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The impact of hydropower on Georgia's GDP

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Abstract

This paper analyses the impact of hydropower on Georgia's GPD. The research process is divided into two parts – secondary sources analysis, followed by a regression formula representing the electricity sector's effect on economic indicators.

As a result, we have developed a tailored framework customized for Georgia, leveraging country-specific, relevant data. The study showed that there is a positive correlation between the increased energy consumption (Energy Supply) and GDP growth. Specifically, a 1% boost in energy consumption results in a 0.15% GDP rise.

Georgia has a significant resource of hydropower. The findings provide a solid basis for crafting policies and strategic decisions regarding the economic processes linked to the analyzed variables.

Keywords: renewable energy, hydropower, sustainable development, Georgia, economic development, GDP and energy

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I. INTRODUCTION

Georgia has an abundance of hydropower resources. [11] With the country's territory spanning 69,700 square kilometers, Georgia's Gross Domestic Product (GDP) accounts for $30.3 billion as of 2023. Within its relatively small territory, Georgia is home to 26,060 rivers [10] indicating its significant hydropower potential. Nonetheless, the country only utilizes a mere 22% of its hydropower resources. [8]

According to the LEPL Environmental Information and Education Centre, Georgia's hydropower resources amount to up to 140 billion kWh per year, of which only 35% is technically exploitable. [13]

In Georgia, hydropower generates 75% of the country's energy, with the remaining primarily being generated by thermal power plants. Based on the data analysis coupled with the consideration of the country's renewable energy resources, not only should Georgia be self-sufficient but also a major energy exporter.

The primary goal of the data analysis presented in the paper is to economically assess the potential of hydropower resources and emphasize their benefits, be it the improvement of the country's internal parameters and the achievement of the UN Sustainable Development Goals on a global scale.

II. LITERATURE REVIEW

How does energy impact economic growth?

A review of the evidence reveals a close correlation between energy and economic upswing. Income growth and energy consumption have always been strongly linked, spanning all continents and historical contexts. [19] High energy consumption is characteristic of affluent countries, while low energy consumption is typical of developing ones.

Energy heavily contributes to almost every economic activity. We can, therefore, confidently conclude that the quality and cost of a country's energy have a marked impact on its economic output. Growing statistical evidence depicts that energy consumption is a pivotal factor and a powerful driving force for economic prosperity.

Although the provision of electricity to rural population does not significantly increase the income of the indigent, studies reveal that accessible and reliable energy considerably benefits businesses.

Hydropower

One of the toughest challenges the modern world is facing today is to steer a narrow course between conflicting priorities such as mitigating climate change and achieving universal access to energy. Hence, in this context, the role and multifaceted advantages of hydropower are crucial. Being the cornerstone of low-carbon electricity generation, hydropower accounts for nearly half of the world's renewable energy. [14] Its contribution surpasses the combined output of all other renewable energy sources, be it solar photovoltaic, bioenergy, wind, and geothermal. In 2021, hydropower supplied 26% of the electricity used worldwide. This was largely due to the globally installed hydropower capacity reaching 1,360 gigawatts, leading to an output of 4,250 terawatt. [15]

The socio-economic impact of hydropower

As of 2021, the hydropower sector employed 2.4 million people. The statistics from 2022 depicted that women made up 25% of the workforce in the industry. Furthermore, the gender distribution revealed a marked gender disparities with a mere 21% of female employees holding technical positions, while 79% were engaged in non-technical roles. [9] In order to address the issue of inequality, governments and companies are taking measures to correct this imbalance through coherent policies, support programs, and initiatives aimed at increasing women’s employment in the sector. Georgia serves as a compelling example with its local generation and import statistics. It is frequently maintained that it is preferable to prioritize energy imports over developing our own generation capacity. This issue comes into sharp focus and gains particular relevance when price becomes a decisive factor. Electricity prices are notoriously volatile and easily manipulated, a reality that extends beyond this region to the entire world. Turkey serves as a prime example of this with its industrial energy costs surging nine-fold between 2014 and 2022. This sharp rise was primarily fueled by the crises triggered by the Russia-Ukraine war.

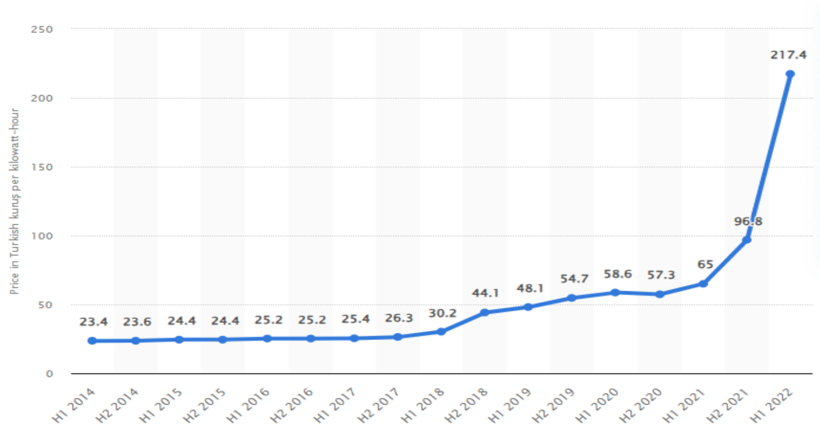

Figure 1: Electricity prices for industry from H1 2014 to H1 2022

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Turkey serves as a stark reminder of the long-term dangers of import reliance and the critical need to develop alternative power generation sources.

For countries with developed economies, this path is already well-defined, as outlined in the documents published by the European Union in 2020 (specifically, the findings of the European Regional Development Fund Report). These documents discuss national policies – both existing and proposed – for utilizing renewable energy sources domestically. The documents also emphasize the challenges directly related to climate change and economic growth, highlighting measures to mitigate the risks associated with the increasing demand for energy carriers. [16]

In 2023, Georgia's electricity exports hit an all-time high, selling $95.4 million worth of power. This figure marks a 13.2% increase compared to the previous year’s $84 million (2022). In total, the country exported 1.5 TWh of energy in 2023, accompanied by a significant decline in imports during the same period. The period under review was marked with a 48.5% drop in electricity import, covering only the needs of Abkhazia, which is supplied with electricity from Russia at a symbolic price (0.1 cents per kWh).

Consequently, 2023 wrapped up with a record-setting balance [7] with the figures depicting a positive trade balance of $94.4 million (+122.0 year-over-year) and net export volume of 0.7 TWh.

III. RESEARCH METHODOLOGY AND ANALYSIS

The study uses a regression formula representing the electricity sector’s effect on economic indicators.

The paper employes SinoTERM, a dynamic multi-regional computable general equilibrium (CGE) model of the Chinese economy to further analyze the economic impact of large-scale hydropower development projects. The model captures the dynamics of regional labor markets and includes an electricity sub-module that, in turn, allows for substitution between different types of electricity. The findings suggest that hydropower development will foster economic growth in the project region, with the sectors such as healthcare, education, and others being expected to enjoy the benefits accrued from hydropower development.

Methodological premise: Every 10,000 yuan (approximately $1375) injected could lead to a 1,000 yuan (approximately $138) increase in the national GDP, with the return on investment (ROI) expected over a ten-year period. By the end of 2040, the real national wage is projected to be about 0.16% higher than estimated in the baseline scenario. The project can only be justifiable if its net environmental benefits outweigh its losses.

Resource: since the 2011 Bonn Conference (Germany) a significant attention has been turned to establishing the nexus among water, energy, and food sectors. It was also noted that global population growth, economic development, and climate change will contribute to an increased demand for energy, water, and food. In his research, Professor Borowski applies the Pearson correlation coefficient (r), which is the most common method for measuring linear correlation. The correlation coefficient is calculated using the following formula:

$$r = \frac{\sum (x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum (x_i - \overline{x})^2 \sum (y_i - \overline{y})^2}}$$

In this formula, xi and yi denote the values of variables x and y, while x and y represent the mean values of these variables.

The correlation result, ranging from −1 and +1, quantifies both the strength and direction of the relationship between two variables. In the conducted study, the correlation coefficient was calculated between variable x = GDP and variable y = energy efficiency. Specifically, the coefficient measured the correlation between GDP (x) and per capita energy efficiency (y).

Drawing from the aforementioned model, we have developed a tailored framework customized for Georgia, leveraging country-specific, relevant data.

Regression Statistics	
Multiple R	0.973702911
R Square	0.94809736
Adjusted R Square	0.944983201
Standard Error	0.236759058
Observations	54

Table 1: Regression Statistics

As shown in Table 1, the Adjusted R-squared value equals 0.944983, indicating that the equation captures all relevant factors affecting GDP, as the variables collectively account for more than 94% of the outcome's variation.

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	51.19725742	17.06575	304.4473757	4.23129E-32
Residual	50	2.802742581	0.056055		
Total	53	54			

Table 2: ANOVA

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-6.11183E-16	0.032218827	-1.9E-14	1	-0.064713418	0.064713418	-0.064713418	0.064713418
x1	0.150084435	0.047276996	3.174576	0.002568649	0.055125793	0.245043076	0.055125793	0.245043076
x2	-0.041822425	0.0340772	-1.22728	0.225462839	-0.110268495	0.026623646	-0.110268495	0.026623646
x3	-0.870963113	0.046026252	-18.9232	1.91842E-24	-0.963409561	-0.778516664	-0.963409561	-0.778516664

Table 3: Correlation-Regression Analysis

Table 3 illustrates the correlation-regression analysis. The variables cover the period from 2011 through the third quarter of 2024, comprising a total of 54 quarterly data points. The dependent variable y represents Gross Domestic Product (GDP), while X1 variable depicts electricity consumption (calculated as local production minus exports plus imports). X2 stands for Foreign Direct investments and X3 is net export (exports minus imports).

The P-value is 0.002569, indicating that the correlation-regression analysis revealed a statistically significant relationship between the independent and dependent variables ($p = 0.002569 < 0.05$). This finding provides compelling evidence that the independent variable indeed affects the dependable variable.

The results from this econometric analysis conclusively indicate that X1 is 0.150084; hence, there is a positive correlation between the increased energy consumption (Energy Supply) and GDP growth. Accordingly, a 1% boost in energy consumption results in a 0.15% GDP rise, as this analysis shows.

The primary aim of the study was to determine the impact of all three independent variables (x1, x2, x3) on the dependent variable. The regression model, built on 54 observations, is highly robust: the Multiple Correlation Coefficient (Multiple R) makes up 0.974, and the Coefficient of Determination (R^2) equals 0.948, indicating that the model explains approximately 94.8% of the variation in the dependent variable.

Variable Interpretation:

- x1 (Coefficient = 0.150): variable x1 has a positive and statistically significant impact on the dependent variable ($p = 0.0026 < 0.05$). This implies that a one-unit increase in x1 leads to an average 0.15 unit rise in the dependent variable, assuming all other variables remain constant.
- x2 (coefficient = -0.042): x2 shows a negative, yet not statistically significant, influence on the dependent variable ($p = 0.225 > 0.05$). Thus, there is insufficient evidence to conclude that x2 makes a substantial impact on the dependent variable.
- x3 (Coefficient = -0.871): the variable x3 has a strong negative impact, which is statistically validated ($p \approx 0.000$). This indicates that an increase in x3 leads to a sharp decline in the dependent variable.

IV. CONCLUSION

Energy is a driving force fueling economic development. In the modern era, renewable energy has taken center stage due to its carbon-neutral nature and negligible environmental footprint.

Georgia has an abundance of hydropower resources, giving this sector substantial potential to stimulate the country's economic growth

Given the regression analysis presented in the paper, several valid conclusions can be drawn:

1. The applied model demonstrates a high explanatory power ($R^2 = 0.948$), indicating that the independent variables largely determine the dependent variable.

2. Of the three variables examined, both x1 and x3 demonstrate a statistically profound effect on the dependent variable. X1 shows a positive influence, indicating growth, while x3 has a strong adverse effect, meaning its growth drastically reduces the dependent variable.

3. X2 effect is statistically negligible, suggesting that its impact may be random or further research is needed to better understand its influence.

The findings provide a solid basis for crafting policies and strategic decisions regarding the economic processes linked to the analyzed variables. Hence, it is pivotal to shift our focus on the factors that have a marked statistical impact on the target indicator.

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