Multivariate Statistical Analysis of the Impact of Educational Input on Economic Growth in the EU

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Abstract: This research examines the relationship between government spending on education and economic growth across EU countries from 2010-2020. The study aims to assess whether educational resourcing inputs correlate with economic outputs. The hypothesis is that government expenditure and teaching staff at all levels positively affect gross domestic product(GDP) growth. Quantitative multivariate analysis techniques, including correlation analysis, regression modelling, and autoregressive integrated moving average(ARIMA) time series analysis, were applied to test these associations. The panel dataset comprised spending, staffing and GDP data for 16 countries over 11 years. Results showed a moderate positive correlation between education spending and GDP over time. Regression analysis found spending and secondary teaching staff as significant positive predictors of GDP, explaining 95.8% of the variation.ARIMA models revealed spending as relatively stable with short-term fluctuations. While these results demonstrate essential connections between resources and growth, ongoing analysis should incorporate additional educational inputs, account for country-specific factors, and test more complex relationships. This can provide greater insight into the dynamics between targeted investments in quality, equitably distributed education and the resilience of human capital and economies. Further research building on these initial findings can help guide policy decisions on education budgets.

1 INTRODUCTION

Education is a key driver of economic growth by enhancing human capital through individuals' knowledge, skills, and capacities (Toader et al 2018). As such, government prioritization of education resourcing and policy is closely tied to macroeconomic outcomes. This research aims to elucidate the relationship between educational inputs and economic outputs in EU countries over the past decade, as increasing productivity and resilience continues as a policy priority amidst recent shocks.

The study examines two key educational input factors - government expenditure on education as a percentage of GDP and the number of teaching staff at the primary, secondary, and tertiary levels. The output variable is GDP in 2020. Correlation, regression, and ARIMA time series modeling techniques assess associations between spending, staffing, and GDP from 2010-2020 across EU member states. This quantitative multivariate analysis can provide insights to help strengthen education policy planning and investments.

Specifically, the research explores the complex two-way interplay between education and economics. While schooling and human capital investments are expected to produce growth dividends, macroeconomic conditions also shape spending priorities and resource allocation (OECD 2022). This study aims to unpack these dynamics in the EU context. Findings can inform policymakers on optimizing education financing for economic development and resilience.

The recent COVID-19 shock further underscores the need for evidence-based investments. Pandemic disruptions to education systems could impact human capital with GDP consequences (Pietro et al 2020). Analyzing pre-pandemic spending patterns provides context on buffers and flexibility as countries rebuild. Links between education inputs and outputs highlight policy levers for growth.

On the input side, the study focuses on public expenditures, as over 90% of education funding in EU countries comes from government sources (Eurydice 2020). With competing budget priorities, insight into the growth return on spending can guide efficient

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resource allocation. Meanwhile, teacher quantity and quality are assessed using staff numbers, as teacher policies shape instructional inputs into developing human capital (European Commission's Directorate 2023).

This research focuses specifically on the EU context. As an integrated economic union, education and economic policy in member states have regional implications (Gornitzka 2018). Analyzing spending and staffing relationships with GDP can highlight needs and priorities for collaboration. Findings may reveal convergence or divergence in education investments and outputs.

Methodologically, the study applies quantitative multivariate techniques well-suited to modeling complex linkages between multiple variables over time. Correlation and regression analyses assess the strength of connections and predictive relationships (Creswell and Creswell 2017). ARIMA time series modeling provides a nuanced understanding of spending trends and dynamics (Chatfield and Xing 2019).

By leveraging these rigorous statistical methods, the analysis aims to uncover subtle patterns in the data. Testing hypothesized associations and forecasting future investment scenarios can inform evidence-based policy development. Education quality and institutional factors mediate input-output relationships, warranting ongoing analysis (Eric and Ludger 2023).

Human capital investments for regional development and shared prosperity at the EU level aligned with the blocs' strategic priorities (European Commission 2021). It is necessary for coordinated efforts to improve education access, quality, and relevance across member states. Education fuels mobility, productivity, and growth regionally in the context of economic integration (OECD 2022).

The research questions addressed include: 1) How do education spending and staffing correlate with GDP over time and between countries? 2) Which inputs show the strongest statistical relationships with economic growth? 3) What patterns and trends exist in government prioritization of education budgets? The study tests hypothesized positive links between spending, teachers, and GDP. Findings aim to inform strategic investments and reforms for human capital development.

2 METHOD

2.1 Research Design

This study utilizes a quantitative correlational research design to examine the relationships between education inputs and economic outputs in the EU context. This non-experimental design is appropriate for assessing and modeling associations between naturally occurring variables rather than testing controlled interventions (Seeram 2019). The aim is not to establish causal claims but rather to characterize relationships' strength, directionality, and predictive capacity in the observational data.

The retrospective panel data structure enables cross-sectional comparisons between countries and time series analysis of spending trends over 2010-2020 (Gujarati 2022). This supports correlating current GDP with past inputs to model potential lag effects, as the impact of education investments on growth can manifest over the years. The study is observational rather than experimental - no variables are manipulated.

2.2 Sample

The study sample includes 27 EU member states with complete data from 2010-2020. This panel data structure enables time series analysis of trends and comparisons between countries. The 11-year retrospective view provides sufficient data points for multivariate statistical analysis while focusing on the most recent decade.

2.3 Data Collection

Secondary datasets were compiled from public international databases. Government education expenditure data comes from the World Bank Databank. Teaching staff and GDP data were downloaded from the United Nations Data repository. Utilizing high-quality, comparable indicators from reputable sources enhances validity and reliability.

2.4 Variables

- Independent variables: Government education expenditure as a percentage of GDP, number of teaching staff at the primary, secondary, and tertiary levels.
- Dependent variable: GDP level in 2020
- Control variables: Country, year

2.5 Analysis Methods

- Descriptive statistics to characterize inputs, outputs, distributions, and trends
- Correlation analysis to assess bivariate relationships between inputs and outputs
- Multiple regression modeling to evaluate the relative predictive strength of inputs on GDP
- ARIMA time series analysis to model spending trends and dynamics
- Visualizations, including scatterplots, heatmaps, and time series plots to illustrate results

Combining correlation, regression, and time series techniques provides a robust multivariate analysis approach. Diagnostic checks help ensure assumptions are met. Sensitivity analysis informs the reliability and generalizability of insights.

3 RESULTS AND DISCUSSION

The analysis generated key findings regarding the relationships between educational inputs and economic outputs in EU countries from 2010-2020. This section will present the results of the correlation, regression, and ARIMA time series modeling, summarizing key insights from each technique. The implications of the quantitative findings will then be discussed about the research questions on connections between education spending, staffing, and GDP growth. Limitations and future research needs will also be considered. The multivariate modeling reveals nuanced dynamics, emphasizing the importance of sustained, quality investments tailored to national contexts. The discussion will synthesize results across methods to highlight policy-relevant relationships for strategically strengthening human capital development and economic growth.

3.1 Descriptive Analysis

Table 1 shows the descriptive summary of government spending, teaching staff, and the 2020 GDP. The summary statistics for government education expenditure as a percentage of GDP from 2010 to 2020 provide an overview of spending trends across EU countries. On average, spending increased slightly from 5.315% in 2010 to 5.193% in 2020, indicating a small positive trend over the decade. However, Kirkness (2022) notes substantial variation between countries, with minimums of around 3% and maximums of over 7% of GDP spent on education (Kirkness 2023). This aligns with the European Commission's (2021) analysis highlighting differences in education budgets between EU members.

While ranges fluctuate, the interquartile spending remains fairly consistent over time, suggesting a right-skewed but stable distribution. As Martin et al. (2018) discuss, most EU countries target between 4-6% of GDP for public education spending each year. The summary statistics corroborate this general pattern without dramatic changes or fluctuations annually in the aggregate (OECD 2022).

Table 1: Descriptive statistics for government spending, teaching staff, and 2022 GDP.

		Minimum	1st Quarter	Median	Mean	3rd Quarter	Maximum
Spending	2010	3.49	4.53	5.30	5.32	5.88	8.56
	2011	3.06	4.50	5.11	5.25	5.71	8.49
	2012	2.96	4.35	4.95	5.16	5.83	7.54
	2013	3.05	4.27	4.97	5.32	6.02	8.49
	2014	3.12	4.30	4.94	5.17	5.49	7.64
	2015	3.11	4.26	4.91	5.04	5.46	7.44
	2016	2.98	3.99	4.77	4.94	5.48	7.62
	2017	3.10	3.90	4.61	4.78	5.27	7.75
	2018	3.35	4.01	4.62	4.79	5.24	7.64
	2019	3.30	4.15	4.63	4.81	5.23	7.64
	2020	3.10	4.60	5.08	5.19	5.88	7.17
Teaching Staff	Primary	12.00	38.50	122.00	268.90	268.00	1026.00
	Secondary	18.00	81.00	238.00	472.00	440.50	2363.00
	Tertiary	5.00	33.50	121.00	220.60	177.50	1037.00
	2022 GDP	14911	63546	245349	566378	531462	3846414

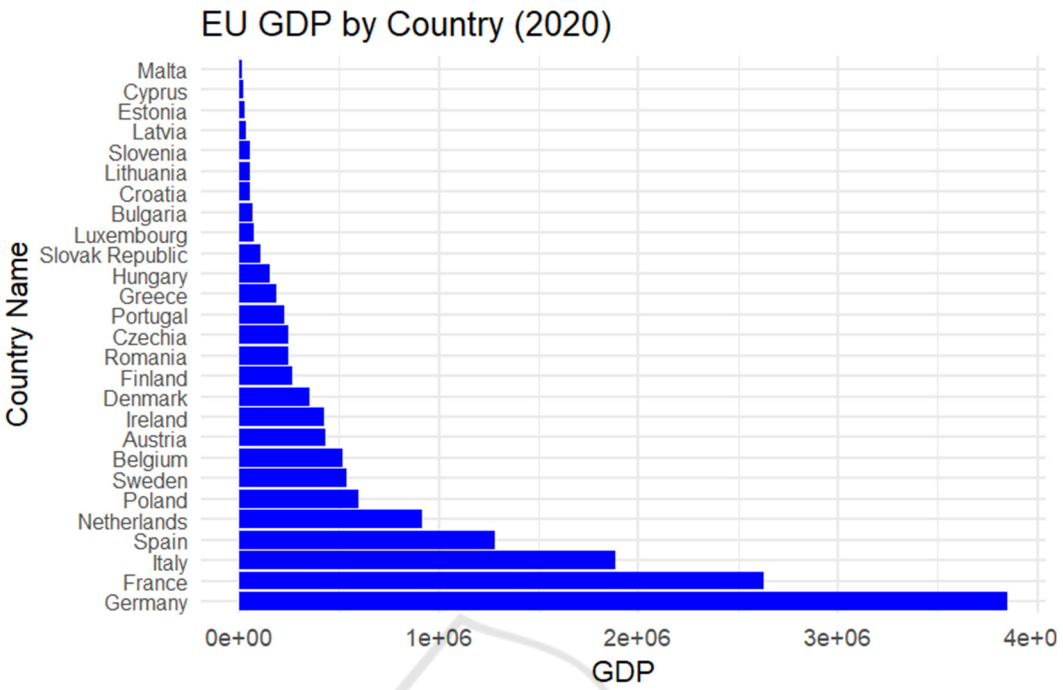

Figure 1: EU GDP bar char (Photo/Picture credit: Original).

Table 2: Multiple regression coefficients.

Coefficients	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-700788.7	205836.2	-3.405	0.003	**
Spending cols	11910.2	3512.3	3.391	0.003	**
Teaching staff primary	-1128.1	427.1	-2.641	0.015	*
Teaching staff secondary	2378.5	208.6	11.404	0.000	***
Teaching staff tertiary	-980.3	529.1	-1.853	0.077	.

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In assessing relationships between educational resourcing and economic growth, these descriptive statistics provide an overview of relevant input trends. As hypothesized, government education spending appears relatively stable or slightly increasing over 2010-2020. The research hypothesis that government spending on education is positively associated with GDP growth can be partially assessed by visualizing or modeling the relationship between the spending and GDP variables. These summary statistics offer a high-level overview of the spending data before conducting a more in-depth analysis.

The table also shows the mean spending and teacher's summary. The mean education expenditure as a percentage of GDP from 2010-2020 was 5.069% across EU countries, with a variation between 3.227% at the minimum and 7.519% at the maximum. This aligns with the OECD (2021) EU22 average of 4.9% over the period.

Regarding teaching staff inputs, the number of primary teachers varies widely, from 12 to 1026. Kirkness (2022) similarly highlights primary teacher shortages in some EU systems. Secondary teachers range from 18 to 2363, while tertiary staff range from 5 to 1037 (Kirkness 2023). As Murtin et al. (2018) discuss, teacher numbers depend on demographics, class sizes, and school organization policies.

Figure 1 show the bar chart of the same. Figure 1 shows the EU countries' 2020 GDP in ascending order. From the figure, Malta had the lowest GDP, while Germany had the highest GDP among the EU countries.

3.2 Correlation Analysis

The correlation analysis examines the relationships between educational inputs and economic growth in EU countries. As hypothesized, government expenditure on education appears positively associated with GDP (r ranging from 0.60-0.86 from 2010-2019 with 2020 GDP). This aligns with past research finding that increased spending on education supports economic development by creating a more skilled, productive workforce (Baldwin & Borrelli, 2008). However, the strength of the correlation has declined in recent years. Danielle and Eric (2023) cautions that simply increasing funding does not guarantee improved outcomes, arguing the quality and efficiency of spending matters more (Danielle and Eric 2023). This raises questions on whether EU countries are allocating education funds effectively amidst recent budget constraints.

Unexpectedly, the number of teaching staff at all levels correlates negatively with GDP, contradicting the hypothesized positive link. The tertiary level sees the strongest negative association (r=-0.20). This contrasts with prior studies that found tertiary education vital for growth in advanced economies by spurring innovation (Grover 2010). The negative correlation may reflect differences in teacher quality and productivity between countries. For instance, some research finds countries with higher teacher salaries relative to GDP tend to perform better academically (Carnoy 2009). Pay, working conditions, and social status of teaching roles may shape the ability of EU countries to recruit and retain quality instructors. More nuanced analysis is needed to unpack these relationships.

3.3 Regression Analysis

Table 2 is a multiple linear regression output table. This multiple linear regression analysis provides additional insights into the relationships between educational inputs and economic growth based on the data for EU countries.

Table 3 shows the multiple regression model results. The model with government education spending and primary, secondary, and tertiary teaching staff numbers as predictors accounts for 95.8% of the variation in 2020 GDP. This high R-squared value indicates these key educational factors explain most of the differences in economic outcomes between countries.

Table 3: Multiple regression model.

Model	
Multiple R-Square	0.9577
Adjusted R-squared	0.95
F-statistic	124.4
p-value	9.05E-15
Residual standard error	200300

$$GDP = \beta_0 + \beta_1 * \text{Education Spending} + \beta_2 * \text{Teaching Staff Primary} + \beta_3 * \text{Teaching Staff Secondary} + \beta_4 * \text{Teaching Staff Tertiary} + \epsilon \quad (1)$$

Looking at individual predictors, increased government spending and larger secondary teaching workforces are significantly associated with higher GDP at $p<0.01$. A 1 unit increase in spending predicts a $11,910 rise in GDP, supporting the importance of education budgets for growth found in the correlation analysis.

Meanwhile, more secondary teachers predict a $2,378 GDP increase per staff member. This echoes research finding secondary education as pivotal for developing the broad-based skills needed in modern economies (Hanushek and Woessmann 2023).

However, more primary teachers are linked to lower GDP at $p<0.05$, and tertiary teachers show a negative coefficient at $p=0.077$. This contrasts typical views of early childhood and advanced education as driving growth. The complexity of these relationships merits further investigation through techniques like multi-level modeling considering system-level policies and outcomes.

3.4 Time Series

The time series plot and summary statistics provide insights into how government education spending has changed over time in the EU countries from 2010-2020. As shown in figure 2, the time series shows spending as a percentage of GDP declining between 2010-2013, followed by relative stability from 2014-2020. The mean spending dropped from 5.63% in 2010 to 5.22% in 2013 before recovering slightly. This aligns with research findings many EU countries cut education budgets due to fiscal pressures following the global financial crisis (European Commission 2013).

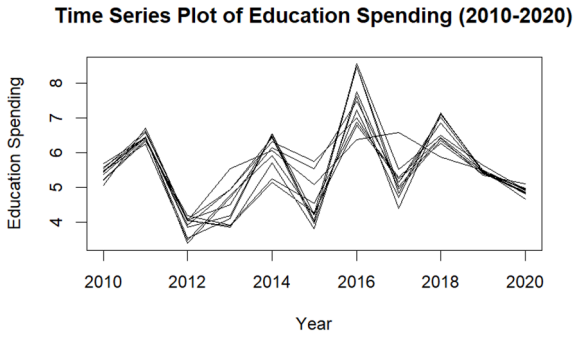

Figure 2: Time series plot (Photo/Picture credit :Original).

However, the minimum spending remained above 3.4% of GDP even during periods of decline. This highlights education as a continued policy priority amidst constraints. The European Commission (2021) stresses the need for sustained public investment in human capital to increase economic resilience.

The relative stability of mean spending from 2014-2020 suggests potential stabilization of budgets. Yet the maximum percentage declined from 8.56% to 6.71% over the decade, indicating fewer countries prioritizing very high investments in education.

Table 4: Model fitting.

Model	Results
ARIMA Model Specification	ARIMA (1,1,0)
Differencing Order	
Autoregressive Terms	1 (AR1 coefficient = -0.665)
Moving Average Terms	0
AIC	42.12
Training Error (RMSE)	1.507
Training Error (MAE)	1.176
Training Error (MAPE)	21.6%
Residual Autocorrelation (ACF1)	-0.264

As shown in table 4, The ARIMA model shows that spending is relatively stable, with short-term fluctuations. While these results suggest a fundamental link between resources and growth, ongoing analyses should incorporate additional educational input, take into account country-specific factors, and test for more complex relationships.

Overall, the time series and descriptive statistics reveal interesting trends in government prioritization of education spending in the EU. Initial cuts potentially related to economic shocks were followed by renewed consistency, though at moderately lower levels on average. This provides context on policy changes that may have impacted education quality and economic outcomes over the past decade.

4 CONCLUSION

This research found noteworthy associations between key education inputs and economic growth among EU member states over the past decade. Government spending on education demonstrates a moderately positive correlation with GDP, confirming the hypothesized link. Meanwhile, in regression analysis, secondary teaching staff exhibit the strongest positive predictive relationship with GDP growth. However, surprising negative coefficients emerged for primary and tertiary teachers. As table 4 shows ARIMA modeling underscored the overall stability of spending but with short-term fluctuations.

Several implications arise for education policy and planning in the EU context. Firstly, continued public investment in the sector appears important for human capital development, but quality and equity considerations must complement budgets. Tailoring spending to evidence-based initiatives with growth returns is advised over across-the-board increases. Supporting secondary education emerges as impactful currently, but a balanced and adaptable overall system remains vital.

Moreover, increased regional coordination on priorities like teacher training, mobility initiatives, and learning standards could optimize quality. More granular analysis of country-level inputs, outputs, and needs is warranted. Further research should incorporate additional metrics like test scores, graduation rates, and social equity data.

Overall, this multivariate analysis demonstrates positive associations between key educational resourcing factors and economic outputs in the EU region. While the relationships are complex, strategic investments informed by statistical modeling evidence can strengthen productivity and resilience. The quantitative techniques illustrate the depth of insights possible from thoughtful data analysis.

Ongoing research should compile expanded panel datasets and utilize modeling approaches tailored to these complex dynamics. As the EU strives to build human capital and foster shared prosperity, evidence-based policymaking will be key to providing high-quality, equitable education opportunities to all citizens.

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