Beykoz Akademi Dergisi, 2024; 12(2), 133-146 ARAŞTIRMA MAKALESİ
Gönderim tarihi: 23.03.2024 Kabul tarihi: 08.08.2024
DOI: 10.14514/beykozad.1457675

EMPIRICAL ANALYSIS OF THE RELATIONSHIP BETWEEN OIL PRICE AND TRADE BALANCE

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Abstract

The impact of the oil shocks in the 1970s and the acceleration of globalization since the 1980s have led to the emergence of a vast literature investigating the relationship between the growth in world trade volume and various macroeconomic variables related to oil prices. Due to its significance as a commodity in economic activities, oil prices have remained a closely monitored indicator to this day. The aim of this study is to analyze the relationship between oil prices and trade balance. The study is conducted for a panel consisting of 8 countries (Bangladesh, Brazil, Colombia, India, Mauritius, Pakistan, Turkey, and South Africa) covering the period from 2006 to 2021. The relationships between variables are analyzed using the Fixed Effects Model and the Driscoll-Kraay estimator. The results of the study indicate the presence of weak relationships between oil prices and trade balance in terms of the Fixed Effects Model, while strong relationships are observed when analyzed with the Driscoll-Kraay Estimator. The study also demonstrates strong relationships between GDP, exchange rates, and trade balance in both prediction models.

Key Words: Oil Prices, Trade Balance, Fixed Effect Model, Driscoll-Kraay Estimator
Jel Classifications: C33, F14, F19

PETROL FİYATLARI İLE DIŞ TİCARET DENGESİ ARASINDAKİ İLİŞKİNİN AMPİRİK ANALİZİ

Öz

1970'li yıllarda yaşanan petrol şoklarının etkisi ve 1980'lerden itibaren küreselleşmenin hızlanmasıyla birlikte dünya ticaret hacmindeki büyüme petrol fiyatlarının çeşitli makro ekonomik değişkenler ile ilişkisinin araştırıldığı geniş bir literatürün oluşmasına yol açmıştır. Günümüzde de ekonomik faaliyetler bakımından önemli bir emtia olması dolayısıyla petrol fiyatları sürekli takip edilen bir gösterge olmuştur. Bu çalışmanın amacı petrol fiyatları ile ticaret dengesi arasındaki ilişkinin analiz edilmesidir. Çalışma 8 ülkeden (Bangladeş, Brezilya, Kolombiya, Hindistan, Mauritius, Pakistan, Türkiye ve Güney Afrika) oluşan panel için yapılmış olup 2006-2021 dönemini kapsamaktadır. Çalışmada değişkenler arası ilişkiler Sabit Etkiler Modeli ve Driscoll-Kraay tahmincisi ile analiz edilmiştir. Çalışmanın sonuçları Sabit Etkiler Modeli bakımından petrol fiyatları ile ticaret dengesi arasında zayıf ilişkilerin varlığını, Driscoll-Kraay Tahmincisi ile analiz edildiğinde güçlü ilişkilerin varlığını göstermektedir. Çalışma diğer değişkenler açısından da her iki tahmin modeli çerçevesinde GSYH ve döviz kurlarının dış ticaret dengesi ile güçlü ilişkilere sahip olduğunu göstermiştir.

Anahtar Kelimeler: Petrol Fiyatları, Dış Ticaret Dengesi, Sabit Etkiler Modeli, Driscoll-Kraay Tahmincisi
Jel Sınıflandırması: C33, F14, F19

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1. Introduction

The last quarter of the 20th century witnessed numerous developments leading to oil shocks. Foremost among these developments was the Arab-Israeli war that commenced in 1973. Shortly after this event, the Iranian Islamic Revolution led to a reduction in oil production by the new regime, causing panic in the world oil market and resulting in a second shock. Given that oil is a key input for many sectors and a significant commodity in terms of final consumption, fluctuations in oil prices have influenced indicators such as countries' gross domestic product (GDP), exports, and imports. However, the impact varies depending on whether a country is a net oil exporter or importer (Wang et al., 2013: 1220-1239; Baek, 2023: 188-200). Indeed, for an oil-exporting country, an increase in oil prices can stimulate export increases, boost oil revenues, and improve the trade balance in favor of the exporting country. Conversely, for an oil-importing country, an increase in oil prices can lead to cost increases, production declines, unemployment, and inflation (Kousar, 2022: 188-197). The oil shocks and their effects on national economies have attracted researchers' attention. In this context, pioneering studies have mainly focused on the general macroeconomic effects of oil prices. These include the works of Sargent (1976), Arndt (1979), Lienert (1981), Islam (1981), and Ysander (1981). In subsequent years, studies by Svenson (1984), Arab and Metwally (1987), and Salvatore and Winczewski (1990) began to directly focus on the effects of oil prices on international trade. In recent years, a significant number of studies related to the topic discussed in the empirical literature section have been conducted.

The aim of this study is to empirically analyze the relationship between oil prices and the trade balance for a panel consisting of 8 countries (Bangladesh, Brazil, Colombia, India, Mauritius, Pakistan, Turkey, and South Africa). The sample of the study consists of data covering the period 2006-2021. The study was conducted under certain constraints. One of these constraints is the inability to include more countries in the study due to the absence of variables and/or the mismatch in the length of the period for existing variables. Another constraint is that although oil prices fluctuate continuously within a year, only one price data point for each year was taken based on statistics from the International Energy Agency. Furthermore, despite the presence of numerous petroleum products in the data, the study primarily focuses on gasoline pump prices, which is another limitation.

The common characteristic of the countries included in the analysis is that they belong to the low and middle-income country group according to the World Bank (n.d.) classification. Although Mauritius appears to be a small country compared to the others, it has been included

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in the panel forming the sample of the study for two main reasons. The first reason is that Mauritius has transformed from a low-income economy based on a single agricultural product such as sugarcane in the late 1960s to a middle-income country based on investment and tourism today (World Bank, 2024). The second main reason is that despite its small land area, Mauritius has significant potential due to its large exclusive economic zone[2]. The countries forming the panel exhibit similarities to Turkey in various aspects. These similarities include efforts to integrate into the existing capitalist system since the last quarter of the 20th century, the similarities in policies aimed at attracting not only direct foreign investments but also portfolio investments, and the predominant adoption of export-oriented growth strategies.

Following the introduction in line with the study's objective, the empirical literature consisting of relevant studies on the topic is presented. Subsequently, in the Data Set, Model, and Method section, the introduction of the variables under analysis and explanations regarding the model constructed with these variables are provided. Within the scope of the study's methodology, tests were initially conducted for model selection, and the presence of heteroskedasticity, autocorrelation, and inter-unit correlation was investigated in the selected fixed effects model. Subsequently, the analysis of relationships between variables and a comparison with the fixed effects model were reported using the Driscoll-Kraay estimator. Finally, the study concludes with an evaluation of the findings obtained earlier.

2. Literature

It can be said that studies investigating the relationship between oil prices and trade balance began to emerge in the literature predominantly after the oil crisis of 1973. However, it is also noticeable that empirical studies have significantly increased in quantity in the 2000s, coinciding with easier access to data and the development of new analytical techniques. In this section, some empirical studies related to the topic will be presented chronologically from the most recent to the earliest.

One of the empirical studies in the literature, conducted by Ogbonna and Ichoku (2023), examined the impact of changes in oil prices on the trade balance of Nigeria's trading partners (Belgium, China, the United Kingdom, and the United States). The study revealed that the United Kingdom and the United States were affected asymmetrically in the long term, and

[2] Exclusive Economic Zone Concept’ is a term that relates not only to economics but also to the field of international relations; therefore, it has not been elaborated on to avoid deviating from the focus of the study.

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Belgium and the United States were affected asymmetrically in the short term. The study employed the NARDL method and covered the period from 1991Q1 to 2019Q4.

Eleyan et al. (2022) conducted a study for the Southeast Asian Nations (ASEAN) member countries, revealing that shocks in oil prices had varying effects on the trade balance due to different characteristics in the petroleum market from country to country. According to the study, the effects of oil prices on the trade balance become more pronounced during global and economic events.

Forson et al. (2022) used Pooled Mean Group (PMG) and Common Correlated Effect Pooled Mean Group (CCEPMG) estimators to examine the adverse effect of crude oil price volatility on the trade balance of 34 Sub-Saharan African countries from January 2004 to December 2017.

Nanovsky (2022) highlighted that a change in oil prices had an impact contrary to traditional theory for Kazakhstan and Russia from 2000Q1 to 2020Q2, suggesting that a decrease in prices negatively affected the trade balance by reducing exports.

Ran and Baek (2021) analyzed the effects of oil shocks on South Korea's trade balance with its three largest trading partners, categorizing them into oil demand shocks, oil supply shocks, and shocks in oil-specific demand. They found that demand shocks had the most significant impact on South Korea's trade balance, while supply shocks had negligible effects.

Ahad and Anwer (2020) examined the relationship between oil prices and the trade balance for BRICS countries from 1992 to 2015, showing positive and significant asymmetric relationships between oil prices and the trade balance for Brazil, India, China, and South Africa.

Alkhateeb and Mahmood (2020) studied the asymmetric effects of oil prices on the trade balance in Gulf Cooperation Council countries, showing positive effects on trade balances in Oman, Saudi Arabia, and the UAE, and negative effects in Kuwait. They also found that decreases in oil prices positively affected the trade balances of Bahrain, Oman, Qatar, and the UAE, while Saudi Arabia exhibited symmetric effects.

Baek (2020) investigated the effects of oil prices on the bilateral trade balance using the NARDL method for South Korea and its top 14 trading partners, revealing asymmetrical short and long-term effects for some trading partners.

Baek and Choi (2020) explored the impact of oil prices on the trade balance between South Korea and four ASEAN countries using linear ARDL, finding significant effects in both the short and long term, and asymmetric effects using the nonlinear ARDL method.

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Faheem et al. (2020) investigated the effects of fluctuations in oil prices on the trade balance for Saudi Arabia, Kuwait, and the United Arab Emirates from 1980 to 2017 using both linear and nonlinear ARDL methods, concluding that the effects were asymmetric.

Baek et al. (2019) stated that changes in oil prices did not cause short-term asymmetrical effects on the trade balance of OPEC member countries (Iran, Nigeria, Saudi Arabia, and Venezuela), but did lead to long-term asymmetrical effects. They also found that changes in oil prices affected the non-oil trade balance asymmetrically in both the short and long term.

Olayungbo (2019) found no Granger causality between oil prices and the trade balance for Nigeria from 1986Q4 to 2018Q1.

Nasir et al. (2018) used the time-varying structural vector autoregressive (TV-SVA) model to examine the reactions of BRICS countries to oil shocks from 1987Q2 to 2017Q2, showing that the responses were different and asymmetric across the countries and deepened according to whether the countries were net oil exporters or importers.

Açıkalın and Uğurlu (2014) demonstrated the negative impact of oil price shocks on Turkey's trade balance from September 2009 to June 2014, which diminished in less than 10 months.

Tiwari et al. (2014) analyzed the relationship between oil prices and the trade balance for India using the Breitung and Candelon approach and VAR-based Granger causality analysis for the periods of January 1980 to December 2011 and August 1994 to December 2011. They found bidirectional causal relationships between oil prices and the trade balance and identified the trade balance as a leading indicator of oil prices for India.

Wu et al. (2013) analyzed the effects of fundamental indicators such as oil prices, income, and exchange rates on China's trade balances with G7 countries from 1975 to 2010 using a panel smooth transition regression (PSTR) model. The empirical results showed that the relationship between fundamental indicators and trade balances was largely nonlinear, time-varying, and varied according to countries' regimes. Additionally, they found that China's bilateral trade balances responded significantly to changes in income, exchange rates, and oil prices.

Svensson (1984) stated that temporary increases in oil prices disrupted the trade balance of a small oil-importing country, while the effects of permanent increases were uncertain.

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3. Data Set, Method, and Analysis

In this study, the relationship between oil prices and trade balance was investigated for 8 countries (Bangladesh, Brazil, Colombia, India, Mauritius, Pakistan, Turkey, and South Africa) from 2006 to 2021. In the existing literature, studies such as Baek (2020), Alkhateeb and Mahmoud (2020), and Forson et al. (2022) used trade balance as the dependent variable. However, GDP was used as the dependent variable in studies by Eleyan et al. (2022), Ogbonna and Ichoku (2023), and Faheem et al. (2020); exchange rates were used in studies by Ogbonna and Ichoku (2023) and Forson et al. (2022); and gasoline prices were used as independent variables in studies by Ahad and Anwer (2020), Wu et al. (2013), and Alkhateeb and Mahmoud (2020). Based on the literature, in this study, the dependent variable was determined as the export-to-import ratio, and the independent variables were GDP (gross domestic product), exchange rates, and gasoline prices. The data sources for the export-to-import ratio, GDP, and exchange rates were the World Bank database, while the data source for gasoline prices was the International Energy Agency. Descriptive statistics for the variables used in the study are presented in Table 1.

Table 1: Descriptive Statistics for Variables

Variables	**Number of Observations**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
eximp	128	0.841	0.151	0.451	1.247
lngdp	128	26.522	1.568	22.673	28.779
lnexc	128	3.567	2.121	0.264	8.228
lnop	128	0.155	0.280	-0.462	0.920

The variable 'eximp' in Table 1 represents the ratio of exports to imports, while 'lngdp', 'lnexc', and 'lnop' represent GDP, exchange rates, and oil prices, respectively.

Given that the sample of the study consists of multiple units (8 countries) and observations over multiple time periods (16 years), panel data analysis is employed. In this context, observations for variables X and Y are represented as in equation (1) (Stock and Watson, 2011: 352):

$$(X_{it}, Y_{it}), i = 1, \ldots, n \; ve \; t = 1, \ldots, T \quad (1)$$

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In equation 1, the subscript i represents the observed units, while the subscript t represents the time of observation. In panel data analysis, relationships between variables can be modeled in three ways: fixed effects, random effects, and pooled least squares. The selection of the method depends on various tests. Major tests for model selection include the F-test, the Hausman test, and the Breusch Pagan LM test. Hypotheses for these tests are formulated as shown in equations (2), (3), and (4):

For the F (Chow) test:

$$H_0: Pooled\ least\ squares\ model\ is\ valid.$$
$$H_1: Fixed\ effects\ model\ is\ valid \quad (2)$$

For the Hausman Test:

$$H_0: Random\ effects\ model\ is\ valid.$$
$$H_1: \quad Fixed\ effects\ model\ is\ valid \quad (3)$$

For the Breusch Pagan LM test:,

$$H_0: Pooled\ least\ squares\ model\ is\ valid.$$
$$H_1: Random\ effects\ model\ is\ valid \quad (4)$$

The results of the tests conducted for model selection are presented in Table 2.

Table 2: Tests for Model Selection

Test Name	Test Statistic	Test Statistic Value	Probability Value	Model Preference
F	F	36.53***	0.0000	Fixed effects
Hausman	chi2	12.72***	0.0000	Fixed effects
Breusch Pagan LM	chibar2	312.03***	0.0000	Random effects

The “***” symbol indicates significance at the %1 level.

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When examining Table 2, the statistics values for the F test, Hausman test, and Breusch Pagan LM test are found to be 36.53, 12.72, and 312.03, respectively, at the 1% significance level. The results of the F test and the Hausman test reject the null hypotheses specified for these tests, indicating the validity of the fixed effects model. However, the Breusch Pagan LM test rejects the null hypothesis associated with this test, indicating the validity of the random effects model. Since two of the tests suggest the fixed effects model while one suggests the random effects model, the analysis proceeds with the fixed effects model.

The fixed effects model assumes the absence of heteroscedasticity (varying variance) and autocorrelation (Tatoğlu, 2021:137). Accordingly, the presence of heteroscedasticity is tested using the Modified Wald test, while the presence of autocorrelation is examined using the Durbin Watson test by Bhargava et al. (1982), the Local Best Invariant by Baltagi and Wu (1999), and the Feasible Generalized Least Squares by Baltagi and Wu (1999). The results of the heteroscedasticity test are presented in Table 3.

Table 3: Heteroscedasticity Test for Fixed Effects Model

Test Name	Test Statistic	Test Statistic Value	Probability Value
Modified Wald Test	Chi2	44.27***	0.0000

The “***” symbol indicates significance at the %1 level.

According to Table 3, the test statistic value of 44.27 at the 1% significance level indicates the presence of heteroscedasticity in the model.

When evaluating the results of autocorrelation tests, the statistic values are compared with 2, and if these values are calculated to be less than 2, autocorrelation is accepted to be present. The results of the autocorrelation tests are shown in Table 4.

Table 4: Autocorrelation Tests for Fixed Effects Model

Test Name	Autocorrelation Coefficient
Bhargava, Franzini, and Narendranathan's Durbin-Watson Test	0.7200
Baltagi-Wu's Local Best Invariant Test	0.9148
Feasible Generalized Least Squares Autocorrelation Test (BFN)	0.7471

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The autocorrelation test results, with statistics values of 0.7200, 0.9148, and 0.7471 for each of the three tests, indicate the presence of autocorrelation.

Panel data models assume no correlation between explanatory variables and conditional errors for a given unit. However, simultaneous correlation among errors across units is often encountered in practice. Therefore, it is necessary to investigate whether there is correlation among units (Stock and Watson, 2011:367; Tatoğlu, 2021:257). Table 5 shows the correlation relationship among the countries included in the analysis.

Table 5: Inter-Unit Correlation Matrix

Countries	Banglades h	Brazil	Colombia	India	Mauritius	Pakistan	Turkiye	South Africa
Bangladesh	1.0000							
Brazil	0.1523	1.0000						
Colombia	-0.4255	-0.2366	1.0000					
India	0.4968	-0.1112	-0.8076	1.0000				
Mauritius	0.6772	-0.0645	-0.5636	0.5811	1.0000			
Pakistan	-0.1285	-0.0087	0.5154	-0.3517	-0.1645	1.0000		
Turkiye	0.1313	-0.0951	-0.4806	0.2163	0.2770	-0.5888	1.0000	
South Africa	0.0014	0.1878	-0.3516	0.2837	-0.2950	-0.1986	0.0584	1.0000

Table 5 reveals that the highest correlation, with a positive direction, is 67.72% between Mauritius and Bangladesh. In terms of negative correlation, the highest correlation is 80.76% between India and Colombia. Another notable observation in the table is the nearly negligible correlation of 0.14% between South Africa and Bangladesh.

While inconsistency may not occur in large samples due to heteroskedasticity, autocorrelation, and correlation between units, efficiency may still be adversely affected. In such cases, when at least one of heteroskedasticity, autocorrelation, and inter-unit correlation exist, two main approaches can be adopted. The first is to correct standard errors without affecting parameter estimates, using robust standard errors. The second approach involves making estimates using appropriate methods (Tatoğlu, 2021: 327). One of these methods was developed by Driscoll-Kraay (1998). This estimator adjusts for cross-sectional averages and ensures that standard error estimates are consistent independently of the cross-sectional dimension (N) (Tatoğlu, 2021:

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359). Table 6 presents the results of both modeling with fixed effects and predictions made using the Driscoll-Kraay method for the variables included in the study.

Table 6: Results of Fixed Effects Model and Driscoll-Kraay Estimator Test

Variable	**Coefficient**	**Fixed Effects Model Estimator**			**Driscoll-Kraay Estimator**		
		Standard Error	**t-Statistic Value**	**Probability Value**	**Standard Error**	**t-Statistic Value**	**Probability Value**
lngdp	-.0086	0.026	-3.27***	0.001	0.019	-4.53***	0.000
logexc	0.093	0.035	2.69***	0.008	0.023	4.10***	0.001
lnop	0.110	0.057	1.93*	0.056	0.037	2.99***	0.009
Intercept term	2.774	0.642	4.32***	0.000	0.436	6.36***	0.000
R^2		0.097			0.097		
F- Statistic Value		4.20***			11.11***		
F-Statistic Probability Value		0.007			0.000		

The symbols "***" and "*" represent the significance levels of 1% and 10%, respectively.

When examining Table 6, it can be observed that while the fixed effects model estimator and the Driscoll-Kraay estimator predict the coefficients and R^2 value exactly the same, the standard errors of the estimates differ between models, with the Driscoll-Kraay estimator yielding lower standard errors. Specifically, the standard errors for the relationships between the variables lngdp, logexc, lnop, and the constant term with the eximp variable in the fixed effects model are calculated as 0.026, 0.035, 0.057, and 0.642, respectively. However, for the Driscoll-Kraay estimator, the standard errors for the same variables are calculated as 0.019, 0.023, 0.037, and 0.436.

Regarding the relationships between variables, it can be seen from Table 6 that in the panel forming the study sample, the lngdp variable is inversely related to the eximp variable, while the logexc and lnop variables are positively related to the eximp variable. According to the fixed effects model, these relationships are significant at the 1% level for lngdp and logexc, and at the 10% level for the lnop variable. However, according to the Driscoll-Kraay estimator, it is found that all independent variables significantly affect the dependent variable eximp at the 1% level.

When evaluating the parameter coefficients of the Driscoll-Kraay estimator, it can be said that a 1% increase (decrease) in the lngdp variable leads to a 0.0086 unit decrease (increase) in the eximp variable; a 1% change in the logexc variable leads to a 0.093 unit change in the same

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direction in the eximp variable. Additionally, it is observed in Table 6 that a 1% change in the lnop variable leads to a 0.110 unit change in the same direction in the eximp variable.

4. Conclusion and Discussion

This study empirically investigates the relationship between the trade balance and oil prices, which hold significant importance in global trade due to their extensive use in both final consumption and production. Despite the frequent fluctuations in prices, the analysis adopts a single price for each year due to limitations such as unavailability of data for some countries. The primary methods used in the study are fixed effects model and Driscoll-Kraay estimators.

The preference for the fixed effects model in the study is based on the results of the Breusch Pagan LM test, which directs the model choice towards random effects, although the F (Chow) test and Hausman tests indicate that the fixed effects model should be preferred.

Following the preference for the fixed effects model, the study reveals some findings regarding the presence of heteroskedasticity, autocorrelation, and cross-sectional correlation. In this context, heteroskedasticity is examined using the Modified Wald test, while autocorrelation is explored through the Durbin-Watson test by Bhargava, Franzini, and Narendranathan, the Baltagi-Wu's Local Best Invariant Test, and the Heteroskedasticity and Autocorrelation Consistent (HAC) tests. These tests confirm the presence of both heteroskedasticity and autocorrelation in the fixed effects model. Cross-sectional correlation tests, on the other hand, show varying levels of both negative and positive correlations among countries.

Since the presence of heteroskedasticity, autocorrelation, and cross-sectional correlation violates the assumptions of the fixed effects model, the Driscoll-Kraay estimator, which takes these into account, is employed. The estimations reveal a significant relationship between the trade balance represented by the ratio of exports to imports and the petrol pump prices, although the significance level is weak at 10%. However, the Driscoll-Kraay estimator indicates a stronger relationship with a significance level of 1%. Regarding other relationships between variables, both GDP and exchange rates are found to have a strong relationship with the trade balance at a 1% significance level according to both estimators.

These results, while supporting the findings of Ahad and Anwer (2020), contradict the conclusion of Svensson (1984), which suggests that temporary increases in oil prices disrupt the trade balance. However, it should be noted that Svenson's (1984) study focused on a small oil-importing country, whereas this study is conducted on a panel of countries of various sizes.

In addition to the fact that oil prices significantly affect the trade balance of countries, the rapid increase in the shift towards alternative energy sources in recent years, the development of environmental awareness, and the greater emphasis on energy efficiency in production, transportation, and final consumption may lead to a decrease in this effect, especially in the medium to long term. In this context, it can be said that empirical studies that include factors replacing oil in terms of their effects on the trade balance will contribute to the literature and enable the development of appropriate policies.

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Gönderim tarihi: 23.03.2024 Kabul tarihi: 08.08.2024
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