Education Levels and Wealth: A Correlation Study

Juan José Garcia
jjgarcia@cs.unc.edu

Smiti Kaul
smiti@cs.unc.edu

Sandeep Kumar
sandeep@cs.unc.edu

Saumya Ray
shree@cs.unc.edu

ABSTRACT

Countries prioritize national expenditure in various sectors of citizen issues based upon evaluations that judge the impact and value of such public funding. This work aims to be such evaluation of the education sector by determining the correlation between citizens' self-development and societal contribution. We hypothesize, public spending on education (% of GDP spent on education) determines educational access (percentage of population enrolled in education) and resources for a government's constituents (GDP per capita). Along these lines, this work computes a correlation between public expenditure on education and educational enrollment levels across low, middle, and high income countries. Correlation is computed with a p-value between education enrollment, GDP per capita, and public expenditure. Clustering is done through a latent variable model upon United Nation's data. Our results match up greater GDP per capita with higher percentage of population enrolled and (approximately) higher percentage of GDP invested in education.

KEYWORDS

public expenditure, education, enrollment, clustering, machine learning

1 INTRODUCTION

National wealth, specifically public expenditure on education, and its consequences in student enrollment have been investigated in numerous studies across a wide range of countries [4, 6, 10]. These countries across can be categorized at three financial levels: low, middle, and high income based upon whether their gross domestic product (GDP) measures are low, middle, and high respectively. Countries with greater wealth as exhibited in their GDP measures possess a greater capacity to support a variety of national issues including public funding for education.

Low and middle income countries have a smaller spending power than high income countries, so it follows that their public spending budget available for education initiatives is smaller as well. This reality has serious implications, for national- and person-level financial circumstances have been found to influence educational access and resources across the globe. Bergh and Fink noted that only one percent of secondary school students in Ethiopia and Kenya advance to higher education while the over seventy percent advance in higher income countries such as South Korea, Finland, the United States [3]. Developing nations such as some in Sub-Saharan Africa where educational expenses are lower possess 25% of the world's uneducated population [7]. In Peru, poor children are less likely to enroll in elementary schools, and educational participation is further inhibited by supplementary costs associated with transportation and school supplies [9].

Existing research supports the investment in public funding for education, and public investment in educational resources and schools also has been found to increase not only enrollment but academic achievement as well [2, 5]. National level improvements in both academic enrollment and achievement has important positive consequences that motivate a correlation study such as ours. Enrolled students gain employable skills, societal values, and the ability to contribute to their national economic and social welfare [7]. Furthermore, the world's enrollment student population is only increasing and it demands greater attention by the government. In the African continent for example, the number of high education students tripped between 1991 and 2006 [1], and a study in the United States found that enrollment in government-funded community colleges increased by roughly half a million students between 2000 and 2005 and again between 2005 and 2009 [8].

Repeatedly, it has been posited that greater economic wealth measured by GDP and a greater public investment

COMP 562, The University of North Carolina at Chapel Hill, USA

in education benefits a country's state of education [10]. We analyze a correlation between the percentage of a country's national population enrolled in school and a country's GDP per capita and expenditure on education. This paper is organized as follows: Section 1 provides the background and motivation for our analysis; Section 2 explains our data; Section 3 details our clustering methodology based upon latent variable modeling; and Section 4 and 5 present our results and conclusion, respectively.

2 DATA

We used two datasets provided by the United Nations at *https://data.un.org/*. The "Public expenditure on education" dataset provides the following information on all countries between 2002 and 2017: expenditure type, level of education, total government expenditure, and GDP. The "Enrollment in primary, secondary, and tertiary education levels" dataset provides the following information on all countries for the same time period: number of student enrolled in primary, secondary, and tertiary education levels and gross enrollment values. We combined this information to form our single, master dataset described in the Table 1.

3 METHODOLOGY

We evaluate the relationship between a country's gross domestic product (GDP) per capita, public expenditure on education, and education enrollment levels. To do so, we minimize the negative log-likelihood of a Beta Mixture Model (Equations 1-4) and cluster countries based on the percentages of population enrolled in primary (x_1), secondary (x_2), and tertiary (x_3) education [1]. Lastly, we compute a p-value to correlate our clusters with low, middle, high GDP per capita; and low, middle, high expenditure on education.

Our (1) likelihood, (2) marginal, (3) prior, and (4) posterior models are specified below. P-values for the hypothetical intervals of each category are presented in table's 2 and 3.

Likelihood

$$p(x_1^{(i)}, x_2^{(i)}, x_3^{(i)}|k) = \prod_{j=1}^{3} Beta(a_{jk}, b_{jk}) \tag{1}$$

Marginal

$$p(x_1^{(i)}, x_2^{(i)}, x_3^{(i)}) = \sum_{k=1}^{k} \prod_{j=1}^{3} Beta(a_{jk}, b_{jk}) P(k) \tag{2}$$

Prior

$$P(k) = Cat(k) \tag{3}$$

[1]Enrollment percentages (x_1, x_2, x_3) assume all countries have the same age distribution.

Posterior

$$p(k|x_1^{(i)}, x_2^{(i)}, x_3^{(i)}) = \frac{p(x_1^{(i)}, x_2^{(i)}, x_3^{(i)}|k)P(k)}{\sum_c p(x_1^{(i)}, x_2^{(i)}, x_3^{(i)}|c)P(c)} \tag{4}$$

	< 3,500	3,500 - 45,000	> 45,000
Cluster 1	3.47e-12	9.9e-1	9.92e-1
Cluster 2	9.96e-1	2.07e-2	4.37e-2
Cluster 3	9.99e-1	2.41e-3	5.59e-2

Table 2: P-values for GDP Per Capita. Less than 5.0e-2 at (i,k) imply a correlation between cluster at row i and GDP per capita interval at column k

	< 3.2%	3.2 - 5.4%	> 5.4%
Cluster 1	2.39e-3	1.25e-1	9.93e-1
Cluster 2	9.60e-1	8.66e-1	9.50e-4
Cluster 3	5.25e-1	2.41e-1	4.35e-1

Table 3: P-values for Public Expenditure. Less than 5.0e-2 at (i,k) imply a correlation between cluster at row i and percentage of GDP spent on education at column k

4 RESULTS

From figures 1 and 2, we see three clearly distinguishable clusters. Table 2 confirms the correlation between enrollment and GDP per capita. We see that countries with a greater GDP per capita invest exhibit overall greater school enrollment levels across primary, secondary, and tertiary education. Additionally, Figure 1 show countries with GDP per capita less than 3.2% of their GDP invested in education do not exhibit significant enrollment in tertiary education, while countries with GDP greater than $3500 have a disproportionately greater investment and outcomes in tertiary education. Here too, there is a clear divide between the purple, blue, and yellow clusters that represent countries with low, middle, and high levels of wealth respectively. Figure 2 also shows that countries in the purple cluster with less than $3500 GDP per capita do not ever appropriate greater than 7% of their funds towards education. In contrast, educational investment by countries with higher income per capita is more broadly distributed but overall exhibits an increase in education enrollment.

Column / Feature Name	Description
Country	Country name
Year	A value between 2002 and 2017
Public expenditure on primary education	% of total government expenditure on education
Public expenditure on secondary education	% of total government expenditure on education
Public expenditure on tertiary education	% of total government expenditure on education
Public expenditure on education	% of a country's GDP
Gross domestic product (GDP)	GDP in current prices in U.S. Dollars (millions)
GDP per capita	Price value in U.S. Dollars
Population	Mid-year population estimate (millions)
Primary education students	Number of students enrolled in primary education (thousands)
Secondary education students	Number of students enrolled in secondary education (thousands)
Tertiary education students	Number of students enrolled in tertiary education (thousands)

Table 1: Data Features

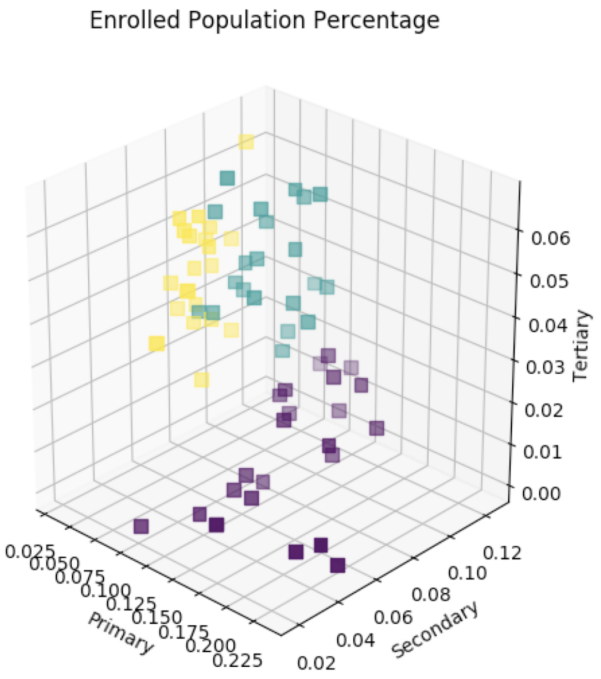

Figure 1

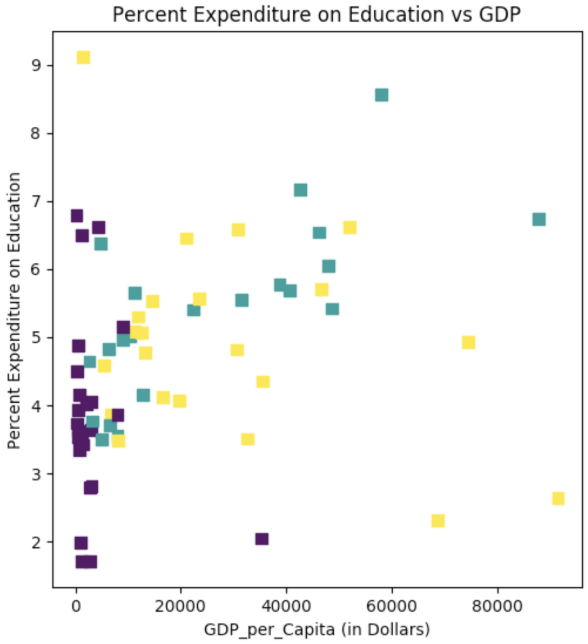

Figure 2

5 CONCLUSION

Our project goal was to analyze the relationship between a country's wealth, public expenditure on education, and enrollment levels. We implemented clustering analysis to achieve our goal using a latent variable model and reached the following conclusions. Countries with a higher gross domestic product do appropriate more money towards public funding of education and exhibit greater enrollment rates across primary, secondary, and tertiary education levels. We used Python, Tensorflow, Jupyter Notebook, Latex, and Overleaf for this project. Our code and related files are available on GitHub at *https://github.com/SaumyashreeRay/PublicEducation*.

6 FUTURE WORK

We used a limited number of features in our analysis. In the future, we would like to include more economic and education descriptors such as education enrollment distribution

by gender or region. Furthermore, we would like to compare our latent variable model with other, simpler models such as k-means clustering to understand how they compare. We also could wish to extend the data by including information over a larger span of years.

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