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THE IMPACT OF RENEWABLE ENERGY CONSUMPTION ON BUDGET DEFICIT: INSIGHTS FROM OECD COUNTRIES

YENİLENEBİLİR ENERJİ TÜKETİMİNİN BÜTÇE AÇIĞI ÜZERİNDEKİ ETKİSİ: OECD ÜLKELERİNDEN BULGULAR

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ABSTRACT

Renewable energy has emerged as a significant alternative to fossil fuels, particularly given the environmental damage associated with the latter. A key concern is that renewable energy consumption may worsen budget deficits due to its higher costs and, as a result, the need for substantial government support. Although there has been ample theoretical discussion of this connection in the literature, there are few empirical data on the subject. Therefore, this study investigates the connection between renewable energy and budget deficits in 26 OECD countries using 1995–2022 data, employing three cointegration tests and Pedroni's (2001) DOLSMG technique. The findings indicate a significant cointegration relationship between renewable energy consumption and budget deficits across the three different tests. Furthermore, according to the DOLSMG estimator, an increase of 1% in the utilization of renewable energy correlates with an approximate worsening of 0.53% in budget balances. Additionally, based on these results, recommendations for the redesign of renewable energy policies are presented.

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ÖZ

Yenilenebilir enerji, fosil yakıtların çevresel zararları göz önüne alındığında günümüzde önemli bir alternatif olarak öne çıkmaktadır. Ancak, yenilenebilir enerji kaynaklarının fosil yakıtlara kıyasla daha yüksek maliyetleri sebebiyle önemli ölçüde hükümet desteği gerektirmesiyle bütçe açıklarını kötüleştirme potansiyeli yaygın bir endişe kaynağıdır. Literatürde bu ilişki teorik düzlemde yaygınca tartışılsa da yeterli ampirik bulguyla desteklenmemektedir. Dolayısıyla bu çalışma konuyla ilgili ilk kapsamlı ampirik araştırmalardan biridir. Çalışmada, 1995-2022 dönemine ait veriler kullanılarak 26 OECD ülkesinde yenilenebilir enerji tüketimi ile bütçe açıkları arasındaki ilişki incelenmektedir. Çalışmada üç farklı eşbütünleşme testi ve Pedroni'nin (2001) önerdiği DOLSMG tekniği uygulanmıştır. Bulgular, yenilenebilir enerji tüketimi ile bütçe açıkları arasında üç farklı testin tümüne göre anlamlı bir eşbütünleşme ilişkisi olduğunu göstermektedir. Ayrıca, DOLSMG tahmincisine göre, yenilenebilir enerji tüketimindeki %1'lik bir artış, bütçe dengelerinde yaklaşık %0,53'lük bir kötüleşme ile ilişkilendirilmektedir. Sonuç olarak elde edilen bulgulara binaen enerji politikalarının yeniden tasarlanmasına yönelik öneriler sunulmuştur.

Keywords: Budget Deficit, Fiscal Deficit, Renewable Energy, Panel Cointegration, OECD.

Anahtar Kelimeler: Bütçe Açığı, Mali Açık, Yenilenebilir Enerji, Panel Eşbütünleşme, OECD.

INTRODUCTION

Since the 1980s, the expansion of free-market policies and practices such as privatization have accelerated, resulting in a decrease in the public sector's share of the overall economy. Nonetheless, in many regions of the world, the public sector continues to be an important part of the economy. Due to its size, budget deficits both influence and are influenced by various macroeconomic factors. This is particularly evident in developing countries, where budget deficits have been extensively analyzed in the literature because of their potential to trigger financial instability and increase risks of default or bankruptcy.

At this juncture, it has been increasingly posited that the transition toward renewable energy sectors may have implications for budget deficit. Energy, as a crucial raw material for production, is an indispensable element of industrial output. This demand is especially pronounced in both developing and industrialized countries with high growth rates. Moreover, in energy-importing nations, the rising demand for energy can create a dual challenge for both

the budget deficit and the current account deficit. For instance, it has been estimated that annual investments in the electricity sector in the MENA region will require approximately 3% of the region's projected GDP to meet growing demand; however, fiscal and macroeconomic constraints significantly limit the capacity of most economies in the region to undertake these investments (Camos et al., 2017:2).

The subsidies provided to the energy sector, particularly their potential negative effects on the budget deficit, have long been a topic of extensive debate (Dartanto, 2013; Li et al., 2017). Furthermore, when examining the renewable energy sector specifically, it becomes evident that, since renewable energy is generally costlier compared to conventional energy sources, governments worldwide have provided substantial support (Shen and Luo, 2015; Yang et al., 2019). Consequently, it is argued that public spending, and thus budget deficit, could increase due to the subsidies aimed at renewable energy (Rausch and Reilly, 2012; Florea et al., 2021). However, renewable energy may be beneficial in terms of reducing reliance on imported energy sources. Moreover, it may help reduce pollution-related health problems and associated healthcare costs.

Despite various concerns related to renewable energy, the connection between renewable energy and budget deficit has not been examined sufficiently in the literature. Currently, there is only one study (Tugcu et al., 2020) that examines the relationship between renewable energy and budget deficit. However, this study is based solely on energy-importing nations, making it impossible to draw meaningful and comprehensive conclusions. Moreover, the dataset they used covers only a 12-year period, which may undermine the robustness of their estimation findings. Therefore, this situation highlights an important gap in the literature.

Based on this gap in the literature, this study analyzes the relationship between renewable energy utilization and budget deficit for 26 OECD countries. The annual dataset spans the period from 1995 to 2022, and Pedroni's (2001) Dynamic Ordinary Least Squares Mean Group (DOLSMG) method, along with three other cointegration tests, is used. renewable energy is measured as the percentage of cumulative final energy consumption, while budget deficit is measured as the general government balance expressed as a percentage of GDP.

For the control variables, the literature is reviewed to identify the relevant macroeconomic variables. The variables include GDP, measured as GDP per capita in constant 2015 US dollars; unemployment, expressed as a percentage of the total labor force based on ILO estimates; trade openness as a percentage of GDP; and the current account balance as a percentage of GDP. Budget balance data is sourced from the OECD, while the remaining data is obtained from the World Bank's WDI database. All estimates are conducted using Stata 15.0.

After this introductory section, the subsequent part of the paper discusses the literature review that examines various approaches to understanding budget deficit and renewable energy. The next section, Methodological Framework and Discussion, describes the data collection process and introduces descriptive statistics. This is followed by a description of the methodological approach, preliminary tests, estimations, and a discussion of empirical findings. Finally, the concluding section summarizes the findings and discusses potential policy implications.

1. LITERATURE REVIEW

This section is intended to review the literature related to renewable energy consumption and budget deficits. However, as far as investigated, there is currently only one empirical study (Tugcu et al., 2020) on this topic, which limits the possibility of conducting a detailed review. Therefore, literature related to the two main variables, renewable energy consumption and budget deficit, and various factors associated with them are investigated under the two subheadings.

1.1. Renewable Energy Consumption and Related Literature

The effects of renewable energy have been analyzed from various perspectives in the literature. These studies range from those related to its mixed impacts on environmental factors (Panwar et al., 2011; Levenda et al., 2021; Sebestyén, 2021), health-related issues (Buonocore et al., 2016; Majeed et al., 2021; Sasmaz et al., 2021), energy security, and political considerations (Johansson, 2013; Sheikh et al., 2016; Burke and Stephens, 2018).

Moreover, recently, its impact on economic variables has also become a popular topic in the literature. One of these popular topics is the link between economic growth and renewable energy consumption. This branch of literature has reached mixed findings through various methodologies, across different geographical regions and income groups. Some studies concluded that renewable energy consumption may unidirectionally cause economic growth, supporting the Growth Hypothesis (Gozgor, 2018:16590; Vural, 2020:6). In contrast, others argue that causation is in the opposite direction, where economic growth may lead to increased renewable energy consumption, supporting the Conservation Hypothesis (Konuk et al., 2021:4825; Chang and Fang, 2022:788). Additionally, some research suggests bidirectional causality, known as the Feedback Hypothesis (Pao and Fu, 2013:381; Sharma et al., 2021:111152), while others claim no causal relationship at all, referred to as the Neutrality Hypothesis (Menegaki, 2011:257; Destek and Aslan, 2017:757). Thus, according to empirical literature, the association between renewable energy consumption and economic growth is still unclear.

The impact of renewable energy on exchange rates and inflation is another area of research. Given that renewable energy is generally costlier than fossil fuel sources, the effects of renewable energy consumption on inflation have also been analyzed. Deka and Dube (2021:78) found that renewable energy use influences both inflation and exchange rates in the long run.

On the other hand, Lu et al. (2023:1) investigated MENA countries and found that causality may run unidirectionally from inflation to renewable energy consumption. Moreover, according to Deka, Cavusoglu, and Dube (2022:14185), there is a bidirectional relationship between exchange rates, inflation, and the utilization of renewable energy in Brazil, based on ARDL model estimations. In the case of European countries, Markowski and Kotliński (2023:1) found that higher renewable energy utilization leads to lower core inflation. Conversely, Arslan and Yıldız (2022:4) reported that while there is no notable short-term relationship between inflation and renewable energy in European countries, renewable energy has a long-term negative impact on inflation.

Moreover, the relationship between renewable energy and other economic variables, such as trade, foreign direct investment, energy import dependency, financial development, current account deficit and employment has also been analyzed with mixed findings (Lehr et al., 2008:117; Aslani et al.,

2014; Zeren and Akkuş, 2020; Nasirov et al., 2021; Azam and Haseeb, 2021; Shahbaz et al., 2022; Bildirici and Kayıkçı, 2022; Ozkan and Okay, 2024; Yadav and Mahalik, 2024).

1.2. Budget Deficit and Related Literature

This section first provides a brief summary of the fundamental theoretical discussions on budget deficit dynamics. It then reviews the sole applied study investigating the impact of renewable energy on budget deficits (Tugcu et al., 2020), followed by an examination of empirical studies addressing other determinants of budget deficits.

A review of the literature reveals three distinct theories regarding the budget deficit: the Keynesian approach, the Ricardian equivalence theorem, and the Political Budget Cycle Theorem. Ricardian equivalence theorem suggests that the method a government chooses to finance its spending, whether through borrowing or taxation, has no effect on the outcome (Ricciuti, 2003; Ikiz, 2020). Economic agents, viewed as rational actors in line with neoclassical arguments, expect future taxes to repay the debt, leading them to save more in the present rather than spend. This behavior neutralizes any economic stimulus that a budget deficit might provide. Consequently, a budget deficit represents a debt to future generations, and changes in the budget deficit do not significantly impact interest rates, investments, or consumption (Barro, 1989). As a result, budget deficit are not influenced by macroeconomic factors and do not produce lasting macroeconomic impacts (Mawejje and Odhiambo, 2020).

On the other hand, the Keynesian view contrasts with the Ricardian equivalence theorem, which aligns with neoclassical economics. According to the Keynesian perspective, economies are likely to remain in an unemployment equilibrium without a natural tendency toward full employment unless the federal government runs a deficit to offset the shortfall in effective aggregate demand, thereby achieving aggregate balance at the full employment output level (Forstater, 2003). Post-Keynesians argue that government budgets should typically be in deficit, as restrictive federal budgets can push the private sector into deficit, leading them to advocate for deficit-financed government spending (Wray, 2003; Kim, 2020).

In addition to these two macroeconomic approaches to budget deficit, another perspective incorporates both economics and political science. Before elections, governments often engage in spending sprees by cutting taxes, increasing transfers, and prioritizing highly visible projects a pattern known as the political budget cycle or political business cycle (Rogoff, 1987:1). The primary motivation for politicians in this cycle is the belief that the electorate is backward-looking, assessing the government's past performance, while politicians seek to secure reelection by maximizing their expected vote share in the upcoming election (De Haan and Klomp, 2013:388). Thus, according to this perspective, political motivations and election cycles can significantly influence budget deficit in addition to macroeconomic factors.

On the other hand, as far as investigated, there is only one study (Tugcu et al., 2020) examining the relationship between budget deficit and renewable energy consumption. In this study, the authors, employing DOLS and FMOLS techniques, found that renewable energy consumption negatively affects budget deficit. However, the study is only conducted for energy importing nations, which restricts its ability to draw comprehensive conclusions. Additionally, the limitation of the dataset to only 12 years constitutes a major drawback in their analysis, weakening the reliability of their findings. Nevertheless, various other factors have been investigated as determinants of the fiscal deficit. Before delving into empirical investigations that estimate factors affecting the budget deficit, it is prudent to review different theoretical arguments regarding the nature of budget deficit.

In addition to these theoretical arguments, an examination of empirical studies highlights multiple factors influencing budget deficit. In line with the Political Budget Cycle Theorem, Roubini and Sachs (1989:1) analyzed the drivers of budget deficit across industrial democracies, noting that countries with shorter average government tenures and multi-party ruling coalitions tend to have higher deficits. These challenges are intensified when smaller coalition members possess veto power, limiting alterations to existing policies. (Roubini and Sachs, 1989:33). Woo (2003) examined a wide array of economic, sociopolitical, and institutional factors identified several key drivers of public deficits, such as financial sector development, income inequality, occurrences of political assassinations, cabinet size, and the degree of centralized control in budget-related decision-making.

Cifuentes-Faura et al. (2022) utilized the MMQ and the MG estimator to analyze the factors influencing budget deficit in Spanish municipalities. Their results indicate that economic growth positively influences deficits over the long term, while unemployment tends to increase deficits in both the short and long terms. Murwirapachena et al. (2013) investigated determinants of budget deficit in South Africa and have concluded that unemployment, economic growth, and government investment positively effect the budget deficit. Combes and Saadi-Sedik (2006) analysis indicate that greater trade openness boost up a country's vulnerability to external shocks. Similarly, Agnello and Sousa (2009) used a GMM estimator to analyze data from 125 countries for the period from 1980 to 2006. They concluded that higher trade openness correlates with increased public deficit volatility.

The relationship between the current account balance and budget deficit has been widely investigated in the literature. Various studies indicate that a budget deficit may negatively affect the current account balance and cause an appreciation of the real exchange rate, which supports twin deficit hypothesis (Kim and Roubini, 2008:362). However, some studies argue the opposite, implying that a worsening budget deficit can improve the current account balance, which is referred as the twin divergence hypothesis. This hypothesis has also been tested in various contexts, yielding mixed findings (Kim and Roubini, 2008; Ncanywa and Letsoalo, 2019).

2. METHODOLOGICAL FRAMEWORK AND DISCUSSION

To analyze the effect of renewable energy on the budget deficit, the literature is first reviewed to identify important control variables. Major macroeconomic variables identified include GDP, unemployment, trade openness, and current account balances. The OECD countries included in the estimation procedure, based on data availability, are in Europe: United Kingdom, Germany, France, Italy, Spain, Netherlands, Sweden, Switzerland, Poland, Belgium, Norway, Austria, Finland, Denmark, Greece, Czechia, Portugal, Slovak Republic, Slovenia, Estonia, Latvia, Lithuania, Hungary; in North America: United States, Canada; and in Asia: Israel, Korea. All estimates are conducted using Stata 15.0, with a detailed description of the data provided in Table 1.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Skew	Kurt	Source
Budget Balances(%GDP)	728	-2.18	4.34	-15.21	26.03	1.01	8.25	OECD
Renewable Energy (% TEC*)	728	17.68	14.13	0.4	61.4	1.27	4.13	WDI
GDP (per capita 2015$)	728	32871	18996	4936	90057	0.71	2.96	WDI
Unemployment (%)	728	8.13	4.33	2.01	27.68	1.45	5.58	WDI
Trade Openness (%GDP)	728	87.20	37.80	22.28	203.9	0.70	2.71	WDI
Current account (%GDP)	728	-0.11	5.57	-20.95	29.83	0.18	4.36	WDI

Note: *% of total energy consumption

GDP is represented as GDP per capita in constant 2015 US dollars, obtained from the World Development Indicators (WDI). The unemployment rate is calculated as a percentage of the total workforce, with data also derived from ILO estimates found in WDI. Another critical variable is trade openness, which is assessed as the total trade volume relative to GDP. The current account balance, which is often examined in connection with the budget deficit through theories such as the twin deficit and twin divergence, is represented as a percentage of GDP and sourced from WDI as well. A positive value indicates a surplus in the current account, while a negative value reflects a deficit in the current account.

Renewable energy utilization is measured as a percentage of final energy consumption, with data sourced from WDI. Finally, the budget deficit is measured through general budget balance expressed as a percentage of GDP, sourced from OECD general government deficit data. In this dataset, positive values indicate budget surpluses, while negative values represent budget deficit. Therefore, while the discussion primarily centers on deficits, it is important to acknowledge that the dependent variable is articulated in a positive manner, indicating fiscal balance rather than deficit; thus, an increase in the deficit results in a decrease in the fiscal balance, and the reverse is also true (Maltritz and Wüste, 2015: 227).

$$\boldsymbol{Bb_{it}} = \beta_0 + \beta_1 \mathbf{Ren_{it}} + \beta_2 \mathbf{lnGdp_{it}} + \beta_3 \mathbf{Une_{it}} + \beta_4 \mathbf{Trade_{it}} + \beta_5 \mathbf{Ca_{it}} + \mathbf{u_{it}} \quad (1)$$

The model tested in this study is outlined in Equation 1. Given that most variables already contain negative values and/or are expressed as percentages, only the natural logarithm of GDP, initially in nominal form, has been applied. Following data collection, the raw data were processed to

examine the homogeneity and cross-sectional dependency (CSD) conditions within the dataset. The Delta test results by Pesaran and Yamagata (2008) indicate heterogeneous slopes, as shown in Table 2. CSD is assessed using the Pesaran CD test (2004), the Breusch and Pagan LM test (1980), and the bias-adjusted LM test by Pesaran et al. (2008). As reported in Table 2, the results from all three tests confirm the presence of CSD within the dataset at a 1% significance level.

Table 2: CD and Homogeneity Tests

	LM Test Statistic	P-value	LM Adj. Statistic	P-value	LM CD Statistic	P-value
CD Tests	815.1	0.00***	42.48	0.00***	17.87	0.00***
			Δ	p-value	Δadj	p-value
Homogeneity Tests			15.61	0.00***	18.03	0.00***

Note: *** indicating significance at the 1% level

In panel econometrics, unit root tests are essential for identifying whether a variable is non-stationary and contains a unit root. This identification is crucial because, if a variable has a unit root, shocks to it may have persistent effects, potentially compromising the reliability of statistical conclusions. Ensuring stationarity is therefore important, as nonstationary can cause to spurious regressions and unreliable results. There are two types of unit root tests. Those are first generation and second generation tests, with the latter being more effective in addressing CSD when present.

Given the dataset characteristics in this study, the MADF test (Taylor & Sarno, 1998; Sarno & Taylor, 1998) is employed to assess unit roots within the panel data. The MADF test extends the traditional ADF test by allowing for the simultaneous analysis of multiple time series. While the ADF test checks for unit roots (indicating non-stationarity) in single time series, the MADF test is more suitable for panel data, enabling the evaluation of several series concurrently. The test's null hypothesis indicates that all time series are non stationary, containing unit roots. Rejection of this hypothesis suggests that at least some series are stationary, implying a tendency to return to a long-term mean rather than following a persistent random walk. As shown in Table 3, the MADF test statistics for all variables are significantly higher than the critical value (CV) of 28.89, indicating stationarity at the 1% significance level across all variables.

Table 3: MADF Unit Root Tests

	MADF	Approximately % CV
Budget Balance(%GDP)	1136.1***	28.89
Renewable Energy (% TEC)	808.74***	28.89
GDP (per capita 2015$)	5000.4***	28.89
Unemployment (%)	4.26e+05***	28.89
Trade Openness (%GDP)	1050.32***	28.89
Current account (%GDP)	37100.86***	28.89

Note: *** indicates significance at 1%.

In econometrics, panel cointegration tests play a crucial role in analyzing long-term connections between non-stationary time series variables within panel data. The concept of cointegration suggests that even if individual series exhibit non-stationarity, they share a common stochastic trend and, therefore, tend to move together over time. Identifying such stable relationships among economic variables is critical for making valid inferences and for accurate forecasting.

Table 4: Kao, Pedroni and Westerlund Cointegration Tests

Kao Cointegration Test			**Pedroni Cointegration Test**		
	Statistic	**P**		**Statistic**	**P**
Modified Dickey Fuller t	-11.92***	0.00	Modified Phillips Perron t	0.97	0.16
Dickey Fuller t	-6.84***	0.00	Phillips Perron t	-8.27***	0.00
Augmented Dickey Fuller t	-5.70***	0.00	Augmented Dickey Fuller t	-5.87***	0.00
Unadj. Mod. Dickey Fuller t	-14.82***	0.00	**Westerlund Cointegration Test**		
Unadjusted Dickey Fuller t	-7.45***	0.00	Variance Ratio	-3.47***	0.00

Note: *** indicates significance level at 1%, under H0: No cointegration.

To strengthen the robustness of the analysis, three separate cointegration tests are conducted: the Kao (1999) test, the Pedroni (1999, 2004) test, and the Westerlund (2007) test. Following Levin et al. (2002), cross-sectional means are subtracted from series averages across the panel to address CSD in the data. In each test, the null hypothesis assumes no cointegration. As shown in Table 4, all five statistics from the Kao test suggest cointegration at the 1% significance level. In the Pedroni tests, two of three statistics indicate cointegration. Similarly, the Westerlund test shows cointegration at the 1% level. Together, these results support the existence of a statistically significant long-term relationship among the variables.

All of the cointegration tests reveal a strong cointegration relationship. However, these tests do not contain details on the direction, strength, or sign of the relationships. To analyze these dimensions more precisely, cointegration estimators are applied, which are categorized as first- or second-generation, depending on whether they account for CSD. In this study, the second-generation DOLSMG estimator, as proposed by Pedroni (2001), is employed due to the CSD and heterogeneity of the data shown in earlier tests, as this method is robust in such cases.

Tatoğlu (2020:223-224) demonstrated that, the DOLSMG estimator is constructed in two stages. First, DOLS estimations are performed for each unit by including lead and lag values in the main estimation equation. Then, the individual unit estimates are united using the Pesaran Smith MG approach. The addition of lead and lag values of the X variables in the DOLSMG estimator effectively addresses potential feedback effects and endogeneity (Tatoğlu, 2020:223-224).

$$\widehat{\boldsymbol{\beta}}_{\boldsymbol{DOLSMG}} = \boldsymbol{N^{-1}}\left[\sum_{\boldsymbol{i=1}}^{\boldsymbol{N}} \left(\sum_{\boldsymbol{t=1}}^{\boldsymbol{T}} \left(\boldsymbol{Z_{i,t}Z'_{i,t}}\right)^{\boldsymbol{-1}}\right]\left(\sum_{\boldsymbol{t=1}}^{\boldsymbol{T}} \left(\boldsymbol{Z_{i,t}\overline{Y}_{i,t}}\right)\right)\right. \quad \textbf{(2)}$$

In the equation (2) from Tatoğlu (2020), Z_{it} represents the vector of explanatory variables, defined as $Z_{i,t} = (X_{i,t}, \bar{X}_i, \Delta X_{i,t-k}, \ldots, \Delta X_{i,t+k})$, while $\overline{Y_{it}} = Y_{i,t} - \bar{Y}_t$ denotes the dependent variable, and the DOLSMG estimator is obtained by averaging the DOLS estimators derived for each unit of i. Thus, the DOLSMG estimator yields more accurate results than both DOLS and FMOLS, and it accounts for endogeneity and serial correlation by including past and future values of ΔX_{it} as additional regressors (Bulut and Karakaya, 2018; Büyükoğlu et al., 2021; Vardar and Koc, 2021).

The estimation results are presented in Table 5. According to the estimation findings, several significant relationships among the analyzed variables are observed, as all absolute t-statistics exceed the critical value at the 1% significance level. Each coefficient is reported together with its corresponding t-statistic, which implies the strength and statistical significance of these relationships. The coefficient for renewable energy is −0.53, with a t-statistic of −20.07, indicating a statistically significant negative association at the 1% level. This finding suggests that a 1% increase in renewable energy consumption relative to total energy consumption is associated with a 0.53% deterioration in the budget balance, holding other factors constant.

Table 5: Pedroni's PDOLS (Group Mean Average)

	Beta	T statistic
Renewable Energy (% TEC)	-0.53	-20.07***
GDP (per capita 2015$)	0.71	2.66***
Unemployment (%)	-0.41	-10.47***
Trade Openness (%GDP)	0.15	6.92***
Current account (%GDP)	0.24	9.83***

Note: *** indicates significance at 1%. $T_{0.99}$ critical value: 2,518

To date, only one study has estimated the relationship between renewable energy utilization and budget deficit (Tugcu et al., 2020:1100), finding that renewable energy utilization negatively impacts budget balance, which aligns with the findings of this study. However, drawing definitive comparisons based on a single study may not provide a sufficient basis for broader conclusions. Nonetheless, the theoretical arguments presented in the introduction suggest that subsidies for both renewable energy and non-renewable energy sources may adversely affect the budget deficit, lending support to this study's findings. The effect of renewable energy may be especially significant, as its associated costs are generally higher than those for non-renewables, leading to more substantial subsidy expenditures for governments. In line with these theoretical insights, the empirical evidence suggests that renewable energy utilization may negatively affect the budget balance, where a negative coefficient implies a shift from surplus toward a budget deficit.

Examining the GDP variable, a 1% increase in the log of GDP per capita is associated with a slight improvement of 0.007% in the budget balance. This suggests movement from a budget deficit toward a budget surplus. Budget deficit are generally expected to rise during recessions and decrease during economic growth, aligning with expectations for a positive coefficient (Lis and Nickel, 2010:386). Since, during recessions, tax revenues generally fall, causing governments to increase spending to stimulate aggregate demand. Conversely, in periods of economic growth, government spending generally decreases. These findings align with existing literature, which consistently indicates that economic growth tends to reduce budget deficit and improve budget balance (Woo, 2003; Lis and Nickel, 2010; Murwirapachena et al., 2013; Maltritz and Wüste, 2015; Bangura et al., 2016; Al-Qudah and Jaradat, 2018; Tevdovski et al., 2021).

The findings related to the unemployment variable indicate that a 1% increase in unemployment is associated with a 0.41% deterioration in the budget balance, ceteris paribus. This result aligns with expectations, as unemployment rates typically rise during economic downturns, leading to increased unemployment benefits provided by governments. Consequently, this situation creates an adverse effect on the budget due to the additional financial burden. Unemployment benefits are considered one of the automatic stabilizers that help regulate the economy during periods of decline. Furthermore, the findings of other studies (Bayar and Smeets, 2009; Murwirapachena et al., 2013; Maltritz and Wüste, 2015; Tevdovski et al., 2021) support this situation and are consistent with the results of this study.

Trade openness is also a significant factor influencing budget deficit. According to estimations, a 1% expansion in trade openness results in a 0.15% improvement in budget balance, with all other factors held constant. Similar findings are also found by Schuknecht (1999), Alper and Çetenak (2018), and Alenoghena et al. (2023). Trade openness can improve budget balance through various channels. First, increased trade activity may lead to higher government revenues from trade-related taxes. Additionally, trade openness may stimulate economic growth and efficiency improvements, which can contribute to an increase in government revenues. Furthermore, a higher volume of international trade may attract foreign investment and promote fiscal discipline. However, it should also be noted that some other studies, such as those by Combes and Saadi-Sedik (2006) and Abanikanda et al. (2023), claim that trade openness may worsen budget balance.

The last control variable, the current account, is an important variable, and the relationship between the budget deficit and the current account has been widely investigated. According to the estimations, a 1% improvement in the current account balance is associated with a 0.24% improvement in the budget balance, holding all other factors constant. These findings align with the current account targeting hypothesis, which posits an inverse relationship to the twin deficit hypothesis. Specifically, it suggests that a worsening in current account balances adversely affects the fiscal deficit, with causality proposed to flow from the budget deficit to imbalances in the current account. For instance, Zubdeh (2021:63) found that an increasing current account deficit could also lead to an escalation in the budget deficit. Similarly, in the

context of Vietnam, Hoa Thi et al. (2023:141) utilized data spanning from 1991 to 2022 and various econometric techniques, concluding that a 1% increase in the trade balance is associated with a reduction in the budget deficit of 0.01% for short and 0.3% for the long term. Moreover, various causality studies suggest that causality may also run from current account balances to budget balance (Summers, 1988; Anoruo and Ramchander, 1998; Xie and Chen, 2014; Banday and Aneja, 2022).

3. CONCLUSION AND POLICY IMPLICATIONS

The effect of renewable energy consumption on the budget deficit of 26 OECD countries is examined in this study using available annual data from 1995 to 2022. Long-term relationships among variables are tested through three cointegration tests. Subsequently, coefficient estimates are derived using the DOLSMG estimator. A literature review is conducted to identify commonly applied macroeconomic variables for use as control variables, including GDP per capita, unemployment rates, trade openness, the current account balance and budget balance data.

According to the estimations, renewable energy utilization has a statistically significant negative coefficient, suggesting that renewable energy consumption may worsen budget balance. The negative effect of renewable energy on budget balance has several economic and financial causes. First, transitioning from fossil sources to renewable energy often requires costly up-front investments in infrastructure, technology, and grid upgrades, which are mostly supported by government subsidies. Moreover, unlike fossil fuels, which tend to generate quicker returns, renewable energy investments involve highly expensive initial spending that may not pay off in the short run. At the same time, fossil fuel industries are generally significant sources of tax revenue. Thus, moving away from fossil fuels to renewable sources can reduce tax revenues.

Also, renewable energy sources like solar and wind are intermittent, meaning they aren't continuous sources of energy. To provide a continuous and reliable energy supply, governments often invest in costly backup systems or energy storage solutions. This may further impact budget balances. Therefore, while the long-term gains from renewable energy are promising, these initial financial demands may place pressure on budget balances in the short term.

There may be various long-term benefits of renewable energy consumption. First, while the initial investment costs for renewable energy maybe high, the operating costs are expected to decrease slowly. This is important with the depletion of fossil reserves, which is expected to push up fossil fuel prices. In contrast, costs of renewable energy technologies are decreasing as advancements in technology increase.

Second, the majority of fossil fuel reserves are owned by few resource rich countries. This means that all other remaining countries are energy dependent on those countries. Renewable energy sources, such as solar and wind, on the other hand, are domestic resources that diminish this dependency. Thus, in the long term, energy dependent countries can reduce this dependency with renewable energy utilization. Also, they can reduce risks such as rising current account deficits, budget imbalances, and inflationary problems that result from the pass-through effects of imported fossil energy.

Third, fossil energy market is very volatile since it is affected from various international shocks. This results in significant uncertainty for countries and firms. However, renewable energy sources are more stable in pricing. This allows healthier and more predictable investment environments.

Finally, the most important long-term benefit of renewable energy in comparison to fossil sources is its environmental and health advantages. Fossil sources are a major cause of global warming, natural disasters, and all other environmental degradations. Those problems in turn creates big long-term financial costs. Therefore, energy transition can reduce these costs and reduce the environmental, health and economic consequences associated with fossil sources.

To support the energy transition away from fossil fuels to renewable energy without deteriorating the fiscal balances of governments, various policy measures can be suggested. First, various countries generally subsidize fossil energy industries to protect their economies from energy price fluctuations, such as those experienced during the COVID-19 pandemic, the Russia-Ukraine conflict, and instabilities seen in the Middle East. By gradually transferring these fossil fuel subsidies to the renewable energy sectors, governments can both reduce reliance on environmentally harmful energy sources and support renewable energy in a budget-neutral way.

Another tool could be financial innovations to distribute the costs of the energy transition from governments to the private sector. For example, governments can use green bonds and other sustainable financing tools, raising funds from investors interested in environmentally friendly initiatives rather than depending solely on tax revenues. Moreover, governments can use new financing options like public-private partnerships. Renewable energy certificates or carbon credits may also be an additional source of income.

For instance, carbon credits are crucial tools in promoting sustainable development. These credits can be tailored and applied to specific projects to incentivize firms to transition from fossil fuels to renewable energy sources. For example, firms and factories that integrate solar or wind energy into their production processes could be rewarded under a carbon credit scheme. Another effective policy approach involves public-private partnerships, which can help address the high upfront costs associated with renewable energy projects. Given that the infrastructure for energy projects is often developed by governments, public-private partnerships provide a mechanism to share the financial burden and associated risks with the private sector. This not only alleviates budgetary pressures on governments but also accelerates the energy transition by leveraging the efficiency and dynamism of the private sector.

Governments also should streamline regulatory procedures to make renewable energy projects more accessible for both businesses and households. Also, creating a regulatory framework that allows households and businesses to resell surplus electricity back to the grid would also help. This is especially useful in rural areas where renewable energy installations are often used as backup during power outages. This approach enables consumers to feed excess energy back into the system, helping to recover some of their investment.

This study represents one of the first comprehensive analyses of the fiscal burden that renewable energy sector place on government budgets, thereby making a significant contribution to the existing literature. However, it is not without limitations. In this context, a few recommendations can be made to guide future research in this area. Firstly, examining the situation by differentiating countries based on their levels of economic development could provide valuable insights, as varying findings are likely to emerge in relation to

different stages of economic maturity. Additionally, if data availability permits, it would be beneficial to investigate the impact of subsidies for renewable energy on budget deficit. Finally, given the potential for different renewable energy sources, such as solar, wind, and geothermal, to have varying effects, it is essential to analyze these impacts separately to further enrich the literature.

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YENİLENEBİLİR ENERJİ TÜKETİMİNİN BÜTÇE AÇIĞI ÜZERİNDEKİ ETKİSİ: OECD ÜLKELERİNDEN BULGULAR

YAHYA ALGÜL

GENİŞLETİLMİŞ ÖZET

Son yıllarda küresel ölçekte gözlemlenen hızlı ekonomik büyüme, fosil yakıtların çevresel zararları göz önüne alındığında, yenilenebilir enerji kaynaklarını önemli bir alternatif olarak konumlandırmıştır. Ancak, yenilenebilir enerji tüketiminin genel olarak fosil yakıtlardan daha yüksek maliyetli olması önemli bir handikaptır. Bu handikabın önüne geçilebilmesi ve yenilenebilir enerji kaynaklarının fosil yakıtlar karşısında daha rekabetçi bir konuma gelerek yaygınlaşabilmesi için hükümetler tarafından yoğun destek mekanizmaları ve teşvikler global düzeyde hayata geçirilmektedir. Dolayısıyla yenilenebilir enerji sektörüne sağlanan bu yoğun destek ve teşviklerin devletlerin bütçe açıkları üzerindeki potansiyel olumsuz etkileri önemli bir endişe haline gelmektedir. Teorik tartışmalar, yenilenebilir enerji kullanımının bütçe açıklarını kötüleştirebileceğine işaret etse de bunu ampirik olarak yeterince desteleyecek çalışma literatürde bulunmamaktadır. Dolayısıyla bu çalışma konuyla ilgili ilk kapsamlı ampirik araştırmalardan biridir.

Bu çalışma, yenilenebilir enerji kullanımının bütçe açıkları üzerindeki potansiyel etkisini, mevcut verilerin sağlandığı 26 OECD ülkesi için incelemektedir. Çalışmada kullanılan yıllık panel veri seti, 1995-2022 dönemini kapsamakta olup Pedroni'nin (2001) Dinamik En Küçük Kareler Ortalama Grup (DOLSMG) yöntemi ile üç farklı eşbütünleşme testi uygulanmıştır. Bu analizde, yenilenebilir enerji tüketimi toplam nihai enerji tüketiminin yüzdesi olarak ölçülürken, bütçe açıkları genel devlet dengesinin GSYİH'ye oranı olarak değerlendirilmektedir. Bu veri setinde, bütçe dengesindeki pozitif değerler bütçe fazlalarını, negatif değerler ise bütçe açıklarını ifade etmektedir. Kontrol değişkenleri ise, sabit 2015 ABD doları cinsinden kişi başına GSYİH olarak ölçülen GSYİH; toplam iş gücünün yüzdesi olarak ifade edilen işsizlik oranı (ILO tahminlerine dayalı); GSYİH'ye oranla ölçülen dış ticari açıklığı ve yine GSYİH'ye oran olarak hesaplanan cari açık dengesi bulunmaktadır. Bütçe dengesi verileri OECD'den, diğer veriler ise Dünya Bankası'nın WDI veri tabanından elde edilmiştir. Tüm analizler Stata 15.0 programı kullanılarak gerçekleştirilmiştir. Bulgular, üç farklı test kapsamında yenilenebilir enerji tüketimi ile bütçe açıkları

arasında anlamlı bir eşbütünleşme ilişkisi bulunduğunu göstermektedir. Ayrıca, DOLSMG tahmincisine göre yenilenebilir enerji tüketimindeki %1'lik bir artışın, bütçe dengelerinde yaklaşık %0,53 oranında bir kötüleşmeyle ilişkilendirildiği tespit edilmiştir.

Yenilenebilir enerjinin bütçe dengesi üzerindeki olumsuz etkisinin çeşitli ekonomik ve finansal nedenleri olduğu söylenebilir. İlk olarak, yenilenebilir enerjiye geçiş, genellikle altyapı, teknoloji ve şebeke modernizasyonları gibi alanlarda yüksek başlangıç yatırımları ve teşvikler gerektirebilir. Bunun yanı sıra, fosil yakıt endüstrileri geleneksel olarak hükümetler için önemli bir vergi geliri kaynağı olmuştur. Bu kaynaklardan uzaklaşmak, özellikle alternatif gelir kaynakları henüz oluşturulmamışsa, vergi gelirlerinde azalmaya yol açabilir. Son olarak, güneş ve rüzgar gibi yenilenebilir enerji kaynakları süreklilik arz etmez. Güvenilir bir enerji arzını sağlamak için hükümetler, genellikle pahalı yedek sistemlere veya enerji depolama çözümlerine yatırım yapmak zorunda kalmaktadır. Dolayısıyla uzun vadede yenilenebilir enerjinin sağladığı kazanımlar umut verici olsa da, bu başlangıçtaki mali yükler kısa vadede bütçe dengesi üzerinde baskı oluşturabilir.

Yenilenebilir enerjiye geçişin mali dengeleri bozmadan desteklenebilmesi için çeşitli politika önlemleri değerlendirilebilir. Öncelikle, birçok hükümet, COVID-19 pandemisi, Rusya-Ukrayna çatışması ve Orta Doğu'daki istikrarsızlık gibi enerji piyasalarını doğrudan etkileyen krizler sırasında ekonomilerini enerji fiyatlarındaki dalgalanmalardan korumak amacıyla fosil yakıtlara yönelik sübvansiyonlar sağlamaktadır. Bu fosil yakıt sübvansiyonlarının kademeli olarak kaldırılması ve ilgili kaynakların yenilenebilir enerji altyapısına yönlendirilmesi, hem çevresel sermayenin hem de kamu maliyesinin korunması bağlamında faydalı olabilir. Bir diğer yaklaşım, yeşil tahviller, kamu-özel sektör ortaklıkları, yenilenebilir enerji sertifikaları, karbon kredileri ve diğer sürdürülebilir finansman yöntemleri gibi finansal yeniliklerin kullanılması olabilir. Bu tür mekanizmalar, enerji dönüşümünün maliyetlerinin toplum ve özel sektör arasında daha adil bir şekilde dağıtılmasını sağlayabilir. Son olarak, yenilenebilir enerji projelerinin hem işletmeler hem de hanehalkları için daha erişilebilir hale gelmesi adına, hükümetlerin düzenleyici prosedürleri sadeleştirmesi önem arz etmektedir.