J. Intell. Comput. Health Inform. Vol. 4, No. 1, 2023
ISSN: 2715-6923 e-ISSN: 2721-9186, pp.1~8 | DOI: 10.26714/jichi.v4i1.11258

A Linear Regression Model for Deploying a Cognitive Web for an Inventory Prediction System

Yenni Fatman, Muammar Ramadhan

Department of Informatics, Universitas Islam Nusantara, Jl. Soekarno-Hatta No. 530, Bandung 40286, Indonesia

Sali Alas M*

Department of Informatics, Universitas Pasundan Bandung, Jl. Setiabudi No. 193, Bandung 40153, Indonesia
*Corresponding author: sali@unpas.ac.id

Article histroy :
Received: 06 JAN 2023
Accepted: 15 FEB 2023
Avalaible online: 31 MAR 2023

Research article

Abstract: Inventory management plays a crucial role in the sales system, as it indirectly impacts customer satisfaction. Inaccurate determination of the quantity of goods to be purchased often leads to unstable stock circulation in warehouses. Numerous factors that influence procurement decisions pose challenges for managers. Several initiatives have been undertaken to maintain optimal stock levels and ensure availability when required. In this study, we developed a linear regression model to estimate the inventory for the upcoming one-month period. Linear regression was selected because of its ability to forecast future trends. This research involved creating a web application that utilized sales data from the previous six months, focusing on examples of products sold in a store. The objective of the application is to assist store owners in making informed decisions regarding stock replenishment in the next period. By doing so, they can fulfill customer demands without excessive inventory accumulation while considering the limitations of storage capacity.

Keywords: INVENTORY; PREDICTION; LINEAR REGRESSION; WEB APPLICATION

1. Introduction

One of the most crucial activities in the sales system is stock management, which involves the storage and detailed recording of goods, as well as the physical arrangement of goods prior to their sale or distribution. Owing to its significant impact on the sales system, meticulous stock management is essential.

Presently, XYZ Stores still rely on manual inventory management, resulting in frequent instances of excess or insufficient stock for sale. This issue arises because the procurement process fails to consider the projected stock conditions for the upcoming period, such as the anticipated stock situation for the next month. Consequently, XYZ Store requires an improved stock management system that can accurately determine the quantity of stock for the following month. Such a system would facilitate easier procurement of product stock for the subsequent one-month period.

XYZ Store needs to carry out forecasting activities to predict stock conditions in the coming months. This activity requires proper forecasting techniques that aim to accurately determine future demand and minimize forecasting errors (Tamaji et al., 2022). The Big Indonesian Dictionary defines a prediction as the result of predicting or estimating the future value of using past data. According to (Tresna et al., 2021) forecasting is a prediction about what will happen in the future.

The use of the linear regression method to predict inventory is a statistical method that tests the extent of a causal relationship between the Causal Factor Variable (X) and the Consequent Variable. Causal Factors are generally denoted by X or also called Predictor while Consequential Variables are denoted by Y or also called Response. Linear Regression or often abbreviated as SLR (Simple Linear Regression) also has advantages and disadvantages, the advantage of this SLR is that it can predict future trends and has advantages in estimating simple model parameters and data based on time series. In addition, this method can perform an analysis using several independent variables (X) so that the prediction results can be more accurate (Indarwati, 2019). The drawback is that the forecast results from the linear regression analysis are estimated values; therefore, the possibility of not matching the actual data still exists. Linear regression can be used in production or sales to make forecasting or

predictions about quality and quantity characteristics (Hidayatus et al., 2022).

The web application is an auxiliary software based on web technology that can run on the Internet or intranet. It is hoped that the application that will be made will make it easier for XYZ store owners to carry out the prediction function in helping purchase goods and can be done from anywhere and from any device.

2. Preliminary

2.1 Forecasting method

Forecasting is a procedure for making factual information about future social situations based on existing information, whereas prediction is a process of systematically estimating something that is most likely to happen in the future based on past and present information that is owned so that errors (the difference between something that happened and the estimated result) can be minimized. Predictions do not have to give a definite answer to what will happen but try to find answers as close as possible to what will happen (Tamaji et al., 2022).

The definition of prediction is the same as that of the forecast. According to the Big Indonesian Dictionary, a prediction is the result of predicting or predicting activities, or estimating future values using past data. According to (Heizer and Render, 2009) and (Gabriel and Shakirat, 2022) forecasting is the art and science of predicting future events. Meanwhile, according to (Tresna et al., 2021), forecasting is a prediction about what will happen in the future.

2.2 Linear regression method

Linear regression measures the effect of an independent variable (predictor) on a dependent variable (response) (Oliver et al., 2022). The measurement of this influence results in the independent variable (X) and dependent variable (Y), which is called a simple linear regression analysis in Eq. (1-4).

$$Y = a+bX \quad (1)$$

Note: y is response variable (Y); x is predictore variable (X); XY is a response variable x predictor variable ($X*Y$); a is constant calculated in Eq. (2); b is the regression coefficient calculated in Eq. (3); Y is the prediction value calculated in Eq. (4).

$$a = \frac{\sum y (\sum x^2) - \sum x . \sum XY}{n \sum x^2 - (\sum x)^2} \quad (2)$$

$$b = \frac{n \sum XY - \sum X . \sum Y}{n \sum x^2 - (\sum x)^2} \quad (3)$$

$$Y=a+b.(n) \quad (4)$$

2.3 Inventory

Inventory, commonly called stock, is a company asset that occupies a fairly important position in a company, be it a trading company or an industrial (manufacturing) company. For companies operating in all sectors, almost 50% of the company's funds will be embedded in inventory, namely, to buy goods ready for sale. Inventories are asset items owned by a company for sale in normal business operations or goods to be used or consumed in making goods to be sold.

The definition of inventory according to (Hui Zao et al., 2020) includes all types of goods that are the main objects of company activity available for processing in the production process or sale. The definition of inventory according to the (Association of Accountants, 2011) is as follows:

a. Available for sale in the ordinary course of business.
b. In the production process for such sales, or.
c. In the form of materials or equipment for use in the production process or the provision of services.

2.4 Web technologies

A website is one of the media platforms used to access information. According to (Setia et al., 2020), the website has become an important place for people to share information.

Web technology, also known as web technology, involves the creation and use of mechanisms that allow different computers to communicate. Resources or building blocks of an effective computer network system can also be shared (Karzan et al., 2019).

3. Metodology

In this section, the methodology used in conducting this research is described.

3.1 Literature review

A literature study is carried out by collecting and reviewing journals, articles, research reports, and other sources that are available online or offline and are related to the research being carried out, especially regarding forecasting methods and linear regression.

3.2 Data collection and analysis

The sample data are obtained by submitting a proposal to the shop where the observations are, namely, Store XYZ. The proposal contains requests for sales samples for six product items starting from January 2022 to June 2022.

3.3 Development and implementation of the linear regression method

Data analysis was performed manually with the help of Excel. Based on the sales data obtained, a simulation was carried out using the linear regression method. The results will be validated, and if correct, a pseudocode/algorithm will be created, which are the logical steps in applying the linear regression method.

The steps at this stage are as follows:

- Doing pre-processing
- Calculation of X, Y, XY, and XX
- Calculation of a and b
- Get the Linear Regression Equation
- Make predictions
- Test MSE, RMSE, and MAPE

3.4 Web application design

At this stage several things need to be done, starting from designing the interface and data flow, documenting the design in the form of flowcharts, and choosing a programming language and framework that provides the

required functionality, until finally, the application can begin to be built. This includes building a prediction module using linear regression.

3.5 Application development and testing

Application development is carried out following the design that was made in the previous stage. The application of Linear Regression as a forecasting method used in this study was also carried out. For testing purposes, the sample data collected from the XYZ store will be used in the application and analyzed for suitability with the results in stage c.

a. Manual linear regression calculation

This manual calculation uses Microsoft Excel and Pseudocode for code associated with commands written in programming languages or computer language codes. Pseudocode was used because of the ease of writing and understanding the instructions contained therein.

The manual calculation will later be tested for the error rate (error prediction). This test was carried out to determine the existing errors to increase user confidence in the calculation results.

- Calculations for ABC products

The calculation uses an example for one product, as shown in Table 1.

Table 1. Sales transaction history

NO	PRODUCT NAME	MONTH	**Qty**
(1)	ABC	January	23
(2)		February	13
(3)		March	13
(4)		April	53
(5)		Mei	44
(6)		June	62

Table 1 shows the sales transaction data at XYZ stores from January 2022 to June 2022. These data are used as historical data in predictive calculations with linear regression to determine the next month's stock situation.

- Completion of prediction calculations for next month

To calculate stock predictions for the next month, July 2022, a linear regression formula is used, namely by calculating values *a*, *b*, and Y, as shown in Table 2.

Table 2. Solution

PRODUCT NAME	MONTH	Qty (y)	x	x"	xy
ABC	November	23	1	1	23
	December	13	2	4	26
	January	13	3	9	39
	February	53	4	16	212
	March	44	5	25	220
	April	62	6	36	372
Total (∑)		208	21	91	892

The calculation details for the constant are given in Eq. (5-6).

$$a = \frac{\sum y\,(\sum x^2) - \sum x.\sum XY}{n\sum x^2 - (\sum x)^2} \quad (5)$$

$$a = \frac{\sum 208\,(\sum 91) - \sum 21.\sum 892}{6\sum 91 - (\sum 21)^2} \quad (6)$$

Calculating details for regression coefficient (*b*), can be seen in Eq.

$$b = \frac{n\sum XY - \sum X.\sum Y}{n\sum x^2 - (\sum x)^2} \quad (7)$$

$$b = \frac{6\sum 892 - \sum 21.\sum 208}{6\sum 91 - (21)^2} \quad (8)$$

Calculating the models can be seen in

$$Y = a+bX \qquad a=1.9 \quad (9)$$

$$Y = 1.9 + 9.3X \qquad b=9.3 \quad (10)$$

To predict the next month's products that will be sold using Eq. (11-12):

$$Y=a+b.(X) \quad (11)$$

$$Y=1.9+9.3 \quad (12)$$

$$Y=67$$

The results of calculations using linear regression for one product show that the prediction of ABC stock for the next month is 67 products.

b. Pseudocode prediction module with linear regression

The algorithm for the prediction module using Linear Regression is developed in pseudocode, as shown in Fig. 1.

c. Application design

The design of the stock prediction system for the XYZ store is based on the following software design principles.

```
Judul
perhitungan_regresi_linier_dengan_
1_produk
Deklarasi
var
prediksi(Y),konstanta(a),
koefisien_regresi(b), respon(y),
predicktor(x), total_bulan(n),
bulan_berikutnya(X),
predictor_kuadrat((x)^2),kuadrat(x^2),
x*y(xy): integer;
Algoritma
x←21
y←208
n←6
X←7
(x)^2 ← (21)^2
x^2 ←91
xy←892
input a← (∑208(∑91)−∑21.∑892)/(6∑91−(∑21)^2)
output a
input b← (6∑892−∑21.∑208)/(6∑91−(21)^2)
output b
input Y← 1,9 + 9,3.(7)
write Y
end
```

Fig 1. Pseudocode prediction module

d. Use case diagrams

Fig. 2 shows the Use Case Diagram of the prediction application to be built. In the use case, it is shown that there are two actors, namely the customer and the application manager (admin). There are nine functions/features in the system, including features for data preparation and features for predictive calculations.

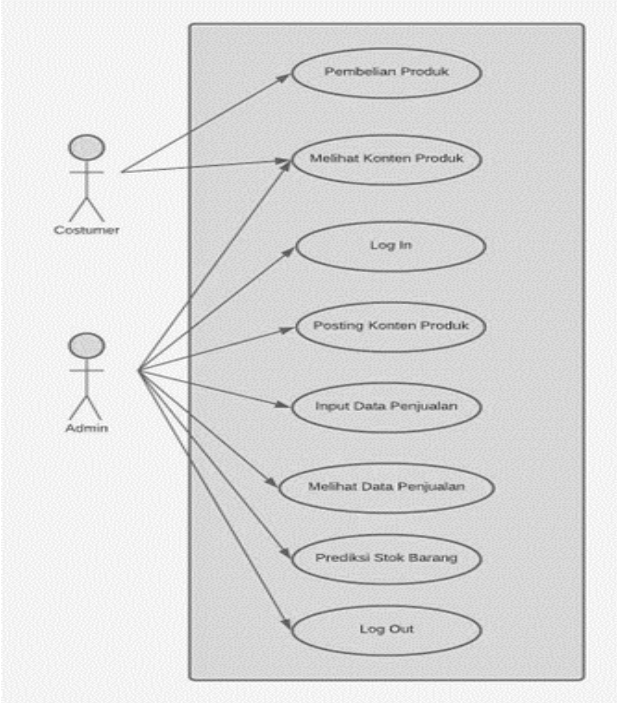

Fig 2. Use case diagram

Table 3. Actors definition

NO	ACTOR	DEFINISI
1	Admin	- Log in - Posting Product Content - Viewer Product Content - Input data Sales - Viewer data Sales - Product Stock Prediction - Log out
2	Customer	- Product Purchase - Viewer Product Content

e. User activity diagrams

The activity diagram shows an overview of user activities, namely Customers and Application Managers. The Activity Diagram is shown in Fig. 3 and 4.

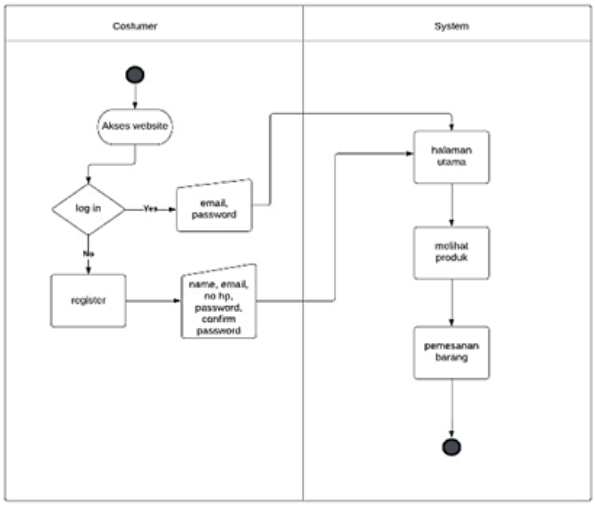

Fig 3. Customer activity diagrams

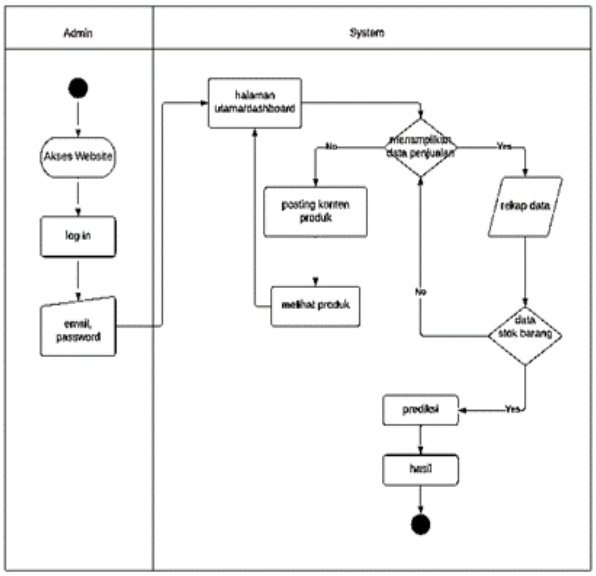

Fig 4. Web Admin Activity Diagrams

f. Prediction module flowchart

The main actor was the Admin. This section describes the prediction process performed by Admin. Shown by Fig. 5.

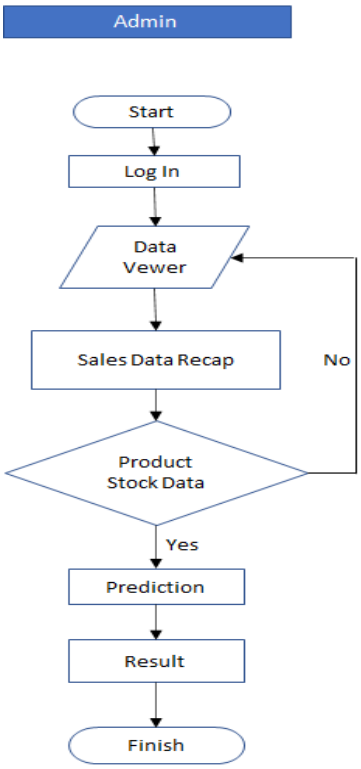

Fig 5. Prediction module flowchart

4. Result and Discussion

This stage is carried out after the design stage and will then be implemented using the PHP programming language and MySQL DBMS.

4.1 Database implementation

There are seven database tables, all of which are implemented using MySQL DBMS, namely:

1. table categories,
2. table migrations,
3. table password_resets,
4. table sales,
5. table products,
6. table sliders,
7. table users

The main table relationships are shown in Fig. 6.

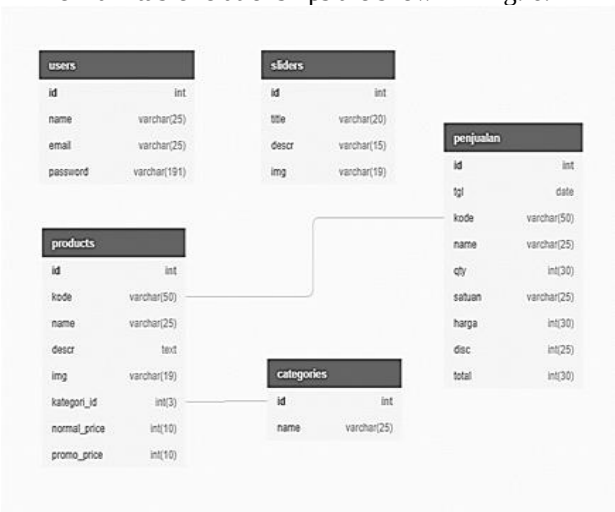

Fig 6. Database Relations Schema

4.2 Interface

(Yenni Fatman)

Sales page interface. This section contains a historical list of products that have been sold.

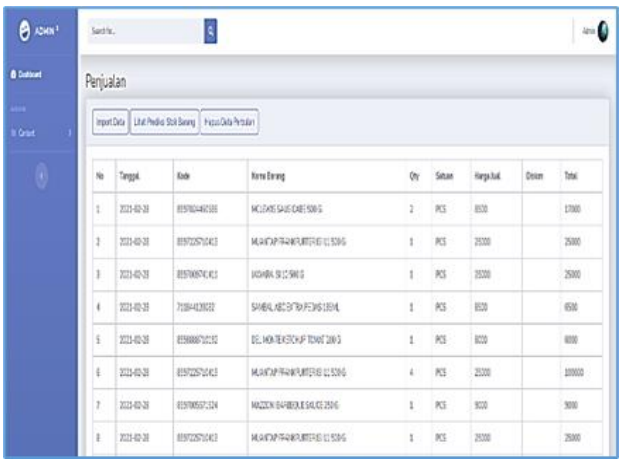

Fig 7. Sales

Stock Prediction Page Interface. On this page, you can see the stock of goods predicted using the linear regression method. Then, from the image below, you can choose the product to be predicted.

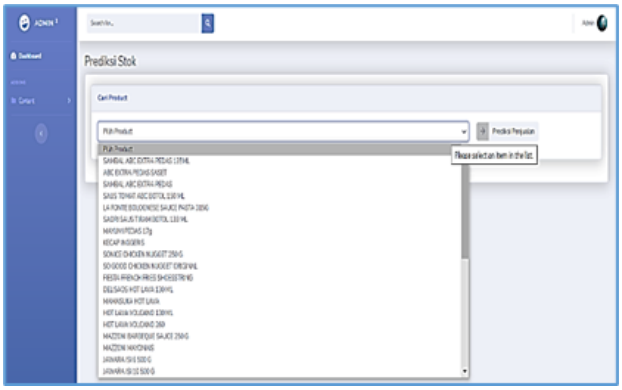

Fig 8. Prediction

Prediction of one product. In this section, after selecting one of the product stocks to be predicted, a prediction chart for that product appears and predictions for the next month's stock product.

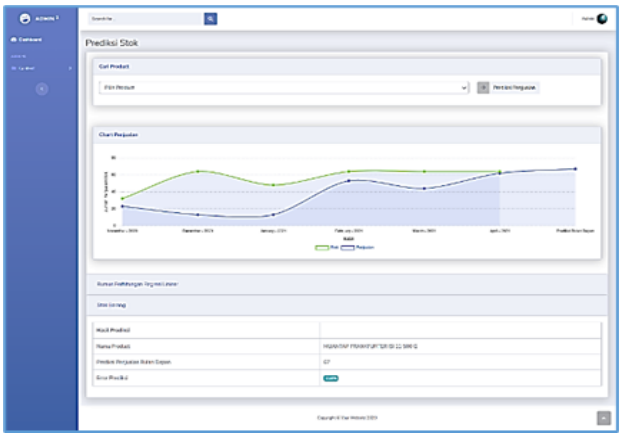

Fig 9. Product Prediction

Prediction calculation formula for one product.

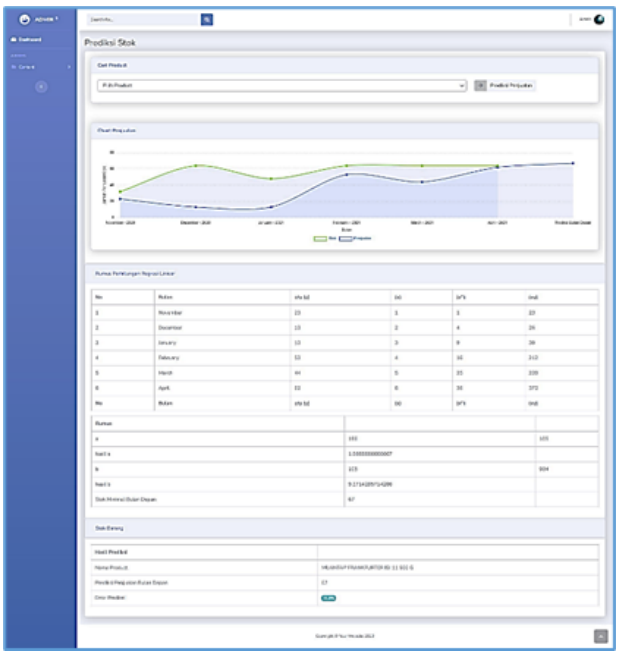

Fig 10. Product prediction formula

The results of the system forecasting for the following month are as follows:

$$a = \frac{196}{105}$$

$$hasil\ a = 1{,}9$$

$$b = \frac{105}{984}$$

$$hasil\ b = 9{,}3$$

$$Y = 1{,}9 + 9{,}3.\,(7)$$

$$hasil\ Y = 67$$

Thus, by calculating for one product in the next month, it is predicted that the next month's product stock will have 67 products.

Remaining stock of goods in one product. On this page, you can see the remaining product stock each month and the results of stock predictions and prediction errors.

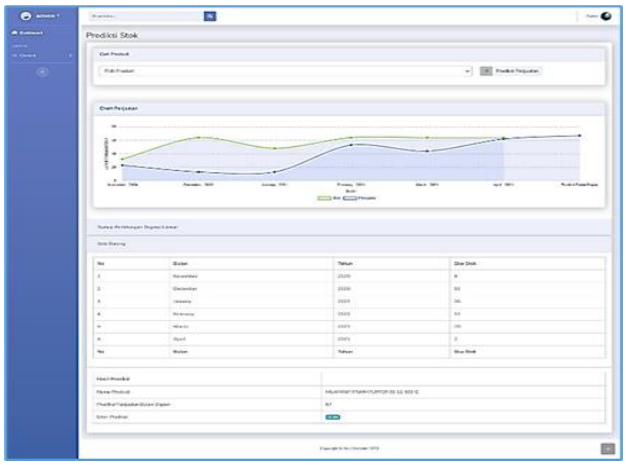

Fig 11. Product remaining

Error prediction for one product. This page shows the results of the sum of the prediction errors and the implementation of the prediction errors.

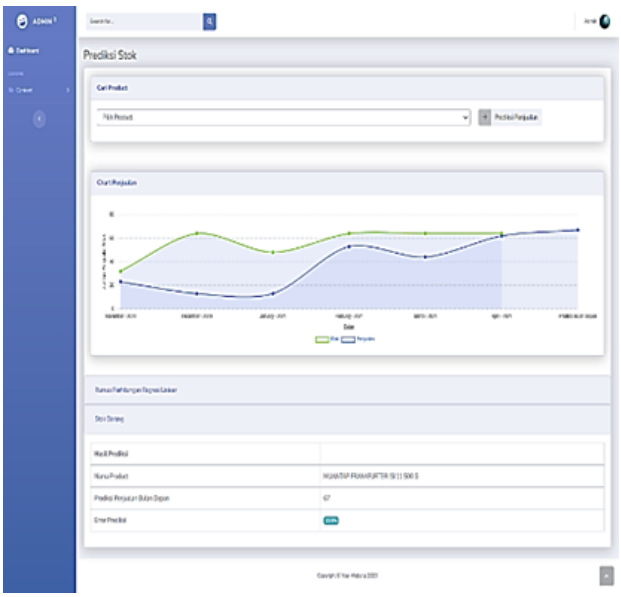

Fig 12. Error prediction

Prediction error formula

er = error regresi

x = next month prediction

(yi- 〖y)〗 ^2 = SSE (Sum Square Error) or (Unexplained diversity).

$$er = \frac{\sqrt{(yi - y)^2}}{x - 2}$$

The result of the prediction error was 11.9%.

Regression error table for various products. This table uses the SSE Linear Regression model and implements the error regression script ($errorReg = $sse / ($next_x - 2);

$valueErrorReg = sqrt($errorReg) ;):

Table 4. Regression error testing

NO	PRODUCT NAME	PERSENTASE ERROR	VALIDALITAS
(1)	ABC	2,39%	Valid
(2)	EFG	5,47%	Valid
(3)	HIJ	7,39%	Valid
(4)	SSS	18,97%	Valid
(5)	AWE	11,9%	Valid
(6)	QWE	4,81%	Valid

If the percentage error is more than 50%, stock prediction will not be performed.

Application Testing. Testing this application is focused on testing Black Box Testing to test the system functionally and observe the execution results of the application and ensure that input will run the right process and produce output according to design. Testing this system will be grouped by a user (customer) and Admin master.

Customer System Testing. Features tested for customer service are shown in Table 5.

Table 5. Customer system testing

NO	TESTING	EXPECTED RESULTS	CONCLUSION
(1)	Sign Up (*nama, email*, no hp, password, confirm password)	The data entered is successful if the data matches the data in the database and will go directly to the main page	Valid
(2)	Product Purchesed (*nama, no hp, alamat, kode pos, produk, harga produk*)	Product purchases cannot be canceled automatically ordered and ordered via Whatsapp	Valid

Admin System Testing. Features tested for admin service are shown in Table 6.

Table 6. Admin system testing

NO	TESTING	EXPECTED RESULT	CONCLUSION
(1)	Sign In (email, password)	The data entered is successful if the data matches the data in the database and will go directly to the main admin page	Valid
(2)	1. Product predictions that are on the sales page (*cari produk, chart penjualan, dan rumus perhitungan regresi*) 2. In the sales page there is a monthly delete data (*pilih bulan, pilih tahun*)	The data on this sales page is from customer data that ordered and will be stored in the database so that the admin can predict the next month's stock.	Valid
(3)	Slider Page has the following features: 1. *Tambah data* 2. *Edit Data* 3. *Hapus Data*	The actions of adding data, editing data and deleting data will affect the main page of the website.	Valid
(4)	Products Page has the following features: 1. *Tambah data* 2. *Edit Data* 3. *Hapus Data*	The actions of adding data, editing data and deleting data will affect the main page of the website.	Valid
(5)	Category Page has the following features: 1. *Tambah data* 2. *Edit Data* 3. *Hapus Data*	The actions of adding data, editing data and deleting data will affect the main page of the website.	Valid

4. Conclusion

After manually simulating the sales history for six months using Microsoft Excel, the inventory for the seventh month can be accurately predicted. This validation confirms the suitability of the specified factors and the usability of the proposed formula for inventory prediction. The developed model was successfully integrated into a web application and tested using black box techniques, resulting in positive outcomes. The use of historical data is crucial in the linear regression method, but it presents issues when encountering high error values when the sales volume is zero. This circumstance raises concerns about prediction quality and necessitates the exploration of additional remedies. Although the impact on stock management, particularly on storage space capacity, cannot be examined at present, it is essential to establish a formula that accounts for multiple product variants to assess this effect effectively.

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