - \frac{(210)^2}{20} = 665$

b. $\sum {x_2}^2 = \sum {X_2}^2 - \frac{(\sum x_2)^2}{n}$
$= 81531{,}2 - \frac{(1275{,}55)^2}{20} = 180{,}439$

c. $\sum y^2 = \sum Y^2 - \frac{(\sum Y)^2}{n}$
$= 1800{,}68 - \frac{(181{,}91)^2}{20} = 146{,}117$

d. $\sum x_1 y = \sum X_1 Y - \frac{(\sum x_1)(\sum Y)}{n}$
$= 1705{,}27 - \frac{(210)(181{,}91)}{20} = -204{,}785$

e. $\sum x_2 y = \sum X_2 Y - \frac{(\sum x_2)(\sum Y)}{n}$
$= 11501{,}5 - \frac{(210)(181{,}91)}{20} = -100{,}198$

f. $\sum x_1 x_2 = \sum X_1 X_2 - \frac{(\sum x_1)(\sum x_2)}{n}$
$= 13606{,}3 - \frac{(210)(1275{,}55)}{20} = 213{,}033$

After performing the calculations above, the next step is to calculate the values of b_1, b_2, and a.

1. Calculating the Value of b_1

$b_1 = \frac{(\sum {x_2}^2)(\sum x_1 y) - (\sum x_1 x_2)(\sum x_2 y)}{(\sum {x_1}^2)(\sum {x_2}^2) - (\sum x_1 x_2)^2}$

$= \frac{(180{,}439)(-204{,}785)-(213{,}033)(-100{,}198)}{(665)(180{,}439)-(213{,}033)^2} = \frac{-15605{,}73}{74608{,}87} = -0{,}209$

2. Calculating the Value of b_2

$b_2 = \frac{(\sum {x_1}^2)(\sum x_2 y)-(\sum x_1 x_2)(\sum x_1 y)}{(\sum {x_1}^2)(\sum {x_2}^2)-(\sum x_1 x_2)^2}$

$= \frac{(665)(-100{,}198)-(213{,}033)(-204{,}785)}{(665)(180{,}439)-(213{,}033)^2} = \frac{-23005{,}74}{74608{,}87} = -0{,}308$

3. Calculating the Value of a

$a = \frac{\sum Y}{n} - b_1.\left(\frac{\sum X_1}{n}\right) - b_2.\left(\frac{\sum X_2}{n}\right)$

$= \frac{181{,}91}{20} - (-0{,}209).-(-0{,}308).\left(\frac{1275{,}55}{20}\right) = 30{,}958$

4. Regression Equation

After obtaining the values of b_1, b_2, and a, the regression equation can be derived. The regression equation is as follows:

y' = a + b_1.x_1 + b_2.x_2

y' = $30{,}958 + (-0{,}209).x_1 + (-0{,}308).x_2$

5. Prediction Calculation

After obtaining the regression equation, prediction calculations can be performed accordingly. The results of these calculations are presented in Table 4, which displays the predicted values for each year. Following this, the accuracy of the predictions is evaluated using the Mean Absolute Percentage Error (MAPE). The MAPE calculation results are provided in Table 5.

Table 4. Prediction calculation

x_1	x_2	y	y'
1	64,22	9,14	10,946
2	58,06	17,83	12,636
3	57,48	13,1	12,606
4	60,47	11,27	11,475
5	61,46	11,14	10,960
6	62,51	10,44	10,428
7	63,81	8,68	9,817
8	68,72	9,74	8,094
9	64,16	7,96	9,291
10	65,99	7,73	8,518
11	63,66	7,22	9,027
12	60,56	7,28	9,774
13	62,7	6,91	8,916
14	64,77	7,22	8,057
15	66,25	6,65	7,392
16	66,1	5,88	7,229
17	66,41	9,61	6,924
18	67,59	9,65	6,351
19	63,08	7,66	7,533
20	67,58	6,8	5,936

6. MAPE Calculation

In Table 5, the MAPE test shows that the error rate generated from the above forecast is 16.182%. Therefore, the forecast has a good model.

Table 5. MAPE calculation

x_1	**x_2**	**y**	**y'**	**error value (%)**
1	64,22	9,14	10,946	19,760
2	58,06	17,83	12,636	29,129
3	57,48	13,1	12,606	3,771
4	60,47	11,27	11,475	1,818

x_1	x_2	y	y'	error value (%)
5	61,46	11,14	10,960	1,612
6	62,51	10,44	10,428	0,120
7	63,81	8,68	9,817	13,105
8	68,72	9,74	8,094	16,896
9	64,16	7,96	9,291	16,724
10	65,99	7,73	8,518	10,191
11	63,66	7,22	9,027	25,029
12	60,56	7,28	9,774	34,255
13	62,7	6,91	8,916	29,024
14	64,77	7,22	8,057	11,597
15	66,25	6,65	7,392	11,154
16	66,1	5,88	7,229	22,940
17	66,41	9,61	6,924	27,949
18	67,59	9,65	6,351	34,186
19	63,08	7,66	7,533	1,663
20	67,58	6,8	5,936	12,708
		MAPE		**16,182**

2.11 IPO Diagram

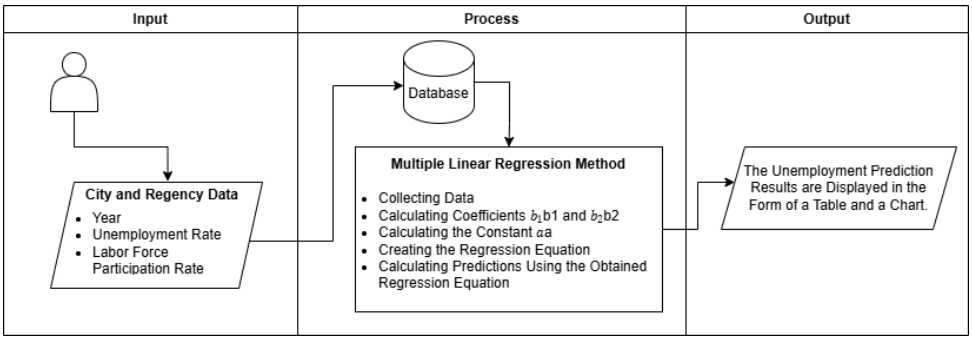

Figure 1. IPO diagram

In Figure 1, the process begins by inputting data from cities and regencies, which includes Year, Unemployment Rate, and Labor Force Participation Rate. The data is then entered into the database. Once the data has been successfully entered into the database, it will be processed using the Multiple Linear Regression method to derive the regression equation, which is used to calculate the predictions. Finally, the predictions are calculated using the obtained regression equation, and the results will be displayed in the form of tables and graphs.

2.12 Use Case Diagram

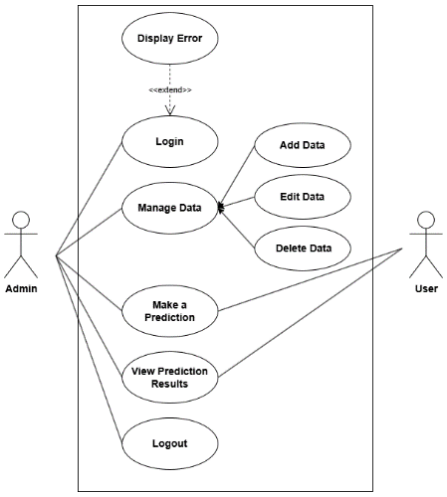

Figure 2. Use case diagram

In Figure 2, there are two entities: admin and user. The admin can access all the available features, which include login, managing data, making predictions, viewing prediction results, and logging out. Meanwhile, the user can only make predictions and view the prediction results.

2.13 Admin Flowchart

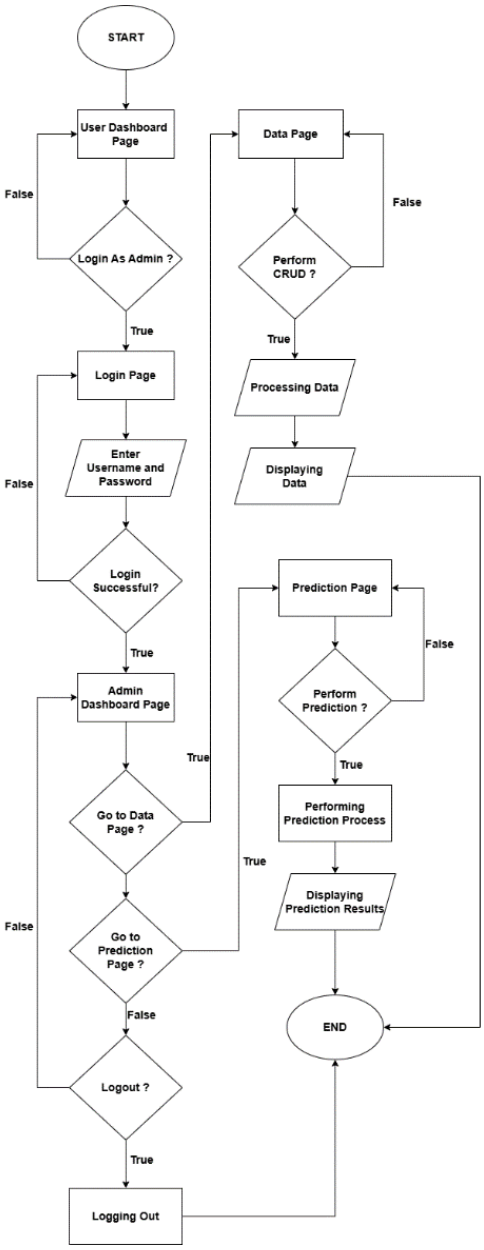

Figure 3. Admin flowchart

In Figure 3, the program starts with the user dashboard page. Then, there is a condition to determine whether the user wants to log in as an admin. If yes, it will proceed to the login page. If not, the user will remain on the user dashboard page. On the login page, the user will perform the login process by entering the username and password. If the login is successful, the user will be directed to the admin dashboard. If the login fails, the user will be returned to the user dashboard. On the admin dashboard, there are options to access the data page or the prediction page. On the data page, the admin can view and manage the data. On the prediction page, the admin can make unemployment predictions. The admin can also log out to exit the admin status and access the user page.

2.14 User Flowchart

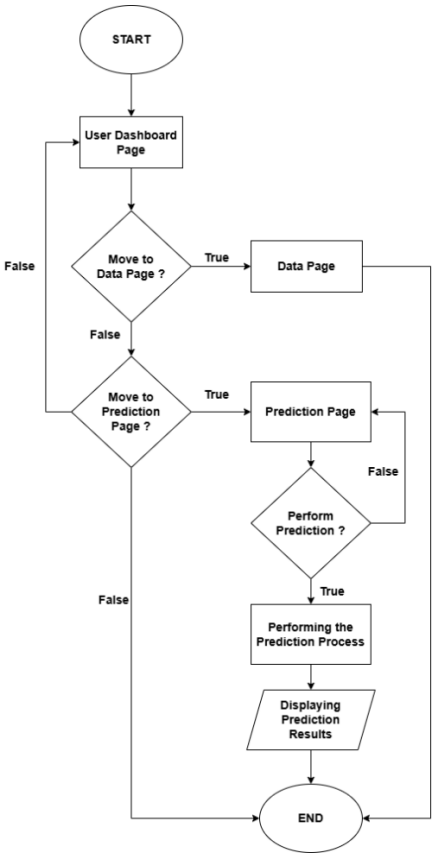

Figure 4. User flowchart

In Figure 4, the program starts with the user dashboard page. Then, the user is given the option to navigate to the data page. If yes, the user will be directed to the data page. If not, the user will remain on the user dashboard page. On the data page, the user can only view the existing data. Next, the user is given another option to navigate to the prediction page. If yes, the user will be directed to the prediction page. If not, the user will remain on the user dashboard page. On the prediction page, the user can make unemployment predictions.

2.15 Multiple Linear Regression Flowchart

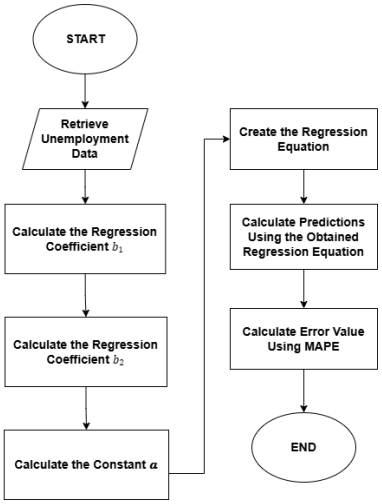

Figure 5. Multiple linear regression flowchart

Figure 5 above is the flowchart for the Multiple Linear Regression method. The process begins by collecting data. Then, calculations are made for the regression coefficients b_1 and b_2. Next, the calculation for the constant a is performed. After obtaining these values, substitution is carried out between variables x_1, x_2, constant a, regression coefficient $b1$, and regression coefficient $b2$ to generate the regression equation. After obtaining the regression equation, the next step is to perform the unemployment prediction by inputting the values of x_1 (Year) and x_2 (Labor Force Participation Rate). After the prediction stage, the process moves on to the testing phase using the Mean Absolute Percentage Error (MAPE). This process aims to evaluate the relative error between the actual data and the predicted data.

3. Results and Discussion

3.1 Login

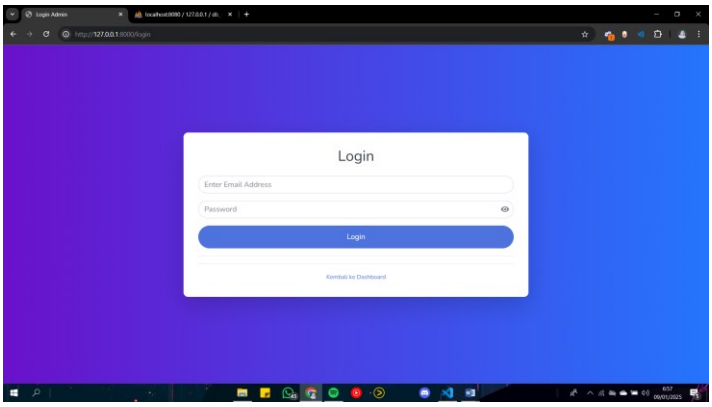

Figure 6. Login page

Figure 6 shows the login page display. The login process is only performed by the admin using the account that is already stored in the database.

3.2 Admin Dashboard

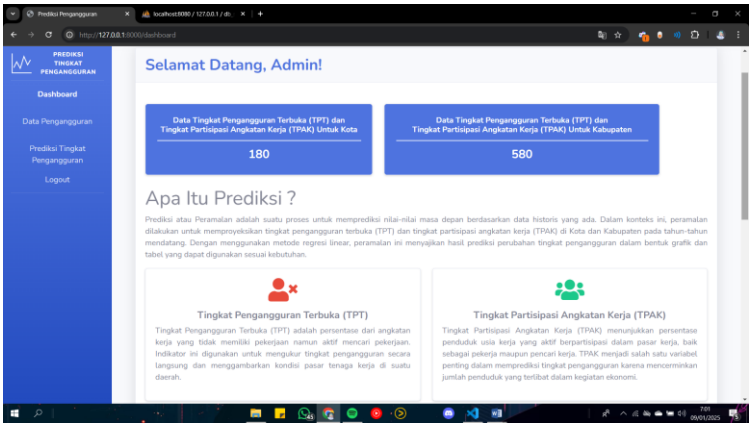

Figure 7. Admin dashboard page

Figure 7 shows the display of the admin dashboard page. This page contains a brief explanation about forecasting, the open unemployment rate, the labor force participation rate, and special access that can only be performed by the admin.

3.3 User Dashboard

Figure 8 shows the display of the user dashboard page. This page contains a brief explanation about forecasting, the open unemployment rate, the labor force participation rate, and the steps to use the website. On this page, there is a "Login as Admin" button to access the login page

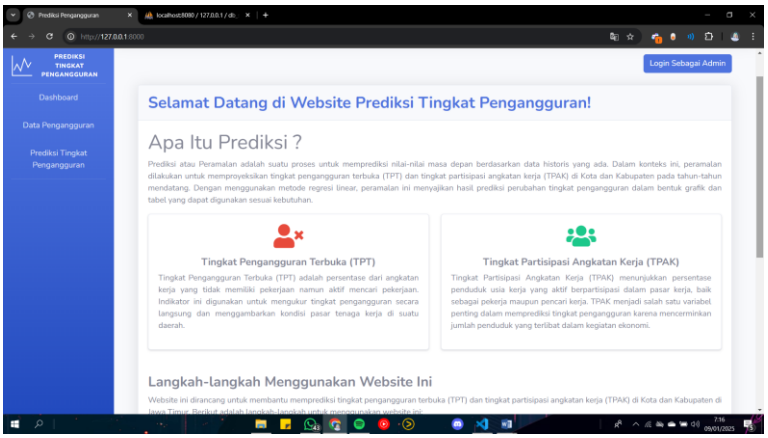

Figure 8. User dashboard page

3.4 Unemployment Data

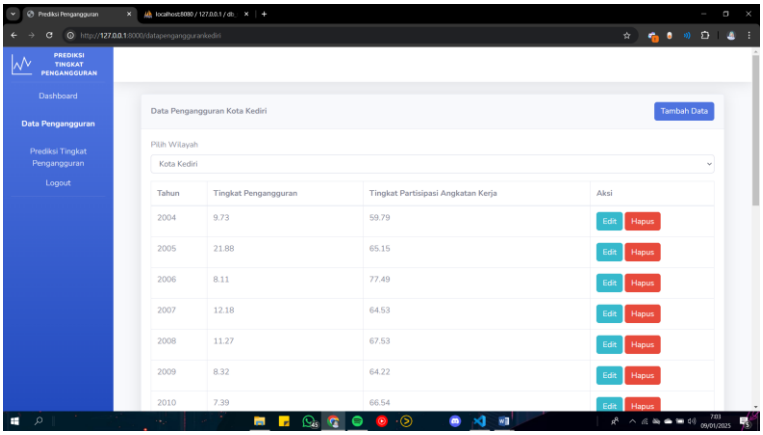

Figure 9. Unemployment data page from the admin side

Figure 9 shows the display of the unemployment data page from the admin side. This page displays unemployment data according to the city or regency selected in the ComboBox. Then, in the action column, there are options to edit or delete the data. On the top-right corner, there is an "Add Data" button to add new data.

3.5 Unemployment Rate Prediction

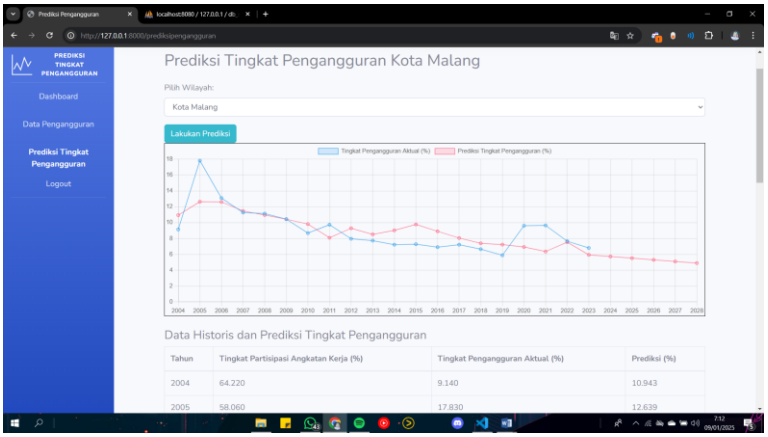

Figure 10. Unemployment rate prediction page

Figure 10 shows the display of the unemployment rate prediction page. On this page, users can predict the unemployment rate according to the city or regency selected in the ComboBox. The prediction results are displayed in both graphical and tabular forms.

3.6 Functional Testing

The functional testing of this system aims to test the features of the system on the Unemployment Rate Prediction website in East Java using the Multiple Linear Regression Method. The results of the system testing can be seen in Table 6.

Table 6. Functional testing

No	Feature Testing	Test Case	Expected Output	Test Status
1	Login	Entering Email and Password according to the account registered in the database	Login is successful and the admin dashboard page is accessed	Success
2	Login	Entering Email and Password that do not match the account registered in the database	Login fails and the user remains on the login page	Success
3	Dashboard Page	Displaying an explanation about the website	Explanation about the website is successfully displayed	Success
4	Unemployment Data Page	Selecting a city to display its data	Data is displayed according to the selected city	Success
5	Unemployment Data Page (Admin)	Pressing the "Add Data" button	Navigates to the Add Data Page	Success
6	Unemployment Data Page (Admin)	Filling in the required attributes according to the specifications	Data is successfully saved	Success
7	Unemployment Data Page (Admin)	Filling in the required attributes incorrectly	Data is not saved	Success
8	Unemployment Data Page (Admin)	Pressing the "Edit" button in the Action column	Navigates to the Edit Data page	Success
9	Data Edit Page (Admin)	Filling in the required attributes correctly	Data is successfully edited	Success
10	Unemployment Data Page (Admin)	Pressing the "Delete" button in the Action column	Data is deleted	Success
11	Unemployment Data Page	Selecting a city to display its data	Data is displayed according to the selected city	Success
12	Unemployment Data Page	Selecting a district to display its data	Data is displayed according to the selected district	Success
13	Unemployment Data Page (User)	User cannot add, edit, or delete data	Buttons for adding data, editing data, and deleting data are not available	Success
14	Unemployment Rate Prediction Page	Selecting a city from the ComboBox and pressing the "Perform Prediction" button	Prediction is performed according to the selected city	Success
15	Unemployment Rate Prediction Page	Selecting a district from the ComboBox and pressing the "Perform Prediction" button	Prediction is performed according to the selected district	Success
16	Unemployment Rate Prediction Page	Displaying the prediction results in the form of a graph and table along with the MAPE value	Prediction results are displayed in the form of a graph and table, along with the MAPE value	Success
17	Logout	Performing the Logout Process	Admin Successfully Logged Out	Success

3.7 Browser Testing

This test is conducted to evaluate the performance and functionality when running in different browsers. The test is carried out on two different browsers: Microsoft Edge version 131.0.2903.63 (64-bit) and Google Chrome version 131.0.6778.86 (64-bit).

Table 7. Browser testing

No	Function Tested	Edge	Chrome
1	Login	✓	✓
	Admin		
2	Admin Dashboard Page	✓	✓
3	Unemployment Data Page	✓	✓
4	Add New Data	✓	✓

No	Function Tested	Edge	Chrome
5	Edit Data	✓	✓
6	Delete Data	✓	✓
7	Perform Unemployment Rate Prediction	✓	✓
8	Logout	✓	✓
	User		
9	User Dashboard Page	✓	✓
10	Unemployment Data Page	✓	✓
11	Perform Unemployment Rate Prediction	✓	✓

✓ = Succeeded
X = Failed

4. Conclusion

This unemployment rate prediction application can be used to help provide an overview of changes in unemployment rates in the East Java region based on historical data, where the multiple linear regression method applied in this system has produced an accurate prediction model by utilizing labor force participation rate (TPAK) data and years as independent variables. This application can be developed with other prediction methods, such as the Double Exponential Smoothing method, ARIMA (Autoregressive Integrated Moving Average), or Weighted Moving Average.

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