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Chicken Menu Sales Forecasting System using Multiplicative Holt-Winters Triple Exponential Smoothing

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***Abstract*— Forecasting is an art and a science predict events that will occur in the future based on data in the past. The ability of the restaurant in Management shows success in taking advantage of business opportunities optimal for interpreting past performance and planning for the future. This research uses Triple HoltWinters Exponential Smoothing Multiplicative method for sales forecasting. Multiplicative Holt-Winters Triple Exponential Smoothing Method has the smallest percentage error (PE) of 9.946% with parameter values (α=0.1, β=0.1, ϒ=0.3). While the largest percentage error (PE) is obtained Multiplicative models with parameter values (α=0.3, β=0.3, ϒ=0.1) produce percentage error (PE) value of 11.879%. Menu sales forecasting results chickens using the Holt-Winters Triple Exponential Smoothing Method Multiplicative in the next month using parameter values (α=0.1, β=0.1, ϒ=0.3) is 4782 pcs.**

***Index Terms*—forecasting; Multiplicative Holt-Winters sales; Triple Exponential Smoothing**

I. INTRODUCTION

The rapidly growing business world requires restaurants to be able to analyze conditions and predict various possibilities in the future. Forecasting is the art and science of predicting future events based on past data [1]. The ability of the restaurant in management demonstrated success in utilizing optimal business opportunities to interpret past performance and plan for the future.

Restaurants that sell various menus of processed chicken in Indonesia too growing very much. Lazizaa Chicken is a fastfood restaurant that sells various menus of processed chicken meat in Indonesia.

Storage of chicken raw materials also affects the quality of the food products that will be produced [2]. The forecasting process certainly has an effect on the sales process. The restaurant must provide more stock of raw materials if customer demand increases [3]. Therefore, careful planning is needed for restaurants to estimate sales and customer demand so that raw material stocks are not lacking or excess.

Forecasting is an art and a science predict events that will occur in the future based on data in the past [1]. The ability of the restaurant in Management shows success in taking advantage of business opportunities optimal for interpreting past performance and planning for the future. This is expected to generate profits and sales accordingly target. Sales forecasting for a restaurant is very useful to know the amount of current or future sales in order to be able to make decisions or decisions according to forecast results.

There are various kinds of forecasting methods or forecasting one of them is Triple Exponential Smoothing Holt-Winters method. Holt-Winters method is the nickname for the Triple Exponential Smoothing method where to produce forecast data, smoothing is carried out three times. The advantages of Holt-Winter's Triple Exponential Smoothing method, this method is very good to predict a data that tends to change on certain periods such as certain seasonal influences with trend elements that arise simultaneously [4].

The choice of the Exponential Smoothing method is a forecasting method influenced from various aspects such as the level of forecasting accuracy. As for the previous researcher, [5] has made forecasts the price of broiler chicken meat in Banyuwangi district. This study used the backpropagation neural network method with a MAPE result of 18.016% and the Multiplicative Holt-Winters model with three components of smoothing parameters. The results show that the model Multiplicative Holt-Winters is able to minimize the percentage of errors better with a MAPE of 12.63%.

Research with the Triple Exponential Smoothing Holt-Winters method has been applied by [6] by forecasting sales in the snack food industry. The data used in this study is Pigela kepok banana chip snack

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sales from January 2016 to December 2020. The forecasting method used in the study this is the Holt-Winters method with a multiplicative and additive model. Results the research produced the smallest MAPE of 8.3% in the Holt-Winters Method multiplicative for α = 0.9, β = 0, and γ = 0.5.

In addition, a comparison study was also conducted by forecasting the number of airplane passengers at the airport Ahmad Yani International. The method used is Holt Winter's method Exponential Smoothing additive and Exponential Smoothing Event Based method. The type of data used is secondary data of PT. Angkasa Pura I (Persero) from January 2013 to December 2019. The research results show that Holt Winter's Exponential Smoothing method is better than MSE 619,998,718 and the MAPE value is 5.644139% compared to the method Exponential Smoothing Event Based which has an MSE of 988,824,976 and MAPE 7.28151% [7].

II. MATERIALS

A. Forecasting

Forecasting is the art and science of predicting future events based on things in the past. Mathematically, forecasting is done based on past data which is then analyzed by a certain method. Past data is collected, studied, then analyzed based on time [8].

Forecasting is used to reduce the risk of uncertainty in future data by analyzing past data naturally. The forecasting function is to assist planning and decision making in the future [9]. Forecasting method is a systematic way of thinking to predict something quantitatively on the basis of relevant data in the past. The forecasting approach can be used in terms of past data analysis. [1].

Forecasting methods are divided in qualitative methods and quantitative methods. In the qualitative method, the opinions of experts are taken into consideration in making prediction decisions. Meanwhile, the quantitative method is forecasting using past information that can be quantified in the form of numerical data [10].

B. Holt-Winter's Triple Exponential Smoothing Method

Exponential Smoothing is a forecasting method for estimating events that will occur in the future by means of a smoothing process to produce forecast data by paying attention to small error values. The Holt-Winters method is a nickname for the Triple Exponential Smoothing method where to produce forecast data smoothing is done three times. The advantage of the Triple Exponential Smoothing Holt-Winter's method is that this method is very good for predicting data that tends to fluctuate and experience changes in certain periods such as certain seasonal influences with trend elements that occur together. This method is also easy to put into practice to complex forecasting models [4].

Holt-Winter's Triple Exponential Smoothing Method was used for overcome the problem of forecasting seasonal data and/or no trend of a data. Forecasting with this method generally does not always have to be on a constant time series data [11]. This method uses three smoothing parameters, namely α (for the level of the process), β (for trend elements), and γ (for seasonal elements) with values between 0 to 1 for each optimal parameter [12]. An alternative method that can reduce doubts about the optimal value is to find the three parameters around 0.1 to 0.3. A value of 0.1 makes the forecast too careful and a value of 0.3 gives a more responsive system [13]. The smoothing equation used in the Holt-Winter's Triple Exponential Smoothing method is level, trend, and seasonality (Sudheer & Suseelatha, 2015).

The use of each method depends on the parameters α, β, and γ. These parameters can affect the value of forecasting accuracy results [3]. Holt-Winter's model uses two approaches as follows:

a. Holt Winter's Multiplicative Model

In this model, seasonal data variations from time series data experience an increase or decrease that is not constant or fluctuations that appear to change. The calculation of the smoothing value equation using this model is as follows:

Calculation of the smoothing equation for the level

$$Lt = \alpha\ (StY{-}t\ s) + (1 - \alpha)(Lt{-}1 + bt{-}1) \quad (1)$$

Calculation of the smoothing equation for the trend

$$bt = \beta(Lt - Lt{-}1) + (1 - \beta)bt{-}1 \quad (2)$$

Calculation of the smoothing equation for seasonal

$$St = \gamma\ (LYtt) + (1 - \gamma)\ St{-}s \quad (3)$$

Forecasting for m periods ahead

$$Ft{+}m = (Lt + mbt)St{+}m{-}s \quad (4)$$

b. Model Holt-Winter's Aditif

In this model, seasonal data variations from constant and fluctuating time series data are relatively stable. The calculation of the smoothing value equation using this model is as follows:

Calculation of the smoothing equation for the level

$$Lt = \alpha\ (Yt - St{-}s) + (1 - \alpha)(Lt{-}1 + bt{-}1) \quad (5)$$

Calculation of the smoothing equation for the trend

$$bt = \beta(Lt - Lt{-}1) + (1 - \beta)bt{-}1 \quad (6)$$

Calculation of the smoothing equation for seasonal

$$St = \gamma\ (Yt - Lt) + (1 - \gamma)\ St{-}s \quad (7)$$

Forecasting for m periods ahead

$$Ft{+}m = Lt + mbt + St{+}m{-}s \quad (8)$$

The calculation is done by calculating the average of the actual data from the season value which is determined as follows:

$$L_S = 1/s\ (Y_1 + Y_2 + \cdots + Y_S\ ) \quad (9)$$

III. METHOD

The research design on the chicken sales forecasting system is shown in Figure 1 as follows:

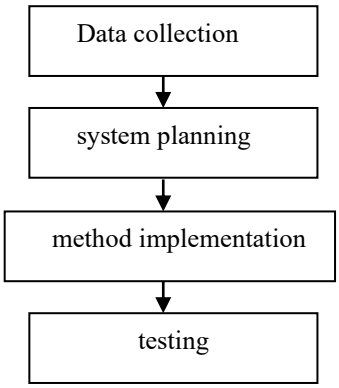

Fig 1. Research Method

A. Data Collection

The method used in this study was by observing chicken sales data at one of the Lazizaa Chicken branches, namely at Lazizaa Probolinggo branch. The calculation test data used in the research is sales data from January 2020 to December 2022.

Tabel 1. Sales Data

Period	Sales
Jan 2020	4324
Feb 2020	4210
Mar 2020	4043
Apr 2020	2954
May 2020	3827
Jun 2020	2803
Jul 2020	2915
Augst 2020	2956
Sept 2020	3439
Oct 2020	3706
Nov 2020	3738
Dec 2020	3993
Jan 2021	4136
Feb 2021	3409
Mar 2021	3807
Apr 2021	3294
May 2021	4226
Jun 2021	2938
Jul 2021	2989
Augst 2021	3095
Sept 2021	3494
Oct 2021	3901
Nov 2021	3951
Dec 2021	4245
Jan 2022	3982
Feb 2022	3351
Mar 2022	3545
Apr 2022	3568
May 2022	4327
Jun 2022	3406
Jul 2022	3527
Augst 2022	3556
Sept 2022	3603
Oct 2022	3985
Nov 2022	3994
Dec 2022	4327

Data to be used as input for calculating the initial value is the first year of data in the data sales from January 2020 to December 2020. Result Value of the initial data used to find the Forecast value for the next year. Calculated forecast value from January 2021 to December 2022. The results of the forecast value will be later will go into testing. Testing is done by calculating the value percentage error using MAPE.

B. System Planning

Chicken sales forecasting system design shown in Figure 2:

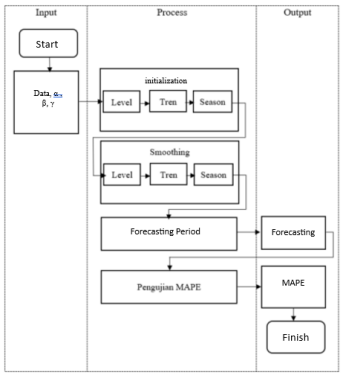

Fig. 2. System Design

The first process is in the form inputting chicken sales data during a certain period in one restaurant Laziza's chicken. Then determine the parameter values α (alpha), β (beta), and ϒ (gamma) from the value range 0.1 to 0.3. The data that has been entered will be entered into the exponential initialization process to determine levels, trends and seasons beginning by using the multiplicative and additive model formulation. After that, The next stage is the exponential smoothing process, estimating levels, trends and season by using the multiplicative and additive model formulation. After the exponential smoothing process then forecasts the period for t for forecasting. After the results of forecasting have been done, then search the smallest forecasting accuracy value using MAPE with optimum parameters. After each smallest MAPE is found in the model formulation Multiplicative and Additive are then compared which model has the accuracy smaller. The final result is the result of forecasting sales for a certain period with optimal parameters.

IV. RESULT AND DISCUSSION

A. Scenario Testing

This research is done for find out how big the percentage error rate is from the Triple Exponential method Smoothing Holt-Winters both Multiplicative and Additive models in sales the chicken at Lazizaa. Measuring the error rate on the menu sales forecasting system chickens using MAPE (Mean Absolute Percentage Error) value calculations.

The test is carried out by calculating the MAPE value to measure determination relative based on the absolute value used to determine the percentage deviation of forecasting results with actual data then multiplied by one hundred and average percentage error.

Each forecasting results from the Holt-Winter's model is tested by calculating the MAPE value.

The smaller the average percentage value of MAPE, the better the model forecasting method implemented. The size of the MAPE value too influenced by the constant values of parameters α (alpha), β (beta), and ϒ (gamma)
used in forecasting. The constant value used in the combination parameters range from 0.1 – 0.3. The value of the selected parameter combination in forecasting is the optimal parameter that produces the smallest MAPE value The test is carried out with a combination of 3 parameter values α (alpha), β (beta), and ϒ (gamma) with a value range of 0.1 to 0.3. There are combinations in each the Holt-Winter's model, where later the smallest MAPE value will be compared between one another. The MAPE calculation process uses chicken sales data per pieces (pcs).

B. Testing the Multiplicative Model Holt-Winters Method

The initial stage in testing the percentage of error values in the system chicken menu sales forecasting using the Triple Exponential method Holt-Winters Smoothing Multiplicative model, namely looking for forecast values at each combination of predetermined parameter values. The calculation results forecast value with parameter values (α=0.1, β=0.1, ϒ=0.1) on menu sales chickens are shown in table 4.2 Forecast values starting from January 2021 until December 2022. The results of the forecast value will later be included MAPE calculation test.

Table 2 Multiplicative Model Calculation Results (α=0.1, β=0.1, ϒ=0.1)

Month - Year	Sales	Level	Trend	Seasonal
Jan 2020	4324	1.32		
Feb 2020	4210	1.24		
Mar 2020	4043	1.11		
Apr 2020	2954	0.81		
May 2020	3827	1.05		
Jun 2020	2803	0.77		
Jul 2020	2915	0.8		
Augs 2020	2956	0.81		
Sept 2020	3439	0.94		
Oct 2020	3706	1.02		
Nov 2020	3738	1.03		
Dec 2020	3993	3642.33	-1.55	1.1
Jan 2021	4136	3588.99	-6.73	1.31
Feb 2021	3409	3499.35	-15.02	1.21
Mar 2021	3807	3478.87	-15.57	1.11
Apr 2021	3294	3523.13	-9.58	0.82
May 2021	4226	3564.4	-4.5	1.06
Jun 2021	2938	3585.69	-1.92	0.77
Jul 2021	2989	3598.88	-0.41	0.8
Augs 2021	3095	3619.98	1.74	0.82
Sept 2021	3494	3629.61	2.53	0.95
Oct 2021	3901	3652.33	4.55	1.02
Nov 2021	3951	3676.18	6.48	1.03
Dec 2021	4245	3701.61	8.38	1.1
Jan 2022	3982	3643.6	1.74	1.29
Feb 2022	3351	3557.33	-7.06	1.18
Mar 2022	3545	3515.06	-10.58	1.1
Apr 2022	3568	3587.35	-2.3	0.84
May 2022	4327	3633.15	2.51	1.08
Jun 2022	3406	3711.84	10.13	0.79
Jul 2022	3527	3788.82	16.81	0.82
Augs 2022	3556	3860.9	22.34	0.83
Sept 2022	3603	3875.78	21.6	0.94
Oct 2022	3985	3897.35	21.59	1.02
Nov 2022	3994	3914.4	21.14	1.03
Dec 2022	4327	3934.87	21.07	1.1

Based on Table 2 it can be seen the results of the forecast value on the chicken menu forecast from January 2021 to December 2022. Monthly sales data January 2020 to December 2020 is used for starting value calculations. From calculation results with parameter values (α=0.1, β=0.1, ϒ=0.1) on sales the chicken menu can be illustrated by actual data graphs with forecast data.

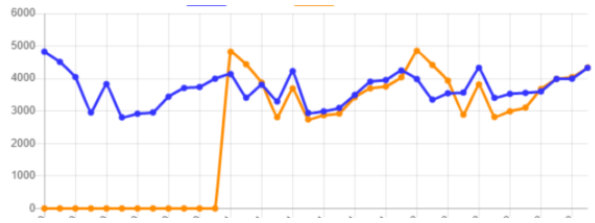

Fig. 3. Graph of the Multiplicative Model (α=0.1, β=0.1, ϒ=0.1)

Figure 3 shows a graph of the results of forecasting chicken menu sales with Multiplicative Holt-Winters Triple Exponential Smoothing method. From The graph shows the difference between the actual value of sales data and the forecast value sale of chicken menu. The forecast value is calculated from January 2021 to December 2022. The results of forecast values and actual values are used to calculate values MAPE percentage. The following is the result of calculating the MAPE value with parameters (α=0.1, β=0.1, ϒ=0.1).

Table 3 MAPE (α=0.1, β=0.1, ϒ=0.1)

Month - Year	Sales	Forecast	MAPE
Jan 2021	4136	4822	16.586
Feb 2021	3409	4436	30.126
Mar 2021	3807	3868	1.602
Apr 2021	3294	2809	14.724
May 2021	4226	3692	12.636
Jun 2021	2938	2740	6.739
Jul 2021	2989	2868	4.048
Augs 2021	3095	2920	5.654
Sept 2021	3494	3420	2.118
Oct 2021	3901	3696	5.255
Nov 2021	3951	3753	5.011
Dec 2021	4245	4850	4.9
Jan 2022	3982	4417	21.798
Feb 2022	3351	3935	31.811
Mar 2022	3545	2886	11.001
Apr 2022	3568	3815	19.114
May 2022	4327	2816	11.833
Jun 2022	3406	2990	17.322
Jul 2022	3527	3105	15.225
Augs 2022	3556	3674	12.683
Sept 2022	3603	3985	1.971
Oct 2022	3985	4041	0
Nov 2022	3994	4334	1.177
Dec 2022	4327	4850	0.162

From the results of the MAPE test using parameter values (α=0.1, β=0.1, ϒ=0.1) produces a MAPE value with an average error percentage of 10.562%. For the

next experiment uses different parameters with a value of α = 0.2. The results of calculating forecast values with parameter values (α=0.2, β=0.1, ϒ=0.1) on chicken menu sales are shown in table 4.4. The results of the forecast value later will be included in the MAPE calculation test.

Table 4 Multiplicative Model Calculation Results (α=0.2, β=0.1, ϒ=0.1)

Month - Year	Sales	Level	Trend	Seasonal
Jan 2020	4324	1.32		
Feb 2020	4210	1.24		
Mar 2020	4043	1.11		
Apr 2020	2954	0.81		
May 2020	3827	1.05		
Jun 2020	2803	0.77		
Jul 2020	2915	0.8		
Augs 2020	2956	0.81		
Sept 2020	3439	0.94		
Oct 2020	3706	1.02		
Nov 2020	3738	1.03		
Dec 2020	3993	3642.33	-1.55	1.1
Jan 2021	4136	3537.2	-11.91	1.31
Feb 2021	3409	3370.86	-27.35	1.22
Mar 2021	3807	3360.76	-25.63	1.11
Apr 2021	3294	3480.42	-11.1	0.82
May 2021	4226	3579.87	-0.04	1.06
Jun 2021	2938	3627.42	4.72	0.77
Jul 2021	2989	3652.66	6.77	0.8
Augs 2021	3095	3690.27	9.85	0.81
Sept 2021	3494	3700.22	9.86	0.94
Oct 2021	3901	3734.86	12.34	1.02
Nov 2021	3951	3767.74	14.39	1.03
Dec 2021	4245	3800.14	16.2	1.1
Jan 2022	3982	3661.52	0.71	1.29
Feb 2022	3351	3481.15	-17.39	1.19
Mar 2022	3545	3408.43	-22.93	1.11
Apr 2022	3568	3573.84	-4.09	0.84
May 2022	4327	3669.39	5.87	1.08
Jun 2022	3406	3820.76	20.42	0.79
Jul 2022	3527	3952.38	31.54	0.81
Augs 2022	3556	4060.54	39.2	0.82
Sept 2022	3603	4043	33.53	0.94
Oct 2022	3985	4042.45	30.12	1.02
Nov 2022	3994	4034.72	26.34	1.02
Dec 2022	4327	4036.75	23.91	1.1

Based on Table 4 it can be seen the results of the forecast value on the chicken menu forecast from January 2021 to December 2022. Monthly sales data January 2020 to December 2020 is used for starting value calculations. Results calculation with parameter values (α=0.2, β=0.1, ϒ=0.1) on menu sales chickens can be described graph of actual data with forecast data.

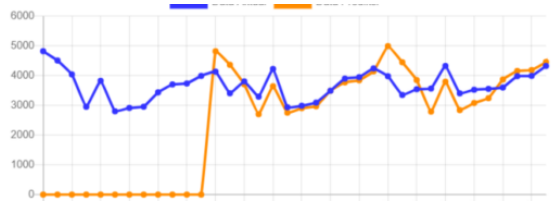

Fig. 4. Graph of the Multiplicative Model (α=0.2, β=0.1, ϒ=0.1)

Figure 4.2 shows a graph of the results of forecasting chicken menu sales with Multiplicative Holt-Winters Triple Exponential Smoothing method. From The graph shows the difference between the actual value of sales data and the forecast value sale of chicken menu. The forecast value is calculated from January 2021 to December 2022. The results of the forecast value and the actual value are used to calculate the test MAPE percentage value. The following is the result of calculating the MAPE value with parameters (α=0.2, β=0.1, ϒ=0.1).

Table 5 MAPE (α=0.2, β=0.1, ϒ=0.1)

Month - Year	Sales	Forecast	MAPE
Jan 2021	4136	4822	16.586
Feb 2021	3409	4365	28.043
Mar 2021	3807	3711	2.522
Apr 2021	3294	2705	17.881
May 2021	4226	3645	13.748
Jun 2021	2938	2755	6.229
Jul 2021	2989	2907	2.743
Augs 2021	3095	2970	4.039
Sept 2021	3494	3494	0
Oct 2021	3901	3775	3.23
Nov 2021	3951	3846	2.658
Dec 2021	4245	4146	2.332
Jan 2022	3982	4995	25.439
Feb 2022	3351	4452	32.856
Mar 2022	3545	3853	8.688
Apr 2022	3568	2792	21.749
May 2022	4327	3797	12.249
Jun 2022	3406	2843	16.53
Jul 2022	3527	3081	12.645
Augs 2022	3556	3244	8.774
Sept 2022	3603	3871	7.438
Oct 2022	3985	4159	4.366
Nov 2022	3994	4189	4.882
Dec 2022	4327	4460	3.074

From the results of the MAPE test using parameter values (α=0.2, β=0.1, ϒ=0.1) produces a MAPE value of 10.779%. For subsequent trials there were a total of 27 combination of parameters that have been determined from the value range 0.1 – 0.3 in Triple Exponential Smoothing Holt-Winters Multiplicative model whose forecasting results available in the attachment. For MAPE test results on the Multiplicative model.

Table 6. MAPE Multiplicative Model

α	β	γ	MAPE
0.1	0.1	0.1	10.562
0.2	0.1	0.1	10.779
0.3	0.1	0.1	10.588
0.1	0.2	0.1	11.011
0.2	0.2	0.1	11.303
0.3	0.2	0.1	11.101
0.1	0.3	0.1	11.363
0.2	0.3	0.1	11.826
0.3	0.3	0.1	11.879
0.1	0.1	0.2	10.255
0.2	0.1	0.2	10.516
0.3	0.1	0.2	10.434
0.1	0.2	0.2	10.67
0.2	0.2	0.2	11.015
0.3	2	0.2	10.957
0.1	0.3	0.2	10.985
0.2	0.3	0.2	11.518
0.3	0.3	0.2	11.765

0.1	0.1	0.3	9.946
0.2	0.1	0.3	10.251
0.3	0.1	0.3	10.273
0.1	0.2	0.3	10.331
0.2	0.2	0.3	10.721
0.3	0.2	0.3	10.811
0.1	0.3	0.3	10.603

Based on Table 6 it can be concluded that the lowest MAPE value obtained in the Triple Exponential Smoothing Holt-Winters Multiplicative model with parameter values (α=0.1, β=0.1, ϒ=0.3) which produce MAPE values 9.946%. While the biggest value is obtained by Multiplicative model with parameters (α=0.3, β=0.3, ϒ=0.1) which produces a MAPE value of 11.879%.

V. CONCLUSION

Multiplicative Holt-Winters Triple Exponential Smoothing Method has the smallest percentage error (PE) of 9.946% with parameter values (α=0.1, β=0.1, ϒ=0.3). While the largest percentage error (PE) is obtained Multiplicative models with parameter values (α=0.3, β=0.3, ϒ=0.1) produce percentage error (PE) value of 11.879%. Menu sales forecasting results chickens using the Holt-Winters Triple Exponential Smoothing Method Multiplicative in the next month using parameter values (α=0.1, β=0.1, ϒ=0.3) is 4782 pcs.

The Triple Exponential Smoothing Holt-Winters method was successfully implemented into a chicken menu sales forecasting system that can be used as reference for the restaurant to be able to analyze conditions and estimate future possibilities such as estimating sales and customer requests so that raw material stocks are not lacking or excess.

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