Prediction of Safety Stock Using Fuzzy Time Series (FTS) and Technology of Radio Frequency Identification (RFID) for Stock Control at Vendor Managed Inventory (VMI)

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Abstract. This research was conducted by prediction of safety stock using Fuzzy Time Series (FTS) and technology of Radio Frequency Identification (RFID) for stock control at Vendor Managed Inventory (VMI). Well-controlled stock influenced company revenue and minimized cost. It discussed about information system of safety stock prediction developed through programming language of PHP. Input data consisted of demand got from automatic, online and real time acquisition using technology of RFID, then, sent to server and stored at online database. Furthermore, data of acquisition result was predicted by using algorithm of FTS applying universe of discourse defining and fuzzy sets determination. Fuzzy set result was continued to division process of universe of discourse in order to be to final step. Prediction result was displayed at information system dashboard developed. By using 60 data from demand data, prediction score was 450.331 and safety stock was 135.535. Prediction result was done by error deviation validation using Mean Square Percent Error of 15%. It proved that FTS was good enough in predicting demand and safety stock for stock control. For deeper analysis, researchers used data of demand and universe of discourse U varying at FTS to get various result based on test data used.

1 Introduction

Stock management is one of production process planning and controls whose purpose is to decrease total cost of stock material and stock level during lead time and acquisition cost. Management developing stock policy which can minimize operational total cost is the main purpose of planning and control. Stock management is an important factor in production process, one factor influencing stock management is demand prediction; demand fluctuation influences product stock and production activity greatly [1].

An important component of chained supply management is stock management. Stock management can spotlight prediction mistake and decision policy depending on demand having potential to prediction mistake. Prediction having the greatest influence to final user's decision can be used to develop demand prediction concept which can give significant influence to the improvement of a company profit [2].

Demand prediction in control management and production supply becomes interesting challenge to be researched because most of them work on data of time series as having been done to overcome problem prediction, like prediction in information system management, health care, economy prediction, selling prediction, budgeting analysis, stock exchange fluctuation, and business analysis, etc [3].

Fuzzy time series (FTS) can design problem of prediction having linguistic value with information having been long time. FTS also can use more observation in prediction having been applied to overcome non-linear. Based on theory of fuzzy compilation, FTS model came from Song and Chissom in 1993, FTS was used to predict the registration of Alabama University. Chen presents new model by using simple fuzzy relation and simple arithmetic calculation [4-5].

Fuzzy time series can predict product need for the next period and this prediction can be arranged based on time period needed. By integrating fuzzy time series to an information system to calculate ROP score of each product, the error average of ROP score got after being examined by using method of Average Forecasting Error Rate (AFER) was 7,13%. Fuzzy times series can predict the number of stock needed in stock room, report stock availability, and give goods stock information so high economy efficiency is got [6].

Time series is an ordered time series arranged from quantitative individual characteristics or collective phenomenon taken from time period successively. To understand time series characteristic, many researchers

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have adopted, analyzed, and developed time series method whose final purpose is to find pattern or formula that can be used to predict the future [7].

Radio Frequency Identification (RFID) technology is one technology used in supply chain management using modern. By using wireless technology, a company can track RFID tags easily without physical contact. RFID technology has been proven to be very useful in planning of production, transportation, and warehousing [8]

RFID can integrate into company business process so that it is possible for every entity marked can communicate with all organization information infrastructure, so it can enhance information of supply chain. In business technology process, RFID shows that it can operate in small and middle retail industry and can describe effect of RFID in business operation [9]

Vendor Managed Inventory (VMI) has very significant benefit for supply chain and each company. VMI gives competitive profit to retailer related to higher product availability provided by suppliers with the chance to increase production and marketing efficiency. VMI can increase fulfillment frequency with a small number and decrease stock level for all involved in distribution and supply chain. VMI can optimize supply chain performance in which the producer is in charge to keep distributor's stock level. Producer has access to distributor's stock data and is in charge to order [10-11].

2 Method

2.1 Data Acquisition

This acquisition data process on application of safety stock prediction using Fuzzy Time Series (FTS) and Radio Frequency Identification (RFID) technology for stock control at Vendor Managed Inventory (VMI) applies RFID censor technology which is censor detecting id tags put on the goods using radio waves and analyzed to be data time series stored at local database on microprocessor by using internet network, data of goods demand history is sent to web server and stored at online database then predicted by using fuzzy time series and used to determine safety stock. Data acquisition route is shown in Fig 1.

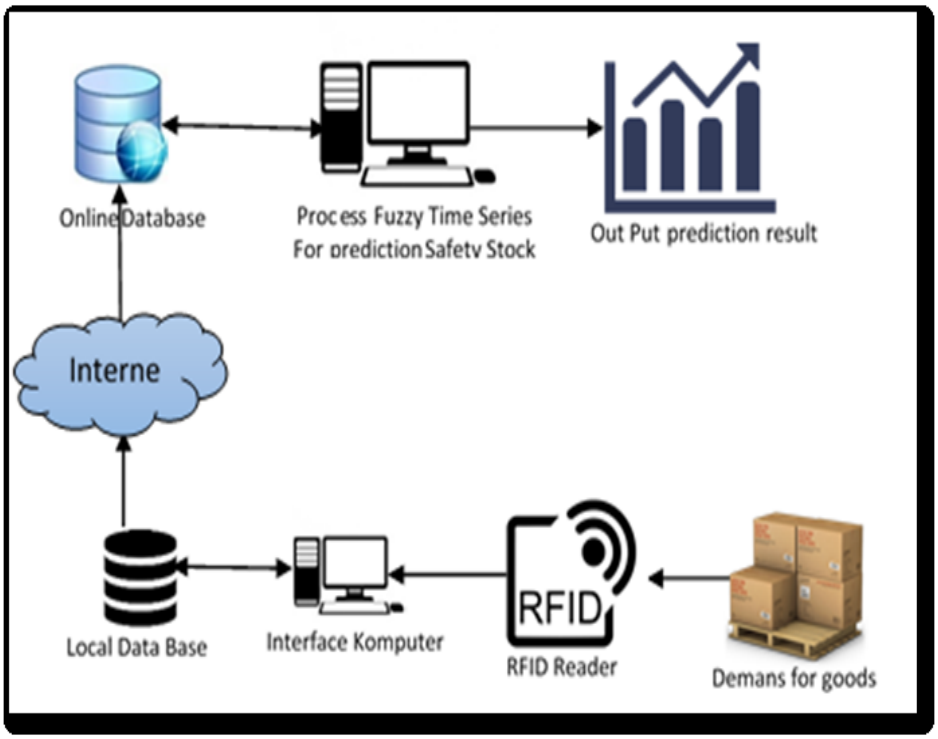

Fig. 1. Acquisition process route of goods demand data

2.2 Modelling by using fuzzy time series

Predicting by using fuzzy time series model is method of data prediction using principles of fuzzy whose base is catching formula of long time data then used to project the future data. Modelling of prediction by using fuzzy time series has some steps as follows :

1. Defining universe of discourse U until *f*uzzy set can be determined as U = [x, y].
2. Determining minimal and maximal score of actual history data (Xmin = x, Xmax = y).

3. Dividing universe of discourse U with some series of data u1, u2, …. un and determining linguistic score.
4. Doing fuzzification and fuzzy set from data of actual histories.
5. Calculating score of fuzzy data of actual history by using the following pattern :

$$\mu NB[x] = \frac{b-x}{b-a} \; 203659 \leq x \leq 471585 \qquad (1)$$

6. Choosing basis of model W which is very appropriate and calculating fuzzy using the following pattern:

$$r(MBF)^{w+1} = \frac{MBF1 + MBF2 + \cdots + MBFw}{w} \qquad (2)$$

7. Doing defuzzyfication of calculation result from the above step then, calculating prediction result by using the following pattern :

$$y = \frac{(A1 * c1 + A2 * c2)}{A1 + A2} \qquad (3)$$

$$v = r(NB) * A1 + r(NM) * A2 + \cdots + r(PB) * A7 \qquad (4)$$

$$Fi = y + v \qquad (5)$$

3 Results and Discussion

Data acquisition process on application of safety stock prediction using Fuzzy Time Series (FTS) and Radio Frequency Identification (RFID) technology for stock control at Vendor Managed Inventory (VMI) has some steps as follows:

a. Acquisition process of goods demand data
History data used to predict by using fuzzy time series is data of every month-actual demand data from PT. Quindo food, period of 2012 – 2016, with 60 data as sample taken from scan tag id on goods using censor technology of RFID as in table 1.

Table 1. Data of actual demand

No	Month	Year	Demand Number	Fuzzification
1	January	2012	382635	A5
2	February	2012	355766	A4
3	March	2012	325994	A4
4	April	2012	344349	A4
5	May	2012	362127	A5
6	June	2012	332272	A4
7	July	2012	344733	A4
8	August	2012	262136	A2
9	September	2012	371755	A5
10	October	2012	344931	A4
11	November	2012	360428	A5
12	December	2012	305567	A3
13	January	2013	398608	A6
14	February	2013	401103	A6
15	March	2013	410591	A6
16	April	2013	391991	A5
17	May	2013	373435	A5
18	June	2013	390023	A5
19	July	2013	415428	A6
20	August	2013	294396	A3
21	September	2013	417544	A6
22	October	2013	439641	A7
23	November	2013	422857	A6
24	December	2013	342836	A4
25	January	2014	366797	A5
26	February	2014	423950	A6
27	March	2014	463070	A7
28	April	2014	445420	A7
29	May	2014	452353	A7
30	June	2014	471585	A7
31	July	2014	327364	A4
32	August	2014	388073	A5
33	September	2014	459309	A7
34	October	2014	452508	A7
35	November	2014	425409	A6
36	December	2014	375814	A5
37	January	2015	339850	A4
38	February	2015	376973	A5
39	March	2015	376571	A5
40	April	2015	371001	A5
41	May	2015	304900	A3
42	June	2015	361767	A5
43	July	2015	278754	A2
44	August	2015	430953	A6
45	September	2015	425458	A6
46	October	2015	453944	A7
47	November	2015	394726	A5
48	December	2015	338991	A4
49	January	2016	287776	A3
50	February	2016	362668	A5
51	March	2016	440171	A7
52	April	2016	348626	A4
53	May	2016	339128	A4
54	June	2016	380019	A5
55	July	2016	203659	A1
56	August	2016	388847	A5
57	September	2016	423256	A6
58	October	2016	446611	A7
59	November	2016	450331	A7
60	December	2016	309796	A3

b. Defining universe of discourse U until fuzzy set can be determined. After actual data was calculated, so minimal and maximal score of sample data was obtained (Xmin = 203659, Xmax = 471585). Based on that score difference, universe of discourse U can be defined as U = [203659,471585].
c. Dividing universe of discourse U with some data series u1, u2, …, un, and calculate linguistic score. Firstly, universe of discourse U was divided into ke 7 intervals which have the same size, using the following way: Xmin + interval length. Interval length= (Xmax – Xmin) / 7, for example, 153 + ((471585 – 203659) / 7) = 38275. u1 = [203659, 241934], u2 = [241934, 280209], u3 = [280209, 318484], u4 = [318484, 356760], u5 = [356760,

395035], u6 = [395035, 433310], u7= [433310, 471585]. Then, we admit them as 7 linguistic scores , such as (Negative Big), (Negative Medium), (Negative Small), (Zero), (Positive Small), (Positive Small), (Positive Big) to describe variance of selling number. Based on that definition, 7 fuzzy sets A1, A2, A3, A4, A5, A6, A7, in which A1= (Negative Big), A2= (Negative Medium), A3= (Negative Small), A4= (Zero), A5= (Positive Small), A6= (Positive Small), A7= (Positive Big). In universe of discourse U with the following scores:
A1=203659, A2=248313, A3=292968, A4=337622, A5=382276, A6=426931, A7=471585.

d. Fuzzification of score from history data. In the condition of membership functions (MBF) and fuzzy sets as illustrated in step 3, actual score of selling number can be fuzzified with the norm : "if actual score of selling number is p and score of p on the interval Uj, so p can be translated as Aj". Fuzzifying final score of selling number is based on the norms summarized in Table 1.
e. Calculating fuzzy score of selling number history data of product A, in each fuzzy set.
f. Choosing base of model w which is very appropriate and calculating fuzzy operation.
g. Defuzzification of calculation in step 5, and then, calculate prediction result. After the calculation of fuzzy was done, we need to translate fuzzy output, next, final prediction result was got. By using Center of Gravity (COG) method and equality of (3) (4) (5) so it got final calculation result as shown in table 2, and prediction result and graphic on application can be shown in Figure 2.

Table 2. Data of prediction result

Month	Year	Actual Score	Fi (Prediction Score)
January	2012	382635	0
February	2012	355766	382636
March	2012	325994	355767
April	2012	344349	325995
May	2012	362127	344350
June	2012	332272	362128
July	2012	344733	332273
August	2012	262136	344734
September	2012	371755	262137
October	2012	344931	371756
November	2012	360428	344932
December	2012	305567	360429
January	2013	398608	305568
February	2013	401103	398609
March	2013	410591	401104
April	2013	391991	410592
May	2013	373435	391992
June	2013	390023	373436
July	2013	415428	390024
August	2013	294396	415429
September	2013	417544	294397
October	2013	439641	417545
November	2013	422857	439642
December	2013	342836	422858
January	2014	366797	342837
February	2014	423950	366798
March	2014	463070	423951
April	2014	445420	463071
May	2014	452353	445421
June	2014	471585	452354
July	2014	327364	471586
August	2014	388073	327365
September	2014	459309	388074
October	2014	452508	459310
November	2014	425409	452509
December	2014	375814	425410
January	2015	339850	375815
February	2015	376973	339851
March	2015	376571	376974
April	2015	371001	376572
May	2015	304900	371002
June	2015	361767	304901
July	2015	278754	361768
August	2015	430953	278755
September	2015	425458	430954
October	2015	453944	425459
November	2015	394726	453945
December	2015	338991	394727
January	2016	287776	338992
February	2016	362668	287777
March	2016	440171	362669
April	2016	348626	440172
May	2016	339128	348627
June	2016	380019	339129
July	2016	203659	380020
August	2016	388847	203659
September	2016	423256	388848
October	2016	446611	423257
November	2016	450331	446612
December	2016	……	450332

3.1 Evaluation and validation of calculation result

From evaluation and validation of error deviation toward fuzzy time series above, error deviation also has been tested by using variance of number of universe of discourse starting from 3, 4, 5, 6 and 7 as well as data number starting from 12, 24, 36, 48 and 60 data so that the result got is shown in Figure 3.

4 Conclusion

Prediction by applying algorithm of Fuzzy time series done with variance of interval score toward universe of discourse and variance of data number can be applied to predict safety stock. It can be proven by testing result using data number of 60 and the average error score got was 15% measured by using method of Mean Absolute Percentage Error (MAPE). Prediction result accuracy is influenced by data number fluctuation, the size (small and big) of interval score of universe of discourse and minimal and maximal score of universe of discourse.

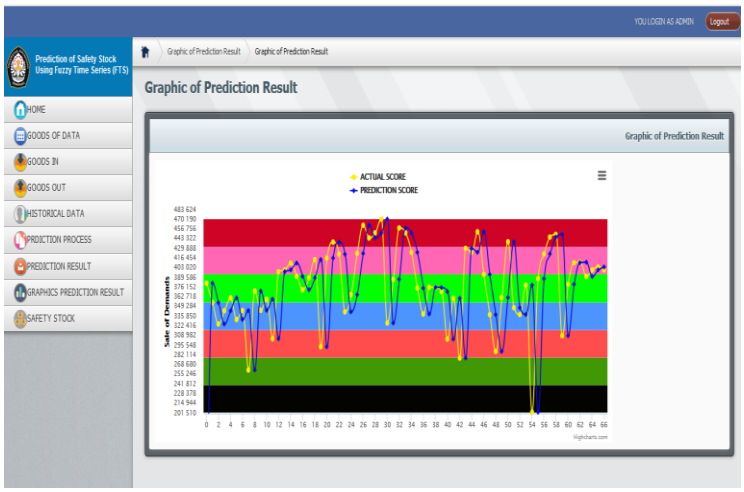

Fig. 2. Graphic of prediction result

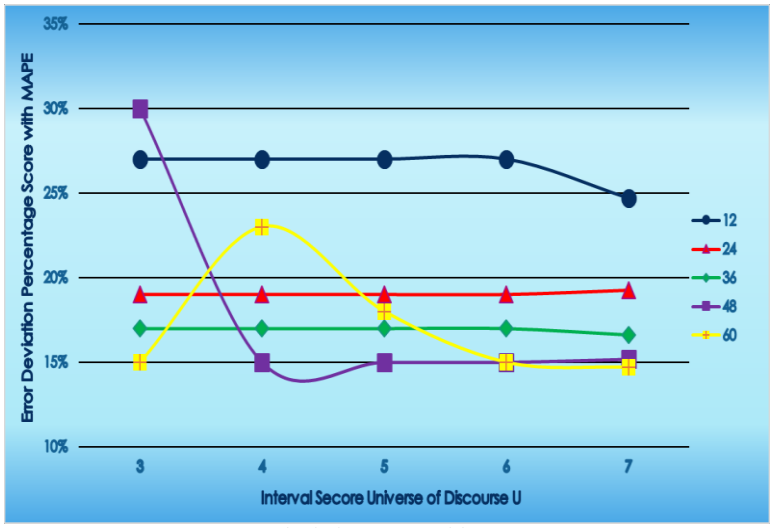

Fig. 3. Error deviation score with MAPE

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