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Prediction of Safety Stock Using Fuzzy Time Series (FTS) and Technology of Radio Frequency Identification (RFID) for Stock Control at Vendor Managed Inventory (VMI) Chamdan Mashuri13,*, SuryonoSuryono12, and JatmikoEndro Suseno2 1Master of Information System, Graduate School, Diponegoro University Semarang Indonesia 2Department of Physics, Faculty of Science and Mathematics, Diponegoro University Semarang Indonesia.

3Department of Information System, Faculty of Information Technology, Hasyim Asy'ari University, Jombang - Indonesia 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. Keywords: Stock, Prediction, Safety stock, Fuzzy time series, RFID, VMI.

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 suplly 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]. FTS can predict product need for the next period and this prediction can be arranged based on time period needed. By integrating FTS 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 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 technologies 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 availibility 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 FTS and RFID technology for stock control at 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 picture 1.

Picture 1. Acquisition process route of goods demand data

2.2

Modelling by using fuzzy time series Predicting by using FTS 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 : Defining universe of discourse U until fuzzy set can be determined as U = [x, y].

Determining minimal and maximal score of actual history data (Xmin = x, Xmax = y). Dividing universe of discourse U with some series of data u1, u2, ... un and determining linguistic score. Doing fuzzification and fuzzy set from data of actual histories. Calculating score of fuzzy data of actual history by using the following pattern : μ???? ?? = ??-?? ??-?? 203659=??=471585 Choosing basis of model W which is very appropriate and calculating fuzzy using the following pattern: ?? ?????? ??+1 = ??????1+??????2+…+???????? ?? Doing defuzzyfication of calculation result from the above step then, calculating prediction result by using the following pattern : ??= (??1*??1+??2*??2) ??1+??2 ??=?? ???? *??1+?? ???? * ??2+…+?? ???? *??7 ????=??+?? 3 Result and Discussion Data acquisition process on application of safety stock prediction using FTS and RFID technology for stock control at VMI has some steps as follows: 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 _Nopember _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 _Nopember _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 _Nopember _2016 _450331 _A7 _ _60 _December _2016 _309796 _A3 _ _ Defining universe of discourse U until fuzzy set can be determined.

After actual data was calculated, so minimal and maximal score of samploe data was obtained (Xmin = 203659, Xmax = 471585). Based on that score difference, universe of discourse U can be defined as U = [203659,471585]. 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 discourseU with the following scores: A1=203659, A2=248313, A3=292968, A4=337622, A5=382276, A6=426931, A7=471585. Fuzzification of score from history data. In the condition of membershipfunctions (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. Calculating fuzzy score of selling number history data of product A, in each fuzzy set. Choosing base of model w which is very appropriate and calculating fuzzy operation. 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 picture 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 picture 3.

Picture 2. Graphic of prediction result

Picture 3.

Error deviation score with MAPE

4 Conclusion Prediction by applying algorithm of FTS 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. References T. Suesut, B. Mongkhoin, Demand Forecasting Approach Inventory Control For CIMS, 1869-1873 (2004) J.D. Schwartz, M.R. Arahal, D.E. Rivera, Control-relevant demand forecasting for management of a production-inventory system, 4053-4058 (2008) B. Garg, M.M.S. Beg, A.Q.

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