Prediction of Central Java's Number of Exports to Four ASEAN Countries in 2022 and 2023 Using the Markov Chain Analysis

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Abstract. Central Java is one of the provinces that has many of natural resources and extraordinary industrial potential, able to offer reliable prospects to various developed countries in ASEAN, namely Singapore, Brunei Darussalam, Malaysia, and Thailand, to become the focus of exploration attention. Therefore, a prediction is made of Central Java's exports to the four ASEAN countries in 2022 and 2023 by applying the Markov chain analysis method. The prediction results obtained that the total exports to Singapore, Brunei Darussalam, Malaysia and Thailand in a row in 2022 are 0.701, 0.001, 0.239, and 0.058. While the predictions for 2023 for the four countries are 0.540, 0.001, 0.409, and 0.050 respectively. Meanwhile, the steady state of the Markov chain is 0.3595 for Singapore, 0.0013 for Brunei Darussalam, 0.6001 for Malaysia, and 0.0389 for Thailand. The results of this prediction can assist parties involved in making economic decisions related to Central Java's exports to developed countries in ASEAN. Information regarding predictions of an increase or decrease in exports from one year to the next can be used as a reference for business people, governments and related organizations to plan more appropriate and efficient economic strategies and policies.

1. Introduction

International trade is one of the main keys of economic growth and sustainable development in a country [1]. In an increasingly connected era of globalization, challenges and opportunities to develop exports cannot be ignored, especially for regions in Indonesia, including Central Java. This province has a wealth of natural resources and extraordinary industrial potential, offering reliable prospects for various countries, including the four developed countries that are at the center of attention, namely Singapore, Brunei Darussalam, Malaysia and Thailand. These four countries have made achievements as centers of global trade, technology and industry, providing extensive opportunities for superior products from Central Java.

The dominant export commodities of Central Java Province are the yarn and textile industry, the wood industry, cork, straw, and livestock [2]. Analysing and identifying superior products and other export potential from Central Java which have high competitiveness in the international market is the main concern. Central Java is one of the leading provinces in Indonesia with extraordinary economic potential. The opening of the global market is increasingly attracting the attention of many parties to explore the export potential of Central Java to these developed countries. Strengthening regional competitiveness and economic position is the main objective of this research. The potential of Central Java's superior products such as yarn and the textile industry, cork, wood, and other wood industries, as

well as corn, rubber, coffee, and various other agricultural sector products that have competitive advantages are the main capital to attract market interest in potential developed countries.

With a long history of economic and trade activities in Indonesia, Central Java offers promising export potential[3]. This research is dedicated to diving in depth into Central Java's exports to four developed countries. Through in-depth analysis, Central Java's superior products that have high competitiveness in the international market are clearly identified.

Seeing that there is good economic potential and quite tight competition in terms of exports, a prediction of the number of Central Java exports will be made by applying the Markov Chain. Markov chains are a technique in mathematics that is used to create models covering various systems and business processes [4]. The Markov chain model is an interesting concept for describing and analyzing the naturalness of changes due to the movement of states [5]. The Markov chain process involves the use of a Markov transition matrix, where each value in the transition matrix is a probability of movement from one state to another [6]

This method, with its advantages and limitations, provides valuable strategic guidance to economic actors and local governments. The advantages of Markov Chain are its ability to predict future states based on the current state, as well as its ability to model complex systems with simple assumptions. However, the Markov Chain method also has limitations. One of the limitations is the assumption that the future state depends only on the current state, and no on past states. This assumption can be unrealistic in some cases, especially if the future state is affected by past event. In addition, this method also requires complete and accurate data to provide accurate result.

In the context of Central Java's exports to developed countries, this research is able to optimize opportunities and have a positive impact on economic growth and sustainable development in the province. The results of this research provide valuable strategic guidance for economic actors in Central Java, including entrepreneurs and local governments, to strengthen product competitiveness and open wider market access. It is hoped that a deeper understanding of Central Java's export potential to four developed countries can strengthen the regional economy and improve people's welfare. In the context of Central Java's exports to developed countries, this research is a significant contribution in optimizing opportunities and providing a positive impact on economic growth and sustainable development of this province.

1. Research Methods

This study was conducted with the aim of forecasting the number of exports from Central Java to four developed countries in ASEAN, namely Singapore, Brunei Darussalam, Malaysia, and Thailand in 2022 and 2023 using the Markov Chain application. The data used in this study are secondary data taken from the official website of the Central Java Statistics Agency (BPS) [7]. The data used is the export volume data of Central Java to Singapore, Brunei Darussalam, Malaysia, and Thailand from 2018 to 2021 in tons. By taking data from 2018 to 2021, including 2019 when the COVID-19 pandemic hit and impacted the global economy, including in ASEAN, we seek to provide an accurate picture of Central Java's exports to Singapore, Brunei, Malaysia, and Thailand in 2022 and 2023. We hope this data will reflect the impact of the COVID-19 pandemic on Central Java's export activities to these countries and provide valuable insights into future export prospects after this challenging period. The following is the data we use in Table 1.

Table 1. Central Java Exports in 2018 – 2021 to ASEAN Countries

Years	Singapore	Brunei Darussalam	Malaysia	Thailand	Total
2018	363187.84	752.64	123752.99	29761.45	517454.92
2019	236725.52	1202.12	510131.11	32969.87	781028.62
2020	241470.71	1773.43	1135501.84	40270.58	1419016.56
2021	123432.07	1569.23	876346.01	31370.24	1032717.55

Based on the data in Table 1, it is known that there are 4 countries that are export destinations for Central Java, namely Singapore, Brunei Darussalam, Malaysia, and Thailand in the period 2018 to 2021. In this case, to facilitate the stochastic process, the four countries that are export destinations will be assumed to be 1, 2, 3, and 4 respectively [8].

The steps in implementing the Markov chain in forecasting the number of Central Java exports are as follows:

    a. Collect data on Central Java exports based on a predetermined time span, in this research the years taken are from 2018 to 2021 [9].

    b. Create a data model in the form of a Markov Chain transition probability matrix.

    c. Predict the amount of Central Java exports using a discrete Markov Chain, where a stochastic process $\{X_n, n = 0,1,2,3 ...\}$ will be called a discrete Markov chain if:

        1. $P\{X_{n+1} = j; X_0 = i_0 ..., X_{n-1} = i_{n-1}, X_n = 1\} \, p\{X_{n+1} = f; X_n = i$

        2. Every n and every state $i_0, i_1, ... i_{n-1}$, meaning that the probability of an event occurring at this time depends on previous events.

    d. Determine the predicted amount of Central Java exports based on a probability matrix.

2. Results and Discussion

Markov chain is a stochastic process where an event only depends on previous events. In this research, the Markov Chain model is used to model the export transition pattern from Central Java to four developed countries in ASEAN based on previous historical export data [10].

Based on the table of Central Java exports in 2018 - 2021, it can be seen that from 2018 to 2020 the number of Central Java exports to the four ASEAN countries experienced fluctuations. Meanwhile, from 2020 to 2021, the number of exports decreased. Next, the table above will create a transition probability matrix.

$$
\mathbf{P} = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array}
\begin{bmatrix}
\overset{1}{0.7018733922} & \overset{2}{0.001454503515} & \overset{3}{0.2391570458} & \overset{4}{0.05751505851} \\
0.3030945524 & 0.001539149743 & 0.6531529024 & 0.04221339546 \\
0.1701676477 & 0.001249759904 & 0.8002033747 & 0.02837921779 \\
0.1195216156 & 0.001519515186 & 0.8485824706 & 0.03037639866
\end{bmatrix}
$$

It can be seen in matrix **P** that it is obtained by dividing Singapore exports by total exports in 2019 to form a probability $\frac{363187.84}{517454.92} = 0.7018733922$. The value P12 is obtained from division between Brunei Darussalam and total exports in 2018, thereby generating probabilities $\frac{752.64}{517454.92} = 0.001454503515$. Values P13 to P44 are also obtained in the same way sequentially.

The transition probability matrix provides information that the probability for Central Java exports to Singapore, Brunei Darussalam, Malaysia, Thailand is 70%, 0.1%, 24% and 6% respectively in 2018. Then in 2019 respectively by 30%, 0.2%, 65%, 4%. In 2020 they were 17%, 0.12%, 80% and 2% respectively. In 2021 they will be 12%, 0.15%, 84% and 3% respectively. Based on the data analysis above, it is known that all states communicate with each other and there is only one class. Therefore, the Markov chain formed is irreducible or cannot be reduced further. The Markov chain transition diagram showed in Figure 1.
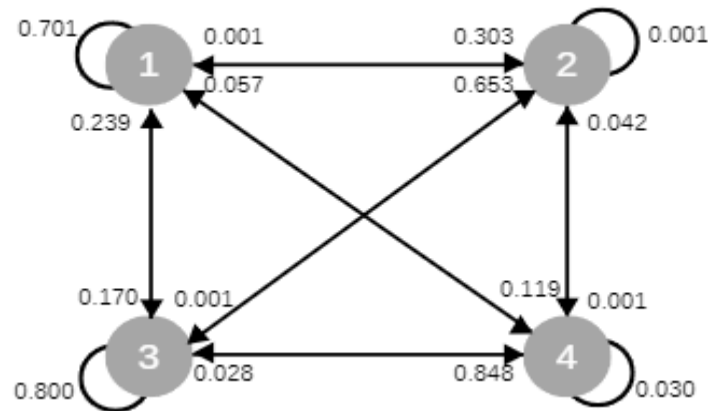
Figure 1. Markov Chain Transition Diagram

Before making predictions, first determine the initial state. In this research using initial state:

$$\text{Initial State} = \begin{bmatrix} 1 & 0 & 0 & 0 \end{bmatrix}$$

Initial state $\pi(0)$ is a type of state symbolized by the binary number 1 or 0. In this research, the contents of the initial state are used to predict the value of Central Java's exports to 4 developed countries in ASEAN, namely Singapore, Brunei Darussalam, Malaysia and Thailand. Then to get a result in the form of % or change the probability form to a percentage, the result of $\pi(1)$ is multiplied by 100%.

2.1. Export Prediction in 2022

Predicting Central Java's exports to four developed countries in ASEAN in 2022 is calculated by the following way:

$$\pi(1) = \pi(0).P$$

$$\pi(1) = \begin{bmatrix} 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0.7018733922 & 0.001454503515 & 0.2391570458 & 0.05751505851 \\ 0.3030945524 & 0.001539149743 & 0.6531529024 & 0.04221339546 \\ 0.1701676477 & 0.001249759904 & 0.8002033747 & 0.02837921779 \\ 0.1195216156 & 0.001519515186 & 0.8485824706 & 0.03037639866 \end{bmatrix}$$

$$= \begin{bmatrix} 0.7018733922 & 0.001454503515 & 0.2391570458 & 0.05751505851 \end{bmatrix}$$

Based on the results of the calculations above, the probability results for Central Java exports to 4 developed countries in ASEAN which include Singapore, Brunei Darussalam, Malaysia, Thailand in 2022 are obtained.

$$\pi(1) \ x \ 100\% = \begin{bmatrix} 70\% & 0.1\% & 23\% & 5\% \end{bmatrix}$$

Then to get the probability in the form of a percentage, the result of $\pi(1)$ is multiplied by 100%. Then the export probability of Central Java to the four developed ASEAN countries in 2022 is 70% to Singapore, 0.1% to Brunei Darussalam, 23% to Malaysia, and 5% to Thailand respectively.

2.2. Export Prediction in 2023

Predicting Central Java's exports to 4 developed countries in ASEAN in 2023 is calculated by the following way:

$$\pi(2) \; = \; \pi(0).\,P^2$$

$$\pi(2) = \begin{bmatrix} 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0.7018733922 & 0.001454503515 & 0.2391570458 & 0.05751505851 \\ 0.3030945524 & 0.001539149743 & 0.6531529024 & 0.04221339546 \\ 0.1701676477 & 0.001249759904 & 0.8002033747 & 0.02837921779 \\ 0.1195216156 & 0.001519515186 & 0.8485824706 & 0.03037639866 \end{bmatrix}^2$$

$$= \begin{bmatrix} 0.5406381954 & 0.001409399906 & 0.4089885258 & 0.04896387899 \end{bmatrix}$$

Based on the results of the calculations above, the probability results for Central Java exports to 4 developed countries in ASEAN which include Singapore, Brunei Darussalam, Malaysia, Thailand in 2023 are obtained.

$$\pi(2)\; x \; 100\% = \begin{bmatrix} 54\% & 0.1\% & 40\% & 4\% \end{bmatrix}$$

Then to get the probability in the form of a percentage, the result of $\pi(2)$ is multiplied by 100%. So the probability of Central Java's exports to the 4 ASEAN developed countries in 2022 is 54% to Singapore, 0.1% to Brunei Darussalam, 40% to Malaysia and 4% to Thailand.

2.3. Steady State

Steady state, in the context of Markov Chains or other dynamic systems, refers to a condition of long-term balance or equilibrium in which the system is in a stable state and does not experience significant changes in time. Steady State is the probability that a system condition does not change over time.

Steady state is obtained if the next transition probability matrix converges to the previous n-step transition probability matrix and also converges to a transition probability matrix π to infinity. In this research, steady state is searched using the Python programming language, and the steady state matrix and exponential results are obtained until it reaches the state condition at the 20th step onwards (P^{20}).

From the calculation results, the steady state matrix results at the 20th step onwards are [0.3593, 0.0013, 0.6001, and 0.0389]. That is, it can be seen that the steady state probability value for Singapore is 35.95%, Brunei Darussalam is 0.13%, Malaysia is 60.01%, Thailand is 3.89%.

3. Conclusion

Based on the results of the analysis that has been carried out using Markov chains to predict the number of exports from Central Java to 4 developed countries in ASEAN, namely Singapore, Brunei Darussalam, Malaysia and Thailand in 2022 and 2023, it can be concluded that the form of the Markov chain formed in this case is irreducible or cannot be reduced further, the number of communication classes formed is one class. Based on the predicted results of the number of Central Java exports to Singapore in 2022, it is known that it will increase in 2022 from 12% to 70% and will decrease in 2023 from 70% to 54%. The number of exports to Brunei Darussalam will decrease in 2022 from 0.15% to 0.1% and will not increase or decrease in 2023, namely remaining 0.1%. In Malaysia, the number of exports will decrease in 2022 from 84% to 23% and will increase in 2023 from 23% to 40%. Meanwhile, in Thailand, it is known that the number of exports will increase in 2022 from 3% to 5% and will decrease in 2023 from 5% to 4%. The steady state probability values for Singapore, Brunei Darussalam, Malaysia, and Thailand are 35.95%, 0.01%, 60.01% and 3.89% respectively.

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