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Article

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Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Parmová, Dagmar Skodova/Teshabaev, Tulkin et. al. (2024). Mitigating CO2 emissions : the synergy of foreign direct investment and renewable energy in Europe and Central Asia. In: International Journal of Energy Economics and Policy 14 (1), S. 620 - 627. https://www.econjournals.com/index.php/ijeep/article/download/15334/7715/35755. doi:10.32479/ijeep.15334.

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2024, 14(1), 620-627.

Mitigating CO_2 Emissions: The Synergy of Foreign Direct Investment and Renewable Energy in Europe and Central Asia

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Received: 30 September 2023 **Accepted:** 30 December 2023 **DOI:** https://doi.org/10.32479/ijeep.15334

ABSTRACT

This study investigates the impact of renewable energy and Foreign Direct Investment (FDI) on CO_2 emissions across 45 countries in Europe and Central Asia for the period of 2000-2019. Utilizing the two-step system generalized method of moments (GMM) estimator; our findings reveal that both FDI and renewable energy play pivotal roles in mitigating CO_2 emissions. Notably, countries with higher levels of renewable energy integration experience a stronger reduction in CO_2 emissions due to FDI. Furthermore, our analysis uncovers an inverted U-shaped relationship between GDP per capita and CO_2 emissions, indicating a nuanced trajectory of environmental impact with economic growth. Additionally, our study identifies an inverse correlation between CO_2 emissions and the agriculture sector as well as government size. The implications of these findings are discussed in the context of policy strategies, providing valuable insights for sustainable development in the Europe and Central Asia region.

Keywords: Renewable Energy, CO_2 Emissions, Foreign Direct Investment, Europe and Central Asia
JEL Classification: O13

1. INTRODUCTION

In the contemporary landscape, the escalating specter of global environmental degradation stands as an alarming testament to the urgent need for comprehensive action. Among the growing number of factors contributing to this crisis, carbon dioxide (CO_2) emissions have emerged as a focal point of concern. The pivotal role of CO_2 emissions in exacerbating climate change, intensifying air pollution, and endangering public health cannot be overstated. Across the globe, policymakers, scientists, and scholars are grappling with the complex task of unraveling the intricate web of drivers behind CO_2 emissions. According to recent reports by reputable environmental agencies, the Earth has witnessed a staggering loss of biodiversity, with a record number of species facing endangerment or extinction due to habitat destruction and pollution. Additionally, air pollution, amplified by CO_2 emissions, has become a silent yet deadly adversary, leading to millions of premature deaths annually. According to Bressler (2021) more than 83 million people may lose life by 2100 due to rise in CO_2 emissions. Against this backdrop, the quest to comprehend the factors underpinning CO_2 emissions has become a pressing imperative (see e.g., Andreoni and Galmarini, 2016; Dong et al., 2020). This urgency stems not only from environmental concerns but also from the profound impact these emissions have on human health, underscoring the critical need for informed policies and sustainable practices to mitigate this crisis.

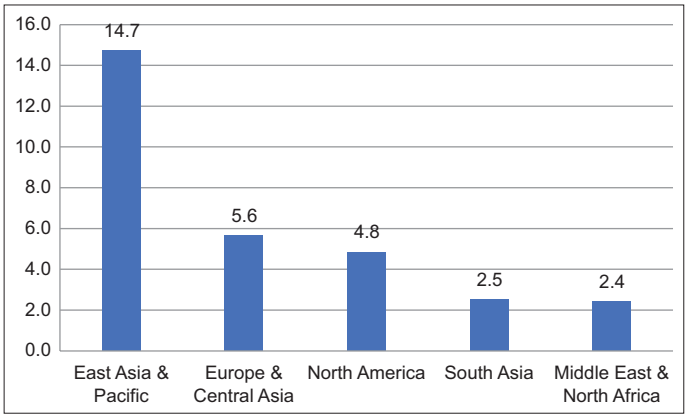
Over the past two decades, the research on the correlates of CO_2 emissions have mushroomed. Related studies have explored the predictors of CO_2 emissions across regions: for example, for

Africa (Maji, 2019), OECD (Iwata et al., 2012), Asia (Parker and Bhatti, 2020), EU (Kasman and Duman, 2015), Latin America (Timilsina and Shrestha, 2009) and Small Island states (Fauzel, 2017). Other studies have assessed the effect of economic variables on CO_2 emissions. In this vein, CO_2 emissions are regressed against trade openness (Hasanov et al., 2018), remittances (Brown et al., 2020), tourism (Shakouri et al., 2017), fiscal policy (Halkos and Paizanos, 2016), energy use and economic growth (Arouri et al., 2012). More recently, another large stream of research have emerged that explore the effect of renewable energy and FDI on CO_2 emissions across countries (Iqbal et al., 2023; Mehmood, 2022; Pata et al., 2023).

In the realm of environmental sustainability and economic development, this study marks a significant contribution as it offers an in-depth exploration into the complex interplay between foreign direct investment (FDI), renewable energy, and CO_2 emissions within the dynamic context of Europe and Central Asia (ECA). What sets this research apart is its exclusive focus on this diverse region, where numerous countries have undergone profound economic transitions and structural reforms, leading to substantial increases in FDI levels (Estrin and Uvalic, 2012). Moreover, according to the data CO_2 emissions produced in the region is above of that in other regions such as North America, Middle East and North Africa, East Asia and others (Figure 1). As a result, this study stands as the pioneering effort to unravel the intricate relationships emerging from these transformative processes, shedding light on the crucial nexus between economic growth, renewable energy integration, and greenhouse gas emissions.

A distinctive feature of this study lies in its novel approach to evaluating the impact of FDI in conjunction with renewable energy on CO_2 emissions in ECA. By delving into the moderating role of renewable energy within the FDI-emissions framework, this research examines a pivotal question: can renewable energy serve as a mitigating force, offsetting the environmental impact of increased FDI? This nuanced perspective not only broadens our understanding of the FDI-CO_2 emissions relationship but also offers unique insights into the potential solutions for mitigating greenhouse gas emissions. Furthermore, this research relies on the use of the two-step system generalized method of moments (GMM) estimator. By employing this empirical methodology, the study effectively tackles the challenges of endogeneity and simultaneity, ensuring the robustness and reliability of the results. Additionally, given the profound economic, political, and cultural ties among the countries in the ECA region, understanding how FDI influences CO_2 emissions becomes paramount. The findings derived from this study not only inform environmental policies at the national level but also hold the potential to shape collective measures aimed at mitigating CO_2 emissions, fostering regional cooperation, and advancing sustainable development agendas. This research thus stands at the forefront of pioneering initiatives, illuminating a path toward a greener, more sustainable future for Europe and Central Asia.

Figure 1: CO_2 emissions, million kt, 2020



2. LITERATURE REVIEW

2.1. Renewable Energy and CO_2 Emissions

The relationship between energy consumption, renewable energy sources, and CO_2 emissions has been a topic of substantial research interest, particularly in the context of climate change mitigation efforts. Earlier studies have explored the relationship between renewable energy and CO_2 emissions for large-N samples (Omri and Nguyen, 2014; Ibrahim and Law, 2014). More recent studies, offer additional evidence for this empirical relationship focusing on regional or single country analysis. Abbasi et al. (2021) conducted a study in Thailand, emphasizing the urgent need for aggressive mitigation strategies to achieve the Nationally Determined Contribution and meet the Paris Agreement targets. The research highlighted that the depletion rate of energy resources significantly impacts CO_2 emissions, necessitating a radical shift in Thailand's energy infrastructure for effective reduction in emissions. Jamil et al. (2022) examined the relationship between CO_2 emissions, renewable energy, and other economic factors in selected G-20 countries. The study revealed a negative association between renewable energy consumption and CO_2 emissions, indicating the potential of renewable energy in reducing environmental pollution. Additionally, the research underlined the importance of wise consumption of remittances and financial development to achieve sustainable environmental goals. Saidi and Omri (2020) explored the impact of both renewable and nuclear energy consumption on CO_2 emissions across 15 OECD countries. Their findings suggested that a combination of nuclear and renewable energy could effectively reduce carbon emissions, emphasizing the complementary nature of these energy sources. The study provided valuable insights into the optimal mix of energy resources for environmental sustainability. Kuldasheva and Salahodjaev (2023) focused on rapidly urbanizing countries and their renewable energy consumption. The study highlighted the role of institutions as mediators in the relationship between renewable energy and CO_2 emissions. This emphasized the importance of supportive policies and governance structures in harnessing the potential of renewable energy for mitigating environmental degradation. Namahoro et al. (2021) addressed the African context, considering regional differences and income levels in their analysis. The study revealed that renewable energy consumption contributed significantly to reducing CO_2 emissions across regions and income levels in Africa. Moreover, the research emphasized the importance of considering energy intensity and economic growth in conjunction with renewable energy efforts to effectively mitigate CO_2 emissions.

Shahnazi and Shabani (2021) delved into the effects of renewable energy, spatial spillover of CO_2 emissions, and economic freedom on CO_2 emissions in the European Union (EU). By utilizing a spatial dynamic panel data model, the study revealed a negative impact of renewable energy consumption on CO_2 emissions, underlining the potential of renewables in environmental conservation. Additionally, it highlighted the existence of spatial dependence, emphasizing the need for collaborative efforts among neighboring countries to mitigate emissions effectively. Mert et al. (2019) explored the interrelationships among FDIs, renewable energy, CO_2 emissions, and environmental regulations in European countries. Their study confirmed the validity of the Environmental Kuznets Curve (EKC) hypothesis and the Pollution Haven Hypothesis (PHH) in different EU country groups. Notably, renewable energy consumption was found to mitigate CO_2 emissions, emphasizing the importance of green technology and energy efficiency for sustainable development. The research also advocated for stricter environmental regulations concerning FDI inflows, aligning with the European Commission's evolving policies. Sharif et al. (2021) provided a nuanced analysis of the relationship between disaggregated renewable energy sources and CO_2 emissions in the USA. Their research, employing quantile regressions, demonstrated the effectiveness of various renewable sources in reducing CO_2 emissions across different quantiles. The study highlighted the significance of understanding the relative importance of each renewable energy type, suggesting tailored policies to maximize the impact of renewable energy initiatives. Pata (2021) focused on the BRIC countries, analyzing the intricate connections between renewable energy generation, globalization, agriculture, CO_2 emissions, and ecological footprint. The findings emphasized the vital role of renewable energy in reducing environmental pressure in Brazil and China. However, the study also highlighted the need for differentiated renewable energy policies, as renewables did not uniformly affect environmental indicators across all BRIC nations. These results underscored the importance of tailored approaches to sustainable energy development based on specific country contexts.

Aslan et al. (2022) investigate the intricate relationships among economic growth, CO_2 emissions, fossil fuels consumption, renewable energy consumption, FDIs, and trade, distinguishing between countries with and without oil reserves. Utilizing Panel Vector Autoregression (PVAR) and Granger causality methods for the period of 1990–2015, the research dissects the dynamics within oil-exporting and oil-importing nations. Surprisingly, the study reveals that economic growth positively impacts CO_2 emissions in both groups. Notably, in oil-importing countries, a negative relationship exists between CO_2 emissions and FDIs, while in oil-exporting nations, CO_2 emissions are positively linked to trade. The findings underscore a challenging dilemma: countries, regardless of their oil status, tend to sacrifice their national income to mitigate carbon emissions, making global emission reduction efforts complex. Variance decomposition analysis highlights that CO_2 emissions define themselves as 98% for oil-importing countries, with GDP being the second most significant contributor to air pollution. Moreover, FDIs, renewable energy, and fossil fuel consumption collectively influence air pollution by 4% over a decade. These revelations provide crucial insights into the complex interplay between economic factors and environmental sustainability, offering valuable implications for policy formulation and global emission reduction strategies. Jebli et al. (2020) explored the relationship between CO_2 emissions, economic growth, renewable energy consumption, and value-added activities in countries with different income levels. Their research showcased the negative impact of renewable energy consumption on CO_2 emissions in most income categories, indicating the potential of renewables in mitigating environmental pollution. The study also revealed nuanced effects on industrial and service value-added sectors, highlighting the multifaceted impact of renewable energy on economic activities.

2.2. FDI and CO_2 Emissions

In a similar vein, empirical research on the nexus between FDI and CO_2 emissions have proliferated over the past decade (Shaari et al., 2014; Akin et al., 2014). For example, Haug and Ucal (2019) explored the nonlinear relationships between foreign trade, FDI, and CO_2 emissions in Turkey. Their study revealed significant asymmetric effects of exports, imports, and FDI on CO_2 emissions per capita. The results indicated that FDI had no statistically significant long-run effects. Importantly, they identified an environmental Kuznets curve, suggesting that increases in real GDP per capita led to CO_2 emissions reductions, albeit with nonlinear patterns. Essandoh et al. (2020) delved into the intricate relationship between international trade, FDI, and CO_2 emissions across 52 countries. Their research highlighted the nuanced differences between developed and developing nations. While developed countries exhibited a negative long-run relationship between CO_2 emissions and trade, developing nations showcased a positive long-run association with FDI inflows. This emphasized the complexity of emissions redistribution in the global economy due to trade and FDI.

In their study, Öztürk and Damla (2016) investigated the relationship between energy consumption, income, FDI inflows, and CO_2 emissions in Turkey. Utilizing the cointegration method and Granger causality analysis for the period 1974–2011, the study found a long-term relationship among the variables. Supporting the Environmental Kuznets Curve hypothesis, the research indicated an inverted U-shaped relationship between income and CO_2 emissions. The pollution halo hypothesis was validated, signifying that FDI inflows have positive effects on the environment, as evidenced by bilateral causality between CO_2 emissions and FDI inflows. Additionally, the Granger causality test revealed a unilateral causality relation from energy consumption to economic growth. This research sheds light on the intricate dynamics between economic growth, FDI, energy consumption, and environmental degradation specific to the Turkish context, offering valuable insights into sustainable development strategies.

Xie et al. (2020) examined the direct and spillover effects of FDI on CO_2 emissions in emerging countries. Using a panel smooth transition regression model, they found that FDI had a dual impact: directly increasing CO_2 concentrations and indirectly decreasing them through economic growth. The study provided valuable insights into the nonlinear and dynamic aspects of FDI's influence on emissions. Khan and Ozturk (2021) address the ambiguous

relationship between financial development and CO_2 emissions in 88 developing countries. Employing the Environmental Kuznets Curve (EKC) framework, the authors examine both the direct and indirect effects of financial development on environmental pollution. Utilizing a robust empirical approach involving difference and system GMM, their analysis spans the period from 2000 to 2014. The study reveals that financial development plays a vital role in curbing pollution, confirming its inhibiting influence across various financial indicators. Moreover, the research validates the presence of the EKC hypothesis in the analyzed economies. Notably, the study demonstrates that financial development mitigates the adverse impact of income, trade openness, and FDI on pollution emissions through indirect channels. Interestingly, the study also explores the Pollution Heaven Hypothesis (PHH) concerning trade openness and FDI, revealing its dependence on the strength of a nation's financial structure. When financial development surpasses certain thresholds, PHH ceases to exist for these variables. Additionally, the study identifies population size as a contributor to pollution emissions while human capital serves as a mitigating factor. These findings yield crucial policy implications, emphasizing the significance of strengthening financial systems to foster sustainable development in the studied economies. Bakhsh et al. (2021) investigated the moderating role of institutional quality and technological innovation on the relationship between FDI and CO_2 emissions in Asian countries. Their study revealed that both institutional quality and technological innovation played crucial roles in mitigating the environmental impact of FDI. The findings emphasized the importance of policy frameworks in shaping the relationship between FDI and CO_2 emissions.

Mahmood (2023) studied the impact of FDI, exports, and imports on emissions in Latin American countries. The research validated the pollution haven hypothesis for exports and imports, suggesting that these activities increased CO_2 emissions. However, the study also highlighted the potential for environmentally positive effects through trade activities, emphasizing the importance of nuanced policy measures in the region.

Shinwari et al. (2022) examined China's foreign investments in Belt and Road Initiative countries. Contrary to other countries' investments, Chinese investments did not worsen CO_2 emissions. This indicated a "halo effect," emphasizing the need for stringent regulations and management policies for foreign investments to ensure positive environmental outcomes.

Kim and Seok (2023) explored the relationship between FDI inflows and CO_2 emissions in South Korea. Their study revealed a complex interplay: FDI initially increased CO_2 emissions, but this effect reversed as economic development progressed. This suggested the applicability of both pollution haven and pollution halo hypotheses, emphasizing the importance of balanced policies as countries transition from developing to developed status.

3. DATA AND METHODOLOGY

The sample of this research is study covers 45 countries from Europe and Central Asia for the period 2000-2019. The dependent variable in this study is CO_2 emissions per person from the World Bank. The variable was logged to corrected for skewed nature of the data. Figure 2 plots the data for top 15 countries in the region. Overall, for the year 2019 CO_2 emissions ranged from 1.01 in Tajikistan to 15.3 in Luxemburg.

The main independent variable is FDI as % of GDP from the World Bank. Overall, FDI ranges from −1303.1% to 1282.6%. The average level of FDI inflows was 15.2% of GDP in our sample. To account for the effect of renewable energy we use renewable energy consumption as % of total energy consumption from the World Bank (Salahodjaev et al., 2022; Mentel et al., 2022).

In order to reduce the omitted variable bias, we include a set of control variables suggested by related studies. GDP per capita is measured in constant 2017 international dollars. Consistent with prior research on the Environmental Kuznets curve hypothesis concerning CO_2 emissions, we have incorporated the squared term of GDP per capita into our empirical model. Trade, defined as bilateral trade (the sum of exports and imports) as a percentage of GDP, has been included in alignment with emerging research on cross-country variations in CO_2 emissions (Akin, 2014; Balogh, 2022). Urbanization, a crucial variable in CO_2 emissions modeling, has been taken into account (see, for instance, Gierałtowska et al., 2022; Szetela et al., 2022). Urbanization is represented as urban population as a percentage of the total population.

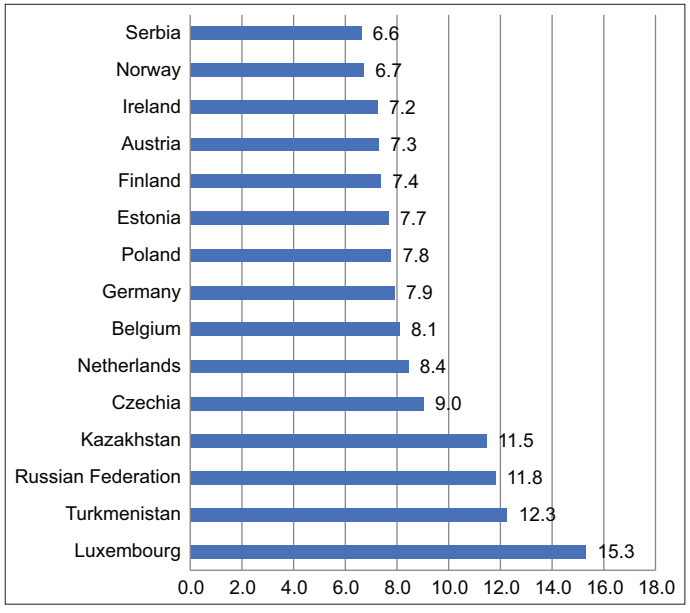
In line with the discussion of data above, the link between CO_2 emissions, FDI and renewable energy can be investigated with the following empirical model:

$$CO_{2i,t} = f(GDP_{i,t}; GDP^2_{i,t}; TOUR_{i,t}; FDI_{i,t}; TO_{i,t}; URB_{i,t}; RE_{i,t}) \quad (1)$$

Eq. (1) can be formulated in linear specification as:

$$CO_{2i,t} = a_0 + a_1 GDP_{i,t} + a_2 GDP^2_{i,t} + a_3 TOUR_{i,t} + a_4 FDI_{i,t} + a_5 TO_{i,t} + a_6 URB_{i,t} + a_7 RE_{i,t} + a_8 RE * FDI_{i,t} + \varepsilon_{i,t} \quad (2)$$

Figure 2: CO_2 emissions per person, top 15 countries for 2019



Where i and t denote country and year, CO_2 represents CO_2 emissions, GDP is GDP per capita, TOUR is tourism per capita, FDI stands for FDI, RE is renewable energy, URB and TO are urbanization and trade, respectively.

Equation (2) can be examined through various panel data methods, including fixed and random effects regression, generalized least squares, and panel-corrected standard errors, among others. Nevertheless, recent studies on CO_2 emissions drivers advocate for the superiority of the two-step system GMM for several reasons (Asongu et al., 2018; Muhammad and Khan, 2021). Notably, the two-step GMM method can effectively tackle issues related to endogeneity and omitted variable bias, resulting in more efficient estimates, especially when the number of nations in the dataset surpasses the number of years. We refrained from employing methods such as VECM, ARDL, or co-integration due to our extensive country sample and limited time periods. Moreover, we introduced interaction terms between financial development and tourism receipts per capita. For detailed information on the two-step GMM estimator, refer to Arellano and Bover (1995). Additionally, we conducted conventional tests for autocorrelations using AR(1) and AR(2) and the Hansen p-value to ensure the econometric reliability of our models. The two-step GMM estimator outperforms the instrumental variable two-stage least squares (IV 2SLS) approach, particularly when dealing with multiple endogenous variables in the model. Table 1 presents the descriptive statistics.

4. RESULTS

The main results are reported in Table 2. First, we report the findings with respect to control variables. As expected, lagged CO_2 emissions are positive and significant suggesting that there is inertia in greenhouse gas emissions trends in Europe and Central Asia. Next, we find that GDP per capita has inverted U-shaped relationship with CO_2 emissions, confirming the EKC hypothesis. The EKC hypothesis was also confirmed for Europe and Central Asia by previous studies (Dogan and Inglesi-Lotz, 2020; Bibi and Jamil, 2021). The turning point for the GDP per capita is approximately 59,000 international dollars. Trade openness is positively linked with CO_2 emission. These results are complimenting evidence for other countries globally (Mahmood et al., 2019). In line with Salahodjaev et al. (2022) we find that tourism has positive effect on CO_2 emissions in ECA: One standard deviation increase in tourism receipts per person leads to 3.3% increase in CO_2 emissions. Tourism can increase CO_2 emissions through several channels, including heightened transportation activities involving air travel and increased road traffic for tourists' mobility. Additionally, the demand for energy-intensive amenities such as air conditioning, hot water, and other services in hotels and resorts contributes to the overall carbon footprint associated with tourism. Turning to our control variables we find that renewable energy mitigates CO_2 emissions in the region. One percentage points increase in renewable energy consumption leads to 0.6% drop in CO_2 emissions. This effect occurs because renewable energy technologies produce electricity without the combustion of fossil fuels, thereby minimizing greenhouse gas emissions, aligning with global efforts to combat climate change. This finding holds immense significance as it underscores the vital role of renewable energy in mitigating global CO_2 emissions, offering a sustainable solution to curb environmental pollution.

By highlighting the effectiveness of renewable energy adoption, the study provides crucial insights for policymakers and stakeholders striving to transition toward eco-friendly energy sources and combat climate change on a global scale. Next, in Column 2 we include the interaction term between FDI and renewable energy consumption. The interaction term is negative significant implying that in countries with increased FDI inflows CO_2 emissions decline when the rise in FDI followed by increase in renewable energy consumption. These results also suggest that increasing FDI in energy sector can accelerate reduction of CO_2 emissions in ECA region. FDI in the renewable energy sector can substantially diminish CO_2 emissions by fostering the development and implementation of clean energy technologies. By injecting capital into renewable projects, FDI enables the expansion of sustainable energy infrastructure, reducing reliance on fossil fuels and subsequently decreasing carbon emissions associated with traditional energy sources. The stability of coefficients derived from the two-step GMM estimation is confirmed by both the AR(2) statistic and Hansen p-value. These results collectively emphasize that the environmental influence of FDI is closely linked to the extent of renewable energy consumption, highlighting the complex relationship between financial variables and environmental harm.

We test the robustness of our main results by including a set of additional control variables as suggested by previous studies (Table 3). In column 1, we include Internet users as % of population as previous studies report that ICT usage is linked to CO_2 emissions (Salahuddin et al., 2016). In column 2, we next include rule of law index to capture the effect of quality of institutions on CO_2 emissions (Muhammad and Long, 2021). In columns 3 and 4, we include agriculture value added as % of GDP and government size as % of GDP from World Bank, respectively. Both these variables

Table 1: Descriptive statistics

Variable	Description	Mean	Standard deviation	Min.	Max.
CO_2	CO_2 emissions per capita	1.69	0.68	−1.12	3.24
GDP	GDP per capita, PPP	31.12	21.61	1.32	120.65
TO	Trade as % of GDP	102.00	48.65	22.49	388.85
TOUR	Tourism receipts per person, '000 USD	0.93	1.66	0.00	24.76
URB	Urbanization rate, %	66.40	18.50	14.30	100.00
RE	Renewable energy consumption, %	18.62	16.67	0.00	81.07
FDI	FDI as % of GDP, net	15.23	95.02	−1303.13	1282.63

FDI: Foreign direct investment

Table 2: Main results

Factors	I	II
CO_2, lag	0.792	0.777
	(20.48)***	(22.18)***
GDP	0.012	0.014
	(6.65)***	(5.89)***
GDP2	−0.000	−0.000
	(6.00)***	(5.83)***
Trade	0.000	0.000
	(1.70)*	(0.49)
Urban	0.001	0.001
	(0.47)	(1.08)
Renewable	−0.006	−0.006
	(4.56)***	(5.89)***
Tourism	0.020	0.025
	(2.97)***	(2.95)***
FDI	−0.000	−0.000
	(0.86)	(2.22)**
Renewable*FDI		−0.000
		(2.08)**
Constant	0.176	0.153
	(2.85)***	(2.35)**
N	749	749
AR (1)	0.001	0.001
AR (2)	0.627	0.797
Hansen p-value	0.413	0.397

*P<0.1, **P<0.05, ***P<0.01. FDI: Foreign direct investment

Table 3: Robustness test: GMM results

Factors	I	II	III	IV
CO_2, lag	0.753	0.864	0.744	0.840
	(29.15)***	(36.64)***	(22.39)***	(30.85)***
GDP	0.015	0.003	0.010	0.008
	(6.76)***	(2.07)**	(4.11)***	(4.37)***
GDP2	−0.000	−0.000	−0.000	−0.000
	(6.53)***	(1.96)*	(3.45)***	(3.54)***
Trade	0.000	0.000	−0.000	0.000
	(2.38)**	(1.32)	(0.69)	(0.80)
Urbanization	−0.000	−0.001	−0.000	0.001
	(0.33)	(1.50)	(0.68)	(1.37)
Renewable	−0.007	−0.005	−0.007	−0.006
	(5.71)***	(6.62)***	(8.70)***	(4.66)***
Internet	−0.001			
	(1.32)			
FDI	−0.000	−0.000	−0.001	−0.000
	(3.44)***	(4.24)***	(2.55)**	(2.34)**
FDI*RE	−0.000	−0.000	−0.000	−0.000
	(3.83)***	(4.00)***	(3.38)***	(3.71)***
Rule of Law		0.020		
		(1.12)		
Agriculture			−0.005	
			(2.63)**	
Government				−0.006
				(4.09)***
Constant	0.198	0.291	0.447	0.182
	(2.23)**	(5.51)***	(6.23)***	(3.28)***
N	886	896	885	895

*P<0.1, **P<0.05, ***P<0.01. FDI: Foreign direct investment, GMM: Generalized method of moments

mitigate CO_2 emissions in ECA region. Across all models both FDI and renewable energy reduce CO_2 emissions. The interaction term is negative and significant again suggesting that CO_2 emissions are lower when increase in FDI is followed by rise in renewable energy consumption.

5. CONCLUSION

In conclusion, this study delved into the intricate interplay between FDI, renewable energy, and CO_2 emissions within the realms of Europe and Central Asia. Firstly, we find that renewable energy mitigates CO_2 emissions. Moreover, our research shows a significant correlation: countries receiving higher levels of FDI experience lower CO_2 emissions when coupled with increased renewable energy integration. This finding underscores the potential of renewable energy sources in mitigating environmental impact, particularly in economies reliant on foreign investments.

Secondly, our study affirms the existence of an inverted U-shaped relationship between GDP per capita and CO_2 emissions, aligning with the established Environmental Kuznets curve. This finding indicates that as economies initially grow, CO_2 emissions rise; however, beyond a certain threshold, economic advancement can be decoupled from escalating environmental degradation, pointing to the importance of balanced, sustainable economic policies. These findings hold significant policy implications for both regional governments and international organizations keen on fostering sustainable development in Europe and Central Asia. Policymakers should actively encourage investments in renewable energy infrastructure. Providing incentives, subsidies, and a favorable regulatory environment can attract private investments, facilitating the transition towards clean energy sources. Governments should incentivize FDI in sectors that prioritize environmental sustainability. Encouraging FDI in renewable energy projects and eco-friendly technologies can lead to a win-win scenario, boosting economic growth while reducing CO_2 emissions. Investment in research and development of renewable energy technologies is crucial. Governments should fund research institutions and incentivize private sector innovation to enhance the efficiency and affordability of renewable energy solutions. By implementing these policy recommendations, governments and international bodies can pave the way for a greener, more sustainable future in Europe and Central Asia, fostering economic growth while preserving the environment for generations to come.

Despite the valuable insights gained from this research, several limitations should be acknowledged. Firstly, the study focused on Europe and Central Asia, limiting the generalizability of findings to other regions. Future research should consider expanding the scope to include diverse geographical areas for a more comprehensive understanding of the relationship between FDI, renewable energy, and CO_2 emissions. Secondly, the study utilized aggregated data, potentially overlooking variations at the country or sub-national level. Utilizing more granular data could provide a finer analysis, capturing nuances that might be crucial for policy recommendations. Additionally, the study primarily relied on quantitative data, leaving out qualitative aspects that could provide a deeper understanding of the socio-cultural, political, and institutional factors influencing renewable energy adoption and CO_2 emissions. Incorporating qualitative research methods, such as interviews and case studies, could offer richer insights into the complexities of the subject. Furthermore, the research period might not capture long-term trends and impacts, especially concerning renewable energy infrastructure development and its effects on

emissions. Longitudinal studies covering extended periods can provide a more nuanced analysis of the relationship over time.

Building upon the limitations identified, several promising avenues for future research emerge. Firstly, conducting comparative analyses across different regions, including developing economies, can reveal contrasting patterns and factors influencing the relationship between FDI, globalization, renewable energy, and CO_2 emissions (Mirziyoyeva and Salahodjaev, 2023; Djalilov et al., 2023; Majewski et al., 2022). Such comparative studies can provide valuable insights into the contextual differences shaping policy effectiveness. Secondly, qualitative research methods, such as case studies and interviews with industry experts and policymakers, can offer a holistic understanding of the barriers and facilitators in the adoption of renewable energy technologies. Addressing these avenues for future research can significantly enhance the understanding of the complex interplay between FDI, renewable energy, and CO_2 emissions, guiding policymakers towards more effective and targeted interventions.

6. ACKNOWLEDGEMENT

This paper was supported by the project GA JU 103/2023/S. Further improving the efficiency of systems through the application of the principles of circular economy in the context of regional management.

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