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INTEGRATED SYSTEM IN FORECASTING STOCKS OF GOODS USING THE EXPONENTIAL SMOOTHING METHOD

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Abstract
Determining the stock of goods is mandatory for a company of buy and sell goods, especially when there are many types of goods to sell. One of the companies that means is PT. Capella Dinamik Nusantara. The company is one of the largest Honda motorcycle distributor companies in Riau. PT. Capella Dinamik Nusantara also sells and purchases Honda motorbike spare Parts for its customers. Considering that there are quite a lot of types of Honda motorbikes and for one Honda motorbike there are already a lot of spare Parts, a system is needed that is able to store all motorbike data and spare Parts, and if possible can help predict the stock of items needed. This research aims to create a decision support system that can help PT. Capella Dinamik Nusantara in predicting the amount of spare part stock needed. The method used in this system is the Exponential Smoothing method with the programming language used is the PHP language which makes this system a Web-based system that is used locally.

Keywords: Exponential Smoothing, Predict, Stock, PHP.

1.0 INTRODUCTION

Inventory (stock) is one of the important assets for small and large companies in running their business for mutual benefit. Generally, inventories in a company are raw materials used to produce finished goods and finished goods that are ready to be resold (Barchelino, 2016). Companies must be able to anticipate the circumstances and challenges that exist in handling inventory management, so as to reduce the costs required to store goods (Tuerah, 2014).

PT. Capella Dinamik Nusantara is a company engaged in the sales and distribution of Honda motorbikes specifically appointed as Main Dealer to oversee the sales of Honda motorbikes in three marketing areas, namely Aceh, Riau and Riau Islands. One of its branches stands on Jl. Soekarno Hatta No.88 Pekanbaru, which is engaged in unit sales, spare part sales and maintenance of Honda motorbikes (Youtricha, 2019). To maintain Honda's motorcycle market share, PT. Capella Dinamik Nusantara, of course, must be able to maintain or even increase sales properly. But on the other hand, PT. Capella Dinamik Nusantara must also fulfill consumer desires in terms of fulfilling spare parts, oil and accessories for consumers' favorite Honda motorbikes. When purchasing a Honda motorbike unit, there are those who immediately buy and install accessories for their favorite motorcycle to make it look cooler. Then if a consumer's Honda motorcycle is damaged either from the consumer itself or because of a factory defect, of course the consumer will make repairs. In this case, of course, consumers do not want the repair process to be long because they have to wait for the part to be re-stocked for a long time. It is very detrimental to the company if many consumers want or need the same parts but there is no stock, causing consumers to switch messages to competitors' places.

In most buying and selling companies have problems in determining the inventory of goods because of the difficulty in predicting or predicting sales in the next period (Ketut et al., 2015). This also applies to PT. Capella Dinamik Nusantara currently due to an increase in Purchase Order (PO) Indents every year.

Table 1. Total PO Indent in Years

Year	Qty	Rupiah Value
2017	3179	Rp 485.860.500
2018	15245	Rp 2.841.888.000
2019	38821	Rp 6.314.412.600

(Source : PT. Capella Dinamik Nusantara, 2020)

From the PO Indent data table at PT. Capella Dinamik Nusantara, we can see that the fulfillment of consumer spare parts by PT. Capella Dinamik Nusantara as the Main Dealer is experiencing problems so that it has an increase in Purchase Order (PO) Indents every year. This is of course detrimental to the company, because Purchase Order (PO) Indent for consumers personally, the shipping cost is more expensive than the cost of sending orders for stock and also Indent Purchase Order (PO) should not be rejected unless the consumer's order part has been discontinued (no longer produced / beyond the back up period). This must be done by PT. Capella Dinamik Nusantara as the official Honda Main Dealer in order to maintain the quality of service to Honda customers. Therefore it is important to implement a system capable of producing forecasts that can assist decision making in determining the number of items to be ordered in the next period.

Currently, many researches on Decision Support Systems have also been made for forecasting goods with various methods, one of which is the Exponential Smoothing method. The exponential smoothing method can be used to predict the value of one period in the next and is also suitable for predicting things with irregular (random) fluctuations (Handoko, 2019).

Based on this background, the researcher decided to create a Decision Support System for forecasting stock items using the Exponential Smoothing method so that it can help make decisions about ordering goods in the next period so that PO Indent orders are reduced.

2.0 METHODOLOGY

System

The purpose of the system has been put forward by several experts to date, one of which is according to Romney and Steinbart in 2015 that a system is a series of two or more interconnected components, which interact to achieve a goal. Most of the systems consist of smaller subsystems that support the larger system. Meanwhile, according to Anastasia Diana & Lilis Setiawati in 2011 which states that the system is a series of interdependent parts and work together to achieve certain goals. Based on the understanding of the system according to these experts, we can briefly summarize that the system is a collection of elements or elements that interact with each other in carrying out activities to achieve a certain goal (Jogianto H.M., 2005).

Information

In everyday expressions, many say that information is everything we communicate, as conveyed by someone through spoken language, newspapers, videos, and others. In this expression, it implies that there is no information if no one carries it. Among those who carry this information, the most frequently discussed is human language through human communication. Although it is not always humans who carry information, communication can also mean smoke, DNA, electricity, or images. Thus, the information here can be considered as a message or the meaning contained in a message. In fact, in everyday reality, we often have to distinguish between the information contained in a sentence or what is written in the sentence. For example, person A says, "You're great," to person B. Not necessarily what person A means is that person B is really great, but there are other meanings. So, there is a meaning contained in that information. Therefore, there are three meanings of the word information. The first is information as a process, which refers to activities to become informed. The second meaning is information as knowledge. Here, information refers to all occurrences in the world (entities) that are infinite, untouchable, or something abstract. As something abstract, information is seen from the meaning contained in the entire medium used, then it can be interpreted differently between the sender and the receiver. The third meaning is that information is considered as a real object or presentation of knowledge. As a real object, information is seen from a

series of symbols and can be captured by the human senses and can be exchanged. Information is considered as the real raw material, which is beyond human which requires further processing (Ati et al., 2014).

Information System

Information system is a system in an organization that brings together the needs of daily transaction processing that supports the managerial functions of the organization's operations with the strategic activities of an organization to be able to provide certain external parties with the information needed for decision making. Information system in an organization can be said as a system that provides information for all levels in the organization whenever needed. This system stores, retrieves, modifies, processes and communicates received information using information systems or other system equipment (Ati et al., 2014).

Decision Support System

Basically, DSS is designed to support all stages of decision making starting from identifying problems, selecting relevant data, determining the approach used in the decision-making process, to evaluating the selection of alternatives. According to Al-Hamdany in 2003, SPK is an interactive information system that supports the decision-making process through the presentation of information designed specifically for problem-solving approaches and application needs of decision makers, and does not make decisions for users (Setiyaningsih, 2015).

Exponential Smoothing Method

According to Render and Heizer in 2005, exponential smoothing is a weighted moving average forecasting technique where the data is weighted by an exponential function (Fachrurrazi, 2015). Exponential Smoothing can be defined based on the calculation stages where the value of the forecast data in period t + 1 is the actual value in period t plus adjustments resulting from the error in the forecasting value that occurred in period t (Gunawan & Joni, 2020).

The forecast value can be found using the following formula:

$St + 1 = \alpha\, Xt + (1 - \alpha)\, St$ ..... (1)

Information :
$St + 1$ = forecast value to t + 1
Xt = actual data to t
α = parameter with a value between 0 to 1
St = forecast value to t

Quadratic Trend Method

Quadratic trends are short and medium term trends. The quadratic trend equation is formulated as follows (Cahyani & Aziz Siregar, 2017):

Y '= a + bX + cX2 (2)

To get the coefficients a, b, and c, the formula is:

$$a = \frac{(\Sigma Y)(\Sigma X4) - (\Sigma X2Y)(\Sigma X2)}{n(\Sigma X4) - (\Sigma X2)2} \quad \text{..... (3)}$$

$$b = \frac{\Sigma XY}{\Sigma X2} \quad \text{..... (4)}$$

$$c = \frac{n(\Sigma X2Y) - (\Sigma X2)(\Sigma Y)}{n(\Sigma X4) - (\Sigma X2)2} \quad \text{..... (5)}$$

Information :
X = Actual data
Y = The value of the Y variable at a certain time
a, b, c = constant
n = amount of data

Double Exponential Smoothing Method

The Double Exponential Smoothing method is a linear model that uses a two-time smoothing process. Brown's rationale for the linear exponential smoothing method is similar to that of linear moving average, because both single and multiple smoothing values lag behind the actual data if there is an element of trend (Arifin, 2019).

The equations used in the Double Exponential Smoothing method include:

$S't + 1 = \alpha Xt + (1 - \alpha) S't$ ..... (6)
$S''t + 1 = \alpha$ S'$t + 1 + (1 - \alpha) S''t$ ..... (7)
at = $S't + 1 + (S't + 1 - S''t + 1)$ ..... (8)
bt = α / (1- α) $(S't + 1 - S''t + 1)$ ..... (9)
Ft + m = at + btm ..... (10)

Information :
$S't + 1$ = Single exponential smoothing value
$S''t + 1$ = Double exponential smoothing value
Xt = Actual data to t
at = Smoothing constant
bt = Smoothing constant
α = Parameters with values between 0 to 1
m = The number of periods to be predicted
Ft + m = Forecast value to t + m

Error Calculation Method

MAD (Mean Absolute Deviation)

Mean Absolute Deviation (MAD) is an error calculation that is used to anticipate the existence of positive and negative values that weaken each other or add to the calculation of errors in the addition by providing an absolute value for each error difference for each period (Armi et al., 2019).

The formula used to calculate MAE is:

MAD = (Σ | Xt-Ft |) / n ..... (11)

Information :
Xt = Actual data for period t
Ft = forecasting data for period t
n = amount of data

MAPE (Mean Absolute Percentage Error)

Mean Absolute Percentage Error (MAPE) is the calculation of error using the average absolute error of each period against the actual data and the resulting value in the form of a percentage (Pakpahan et al., 2020).

The formula used to calculate MAPE is:

MAPE = Σ (| Xt-Ft |) / Xt (100%) / n ..... (12)

Information :
Xt = Actual data for period t
Ft = forecasting data for period t
n = amount of data

MSE (Mean Square Error)

Mean Square Error (MSE) is an error calculation used to assess errors for more extreme deviations by anticipating the existence of positive and negative values that weaken each other or add to the calculation of errors in the addition by providing an absolute value for each difference in error for each period which is then squared (Armi et al., 2019).

The formula used to calculate MSE is:

MSE = (Σ | Xt-Ft | ^ 2) / n ..... (13)

Information :
Xt = Actual data for period t
Ft = forecasting data for period t
n = amount of data

SDLC (System Development Life Cycle) Method

The System Development Life Cycle (SDLC) is a classic methodology used to develop, maintain and use information systems. The system life cycle is also a methodology in itself, but the pattern is more influenced by the need to develop a faster system. Faster system development can be achieved by increasing the life cycle and the use of computer-based development tools (Wahyudi, 2018).

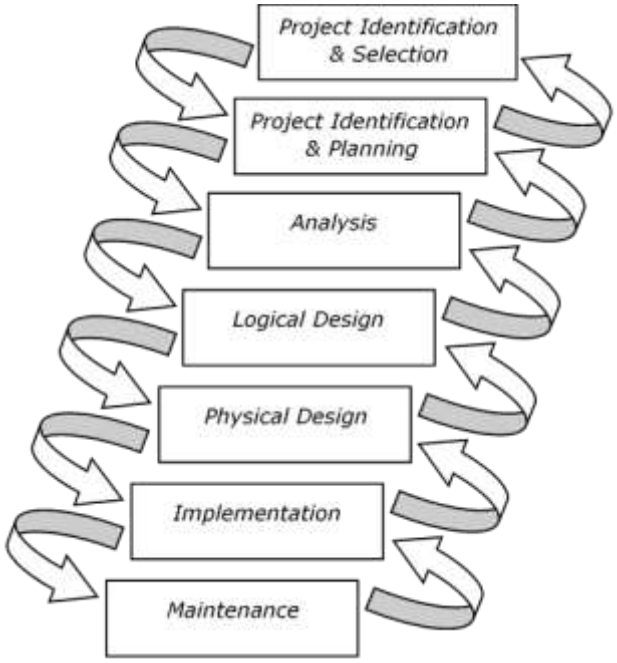

Figure 1. Stages in System Development Life Cycle (SDLC)
(Source: Yunarto, 2018)

Research Stages

In this study, researchers conducted interviews with the section head section of the RRO PT. Capella Dinamik Nusantara to collect Purchase Order Indent data that will be used for research. The data obtained is still mixed data containing various kinds of goods and must be processed into sales data per monthly period. After the data is processed, then the data can be used to forecast the number of items that must be ordered in the next period using the Exponential Smoothing method. As a reference for the accuracy of forecasts, error checking is carried out using the MAD, MAPE and MSE methods with the smallest value as the value for better forecasting.

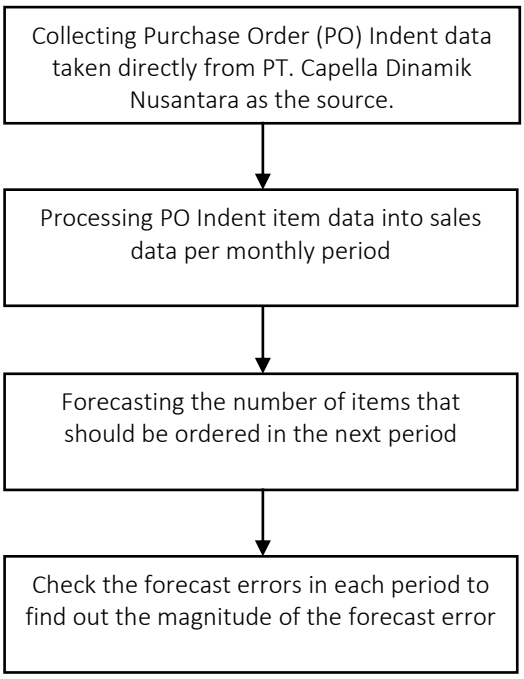

Figure 2. Research Stages

3.0 RESULTS AND DISCUSSION

Tested Data

The data to be tested in this study were obtained directly from the section head of PT. Capella Dinamik Nusantara, the Parts RRO, which is then processed into data for the total quantity of goods 91005KVBN50 (BRG, COMP DRIVE SHAFT) ordered in Purchase Order Indents per month.

Table 2. PO Indent Quantity Table Part 91005KVBN50 in Months

Month	*Qty* (Pcs)
January 2017	186
February 2017	144
March 2017	209
April 2017	134
May 2017	206
June 2017	374
July 2017	138
August 2017	136
September 2017	162
October 2017	640
November 2017	529
December 2017	321
January 2018	981
February 2018	1254
March 2018	1118
April 2018	1249
May 2018	959

Month	*Qty* (Pcs)
June 2018	521
July 2018	1660
August 2018	1626
September 2018	1473
October 2018	1615
November 2018	1775
December 2018	1014
January 2019	3324
February 2019	7062
March 2019	2659
April 2019	2811
May 2019	3187
June 2019	1908
July 2019	3892
August 2019	2755
September 2019	3124
October 2019	3148
November 2019	2636
December 2019	2315

(Source: PT. Capella Dinamik Nusantara)

Calculation of the Exponential Smoothing Method

For the Exponential Smoothing method, this system uses sales data and forecasts for the previous 1 period, the forecast calculation uses the weight determined by the user later.

Example:
The following is presented the data from the Exponential Smoothing forecasting with a weight value of 0.5:

Table 3. Exponential Smoothing Forecasting

Month	*Qty* (y)	*Exponential Smoothing*
January 2017	186	0
February 2017	144	186
March 2017	209	165
April 2017	134	187
May 2017	206	160,5
June 2017	374	183,25
July 2017	138	278,625
August 2017	136	208,3125
September 2017	162	172,15625
October 2017	640	167,078125
November 2017	529	403,5390625
December 2017	321	466,2695313
January 2018	981	393,6347656

Month	*Qty* (y)	*Exponential Smoothing*
February 2018	1254	687,3173828
March 2018	1118	970,6586914
April 2018	1249	1044,329346
May 2018	959	1146,664673
June 2018	521	1052,832336
July 2018	1660	786,9161682
August 2018	1626	1223,458084
September 2018	1473	1424,729042
October 2018	1615	1448,864521
November 2018	1775	1531,932261
December 2018	1014	1653,46613
January 2019	3324	1333,733065
February 2019	7062	2328,866533
March 2019	2659	4695,433266
April 2019	2811	3677,216633
May 2019	3187	3244,108317
June 2019	1908	3215,554158
July 2019	3892	2561,777079
August 2019	2755	3226,88854
September 2019	3124	2990,94427
October 2019	3148	3057,472135
November 2019	2636	3102,736067
December 2019	2315	2869,368034

Exponential Smoothing Calculation:

For February 2017 forecasting, the value is obtained from the actual data for January 2017 as a benchmark for the previous forecast value in March 2017.

Smar-17 = α * Xfeb-17 + (1 - α) Sfeb-17
Smar-17 = (0.5 * 144) + (1-0.5) * 186
Smar17 = 165

And so on until December 2019 with the total to be ordered is 52246.63197 with forecasting data of 36.
Then for the calculation of the error using MAD, MAPE and MSD per each sales period:

- MAD
MAD = (Σ | Actual - Forecasting |) / n
MAD = 20163.63091 / 36
MAD = 560,1008585

- MAPE
MAPE = (Σ | (Actual - Forecasting) / Actual |) / n * 100%
MAPE = 13,9573818 / 36 * 100%
MAPE = 38.77%

- MSD
MSD = (Σ | Actual - Forecasting | ^ 2) / n

MSD = 38352506.1 / 36
MSD = 1065347,392
In the above calculation, I use a weight of 0.5 where this weight is the weight of the middle value that is not too partial to the actual data or in favor of the previous forecast data. Based on the above calculations, the forecast results obtained in March 2017 amounted to 165 and if it is carried out continuously until December 2019 we can perform error calculations to ensure the accuracy of the data forecast with more data (more data, the more accurate calculation of errors) and the results of the calculation of the MAD error = 560,1008585; MAPE = 38.77%; MSD = 1065347,392.

Comparison of the Exponential Smoothing Method with Other Methods

The following table shows the results of forecasting part 91005KVBN50 data (BRG, COMP DRIVE SHAFT) with the calculation of the error with the Exponential Smoothing method and other methods:

Table 4. Comparison Forecasting

Month	Qty (y)	Quadratic	Exp Smth 0,5	2 Exp Smth 0,5
January 2017	186	0	0	0
February 2017	144	1822,443194	186	186
March 2017	209	1329,205572	165	144
April 2017	134	871,1422943	187	198,5
May 2017	206	448,2533609	160,5	139,75
June 2017	374	60,53877177	183,25	195,625
July 2017	138	-292,001473	278,625	380,1875
August 2017	136	-609,3673735	208,3125	188,78125
September 2017	162	-891,5589297	172,15625	126,234375
October 2017	640	-1138,576142	167,078125	139,0390625
November 2017	529	-1350,419009	403,5390625	625,9804688
December 2017	321	-1527,087532	466,2695313	640,2207031
January 2018	981	-1668,581711	393,6347656	407,9755859
February 2018	1254	-1774,901546	687,3173828	988,1704102
March 2018	1118	-1846,047036	970,6586914	1404,426514
April 2018	1249	-1882,018182	1044,329346	1334,883911
May 2018	959	-1882,814984	1146,664673	1394,277283
June 2018	521	-1848,437441	1052,832336	1082,806305
July 2018	1660	-1778,885555	786,9161682	535,9869843
August 2018	1626	-1674,159323	1223,458084	1534,535408
September 2018	1473	-1534,258748	1424,729042	1781,538662
October 2018	1615	-1359,183828	1448,864521	1651,40481
November 2018	1775	-1148,934564	1531,932261	1716,270144
December 2018	1014	-903,5109553	1653,46613	1867,168942
January 2019	3324	-622,9130025	1333,733065	1120,851406
February 2019	7062	-307,1407054	2328,866533	3217,55917
March 2019	2659	43,80593597	4695,433266	7506,346319
April 2019	2811	429,9269217	3677,216633	4064,456526
May 2019	3187	851,2222517	3244,108317	3004,619947
June 2019	1908	1307,691926	3215,554158	3067,255815

Month	Qty (y)	Quadratic	Exp Smth 0,5	2 Exp Smth 0,5
July 2019	3892	1799,335945	2561,777079	1833,850828
August 2019	2755	2326,154308	3226,88854	3528,036875
September 2019	3124	2888,147015	2990,94427	2905,574168
October 2019	3148	3485,314066	3057,472135	3081,314949
November 2019	2636	4117,655462	3102,736067	3159,921407
December 2019	2315	4785,171203	2869,368034	2664,59267
Total	57245	525,2101855	52246,63197	57818,1434

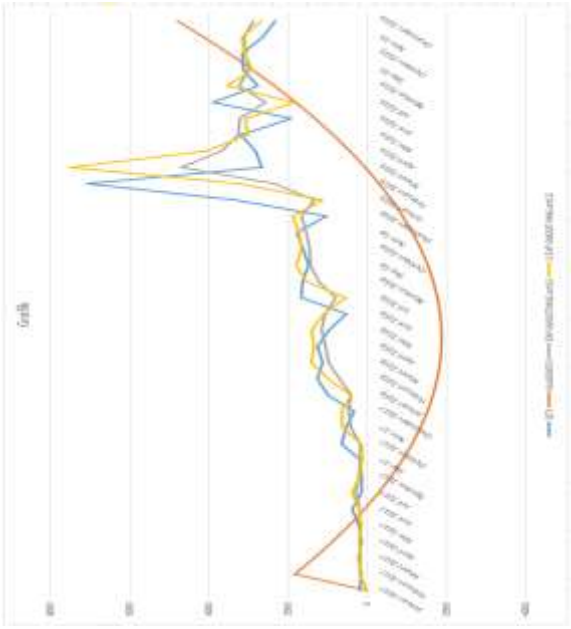

Figure 3. Method Comparison Chart

Table 5. Comparison of Error Calculation Table

Type	Quadratic	Exp Smth 0,5	2 Exp Smth 0,5
MAD	1922,984837	560,1008585	666,9563478
MAPE	260,29%	38,77%	47,48%
MSD	5535945,62	1065347,392	1526671,816

From the comparison chart of the methods that have been presented, we can clearly see that the quadratic trend method is not very suitable for the stock forecasting system because with the quadratic trend method, forecasting that was initially positive can become minus and return to positive in the form of a parabola, this of course cannot be applied in stock forecasting system because the forecasting results are very far from accurate when viewed from the error calculation table, while for the Double Exponential Smoothing method from the graph we can see that the forecasting results are too close to the actual previous sales data, of course this is not good because if sales are in one month suddenly increases drastically, then the forecasting for the next month using the Double Exponential Smoothing method will follow the actual sales data too much, so if sales in one month suddenly decline drastically, then the forecast also drops drastically, so if suddenly the next month's sales tnya continue to increase or decrease this will result in losses due to too much or too little stock. For the Exponential Smoothing method, we can see that

the graph does not really follow the actual sales data, so that if there is an increase in sales in a month or a decrease in sales, the forecast will remain stable, not closely following the actual data, so the stock will remain stable.

Table 6. Exponential Smoothing Weight Comparison Forecasting

Weight	MAD	MAPE	MSE
0,1	683,769315	40,80%	1476851,947
0,2	536,7793949	36,02%	1114566,083
0,3	532,4144054	36,67%	1042206,103
0,4	547,2744575	37,93%	1040214,607
0,5	560,1008585	38,77%	1065347,392
0,6	569,843052	39,30%	1105173,016
0,7	583,6362701	40,16%	1155795,719
0,8	598,4195521	41,20%	1216607,043
0,9	610,6246129	42,21%	1288430,343

Table 7. Double Exponential Smoothing Weight Comparison Forecasting

Weight	MAD	MAPE	MSE
0,1	549,5251433	37,12%	1067902,837
0,2	590,6494479	40,71%	1075802,045
0,3	605,7376206	42,43%	1179682,35
0,4	639,4147166	44,84%	1332541,965
0,5	666,9563478	47,48%	1526671,816
0,6	699,965007	49,82%	1767863,078
0,7	749,7196103	53,60%	2071856,622
0,8	843,5564113	59,84%	2462845,809
0,9	942,94718	66,13%	2974069,638

Based on the error comparison calculation table that has been presented, by comparing the MAD and MAPE values which are smaller, we can see that the Exponential Smoothing method has the lowest error calculation. Even giving weight to the Exponential Smoothing method has a smaller risk than the Double Exponential Smoothing method.

Program Module

Login Page

This page is the page that the user will see for the first time before accessing the program and requires access rights to access the program.

Figure 4. Login Page

Main Menu Page

This page is the page that the user will see for the first time after accessing the program.

Figure 5. Main Menu Page

Part Data Input Page

This page is the page where the administrator inputs part data into the database.

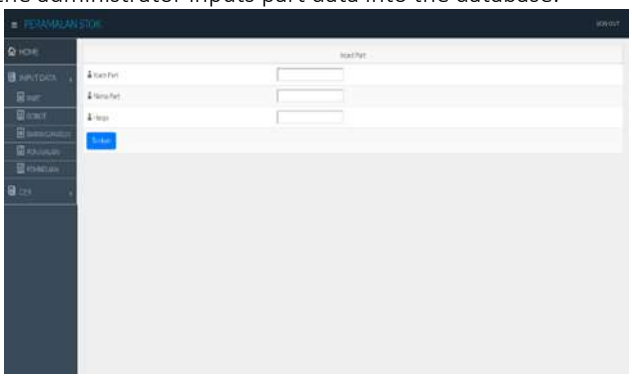

Figure 6. Part Data Input Page

Weight Data Input Page

This page is the page where the administrator will input the weight data into the database.

Figure 7. Weight Data Input Page

Incoming Goods Data Input Page

This page is the page where the administrator will input goods data into the database.

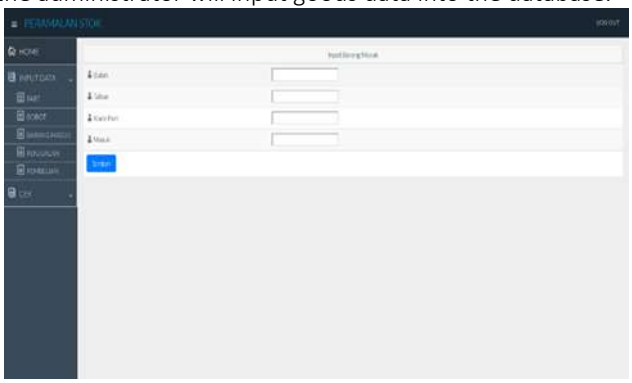

Figure 8. Incoming Goods Data Input Page

Purchase Data Input Page

This page is a page where the administrator can input purchase data into the database.

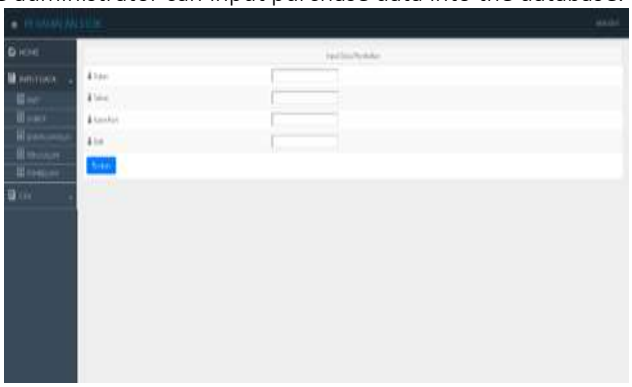

Figure 9. Puchase Data Input Page

Sales Data Input Page

This page is the page where the administrator will input sales data into the database.

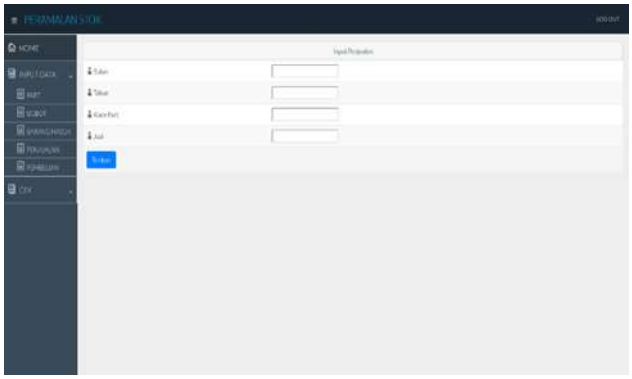

Figure 10. Sales Data Input Page

Part Analysis Page

This page is a page where the results of a spare part analysis are displayed. This page displays stock data, incoming quantities, sales, forecasts and purchase recommendations for a spare part in one year period.

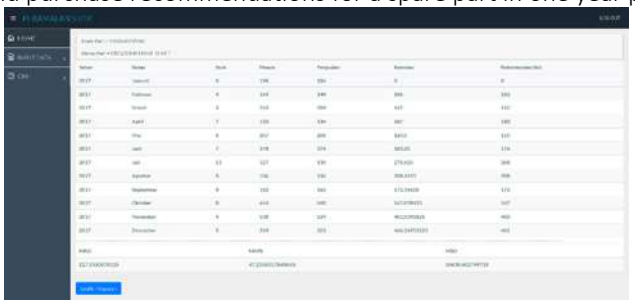

Figure 11. Part Analysis Page

Chart Page

This page is a page where the analysis results in the form of sales data and forecasting data are displayed in a graph over a period of a year.

Figure 12. Chart Page

4.0 CONCLUSION

1. Based on the research that has been done, the results of the analysis show that the Exponential Smoothing method is more suitable for forecasting stock at Parts RRO PT. Capella Dinamik Nusantara with a lower risk of error value than the Quadratic and Double Exponential Smoothing methods of using any weight value.
2. With the creation of this Decision Support System, complex forecast calculations with a lot of data, sales data, order data and forecasting results can be processed quickly and displayed in the form of reports, so as to shorten the analysis time which is usually done manually.

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