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Fuzzy Time Series Markov Chain for Rice Production Forecasting

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Abstract

Forecasting is an activity to get an estimate of the value that will appear in the future by paying attention to past events. Forecasting can be used as decision support in determining a policy in various fields. Forecasting can be done using statistical methods such as regression analysis, trend analysis, MA, and ARIMA. In this paper, the fuzzy time series markov chain method will be forecast which will be applied to rice production data in D.I. Yogyakarta Province. The fuzzy time series markov chain method was chosen because it does not need to meet certain assumptions so that the fuzzy time series markov chain can be applied to time series data with stationary and non-stationary patterns. This study aims to analyze fuzzy time series markov chain for rice production forecasting. This study uses time series analysis. The data used in this research is secondary data. The data used in this study is data on rice production in D.I. Yogyakarta Province in 1970-2017 taken from the website www.pertanian.go.id. Historical data consists of 48 data. Solving this research problem using fuzzy time series markov chain method. The results of the study show that forecasting with 11 fuzzy sets is declared the best forecast with a mean absolute percentage error of 4.156%.

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Keywords
fuzzy time series markov chain; rice; production; forecasting

I. Introduction

Background is the basis or starting point to provide an understanding to the reader or listener about what we want to convey. Based on its understanding, the background is a brief explanation of the topic or object of research, as well as an explanation of the reasons why the chosen topic is important to discuss.

Forecasting is an activity to get an estimate of the value that will appear in the future by paying attention to past events. Forecasting can be used as decision support in determining a policy in various fields. Forecasting can be done using statistical methods such as regression analysis, trend analysis, MA, and ARIMA. According to Song and Chissom (1993), these

methods will fail in the process when used on historical data in the form of linguistic values. Data with linguistic value in question is data that is not in the form of real numbers containing elements of uncertainty such as "low", "medium", "high", "weak", "strong", and the like. Therefore, to overcome this problem, a method is developed, namely fuzzy time series. Fuzzy time series uses the concept of fuzzy logic to translate these linguistic values into firm values.

The fuzzy time series method at the beginning of its emergence was used to predict student admissions at the University of Alabama with time variant and time invariant models (Song and Chissom, 1993). Then the simpler fuzzy time series method, namely arithmetic operations and fuzzy logical relationship group, was proposed by Chen (1996) and can provide better forecasting results to predict student admissions at the University of Alabama. Research using the fuzzy time series markov chain method was first proposed by Tsaur (2012) to predict the exchange rate of the Taiwanese currency against the US Dollar. From this research, it is found that the fuzzy time series markov chain method provides a better level of accuracy when compared to the previous method.

In this paper, the fuzzy time series markov chain method will be forecast which will be applied to rice production data in D.I. Yogyakarta Province. The fuzzy time series markov chain method was chosen because it does not need to meet certain assumptions so that the fuzzy time series markov chain can be applied to time series data with stationary and non-stationary patterns. In addition, in the fuzzy time series markov chain method, adjustments are made to the forecast value so that the forecast value can approach the actual data pattern.

In the fuzzy time series markov chain method, there are no rules that limit the determination of the number of fuzzy sets used or in other words the number of fuzzy sets depends on the researcher. The difference in the number of sets can affect the fuzzy logical relationship and fuzzy logical relationship group so that it affects the forecasting results. Therefore, in this paper, we will forecast the fuzzy time series markov chain method with a number of different fuzzy sets, namely 7, 9, 11, and 13 fuzzy sets to determine the number of fuzzy sets that provide the best forecasting results for forecasting rice production in Indonesia D.I. Yogyakarta Province.

The purpose of the research is that data can be found, developed, and proven. Meanwhile, the results of the research will gain new knowledge so that it can be used to understand, solve, and anticipate problems. The purpose of a study can be to identify or describe a concept or to explain or predict a situation or solution to a situation that indicates the type of study to be conducted. The research objective is a discussion of the formulation in the research sentence which shows the results obtained after the research process is completed. Where the process of making writing in this purpose is based on the problems that have been presented in the background. This study aims to analyze fuzzy time series markov chain for rice production forecasting.

II. Research Method

Research methods are steps taken by researchers to collect data or information to be processed and analyzed scientifically. In terms of type, research methodology basically has three benefits (Asyraini et al., 2022; Octiva, 2018; Pandiangan, 2015). First, gaining new knowledge or discoveries. Second, it can be used to prove or test the truth that already exists. Third, it helps in developing richer and more knowledge. Research should have the following characteristics research should be systematic. Research must be objective and rational. Research must have a use or benefit. Research has two main characteristics, namely scientific

and sustainable. Research is said to be scientific because it is carried out through systematic procedures and objective fact-finding. Meanwhile, in terms of sustainability, research is a continuous process.

This study uses time series analysis. Time series analysis is the process of modeling and describing a time-dependent sequence of data points (Octiva et al., 2018; Pandiangan, 2018). The purpose of this method is to extract all useful information from the data set. This information is used to create and model future forecasts. The advantage of time series data is its ability to estimate, predict and estimate the value of data in the next period based on previous data. In addition, time series data can also be used to estimate previous time data with available time series data (Jibril et al., 2022; Pandiangan et al., 2018; Pandiangan, 2022).

The data used in this research is secondary data. Secondary data is data taken through intermediaries or parties who have collected the data previously, in other words the researcher does not directly take the data himself into the field (Octiva et al., 2021; Pandiangan et al., 2021; Pandia et al., 2018). Primary data is usually always specific because it is tailored to the needs of the researcher (Pandiangan et al., 2022; Tobing et al., 2018). The data used in this study is data on rice production in D.I. Yogyakarta Province in 1970-2017 taken from the website www.pertanian.go.id. Historical data consists of 48 data.

Solving this research problem using fuzzy time series markov chain method. Fuzzy time series method with markov chain, the merger aims to obtain the largest probability using a transition probability matrix. The fuzzy time series markov chain method provides a fairly good accuracy compared to the fuzzy time series method. The fuzzy time series method at the beginning of its emergence was used to predict student admissions at the University of Alabama with time variant and time invariant models (Song and Chissom, 1993). Then the simpler fuzzy time series method, namely arithmetic operations and fuzzy logical relationship group, was proposed by Chen (1996) and can provide better forecasting results to predict student admissions at the University of Alabama. Research using the fuzzy time series markov chain method was first proposed by Tsaur (2012) to predict the exchange rate of the Taiwanese currency against the US Dollar. From this research, it is found that the fuzzy time series markov chain method provides a better level of accuracy when compared to the previous method. The fuzzy time series markov chain method was chosen because it does not need to meet certain assumptions so that the fuzzy time series markov chain can be applied to time series data with stationary and non-stationary patterns. In addition, in the fuzzy time series markov chain method, adjustments are made to the forecast value so that the forecast value can approach the actual data pattern.

III. Discussion

3.1 Research Overview

The Special Region of Yogyakarta (Javanese: Dhaérah Istiméwa Ngayogyakarta) is a Special Region at the provincial level in Indonesia which is the fusion of the Sultanate of Yogyakarta and the Duchy of Paku Alaman. This Special Region, which has an area of 3,185.80 km2, consists of one municipality, and four districts, which are further divided into 78 sub-districts and 438 urban villages. According to the 2010 population census, it has a population of 3,452,390 with a proportion of 1,705,404 men and 1,746,986. women, and has a population density of 1,084 people per km2.

DIY is located in the south-central part of Java Island, geographically it is located at 8º 30' - 7º 20' South Latitude, and 109º 40' - 111º 0' East Longitude. Based on the landscape, the DIY region can be grouped into four physiographic units, namely physiography of Merapi

Volcano, physiographic unit of Sewu Mountains or Thousand Mountains, physiographic unit of Kulon Progo Mountains, and Lowland physiographic unit.

The data used in this study is data on rice production in D.I. Yogyakarta Province in 1970-2017 taken from the website www.pertanian.go.id. Historical data consists of 48 data. The pattern of rice production data can be seen in Figure 1.

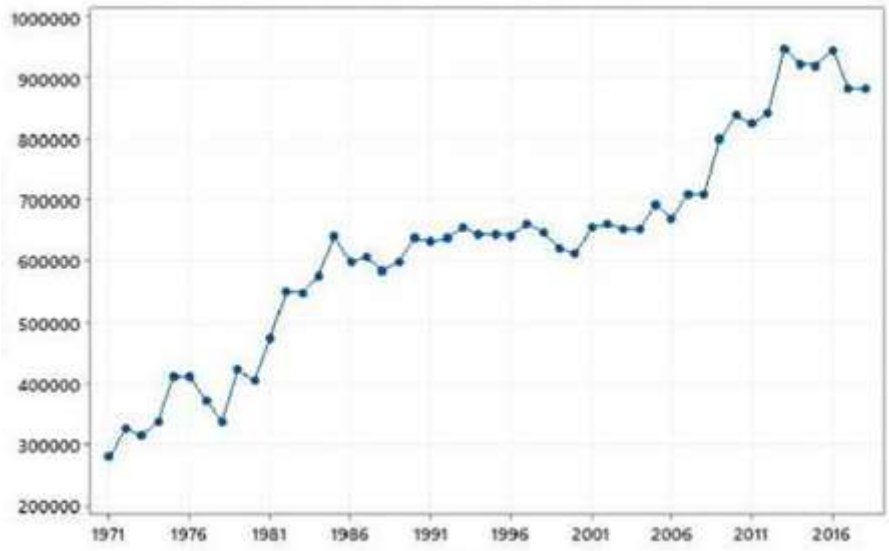

Figure 1. *Rice Production in D.I. Yogyakarta Province, 1970-2017*

3.2 Application of Fuzzy Time Series Markov Chain

Forecasting steps using the fuzzy time series markov chain method are:

1. Determine the set of universes.
2. Divide the universal set U into several parts with equal intervals.
3. Defining fuzzy sets in the universal set U.
4. Fuszzification of historical data. The historical data is then categorized into the appropriate fuzzy sets, based on pre-established intervals.
5. Determine the fuzzy logical relationship and fuzzy logical relationship group.

The final forecast value of rice production can be seen in Table 1, the 6th column. For forecasting one period ahead, the prediction of the value of rice production in 2018 is 881,106 tons.

Table 1. Initial Forecasting Value of Fuzzy Time Series Markov Chain

Number	Year	Actual Data	Early Forecasting	Adj. Value	Final Forecast
1	1970	280,863	#	0	#
2	1971	326,556	328,377.714	0	328,377.714
3	1972	315,480	358,839.714	0	358,839.714
4	1973	338,934	351,455.714	0	351,455.714
5	1974	410,755	367,091.714	95,071.429	462,163.143
6	1975	412,857	417,081.071	0	417,081.071
7	1976	373,415	418,132.071	-95,071.429	323,060.643
8	1977	338,614	390,079.048	0	390,079.048
9	1978	423,168	366,878.381	95,071.429	461,949.810
10	1979	405,385	423,287.571	0	423,287.571

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45	2014	919,573	921,824.000	0	921,824.000
46	2015	945,136	919,573.000	0	919,573.000
47	2016	882,702	945,136.000	0	945,136.000
48	2017	881,106	882,702.000	0	882,702.000
49	Prediction 2018	881,106.000	0	881,106.000	

3.3 Testing the Effect of the Number of Fuzzy Sets

Testing the effect of the number of fuzzy sets is carried out to see the results of forecasting the fuzzy time series markov chain method for each number of different fuzzy sets as a comparison parameter. The test is done by comparing the mean absolute percentage error of each number of fuzzy sets. Better forecasting results are indicated by a smaller mean absolute percentage error. In this test, rice production forecasting is carried out using the fuzzy time series markov chain method with 7, 9, 11, and 13 fuzzy sets. The results of testing the effect of the number of fuzzy sets are shown in Table 2.

Table 2. Mean Absolute Percentage Error Value Based on the Number of Fuzzy Sets

Number of Fuzzy Sets	Forecasting Results	Mean Absolute Percentage Error Value
7	881,106.000	4.929%
9	881,106.000	4.605%
11	864,068.667	4.156%
13	869,511.538	3.929%

The mean absolute percentage error generated varies according to the number of fuzzy sets used. This shows that the number of fuzzy sets has an influence on forecasting with the fuzzy time series markov chain method in predicting rice production. The smallest mean absolute percentage error generated is 3.929% obtained from forecasting with 13 fuzzy sets, while the mean absolute percentage error value generated from forecasting with 7, 9, and 11 fuzzy sets is 4.929%, 4.605%, and 4.156%. This shows that forecasting using 13 fuzzy sets provides better performance than using the number of other fuzzy sets, but forecasting fuzzy time series markov chain with 13 fuzzy sets can only predict one period ahead. If it is used to predict two or more future periods, it will give the same forecasting results. This happens because the last sequence of data has a fuzzy logical relationship group one to one so that the forecast value generated is the previous data. Forecasting that can only be done one period ahead also occurs in forecasting with 7 and 9 fuzzy sets. Meanwhile, in forecasting with 11 fuzzy sets, forecasting can be carried out more than one period ahead because the last sequence of data is included in the one-to-many fuzzy logical relationship group so that the resulting forecast value is more varied. Therefore, although forecasting fuzzy time series markov chain with 11 fuzzy sets has a higher mean absolute percentage error when compared to forecasting fuzzy time series markov chain with 13 fuzzy sets, forecasting fuzzy time series markov chain with 11 fuzzy sets can provide forecasting results that are not only

limited to one period ahead. Among the forecasts with the number of different fuzzy sets, forecasting with 11 fuzzy sets is declared the best forecast with a mean absolute percentage error of 4.156%.

IV. Conclusion

The results of the study show that forecasting with 11 fuzzy sets is declared the best forecast with a mean absolute percentage error of 4.156%.

References

Asyraini, Siti, Fristy, Poppy, Octiva, Cut Susan, Nasution, M. Hafiz Akbar, & Nursidin, M. (2022). Peningkatan Kesadaran Protokol Kesehatan di Masa Pandemi Bagi Warga di Desa Selamat Kecamatan Biru-biru. Jurnal Pengabdian Kontribusi (Japsi), 2(1), 33-36.

Chen, S. M. (1996). Forecasting Enrollments Based on Fuzzy Time Series, Fuzzy Sets, and Systems. 81, 311-319.

Jibril, Ahmad, Cakranegara, Pandu Adi, Putri, Raudya Setya Wismoko, & Octiva, Cut Susan. (2022). Analisis Efisiensi Kerja Kompresor pada Mesin Refrigerasi di PT. XYZ. Jurnal Mesin Nusantara, 5(1), 86-95.

Octiva, Cut Susan. (2018). Pengaruh Pengadukan pada Campuran Limbah Cair Pabrik Kelapa Sawit dan Tandan Kosong Kelapa Sawit terhadap Produksi Biogas. Tesis. Medan: Fakultas Teknik, Program Studi Teknik Kimia, Universitas Sumatera Utara. https://repositori.usu.ac.id/bitstream/handle/123456789/12180/157022002.pdf?sequence=1&isAllowed=y.

Octiva, C. S., Irvan, Sarah, M., Trisakti, B., & Daimon, H. (2018). Production of Biogas from Co-digestion of Empty Fruit Bunches (EFB) with Palm Oil Mill Effluent (POME): Effect of Mixing Ratio. Rasayan J. Chem., 11(2), 791-797.

Octiva, Cut Susan, Indriyani, & Santoso, Ari Beni. (2021). Effect of Stirring Co-digestion of Palm Oil and Fruith for Biogas Production to Increase Economy Benefit. Budapest International Research and Critics Institute-Journal, 4(4), 14152-14160. DOI: https://doi.org/10.33258/birci.v4i4.3521.

Pandia, S., Tanata, S., Rachel, M., Octiva, C., & Sialagan, N. (2018). Effect of Fermentation Time of Mixture of Solid and Liquid Wastes from Tapioca Industry to Percentage Reduction of TSS (Total Suspended Solids). IOP Conference Series: Materials Science and Engineering, 309, 012086. DOI: 10.1088/1757-899X/309/1/012086.

Pandiangan, Saut Maruli Tua. (2015). Analisis Lama Mencari Kerja Bagi Tenaga Kerja Terdidik di Kota Medan. Skripsi. Medan: Fakultas Ekonomi dan Bisnis, Program Studi Ekonomi Pembangunan, Universitas Sumatera Utara. https://www.academia.edu/52494724/Analisis_Lama_Mencari_Kerja_Bagi_Tenaga_Kerja_Terdidik_di_Kota_Medan.

Pandiangan, Saut Maruli Tua. (2018). Analisis Faktor-faktor yang Mempengaruhi Penawaran Tenaga Kerja Lanjut Usia di Kota Medan. Tesis. Medan: Fakultas Ekonomi dan Bisnis, Program Studi Ilmu Ekonomi, Universitas Sumatera Utara. http://repositori.usu.ac.id/bitstream/handle/123456789/10033/167018013.pdf?sequence=1&isAllowed=y.

Pandiangan, Saut Maruli Tua, Rujiman, Rahmanta, Tanjung, Indra I., Darus, Muhammad Dhio, & Ismawan, Agus. (2018). An Analysis on the Factors which Influence Offering the Elderly as Workers in Medan. IOSR Journal of Humanities and Social Science

(IOSR-JHSS), 23(10), 76-79. DOI: 10.9790/0837-2310087679. http://www.iosrjournals.org/iosr-jhss/papers/Vol.%2023%20Issue10/Version-8/K2310087679.pdf.

Pandiangan, Saut Maruli Tua, Resmawa, Ira Ningrum, Simanjuntak, Owen De Pinto, Sitompul, Pretty Naomi, & Jefri, Riny. (2021). Effect of E-Satisfaction on Repurchase Intention in Shopee User Students. Budapest International Research and Critics Institute-Journal, 4(4), 7785-7791. DOI: https://doi.org/10.33258/birci.v4i4.2697.

Pandiangan, Saut Maruli Tua, Oktafiani, Fida, Panjaitan, Santi Rohdearni, Shifa, Mutiara, & Jefri, Riny. (2022). Analysis of Public Ownership and Management Ownership on the Implementation of the Triple Bottom Line in the Plantation Sector Listed on the Indonesia Stock Exchange. Budapest International Research and Critics Institute-Journal, 5(1), 3489-3497. DOI: https://doi.org/10.33258/birci.v5i1.4016.

Pandiangan, Saut Maruli Tua. (2022). Effect of Packaging Design on Repurchase Intention to the Politeknik IT&B Medan Using E-Commerce Applications. Journal of Production, Operations Management and Economics (JPOME), 2(1), 15–21. http://journal.hmjournals.com/index.php/JPOME/article/view/442.

Song Q, & Chissom B. (1993). Forecasting Enrollments with Fuzzy Time Series Part I. Fuzzy Sets and System, 54, 1-9.

Song Q, & Chissom B. (1993). Forecasting Enrollments with Fuzzy Time Series Part II. Fuzzy Sets and System, 62, 1-8.

Tsaur, C. R. (2012). A Fuzzy Time Series-Markov Chain Model with an Aplication to Forecast the Exchang Rate Between Taiwan and US Dollar. ICIC International, 8.

Tobing, Murniati, Afifuddin, Sya'ad, Rahmanta, Huber, Sandra Rouli, Pandiangan, Saut Maruli Tua, & Muda, Iskandar. (2018). An Analysis on the Factors Which Influence the Earnings of Micro and Small Business: Case at Blacksmith Metal Industry. Academic Journal of Economic Studies, 5(1), 17-23. https://www.ceeol.com/search/article-detail?id=754945.