Eurasian Academy of Sciences
Eurasian Business & Economics Journal
2026 Volume:43 S: 40- 62
Published Online January 2026 (http://busecon.eurasianacademy.org)
https://doi.org/10.17740/eas.econ.2026-V43-03

When Foreign Investment Turns Brown: FDI and Renewable Energy Consumption in Turkic Republics

İlkut Elif KANDİL GÖKER* **Nimet VARLIK**** **Nadide GÜLBAY YİĞİTELİ*****

*İlkut Elif KANDİL GÖKER, Doç. Dr. Ankara Üniversitesi, Gayrimenkul Geliştirme ve Yönetimi Bölümü, egoker@ankara.edu.tr, ORCID: 0000-0002-5290-3514

**Nimet VARLIK, Doç. Dr. Kırıkkale Üniversitesi, İktisat Bölümü, nvarlik@kku.edu.tr, ORCID: 0000-0002-7280-306X

***Nadide GÜLBAY YİĞİTELİ, Doç. Dr. Ankara Üniversitesi, Gayrimenkul Geliştirme ve Yönetimi Bölümü, ngyigiteli@ankara.edu.tr, ORCID: 0000-0002-0632-7253

Received Date: 03.11.2025 Accepted Date:03.02.2026

ABSTRACT

Focusing on the energy transition in the Turkic Rebuplics, this study explores how foreign direct investment (FDI) inflows influence the renewable energy consumption across six Turkic countries-Türkiye, Azerbaijan, Kazakhstan, Kyrgyzstan, Uzbekistan, and Turkmenistan-during the 2000-2023 period, using panel data analysis. The empirical results indicate that per capita gross domestic product growth contributes positively to the renewable energy consumption, whereas FDI inflows effect negatively. The analysis uncovers two contrasting associations: improvements in per-capita gross domestic product coincide with an expansion of renewable energy, whereas larger FDI inflows coincide with a reduction. These findings suggest that foreign investments in the region are primarily directed toward fossil fuel intensive sectors, thereby supporting the Pollution Haven Hypothesis for the developing economies examined. This paper adds a regional perspective that has been largely absent from prior FDI studies and connects the FDI debate to energy-policy implications.

Keywords: Renewable energy, foreign direct investment, Turkic Republics
Jel Codes: F18, Q56

Yabancı Yatırım Kahverengiye Döndüğünde: Türk Cumhuriyetlerinde Doğrudan Yabancı Yatırımlar ve Yenilenebilir Enerji Tüketimi

ÖZET

Türk Cumhuriyetleri'ndeki enerji dönüşümüne odaklanan bu çalışma, panel veri analizi kullanarak, 2000-2023 döneminde Türkiye, Azerbaycan, Kazakistan, Kırgızistan, Özbekistan ve Türkmenistan olmak üzere altı Türk ülkesinde doğrudan yabancı yatırım (DYY) akışlarının yenilenebilir enerji tüketimini nasıl etkilediğini araştırmaktadır. Ampirik bulgular, kişi başına gayri safi yurtiçi hasıla büyümesinin yenilenebilir enerji kullanımını pozitif etkilerken, DYY girişlerini negatif etkilediğini göstermektedir. Analiz, iki zıt ilişkiyi ortaya koymaktadır: kişi başına gayrisafi yurtiçi hasıladaki artışlar yenilenebilir enerji kullanımını yaygınlaştırırken, DDY'ler azaltmaktadır. Bu bulgular, bölgedeki yabancı yatırımların öncelikle fosil yakıt yoğun sektörlere yöneldiğini ve böylece incelenen gelişmekte olan ekonomiler için Kirlilik Cenneti Hipotezini desteklediğini göstermektedir. Bu makale, önceki DYY çalışmalarında büyük ölçüde eksik olan bölgesel bir bakış açısını eklemekte ve DYY tartışmasını enerji politikası çıkarımlarıyla ilişkilendirmektedir.

Anahtar Kelimeler: Yenilenebilir Enerji, Doğrudan Yabancı Yatırmlar, Türk Cumhuriyetleri
Jel Kodları: F18, Q56

1. Introduction

Energy plays a significant role in production, transportation, promoting agricultural activities, fulfilling basic human needs, and developing an economy, serving as the driving force behind economic growth (Kang et al., 2021). As per capita income increases in the global economy and population growth continues in India, Sub-Saharan Africa, and other developing economies, more energy demand is expected to emerge to ensure increased social welfare (Marton and Hagert, 2017). Therefore, energy has become one of the most important strategic issues for developed and developing countries.

Global warming, climate change, and air pollution caused by the use of non-renewable energy sources (RES) continue to be a significant problem, leading to over 5 million premature deaths each year in emerging and developing economies outside of China (IEA, 2025). Therefore, it is important to increase the use of sustainable and clean energy, known as renewable energy, instead of non-RES that create negative externalities due to the air pollution and environmental problems they cause (IEA, 2025; Shin et al., 2018).

A key strategy for addressing climate change, mitigating global warming, and improving air quality is to curtail dependence on fossil fuels-namely coal, oil, and natural gas-which together supply nearly 80% of the world's primary energy[1] and generate about 75% of global greenhouse gas emissions. The transition toward renewable alternatives such as solar, wind, hydro, geothermal, biomass, biofuels, tidal, and wave energy is therefore essential (Wang et al., 2). Renewable, or inexhaustible, energy sources harness naturally replenished elements including sunlight, rainfall, geothermal heat, and ocean movements. These sources are widely regarded as environmentally friendly options that minimize ecological harm (Shahzad et al., 2018). Among the major renewables are hydro, biomass, wind, and hydrogen energy.

The most significant global environmental agreements aimed at significantly reducing environmental degradation and increasing the use of RES for the stability of the global climate are the Kyoto Protocol (1997) and the Paris Agreement (2015) [2]. These agreements propose using green energy[3] sources in energy consumption (EC) as the most appropriate solution to reduce carbon dioxide levels. In this regard, many developed and developing countries want to use RES as an alternative to traditional ones (Shah et al. 349). The Energy Institute (2024) reports that renewables accounted for 14.6% of global primary EC, representing a 0.4 percentage point rise from the preceding year. Through the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations has committed to mobilizing financial resources that support renewable-energy investment projects in developed and developing economies. In addition, the United Nations has agreed to jointly mobilize $100 billion per year, including the Green Climate Fund (GCF) established at the Climate Change Conference (COP16) in 2010 (Wall et al., 2019).

Statistics show that using all energy sources is becoming increasingly important due to the growing global demand. Accordingly, total primary EC in 2023 increased by 2% over the 2022 level, 0.6% over the ten-year average, and 5% over the pre-COVID level of 2019 (Energy Institute, 2024). The International Energy Agency (IEA, 2023) forecasts that worldwide primary EC will expand by approximately 1.8% per year over the 2005–2030 period.

[1] Primary energy sources include coal, oil, natural gas, nuclear, biomass, hydroelectric, solar, wind, and wave energy (Özbektaş et al. 344).
[2] For more information, see Miyamoto and Takeuchi 318-349.
[3] Green Energy is defined as a type of energy obtained from renewable natural resources such as sunlight, wind, tides, and geothermal heat, which have been used for millions of years and are defined as limited resources, and which do not harm nature (Alizada, 2022: 4-5).

The IEA World Energy Outlook 2023 Report (WEO, 2023) contains forecasts for the global energy market in 2030. According to the report, the number of electric vehicles was 1 million in 2015 and reached 15 million in 2023. This indicates that this number will be approximately 40 million in 2030. Such a transformation is expected to lead to a decline in global oil demand and, consequently, to charging cars via electricity based on renewable energy. It is also forecasted that 80% of new electricity capacity will be generated by renewable energy by 2030.

Investing in clean energy technologies is essential to increase the share of renewable energy in total energy production. One of the most effective ways to promote the spread of technologies for clean energy production is to support foreign direct investment (FDI) inflows (Przychodzen and Przychodzen, 2020). In addition to the macroeconomic effects of FDI such as growth and employment (Li and Liu, 2005; Sadorsky, 2010), there are many other effects, like the transfer of human capital, increased production, and the spread of technology (Lee, 2013, Wall et.al., 2019; Bulut, et. al., 2021; Soto, 2024) and pollution havens (Javorcik and Wei, 2003; Marton and Hagert, 2017).

The objective of this study is to examine whether FDI inflows have a positive or negative impact on renewable energy consumption (REC) in a sample of six Turkic Republics, namely Azerbaijan, Kazakhstan, Kyrgyzstan, Uzbekistan, Turkmenistan, and Türkiye. Can we find evidence that FDI contributes to a decrease in the use of energy from non-renewable sources and an increase in the use of energy from renewable sources? Can FDI increase the use of “green” energy or decrease the use of non-RES such as gas, oil, and coal in terms of energy sources used in developing countries?

Empirical findings in the economic literature mostly suggest that FDI brings investments that reduce non-renewable energy use and promote green energy in high-income and low- and lower-middle-income countries (Doytch and Narayan, 2016: 292). The hypotheses to be tested within the framework established in this study are: i) FDI significantly affects renewable EC in selected Turkic Republics located in Central Asia, ii) there is no relationship between FDI and REC in these countries.

The study differs from previous studies examining the relationship between FDI and REC in two ways. To the best of our knowledge, there is no existing research that specifically investigates the impact of foreign direct investment on REC in the Turkic Republics. The empirical findings obtained are expected to be the first to address a region generally overlooked in the literature and to contribute to the literature. Second, while the literature focuses more on the effects of FDI on economic growth, this study provides findings on whether FDI contributes to an increase in renewable energy use, informing decision-makers on integrating energy policies with foreign investment strategies.

The study consists of four sections, including the introduction. The subsequent sections outline the theoretical framework for the relationship between FDI and renewable energy and review the relevant literature. Then, the renewable energy policies of the Turkic Republics, which form the study sample, are examined. The following chapters cover the methodology, data, and findings, respectively, while the final chapter, the conclusion, evaluates the empirical findings and presents policy recommendations.

2. FDI and Renewable Energy: Theoretical Basis

Recent years have seen growing foreign direct investment in renewable energy and contributed to the international spread of REC (Wall et. al., 2019). Economic literature argues that FDI inflows can affect REC in two ways: positively and negatively. The positive effect is expected to be that FDI allows for technology diffusion through sustainable production, thereby alleviating global pressure on energy demand growth (Lee et al., 2011). The negative impact raises the question of whether high-income investors will act as pollution havens for middle-income countries (Marton and Hagert, 2017). If the spillover effects of FDI contribute to improving the country's environmental quality, FDI promotes technology transfer and thus accelerates the transition to a green economy. Such an outcome would be consistent with the pollution halo hypothesis, rather than the pollution haven hypothesis (PHH), as it reflects positive environmental externalities of foreign investment. Such an outcome encourages reducing dependence on non-renewable energy derived from fossil fuels (Soto, 2024).

Therefore, the impact of FDI on renewable energy is examined from two perspectives: the technology diffusion theory and the PHH.[4] One of the main channels through which FDI affects REC is technology diffusion, a crucial element in enhancing technological advancement and productivity in national economies (Ferrier et al., 2016). FDI serves as an important channel for developing countries to access advanced technologies through technology diffusion (Lee et al., 2011) and leads the growth of firms in the host economy by increasing productivity through the diffusion of advanced technology (Mielnik et al., 2002). However, the technology diffusion theory is based on the idea that the host country must have reached a certain level of development for diffusion to succeed. It is assumed that less developed countries have not reached a capital-intensive industrialization sufficient to attract high levels of FDI (Cole and Elliott, 2005). The study by Fang et al. (2024), on 65 OECD and non-OECD countries supports this view. This study found that the technology diffusion effects of FDI are not conducive to transforming the host country's EC structure toward renewable energy. The authors' findings show that the negative effects of FDI are more pronounced in low-income and non-OECD countries.

Another effect generated by FDI through renewable energy is addressed within the PHH framework. The PHH was developed as an argument against the Environmental Kuznets Curve (EKC). The EKC, a model used in development economics, posits that pollution increases with economic growth up to a certain income level, after which it decreases. In other words, the EKC is built on the hypothesis that an economy's pollution level follows an inverted U-curve. Increasing income in the economy, along with structural change and increased environmental regulation, causes the curve to reach a turning point and the pollution level to decline after reaching a "peak" (Suri and Chapman, 1998). The PHH explains how differences in environmental regulations between developed and developing countries can lead to the spread of pollution-intensive industries. This hypothesis criticizes the assumptions behind the EKC and explains the reversal of the U-curve as the ability of a country to export pollution-intensive industries at a certain income level, thereby "pushing" the problem onto a less developed country. Accordingly, the increase in capital inflows will raise the income of the less developed or developing country, but at the same time, the host country's pollution level will increase due to rising energy demand (Cole, 2004; Musah et al.,2022). Moreover, according to the Pollution Haven Hypothesis, disparities in environmental standards across developed and developing economies can prompt developed countries to shift their industrial activities elsewhere. In contrast, developing countries may specialize in the most polluting industrial sectors (Cole, 2004).

The impact of FDI on renewable energy use is a significant phenomenon for global economies. Findings from studies in economic literature vary across different country examples.

[4] The pollution impact of FDI inflows is explained in terms of its negative environmental effects under the PHH, while its positive effects are interpreted from the perspective of the Pollution Halo Effect Hypothesis (PHEH) (see Musah et al., 2022; Caetano et al., 2022). This study addresses the negative impact of FDI inflows within the framework of the PHH.

Traditionally, in many developing countries, FDI has been concentrated in sectors that still rely heavily on natural resource use, particularly agriculture, mining, and fuel production (Mabey and McNally, 2003). Studies show that the effects of FDI on renewable energy through technology diffusion are more pronounced in economically and technologically developed regions, for example, positively affecting China's energy industry performance (Liu et al., 2016). The work of Doytch and Narayan (2016) indicates that FDI has the effect of reducing non-REC and increasing REC. Accordingly, financial services are provided in high-income countries, and FDI is used to reduce industrial EC from non-renewable sources and increase REC. This finding also supports the work of Cole and Elliott (2005). Marton and Hagert (2017), who examined middle-income countries, found that FDI negatively correlates with renewable energy in these countries, but the adverse effect is low. The authors explain the small effect by the time it takes for technology to spread. It is argued that while FDI may reduce the share of renewable energy now, it could lead to a potential increase in the share of renewable energy in the future. Khandker et. al. (2018) point out that FDI plays an important role in developing renewable energy in Bangladesh and that policies aimed at increasing FDI are therefore important.

Javorcik and Wei (2003) demonstrate that FDI has effects supporting the PHH in transition economies, but they argue that this effect is weak. Their study examined whether the PHH is valid in Türkiye within the framework of the EKC hypothesis and covering an extended time period. Bulut et al. (2021) demonstrated that the PHH and EKC hypotheses are valid in Türkiye and, therefore, that electricity production from RES has negative effects on environmental quality in Türkiye. Another study conducted for Türkiye also found evidence supporting the validity of the PHH and the EKC (Gökmenoğlu and Taşpınar, 2016). Similarly, Wencong et al. (2023), showing that FDI has a positive relationship with renewable energy in other transition economies, argue that this points to the existence of the PHH in transition economies. Arain et al. (2020), in their study examining the relationship between FDI inflows and income growth, CO2 emissions, and REC in the Chinese economy, found that FDI inflows lead to environmental degradation.

Grabara et al. (2021), examining the relationship between FDI and renewable energy in Kazakhstan and Uzbekistan during 1992–2018, found that FDI negatively affects renewable energy use. The reason is that non-RES still serve as the primary investment inputs in these countries. Türköz (2023) concluded that FDI inflows to Türkiye have increased the consumption of carbon-based fossil fuels rather than clean energy use.

Li et al. (2022), studying 77 developing countries, argue that FDI contributes to these countries' sustainable development by introducing emission-reducing technologies and industrial restructuring. Investment in renewable energy serves as an important transmission channel here. Soto (2024)'s study on Latin American countries demonstrates that FDI positively and significantly promotes REC.

3. Renewable Energy Policies in Turkic Republics

Azerbaijan

Azerbaijan has significant potential in wind and solar energy resources, as well as biomass, geothermal, and hydroelectric power. This highlights the high potential of renewable energy. The State Oil Company of the Azerbaijan Republic (SOCAR), which is entirely state-owned, occupies a central role in the country’s energy sector. SOCAR primarily focuses on conventional energy sources based on fossil fuels (International Renewable Energy Agency, 2019).

To stimulate electricity production from renewable sources and improve the efficient utilization of hydrocarbon resources, Azerbaijan launched a program on the alternative energy sources in 2004 (COMCEC, 2021). In addition, the “Azerbaijan 2020: Vision for the Future” document, adopted in 2012, emphasized the importance of climate change and addressed its potential socio-economic impacts. The document also stated that by 2020, CO2 levels should comply with the standard set by OECD countries to expand the use of renewable energy (Alizada, 2022). This document is one of the policy instruments introduced to encourage FDI toward sustainable development.

Since 2005, with the opening of the Baku-Tbilisi-Ceyhan and Baku-Tbilisi-Erzurum oil and natural gas pipelines, value-added, oil production, and oil exports in the Azerbaijani economy have increased significantly (Suleymanov and Aliyev, 2015). Oil continues to provide the the most significant contribution to Azerbaijan’s economy.[5]

Within the framework of the Development of Alternative and RES, the strategy on using alternative and renewable energy resources in the Republic of Azerbaijan for 2012–2020 included targets. These targets aimed to achieve a 20% reduction in greenhouse gas emissions relative to 1990 levels, raise the share of renewables in total EC to 20%, and enhance energy efficiency by the same proportion by the year 2020 (International Renewable Energy Agency, 2019). In addition, for the period 2015-2020, a draft State Strategy on the Use of Alternative and RES was prepared by ABEMDA and submitted to the Presidential Administration. The main objective of this draft was to ensure electricity and heat generation, energy efficiency, and a sustainable energy supply to consumers through the widespread use of alternative and RES (Amir and Mehman, 2018).

According to World Bank statistics, the Azerbaijani economy experienced stagnation in 2016 and 2020, with contractions of -3.1% and -4.3%, respectively. This situation highlights the importance of utilizing Azerbaijan’s potential renewable energy resources for sustainable development. However, the strong dominance of the oil industry in the economy makes the transition to renewable energy more difficult for Azerbaijan, whose economy is heavily dependent on fossil fuels (Vidadili et al., 2017). Although projects aimed at the use of renewable energy resources continue to be implemented in the country (International Renewable Energy Agency, 2019), considering the scale of existing energy resources and the country’s long-term goals, the distribution of these energy sources remains limited (Table 1). Moreover, between 2019 and 2023, no increase has been observed in the share of renewable energy supply within total EC.

Table 1

Renewable Energy Supply (Thousand Average Conversion Rate of Ton Oil Equivalent)

	2019	2020	2021	2022	2023
Energy supply	17,085.6	16,642.8	17,566.6	18,655.4	18,850.2
Renewable energy supply	263.4	212.7	225.1	245.9	261.2
Hydropower	134.6	92.0	109.8	137.2	151.6
Biomass and waste	115.9	108.4	102.6	96.1	97.9
Wind power	9.1	8.3	7.9	7.2	4.8
Solar power	3.8	4.0	4.8	5.2	6.9

[5] In 2023, petroleum products accounted for 92% of Azerbaijan’s total exports. The country’s largest trading partner in exports is Russia (Baku Research Institute).

Share of renewable energy supply in EC (%)	1.6	1.3	1.3	1.3	1.4

Source: The State Statistical Committee of the Republic of Azerbaijan, Statistical Yearbook.

Within the scope of achieving its climate targets, Azerbaijan has presented low-carbon development as a solution and committed to reducing its greenhouse gas emissions by 35% by 2030 (International Renewable Energy Agency, 2019).

Kazakhstan

Kazakhstan's energy sector, based on coal, gas, and oil resources, was developed during the Soviet Union period. Following independence, the economic crises in the country reduced the efficiency of investments in the energy sector and restricted financial opportunities (Karatayev and Clarke, 2016). Although the country's growth rates declined significantly during the 2008 Global Crisis (from 8.9% in 2007 to 3.2% in 2008 and 1.2% in 2009), capital inflows into the country continued (Narin and Marşap, 2010). A significant factor behind the persistence of foreign capital inflows even during crisis periods was the country's abundant energy resources.

Like Azerbaijan, the Kazakh economy is also heavily dependent on oil exports. It ranks as the world's eleventh-largest oil producer and possesses its second-largest proven oil reserves (IMF). However, to ensure productive investments in the economy, it has become increasingly important for the country to move away from the oil industry and adopt environmentally friendly hydrogen production methods (Saqlain, 2023), thereby taking measures toward a transition to green energy. In this direction, after ratifying the Kyoto Protocol, Kazakhstan set targets to shift electricity generation toward renewable sources (Karatayev and Clarke, 2016).

In 2016, the Paris Agreement was signed, and commitments were made to develop a "Green Economy" and renewable energy (Dzwigol et al., 2023). It aims to ensure that renewable energy will account for 30% of electricity production by 2030 and 50% by 2050. Among the Central Asian countries, Kazakhstan has the highest CO2 intensity. As of 2024, the global average CO2/GDP ratio was 0.26%, while in Kazakhstan it reached 0.45%. Approximately 50% of the country's energy sector relies on fossil fuels, particularly coal (Table 2). Meanwhile, renewable energy supply remains very low within the national economy (UNECE, 2024).

Table 2

Related Indicators for Kazakhstan Renewable Energy Supply (Tones of Total Energy Supply)

	2019	2020	2021	2022	2023
Renewable energy supply	1,058,849	1,099,161	1,119,917	1,198,209	1,244,632
Share of renewable energy supply in EC (%)	1.9	1.8	2.0	-	-
Primary energy supply (million tones of oil equivalent)	2,875	2,649	2,960	2,949	2,981
Share of REC in total EC(%)	11.73	9.65	12.75	13.29	-

Source: CEIC Data

Kazakhstan's energy supply indicators show that EC in the country has increased yearly. Since 2019, the level of energy supply has been on the rise. In 2023, renewable energy contributed 5.92% to Kazakhstan's total electricity production, surpassing the planned target of 5% (Abazov et. al., 2025). This progress indicates growth in the country's renewable energy resources. Compared with Azerbaijan, Kazakhstan has demonstrated a more successful performance in advancing its renewable energy targets. While RES accounted for approximately 6% of total electricity generation in Kazakhstan in recent years, they made up only about 1% in Azerbaijan.

According to the Bureau of National Statistics, in 2023, Kazakhstan's most significant share of final EC was oil and petroleum products at 33.5%, followed by coal at 19.4%. Electricity consumption accounted for 15% of total final energy use, while natural gas represented 16.7%.

Kyrgyzstan

Kyrgyzstan, due to its high altitude and mountainous geography, is located within a cold climate zone. Because of these geographical characteristics, the priority in Kyrgyzstan's energy demand is not so much for lighting and cooking, but rather for heating residential areas (Mehta et al., 2022). Residential EC, heat and electricity generation account for more than 70% of the energy sector's greenhouse gas emissions (UNECE, 2024). Therefore, decarbonizing Kyrgyzstan's energy sector is crucial for the country to achieve its carbon emission reduction targets under the Paris Agreement.[6]

Although Kyrgyzstan possesses substantial water and energy resource potential and reserves, it remains an economy significantly dependent on energy imports. Its dependence on imports of natural gas, petroleum products, and, to some extent, coal accounts for more than 50% of total EC (Kasymova et al., 2024). The country has abundant renewable energy resources, being the main sources (IEA 2020a). However, the utilization of these resources in Kyrgyzstan remains very low. Fossil fuels, primarily oil and coal, account for 72% of the country's total energy supply, while the remaining 28% comes from hydropower (UNECE, 2024). Therefore, considering the technological development of the economy and especially the climate change processes, it is essential to further expand hydropower on a larger scale and transition toward renewable energy (Kasymova et al., 2024).

Kyrgyzstan has made the development of renewable energy one of its priority goals. Kyrgyzstan was the first country in Central Asia to implement a renewable energy-based law. With the adoption of The Law on Renewable Energy at the end of 2008, the country's renewable energy sector began to be regulated for the first time from legal, organizational, economic, and financial perspectives. Its main objective is to push the development of renewable energy resources to improve the country's energy structure and diversify its energy sources (Mehta et al., 2022).

The National Energy Program and the Strategy for Fuel and Energy Sector Development (2010-2025) also incorporates core policies for advancing sustainable energy. The law prioritizes the rapid expansion of RES, particularly hydropower (IEA, 2020a). Strategic agreements are being signed with China on various issues, such as exploring, developing, and exporting energy resources, to promote renewable energy in Kyrgyzstan. Some of these are the creation of the Kyrgyzstan-Turkmenistan-China natural gas pipeline, establishing solar power plants, and wind energy projects (Doğan, 2023). However, prioritizing institutional reforms to encourage the FDI environment in Kyrgyzstan, particularly the implementation of simplified investment procedures for green investments, is important (Omurzakov and Pazylova, 2025).

Uzbekistan

Uzbekistan's energy policy is closely linked to its economic and political system. Natural gas is the most important energy source used in Uzbekistan's EC and is considered one of the

[6] Kyrgyzstan ratified the Paris Agreement on climate change in November 2019.

driving forces of the country's economy. Contributing to 20% of the country's tax revenues and 18% of its GDP, the natural gas sector accounts for more than 80% of the country's energy and 85% of its electricity production. In terms of consumption, natural gas is again the most significant source used in EC, accounting for 86%. Natural gas consumption is followed by oil (8%) and coal (5%). Hydroelectric usage in the country is at 1%, and wind, solar, and biofuel usage is negligible (Table 3; IEA 2020b).

Table 3

Renewable Energy Resources of the Republic of Uzbekistan (by Megawatt; MW)

	2019	2020	2021	2022	2023-2030 (Target)
Energy Supply	1,074.1	886.8	1,961.5	2,061.6	14,017.8
Traditional energy	1,050	1,807	1,777	2,259.4	10,910.2
Total RES	24.1	119.8	504.5	542.2	7,387.6
Wind power	-	-	-	100	1,600
Solar power	-	-	300	400	4,300
Hydropower	24.1	119.8	204.5	242.2	1,487.6

Source: National Statistic Committee of the Republic of Uzbekistan, 2023.

Although Uzbekistan possesses substantial wind and solar energy potential, the country has yet to develop any large-scale renewable power plants. According to Painuly (2001), the obstacles hindering the broader deployment of renewable energy technologies in Uzbekistan include market inefficiencies and distortions, economic and financial constraints, institutional and technical limitations, as well as social challenges.

Several measures are being taken to create a legal framework for the development of the country's renewable energy sector in Uzbekistan. Kyrgyzstan enacted renewable energy and PPP laws. Furthermore, plans have been introduced to construct new renewable energy facilities including solar, wind, and hydroelectric power plants with a combined capacity exceeding 8,400 MW, aiming to raise the share of renewables in the nation’s total electricity generation to 25% (EGCO, 2025).

Turkmenistan

Turkmenistan, one of the countries with the largest natural gas reserves in the world, is a country with significant energy potential for both China and European countries (İsmayilov and Budak, 2014). Natural gas production, which forms the basis of the country's heating and electricity needs, is the largest source of income (Nazarov, 2024), and is carried out by Türkmengaz. Turkmenistan's natural gas reserves are 2 trillion cubic meters, while its oil reserves are 400 million tons (TURKTOB, 2024).

Although the energy sector holds significant potential for foreign investors in the country, the level of foreign capital entering the country in this sector is very low (approximately $1.7 billion as of 2024). Oil and natural gas are forefront of foreign capital investments (Nazarov, 2024).

A significant part of Turkmenistan's energy policy is dedicated to RES. Although the country has high potential for RES due to its climate and geographical conditions, there is virtually no market for renewable energy. The sector is in its development phase, and various steps are being taken to increase the use of renewable sources. Progress is being made in the energy sector, focusing on environmentally friendly and sustainable projects. The energy policies implemented aim to ensure energy independence in the economy and increase energy supply security (TEB, 2025). Being less affected by fluctuations in energy prices and reducing dependence on external energy sources are among the priority objectives in renewable energy projects.

The country is implementing a range of initiatives and strategic plans aimed at decreasing reliance on fossil fuels and advancing sustainable energy development. This is because Turkmenistan is among the largest fossil fuel producers. The largest fossil fuel producers of renewable energy are Kazakhstan, Turkmenistan, and Uzbekistan. These countries are net fossil fuel exporters and have the region's highest per capita CO_2 emissions (Eshchanov et al., 2022). Turkmenistan's potential for other types of renewable energy, such as bioenergy, hydroelectric, and geothermal energy, is relatively low.

With its vast potential in traditional fossil fuels and RES, Turkmenistan is undergoing a comprehensive transformation process in line with energy security, export revenue growth, and sustainable development goals. Turkmenistan, which is a major supplier in the global energy market, particularly with its natural gas and oil reserves, plays an important role in regional and global energy supply through international pipelines (TEB, 2025). All of the country's total production from renewable sources comes from hydroelectric energy. Total hydroelectric production was 3GW between 2000 and 2020, and reached 6GW in 2022 (IEA, 2025).

Türkiye

Türkiye is a transcontinental country extending from Anatolia in Western Asia to Thrace in Southeastern Europe. In this regard, Türkiye is strategically positioned as an oil and natural gas transit country. It is a secure geography that is becoming increasingly important among energy-producing and energy-consuming countries in the region (Ediger, 2008). However, Türkiye's economy heavily depends on imports of fossil fuels such as oil and natural gas (93% and 99%, respectively; IEA, 2025).

Three major problems exist in Türkiye's energy system, which are noteworthy. These are: (i) the country's dependence on imported energy sources, (ii) the fact that EC consists of fossil fuels, and (iii) the low energy efficiency in the country compared to other countries (Ediger, 2008). Due to these problems, the government has prioritized energy supply security in the country and has given priority to domestic exploration and expansion of production in order to reduce dependence on fossil fuel imports. In line with this, domestic energy production in Türkiye grew by 59% between 2014 and 2019. A large part of this increase came from renewable sources, which accounted for 54% of total energy production in 2019. Geothermal energy, in particular, accounted for 21% of total energy production in 2019, while coal accounted for 39% of total production. In addition, the share of renewable electricity production reached 44% in 2019 (Erdoğan et al., 2018, IEA, 2025).

For energy supply security, diversifying energy sources and effectively utilizing energy efficiency have been included among the country's fundamental policies and priority objectives. Targets have been established to expand the share of indigenous and renewable energy resources— including wind, solar, hydro, geothermal, biomass, and domestic coal— within the national energy portfolio, along with the implementation of measures required to realize these objectives. It has been indicated that the widespread use of renewable energy in free zones and organized industrial zones would contribute to the green economy and attract FDI in high-tech areas to the region (Republic of Türkiye, Ministry of Foreign Affairs, 2022).

In Türkiye, it is planned to increase solar and wind energy capacity by 10 gigawatts (GW) between 2017 and 2027. The majority of this additional capacity (approximately 70%) is expected to come from renewable sources (IEA, 2025), with the remainder coming from fossil fuels (particularly domestic lignite), nuclear, and hydroelectric energy (Aydın, 2019). In addition, in 2024, 35.2% of electricity production in Türkiye was from coal, 18.9% from natural gas, 21.5% from hydroelectric energy, 10.5% from wind, 7.5% from solar, 3.2% from geothermal energy, and 3.2% from other sources (Republic of Türkiye¸ Ministry of Foreign Affairs, 2022). The development of RES is shown in Table 4.

Table 4

Development of Renewable Energy Resources of Türkiye (MW)

Resource	2015	2016	2017	2018	2019	2020	2021	2022	2023
Hydro	25.868	26.682	27.273	28.291	28.503	30.985	31.493	31.568	31.596
Wind	4.498	5.751	6.516	7.005	7.591	8.832	10.607	11.303	11.643
Solar	310	833	3.421	5.063	5.995	6.667	7.816	9.153	11.120
Geothermal	624	821	1.064	1,283	1.515	1.613	1.676	1.686	1.691
Biomass	345	467	575	739	1.163	1.485	2.035	2.211	2.440
Total	31.645	34.554	38.849	42.381	44.767	49.582	53.627	55.921	58.491

Source: www.tskb.com.tr (TSKB), access date: 28 September 2025

In Türkiye, renewable energy supply shows a steady upward trend. The installed capacity from RES was 31.6 GW in 2015, growing at an average annual rate of 8.1% to reach approximately 58.5 GW by 2023. Furthermore, the share of RES in the total installed capacity increased from 43.3% in 2015 to 55.2% by 2023.

4. Methodology

This study aims to determine the effect of FDI in the Turkic Republics sample on the share of REC in the country's total EC. The data used in the study consists of annual data published in the World Bank Database. Türkiye, Azerbaijan, Kazakhstan, Uzbekistan, Turkmenistan, and Kyrgyzstan, for which continuous data on the variables included in the model were available, formed the study sample. The most recent data published by the World Bank on the variables considered are for 2023. The study period was set as 2000-2023 to create a balanced panel. The empirical findings aim to contribute to the literature, which has limited empirical findings on renewable energy in the Turkic Republics. According to the research question, REC in the Turkic Republics was defined as a function of per capita GDP growth and FDI inflows. In this study, two basic models are established, and their closed and open function forms are expressed by Equations 1 through Equations 4. In this case, the models of the study are ultimately constructed as follows:

Model-1

$$\text{restfec} = f\,(\text{gdppcg, fdini}) \quad (1)$$

$$\text{restfec} = \alpha_{it} + \beta_1 \text{gdppcg} + \beta_2 \text{lnfdini} + \varepsilon_{it} \quad (2)$$

Model-2

$$\text{restfec} = f\,(\text{gdppcg, fdinigdp}) \quad (3)$$

$$\text{restfec} = \alpha_{it} + \beta_1 \text{gdppcg} + \beta_2 \text{fdinigdp} + \varepsilon_{it} \quad (4)$$

The dependent variables in the models are restfec, which shows the renewable energy share of total final EC (%). gdppcg and fdini represents GDP per capita growth and FDI net inflows value (BoP, current US$), respectively in Model 1. Moreover, fdinigdp symbolizes the share of

FDI net flows in GDP (%) in Model 2. All variables except fdini are included in the model as percentages. On the contrary, fdini is used logarithmically in Model 1. In the models, α represents the constant term, i represents the countries, t represents the time dimension, ε represents the error term, and β represents the slope parameter.

Panel data analysis was employed in this study, allowing for the simultaneous evaluation of cross-sectional and time dimensions. Before proceeding to panel data analysis, the stationarity of the series must be tested. A cross-sectional dependence test must first be performed to decide which tests to use for stationarity testing. Cross-sectional dependence refers to the situation where the error terms are correlated across different countries in the panel. In this case, a shock occurring in one country can also affect another. This study uses the Breusch-Pagan (1980) LM Test to test whether the series contains cross-sectional dependence, since t=24 years, n=6 countries, and t>n. The test is based on the sum of the squares of the pairwise correlations between the estimated residuals scaled by the time dimension. It is particularly suitable for small/medium n large t panels. The null hypothesis of the test is that there is no cross-sectional dependence, $\left(\varepsilon_{it}, \varepsilon_{jt}\right) = 0, i \neq j$. The obtained LM statistic asymptotically follows an $X^2_{N(N-1)/2}$ distribution. If the critical values are exceeded or the p-value is less than the 5% significance level, H_0 is rejected, and it is concluded that there is cross section dependence in the panel (Breusch and Pagan, 1980). Second-generation unit root tests should be used for series containing cross-sectional dependence, while first-generation unit root tests should be used for series without.

We used the (Maddala and Wu, 1999) unit root test as a first-generation unit root test and the (Pesaran, 2007) CIPS test (Cross-sectionally Augmented IPS) as a second-generation unit root test in the study. The Fisher-type panel unit root test was applied to examine the stationarity properties of panel data series for variables without cross-sectional dependence (Maddala and Wu, 1999). Using Fisher's combining method, this approach aggregates the p-values of the ADF/PP unit root tests performed separately for each cross-section. Accordingly, the test statistic is defined as $P = -2\sum_{i=1}^{N} \ln(p_i)$ and follows an X^2_{2N} distribution asymptotically. The test's null hypothesis is that there is a unit root in all sections (none are stationary); the alternative hypothesis is that at least one section is stationary. If the critical values are exceeded or the p-value is less than the 5% significance level, H_0 is rejected, and evidence of stationarity in the panel is obtained. The CIPS (Cross-sectionally Augmented IPS) panel unit root test was applied to examine the stationarity properties of panel data series with cross-sectional dependence (Pesaran, 2007). The CIPS approach relies on the cross-sectional mean of the t-statistics obtained from the following CADF regression for each cross-section i:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \gamma_i \hat{y}_{t-1} + \delta_i \Delta\hat{y}_t + \sum_{j=1}^{p_i} \theta_{ij}\, \Delta y_{i,t-j} + \varepsilon_{it}$$

The null hypothesis of the test is that there is a unit root in the panel (H_0: all series are I(1)), while the alternative hypothesis is that at least one series is stationary (H_1: at least one series is I(0)). If the obtained statistic exceeds the critical values or if the p-value is less than the 5% significance level, H_0 is rejected and evidence of stationarity is found for the panel. Since the CIPS test eliminates cross-section dependence by including the panel mean in the model, it is preferred over first-generation LLC/IPS tests in panels where dependence is detected by CD/LM-type tests (Pesaran, 2007).

Panel data estimation with stationary series is performed in two ways: fixed and random effects. The Hausman test determines which model results are valid (Hausman, 1978). The Hausman test tests the difference between a consistent but inefficient fixed effects estimator and an efficient but consistency-dependent random effects estimator. H_0 states that the fixed effects estimator is consistent, while H_1 states that the random effects estimator is consistent. Diagnostic tests are performed to determine whether the basic assumptions of the selected model are valid. The Wald Test is used to determine whether the model contained a heteroscedasticity problem, and the Enhanced Bhargava et al. DW and Baltagi-Wu LBI tests are used to determine whether there is an autocorrelation problem.

The diagnostic test results determined that there was no autocorrelation in either model, but there was a heteroscedasticity problem in the study. Therefore, it was decided that the current model results could not be interpreted and that the model should be estimated again with a robust estimator. In this regard, the robust estimator PCSE (Panel-Corrected Standard Errors) developed by Beck and Katz was used (Beck and Katz, 1995). In this approach, the coefficients are estimated using classical OLS. However, the standard errors are corrected according to the panel structure, considering the variance-covariance structure of the error terms. This keeps the coefficient estimates constant, but makes the significance tests and confidence intervals more reliable.

Data

The study aims to reveal the effect of FDI inflows on REC in the country. Therefore, the variable representing the share of REC in total final EC was used as the dependent variable, while the variable representing net FDI inflows was used as the independent variable. Moreover, the economic growth variable expressed in gross domestic product per capita was added to the model as a control variable. In order to validate the findings, the ratio of net FDI inflows to total gross domestic product was also used as an independent variable in Model 2. Table 5 shows the variables and their explanations used in the models.

Table 5

Variables

Acronyms	Variables	Expected result
restfec	Renewable energy share of total final EC (%)	Dependent Variable
gdppcg	GDP per capita growth (annual %)	(+) or (-)
fdini	Foreign direct investment, net inflows (BoP, current US$)	(+) or (-)
fdinigdp	Foreign direct investment, net inflows (% of GDP)	(+) or (-)

Source: World Bank https://databank.worldbank.org/metadataglossary

5. Findings

The methodology began with examining the descriptive statistics for the variables included in the models. We estimated two models to make the results robust related to the effect of FDI on the share of REC. The first model was estimated using the variable lnfdini, and the second was estimated using fdinigdp. Therefore, the test results are reported for all variables used in models.

Table 6

Descriptive Statistics

	restfec	fdinigdp	gdppcg	lnfdini
Mean	8.335	5.610	4.678	21.123
Median	2.265	3.233	4.261	21.443
Maximum	36.005	55.072	32.997	23.816
Minimum	0.002	-5.677	-9.032	14.674
Std. Dev.	10.454	8.085	5.139	1.773
Skewness	1.115	3.794	1.727	-0.916
Kurtosis	2.780	21.495	11.553	4.071
Jarque-Bera	30.117	2397.903	510.591	27.061
Probability	0.000	0.000	0.000	0.000
Observations	144	144	144	144

There are 144 observations in the panel consisting of 24 years for six countries (Table 6). The share of REC in total final EC (restfec) averages 8.33%. In the sample, per capita gross domestic product growth averages 4.67%, while the ratio of FDI inflows to gross domestic product averages 5.61%. The kurtosis, skewness, and standard deviation values indicate that the series do not follow a normal distribution, and the Jarque-Bera statistics ($p<0.05$) also show that none of the series are normally distributed. Among the assumptions of panel data analysis, the normal distribution of the series is not specified as a strict condition (Wooldridge, 2010). The normal distribution condition is considered an important criterion, especially for the validity of t and F tests in small samples in least squares estimations.

Table 7

Correlation Matrix

	restfec	fdinigdp	gdppcg	lnfdini
restfec	1.000			
fdinigdp	-0.175*	1.000		
gdppcg	-0.189*	0.383*	1.000	
lnfdini	-0.259*	0.207*	0.107	1.000

Note: *** p<0.01, ** p<0.05, * p<0.1

Pearson correlation coefficients between variables below 0.80 indicate no multicollinearity problem. The absence of high correlation between the independent variables included in the model indicates that these independent variables can be used together in the same model. However, a statistically negative relationship is also observed between FDI inflows into the country and REC.

Table 8

Cross-Sectional Dependence Test

Variable	Stat.	d.f	Prob.	Decision
restfec	68.855	15	0.000	Second-Generation
gdppcg	37.058	15	0.001	Second-Generation
fdinigdp	23.984	15	0.065	First-Generation
lnfdini	126.750	15	0.000	Second-Generation

Note: H_0 shows there is no cross-sectional dependency under the null hypothesis. CD ~ N (0,1)

A cross-sectional dependence test was first performed to determine which tests to use in the stationarity test. Cross-sectional dependence means that a shock occurring in one country can also affect another. In this study, since t=24 years, n=6 countries, and t>n, the Breusch-Pagan LM Test was used to test whether the series contained cross-sectional dependence. According to the Breusch-Pagan LM test results, there was no cross-sectional dependence in the fdinigdp variable, and the stationarity test of this series could be performed with first-generation unit root tests. However, it was decided that second-generation unit root tests should be used for the rest of the variables, which contained cross-sectional dependence.

Table 9

Unit Root Test Results

	Level		First Difference		
	Constant	**Constant & Trend**	**Constant**	**Constant & Trend**	**Test**
restfec	-2.043	-3.129	-3.033	-4.905	Pesaran (2007) CIPS test
gdppcg	-2.571	-2.891			
lnfdini	-2.514	-3.461			
fdinigdp	31.079	38.227			Maddala and Wu (1999)
prob.	0.002***	0.000***			

Note: Critical Value at %5 for constant is -2.34, for constant and trend is -2.87.

The first-generation unit root test used in the study is the Maddala and Wu test, and the second-generation unit root test is the Pesaran CIPS test. The probability values were greater than the critical value according to CIPS test results obtained for the restfec, gdppcg, and lnfdini. Therefore, it was found that these variables contain a unit root, so the analysis was repeated by taking their first differences. For the fdinigdp variable, the Maddala and Wu test was used as the first-generation unit root test, and the decision was made as to whether it contained a unit root based on whether the probability value was p<0.05. According to the unit root test results, the other variables were stationary at the level, except for the restfec variable. The restfec series were made stationary by taking the first difference. So, it was included in the model as drstfec.

The Hausman test was used to determine whether the results of the fixed effects or random effects models should be interpreted based on the panel data analysis. The result p<0.10 indicated the fixed effects model. To determine whether the assumptions of the fixed effects model were valid, the Wald Test was used for heteroscedasticity, and the Enhanced Bhargava et al. DW and Baltagi-Wu LBI tests were used for autocorrelation detection. According to the Wald test results, since the probability value was less than 5%, the model contained a heteroscedasticity problem. Since the autocorrelation test results were close to 2, it was determined that the model did not contain autocorrelation (Table 10).

Table 10

Hausman, Heteroskedasticity, Autocorrelation Test Results

	Model 1			Model 2		
Test	**Stat.**	**Prob.**	**Decision**	**Stat.**	**Prob.**	**Decision**
Hausman Test	4.990	0.082*	Fixed Effect	1.720	0.423	Random Effect
Wald Test	3,069.440	0.000***	There is Heteroskedasticity			
Lagrange Multiplier LM Test				286.350	0.000***	There is Heteroskedasticity
Modified Bhargava et.al. DW Test	2.011		There isn't Autocorrelation	1.937		There isn't Autocorrelation
Baltagi-Wu LBI Test	2.059		There isn't Autocorrelation	1.996		There isn't Autocorrelation

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Robust estimators must be used to eliminate the problem of heteroskedasticity in the models. Since the number of periods in the data set exceeds the number of cross-sections, the PSCE estimator was used among the robust estimators. The PCSE estimator accounts for heteroskedasticity and contemporaneous correlation across cross-sections (Beck and Katz, 1995). The results of the robust estimator are presented in Table 11.

Table 11

Panel-Corrected Standard Errors Test Results

VARIABLES	**Model 1**	**Model 2**
gdppcg	0.0503**	0.0525*
	(0.0252)	(0.0302)
lnfdini	-0.341**	
	(0.138)	
fdinigdp		-0.0249*
		(0.0144)
Constant	7.030**	-0.0812
	(3.056)	(0.240)
Observations	138	138
Number of id	6	6

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

According to the results presented in Table 11, a positive and statistically significant relationship was identified between drestfec and gdppcg. A one-percentage-point increase in gdppcg increased drestfec by approximately 0.05 percentage points. A negative and statistically significant relationship was found between drestfec and lnfdini. Since lnfdini is used in logarithmic form, a 1% increase in FDI inflows reduced drestfec by about 0.0034 percentage points. These findings indicate that, in the sample of the Turkic Republics, FDI inflows tend to reduce the share of REC in total energy use, whereas growth in per-capita GDP promotes it.

The effect of FDI on REC, the core research question of the study, was re-estimated in Model 2, where the ratio of net FDI inflows to GDP (fdinigdp) was employed as an alternative indicator of FDI. The results of Model 2 support those of Model 1. According to Model 2, there is again a positive and statistically significant relationship between drestfec and gdppcg. A one-percentage-point increase in gdppcg raised drestfec by around 0.05 percentage points. A negative and statistically significant relationship was found between drestfec and fdinigdp. Specifically, a one-percentage-point increase in fdinigdp decreased drestfec by about 0.025 percentage points. In summary, as the share of FDI in GDP increases, the share of REC in total EC declines, suggesting that FDI inflows in the Turkic Republics are still directed toward non-renewable sectors.

6. Conclusion

This study examines the impact of FDI inflows on the share of REC in total EC in six Turkic Republics from 2000 to 2023. Panel data analysis results show a negative and statistically significant relationship between FDI inflows and REC, while per capita income growth increases REC. These findings reveal that energy-intensive and fossil fuel-based investments are still dominant in these countries.

Overall, these results indicate that economic growth promotes renewable energy adoption within the scope of the countries examined. However, FDI inflows (in levels, logged) reduce renewable energy share, implying that FDI have been targeted at traditional or carbon-intensive sectors. What emerges from the results reported here is that FDI's quality and sectoral composition are at least as critical as its volume. When compared with the literature, the findings of this study are consistent with those of Marton and Hagert (2017) and Grabara et al. (2021), which point to the negative impact of FDI on renewable energy use. Furthermore, the findings are also consistent with those of Türköz (2023) and Bulut et al. (2021). In contrast, these findings do not align with studies such as Doytch and Narayan (2016), Khandker et. al. (2018), and Soto (2024), which argue that FDI promotes REC. This discrepancy can be explained by regional differences, the fossil fuel-heavy nature of the energy portfolio, and the limited level of technology diffusion.

The increase in FDI inflows to the Turkic Republics, classified as developing countries, has reduced the share of REC in total EC. These results also suggest that the PHH holds rather than PHEH for Turkic Republics. To overcome this problem, it is necessary to implement policies such as creating regulatory frameworks that facilitate investors' orientation towards renewable energy projects, providing tax breaks, customs exemptions, green bonds, and low-interest loans for FDI in renewable energy. Governments should prioritize clean technology and energy efficiency projects with these policy instruments. Given the global attention on sustainable development, countries prioritizing RES and directing a significant portion of their FDI toward RES reflect their vision for sustainable development goals. Meanwhile, environmental screening mechanisms are vital to attract environmentally friendly FDI. The relationship between the existence of environmental screening mechanisms and environmentally friendly FDI is another research question, and it awaits researchers' interest.

References

- Abazov, R., Zhuparova, A., Molchanovskaya, A., & Yeleussizova, B. (2025). Kazakhstan: Challenges and Strategies Towards Green Transformation and Sustainable development, Project Paper No. 21
- Alizada, N. (2022). Karabakh's Green Energy Potential." *Journal of Eurasian Inquiries* 11.1 1-15.
- Amir, A. A. & Mehman, N. A. (2021). Plannig Activities and Strategy for the use of Alternative and Renewable Energy Sources in Azerbaijan, *Euroasia Journal of Social Sciences & Humanities*, 8.18: 33-38.
- Arain, H., Sharif, A., Shahbaz, M., & Kakar, Z. K. (2020). Dynamic connection between inward foreign direct investment, renewable energy, economic growth and carbon emission in China: Evidence from partial and multiple wavelet coherence. *Environmental Science and Pollution Research*, 27, 40456–40474.
- Aydın, C. İ. (2019). Identifying ecological distribution conflicts around the inter-regional flow of energy in Türkiye: A mapping exercise. Frontiers in Energy Research, 7, 33
- Baku Research Institute. Oil as a Perpetuum Mobile of Azerbaijan, Access date: 21 April 2023. https://bakuresearchinstitute.org/en/oil-as-a-perpetuum-mobile-of-azerbaijan/
- Beck, N., & Katz, J. N. (1995). What to do (and not to do) with time-series cross-section data. *American Political Science Review, 89*(3), 634–647.
- Breusch, T. S., & Pagan, A. R. (1980). The Lagrange multiplier test and its applications to model specification in econometrics. *The Review of Economic Studies, 47*(1), 239–253.
- Bulut, Ü., Uçler, G., & Inglesi-Lotz, R. (2021). Does the pollution haven hypothesis prevail in Turkey? Empirical evidence from nonlinear smooth transition models. *Environmental Science and Pollution Research*, 28, 38563–38572.
- Bureau of National Statistics, Access date: 12 June 2025, https://stat.gov.kz/en/industries/business-statistics/stat-energy/.
- Caetano, R. V., Natali, M., & Silva, F. (2022). A sectoral analysis of the role of foreign direct investment in pollution and energy transition in OECD countries. *Journal of Environmental Management*, 302, 114018.
- CEIC data. Access date: 05 June 2025, https://www.ceicdata.com/en/kazakhstan/environmental-energy-production-and-consumption-non-oecd-member-annual/renewable-energy-supply-tonnes-of-total-energy-supply.
- Cole, M. A. (2004). Trade, the pollution haven hypothesis and the environmental Kuznets curve: Examining the linkages. *Ecological Economics*, 48(1), 71–81.
- Cole, M. A., & Elliott, R. J. R. (2005). FDI and the capital intensity of "dirty" sectors: A missing piece of the pollution haven puzzle. *Review of Development Economics*, 9(4), 530–548.
- COMCEC (2021), Standing Committee for Economic and Commercial Cooperation of the Organization of the Islamic Cooperation. www.comcec.org/wp-content/uploads/2021/07/2_azerbaija-n.pdf Access date: 09.06.2025

- Cusup, P., Ravanoğlu, G. A., & Sulaymanova, B. (2020). Effects of energy on economic growth: ARDL bounds testing for Kyrgyzstan. *Reforma*, 87(3), 48–63.
- Doğan, B. (2023). Investigation of energy collaborations within the scope of the modern Silk Road, with a focus on Kyrgyzstan–China relations. *Sakarya University Turkish Academic Journal, 2*(2), 116–125.
- Doytch, N., & Narayan, S. (2016). Does FDI influence renewable energy consumption? An analysis of sectoral FDI impact on renewable and non-renewable industrial energy consumption. *Energy Economics, 54*, 291–301.
- Dzwigol, H., Dzwigol-Barosz, M., Kwilinski, A., & Miskiewicz, R. (2023). The role of environmental regulations, renewable energy, and energy efficiency in finding the path to green economic growth. *Energies, 16*(7), 3090.
- Ediger, V. Ş. (2008). National energy report of Turkey: Energy situation, challenges, and policies for sustainable development. In *AASA Beijing Workshop on Sustainable Energy Development in Asia*, 17–18.
- EGCO, The Electricity Generating Public Company Limited, https://www.egco.com/en/business/power-business, access date: 10.11.2025
- Energy Institute. (2024). Statistical Review of World Energy", 73. Edition, access date: 28 April 2024,https://www.energyinst.org/__data/assets/pdf_file/0006/1542714/684_EI_Stat_Review_V16_DIGITAL.pdf.
- Erdoğan, S., Gedikli, A., & Genç, S. Y. (2018). An overview of Turkey's national energy policies. *Politico-Economic Evaluation of Current Issues*, 143.
- Eshchanov, B., Abdurakhmanov, K., & Omuraliev, N. (2022). *Renewable energy policies of the Central Asian countries.* Oslo: Norwegian Institute of International Affairs (NUPI).
- Fang, X., Yang, Z., Zhang, Y., & Miao, X. (2024). Foreign direct investment and the structural transition of energy consumption: Impact and mechanisms. *Humanities and Social Sciences Communications, 11*(1), 1–13.
- Ferrier, G. D., Reyes, J., & Zhu, Z. (2016). Technology diffusion on the international trade network. *Journal of Public Economic Theory, 18*(2), 291–312.
- Gökmenoğlu, K., & Taspinar, N. (2016). The relationship between CO_2 emissions, energy consumption, economic growth and FDI: The case of Turkey. *The Journal of International Trade & Economic Development, 25*(5), 706–723.
- Grabara, J., Dabylova, M., & Sarsenova, A. (2021). Empirical research on the relationship amongst renewable energy consumption, economic growth and foreign direct investment in Kazakhstan and Uzbekistan. *Energies, 14*(2), 332.
- Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica, 46*(6), 1251–1271.
- Industrial and Development Bank of Turkey (TSKB). Energy Outlook 2023. Access date: 28 September 2025, www.tskb.com.tr
- International Energy Agency, IEA. Kyrgyzstan Energy Profile: Sustainable Development. 2020a, Access date: 20 March 2025, https://www.iea.org/reports/kyrgyzstan-energy-profile.

- International Energy Agency, IEA. Uzbekistan energy profile. International Energy Agency. 2020b, Access date: 18 June 2025. https://www.iea.org/reports/uzbekistan-energy-profile
- International Energy Agency, IEA. Turkey, Energy Policy Review. 2021, Access date: 04 August 2025, https://www.iea.org/reports/turkey-2021
- International Energy Agency, IEA. World Energy Outlook 2023, Access date: 24 September 2025.https://iea.blob.core.windows.net/assets/86ede39e-4436-42d7-ba2a-edf61467e070/WorldEnergyOutlook2023.pdf.
- International Monetary Fund, IMF. World Economic Outlook Database.”2018, Access date: 24 March 2025. https://www.imf.org/en/Publications/SPROLLS/world-economic-outlook-databases#sort=%40imfdate%20descending
- International Renewable Energy Agency (2012). Technology Needs Assessment for Climate Change Mitigation and Adaption, access date: 18 July 2025. https://tech-action.unepccc.org/wp-content/uploads/sites/2/2013/12/technologyneedsassessment-mitigation-azerbaijan-13.pdf
- International Renewable Energy Agency. (2019). Access date:18 July 2025. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Dec/IRENA_RRA_Azerbaijan_2019.PDF
- İsmayılov, E., & Budak, T. (2014). Turkmenistan’s energy policy in the post-independence period. *Bilge Strategy, 6*(11), 29–49.
- Javorcik, B. S., & Wei, S.-J. (2003). Pollution havens and foreign direct investment: Dirty secret or popular myth? *Contributions to Economic Analysis & Policy, 3*(2).
- Kang, X., Khan, M. I., Ullah, R., & Khan, A. (2021). Does foreign direct investment influence renewable energy consumption? Empirical evidence from South Asian countries. *Energies, 14*(12), 3470.
- Karatayev, M., & Clarke, M. L. (2016). A review of current energy systems and green energy potential in Kazakhstan. *Renewable and Sustainable Energy Reviews, 55*, 491–504.
- Kasymova, V., & Arkhangelskaya, A. (2024). Development of renewable energy sources in the Kyrgyz Republic: Current status, problems and prospects. *Reforma, 99*, 12–22.
- Khandker, L. L., Amin, S. B., & Khan, F. (2018). Renewable energy consumption and foreign direct investment: Reports from Bangladesh. *Journal of Accounting, 8*(3), 72–87.
- Lee, J. W. (2013). The contribution of foreign direct investment to clean energy use, carbon emissions and economic growth. *Energy Policy, 55*, 483–489.
- Lee, H., Lee, J., & Kim, H.-H. (2011). *Foreign direct investment, technology diffusion, and host country productivity growth* (ADB Economics Working Paper Series No. 272). Manila: Asian Development Bank.
- Li, F., Zhang, J., & Li, X. (2022). Research on supporting developing countries to achieve green development transition: Based on the perspective of renewable energy and foreign direct investment. *Journal of Cleaner Production, 372*, 133726.
- Li, X., & Liu, X. (2005). Foreign direct investment and economic growth: An increasingly endogenous relationship. *World Development, 33*(3), 393–407.

- Liu, W., Tang, Z., & Chen, J. (2016). Impacts of FDI renewable energy technology spillover on China's energy industry performance. *Sustainability, 8*(9), 846.
- Mabey, N. & R. McNally - Lyuba Zarsky. *Foreign Direct Investment and the environment: from pollution havens to sustainable development. WWF-UK,* 2003-07. https://awsassets.panda.org/downloads/pollutionhavens2ndeditionfinal.pdf.
- Maddala, G. S., and Wu, S. (1999). A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and Statistics, 61*(S1), 631–652.
- Marton, C., & Hagert, M. (2017). *The effects of FDI on renewable energy consumption* (Bachelor's thesis). Lund University, Lund, Sweden.
- Mehta, K., Aitzhanova, A., Sadykova, A., & Kydyraliev, A. (2022). Comprehensive analysis of the energy legislative framework of Kyrgyzstan: Investigation to develop a roadmap of Kyrgyz renewable energy sector. *Cleaner Energy Systems, 2*, 100013
- Mielnik, O., & Goldemberg, J. (2002). Foreign direct investment and decoupling between energy and gross domestic product in developing countries. *Energy Policy, 30*(2), 87–89.
- Miyamoto, M., & Takeuchi, K. (2019). Climate agreement and technology diffusion: Impact of the Kyoto Protocol on international patent applications for renewable energy technologies. *Energy Policy*, *129*, 1331–1338.
- Musah, M., Mensah, I. A., Alfred, M., Mahmood, H., Murshed, M., Omari-Sasu, A. Y., Boateng, F., Nyeadi, J. D., & Coffie, C. P. K. (2022). Reinvestigating the pollution haven hypothesis: The nexus between foreign direct investment and environmental quality in G-20 countries. *Environmental Science and Pollution Research, 29*(21), 31330–31347.
- Narin, M., & Marşap, A. (2010). The economies of the Turkic republics after the global crisis and their trade relations with Turkey. In *Proceedings of the International Conference on Eurasian Economies* (pp. 4–5). İstanbul, Türkiye.
- National Statistic Committee of the Republic of Uzbekistan (2024). Energy efficiency and fuel balance, access date: 18 March 2025, https://stat.uz/en/official-statistics/energy-efficiency-and-fuel-balance
- Nazarov, S. (2024). Latent renewable energy in Turkmenistan. *Smart Green Energy Production, 11*, 57.
- Omurzakov, S. A., & Pazylova, A. S. (2025). Foreign direct investment in Central Asia: Kyrgyzstan's experience. *International Journal of Humanities and Natural Sciences, 3*(2), 250–256.
- Özbektaş, S., Şenel, M. C., & Sungur, B. (2023). Renewable energy status and installation costs in the world and Turkey. *Engineer and Machinery*, *64*(711), 317–351.
- Painuly, J. P. (2001). Barriers to renewable energy penetration: A framework for analysis. *Renewable Energy, 24*(1), 73–89.
- Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics, 22*(2), 265–312.
- Przychodzen, W., & Przychodzen, J. (2020). Determinants of renewable energy production in transition economies: A panel data approach. *Energy, 191*, 116583

- Republic of Türkiye, Ministry of Foreign Affairs. (2022). Economic Relations between Türkiye and Azerbaijan 2022. Access date: 26 September 2025. https://www.mfa.gov.tr/economic-relations-between-turkey-and-azerbaijan.en.mfa
- Republic of Türkiye Ministry of Energy and Natural Resources (2025). Energy. access date: 23 April 2025, www.enerji.gov.tr.
- Sadorsky, P. (2010). The impact of financial development on energy consumption in emerging economies. *Energy Policy, 38*(5), 2528–2535.
- Saqlain, M. (2023). Sustainable hydrogen production: A decision-making approach using VIKOR and intuitionistic hypersoft sets. *Journal of Intelligent Management Decision, 2*(3), 130–138.
- Shahzad, U., Hussain, M., Qin, F., & Amir, M. (2018). Reinvestigating the role of coal consumption in Indian economy: An ARDL and causality analysis. *European Online Journal of Natural and Social Sciences, 7*(2), 348–357.
- Shin, H., Ellinger, A. E., Nolan, H. H., DeCoster, T. D., & Lane, F. (2018). An assessment of the association between renewable energy utilization and firm financial performance. *Journal of Business Ethics, 151*(4), 1121–1138.
- Soto, G. H. (2024). The role of foreign direct investment and green technologies in facilitating the transition toward green economies in Latin America. *Energy, 288*, 129933.
- Suleymanov, E., & Aliyev, K. (2015). Macroeconomic analysis and graphical interpretation of Azerbaijan economy in 1991–2012. *Expert Journal of Economics, 3*(1), 26–40.
- Suri, V., & Chapman, D. (1998). Economic growth, trade and energy: Implications for the environmental Kuznets curve. *Ecological Economics, 25*(2), 195–208.
- The State Committee of the Republic of Uzbekistan on Statistics. (2020) Sustainable Development Goals. Access date: 22 April 2025. Statistical indicators of achievement of national SDGs in the Republic of Uzbekistan. https://nsdg.stat.uz/en/publications/19.
- The State Statistical Committee of the Republic of Kazakhstan. (2023). Fuel and energy balance of the Republic of Kazakhstan Access date: 25 June 2025, https://stat.gov.kz/en/industries/business-statistics/stat
- The State Statistical Committee of the Republic of Azerbaijan. (2024). Energy of Azerbaijan, Statistical yearbook, www.stat.gov.az, access date: 27.08.2025
- Turkish Energy Association, TEB. (2025). Turkish Energy Union Report 2025. Electrical Engineers Association 10 June 2025, https://www.emo.org.tr/genel/bizden_detay.php?kod=148562&tipi=2&sube=, Access date: 10.11.2025
- Turkish Seed Union (TÜRKTOB, (2024). Turkmenistan Country Report 2024. Access date: 26 August 2025. http://www.turktob.org.tr
- Türköz, K. (2023). Effects of foreign direct investments on renewable and fossil energy consumption: Hidden cointegration analysis findings for Turkey. *Journal of Yasar University, 18*(69), 1–18.
- Vidadili, N., Suleymanov, E., Bulut, C., & Mahmudlu, C. (2017). Transition to renewable energy and sustainable energy development in Azerbaijan. *Renewable and Sustainable Energy Reviews, 80*, 1153–1161.

- Wall, R., Grafakos, S., Gianoli, A., & Stavropoulos, S. (2019). Which policy instruments attract foreign direct investments in renewable energy? *Climate Policy, 19*(1), 59–72.
- Wang, Z., Bui, Q., Zhang, B., & Pham, T. (2020). Biomass energy production and its impacts on the ecological footprint: An investigation of the G7 countries. *Science of the Total Environment, 743*, 140741.
- Wei, X., Mohsin, M., & Zhang, Q. (2022). Role of foreign direct investment and economic growth in renewable energy development. *Renewable Energy, 192,* 828–837.
- Lu, W., Kasımov, I., & Saydaliev, H. B. (2023). Foreign direct investment and renewable energy: Examining the environmental Kuznets curve in resource-rich transition economies. *Renewable Energy, 208,* 301–310.
- Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data* (2nd ed.). MIT Press.
- World Bank Group (2017). Global Investment Competitiveness Report 2017/2018: Foreign Investor Perspectives and Policy Implications. Washington, DC: World Bank. Access date: 20 January 2025. https://documents1.worldbank.org/
- World Bank Group Data. (2023). Tracking SDG 7: The Energy Progress Report 2023. Access date: 27 February 2025. https://data.worldbank.org/indicator/EG.FEC.RNEW.ZS.
- United Nations Climate Change, UNCC. “What is the Kyoto Protocol?” Access date: 12 April 2025, https://unfccc.int/kyoto_protocol.
- United Nations Economic Commission for Europe, UNECE. (2024). Energy Policy Brief: Kazakhstan. Accees date: 11.03.2025, http://efaidnbmnnnibpcajpcglclefindmkaj/https://unece.org/sites/default/files/2024-09/kazakhstans-policy-brief%20%287%29.pdf.
- Zakhidov, R. A. (2008). Central Asian countries energy system and role of renewable energy sources. *Applied Solar Energy, 44*(3), 218–223.