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THE IMPACT OF RENEWABLE ENERGY CONSUMPTION ON THE WELL-BEING OF THE POPULATION OF THE REPUBLIC OF MOLDOVA

Introduction

Renewable energy serves as a cornerstone for economic development, providing a pathway toward sustainable growth and improved living standards. Investments in renewable energy infrastructure not only create employment opportunities but also catalyze economic expansion, thereby elevating income levels and fostering economic stability (Nemet, 2006).

Moreover, the accessibility of renewable energy sources plays a pivotal role in promoting human development. Unlike conventional energy sources, renewable energy technologies, such as solar and wind power, often feature decentralized distribution networks, making energy more accessible to remote and underserved communities (International Renewable Energy Agency, 2019). Enhanced access to energy translates into increased economic productivity, improved healthcare services, and better educational opportunities, thereby contributing to holistic human development.

The environmental sustainability offered by renewable energy further bolsters its impact on human development. By generating fewer greenhouse gas emissions and reducing environmental pollution, renewable energy technologies contribute to cleaner air and water, thereby mitigating public health risks and enhancing overall well-being (United Nations Development Programme, 2020).

Moreover, the transition toward renewable energy enhances energy security, a critical component of human development. Diversification of energy sources reduces dependence on imported fossil fuels, ensuring a stable and reliable energy supply (International Energy Agency, 2020). This stability not only supports economic activities but also safeguards access to essential services, thereby bolstering societal resilience against energy crises or disruptions.

Finally, the pursuit of renewable energy fosters education and innovation, driving progress in human capital development. Investments in education and research and development within the renewable energy sector spur technological innovation and cultivate skilled labor (Jacobsson & Lauber, 2006). By nurturing a culture of innovation and knowledge-sharing, renewable energy initiatives contribute to higher levels of education and innovation, propelling societies toward greater heights of human development.

Renewable Energy Landscape in Moldova

Moldova's renewable energy sector has experienced notable growth in recent years, driven by governmental initiatives, international collaborations, and advancements in technology. Wind, solar, biomass, and hydropower are prominent renewable energy sources being developed in the country. The government has implemented various policies to incentivize renewable energy deployment, including feed-in tariffs and investment incentives. Despite progress, challenges such as limited infrastructure and financing constraints persist, hindering the sector's full potential (Grigore & Rusu, 2019).

Data

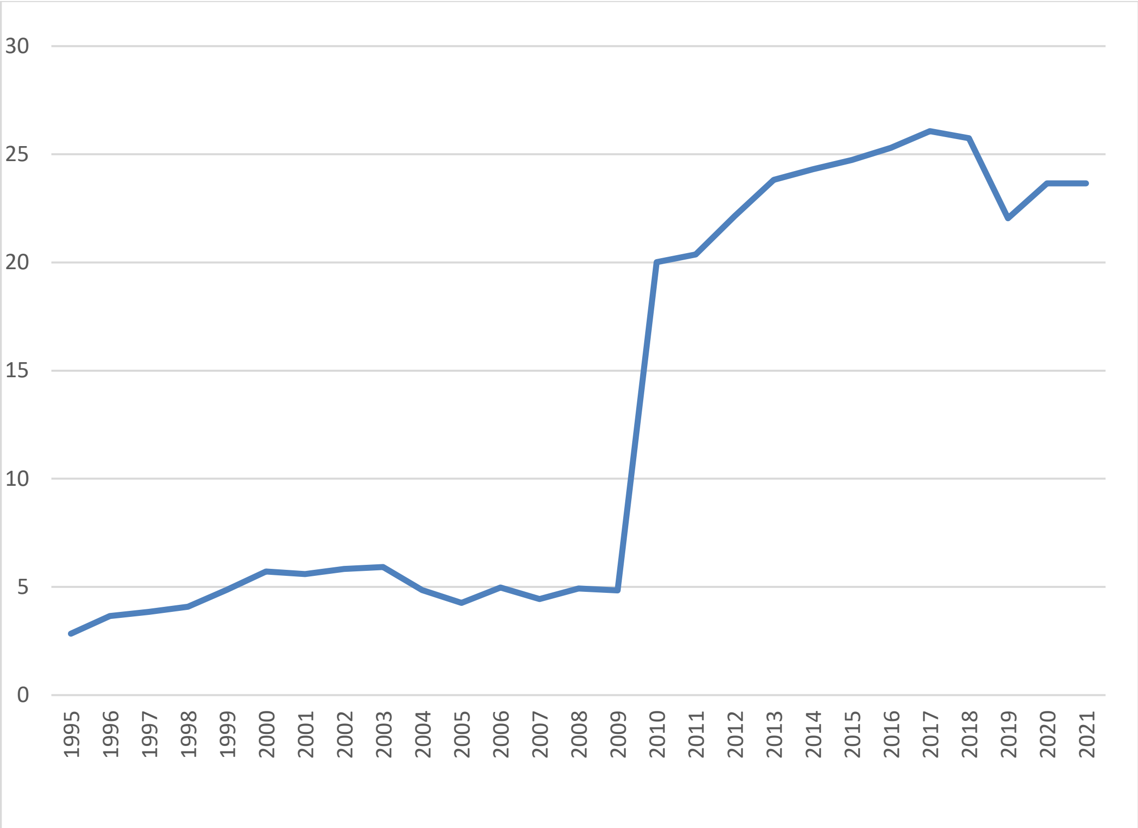
The Data covers the period between 1995 to 2021 inclusive. A brief description of the variables is provided in Table 1. Lack of data did not allow an extension of this analysis for an extended amount of time. All the variables except Total Solar Irradiance (TSI) were taken from the World Bank Open Source Data.

We consider the Human Development Index as a suitable measure for welfare in the Republic of Moldova. The HDI is calculated by combining the life expectancy index, the education index and the GINI index. With a mean HDI of 705.5926 and a range from 617 to 776 among the observed years, Moldova's HDI reflects the country's progress in key areas such as life expectancy, educational attainment, and standard of living.

A higher HDI value indicates a higher level of human development, signifying greater access to healthcare, education, and economic opportunities for the population. In Moldova, efforts to improve HDI have been central to governmental policies and development initiatives, aiming to uplift the standard of living and enhance the well-being of its citizens.

However, despite progress in certain aspects, Moldova faces challenges in achieving sustained improvements in HDI across all dimensions. Economic disparities, healthcare accessibility, and educational quality remain areas of concern, affecting the overall HDI score and highlighting the need for targeted interventions to address underlying structural issues.

Renewable Energy Consumption (% of total final energy consumption) emerges as a compelling focus of our analysis, demonstrating a noteworthy trend depicted in Figure 1: a substantial leap from 5% in 2009 to 20% in 2010. This remarkable surge prompts exploration into its underlying drivers, which could encompass a range of factors such as policy interventions, technological advancements, or shifts in governance. Notably, the observed increase coincides with Moldova's transition from a communist regime to a more liberal governance structure in 2009. Further investigation into these dynamics will be integral to our subsequent analysis.



Source: The World Bank, https://data.worldbank.org/country/MD

Figure 1. Renewable Energy Consumption (% of total final energy consumption).

Total Solar Irradiance was taken from Copernicus' Climate Data Store, in particular using RMIB's (Royal Meteorological Institute of Belgium) data on TSI for the specific coordinates of Moldova.[1] The Total Solar Irradiance (TSI) is a measure of the total solar power received per unit area at the top of the Earth's atmosphere. In the context of the Republic of Moldova, TSI serves as a key indicator of solar energy availability and potential for solar power generation. With an average TSI of 1361.349 W/m² observed across the country, Moldova benefits from relatively consistent solar radiation levels throughout the year. This solar resource presents opportunities for leveraging solar energy technologies to meet energy demands, reduce greenhouse gas emissions, and enhance energy security.

TSI data provides valuable insights for policymakers, energy planners, and renewable energy developers in Moldova. By understanding the spatial and temporal variability of solar irradiance, stakeholders can optimize the deployment of solar energy systems, such as photovoltaic panels and concentrated solar power plants, to maximize energy production and economic benefits.

[1] Latitude: 47.4116° N to 48.4900° N, Longitude: 26.6100° E to 30.1356° E

Table 1.

Variable Description

Variable	HDI	Renewable energy consumption (% of total final energy consumption)	Total Solar Irradiance (1 Astronomical Unit)	Total greenhouse gas emissions (kt of CO2 equivalent)	Nitrous oxide emissions (thousand metric tons of CO2 equivalent)	Annual freshwater withdrawals, total (% of internal resources)
Obs	27	27	27	27	27	27
Mean	705.5926	13.05704	1361.349	12990.59	966.7258	65.60742
Std. Dev.	54.1126	9.616174	0.3889613	1551.056	173.7366	32.96014
Min	617	2.84	1360.896	11426.03	741.3358	51.66667
Max	776	26.07	1362.274	18557.85	1474.54	211.3333

Source: The World Bank, https://data.worldbank.org/country/MD, Copernicus DOI: 10.24381/cds.85a8f66e

Methodological Approach

To examine the impact of renewable energy consumption on welfare indicators in Moldova, we first use standard OLS regressing HDI on Renewable Energy Consumption, as shown in the main equation below:

$$y_t = X'\beta + \ \delta R_t + \ \varepsilon_t$$

Where y is the natural log Human Development Index, R is Renewable Energy Consumption and X are other various controls as presented in columns 2 and 3 in Table 2. The regressor of interest is δ as it shows the effect of Renewable energy consumption on the HDI.

Table 2 shows that, while renewable energy consumption appears to have a positive association with HDI in Model 1, this relationship becomes less clear when additional variables are included in the analysis. Other variables such as total GHG emissions, nitrous oxide emissions, and freshwater withdrawals do not show consistent or statistically significant relationships with HDI across the different models and the results are more or less economically insignificant.

Table 2.

OLS Results

	1	**2**	**3**
Renewable Energy	0.0067896***	0.0069638	0.0058522
Total Greenhouse Gas Emissions		-2.19e-06	1.13e-06
Nitrous Oxide Emissions		-0.0001044	-0.0000386
Annual Freshwater Withdrawals			-0.0007672
Constant	6.467488	6.594643	6.552693
Number of obs	27	27	27
Procedure	OLS	OLS	OLS
F-statistic	67.94	26.06	27.88
R-squared	0.6999	0.7727	0.8182
Root MSE	0.04359	0.03956	0.03617

Source: **: 5% sig. ***: 1% sig. P-values based on regression analysis. Elaborated by the author based on the data from: The World Bank, https://data.worldbank.org/country/MD, Copernicus DOI: 10.24381 /cds. 85a8f66e

We proceed with 2SLS regression. This econometric technique mitigates endogeneity issues, ensuring robust estimates of the relationship between renewable energy consumption and welfare outcomes. Endogeneity arises when independent variables are correlated with the error term in regression analysis, leading to biased and inconsistent parameter estimates. In the context of studying the impact of renewable energy consumption on welfare outcomes such as the Human Development Index (HDI), endogeneity may occur due to omitted variables, reverse causality, or measurement errors.

2SLS regression addresses endogeneity by using instrumental variables (IVs) to instrument for the endogenous variables. In our context, we use Total Solar Irradiance as an instrument for Renewable Energy Consumption, which is relevant. We assume that it is also an exogenous instrument and that it is not directly affecting HDI apart from its relationship with the main regressor. We do note that perhaps TSI does encompass all forms of renewable energy and solely focuses on solar power generation, but due to data limitations this was the best choice moving forward.

Results for this 2SLS are presented in Table 3. Column 3 shows that the coefficient for renewable energy consumption is 0.0161518. This suggests that a one percentage increase in renewable energy consumption of total energy consumption is associated with an approximate increase of 1.6% in HDI. In simpler terms, as the consumption of renewable energy increases, there is a corresponding positive impact on the HDI.

Table 3.

2SLS Results

	1	**2**	**3**
Renewable Energy	0.0208114***	0.0148306**	0.0161518**
Total Greenhouse Gas Emissions	-	0.0000524	0.0000513
Nitrous Oxide Emissions	-	-0.0005753	-0.0006536
Annual Freshwater Withdrawals	-	-	0.0007105
Constant	6.284405	6.238264	6.263893
Procedure	IV	IV	IV
Number of obs	27	27	27
R-squared	-	0.1739	0.0052
Root MSE	0.13881	0.0696	0.07638

Source: **: 5% sig. ***: 1% sig. P-values based on regression analysis. Elaborated by the author based on the data from: The World Bank, https://data.worldbank.org/country/MD, Copernicus DOI: 10.24381/cds. 85a8f66e

Conclusion

In conclusion, the analysis highlights the significant impact of renewable energy consumption on human development, as evidenced by the positive relationship observed between renewable energy consumption and indicators of human development. Through robust econometric techniques such as instrumenting renewable energy consumption trough total solar irradiance, we have demonstrated that increased adoption of renewable energy positively influences human development indices in the Republic of Moldova.

In light of these findings, policymakers, stakeholders, and communities are encouraged to prioritize and accelerate the adoption of renewable energy solutions. By harnessing the economic, social, and environmental benefits of renewable energy, countries can advance their sustainable development agendas and achieve tangible improvements in human well-being and quality of life.

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