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RESEARCH ARTICLE

Production and Sustainability in Türkiye's Fisheries Sector: The Role of Economic Variables

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Abstract: This study investigates the impact of basic economic variables on production processes in Türkiye's fisheries sector, emphasizing sustainable development strategies. Using a dataset from the Turkish Statistical Institute covering annual data from 2003 to 2023, the research employs the ARDL model to examine the long-term and short-term effects of capital investments, labor costs, and energy expenses on total production. Results indicate that capital investments significantly enhance productivity, though misallocation can negatively impact efficiency. Labor and energy costs exhibit a negative effect, underlining the importance of cost optimization for sectoral sustainability. Based on these findings, the current study proposes strategic policy recommendations such as; efficient capital allocation, labor cost optimization through training programs, and the adoption of renewable energy sources to reduce operational expenses. These recommendations aim to support sustainable growth in the Turkish fisheries sector, enhance food security, and bolster economic resilience.

Anahtar kelimeler:

Sermaye yatırımları
Enerji maliyeti
Balıkçılık sektörü
İş gücü maliyeti
Sürdürülebilirlik
Türkiye

Türkiye Balıkçılık Sektöründe Üretim ve Sürdürülebilirlik İlişkisi: Ekonomik Değişkenlerin Rolü

Öz: Bu çalışma, sürdürülebilir kalkınma stratejilerine vurgu yaparak, Türkiye'nin balıkçılık sektöründeki üretim süreçleri üzerinde temel ekonomik değişkenlerin etkisini araştırmaktadır. Türkiye İstatistik Kurumu'ndan alınan 2003-2023 yılları arasındaki yıllık verileri kapsayan araştırma, sermaye yatırımlarının, işçilik maliyetlerinin ve enerji giderlerinin toplam üretim üzerindeki uzun vadeli ve kısa vadeli etkilerini incelemek için ARDL modelini kullanmaktadır. Sonuçlar, sermaye yatırımlarının üretkenliği önemli ölçüde artırdığını, ancak yanlış tahsisin verimliliği olumsuz etkileyebileceğini göstermektedir. İşgücü ve enerji maliyetleri olumsuz bir etki göstererek, sektörel sürdürülebilirlik için maliyet optimizasyonunun önemini vurgulamaktadır. Bu bulgulara dayanarak, mevcut çalışma; verimli sermaye tahsisi, eğitim programları aracılığıyla işgücü maliyeti optimizasyonu ve operasyonel giderleri azaltmak için yenilenebilir enerji kaynaklarının benimsenmesi gibi stratejik politika önerileri sunmaktadır. Bu öneriler, Türkiye balıkçılık sektöründe sürdürülebilir büyümeyi desteklemeyi, gıda güvenliğini artırmayı ve ekonomik dayanıklılığı güçlendirmeyi amaçlamaktadır.

Introduction

The fisheries sector plays a fundamental role in the economic development and food security of many countries in the world. Especially in countries like Türkiye, which has a long coastline and abundant seafood resources, fisheries is very important both as an economic resource and andin terms of creating employment opportunity (Bilgin, 2012). In Türkiye, the fisheries sector covers a wide supply chain from production to marketing, as well as fishing and aquaculture activities. However, in recent years, the need to improve the production processes in line with the principles of sustainable development and to increase economic efficiency has become even more important (Topçu, 2012). As stated by the Food and Agriculture Organization (FAO, 2022), fisheries and aquaculture activities contribute to both global nutritional security and livelihoods. However, issues such as overuse of natural resources, overfishing and marine pollution place significant pressure on fish populations (Cochrane, 2001).

In Türkiye, the protection of ecosystems such as the Mediterranean and Black Sea and the dissemination of

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sustainable fishing practices are of great importance in this context. In the literature, it is frequently emphasized that a balance should be established between the environmental and economic sustainability of the fishing sector (Jacobsen, 2016; Pierce et al., 2012). In studies conducted in line with sustainable development goals in the fishing sector, the protection and efficient use of natural resources are at the forefront. In studies such as Creighton (2015) and Cashion et al. (2017), it has been stated that ensuring environmental sustainability is fundamental to the long-term economic success of the sector. In particular, it has been emphasized that fish stocks are decreasing on a global scale and that current fishing practices are straining environmental boundaries. In addition, studies on environmentally friendly policies implemented in the European Union show that measures taken at the local level can have global effects (Bostock et al., 2016).

The fishing sector in Türkiye is addressed in terms of economic variables such as capital investments, labor costs and energy costs. Capital investments are of critical importance, especially in terms of the renewal and modernization of boats, nets and other technical equipment (Oyakhilomen and Zibah, 2020). Such investments both increase the production capacity in the sector and strengthen international competitiveness (Mobsby et al., 2020). At the same time, optimizing labor costs can positively affect the total production volume of the sector by increasing the efficiency of production processes (Creighton et al., 2015). Energy costs play a decisive role in the economic efficiency of the sector. Energy inputs such as fuel and electricity are one of the main cost elements in both fishing and processing processes (Erkayral and Aksoy, 2022).

In the literature, the balance between energy and capital investments plays a critical role in ensuring the sustainability of production processes (Carneiro et al., 2022). In particular, the development of policies that increase energy efficiency can offer both environmental and economic benefits. In addition, supporting small-scale fisheries and aquaculture practices can promote socio-economic development in rural areas (Muhamad et al., 2024). Small-scale fisheries are considered as a social and economic balancing element in the midst of unbalanced competition with large-scale industrial fisheries (Pierce et al., 2012).

Türkiye's fisheries sector is also vulnerable to the effects of climate change. Blanchard et al. (2012) and Cheung et al. (2009) stated that the effects of climate change on marine ecosystems had not only biological but also economic and social consequences. This situation shows that fisheries policies in coastal countries like Türkiye should be re-evaluated. Innovative policies are required, especially to reduce energy costs and minimize environmental impacts (Mobsby et al., 2020).

The main purpose of this study is to examine the relationships between production and sustainability in the fisheries sector in Türkiye from the perspective of economic variables. The study aims to understand the effects of basic economic factors such as capital investments, labor costs and energy costs on the production processes in the sector and to evaluate the role of these interactions in the context of sustainable development. In addition, it aims to present a holistic analysis of the sector by comparing the dynamics specific to the fisheries sector in Türkiye with the approaches in the global literature.

Material and Methods

The dataset used in this study consists of annual data on the Turkish fisheries sector for the period 2003-2023. All data are obtained from sectoral statistics published by the Turkish Statistical Institute (TurkStat). The research aims to comprehensively analyze the effects of capital investments, energy expenditures and labor costs on production by detailing the main economic variables affecting production processes in the sector.

Capital investment data includes a broad definition of fixed capital expenditures in the sector. In this context, both domestic and foreign investments are considered, and the purchase of various fishing equipment is analyzed. In particular, this includes new or old engines, fishing vessels, nets and technical equipment. These investments are of great importance for adopting technological innovations in the fisheries sector and increasing production capacity. The use of modern equipment contributes to the economic sustainability of fishing activities by increasing productivity in the sector.

Energy expenditure data includes the cost of water, electricity and fuel oil used in the fishing sector. These expenditures stand out as an important cost item in the operational processes of fishing vessels. High energy consumption accounts for a large share of total expenses in the sector, especially due to the operation of motorized vessels and the use of cooling systems. Therefore, energy costs have a significant impact on the efficiency and cost effectiveness of production processes. Optimization of energy consumption is a critical requirement for both economic and environmental sustainability.

In addition to these two key variables, the dataset also includes labor costs. Labor costs include salaries, social security payments and other labor expenditures of employees employed in the sector. The labor-intensive nature of the fisheries sector causes labor costs to occupy an important place in the total cost structure. In this context, the impact of labor costs should be carefully considered in productivity analyses. This data provided by TurkStat allows us to provide a detailed analysis of sectoral costs and provide strategic recommendations for more efficient use of resources.

In the study, long and short-term relationships were analyzed using the ARDL (Autoregressive Distributed Lag) econometric model. This method provides a suitable tool to examine the effects of economic variables in the fisheries sector in detail. The model was designed to measure the causal relationships between economic factors and production processes and the magnitude of these relationships. The data set consists of annual data obtained from reliable national institution, Turkish Statistical

Institute (TUIK) for the period 2003-2023 and statistical tests were applied to determine the correlation between the variables in the analysis.

This dataset provides a comprehensive basis for assessing the impact of capital and energy use and labor costs on production in the fisheries sector. Thus, we aim to contribute to the shaping of policies by providing concrete data on strategies that can be developed to improve the economic sustainability of the fisheries sector. The ARDL model allows both short-run and long-run relationships to be evaluated within the same model and provides efficient results even when the stationarity of the series are different (Pesaran and Shin, 1999). The ARDL method allows stationary series at I(0) and I(1) level to be analyzed together. Thus, the existence of long-run relationships between variables can be tested in a more flexible structure (Pesaran, et al., 2001).

Before constructing the model, unit root tests were applied to determine the stationarity level of the data. The unit root tests used in this study are ADF (Augmented Dickey-Fuller) and Phillips-Perron tests. The ADF test analyzes whether the series are stationary or not and provides a result with improved accuracy by adding additional lag levels according to the autocorrelation structure of the tested series (Dickey and Fuller, 1979). An alternative test, the Phillips-Perron test, provides more robust results than the ADF test, especially in the presence of structural breaks and serial correlation in the series (Phillips and Perron, 1988).

After determining the stationarity levels of the series according to the results of the unit root tests, the long-run and short-run relationships between the variables are analyzed with the ARDL model. Bound test method was used to determine the existence of long-run relationships. Bound test is an approach that tests whether there is a long-run relationship between the dependent and independent variables in the ARDL model and shows the statistical significance of the model (Pesaran et al., 2001). Once the long-run relationships are identified, an error correction model (ECM) is constructed to analyze short-run interactions. The ECM shows how short-run deviations between variables are corrected in the long run and is particularly important in econometric models to analyze the correction of short-term imbalances (Engle and Granger, 1987).

In order to test the appropriateness of the ARDL model, various specification tests were performed. Breusch-Godfrey LM test was applied to examine the presence of autocorrelation in the model. This test detects whether there is serial correlation in the model (Breusch, 1978; Godfrey, 1978). The Breusch-Pagan-Godfrey test was used to test for heteroskedasticity; this test tests the validity of the assumption of constant variance in the error terms of the model (Breusch and Pagan, 1979). The Ramsey RESET test is used to check whether the functional form of the model is correct (Ramsey, 1969). The normality test examines whether the error terms are normally distributed; this test is important for testing the assumptions of the model.

Finally, Cusum and Cusum of Squares plots were analyzed to assess the reliability of the model. These graphs allow to visually assess whether the parameters of the model are stable over time (Brown et al., 1975). If the values in the plots are within the critical limits, the reliability and parameter stability of the model are confirmed. These analyses are an important part of the study to ensure the stability and reliability of the model's prediction results.

Results

The analysis assesses the impacts of energy costs, labor costs and capital investments on total fish production between 2003 and 2023. The results of the data analysis aim to provide important findings on sectoral efficiency and cost-effectiveness.

Table 1. Descriptive statistics of variables (production, capital investment, labor and energy cost)

Variables*	***N***	**Mean**	**Std. Deviation**
Production	21	11.6531	0.33745
Capital Inv.	21	17.4235	0.72443
Labor Cost	21	18.6213	0.58230
Energy Cost	21	18.9934	0.44852

*Since all variables consist of unit data, econometric analysis was performed by taking the natural logarithm of each variable.

Table 1 summarizes mean and SD of log transformed descriptive statistics (production, capital investments, labor costs and energy costs). The production variable has a mean value of 11.65 ± 0.337 and indicated that the production level has a fairly stable structure during the analysis period and shows low fluctuation. The capital investments variable reached a mean value of 17.42 units and exhibited a wider variability compared to the other variables with a standard deviation of 0.724. This situation indicates that capital investments followed a more fluctuating course during the analysis period. The mean of labor costs was determined as 18.62 ±0.582 units indicating higher fluctuation in labor costs compared to the production level. Energy costs have a mean value of 18.99 units and the standard deviation value is calculated as 0.449. The low standard deviation value of energy costs suggests that this variable has a relatively stable structure during the analysis period. In general, the statistical properties of these variables, provide an important basis for understanding the general levels and variability of the economic variables considered in the study. While lower fluctuations are observed in production and energy costs in particular, a wider variation is noted in capital investments and labor costs. This situation can be evaluated as an important finding that should be taken into account in sectoral analyses.

Table 2. ADF unit root test

I(0)			I(1)		
Variables	**t-stat**	**p-value**	**Variables**	**t-stat**	**p-value**
Production	-1.677	0.3992	Production	-4.298	0.0006
Capital Inv.	-2.092	0.6633	Capital Inv.	-5.856	0.0002
Labor Cost	0.636	0.9659	Labor Cost	-4.199	0.0288
Energy Cost	1.437	0.9225	Energy Cost	-1.993	0.0341

Table 3. Philips peron unit root test

I(0)			I(1)		
Variables	**t-stat**	**p-value**	**Variables**	**t-stat**	**p-value**
Production	-1.778	0.4922	Production	-8.238	0.0000
Capital Inv.	-0.834	0.8384	Capital Inv.	-6.021	0.0001
Labor Cost	1.264	0.9003	Labor Cost	-3.217	0.0401
Energy Cost	1.353	0.8920	Energy Cost	-2.642	0.0314

ADF (Augmented Dickey-Fuller) and Phillips-Perron unit root tests were applied to determine the stationarity levels of the variables used in the study. These tests are important to determine whether the time series are stationary and whether it is possible to establish a long-run relationship between the series. In the unit root tests, the stationarity of the variables at level (I(0)) and first difference (I(1)) were analyzed.

According to the ADF test results shown in Table 2, none of the variables tested at level are stationary. This indicates that the variables deviate from the mean over time and do not return to the long-run equilibrium level. However, when the first differences of the variables are taken, it is observed that the variables become stationary. This result indicates that the variables are in the I(1) process, that is, they become stationary when first differences are taken.

The Phillips-Perron test results shown in Table 3 are also consistent with the ADF test. This test developed by Phillips and Perron (1988) has a more robust structure against autocorrelation and heteroscedasticity problems in the series. According to the results of the Phillips-Perron test, variables that are non-stationary at the level become stationary when first differences are taken. This consistency provides strong evidence that the analyzed series can be cointegrated.

In general, both tests indicate that the variables become stationary in their first differences. These results support the appropriateness of the ARDL model to be used in this study. This is because ARDL models have the flexibility to analyze both level stationary (I(0)) and first difference stationary (I(1)) variables. Therefore, the results of unit root tests provide an appropriate basis for analyzing long-run relationships based on the ARDL model.

In this study, ARDL model is used to examine the long-run effects of economic variables affecting production in the Turkish fisheries sector. The chosen model structure analyzes the relationships between the dependent variable total production and capital investments, labor costs and energy costs. The advantage of the ARDL model is that it can take into account short-run dynamics while testing for the existence of long-run relationships between series.

According to the results (Table 4), the long-run effects of capital investments, labor costs and energy costs on total production in the fisheries sector are significant. The positive long-run coefficient of production indicates that productivity can be increased through the use of modern equipment and technologies. This finding emphasizes the importance of capital investments to ensure sustainable production in the sector.

However, the fact that capital investments have a negative coefficient indicates that misallocation of capital may have a negative impact on production. In capital-intensive sectors such as the fisheries sector, making appropriate investments is critical for productivity in the sector.

The negative impact of labor costs on production shows the impact of the labor-intensive structure of the sector on production costs. This finding indicates that labor costs should be managed effectively in order to reduce costs and increase profitability in the sector. Similarly, energy costs have a negative coefficient, indicating the importance of energy efficiency in operational processes in the fisheries sector.

Table 4. General results of ARDL model and long-run relationships (Selected Model: ARDL (2, 2, 0, 2))

Variables	Coefficient	Probability	
Production	0.767851	0.0113**	
Capital Inv.	-0.38257	0.0162**	
Labor Cost	-1.21845	0.0298**	
Energy Cost	-0.50833	0.0064***	
R-squared	0.867345	Akaike info criterion	-1.498745
Adj. R-sq	0.718456	Schwarz info criterian	-1.123657
Log L	19.72346	Hannan – Quinn criter.	-1.632358
		Durbin-Watson stat	2.2073456

* for 10% significance level, ** for 5% significance level, *** for 1% significance level

The overall performance indicators of the model are high, and the explanatory power of the model is satisfactory. These results indicate that capital investments should be directed correctly, and energy costs should be optimized to ensure the economic sustainability of the Turkish fisheries sector. The findings of the study provide a significant contribution to the literature for developing strategies to increase efficiency in the sector.

Table 5. Bound test results

Model	k	m	F	*Signif*	I(0)	I(1)
				1%	3.42	4.84
(2,2,0,2)	3	18	5.2763*	5%.	2.45	3.63
				10%	2.01	3.1

(k): Number of explanatory variables, (m): Maximum number of lags, (*) indicates 1% significance level

According to the bound test results (Table 5), the F-statistic value is calculated as 5.2763 and this value exceeds the boundary values (critical values) at 1% significance level. The bound test is used to test whether there is a long-run relationship between the explanatory variables and the dependent variable in the model. In this test, the F-statistic is compared with the critical values according to certain significance levels.

Since the F-statistic value obtained in this study exceeds both I(0) and I(1) critical thresholds at 1% significance level, it indicates the existence of a long-run relationship in the model. This result indicates that there is a long-run equilibrium relationship between total production in the fisheries sector, which is the dependent variable, and capital investments, labor costs and energy costs.

This finding provides an important clue for developing sustainable production policies in the fisheries sector in line with the objective of the study. The existence of a long-run relationship indicates that variables such as capital investments, labor costs and energy costs can have lasting effects on production processes in the sector and the management of these factors should be taken into account in long-term strategic planning.

Table 6. Short-run error correction model

Variables	Coefficient	t-stat	Probability
CointEq(-1)	-0.2489	5.6378	0.0031
R-squared	0.901569	Akaike info criterion	-1.925130
Adj. R-sq	0.821855	Schwarz info criterian	-1.793851
Log L	18.72457	Hannan – Quinn criter.	-1.96853
		Durbin-Watson stat	2.146852

In this study, the short-run error correction model (ECM) is used to analyze how long-run imbalances are corrected in the short-run. According to Table 6, the error correction term (CointEq(-1)), which is an important component of the ECM, expresses the speed at which the system returns to long-run equilibrium. The coefficient of CointEq(-1), which is called the short-run error correction term, shows how long it takes for the system to return to long-run equilibrium after short-term shocks in the fisheries sector. The value of -0.2489 obtained in this study indicates that the economic imbalances occurring in the short run are corrected at a certain speed and the system returns to the long-run equilibrium level. In natural resource-based sectors such as the fisheries sector, environmental and economic fluctuations are quite frequent. Therefore, the sector's ability to quickly adapt to these shocks is critical for both sustainable production and efficient use of resources.

The fact that the coefficient of CointEq(-1) is significant and positive indicates that the effects of fluctuations in key economic variables such as investments, labor and energy costs in the sector are balanced in a short time. In the fisheries sector, sudden increases or decreases in inputs such as capital investments and energy costs can affect production costs and total output in the short run. However, a strong error correction mechanism ensures that such imbalances in the sector are quickly recovered and the long-run equilibrium level is reached. This reflects the resilience of the fisheries sector and its capacity to adapt to sustainable development goals.

The Turkish fisheries sector is highly sensitive to changes in labor costs due to its labor-intensive structure. This sensitivity makes the impact of labor costs on productivity in the sector even more important. For example, a sudden increase in labor costs may increase production costs in the short run and negatively affect the profitability of the sector. However, the positive value of the coefficient of CointEq(-1) indicates that such cost increases will not destabilize the sector; on the contrary, the sector can adapt to these changes and return to its long-term production targets. This flexibility points to the potential of the fisheries sector to ensure sustainability in production activities.

Energy costs also stand out as an important cost factor in the operational processes of the sector. High energy costs constitute a major cost burden in the sector, especially due to the operations of fishing vessels and the use of cooling systems. However, as the CointEq(-1) coefficient shows, despite the fluctuations in energy costs, the sector has the ability to adapt in the short term. This adjustment mechanism supports the sector's productivity growth and ensures that the negative effects on total output are limited in the long run. Therefore, the strong error correction coefficient suggests that the sector has a high capacity to manage possible shocks in variables such as energy costs and can maintain sustainability in this process.

In conclusion, the significant and positive value of the CointEq(-1) coefficient indicates that the Turkish fisheries sector is resilient to economic and environmental changes and that sustainable production activities in this sector can be carried out in line with sustainable development goals. The fact that the sector has such a flexible structure can be considered as an important finding for decision makers and policy makers.

A series of specification tests, which are shown in Table 7, were applied to test the validity and reliability of the model. These tests are important to assess whether the model ensures autocorrelation, heteroskedasticity, normality and the correct functional form.

Table 7. Specification Tests

Tests	Probability
Serial Correlation LM test (Breusch–Godfrey)	0.1143
Heteroscedasticity test (Breusch–Pagan–Godfrey)	0.8344
Jargue–Bera Normality test	0.4416
Ramsey Reset Test	0.7153

First, the Breusch-Godfrey LM Test for Serial Correlation is applied, and the p-value is 0.1143. This result indicates that the error terms are not serially correlated and there is no autocorrelation problem. The absence of autocorrelation is important in terms of showing that the estimates of the model are independent, and the assumption of inter-series relationship is met (Breusch, 1978; Godfrey, 1978).

Breusch-Pagan-Godfrey test was performed as a heteroskedasticity test and the p-value was found to be 0.8344. This result indicates that the error terms in the model have a constant variance and there is no heteroskedasticity problem. The constant variance of the error terms increases the stability of the model and the reliability of the forecasts. This is especially important for the assumption that the variance between observations obtained in different periods should remain constant.

The Jarque-Bera normality test was applied to check whether the distribution of error terms in the model is normal. The p-value of 0.4416 indicates that the error terms are normally distributed. The normal distribution of the error terms indicates that the model works in accordance with its assumptions and increases the validity of the estimation results. This result indicates that various distributional properties of the model are also confirmed.

Finally, the Ramsey RESET test is used to assess whether the model is in the correct functional form. The p-value of 0.7153 obtained as a result of the test indicates that the model is constructed in a correct functional form. This suggests that there are no missing variables or misspecification in the model and the overall structure of the model is appropriate for the analysis.

The results of these tests indicate that the estimation power and validity of the ARDL model used are high. The absence of autocorrelation and heteroskedasticity in the model, the normal distribution of the error terms and the correct functional form suggest that the model is a reliable tool for analyzing production processes in the Turkish fisheries sector.

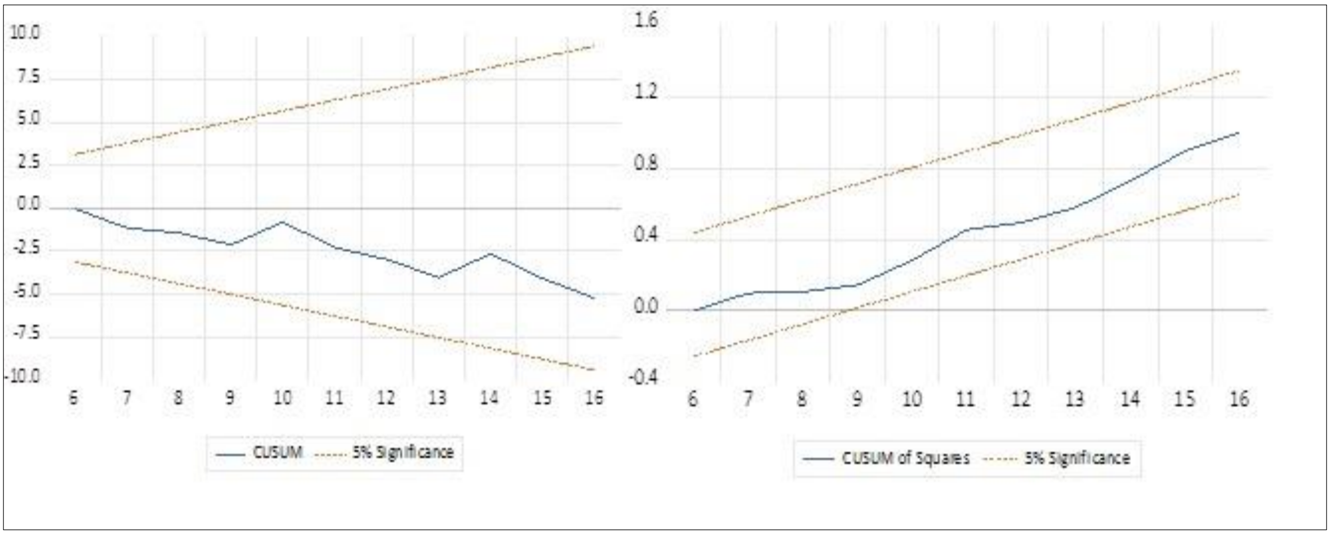

Figure 1. Cusum and cusum square

In figure 1, CUSUM and CUSUM of squares plots are used to assess whether the parameters of the model are stable over time. In these plots, the parameters of the model are considered to be stable as long as the line remains within the 5% significance limits.

The first graph, the CUSUM graph, shows the overall parameter stability of the model. The fact that the blue line is within the 5% significance limits indicates that the parameters in the model are stable over time and the long-run relationships of the variables are preserved in a way that does not affect the predictive power of the model. This supports the reliability of the model in terms of estimating the production processes in the Turkish fisheries sector.

The second graph, the CUSUM of Squares graph, measures the stability of the parameters based on their squares. In this graph, the fact that the blue line remains within the 5% significance limits indicates that the variance of the error terms of the model is constant over time and there is no structural break or sudden change. It shows that the effects of the variables in the model, especially capital investments, labor costs and energy costs, are consistent and stable. This implies that the model produces reliable and valid results.

These analyses show that the predictive performance of the model examining the effects of economic variables on production in the Turkish fisheries sector is high and long-term strategic decisions can be made with confidence based on this model.

Discussion and Conclusion

This study aims to analyze the effects of capital investments, labor costs, and energy costs affecting production processes in the fisheries sector in Türkiye and to provide strategic policy recommendations for sectoral sustainability. The findings of the study have yielded results that are consistent with both national and international literature and have made significant contributions to existing literature.

The findings have shown that capital investments have a significant impact on production in the sector. However, the negative coefficient of capital investments reveals that if the investments are directed incorrectly, they may lead to productivity losses. This result is consistent with the studies conducted by Creighton et al. (2015) and Oyakhilomen and Zibah (2020). Creighton et al. (2015) stated that effective management of capital investments can increase productivity in the fisheries sector. Oyakhilomen and Zibah (2020) emphasize that misdirected investments cause resource waste and long-term production losses. In the context of Türkiye, directing capital investments to the right areas and increasing access to modern technology are of critical importance in terms of ensuring sectoral sustainability. In particular, the use of innovative equipment and environmentally friendly technologies can be encouraged to ensure both economic and environmental sustainability.

The negative impact of labor costs on production shows that the labor-intensive structure in the sector increases total costs and negatively affects productivity. This finding is consistent with the studies conducted by Jacobsen et al. (2016) and Muhamad et al. (2024). While Jacobsen et al. (2016) emphasized the competitiveness-enhancing effects of optimizing labor costs, Muhamad et al. (2024) stated that labor management is a critical element for sustainable production in small-scale enterprises. In the context of Türkiye, encouraging training programs and certification systems for employees to increase labor productivity can optimize labor costs and increase productivity. In addition, focusing on the use of more automation and technology in the sector to balance labor costs can support sustainable development in the sector by controlling costs.

The negative impact of energy costs on production shows that high energy consumption in the sector increases costs and reduces profitability. This finding is consistent with the studies conducted by Mobsby et al. (2020) and Cochrane (2001) are in line with the studies conducted by Mobsby et al. (2020) while emphasizing the positive effects of optimizing energy costs on cost efficiency, Cochrane (2001) detailed the role of energy efficiency increasing policies on sustainability in the fisheries sector. The use of renewable energy sources should be encouraged to increase energy efficiency in the Turkish fisheries sector. In particular, environmentally friendly energy solutions such as solar and wind energy can both reduce costs and minimize environmental impacts. This policy can be considered as a model applicable not only for Türkiye but also for other developing countries with high energy costs.

The policy recommendations include concrete steps for the efficient management of economic variables in the sector. First, effective management of capital investments should be ensured, and public-private sector cooperation should be encouraged to increase access to innovative technologies. This can accelerate technological transformation in the sector and increase efficiency. Secondly, training and certification programs that will increase the competencies of employees in the sector should be expanded in order to control labor costs. Such programs will support sectoral competitiveness by increasing the productivity of the workforce. Thirdly, incentive programs should be developed to increase energy efficiency and to spread the use of sectoral renewable energy. Cost reductions can be achieved in production processes by providing access to low-cost energy solutions for small-scale enterprises.

The results of the study are consistent with the existing findings in the literature, and they offer important contributions specific to the fishing sector, especially in the context of developing countries. The results obtained provide strategic clues that can be valid not only in the fishing sector in Türkiye but also in other countries with similar economic and environmental conditions. For example, supporting small-scale enterprises and using renewable energy resources can also provide a model that can be applied in other natural resource-based sectors. In this context, the results of the study are an important reference for policy makers at both national and international levels.

Conflict of Interest

The author(s) declare no conflict of interest.

Ethics Approval

Ethics committee permission is not required for this study.

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