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The Relationship Between Public Expenditures and the Green Economy: An Empirical Analysis Focusing on E7 and D8 Countries

Kamu Harcamaları ile Yeşil Ekonomi Arasındaki İlişki: E7 ve D8 Ülkeleri Özelinde Ampirik Bir Analiz

ABSTRACT

Public expenditures, undertaken to meet collective needs, exert a significant influence across various economic domains, including production, consumption, investment, resource allocation, national income, and economic development. Positioned at the core of sustainable development, the green economy model plays a crucial role in fostering societal progress by ensuring environmental sustainability for a better future. Within this framework, this study aims to examine the impact of public expenditures on green development in E7 and D8 countries during the period 2010–2023. The Driscoll-Kraay (DK) standard error model was employed for the empirical analysis. The findings reveal that public sector spending on environmental protection and infrastructure investments, along with total natural resource rents, has a positive and statistically significant impact on the Sustainable Development Index, a key indicator of the green economy. Furthermore, the results indicate that public expenditures aimed at mitigating environmental threats contribute more effectively to the advancement of the green economy in D8 countries than in E7 countries. Empirical studies analyzing the relationship between public expenditures and the green economy within the context of the selected countries remain scarce in the literature. In this regard, the present study is expected to make a significant contribution by elucidating the role of public expenditures—an essential driver of sustainable development—in shaping the green economy.
Keywords: Public Expenditures, Sustainable Development, Green Economy, DK Method.

ÖZET

Kolektif ihtiyaçları karşılamak için yapılan kamu harcamaları, üretim, tüketim, yatırım, kaynak tahsisi, milli gelir ve ekonomik kalkınma dahil olmak üzere çeşitli ekonomik alanlarda önemli bir etkiye sahiptir. Sürdürülebilir kalkınmanın merkezinde yer alan yeşil ekonomi modeli, daha iyi bir gelecek için çevresel sürdürülebilirliği sağlayarak toplumsal ilerlemenin teşvik edilmesinde önemli bir rol oynamaktadır. Bu çerçevede, bu çalışma 2010-2023 döneminde E7 ve D8 ülkelerinde kamu harcamalarının yeşil kalkınma üzerindeki etkisini incelemeyi amaçlamaktadır. Çalışmada ampirik analiz için Driscoll-Kraay (DK) standart hata modeli kullanılmıştır. Çalışma bulguları, kamu sektörünün çevre koruma ve altyapı yatırımlarına yönelik harcamalarının, toplam doğal kaynak rantıyla birlikte, yeşil ekonominin temel göstergesi olan Sürdürülebilir Kalkınma Endeksi üzerinde pozitif ve istatistiksel olarak anlamlı bir etkiye sahip olduğunu ortaya koymaktadır. Ayrıca sonuçlar, çevresel tehditleri azaltmaya yönelik kamu harcamalarının D8 ülkelerinde yeşil ekonominin ilerlemesine E7 ülkelerine kıyasla daha etkili bir şekilde katkıda bulunduğunu göstermektedir. Seçilen ülkeler bağlamında kamu harcamaları ve yeşil ekonomi arasındaki ilişkiyi analiz eden ampirik çalışmalar literatürde az sayıdadır. Bu bağlamda, bu çalışmanın sürdürülebilir kalkınmanın temel itici güçlerinden biri olan kamu harcamalarının yeşil ekonomiyi şekillendirmedeki rolünü açıklayarak literatüre önemli bir katkı sağlaması beklenmektedir.
Anahtar Kelimeler: Kamu Harcamaları, Sürdürülebilir Kalkınma, Yeşil Ekonomi, DK Metodu.

1.   INTRODUCTION

The green economy, as defined by the World Bank, refers to the efficient use of natural resources. Efficient resource use prevents resource waste and ensures that limited resources are passed on to future generations in a usable state. Additionally, increasing resource efficiency enhances environmental awareness and provides important insights into measures needed to prevent natural disasters (World Bank, 2013; Dercon, 2014). The growing environmental awareness and measures taken, especially the increased use of renewable energy, have significantly reduced global greenhouse gas emissions. The green economy, a driving force behind green development, lies at the heart of sustainable development. The concept of sustainable development was first introduced in 1987 in a report titled "Our Common Future" published by the United Nations (UN). Also known as the Brundtland Report, it defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Thus, for economic development to be sustainable, social and environmental progress must also be achieved. Today, development economics examines not only economic indicators but also environmental, social, and cultural developments in most empirical or qualitative studies. In this context, the relationship between green development, green economy, and sustainable development is explored through global areas such as population growth, food security, urbanization, energy, and ecosystems (Vincent et al., 2002; Swanson & Lundethors, 2003; Toman, 2012; Kasztelan, 2017).

The UN, first in 1992 with "Agenda 21" and later in 2016 with "Agenda 2030," emphasized the need for a holistic approach to sustainable development goals, similar to the Brundtland Report. Agenda 2030 expanded the dimensions of development by adding areas such as income inequality, fair living, poverty and corruption reduction, and gender inequality. The complex structure of the green economy consists of functions that can be improved individually but have a collective societal impact. In this context, public sector investment expenditures aimed at increasing economic prosperity deeply affect all these areas. Therefore, the green economy highlights the essential role of public expenditures in addressing critical global issues such as climate change. The primary objectives of public expenditures include ensuring state security, efficient resource allocation, income equity, public investments in areas where private enterprises do not operate, and maintaining economic stability (Musgrave, 1959; Hutchison, 1976). Public investments in renewable energy, a sector where private enterprises are often absent, have also triggered environmental protection expenditures. Thus, public economics plays a significant role in establishing the green economy. With new resources allocated to public economics for sustainable development, countries' performance differences in the green economy have begun to be linked to the effectiveness of public environmental expenditures. Consequently, the relationship between public expenditures and the green economy has been analysed from various perspectives. This study investigates the causal relationship between public expenditures and the green economy, focusing on E7 and D8 countries using data from 2010-2023 and the Driscoll-Kraay (DK) causality analysis. The findings and conclusions of the study reveal the impact of public expenditures on the green economy and provide new and diverse policy recommendations for sustainable development in the analysed countries. Thus, this study contributes significantly to the literature and serves as an important resource for future research due to its unique variables and analytical model.

2.   LITERATURE REVIEW

The literature includes various studies on public expenditures and green economic development. Some studies focus on the relationship between public expenditures and economic growth or between the green economy and sustainable development, while others directly link public expenditures with the green economy. The originality of this study lies in its use of up-to-date data and its focus on E7 and D8 countries, allowing for comparisons between these two groups. In this regard, the study is considered a contribution to the existing literature. The leading studies in the literature are summarized in Table 1, organized by publication year, author(s), dataset, method, and results.

Table 1. Literature Review

Years	Author(s)	Dataset	Method	Results
2013	Bina, O.	Twenty-four sources on the green economy (policy documents and research papers from international organizations and think tanks).	Qualitative Analysis.	The study found that the green economy played a significant role in building consensus during Rio+20, but the expected outcomes were not achieved. Green discourse remained limited internationally but contributed to revitalizing discussions on 21st-century sustainable development models.
2018	Aldieri, L., & Vinci, C. P.	Data from international firms (2002-2010) on net sales, number of employees, annual capital expenditures, annual R&D expenditures, annual operating profit, and main industrial sectors according to the ICB classification.	Generalized Method of Moments (GMM).	The study confirmed the prevalence of Marshallian spillovers in firms, showing a negative impact of displacement effects in the green economy.
2019	Lin, B., & Zhu, J.	Data from 282 Chinese provinces (2005-2016) on public education and R&D expenditures.	Generalized Method of Moments (GMM).	The study found that public R&D and education expenditures support green economic growth.
2021	Mikhno, I., Koval, V., Shvets, G., Garmatiuk, O., & Tamošiūnienė, R	Indicators and impact tools for ecological and economic development levels.	Qualitative Analysis.	The study suggested that the proposed indicators could be used for further R&D to influence environmental and economic development levels.
2021	Yumei, H., Iqbal, W., Irfan, M., & Fatima, A.	Data from Belt-Road Initiative (BRI) countries (2008-2018) on government expenditures on education and R&D, and green economic performance index (GEE).	Generalized Method of Moments (GMM).	The study found that BRI countries, except Pakistan and Bangladesh, experienced a gradual decline in GEE from 2010-2018 and made progress in green development. GMM analysis showed that both education and R&D positively impact the green economy.
2021	Zhang, D., Mohsin, M., Rasheed, A. K., Chang, Y., & Taghizadeh-Hesary, F.	Data from Belt and Road Initiative (BRI) countries (2008-2018) on government expenditures on education and R&D, and green economic performance index (GEE).	Generalized Method of Moments (GMM).	The study found that both education and R&D expenditures positively impact the green economy in BRI countries.
2022	Huang, X., Huang, X., Chen, M., & Sohail, S.	Data from selected Asian economies (1991-2019) on public sector education and R&D expenditures and green economic growth.	Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS).	The study found that both education and R&D expenditures significantly contribute to green economic growth in most Asian economies.
2022	Liu, Z., Yin, T., SURYA PUTRA, A. R., & Sadiq, M	Data from China (2008-2018) on public expenditures and green performance indicators.	Least Squares (LS) and Quantile Regression Analysis.	The study found a bidirectional correlation between fiscal policy and CO_2 pollution, while energy use showed a unidirectional causal relationship. The study also showed that China is transitioning towards a green economy through fiscal policies.
2023	Guo, Y., Rosland, A., Ishak, S., & Senan, M. K. A. M.	Data from China (2008-2018) on public expenditures and green technology and industry growth indicators.	Generalized Autoregressive Conditional Heteroscedasticity (GARCH) Data Analysis.	The study found that public expenditures on renewable energy investments and environmentally sensitive infrastructure projects promote green development in China.
2023	Liu, Z., & Abu Hatab, A.	Data from the highest-emitting economies (2008-2018) on public R&D expenditures, green economic development index, and stakeholder engagement indicators.	Data Envelopment Analysis (DEA).	The study found that stakeholder engagement increases the efficiency of public spending, thereby promoting green initiatives and contributing to the green economy.
2023	Li, L., Shen, Z., Song, M., & Vardanyan, M.	Data from 239 Chinese cities (2007-2019) on fiscal expenditures and industrial pollution levels.	Generalized Method of Moments (GMM).	The study found that local fiscal expenditures positively and significantly impact industrial wastewater production, sulphur dioxide emissions, and dust pollution levels.
2025	Zarghami, S. A.	Data from 41 OECD and European countries on Sustainable Development Goal 7 (SDG 7).	Structural Analysis.	The study suggested that governments should collaborate to enhance the impact of economic policies, promote innovation, strengthen labour markets with inclusive policies, and facilitate energy investments through international financial regulations.

3.   METHODOLOGY

The study methodology was developed based on the hypothesis that "public expenditures have a positive impact on the green economy in E7 and D8 countries." In this context, the Driscoll-Kraay (DK) analysis method was chosen. A multivariate framework was established to empirically analyse the impact of public expenditures on the green economy.

3.1.   Dataset and Model Description

The relationship between public expenditures and the green economy was analysed using data from E7 and D8 countries for the period 2010-2023. The basic model developed by Driscoll and Kraay is represented by the following equation (Sarafidis & Wansbeek, 2012):

$$Y_{it} = X_{it}\beta + \varepsilon_{it}, \ i = 1, \dots, N, \ t = 1, \dots, T \tag{1}$$

Here, Y_{it} represents the dependent variable (SDI), and X_{it} represents the independent variables (PEX, TNRANT, PINEX). The DK regression model, which is robust to all possible spatial and temporal correlations, was selected for the analysis. The model's standard error terms maintain consistency in covariance matrix estimators despite the size of (N and T) (Baltagi & Baltagi, 2008; Kırıkçı & Yanar, 2020).

The model for E7 countries:

$$logSDI_{it} = \beta_0 + \beta_1 PEX_{it} + \beta_2 TNRANT_{it} + \beta_3 PINEX_{it} + \varepsilon_{it} \tag{2}$$

The model for D8 countries:

$$logSDI_{it} = \beta_0 + \beta_1 PEX_{it} + \beta_2 TNRANT_{it} + \beta_3 PINEX_{it} + \varepsilon_{it} \tag{3}$$

In models (2) and (3):

β_0; constant term,

$\beta_1, \beta_2, \beta_3$; slope coefficients,

ε; error term,

i; observation,

t; time.

Table 2. Variable Descriptions

Abbreviation	Description	Data Source
SDI	Sustainable Development Index	Sachs et al., (2024)
PEX	Public Environmental Expenditures (% of GDP)	World Bank (WB) (2024)
TNRANT	Total Natural Resource Rents	World Bank (WB) (2024)
PINEX	Public Infrastructure Investment Expenditures (% of GDP)	World Bank (WB) (2024)

From the variables shown in Table 2;

Sustainable Development Index (SDI): In order to understand the relationship between public expenditures and green economy, SDI data of E7 and D8 countries were obtained from Sachs et al. (2024) and inspired by Hickel, (2020) and Diaz-Sarachaga et al. (2018).

Public Environmental Expenditures (PEX): These mainly include expenditures on reducing air, water, soil, and noise pollution, protecting biodiversity; wastewater and waste management; and environmental research and development. This variable was used in this study based on Krajewski, (2016) and obtained from World Bank Indicators.

Total Natural Resources Rent (TNRANT): Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents. This variable is used in this study, inspired by Jović et al. (2016) and Mehar et al. (2018). TNRANT was obtained from the World Bank database.

Public Infrastructure Investment Expenditures (PINEX): PINEX are a form of 'real assets,' which contain physical assets we see in everyday life like bridges, roads, highways, sewage systems, or energy. Such a type of asset is quite crucial in a country's development. The PINEX variable was obtained from the World Bank database and used in this study based on Leduc, S., & Wilson, D. (2013), Eaves et al. (2024), and Hidayat et al. (2024).

The main hypothesis is, "High public expenditure has a positive impact on the green economy." Therefore, the explanation variables of the study are expected to have a positive impact on the green economy. Table 3 shows the correlation relationship between variables determined in this context and these variables.

Table 3. Correlation Matrix of the Variables

	logSDI	%PEX	%TNRANT	%PINEX
logSDI	1	0,298	-0,049	0,864
%PEX	0,298	1	0,528	0,266
%TNRANT	-0,049	0,528	1	0,750
%PINEX	0,864	0,266	0,750	1

According to Table 3, sustainable development and public environmental expenditure are positive and weak, and the total rent of natural resources is negative and very weak. On the other hand, the positive correlation between the investment of sustainable development and the investment of public infrastructure is high.

Table 4 shows statistical descriptive information for each variable in the individual models of the countries of the E7 and D8 groups.

Table 4. Descriptive Statistics

Countries	Variables	Median	Max.	Min.	Std. Deviation
E7 Group Countries	logSDI	62,8	86,0	43,0	16,6
	%PEX	67,5	91,0	56,0	21,1
	%TNRANT	23,0	31,0	14,0	4,9
	%PINEX	36,0	57,0	21,0	22,4
Countries	**Variables**	**Median**	**Max.**	**Min.**	**Std. Deviation**
D8 Group Countries	logSDI	66,0	87,0	54,0	25,4
	%PEX	79,0	96,0	48,0	21,4
	%TNRANT	12,7	20,0	11,0	7,5
	%PINEX	60,0	68,0	34,0	15,9

4. FINDINGS

Table 5 shows the results obtained with the Breusch and Pagan (1980) LM, Pesaran (2004) CD and Fress tests used for the Cross-Section Dependence (CSD) test.

Table 5. CSD Results

Tests	E7 Group Countries	D8 Group Countries
Breusch and Pagan LM	780.457 $(p = 0.0000)^{**}$	650.596 $(p = 0.0000)^{**}$
Pesaran CD	96.252 $(p = 0.0000)^{**}$	84.198 $(p = 0.0000)^{*}$
Fress	$\alpha = 0.10: 0.2178$ $\alpha = 0.05: 0.3055$ $\alpha = 0.01: 0.4004$	$\alpha = 0.10: 0.2178$ $\alpha = 0.05: 0.3055$ $\alpha = 0.01: 0.4004$

*** $p \leq 0,01$, ** $0,01 < p \leq 0,05$ ve * $0,05 < p \leq 0,1$.

From the perspective of cross-sectional dependence, the results of the LM, CD, and Fress tests in Table 5 are statistically significant for E7 and D8 countries ($p \leq 0.01$). Accordingly, the LM test results indicate a strong cross-sectional dependence between E7 and D8 countries. In other words, the null hypothesis (H_0), which assumes no cross-sectional dependence between E7 and D8 countries, is rejected.

Tablo 6. Driscoll-Kraay (DK) Estimation Results

Countries	Regressor	Coefficient	Prob > F = (0.0000)***
E7 Group Countries	Constant	-6.204^{**}	0.062
	Ln PEX	0.355^{*}	0.056
	Ln $TNRANT$	0.014^{**}	0.004
	Ln $PINEX$	0.201^{**}	0.059
	Wald test	89.01	0.000
	R^2	0.6924	
Countries	**Regressor**	**Coefficient**	**Prob > F = (0.0000)***
D8 Group Countries	Constant	4.015^{*}	0.083
	Ln PEX	0.498^{**}	0.063
	Ln $TNRANT$	0.010^{**}	0.001
	Ln $PINEX$	0.101^{**}	0.014
	Wald test	70.20	0.000
	R^2	0.7978	
	Number of groups (total)	15	

* and ** show level of significance at 1%, and 5%, respectively.

According to Table 6, which presents the DK results, the models for E7 and D8 countries have been analyzed independently. In both country groups, the effects of independent variables on dependent variables are found to be statistically significant. In the E7 group, represented by Model (2), the R^2 value is 69%, indicating that the independent variables in Model (2) explain 69% of the variation in the Sustainable Development Index (SDI). On the other hand, when Model (3) is analysed, the R^2 value for D8 countries is determined to be 0.7978, suggesting that the explanatory power of the model for D8 countries is 80%.

It is noteworthy that public environmental expenditures exhibit a positive and statistically significant relationship with the Sustainable Development Index in both E7 and D8 country groups. These results indicate that a 1% increase in public environmental expenditures leads to a 0.355% increase in the SDI for E7 countries and a 0.498% increase for D8 countries. This finding highlights the critical role of public environmental expenditures in sustainable development. Moreover, this result aligns with the findings of Horoshkova et al. (2020), which conclude that government spending on environmental protection supports sustainable development.

When examining the relationship between total natural resource rents and sustainable development in Table 6, a statistically significant and positive, yet weak, relationship at the 5% significance level is observed in both country groups. Specifically, in the E7 countries, a 1% increase in total natural resource rents corresponds to a 0.014% increase in the SDI, while in the D8 countries, this increase is 0.010%. This finding suggests that natural resources play a role in achieving sustainable development goals in both E7 and D8 countries. The results obtained are consistent with the findings of Fu & Liu (2023).

Regarding the relationship between public infrastructure investment expenditures and the Sustainable Development Index, a statistically significant and positive relationship at the 5% level is identified in both country groups. In the E7 group, a 1% increase in public infrastructure investment expenditures leads to a 0.201% increase in the SDI, whereas in the D8 group, this increase is 0.101%. These findings are in line with the results of Fay et al. (2011).

5. CONCLUSION and RECOMMENDATIONS

In this study, the relationship between public expenditures and the green economy in E7 and D8 countries has been empirically examined. Within this framework, each country group was analysed separately, leading to significant insights into their sustainable development processes. The analysis utilized annual data from the period 2010–2023. To test cross-sectional dependence among variables, Breusch and Pagan's (1980) LM test, Pesaran's (2004) CD test, and the Fress test were employed. For Model (2) and Model (3), the panel regression-based robust standard error approach, known as the Driscoll-Kraay (DK) method, was applied.

A general assessment of the empirical findings suggests that the results are consistent with and supportive of the existing literature. According to the DK estimator results, which examine the interaction between public expenditures and the green economy at the core of sustainable development, public environmental expenditures exhibit a positive and statistically strong causal relationship with the Sustainable Development Index (SDI). This implies that government environmental protection expenditures contribute to fostering the green economy. A comparative analysis between the two country groups indicates that the significance level of this relationship is 1% for E7 countries and 5% for D8 countries. This suggests that public expenditures aimed at mitigating environmental threats have a relatively stronger impact on the green economy in D8 countries than in E7 countries.

On the other hand, the relationship between total natural resource rents and sustainable development was found to be positive but statistically weak. Despite having a favourable effect on sustainable development during the 2010–2023 period for both country groups, this interaction was observed to be more pronounced in E7 countries. Since sustainable development is a function of green growth, this finding highlights the crucial role of natural resource rents—particularly underground resources—in driving green economic development in E7 countries.

The analysis of the relationship between public infrastructure investment expenditures and the Sustainable Development Index reveals a positive and statistically significant relationship at the 5% level for both country groups. However, public infrastructure investments appear to have a greater impact in E7 countries.

Based on the study's findings, several policy recommendations have been developed for policymakers focusing on achieving green economic growth and, consequently, sustainable development. The results indicate that increases in public environmental and infrastructure investment expenditures, as well as in total natural resource rents, contribute positively to the Sustainable Development Index in E7 and D8 countries. Furthermore, the green economy—positioned at the core of sustainable development—also benefits from these expenditures.

Across all countries included in the analysis, increasing public environmental expenditures will enhance environmental quality and green transformation by fostering greater demand for industrial transitions that reduce greenhouse gas emissions. Public resources will primarily be directed toward renewable energy production. Additionally, public infrastructure investments will promote initiatives aimed at ensuring environmental sustainability while leveraging rising natural resource rents to boost employment in the renewable energy sector. This will enhance social welfare and increase public benefits.

Therefore, expanding the share of such government investment expenditures will not only contribute to combating environmental threats and addressing climate change but will also accelerate green economic growth and pave the way for new green entrepreneurship. Policymakers should view this cyclical structure as an opportunity to build a more environmentally conscious society, as the development of the green economy will be a key factor in shaping more liveable cities.

Fostering this awareness among individuals will transform environmental sustainability into a lifestyle and a fundamental aspect of daily living. Consequently, public policy should be grounded in the principle of "development with respect for human dignity and nature," ensuring that this philosophy becomes an integral part of people's lives. This understanding should be disseminated throughout society in a bottom-up manner, fostering widespread adoption across all levels of the population.

Furthermore, this perspective should encourage policymakers to allocate a larger share of public investments toward green technologies and environmentally friendly R&D activities, expecting contributions from farms, digital platforms, and industrial establishments that produce eco-friendly products. Ultimately, achieving sustainable development through a green economy requires a well-analysed and interactive relationship between policymakers and society.

The findings of this study serve as a valuable guide for future research, particularly in analysing the interplay between societal structures, socio-cultural characteristics, and economic factors within the framework of environmental awareness, renewable energy, and public investments. Future studies should build upon these results to develop new insights, emphasizing the role of green economy-centred sustainable development and the reciprocal interaction between policymakers and society.

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