e-Navi

Available online at http://www.e-navigation.kr/
e-Navigation Journal

Original article

Forecasting Pangasius Export Volumes in the Mekong Delta for the Period 2026 - 2035

Thi Hoa DANG[1], Minh Duc NGUYEN[2*], Thi Minh Hoang DO[3], Thi Thu Hang PHAM[4]

[1] Faculty of International Trade, College of Foreign Economic Relations, Vietnam, hoadang1987@gmail.com

[2*] Faculty of Economics, Vietnam Maritime University, Vietnam, ducnguyen@vimaru.edu.vn, Corresponding Author

[3]Faculty of Economics, Vietnam Maritime University, Vietnam, hoangdtm.kt@vimaru.edu.vn

[4]Faculty of Economics, Vietnam Maritime University, Vietnam, hangptt.ktcb@vimaru.edu.vn

Abstract

This study forecasts pangasius export volumes in the Mekong Delta for the period 2026-2035 to provide a basis for planning and developing the logistics service chain. Based on quarterly time series data from 2014 to 2025, a time series linear regression model is first employed to establish the underlying growth trend; however, it fails to capture the seasonal characteristics of the data. Therefore, the Holt-Winters model is applied to simultaneously account for both trend and seasonality, indicating that export volumes may reach approximately 938 thousand tons by 2035. Nevertheless, this approach is limited in long-term forecasting due to its assumption of structural continuity from the past. To address this limitation, the study incorporates an uncertainty forecasting approach based on Uncertainty Theory, integrating expert judgment to reflect the potential range of market fluctuations. The results suggest that the expected export volume in 2035 is approximately 917 thousand tons. The study contributes by proposing an integrated approach combining statistical models and uncertainty-based methods, providing a reference for the development of logistics service systems supporting pangasius exports in the Mekong Delta.

Keywords: Forecasting production, Time Series Regression Model, Holt-Winters, Uncertainty Theory, exported Catfish, Mekong Delta.

https://doi.org/10.52820/j.enavi.2026.26.001

1. Introduction

According to a report by the Vietnam Association of Seafood Exporters and Producers (VASEP, 2024), pangasius is one of Vietnam's key seafood export products, in which the Mekong Delta plays a central role, accounting for more than 90% of the country's total export volume. The development of this sector is closely associated with the cold chain logistics system, including cold storage, refrigerated containers and refrigerated transportation. According to Tsolakis et al. (2014), Christopher (2016) from a supply chain perspective, the scale and fluctuations of export volume directly affect the demand for logistics services, particularly under conditions where seafood products require strict temperature control and transportation time.

According to Asche et al. (2015), FAO (2022) pangasius export activities are strongly influenced by uncertain factors such as demand fluctuations, technical barriers and global economic shocks, causing the data series to exhibit both trend and seasonality while remaining difficult to predict in the long term. In this context, forecasting export volume plays an important role in logistics system planning, yet existing studies mainly focus on point forecasting, while uncertainty forecasting approaches have received increasing attention (Hyndman & Athanasopoulos, 2021; Petropoulos et al., 2022).

On that basis, this study forecasts the export volume of pangasius in the Mekong Delta for the period 2026-2035 by combining time series linear regression, the Holt-Winters model, and the uncertainty forecasting method. The study contributes in three aspects: First, it proposes an integrated forecasting framework combining time series models and Uncertainty Theory; Second, it provides a more realistic forecasting range through the integration of expert judgment; Third, it links forecasting results with implications for logistics system development, particularly cold chain infrastructure and logistics centers serving seafood exports in the Mekong Delta.

2. Literature Review

2.1. Literature Review on Time Series Forecasting

Time series data in the fields of economics and trade often simultaneously exhibit long-term trends and seasonal fluctuations. The identification and modeling of these two components play an important role in the accuracy of forecasting models (Chatfield, 2000; Hyndman & Athanasopoulos, 2021). Among commonly used time series forecasting methods, the Holt-Winters model (triple exponential smoothing) is considered one of the appropriate methods for data series with both trend and seasonality.

The Holt-Winters model allows the decomposition of a data series into three basic components, including level, trend and seasonality, thereby relatively fully reflecting the internal structure of economic time series data over time (Winters, 1960). According to Chatfield (2000), Compared to models based on the assumption of stationarity, this method does not require strict conditions on the structure of the data series and is therefore widely applied in economic and trade forecasting.

In addition to point forecasting models, recent studies have also emphasized the role of forecasting methods under uncertainty conditions. These include interval forecasting and probabilistic forecasting approaches (Chatfield, 1993; Gneiting & Katzfuss, 2014). Recent studies have also emphasized the role of forecasting methods under conditions of market uncertainty (von der Gracht & Darkow, 2010; Arora et al., 2025). In cases where historical data are insufficient to fully reflect future variations, Uncertainty Theory proposed by Liu (2010) provides a mathematical framework for modeling uncertain variables based on expert belief degrees rather than frequency probability. This approach allows the integration of qualitative information from experts with quantitative forecasting results to better reflect the potential range of variation of the studied variable. According to Petropoulos et al. (2022), uncertainty forecasting approaches are increasingly considered useful tools in forecasting studies and strategic planning in volatile business environments.

For Vietnam's pangasius export sector, particularly in the Mekong Delta region, forecasting export volume plays an important role in the capacity planning of the logistics service system. However, forecasting studies in this field remain relatively limited and mainly rely on basic statistical models or simple trend analyses. In addition, the pangasius export market is strongly influenced by many uncertain factors such as demand fluctuations in importing markets, technical trade barriers, changes in import policies, and global economic shocks. In this context, traditional forecasting methods based entirely on historical data sometimes face difficulties in fully capturing the level of market uncertainty.

To overcome these limitations, combining time series forecasting methods with uncertainty-based approaches is considered an appropriate research direction. In this study, the Holt-Winters model is used to capture the growth trend and seasonal factors of the pangasius export volume data series. At the same time, the uncertainty forecasting method (Uncertainty Theory) proposed by Liu (2010) is applied to determine the potential range of variation in future export volumes. The combination of these two approaches allows both statistical rigor in forecasting and the representation of uncertainty in the seafood export market. Based on updated data from 2014 to 2025, the study aims to develop forecasting scenarios for pangasius export volumes in the Mekong Delta for the period 2026-2035, thereby providing a reference basis for planning and developing the logistics service chain for this sector.

2.2. Research Methodology

The study is conducted through three main steps: data collection, forecasting model development, and analysis of forecasting results. First, the research data consist of a time series of pangasius export volumes in the Mekong Delta on a quarterly basis for the period 2014-2025. These data are compiled from the database of Vietnam Market Analysis and Forecast Joint Stock Company (AgroMonitor) and reflect export volumes to major importing markets. In the initial step, the study employs a Time Series Regression Model to establish the underlying growth trend of export volumes. However, observation of the data series indicates the clear presence of seasonal patterns and quarterly fluctuations; therefore, the Holt-Winters model is applied to simultaneously capture both trend and seasonality, thereby improving short-term forecasting accuracy. Nevertheless, this method assumes that historical structures are maintained in the future, and thus has limitations in long-term forecasting, particularly in the context of strong fluctuations in the pangasius export market. Therefore, the study further employs the uncertainty forecasting method (Uncertainty Theory) to better reflect uncertain factors in the pangasius export sector.

The first method applies the Time Series Regression Model to establish the underlying growth trend of pangasius export volumes. This approach assumes that past growth dynamics (from 2014 to 2025) can be used as a reliable representation of future performance, reflecting the combined effects of all factors in the past. The model is expressed as follows:

$$Y_t = \beta_0 + \beta_1 \cdot T + \epsilon_t \tag{1}$$

Where Y_t is the export volume of pangasius (tons) in year t, T is the time variable, and β_1 represents the average annual growth rate. This method provides a baseline forecast under the "business-as-usual" scenario.

To evaluate forecasting accuracy and model adequacy, three standard indicators are used. First, the Root Mean Square Error (RMSE) measures the standard deviation of the residuals, as defined in Equation (2). Second, the Mean Absolute Percentage Error (MAPE) represents accuracy in percentage terms, as presented in Equation (3), which is particularly useful for communicating results to policymakers.

$$RMSE = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(y_t - \hat{y}_t)^2} \tag{2}$$

$$MAPE = \frac{100\%}{n}\sum_{t=1}^{n}\left|\frac{y_t - \hat{y}_t}{y_t}\right| \tag{3}$$

Finally, the adjusted coefficient of determination $\text{Adj.}R^2$ is used to test the explanatory power of the model, while taking into account adjustments for unnecessary variables.

Observation of the collected data series shows a clear presence of seasonality and quarterly fluctuations; therefore, the study continues to employ the Holt-Winters model (triple exponential smoothing) to forecast the export volume trend for the period 2026-2035. In this model, the data series is decomposed into three components including level (L), trend (T), and seasonality (S). Modeling these three components simultaneously allows a relatively comprehensive representation of the variation characteristics of the export volume data series. Within the Holt-Winters model (triple exponential smoothing), the time series is decomposed into three basic components including level (Level-L), trend (Trend-T), and seasonality (Seasonality-S). Correct identification and interpretation of these three components play an important role throughout the forecasting process.

Y_t: Actual value at time t

L_t: Level at time t

T_t: Trend at time t

S_t: Seasonal index at time t

α, β, γ: Smoothing parameters $(0 \leq \alpha, \beta, \gamma \leq 1)$

m: Length of the seasonal cycle

Level $$L_t = \alpha \frac{Y_t}{S_{t-m}} + (1-\alpha)(L_{t-1} + T_{t-1}) \quad (4)$$

Trend $$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1} \quad (5)$$

Seasonality $$S_t = \gamma \frac{Y_t}{L_t} + (1-\gamma)S_{t-m} \quad (6)$$

h-step ahead forecast:

$$\hat{Y}_{t+h} = (L_t + hT_t) \times S_{t-m+h} \quad (7)$$

Finally, in the context of international seafood trade being strongly influenced by unpredictable factors such as technical barriers (SPS), fluctuations in market demand, logistics costs, and global economic shocks, the use of the Holt-Winters model alone may not fully reflect the level of market uncertainty in the long term. To overcome these limitations, this study applies Uncertainty Theory proposed by Liu (2010). Based on the expert consultation process, the data are not a single observed value but a specific data structure called "Expert's Experimental Data". This data is defined as a pair (x_i, α_i). The expected value $E[\xi]$ of pangasius export volume in 2035 is calculated as follows.

$$E[\xi] = \frac{\alpha_1 + \alpha_2}{2} x_1 + \sum_{i=2}^{n-1} \frac{\alpha_{i+1} - \alpha_{i-1}}{2} x_i + \frac{1 - \alpha_{n-1}}{2} x_n \quad (8)$$

In this equation, ξ represents an uncertain variable, denoting the future export volume of pangasius, while x_i are specific forecast values determined from different economic scenarios. The parameter α_i represents the degree of belief of experts that the actual value of the volume will be less than or equal to the corresponding value x_i. This approach allows consideration of qualitative market fluctuations in the long term that traditional statistical methods may not fully capture.

3. Research Results and Discussion

3.1. Analysis of Input Data

The data to be collected include the export volume of pangasius in the Mekong Delta in tons, along with macroeconomic factors that may affect pangasius export volumes. From detailed data of major importing markets, the authors aggregate pangasius export volumes of the Mekong Delta by quarter and by year for the period from 2014 to 2025 as shown in Figure 1.

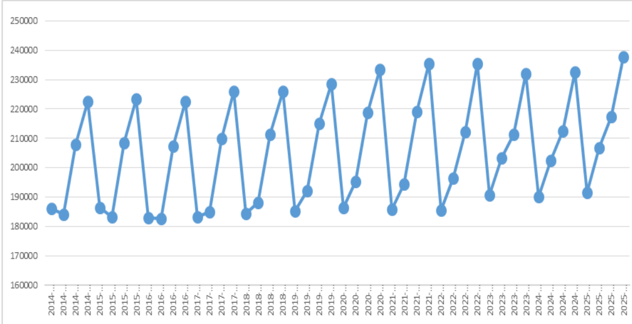

Figure 1. Pangasius export volume in the Mekong Delta for the period 2014-2025

Source: Compiled by the authors from AgroMonitor data

3.2. Forecasting Results Based on the Time Series Regression Model

The linear regression model assumes that past growth dynamics will continue into the future. The technical parameters of the model are presented in Table 1.

Table 1. Parameters of the Time Series Regression Model

Parameter	Value	Std. Error	Significance
Intercept (β0)	195,481.55	5,069.75	$p < 0.001$
Time Trend (β1)	406.34	180.13	$p = 0.0289$
Adj. R2	0.0800	-	Relatively low explanatory power
F-statistic	5.0889	-	$p = 0.0289$
RMSE	16,924.41	-	Tons
MAPE	7.48%	-	Acceptable level of error
Durbin-Watson	2.1490	-	No Autocorr.

Source: Compiled by the authors

The forecasting results show a stable growth trajectory. Pangasius export volume is projected to increase from 864,006.88 tons in 2026 to 922,519.84 tons in 2035. This reflects a steady growth rate driven by the development momentum of the seafood sector over the past decade. A visual representation of these forecasting results, including historical data and the projected trend line, is presented in Figure 2.

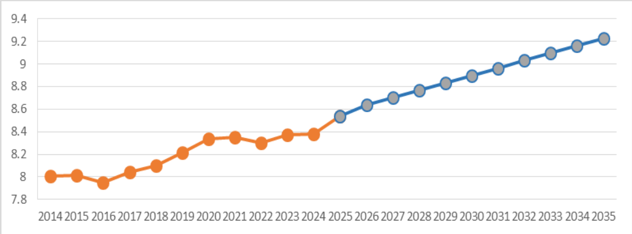

Figure 2. Linear growth of pangasius export volume in the Mekong Delta.

Source: Compiled by the authors

The graph shows that pangasius export volume exhibits a stable upward trend over time, with a relatively smooth increasing trend line and no significant fluctuations. The historical period reflects relatively smooth growth, indicating the continuity and regularity of the data series. Therefore, the Holt-Winters model is appropriate as it can simultaneously capture both the upward trend and seasonal factors, thereby improving forecasting accuracy in the long term.

3.3. Forecasting Results Based on the Holt-Winters Model

Table 2 presents the estimated smoothing parameters and forecasting accuracy of the Holt-Winters model. The results include the optimized values of α, β, γ along with RMSE and MAPE used to evaluate model performance.

Table 2. Estimated Parameters and Forecast Accuracy of the Holt-Winters Model

α	β	γ	RMSE	MAPE
0.002696088	1	0.089053703	25793.97	0.10

Source: Compiled by the authors

The forecasting results of pangasius export volume in the Mekong Delta for the period 2026-2035 using the Holt-Winters model are presented in Figure 3.

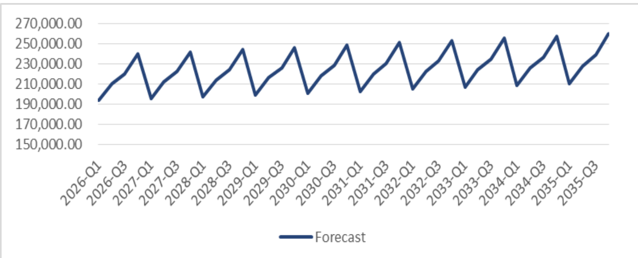

Figure 3. Forecast of pangasius export volume in the Mekong Delta by quarter for the period 2026–2035 (tons) using the Holt-Winters model

Source: Compiled by the authors

The results show that total projected export volume maintains a relatively stable growth trend throughout the study period. By the end of the forecasting period, export volume may reach approximately 938,124 tons in 2035, indicating stable growth potential of the pangasius export sector in the medium term. In terms of seasonal structure, the forecasting results show that the fourth quarter remains the quarter with the highest export volume in the year, while the first quarter tends to have lower volume compared to the other quarters. For example, in 2035, the projected export volume reaches 210,410 tons in the first quarter, 228,346 tons in the second quarter, 239,099 tons in the third quarter, and 260,268 tons in the fourth quarter. This distribution pattern is relatively consistent with the seasonal characteristics of aquaculture activities and seafood import demand in major consuming markets.

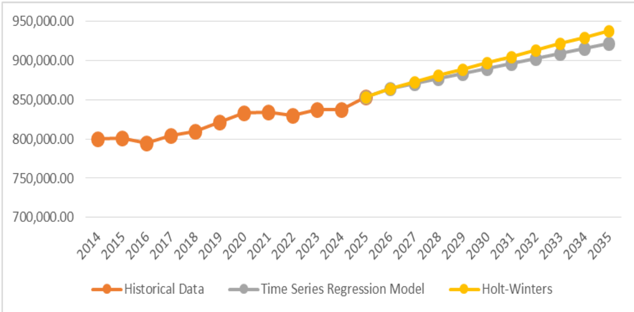

Figure 4. Forecast results of the Time Series Regression Model and Holt-Winters

Source: Compiled by the authors

Based on the graph, it can be seen that the Holt-Winters model closely follows the upward trend of the historical data and provides relatively stable forecasting results in the short and medium term. However, this model is essentially based on the assumption that past patterns (trend and seasonality) will continue in the future, and therefore does not reflect shocks or structural changes in the market. In the context of the pangasius sector being strongly affected by uncertain factors such as technical barriers (SPS), fluctuations in international market demand, logistics costs, and climate change, extending Holt-Winters forecasts to distant horizons such as 2035 may increase forecasting errors. This model has difficulty capturing nonlinear scenarios or sudden changes, leading to the risk of over-smoothing the actual trend. Therefore, to overcome this limitation, the study needs to combine the Uncertainty Theory method to integrate expert knowledge and reflect possible value ranges under uncertain conditions, thereby improving the reliability of long-term forecasting.

3.4. Forecasting Results Based on the Uncertainty Theory Method

To incorporate expert evaluation using Uncertainty Theory, the study is conducted based on experimental data through consultation with four selected experts with extensive expertise in seafood export logistics. The expert group includes: Leaders of seafood processing and export enterprises in the Mekong Delta; officials in the fisheries sector; cold chain logistics experts; and seafood market research experts. The expert information is summarized in Table 3.

Table 3. Profile of the Expert Panel

Exp.	Role/Organization	Perspective	Exp. (Yrs)
1	Seafood market research expert	Macroeconomics	18
2	Fisheries sector official	Policy/General planning	22
3	Leader of seafood processing and export enterprise	Logistics demand	15
4	Cold chain logistics expert	Logistics	20

Source: Compiled by the authors

Instead of directly forecasting absolute volumes, which may be subject to large fluctuations, experts are asked to estimate the Compound Annual Growth Rate (CAGR) for the period 2026-2035. The consensus results of the expert group are aggregated into an experimental data series consisting of five representative points, as presented in Table 4.

Table 4. Experimental Data Series for 2035

Index (i)	Rate x_i (ton)	Belief Degree α_i
1	915,000	0.00
2	940,000	0.35
3	950,000	0.65
4	965,000	0.88
5	990,000	1.00

Source: Compiled by the authors

The uncertainty interval for 2035 is wider than that of 2030, reflecting an increasing level of uncertainty in long-term forecasts. The experimental data are constructed based on both statistical models and expert opinions to ensure consistency and practicality.

The experimental uncertainty distribution Φ(x) of pangasius export volume in 2035 is constructed as a piecewise linear function (Figure 2). Unlike the standard uniform distribution, the curve in the graph shows different slopes across value intervals, reflecting the non-uniform levels of expert belief for different.

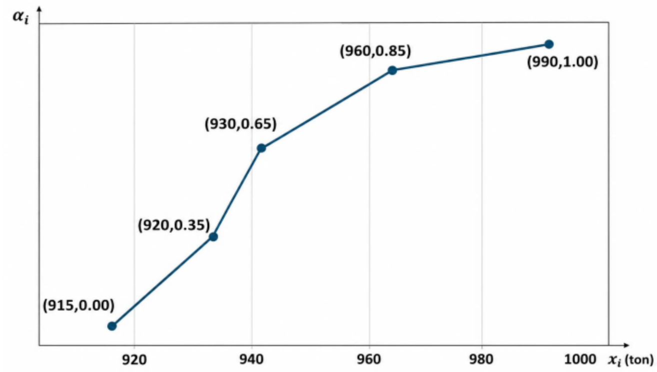

Figure 5. Graph of the experimental uncertainty distribution

Source: Compiled by the authors

The expected growth rate E[ξrate] is calculated as follows $E[\xi rate] = \sum_{i=1}^{n-1} \frac{r_i + r_{i+1}}{2} (\alpha_{i+1} - \alpha_i)$ (9)

$$E[\xi rate] = 0.35\frac{-2.5455 + 0.1172}{2} + 0.30\frac{0.1172 + 1.1822}{2}$$

$$+0.23\frac{1.1822 + 2.7798}{2} + 0.12\frac{2.7798 + 5.4425}{2}$$

≈ 0.7189% (10)

Using this expected growth rate, the study forecasts the pangasius export volume of the Mekong Delta in 2035 from the 2025 volume.

$Y_{2035} = 853{,}787.34 \times (1 + 0.007189)^{10}$

≈ 917,100.75 tons

The calculation results show that the projected export volume in 2035 reaches approximately 917,101 tons. This value reflects a positive but cautious growth trend, consistent with the fluctuating characteristics of the pangasius export market in the context of many remaining uncertainties.

4. Discussion and Implications for the Development of the Logistics Service Chain

The forecasting results in the study show that pangasius export volume in the Mekong Delta maintains a stable growth trend during the period 2026-2035. According to the Holt-Winters model, export volume is projected to increase from approximately 864,641 tons in 2026 to about 938,124 tons in 2035, while the forecasting results based on the uncertainty method indicate that the volume may reach approximately 917,100.75 tons by the end of the forecasting period.

By 2035, export volume is expected to increase by approximately 23.7% from the first quarter to the fourth quarter (from 210,410 tons to 260,268 tons), implying a corresponding increase in cold chain logistics demand during peak periods. This upward trend suggests that cold storage capacity and refrigerated transport demand may need to increase by approximately 20-25% in peak quarters. In this context, the synchronized development of the components of the logistics service chain-particularly cold chain infrastructure, specialized logistics centers, and supply chain management mechanisms-becomes an important factor to ensure the capacity for storage, transportation, and distribution of exported seafood products.

4.1. Cold Chain Logistics Infrastructure

The forecasting results of export volume show that the demand for the cold chain logistics system in the Mekong Delta will continue to increase in the medium term. For frozen seafood products such as pangasius, the cold chain logistics system plays a decisive role in ensuring product quality, extending storage time, and meeting the technical standards of importing markets.

In practice, the cold chain logistics system in the region still has certain limitations, particularly the shortage of cold storage capacity, the uneven distribution of storage facilities, and the lack of connectivity among stages in the cold chain. The increase in export volume during the forecasting period may put additional pressure on the existing cold storage system, especially during peak export periods in the third and fourth quarters.

Therefore, the expansion and upgrading of cold chain logistics infrastructure should be considered a priority in the regional seafood logistics development strategy. First, it is necessary to strengthen investment in modern cold storage systems in areas concentrated with processing plants and near major transportation routes to reduce intra-regional transportation costs. At the same time, the application of advanced preservation technologies and smart temperature management solutions can also contribute to improving the operational efficiency of the cold chain. The coordinated development of cold chain infrastructure reduces post-harvest losses and enhances

the competitiveness of Vietnamese pangasius in international markets.

4.2. Logistics centers for seafood exports

In addition to expanding cold storage infrastructure, the forecast results of export volume also indicate the need to develop specialized logistics centers for seafood exports in the Mekong Delta. In the context of continuously increasing export volumes, the current fragmented logistics model may lead to higher transportation costs, longer cargo handling times, and reduced efficiency in the utilization of logistics infrastructure.

The establishment of seafood logistics centers can help integrate multiple logistics services within a single functional space, including cold storage, packaging and sorting services, quality inspection, refrigerated container handling and transportation services connected to seaports. This model allows the optimization of cargo flows from aquaculture areas to processing plants and from processing plants to export ports.

In addition, specialized logistics centers also play an important role in enhancing coordination among enterprises within the seafood value chain. The concentration of logistics activities at specialized centers can reduce transaction costs, improve infrastructure utilization efficiency, and facilitate the application of modern logistics management technologies.

In the long term, the planning and development of seafood logistics centers need to be aligned with the planning of aquaculture areas, transportation systems, and export seaports. Effective connectivity between logistics centers and major transport corridors will contribute to improving the overall efficiency of the seafood supply chain in the region.

4.3. Supply chain management

The increase in export volume not only requires the expansion of logistics infrastructure but also improvements in seafood supply chain management. In the pangasius export sector, the involvement of multiple actors such as farmers, processors, logistics firms, and international importers means that weak coordination can raise logistics costs and reduce responsiveness to market fluctuations. As the international seafood market is increasingly shaped by technical barriers and traceability requirements, strengthening supply chain management is essential to enhance transparency and product quality control. This requires closer cooperation between processing-export enterprises and logistics providers to develop integrated systems for monitoring and managing the flow of goods.

At the same time, the application of digital technologies-such as logistics data platforms, electronic traceability systems, and intelligent transport management-can improve operational efficiency, reduce costs, and shorten delivery times. Overall, developing the logistics service chain for pangasius exports in the Mekong Delta should follow a systemic approach, combining cold chain infrastructure, specialized logistics centers, and enhanced supply chain management to improve efficiency and competitiveness in international markets.

5. Conclusion

This study develops a quantitative framework to forecast pangasius export volumes in the Mekong Delta for the period 2026-2035, while clarifying implications for the development of the logistics service chain supporting this sector. By combining the Holt-Winters time series model with an uncertainty-based approach grounded in Uncertainty Theory, the study overcomes the limitations of single-method forecasting and provides a more comprehensive view of export market dynamics.

The results indicate a relatively stable upward trend in export volumes, increasing from about 864,641 tons in 2026 to approximately 938,124 tons in 2035. When accounting for market uncertainty, the expected volume is estimated at around 917,100.75 tons, suggesting continued growth under varying market conditions.

These findings imply that rising export volumes will place increasing demands on the logistics system. Accordingly, the development of the logistics service chain should focus on three key areas: upgrading cold chain infrastructure to ensure product quality, establishing specialized logistics centers to optimize cargo flows and reduce costs, and strengthening supply chain management through closer coordination among stakeholders.

From a policy perspective, the study provides a useful reference for planning logistics development for seafood exports in the Mekong Delta. Better alignment between logistics planning, transport infrastructure, and supply chain organization will contribute to improving efficiency, reducing costs, and enhancing the international competitiveness of Vietnam's pangasius sector.

References

Arora, R., Sachs, A.-L., Svetunkov, I., Muth, M., & Boylan, J. E. (2025). Forecasting demand during and after supply chain disruptions using a shock smoother ETS. International Journal of Production Research. https://doi.org/10.1080/00207543.2025.2577158

Asche, F., Bellemare, M. F., Roheim, C., Smith, M. D., & Tveterås, S. (2015). Fair enough? Food security and the international trade of seafood. World Development, 67, 151–160. https://doi.org/10.1016/j.worlddev.2014.10.013

Chatfield, C. (1993). Calculating interval forecasts.Journal of Business & Economic Statistics, 11(2), 121–135. https://doi.org/10.1080/07350015.1993.10509939

Chatfield, C. (2000). Time-series forecasting. Chapman & Hall/CRC.

Christopher, M. (2016). Logistics & supply chain management (5th ed.). Pearson Education.

Food and Agriculture Organization of the United Nations (FAO). (2022). The state of world fisheries and aquaculture 2022: Towards blue transformation. FAO. https://www.fao.org

Gneiting, T., & Katzfuss, M. (2014). Probabilistic forecasting.Annual Review of Statistics and Its Application, 1, 125-151.https://doi.org/10.1146/annurev-statistics-062713-085831

Hyndman, R. J., & Athanasopoulos, G. (2021). Forecasting: Principles and practice (3rd ed.). OTexts. https://otexts.com/fpp3/

Liu, B. (2010). Uncertainty Theory, 5th ed., Springer-Verlag, Berlin, Germany

Petropoulos, F., Apiletti, D., Assimakopoulos, V., Babai, M. Z., Barrow, D. K., Ben Taieb, S., Bergmeir, C., Bessa, R. J., Bijak, J., Boylan, J. E., Browell, J., Carnevale, C., Castle, J. L., Cirillo, P., Clements, M. P., Cordeiro, C., Cyrino Oliveira, F. L., De Baets, S., Dokumentov, A., … Ziel, F. (2022). Forecasting: theory and practice. International Journal of Forecasting, 38(3), 705-871. https://doi.org/10.1016/j.ijforecast.2021.11.001

Tsolakis, N. K., Keramydas, C. A., Toka, A. K., Aidonis, D. A., & Iakovou, E. T. (2014). Agrifood supply chain management: A comprehensive hierarchical decision-making framework and a critical taxonomy. Biosystems Engineering, 120,47-64.https://doi.org/10.1016/j.biosystemseng.2013.10.014

Vietnam Association of Seafood Exporters and Producers (VASEP). (2024). Vietnam seafood export report. VASEP. https://www.vasep.com.vn

von der Gracht, H. A., & Darkow, I.-L. (2010). Scenarios for the logistics services industry: A Delphi-based analysis for

2025. International Journal of Production Economics, 127(1), 46–59. https://doi.org/10.1016/j.ijpe.2010.04.013

Winters, P. R. (1960). Forecasting sales by exponentially weighted moving averages. Management Science, 6(3), 324–342. https://doi.org/10.1287/mnsc.6.3.324

Received	**27 March 2026**
1st Revised	**14 April 2026**
2nd Revised	**13 May 2026**
Accepted	**20 May 2026**