Correlation Between Education Spending and GDP Growth in North America

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This study explores the correlation between government expenditure on education as a percentage of GDP and GDP growth in North American countries from 2016 to 2023. The analysis uses data from 20 countries to examine trends, relationships, and patterns between these variables. Key findings reveal that education spending generally centers between 3% and 6% of GDP, while GDP growth rates show wide variation. Correlation analysis suggests no strong linear relationship between education spending and GDP growth, with a correlation coefficient of -0.01. While these findings provide insights into resource allocation, they also highlight limitations in isolating the impact of education spending on economic growth. The study discusses the need for complementary policies and suggests directions for future research to better understand the intricate dynamics between these two indicators.

I. Introduction

Education is often seen as a cornerstone of economic development. Governments allocate significant portions of their GDP to education, intending to improve human capital and foster economic growth. However, the relationship between education spending and GDP growth remains complex, with various socio-economic factors at play. This study focuses on North America from 2016 to 2023, aiming to answer the main question: How does government expenditure on education as a percentage of GDP correlate with GDP growth?

The study utilizes datasets on education spending (% of GDP) and GDP growth rates to identify trends and patterns. By analyzing these indicators, the research contributes to a deeper understanding of policy effectiveness in resource allocation for education. Additionally, the study underscores the importance of examining external factors that may mediate the education-growth relationship.

II. Data Sources

The datasets were collected from the World Bank. It used for this study include:

A. Education Spending Data

Government expenditure on education as a percentage of GDP. Samples from the dataset (pipeline output) are shown below (Fig. 1).

	Country Name	Country Code	Year	Value
0	Antigua and Barbuda	ATG	2016	2.251775
1	Bahamas, The	BHS	2016	2.586607
2	Belize	BLZ	2016	5.721710
3	Bermuda	BMU	2016	1.915444
4	Barbados	BRB	2016	4.683830

Fig. 1: Education spending dataset

B. GDP Growth Data:

Annual percentage change in GDP. Samples from the dataset (pipeline output) are shown below (Fig. 2).

	Country Name	Country Code	Year	Value
0	Antigua and Barbuda	ATG	2016	4.099766
1	Bahamas, The	BHS	2016	-0.961909
2	Belize	BLZ	2016	0.054552
3	Bermuda	BMU	2016	-0.657206
4	Barbados	BRB	2016	1.791930

Fig. 2: GDP growth dataset

The datasets encompass 20 North American countries throughout 2016-2023. Preprocessing ensured the removal of missing values, normalization where necessary, and alignment of data points across both datasets. A total of 11 missing values in education expenditure were identified and addressed. The dataset was sourced from the World Bank Open Data platform, ensuring reliable and consistent information for cross-country comparison.

C. Licences

source. This ensures that the data can be used freely while maintaining transparency and reliability.

III. Methodology

The analysis involved the following steps:

A. Preprocessing:

To ensure a robust and reliable analysis, missing values within the datasets were systematically addressed by dropping rows with incomplete data. This step was essential to minimize potential biases and enhance the overall integrity of the analysis. A key priority was ensuring alignment and consistency across the datasets, achieved by merging them on critical identifiers such as country name, country code, and year. This approach facilitated seamless integration and allowed for coherent analysis across various dimensions. Furthermore, rigorous outlier detection and validation processes were performed to identify and address anomalies, particularly focusing on negative GDP growth rates, which can often signify data errors or unique economic conditions requiring deeper investigation. These steps collectively enhanced the quality and reliability of the data, enabling more accurate and meaningful insights.

B. Exploratory Data Analysis (EDA)

The distributions of education expenditure and GDP growth were visualized to identify underlying patterns and potential anomalies within the data. This approach provided valuable insights into the relationships between these variables and helped in pinpointing outliers or trends that might warrant further investigation. Additionally, temporal trends over the 2016–2023 period were examined for selected countries, such as the United States, to understand changes over time and contextualize economic and educational shifts. These analyses offered a comprehensive view of both variable distributions and longitudinal dynamics, supporting a deeper exploration of the data.

The histogram in Figure. 3, the distribution of education spending as a percentage of GDP across various observations. The majority of countries cluster around 3% to 6%, with the highest frequency observed in the 4% range. This suggests that most countries allocate a moderate share of their GDP toward education. However, the distribution reveals a slight skew toward higher values, as indicated by a few countries spending over 7% to 9% of their GDP on education.

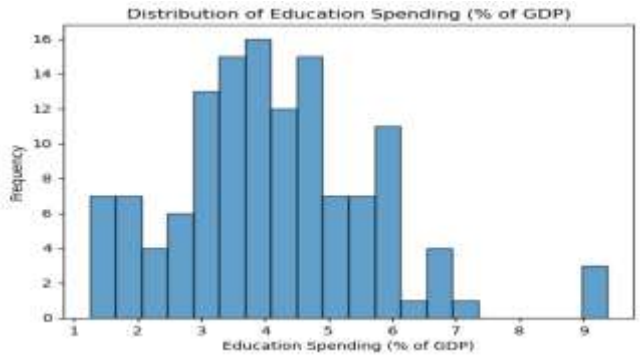

Fig. 3: Distribution of Education Spending (% of GDP)

Figure 04 suggests the distribution of GDP growth rates across different observations. The data is centered around 0% to 5%, reflecting a concentration of countries experiencing modest growth. The distribution is relatively symmetrical, though there are notable outliers on both ends, with some countries exhibiting extreme negative growth rates below -20% and others achieving high growth rates exceeding 15%. This highlights the variability in economic performance across countries and periods, with a notable majority experiencing moderate growth.

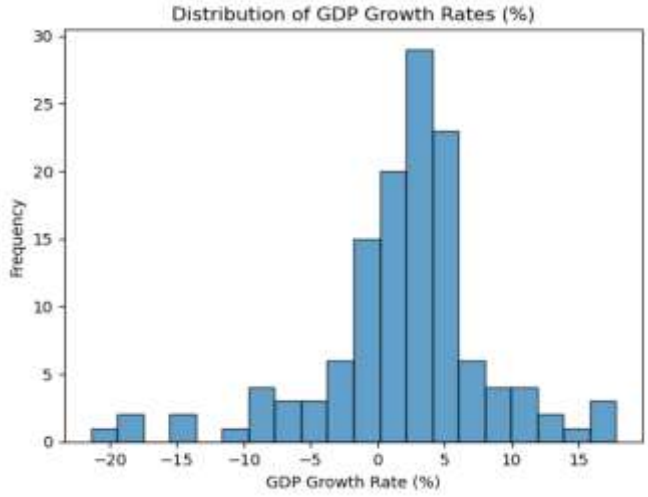

Fig 4: Distribution of GDP Growth Rates (%)

C. Correlation

Pearson correlation coefficients were computed to quantitatively measure the linear relationship between education expenditure and GDP growth, providing insights into the strength and direction of their association. To enhance interpretability, a heatmap was generated (Fig. 5), offering a visual representation of the correlations between multiple variables. This approach facilitated the identification of significant relationships and patterns within the data, enabling a more intuitive understanding of the interdependence among key factors. Together, these analyses supported

a comprehensive exploration of the data's underlying relationships.

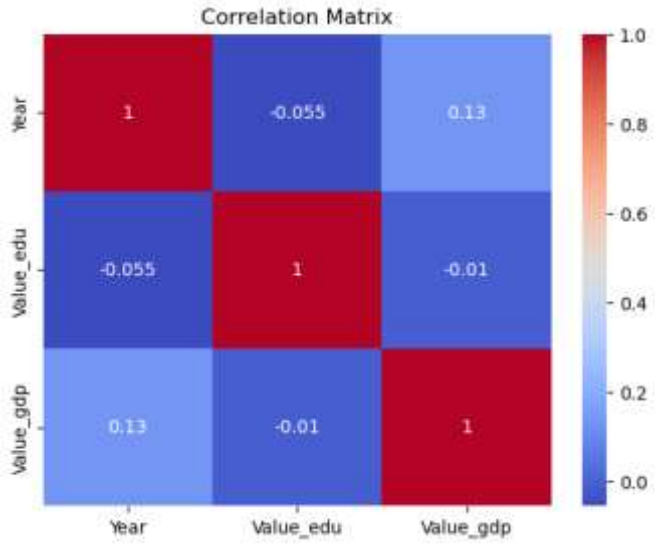

Fig. 5: Heatmap of correlation matrix

D. Visualizations

Scatter plots were created to visually illustrate the relationships between key variables, enabling a clear understanding of potential correlations or patterns in the data. Complementing this, histograms were utilized to provide a detailed view of the distribution of education spending and GDP growth rates, highlighting central tendencies, variability, and outliers. To examine changes over time, line charts were employed to capture temporal trends and variations for individual countries, offering a dynamic perspective on how these variables evolved during the study period. Together, these visualizations offered a multifaceted exploration of the data, combining relational, distributional, and temporal insights.

IV. Analysis and Results

This section presents a detailed analysis of the distribution of education spending and GDP growth rates, explores their correlations to assess potential relationships, and examines country-specific trends, with a focus on the United States, to highlight patterns and resilience amid economic fluctuations.

A. Distribution Analysis

The distribution analysis reveals that most countries allocate between 3% and 6% of their GDP to education, reflecting a common approach to educational investment, with outliers like Cuba dedicating over 7%. GDP growth rates, on the other hand, exhibit significant variation, ranging from -20% to 15%. While most countries experience moderate growth rates between 0% and 5%, some years show notable economic contractions, highlighting the diverse economic dynamics across regions.

B. Correlation Analysis

The correlation matrix visualized in the heatmap highlights the relationships between the variables Year, Value_edu (education spending as a percentage of GDP), and Value_gdp (GDP growth rates). The Pearson correlation coefficient between education spending and GDP growth was calculated as -0.01, indicating no significant linear relationship between these two variables. This negligible correlation suggests that education spending alone does not have a direct or measurable impact on GDP growth when analyzed in isolation.

This lack of correlation can be attributed to the multifaceted nature of economic growth, which is influenced by a broad range of factors. For instance, variables such as technological advancements, workforce dynamics, levels of industrialization, trade policies, and government regulations play critical roles in shaping a country's economic trajectory. Additionally, external shocks, such as the COVID-19 pandemic, may disrupt traditional growth patterns, obscuring potential long-term relationships between education spending and GDP growth.

The heatmap further underscores these findings, with weak or negligible correlations between education spending, GDP growth, and years. For instance, a slight positive correlation of 0.13 between GDP growth and years indicates a small upward trend in GDP growth over time. However, the lack of a significant relationship between education spending and other variables suggests that the impact of education investment on economic performance may manifest longer time horizons or interact with other contextual factors that are not captured in this analysis.

While education spending is an important investment in human capital, its relationship with GDP growth is complex and likely influenced by various external and structural factors, making it difficult to isolate a direct linear connection within the scope of this dataset.

C. Country-Specific Trends

For the United States, education spending remained stable at around 4-5% of GDP, reflecting consistent government prioritization. GDP growth, however, showed significant fluctuations, including a sharp decline in 2020 due to the COVID-19 pandemic, followed by a recovery in subsequent years. Similar patterns were observed in other countries, highlighting

the resilience of education budgets amid economic volatility (Fig. 6).

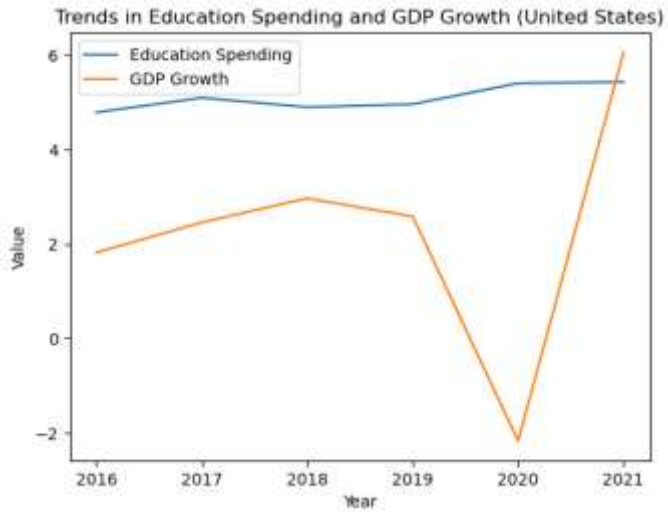

Fig 6: US trends on education spending and GDP growth

V. Discussion

The analysis highlights a weak correlation between education spending and GDP growth. This suggests that while education investment is critical for long-term development, its direct impact on short-term economic growth may be limited. Factors such as economic structure, workforce dynamics, and technological advancements could mediate this relationship, underscoring the multifaceted nature of economic growth.

The stability in education spending contrasts with the volatility in GDP growth, emphasizing the resilience of education budgets even during economic downturns. For instance, during the COVID-19 pandemic, education spending remained relatively stable despite sharp GDP contractions. However, the lack of a strong relationship raises questions about the efficiency of resource allocation and the need for complementary policies, such as investments in innovation and infrastructure, to maximize the economic benefits of education spending.

Additionally, the results highlight the importance of considering regional and socio-economic contexts when evaluating the impact of education spending. Countries with higher education expenditure may experience different growth trajectories depending on the quality and efficiency of their educational systems.

VI. Conclusion and Future Work

This study provides a comprehensive analysis of the relationship between education spending and GDP growth in North America. While education expenditure remains a consistent percentage of GDP, its direct correlation with economic growth appears minimal. These findings underscore the importance of considering other factors alongside education investment in driving economic growth.

Future research should explore additional variables such as workforce productivity, technological adoption, and socio-economic conditions to better understand the drivers of GDP growth. Methods such as case studies, regression models, and time-series analysis could provide deeper insights into how these factors influence economic outcomes over time. Moreover, longitudinal studies could offer insights into the long-term impact of education spending on economic development.

This research also highlights the importance of policy design. Allocating funds to education is necessary but insufficient on its own; targeted strategies are needed to ensure that investments translate into tangible economic benefits. Policymakers must consider enhancing educational quality, promoting innovation, and fostering inclusive economic growth to maximize returns on educational expenditure.

References

[1] Education and GDP Growth Data, 2016-2023, North America.

[2] World Bank Open Dataset Online: https://data.worldbank.org

[3] Licenses: https://datacatalog.worldbank.org/public-licenses#cc-by