Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM
ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

Forecasting Freight on Board for Gonggong Export in Batam Using Markov Chain

Andini Setyo Anggraeni[1*], Faradiba Jabnabillah[1], Widya Reza[1], Dia Cahya Wati[2]

[1]Department of Mathematics, Institut Teknologi Batam, Batam, Indonesia
[2]Sains Data, Universitas Insan Cita Indonesia, Jakarta, Indonesia
*E-mail: Andini@iteba.ac.id

Received: February 7, 2024. Accepted: March 16, 2024. Published: May 17, 2024

Abstract: As an archipelagic country, Indonesia has great potential in the fisheries sector. As a free trade zone, Batam is important in exporting fishery products. One of the fishery export products in Batam City is gonggong snails. It is a favorite seafood item in Riau Islands Province and has high economic value. However, previous studies focused more on the content of gonggong snails and their industrial feasibility; there has been no specific research on the analysis of gonggong snail exports in Batam City, even though gonggong snails are one of Batam City's export products. In this research, we will forecast the freight on board (FoB) value for gonggong exports in Batam City using a discrete-time Markov chain with two states: above and below the moving average. There are several types of moving averages, including simple moving averages and weighted moving averages. An initial analysis will determine the moving averages' type and duration following the Gonggong export FOB data in Batam. The data used is the Gonggong export FoB data for Batam City from January 2020 to November 2023. Based on this data, the transition probability matrix will be calculated based on the number of export transitions below and above the Weighted Moving Average 6 (WMA 6) value. Limiting probability from the Markov chain will be used to predict the long-term FOB value of fishery product exports up to steady-state conditions. It was found that steady-state conditions would be reached after 17 months, with a probability of FOB exports below WMA6 of 55.06% and FOB exports above WMA6 of 44.94%.

Keywords: Export; Gonggong; Markov Chain; Probability Transition; Steady State.

Introduction

As an archipelagic country, Indonesia has the potential for marine and fisheries resources that can improve the Indonesian economy [1]. As a free trade zone, Batam is essential in exporting fishery products. One of the fishery export products in Batam City is gonggong snails. The gonggong snail is a gastropod-class animal living in littoral and sublittoral areas. Globally, gonggong snails are distributed in the Indo-Pacific region, especially in Southeast Asia, one of which is Indonesia [2]. The sea snail gonggong is an icon of Tanjungpinang-Riau Islands Province. It is a favorite seafood item in Riau Islands Province and has high economic value [3]. Gonggong snails are an essential fisheries commodity with high economic value. They are made into various processed food products, and their shells are used as decorations. Gonggong snail meat extract also contains anti-bacterial that can kill pathogenic bacteria [4]. However, in January 2020, freight on board (FoB) Gonggong exports reached IDR 150,517,039 and continued to fall to IDR 62,200,000 in January 2021, IDR 56,620,000 in January 2022, and IDR 37,680,000. Gonggong exports began to increase in July 2023, amounting to IDR 95,500,000. Therefore, further analysis is needed regarding projected exports of fishery products in Batam City, especially exports of Gonggong snails, as seen from the FoB size.

Previous research discusses the analysis and forecasting of fisheries exports, including research by Sri Bintang et al. (2019) on forecasting seaweed exports using fuzzy time series with and without Markov chains. [5], research by Rudi Hartanto et al. (2021) on the export of Indonesian skipjack tuna fish to the United States market [6], and Sirisha et al. (2020) research on shrimp exports in India using Markov chains [7]. Meanwhile, previous research on Gonggong snails includes research by Yoswaty et al. (2016) on the anti-bacterial analysis of Gonggong snail ethanol extract. [4], Viruly et al. (2019) conducted research on protein profiles of Gonggong Snail [8] and research by Ansyar Bora et al. (2019) regarding feasibility analysis of the Gonggong industry in Batam City [9]. However, these studies focus more on the content of Gonggong snails and their industrial feasibility, there has been no specific research on the export analysis of Gonggong snails in Batam City. Even though Gonggong snails are one of Batam City's export products, therefore, this research will forecast the export of Gonggong Snails in Batam City.

Gonggong export forecasting will be based on Gonggong Export Freight on Board data from January 2020 to November 2023. The method used is a discrete-time Markov chain with two states: above the moving average and below the moving average. There are several types of moving averages, including simple moving averages and weighted moving averages. An initial analysis will determine the moving average's type and duration following the FoB data for Gonggong exports in Batam. It is hoped that the output of this research will contribute to the development of fishery product exports, especially Gonggong exports in Batam City.

How to Cite:
Anggraeni, A. S., Jabnabillah, F., Reza, W., & Cahya Wati, D. (2024). Forecasting Freight on Board for Gonggong Export in Batam Using Markov Chain. *Jurnal Pijar Mipa*, *19*(3), 469–472. https://doi.org/10.29303/jpm.v19i3.6534

Research Methods

This research is quantitative, with the research location being Batam City. The population of this research is freight-on-board exports of fishery products from Batam City. In contrast, the sample for this research is freight-on-board exports of Batam Gonggong snails from January 2020 to December 2023. The data collection technique used in this research is document collection. The document used is the Batam City Export FOB document. The data is secondary data from the Ministry of Maritime Affairs and Fisheries. The data is monthly FOB export data for fishery product commodities, especially Gonggong Snails, in Rupiah from January 2020 to December 2023. Data is sorted based on the Harmonized Commodity Description and Coding System (H.S. Code).

Data modeling will be carried out with a discrete-time Markov chain with two states: export exceeding the moving average value and export below the moving average value. This research will compare two types of moving averages, i.e., simple moving averages (SMA) and weighted moving averages (WMA). This research also compares two moving average durations, i.e., semiannual (6 months) and annual (1 year).

The SMA forecasting method is the arithmetic mean of the most recent observations. In every forecasting period, the newest observation is included, and the oldest is dropped out [10]. SMA was ranked as the top choice in most surveys conducted to ascertain the usage, familiarity, and satisfaction of forecasting methods among practitioners [11]. The basic formula for the SMA can be written as:

$$\hat{y}_t = \frac{1}{k}\sum_{i=1}^{k} y_{t-1}$$

where y_t Is an actual value, $\hat{y}_t$ is a forecast for the observation t and k are the length of the SMA [12].

The weighted moving average (WMA) method calculates data forecasting values through moving average values that are given different weights for each time period [13]. The weighted moving average (WMA) method has a moving average, but the latest value in the periodic series is given greater weight for calculating the forecast [14]. The WMA value can be calculated using equation (1).

$$F_t = \frac{\sum(X_t \times b)}{\sum b} \quad (1)$$

Notes:

F_t : WMA value in period t

X_t : Actual value in period t

b : Assessment according to the length of the period

The discrete-time stochastic process X_n is a Markov Chain if it satisfies equation (2)

$$P(X_n = j \mid X_0 = x_0, X_1 = x_1, \ldots, X_{n-1} = i) = P(X_n = j \mid X_{n-1} = i) = p_{ij} \quad (2)$$

For all $n \geq 1$ and all $x_0, x_1, \ldots, i, j \in S$. Then, the probability transition for $i, j = 0,1,2$ is denoted in the matrix shown in equation (3)

$$P_{ij} = \begin{bmatrix} P_{00} & P_{01} \\ P_{10} & P_{11} \end{bmatrix} \quad (3)$$

where $\sum_{j=0}^{1} P_{ij} = 1$, $i = 0, 1$. P_{ii} is the probability of remaining in a state i. P_{ij} is transition probability from state i to state $j, i \neq j$ [15].

Maximum likelihood estimation (MLE) was used to estimate the transition probabilities for each disease with its respective standard errors. P_{ij} follows a binomial model in equation (4)

$$L(P_{ij} | N, x) = \binom{N_i}{x_{ij}} P_{ij}^{x_{ij}} (1 - P_{ij})^{N_i - x_{ij}} \quad (4)$$

Where N_{ij} is the number of observed transition that starts from state i to j and $\sum_j P_{ij} = 1$. From equation (4) and the assumption of constant transition probabilities over the period, the transition probability matrix is estimated as a multinomial distribution given in equation (5)

$$\hat{P}_{ij} = \frac{x_{ij}}{\sum_j x_{ij}} = \frac{x_{ij}}{N_i} \quad (5)$$

For $i, j = 0,1,2,3,4$, with standard errors from the sampling distribution of the maximum likelihood estimation given in equation (6).

$$\hat{s}.e(P_{ij}) = \sqrt{\frac{\hat{P}_{ij}\,(1 - \hat{P}_{ij})}{N_i}} \quad (6)$$

The method for estimating the nth-step transition probability matrices for each disease uses the eigenvalue and eigenvector approach. Hence, it can be estimated using the decomposition as equation (7).

$$P^n = Q\Lambda^n Q^{-1} \quad (7)$$

where Q is 2 × 2 nonsingular matrix and Λ^n is a diagonal matrix corresponding to the eigenvalues $\lambda_j, j = 0,1$. Thus, matrix Λ^n shown in equation (8)

$$\Lambda^n = \begin{pmatrix} \lambda_0^n & 0 \\ 0 & \lambda_1^n \end{pmatrix} \quad (8)$$

The vector π is said to be the stationary distribution of a chain if $\pi = (\pi_j, j \in S)$ fulfill equations (9) and (10)

$$\pi_j \geq 0, \forall j \in S \text{ and } \sum_j \pi_j = 1 \quad (9)$$

$$\pi = \pi P \text{ or } \pi(P - I) = 0 \quad (10)$$

Results And Discussion

The data used in this research is monthly freight on board (FoB) exports of gonggong snails for Batam City from January 2020 to November 2023. Freight On Board (FOB) is an exporter (seller) that should only pay the cost of shipping goods to the nearest port or port from their warehouse [16]. The data can be seen in Table 1. The data is then plotted and compared with the simple moving average with a length of 6 months (SMA6), simple moving average with a length of 12 months (SMA12), weighted moving average with length 6 months (WMA 6), and weighted moving average with length 12 months (WMA12) to see the most suitable moving average type and duration.

The plot of FoB exports of Gonggong Snails and the moving average can be seen in Figure 2. Based on Figure 2, it can be seen that the most suitable moving average is weighted moving average 6 (WMA6).

Batam City Gonggong, export FOB data, will be modeled using a two-status Markov chain: export FOB below WMA6 and above WMA6. Modeling can be seen in Figure 2.

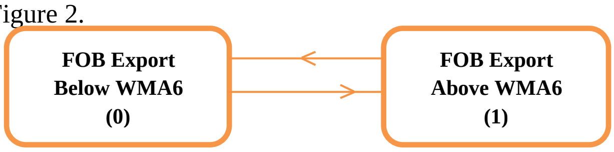

Figure 1. Markov Chain Model of FOB Expor Gonggong

Table 1. Freight on Board Expor Gonggong.

Date	FoB Gonggong(IDR)
January 2020	150,517,039.00
February 2020	94,366,073.00
March 2020	222,500,000.00
⋮	⋮
Decembre 2020	70,350,000.00
January 2021	62,200,000.00
February 2021	59,700,000.00
March 2021	95,250,000.00
⋮	⋮
August 2023	89,500,000.00
Septembre 2023	83,000,000.00
Octobre 2023	84,000,000.00
Novembre 2023	62,500,000.00

Table 2. Number of transitions at any state at the end of the period.

State	Below WMA6	Above WMA6
Below WMA6	15	6
Above WMA6	7	13

Figure 2 shows that in February 2023-October 2023, Gonggong's exports were above WMA6, while in November 2023, Gonggong's exports were below WMA6. Many transitions between states can be seen in Table 2. The results of the MLE process are presented in Table 3, where both the estimates and standard errors of the transition probabilities are provided. The transition probability matrix for export Gonggong is given as equation (11).

$$P = \begin{bmatrix} 0.75 & 0.25 \\ 0.31579 & 0.68421 \end{bmatrix} \quad (11)$$

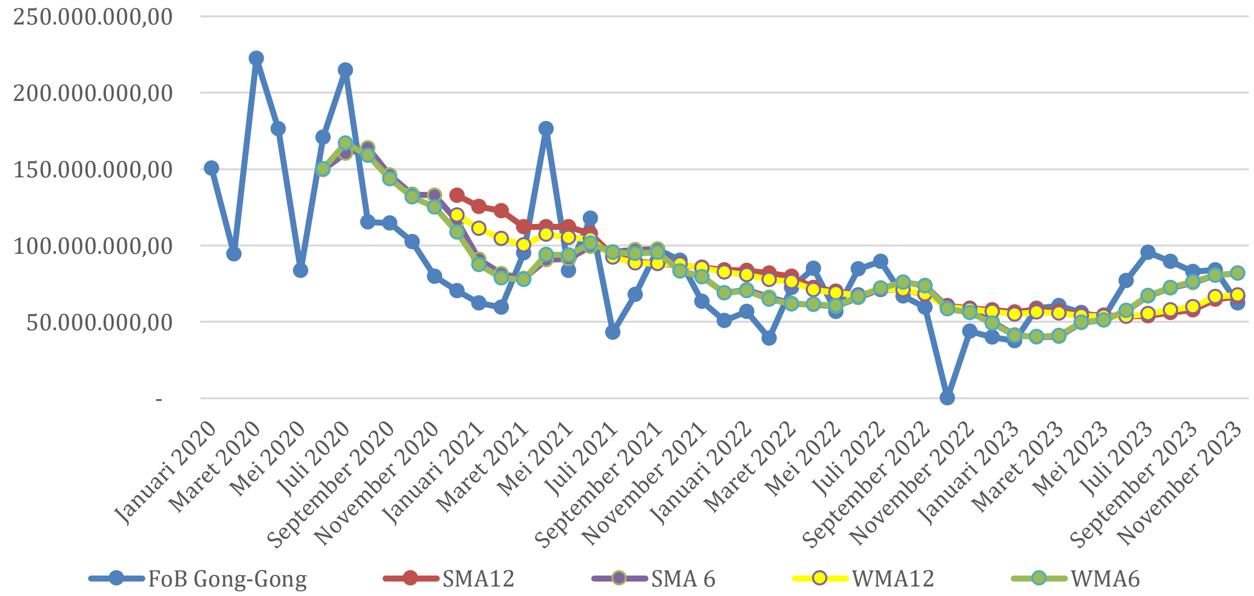

Figure 2. Freight on Board Gonggong

Table 3. Estimation of Transition Probability and Standard Error

Parameters	Estimate	S.E.
P_{00}	0.75	0.070552
P_{01}	0.25	0.070552
P_{10}	0.31579	0.07449
P_{11}	0.68421	0.07449

The P^n The transition probability matrix predicts the transition probabilities at any time step. P^n The transition probability matrix is estimated as equation (12).

$$P^n = \begin{bmatrix} 0.55056 + (0.44943)(0.36428)^n & (0.44944) + (-0.44943)(0.36428)^n \\ 0.55056 + (-0.55056)(0.36428)^n & (0.44944) + (0.55056)(0,36428)^n \end{bmatrix} \quad (12)$$

Probability transition for the next month (P^1) can be estimated using equation (12) with n=1, estimated in equation (13). Probability transition for the next 2 months (P^2) can be estimated using equation (12) with n=2, estimated in equation (14), and so on.

$$P^1 = \begin{bmatrix} 0.71428 & 0.28571 \\ 0.35 & 0.65 \end{bmatrix} \quad (13)$$

$$P^2 = \begin{bmatrix} 0.6102041 & 0.3897959 \\ 0.4775000 & 0.5225000 \end{bmatrix} \quad (14)$$

It is found that if Gonggong's exports are below the weighted average exports for the last 6 months (WMA6), then next month, probability exports will remain below the weighted average exports for the last 6 months (P_{00}^1) is 71.43%, the probability that exports will be above the weighted average exports for the last 6 months (P_{01}^1) is 28.57%, and for the next 2 months, the probability that exports will remain below average (P_{00}^2) is 61.02%, the probability of exports will be above the weighted average exports for the last 6 months (P_{01}^2) is 38.98%. If Gonggong's exports are above the weighted average exports for the last 6 months (WMA6), then next month, the probability that exports will remain above the weighted average exports for the last 6 months (P_{11}^1) is 65%, the probability that exports will be below the weighted average exports for the last 6 months (P_{10}^1) is 35%, and for the next 2 months, the probability that exports will remain above average (P_{11}^{2}) is 52.25%, the probability that exports will be below the weighted average exports for the last 6 months (P_{10}^{2}) is 47.75%.

Next, steady-state conditions will be calculated to determine the equilibrium conditions for gonggong exports in the long term. Gonggong exports reach equilibrium conditions at n=17, with π_0=0.550562 and π_1==0.449438. From our analysis, we find that in the steady state, the opportunity for Gonggong exports to be below the weighted average for the last 6 months is 55.814%, and the chance for Gonggong exports to be above the 6-month average for the last 6 months is 44.186%. In the long term, exporting Gonggong has a greater probability of decreasing (below the 6-month average), so the government must make policies and interventions to anticipate this condition.

Conclusion

Freight on board Gonggong snail exports in the long term will exceed the half-term weighted average of exports after 17 months with a probability of 44.9438%, while the likelihood that Gonggong's FOB exports will be below the half-term weighted average is 55.0562%. In the long term, exporting Gonggong has a greater probability of decreasing (below the half-term weighted average), so the government must make policies and interventions to anticipate this condition.

References

[1] Gusriani, N. (2018, March). Markov chain model for demersal fish catch analysis in Indonesia. In *IOP Conference Series: Materials Science and Engineering* (Vol. 332, No. 1, p. 012022). IOP Publishing.

[2] Supratman, O., & Syamsudin, T. S. (2018). Karakteristik Habitat Siput Gonggong Strombus turturella di Ekosistem Padang Lamun. *Jurnal Kelautan Tropis*, *21*(2), 81-90.

[3] Viruly, L., Andarwulan, N., Suhartono, M. T., & Nurilmala, M. (2019). Morphologycal and Molecular Partial Histone-H3 Characterization of Bintan Sea Snail Gonggong (Strombus sp.) as a Species Validation. *HAYATI Journal of Biosciences*, *26*(2), 56-56.

[4] Yoswaty, D., & Zulkifli, Z. (2016). Antibacterial Analysis of the Ethanol Extract of Gonggong Snail (Strombus canarium) against Pathogenic Bacteria. *Jurnal Perikanan Universitas Gadjah Mada*, *18*(2), 83-89.

[5] Bintang, A. S., Huang, W. C., & Asmara, R. (2019). Forecasting of Indonesia seaweed export: a comparison of fuzzy time series with and without Markov chain. *Agricultural Social Economic Journal*, *19*(3), 155-164.

[6] Hartanto, T. R., Suharno, S., & Burhanuddin, B. (2021). Daya saing ekspor ikan tuna-cakalang-tongkol indonesia di pasar amerika serikat. *Jurnal Pengolahan Hasil Perikanan Indonesia*, *24*(2), 227-235.

[7] Sirisha., K. J. V. K. & Rao., D. V. S. (2020). Direction of Trade and the Structural Stability of Indian Shrimp Exports: Markov Chain Analysis. *International Journal of Current Microbiology and Applied Sciences,9(7)*, 3069–3077.

[8] Viruly, L. I. L. Y., Andarwulan, N., Suhartono, M. T., & Nurilmala, M. (2019, May). Protein profiles and DNA isolation of hemolymph gonggong snail (Strombus sp.) from Bintan. In *IOP Conference Series: Earth and Environmental Science* (Vol. 278, No. 1, p. 012078). IOP Publishing.

[9] Bora, M., Jama, J., Setyabudhi, A. L., & Susanti, A. (2019). Feasibility Analysis for Local Industry of Gonggong Crackers in Batam. *International Journal of Scientific & Technology Research*, *8*(6), 134-136.

[10] Ali, M. M., Babai, M. Z., Boylan, J. E., & Syntetos, A. A. (2015). On the use of Simple Moving Averages for supply chains where information is not shared. *IFAC-PapersOnLine*, *48*(3), 1756-1761.

[11] Ali, M. M., & Boylan, J. E. (2012). On the effect of non-optimal forecasting methods on supply chain downstream demand. *IMA Journal of Management Mathematics*, *23*(1), 81-98.

[12] Svetunkov, I., & Petropoulos, F. (2018). Old dog, new tricks: a modelling view of simple moving averages. *International Journal of Production Research*, *56*(18), 6034-6047.

[13] Hariadi, W., & Sulantari, S. (2022). Forecasting Tingkat Inflasi Year-on-Year Indonesia Dengan Metode Weighted Moving Average (WMA). *UJMC (Unisda Journal of Mathematics and Computer Science)*, *8*(2), 45-54.

[14] Rizqi, M., Cahya, A., & El Maida, N. (2021). Implementasi Metode Weighted Moving Average Untuk Sistem Peramalan Penjualan Markas Coffee. *INFORMAL: Informatics Journal*, *6*(3), 154-159.

[15] Serfozo, R. (2009). *Basics of applied stochastic processes*. Springer Science & Business Media.

[16] Putri, Y. D., Porwani, S., & Indriansyah, A. (2022). Procedure For Exporting Imported Post Delivery Goods at the Hanggar of the Kppbs TMP B Office in Palembang. *Jurnal Ekonomi*, *11*(03), 266-277.