# Quality of Education's Effects on Renewable Energy Consumption

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**Introduction**

The world has made rapid progress in adopting sources of renewable energy in the past decade; worldwide renewable energy production in 2019 was almost twice that of 2009 (Our World in Data 2019)[1]. Many new technologies, including the emergence of more affordable solar panels and competitive EV models from Tesla, Porsche, Ford, GM, and other manufacturers, have aided nations in reducing their reliance on fossil fuel imports and greenhouse emissions ("Electric Vehicle Benefits")[2]. While the adoption of renewable energy may be strongly correlated with GDP or GDP per capita due to the costliness of renewable energy technology (Johnson 2014)[3], it will be valuable nevertheless to build upon existing literature and analyze the impact of similar factors on renewable energy adoption. This will provide insight into how renewable energy adoption can be expedited around the world to reduce greenhouse gas emissions. In this vein, a particularly interesting question is whether better-educated populations strive to consume more renewable energy as a result of environmental concerns driven by education.

My initial hypothesis is that countries with better education systems will consume more renewable energy because of increased environmental awareness. Faruq and Taylor (2011) demonstrate that there is a positive relationship between GDP per capita and quality of education (p. 224). In addition, Thai-Ha et al. (2011) find that countries that consume more renewable energy, more non-renewable energy, or both experience more economic growth (p. 74). If countries with higher GDP per capita tend to have higher quality education systems, I predict that these countries will also consume more renewable energy relative to those with lower GDP per capita; countries like Sweden, Norway, and Germany are examples of leaders in renewable energy that have high quality education systems and relatively high GDP per capita and economic growth rates. According to my hypothesis, then, countries with higher GDP per capita will have higher quality education systems, and I predict that these countries will consume more renewable energy than countries with lower GDP per capita. It will be interesting to analyze whether more economically developed countries consume more renewable energy to drive economic growth relative to developing nations.

My objective for this research paper is to analyze the effects of higher-quality education systems on countries' renewable energy consumption. My secondary objective will be to assess the impact of other factors related to education on renewable energy adoption, such as countries' population demographics and trade openness.

My regression will employ econometric literature by Wall et al. (2019), Doytch and Narayan (2015), Tsaurai and Ngcobo (2019), Faruq and Taylor (2011), Thai-Ha et al. (2011), and Al-mulali et al. (2016) to build a persuasive framework and control for a variety of possible unobservables in the analysis of education's effects on renewable energy consumption in 77 countries in the first main regression and 194 countries in the second, third, and fourth main regressions.

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[1] https://ourworldindata.org/renewable-energy
[2] https://www.energy.gov/eere/electricvehicles/electric-vehicle-benefits
[3] https://www.economist.com/the-economist-explains/2014/01/05/why-is-renewable-energy-so-expensive

**Literature Review**

In “Which policy instruments attract foreign direct investments in renewable energy?”, Wall et al. (2019) examine the relationship between environmental policies and foreign direct investment in renewable energy and identify which policies attract the most foreign direct investment in renewable energy. The authors employ an ordinary least squares (OLS) model with a country-level panel data which includes quality of education as a control variable (Wall et al., 2019, p. 63). Thai-Ha et al.’s (2020) work “Renewable and Nonrenewable Energy Consumption, Economic Growth, and Emissions: International Evidence” finds that consuming more renewable and non-renewable energy increases economic growth for both developing and developed countries (p. 74). The quality of education control variable in Wall et al.’s work and renewable energy consumption in Thai-Ha et al.’s galvanized me to study the relationship between education quality and renewable energy consumption. Using these papers’ models as a foundation, the GDP, education quality, and renewable energy consumption variables will be important to control for in my regression.

Doytch and Narayan’s (2015) work, “Does FDI influence renewable energy consumption? An analysis of sectoral FDI impact on renewable and non-renewable industrial energy consumption,” explores the effects of foreign direct investment on industrial energy consumption by controlling for GDP per capita and energy prices (2015, p. 291). The authors find that in high-income countries, increased foreign direct investment in financial services decreased consumption of non-renewables and increased consumption in renewable energy (Doytch and Narayan, 2015, p. 293, 300). Similarly, in “Quality of Education, Economic Performance and Institutional Environment,” Faruq and Taylor (2011) discover that there is a positive relationship between nations’ quality of education and GDP per capita (p. 224). To control for the effects of GDP per capita on education, GDP per capita will be integral to the education-renewable energy regression in this paper, and a variable capturing energy prices will control for the effects of higher non-renewable energy prices on renewable energy consumption.

Tsaurai and Ngcobo’s (2019) paper, “Renewable Energy Consumption, Education and Economic Growth in Brazil, Russia, India, China, South Africa,” studies the impact of renewable energy consumption on economic growth and discovers that higher levels and quality of education directly increase the amount that renewable energy consumption drives economic growth (2019, p. 32). Therefore, if the world continues consuming more renewable energy instead of non-renewable energy (Our World in Data 2019)[4], countries can boost the amount that renewable energy drives economic growth by improving their education systems (Tsaurai and Ngcobo, 2019, p. 32). Besides economic growth, renewable energy consumption, and education-related variables, the authors also control for trade openness (Tsaurai and Ngcobo, 2019, p. 29). Likewise, Zeren and Akkuş (2019) discover that higher levels of trade openness is a determinant of higher national non-renewable energy consumption (p. 322). Due to this effect, trade openness should be controlled for in my regression.

According to The World Bank’s “SE4ALL Global Tracking Framework,” rising energy demand and population growth negatively affect growth in renewable energy and “wipe out” gains made in renewable energy consumption (2013). Since population size has a negative effect on renewable energy consumption, it is necessary to control for population and other demographic-related variables in my regression.

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[4] https://ourworldindata.org/renewable-energy

In “Does moving towards renewable energy cause water and land inefficiency? An empirical investigation” by Al-mulali et al. (2016), the authors control for urbanization, GDP growth, and trade openness in their analysis of the effects of renewable energy production on countries’ ecological footprints (2016, p. 304). According to Al-mulali et al., renewable energy production increases land and water inefficiency because it increases countries’ ecological footprints and degradation of the environment (Ali-mulali et al., 2016, p. 303, 311). This relationship indicates that countries with less land area may be more constrained in adopting renewable energy than countries with more land area due to land inefficiency concerns (Ali-mulali et al., 2016, p. 311). To control for this, my regression will control for countries’ land area.

This paper will employ the regression framework from the literature above to illuminate the hypothesized relationship between countries’ education systems and their renewable energy consumption.

**Theory of Equations**

This work aims to build off the framework created by the econometric literature by Wall et al. (2019), Doytch and Narayan (2015), Tsaurai and Ngcobo (2019), Faruq and Taylor (2011), Thai-Ha et al. (2011), and Al-mulali et al. (2016). The LHS[5] variable, renewable energy consumption as a percentage of total national energy consumption, will be regressed on the education-related and energy, trade, and demographic-related independent variables for each country from 1998 to 2018.

Renewable energy consumption can be represented by dependent variable $Y_i$.

$Y_i$ =,

In their regression analyzing the effects of policy on foreign investment in renewable energy, Wall et al. include quality of education-related variables as general controls for the degree that more highly educated populations attract foreign direct investment (Wall et al., 2019, p. 64). Tsaurai and Ngcobo (2019) also employ education as an independent variable in their renewable energy-economic growth regression (p. 29). The quality of nations' education systems will be proxied by PISA, or the Programme for International Student Assessment, which measures 15-year-olds' performance on mathematics, science, and reading exams. This regression will employ PISA science, math, and science exam scores specifically, which are measured once every three years. In a second regression, I will proxy education quality with gross secondary school enrollment percentages on a country level. I expect PISA exam scores to be positively correlated with renewable energy consumption as a percentage of total final energy consumption, and I expect gross secondary enrollment percentages to be positively correlated with renewable energy consumption as well.

In a third regression, I will use educational attainment by education level as a proxy for educational quality, in which the education levels are primary, bachelor's, short-cycle tertiary, and doctorate. The data is measured as a percentage of the 25-years-old and above population that has attained each level. A fourth regression will use government spending on education as a proxy for quality of education, which includes government expenditures for primary, secondary, and tertiary public institutions as a percentage of total public education expenditures, and government expenditure on education as a percentage of total GDP. I expect educational attainment and government expenditures on education to be positively correlated with renewable energy consumption. The four education-related independent variable categories of interest will be grouped into the variable $SCHOOL_{jy}$.

In addition, Wall et al. control for countries' GDP to further isolate the effect of policy on foreign direct investment in renewable energy (2019, p. 63). Doytch and Narayan use GDP per capita (2015, p. 293). This regression will employ national GDP in current USD$, represented by *GDPUSD*, and GDP per capita in current USD$, *GDPCAP*, which will serve as national economy-level controls. Like education, I expect both the GDP (*GDPUSD*) and GDP per capita

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[5] Left-hand side

(*GDPCAP*) variables to be positively correlated with renewable energy consumption. The main regression will begin as follows:

$$Y_i = ß_0 + ß_1 SCHOOL_{jy} + ß_2 GDPUSD + ß_3 GDPCAP + \mu$$

In addition to education, Tsaurai and Ngcobo (2019) add infrastructural development and "trade openness" (p. 29) fixed effects to isolate the effects of renewable energy consumption on economic growth (p. 29). Trade openness is also a component of the regression in Al-mulali et al.'s work (2016, p. 304). This regression will include trade openness, which can be proxied by the ratio of exports and imports to GDP, *TRDOPEN*. I don't expect there to be a significant relationship between renewable energy consumption and *TRDOPEN*. This regression will also control for *LABOR*, which represents the percentage of the total working age population with intermediate education. I expect *LABOR* to be negatively correlated with renewable energy consumption because highly skilled workers may work in industries that are not natural resource intensive.

$$Y_i = ß_0 + ß_1 SCHOOL_{jy} + ß_2 GDPUSD + ß_3 GDPCAP + ß_4 LABOR + ß_5 TRDOPEN + \mu$$

In their analysis of the impact of foreign direct investment on industrial energy consumption, Doytch and Narayan control for energy prices (2015, p. 293) to help capture the effects of these rising prices on energy consumption. This regression should also control for energy prices. To accomplish this, $ENPRICE_g$ can employ the Primary Commodity Price Index, a weighted average of primary commodity indices based on benchmark prices that are representative of the global market ("Technical Documentation," 2021). I will create $ENPRICE_g$, in which g = 1, 2 for the yearly mean of the weighted average of the crude oil and coal price indices, respectively. I expect $ENPRICE_g$ to be positively correlated with renewable energy consumption; rising energy prices will encourage more renewable energy consumption. In addition, this regression should also control for fossil fuel consumption, *FOSFUEL*, which is the percentage of countries' energy consumption powered by fossil fuels. *FOSFUEL* should not be considered the base group for the renewable energy consumption percentage variable because the two percentages do not add up to 100% for the countries in the dataset. I expect *FOSFUEL* to be negatively correlated with renewable energy consumption.

$$Y_i = ß_0 + ß_1 SCHOOL_{jy} + ß_2 GDPUSD + ß_3 GDPCAP + ß_4 LABOR + ß_5 TRDOPEN + ß_6 ENPRICE_g$$

$$+ ß_7 FOSFUEL + \mu$$

In "Does moving towards renewable energy cause water and land inefficiency? An empirical investigation," Al-mulali et al. control for land area and urbanization in their regression of countries' ecological footprints on renewable energy production (Al-mulali et al., 2016, p. 304). Countries with greater land mass may be more likely to build renewable energy sources such as wind turbines and solar panel farms despite land inefficiency concerns (Al-mulali et al., 2016, p. 304). The authors use urbanization as a RHS[6] variable to control for the possible causality between urban populations and energy consumption (Al-mulali et al., 2016, p. 306). To control for these effects, this paper will also control for countries' population percentages living in urban areas, *POPURB*, and land area, *LAND*, in the regression of renewable energy consumption on education. I expect *POPURB* to be positively correlated with renewable energy consumption because highly educated individuals and schools are drawn to large urban areas. Based on the conclusions of Al-mulali et al. (2016), I expect *LAND* to be positively correlated with renewable energy consumption because countries with more land may more easily find space for land-inefficient renewable energy sources (p. 311).

$$Y_i = ß_0 + ß_1 SCHOOL_{jy} + ß_2 GDPUSD + ß_3 GDPCAP + ß_4 LABOR + ß_5 TRDOPEN + ß_6 ENPRICE_g$$

$$+ ß_7 FOSFUEL + ß_8 POPURB + ß_9 LAND + \mu$$

Besides controlling for the size of countries' urban populations, the regression should also control for other demographic-related variables. Demographics will be represented by $POP_e$, in which e = 1, 2, 3, 4 for the percentage of each country's population between 0-14-years-old, 15-64-years-old, and 65+ years-old, and the total population count of each country, respectively. This will enable the regression to control for countries' populations, which may significantly affect renewable energy consumption and education. Since the 15–64-year-old population is the largest of the three demographic groups, it will be the base group and will be omitted from the regressions. I expect the 0-14-year-old age group variable to be positively correlated with renewable energy consumption, the 15-64 age group to be negatively correlated with renewable energy consumption, and the 65+ age group to be positively correlated with renewable energy consumption. I also expect the total population count variable to be negatively correlated with renewable energy consumption because rising energy demand and population growth negatively affect growth in renewable energy, per The World Bank ("SE4ALL Global Tracking Framework", 2013). Unemployment, *UNEMP*, will also be added as a RHS variable to control for possible effects of countries' unemployed populations on renewable energy consumption. I do not expect a significant relationship between unemployment and renewable energy consumption.

$$Y_i = ß_0 + ß_1 SCHOOL_{jy} + ß_2 GDPUSD + ß_3 GDPCAP + ß_4 LABOR + ß_5 TRDOPEN + ß_6 ENPRICE_g$$

$$+ ß_7 FOSFUEL + ß_8 POPURB + ß_9 LAND + ß_{10} UNEMP + ß_{11} POP_e + \mu$$

The main regression model this paper employs is the following:

[6] Right-hand side

$Y_i = ß_0 + ß_1 SCHOOL_{jy} + ß_2 GDPUSD + ß_3 GDPCAP + ß_4 LABOR + ß_5 TRDOPEN + ß_6 ENPRICE_g + ß_7 FOSFUEL + ß_8 POPURB + ß_9 LAND + ß_{10} UNEMP + ß_{11} POP_e + \mu$ in which $Y_i$ is the renewable energy consumption percentage of total national energy consumption.

**Data Section**

This work includes a panel data for 77 countries[7] for the first regression and 194 countries[8] for the second, third, and fourth regressions. The panel data is composed of data sets from select sources covering a 21-year time period from 1998 – 2018. This time period was chosen because the data was most complete and consistent starting in 1998. The panel data ends in the year 2018 because the dataset was not complete past this date. The data is measured from 1998 to 2018 unless stated otherwise. Summary statistics are provided in Appendix F.

In the regression, the education proxy, $SCHOOL_{jy}$, is composed of four primary independent variables of interest. In the first regression, education quality will be represented by PISA, or the Programme for International Student Assessment, which is an international exam taken by 15-year-olds and administered every three years. This paper will analyze PISA science, math, and reading exam scores specifically. The PISA data is limited to the 2000 to 2018 timeframe and was measured in 2000, 2003, 2006, 2009, 2012, 2015, and 2018, with some exceptions for some countries. The PISA data set is composed of three different variables: (1) Each country's mean performance on the science exam, (2) each country's mean performance on the mathematics exam, and (3) each country's mean performance on the reading exam. The PISA science, mathematics, and reading data was extracted from Our World in Data[9]. In the second regression, gross secondary school enrollment percentages on a country level will be a proxy for quality of education. The enrollment data was measured yearly and was extracted from The World Bank[10]. The third proxy for education quality consists of primary, bachelor, short-cycle tertiary, and doctorate degree attainment percentages. The data is measured yearly as a percentage of the 25-years-old and above population that has attained each education level. This data was extracted from The World Bank[11]. The fourth proxy for education quality includes government expenditures for primary, secondary, and tertiary public institutions as a percentage of total public education expenditures, and government expenditure on education as a percentage of total GDP. This data is measured yearly as percentages and was extracted from The World Bank[12].

As the line of best fit indicates in Figure 1, countries with a higher mean mathematics exam score generally consume less renewable energy as a percentage of total final energy consumption. Figures 2 and 3 also demonstrate inverse relationships between countries'

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[7] Appendix A and Appendix B
[8] Appendix C and Appendix D
[9] Source for PISA exam score data: https://databank.worldbank.org/source/world-development-indicators
[10] Source for secondary school enrollment data: https://databank.worldbank.org/source/world-development-indicators
[11] Source for educational attainment data: https://databank.worldbank.org/source/world-development-indicators
[12] Source for government education expenditure data: https://databank.worldbank.org/source/world-development-indicators

renewable energy consumption as a percentage of total final energy consumption and the mean PISA reading and science exam scores.

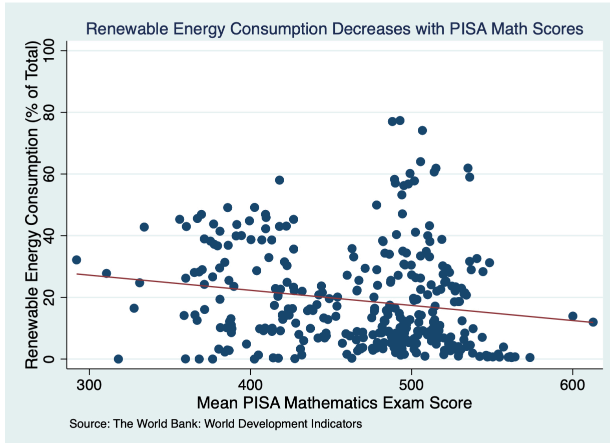


Figure 1: Countries' renewable energy consumption as a percentage of total final energy consumption and countries' mean PISA mathematics exam scores.

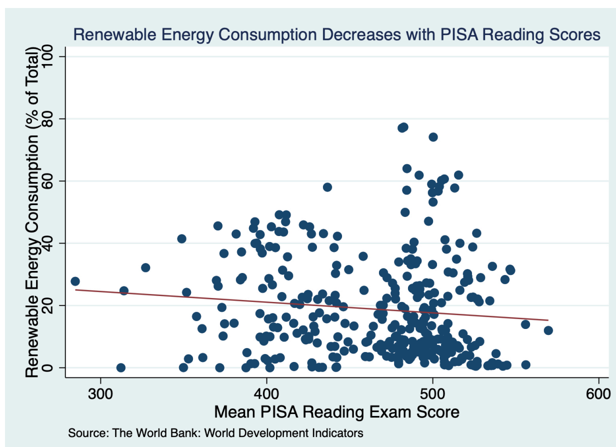


Figure 2: Countries' renewable energy consumption as a percentage of total final energy consumption and countries' mean PISA reading exam scores.

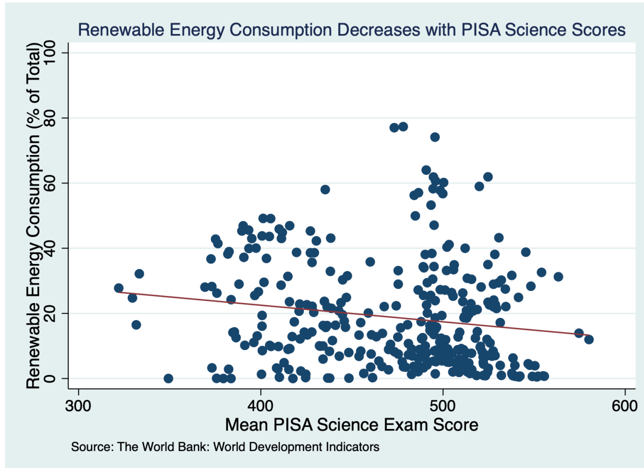


Figure 3: Countries' renewable energy consumption as a percentage of total final energy consumption and countries' mean PISA science exam scores.

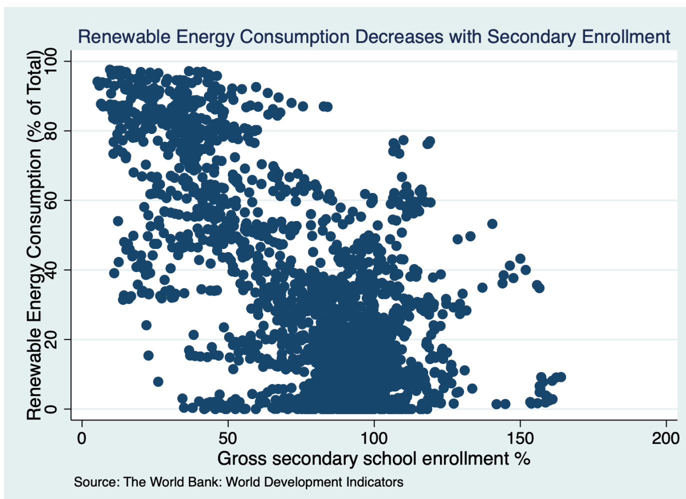


Figure 4: Countries' renewable energy consumption as a percentage of total final energy consumption and countries' gross secondary enrollment percentages.

Figure 4 demonstrates an inverse relationship between gross secondary school enrollment percentages and renewable energy consumption as a percentage of total final energy consumption. The outlier countries that had renewable energy consumption above 70% and secondary enrollment percentages above 60% are Bhutan, Iceland, Nepal, and Paraguay. Figure 5, which plots the relationship between government spending on education and renewable energy consumption, also provides some interesting insight: According to the best fit line, countries with higher government expenditures on education as a percentage of GDP generally consume less renewable energy.

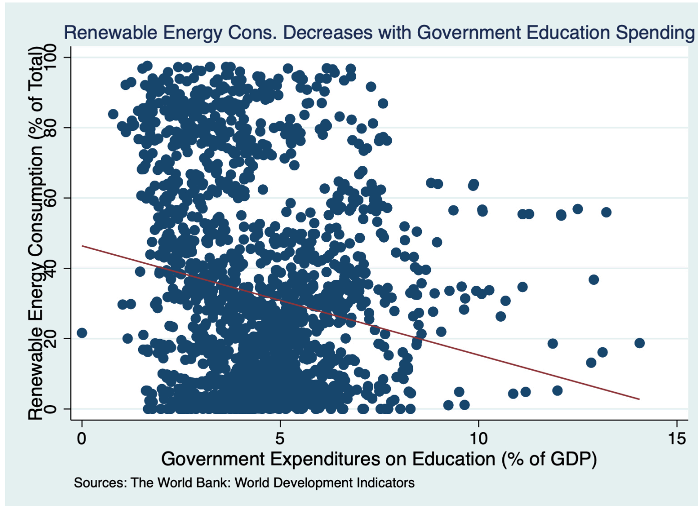


Figure 5: The percentage of GDP that countries' governments spend on education and countries' renewable energy consumption as a percentage of total final energy consumption.

The renewable energy consumption as a percentage of total energy consumption, or $Y_i$, and GDP and GDP per capita variables, *GDPUSD* and *GDPCAP*, were measured yearly on a country-level and were extracted from The World Bank[13]. The age-related demographics variable, $POP_e$, in which e=1 to 4, includes the percentage of each country's population in the 0-14 (e=1), 15-64 (2), and 65+ year-old (3) age groups, was measured yearly and was extracted from The World Bank[14]. The population count data, which is e=4 in $POP_e$, was measured yearly and was extracted from The World Bank[15]. The unemployment variable, *UNEMP*, measures the percentage of each country's labor force with basic education that is unemployed, and this data was measured yearly by country and was extracted from The World Bank[16].

According to Figure 6, there appears to be an inverse relationship between a country's renewable energy consumption as a percentage of total final energy consumption and its GDP. Countries with higher GDP appear to consume less renewable energy as a percentage of total energy consumption. The countries with relatively high GDP in USD$ and low renewable energy consumption as a percentage of total final energy consumption are China, Japan, and the United States.

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[13] Source for GDP and GDP per capita data: https://databank.worldbank.org/source/world-development-indicators
[14] Source for population demographics data: https://databank.worldbank.org/source/world-development-indicators
[15] Source for population data: https://databank.worldbank.org/source/world-development-indicators
[16] Source for unemployment data: https://databank.worldbank.org/source/world-development-indicators

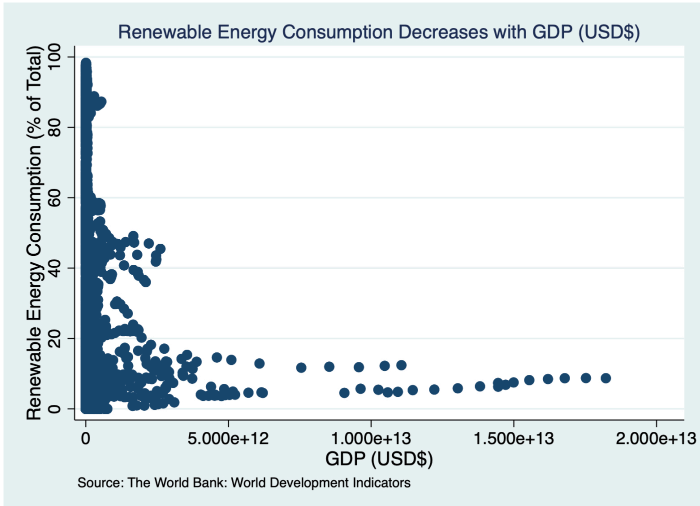


Figure 6: The GDP of each country in USD$ and countries' renewable energy consumption as a percentage of total final energy consumption.

According to Figure 7, countries with higher GDP per capita in USD$ have lower levels of renewable energy consumption as a percentage of total final energy consumption. There were several outlier nations that had a GDP per capita in USD$ above $50,000 and renewable energy consumption as a percentage of total final energy consumption above 50%. These nations are Iceland, Liechtenstein, Norway, and Sweden.

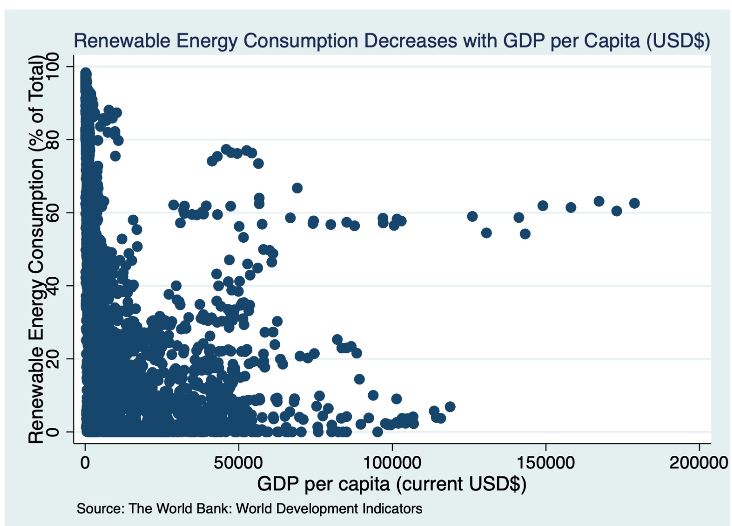


Figure 7: The GDP per capita of each country in USD$ and countries' renewable energy consumption as a percentage of total final energy consumption.

Figures 8, 9, and 10 display the relationship between countries' population demographics and those countries' renewable energy consumption as a percentage of total final energy consumption. According to Figure 8, countries with a higher percentage of people between the ages of 0-14-years-old generally consume more renewable energy as a percentage of total final energy consumption. The outlier countries, which had 0-14-year-old population percentages above 40% and renewable energy consumption above 95%, are Burundi, Dem. Rep. of the Congo, Ethiopia, and Chad. Figure 9, which displays that relationship but for the 15-64-year-old population percentage variable, displays a negative relationship between this population and renewable energy consumption. The outlier countries had 15-64-year-old population percentages that were more than 55% and renewable energy consumption percentages that were above 90%, and these countries are Bhutan, Nepal, and Rwanda. The graph depicting the relationship between renewable energy consumption as a percentage of total final energy consumption and the percentage of countries' populations above 64-years-old, Figure 10, is not as clear. There appears to be an inverse relationship between higher percentages of populations above 64-years-old and higher levels of renewable energy consumption as a percentage of total final energy consumption. The outlier country in Figure 10 is Iceland, which had a renewable energy consumption percentage above 60% and a 65-years-old and above population percentage above 10%. Figure 11 demonstrates an unexpected relationship: Countries with higher percentages of the total population living in urban areas, which is represented by *POPURB*, consume less renewable energy as a percentage of total final energy consumption than countries with lower percentages of the total population living in urban areas. The outlier countries in Figure 11, which have a renewable energy consumption percentage above 60% and an urban population percentage above 80%, are Gabon and Iceland. I expected a positive relationship between these two variables.

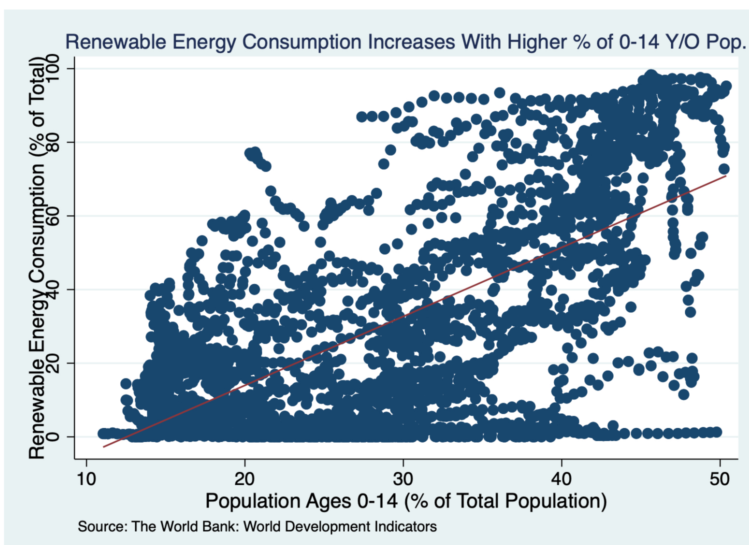


Figure 8: The percentage of each country's population between 0-14-years-old and countries' renewable energy consumption as a percentage of total final energy consumption.

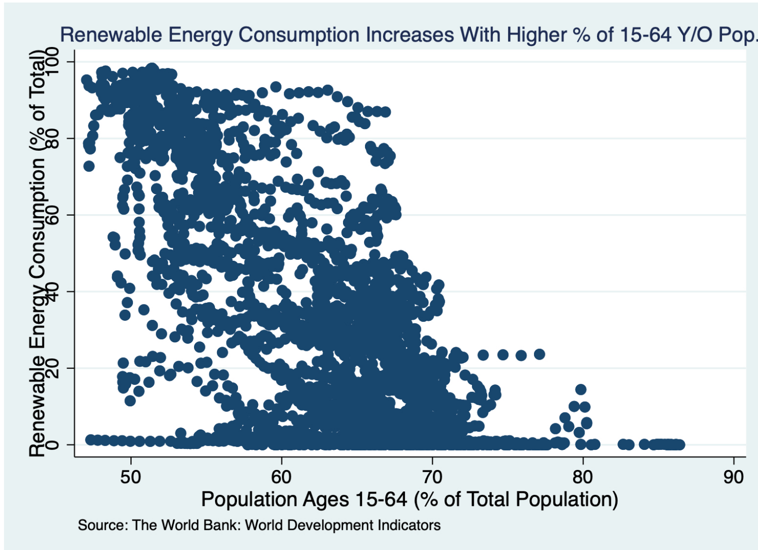


Figure 9: The percentage of each country's population between 15-64-years-old and countries' renewable energy consumption as a percentage of total final energy consumption.

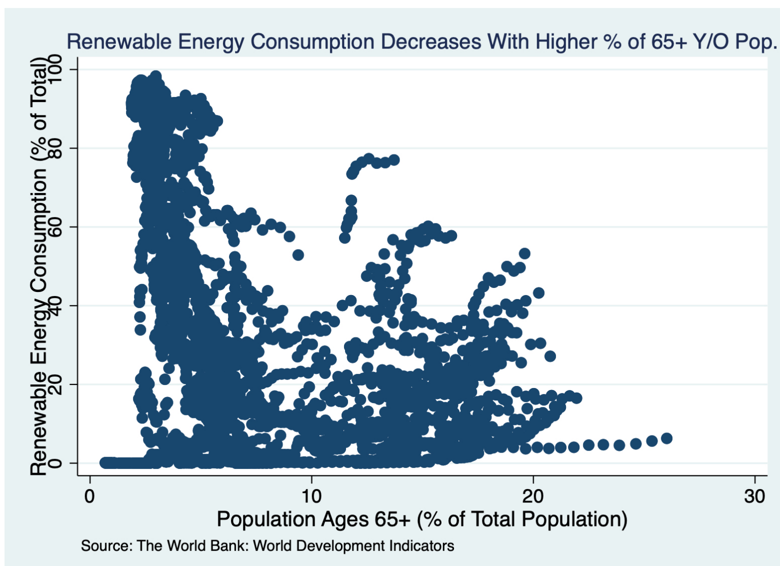


Figure 10: The percentage of each country's population above 64-years-old and countries' renewable energy consumption as a percentage of total final energy consumption.

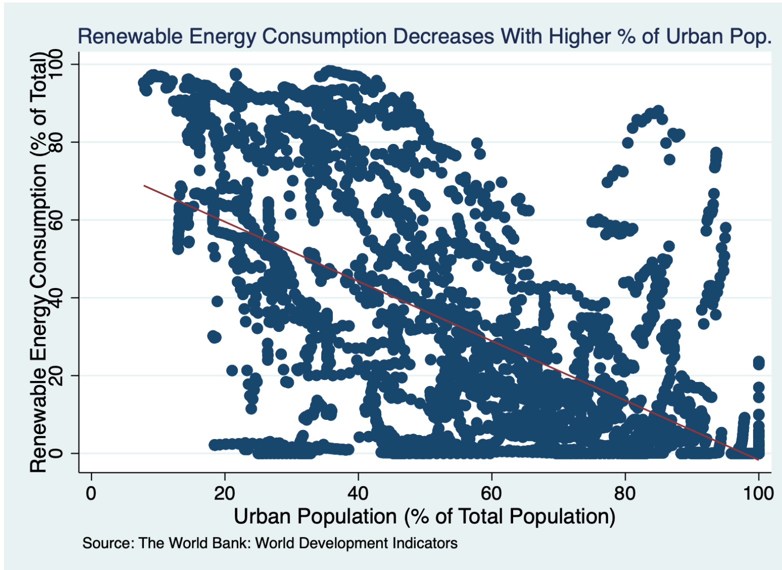


Figure 11: The percentage of each country's population that lives in an urban area and countries' renewable energy consumption as a percentage of total final energy consumption.

The land area data, *LAND*, was not measured yearly, was measured in square kilometers, and was extracted from The World Bank, and the fossil fuel consumption as a percentage of total final energy consumption data, *FOSFUEL*, was also measured yearly and was extracted from The World Bank[17]. The fossil fuel energy price data, $ENPRICE_g$, was measured monthly but not on a country-specific level, and it was extracted from the International Monetary Fund database[18]. $ENPRICE_g$ includes g=1, 2 for (1) the yearly mean of the weighted average of the crude oil price index, and (2) the yearly mean of the weighted average of the coal price index, all in USD$ in which 2016 is the base year and 2016=100. I employed the monthly data to create yearly means for each variable within $ENPRICE_g$. $ENPRICE_g$ employs the Primary Commodity Price Index, which is a weighted average of primary commodity indices based on benchmark prices that are representative of the global market ("Technical Documentation," 2021). This data may help control for the effects of fluctuating energy prices on energy consumption. The trade openness data for *TRDOPEN* was extracted from Our World in Data and represents the sum of each country's exports and imports as a percentage of that country's GDP each year[19].

The percentage of the labor force with intermediate education, *LABOR*, was measured yearly and was extracted from The World Bank[20]. According to The World Bank, intermediate education is upper-secondary or post-secondary education, excluding terminal degrees. The relationship between this variable and renewable energy consumption is shown in Figure 12. As shown by the best fit line, countries with higher percentages of workers with an intermediate

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[17] Source for land area and fossil fuel consumption data: https://databank.worldbank.org/source/world-development-indicators
[18] Source for energy price index data: https://www.imf.org/en/Research/commodity-prices
[19] Source for trade openness data: https://ourworldindata.org/grapher/trade-openness
[20] Source for labor force with intermediate education data: https://data.worldbank.org/indicator/SL.TLF.INTM.ZS

education level generally consume more renewable energy. The outlier nation in Figure 12 is Botswana, which reported a labor force with intermediate education rate of 100%, while its renewable energy consumption was 29.36%.

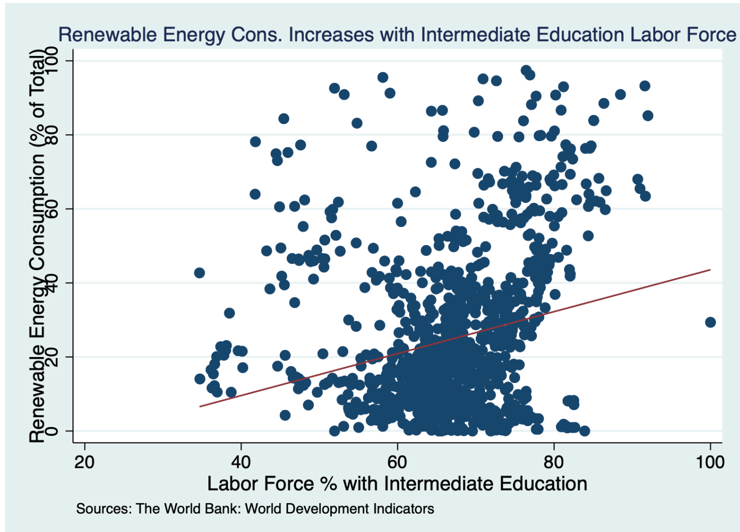


Figure 12: Labor force percentage with intermediate education and countries' renewable energy consumption as a percentage of total final energy consumption.

| | **MATH** | **SCIENCE** | **READ** |
|---|---|---|---|
| **MATH** | 1 | | |
| **SCIENCE** | 0.9674 | 1 | |
| **READ** | 0.9416 | 0.9666 | 1 |

Figure 13: Correlation matrix for mean PISA mathematics, science, and reading scores.

According to Figure 13, mathematics, science, and reading mean PISA exam scores are highly correlated. These relationships suggest that they will have the same sign in the subsequent regression.

**Results**

Before conducting a full regression of renewable energy on mean PISA exam scores and the control variables, it is vital to analyze the effects of the independent variables piece-by-piece to better understand the true relationships in the data. According to Specifications (1) and (2) of Side Regression I, mean PISA mathematics and reading scores by themselves are negatively correlated with national renewable energy consumption. When mean reading PISA scores are included with mathematics—or both science and mathematics—PISA scores in the same regression, however, the mean reading PISA score coefficient flips signs and becomes positive. Specifications (5) and (6) control for natural resource and demographic-related variables, respectively, in addition to the mean PISA scores.

**Side Regression I**

Dependent Variable: Renewable Energy Consumption as a Percentage of Total Final Energy Consumption

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| VARIABLES | RENEW | RENEW | RENEW | RENEW | RENEW | RENEW |
| | | | | | | |
| MATH | -0.040** | | -0.180*** | -0.066 | -0.007 | -0.135 |
| | (-2.561) | | (-3.971) | (-1.089) | (-0.178) | (-1.647) |
| READ | | -0.021 | 0.166*** | 0.289*** | 0.177*** | 0.193** |
| | | (-1.220) | (3.285) | (4.358) | (3.531) | (2.188) |
| SCIENCE | | | | -0.248*** | -0.240*** | -0.156 |
| | | | | (-2.823) | (-4.122) | (-1.536) |
| FOSFUEL | | | | | -0.681*** | |
| | | | | | (-22.786) | |
| CRUDEDOIL | | | | | 0.027 | |
| | | | | | (0.338) | |
| COAL | | | | | -0.007 | |
| | | | | | (-0.056) | |
| TRDOPEN | | | | | -0.026** | |
| | | | | | (-2.431) | |
| LAND | | | | | 0.000 | |
| | | | | | (0.602) | |
| POPURB | | | | | | -0.202*** |
| | | | | | | (-2.735) |
| UNEMP | | | | | | 0.056 |
| | | | | | | (0.455) |
| GDPUSD | | | | | | -0.000 |
| | | | | | | (-1.632) |
| GDPCAP | | | | | | 0.000** |
| | | | | | | (2.031) |
| POP014 | | | | | | 0.959** |
| | | | | | | (2.350) |

| | | | | | | |
|---|---|---|---|---|---|---|
| POP65PLUS | | | | | | 1.252*** |
| | | | | | | (3.315) |
| POPTOTAL | | | | | | -0.000 |
| | | | | | | (-0.048) |
| LABOR | | | | | | 1.155*** |
| | | | | | | (8.239) |
| Constant | 37.640*** | 28.858*** | 25.549*** | 32.182*** | 103.267*** | -38.537* |
| | (5.153) | (3.525) | (3.160) | (3.860) | (15.098) | (-1.842) |
| | | | | | | |
| Observations | 330 | 333 | 330 | 330 | 263 | 255 |
| R-squared | 0.020 | 0.004 | 0.051 | 0.074 | 0.708 | 0.359 |
| T-statistics in parentheses | | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | | |

After conducting Side Regression I, mean reading, science, and mathematics PISA scores are added one-by-one in Specifications (1)-(3) of Main Regression I, and then together in Specification (5).

**Table 1: Main Regression I**

Dependent Variable: Renewable Energy Consumption as a Percentage of Total Final Energy Consumption

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| VARIABLES | RENEW | RENEW | RENEW | RENEW | RENEW |
| | | | | | |
| READ | -0.102*** | | | 0.070 | 0.213*** |
| | (-4.272) | | | (1.260) | -3.043 |
| SCIENCE | | -0.129*** | | | -0.238*** |
| | | (-5.603) | | | (-3.249) |
| MATH | | | -0.122*** | -0.182*** | -0.096* |
| | | | (-5.500) | (-3.452) | (-1.662) |
| FOSFUEL | -0.593*** | -0.599*** | -0.600*** | -0.605*** | -0.607*** |
| | (-16.084) | (-16.715) | (-16.617) | (-16.670) | (-17.120) |
| CRUDEDOIL | -0.118 | -0.100 | -0.099 | -0.091 | -0.072 |
| | (-1.326) | (-1.162) | (-1.150) | (-1.045) | (-0.852) |
| COAL | 0.189 | 0.163 | 0.158 | 0.145 | 0.13 |
| | (1.396) | (1.244) | (1.194) | (1.100) | -1.005 |
| TRDOPEN | -0.076*** | -0.068*** | -0.069*** | -0.064*** | -0.055*** |
| | (-4.943) | (-4.532) | (-4.546) | (-4.092) | (-3.542) |
| LAND | 0.000 | 0.000 | 0.000 | 0.000 | 0 |
| | (1.138) | (1.312) | (0.975) | (0.869) | -1.126 |
| POPURB | -0.147** | -0.164*** | -0.142** | -0.140** | -0.174*** |
| | (-2.372) | (-2.729) | (-2.356) | (-2.322) | (-2.912) |
| UNEMP | 0.049 | 0.054 | 0.019 | -0.016 | -0.002 |

| | | | | | |
|---|---|---|---|---|---|
| | (0.400) | (0.463) | (0.163) | (-0.130) | (-0.017) |
| GDPUSD | -0.000* | -0.000 | -0.000 | -0.000 | 0 |
| | (-1.712) | (-1.444) | (-1.564) | (-1.612) | (-1.338) |
| GDPCAP | 0.000*** | 0.000*** | 0.000*** | 0.000*** | 0.000*** |
| | (4.172) | (4.519) | (4.747) | (4.559) | -4.03 |
| POP014 | -0.561 | -0.703* | -0.797* | -0.804* | -0.866** |
| | (-1.347) | (-1.735) | (-1.928) | (-1.950) | (-2.148) |
| POP65PLUS | -1.213*** | -1.096** | -1.214*** | -1.156** | -1.004** |
| | (-2.620) | (-2.443) | (-2.665) | (-2.529) | (-2.237) |
| POPTOTAL | -0.000 | -0.000 | -0.000 | -0.000 | 0 |
| | (-1.300) | (-1.455) | (-1.518) | (-1.473) | (-1.463) |
| LABOR | 0.325*** | 0.379*** | 0.383*** | 0.388*** | 0.430*** |
| | (2.81) | (3.34 ) | (3.36) | (3.41) | (3.841) |
| 2003.Year | -1.902 | -1.296 | -1.380 | -1.047 | -0.240 |
| | (-0.831) | (-0.583) | (-0.619) | (-0.467) | (-0.109) |
| 2006.Year | -0.652 | 0.003 | -0.494 | -0.118 | 1.239 |
| | (-0.229) | (0.001) | (-0.179) | (-0.043) | (0.452) |
| 2009.Year | -5.735* | -4.699 | -4.924* | -4.241 | -2.879 |
| | (-1.875) | (-1.587) | (-1.654) | (-1.404) | (-0.967) |
| 2012.Year | - | - | - | - | - |
| | | | | | |
| 2015.Year | - | - | - | - | - |
| | | | | | |
| Constant | 131.790*** | 142.387*** | 140.849*** | 135.133*** | 137.460*** |
| | (6.356) | (7.177) | (7.114) | (6.663) | -6.939 |
| | | | | | |
| Observations | 213 | 213 | 212 | 212 | 212 |
| R-squared | 0.737 | 0.752 | 0.751 | 0.753 | 0.766 |
| T-statistics in parentheses | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | |

In Main Regression I, some independent variables that were predicted to be statistically significant are not. *ENPRICE*$_g$, which is composed of energy price data in USD$ with 2016 as the base year, is not statistically significant. Surprisingly, neither the size of countries' land area, *LAND*, nor the unemployed rate for workers with basic education, *UNEMP*, is statistically significant. The total population count of each country, *POPTOTAL*, is also not statistically significant in these specifications. The variables that are statistically significant at the 99 percent confidence level are mean PISA reading scores (*READ*), mean PISA science scores (*SCIENCE*), the percentage of energy consumption from fossil fuels (*FOSFUEL*), trade openness (*TRDOPEN*), the percentage of the population living in urban areas (*POPURB*), GDP per capita (*GDPCAP*), and the percentage of the total working age population with intermediate education (*LABOR*). The variables that are statistically significant at the 95 percent confidence level are the 0-14-years-old population percentage (*POP014*) and the 65-years-old and above population percentage (*POP65PLUS*). The variable that is statistically significant at the 90 percent confidence level is mean PISA mathematics scores (*MATH*). Coefficients stayed relatively constant across Specifications (1) – (5).

Similar to the results of Side Regression I, the mean mathematics and science PISA exam scores are negatively correlated with renewable energy consumption in Main Regression I. One-hundred-point increases in a country's mean mathematics PISA exam score and mean science PISA exam score are associated with 9.6 and 23.8% decreases in that country's renewable energy consumption, respectively. Appendix G demonstrates that many of the countries with the highest mean PISA science scores, such as Hong Kong, Japan, Macao, Russian Federation, and Singapore, have relatively low levels of renewable energy consumption. As hypothesized, however, reading scores and renewable energy consumption are positively correlated: A one-hundred-point increase in a country's mean reading PISA exam score increases renewable energy consumption by 21.3%, and this is statistically significant at the 99 percent confidence level. This indicates that there may be a causal relationship between the quality of countries' reading programs in schools and national renewable energy consumption. From this finding, it seems reasonable to infer that better reading programs may heighten environmental consciousness. Appendix H compares countries with both higher-than-average PISA reading scores and renewable energy consumption. As depicted in Appendix H, the positive relationship between renewable energy consumption and mean PISA reading scores is generally being driven by Europe. Appendix I includes a plot of PISA scores by country and displays strong collinearity between mathematics, reading, and science scores.

According to Appendix P, which shows regression results for European countries specifically, the coefficients on mean PISA mathematics, reading, and science scores generally match those of the international sample in Main Regression I. In Appendix R, which is a regression specifically using South American countries, the coefficient on mean PISA reading scores is again positive, but the mean PISA science scores variable also has a positive coefficient, though it is not statistically significant.

One important finding in the first specification is that a country's level of trade openness is negatively correlated with renewable energy consumption, and this is a statistically significant relationship. A one percentage point increase in countries' level of trade openness decreases renewable energy consumption by .055 percentage points. The effect of trade openness on renewable energy consumption is not surprising, as some of the largest players in international trade have historically had relatively lower levels of renewable energy consumption, controlling for GDP (Liu and Urpelainen 2021). This conclusion is supported by Appendix T, which displays the countries with the highest mean trade openness levels across all years and their corresponding renewable energy consumption levels. Many of the countries with the highest mean trade openness, such as Luxembourg, Singapore, and Malta, consume relatively low renewable energy. In addition, contrary to my initial hypothesis, the size of countries' land area has no effect on national renewable energy consumption. This finding is contradictory to the work of Al-mulali et al. (2016), which demonstrates that countries with less land area may be less likely to adopt renewable energy because of the land-inefficiency of renewable energy sources (p. 311).

According to Main Regression I, the percentage of countries' populations living in urban areas (*POPURB*) and the unemployment rate for workers with basic education (*UNEMP*) are negatively correlated with renewable energy consumption, although *UNEMP* is not statistically significant. A one percentage point increase in the percentage of countries' populations living in urban areas decreased renewable energy consumption by .174 percentage points. The negative correlation between *POPURB* and renewable energy consumption indicates that countries with less people living in urban areas consume more renewable energy than those with more people living in urban areas, which is contrary to my hypothesis, which predicted that countries with a larger population percentage living in urban areas would consume more renewable energy due to public transportation and increased clean energy infrastructure possibilities (Renewable Energy in Cities, 2016).

Also contrary to my initial hypothesis is that GDP in USD$, GDP per capita in USD$, and total population count have no effect on renewable energy consumption. Faruq and Taylor (2011) demonstrate that countries with higher GDP per capita have higher quality education systems (p. 224), and the lack of evidence of this relationship in my paper suggests that either (1) mean PISA exam scores are not indicative of education quality, or (2) the effects of GDP and GDP per capita were controlled for by other variables in Main Regression I. The lack of an effect of GDP or GDP per capita on renewable energy consumption may be influenced by outlier nations such as Burundi, Ethiopia, Bhutan, Nepal, and Paraguay, which had high levels of renewable energy consumption despite having relatively lower GDP and GDP per capita compared to other nations in the dataset.

Lastly, and surprisingly, the demographic-related variable in the main regression, $POP_e$, is negatively correlated with renewable energy consumption. The population percentages between 0-14-years-old and 65-years-old and above are statistically significant at the 95% confidence level. A one percentage point increase in the percentage of countries' populations between 0-14-years-old decreased renewable energy consumption by .866 percentage points more than the base group of 15-64-year-olds, while a one percentage point increase in the percentage of countries' populations above 64-years-old decreased renewable energy consumption by 1.004 percentage points more than the base group. I predicted that growth in both age groups would increase renewable energy consumption relative to the base group because these groups likely use fossil fuels less than the base group of 15-64-year-old individuals due to less commuting and traveling. Puzzlingly, it appears that countries with larger percentages of people above 64-years-old decrease renewable energy consumption more than increases in the 0-14-year-old group and significantly more than the base group in these specifications. Controlling for quality of education through PISA exam scores, then, a larger population percentage between 15-64-years-old appears to result in higher renewable energy consumption. Subsequent regressions II-IV display the opposite relationship, however.

In Main Regression II, Specification (1) regresses renewable energy consumption solely on gross secondary enrollment percentages, while Specifications (2) and (3) control for natural resource and demographic-related variables, respectively. Specification (4) regresses renewable energy consumption on gross secondary enrollment percentages and all controls.

**Table 3: Main Regression II**

Dependent Variable: Renewable Energy Consumption as a Percentage of Total Final Energy Consumption

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| VARIABLES | RENEW | RENEW | RENEW | RENEW |
| | | | | |
| ENROLL | -0.663*** | -0.305*** | -0.098*** | -0.092*** |
| | (-45.239) | (-23.111) | (-2.769) | (-3.526) |
| FOSFUEL | | -0.594*** | | -0.573*** |
| | | (-45.603) | | (-31.725) |
| CRUDEDOIL | | -0.117 | | -0.051 |
| | | (-1.560) | | (-0.880) |
| COAL | | 0.395** | | 0.211 |
| | | (2.084) | | -1.399 |
| TRDOPEN | | -0.080*** | | -0.058*** |
| | | (-10.884) | | (-7.864) |
| LAND | | -0.000 | | 0.000*** |
| | | (-1.521) | | -4.093 |
| POPURB | | | -0.296*** | -0.165*** |
| | | | (-8.019) | (-5.669) |
| UNEMP | | | -0.114** | -0.083* |
| | | | (-2.023) | (-1.772) |
| GDPUSD | | | -0.000*** | -0.000*** |
| | | | (-6.075) | (-8.897) |
| GDPCAP | | | 0.000*** | 0.000*** |
| | | | (3.979) | -6.021 |
| POP014 | | | 2.134*** | 0.509*** |
| | | | (17.529) | -4.129 |
| POP65PLUS | | | 2.147*** | 0.051 |
| | | | (10.647) | -0.28 |
| POPTOTAL | | | 0.000*** | 0 |
| | | | (2.828) | -1.4 |
| LABOR | | | 0.909*** | 0.312*** |
| | | | (16.126) | -6.159 |
| 1999.Year | 1.608 | 4.448 | -1.127 | 0.831 |
| | (0.567) | (1.586) | (-0.316) | (0.277) |
| 2000.Year | 2.289 | 7.422* | -1.394 | 2.834 |
| | (0.802) | (1.814) | (-0.406) | (0.746) |
| 2001.Year | 3.024 | 2.987 | -0.498 | 0.319 |
| | (1.066) | (1.382) | (-0.145) | (0.135) |
| 2002.Year | 4.627 | 7.728** | 0.392 | 2.194 |
| | (1.629) | (2.138) | (0.116) | (0.640) |

| | | | | |
|---|---|---|---|---|
| 2003.Year | 4.142 | 6.423* | 0.647 | 2.074 |
| | (1.443) | (1.946) | (0.189) | (0.654) |
| 2004.Year | 3.598 | -13.717*** | 0.378 | -6.804** |
| | (1.270) | (-3.509) | (0.112) | (-2.209) |
| 2005.Year | 4.628 | -3.359* | 2.287 | -0.645 |
| | (1.636) | (-1.786) | (0.694) | (-0.340) |
| 2006.Year | 5.865** | -1.320 | 1.899 | -0.123 |
| | (2.059) | (-0.528) | (0.581) | (-0.054) |
| 2007.Year | 7.181** | -9.959*** | 2.312 | -4.315** |
| | (2.538) | (-4.713) | (0.706) | (-2.403) |
| 2008.Year | 6.747** | -35.387** | 4.003 | -20.681 |
| | (2.371) | (-2.231) | (1.222) | (-1.638) |
| 2009.Year | 8.227*** | -9.710** | 6.428** | -5.494 |
| | (2.874) | (-2.176) | (1.988) | (-1.586) |
| 2010.Year | 8.303*** | -20.009** | 5.925* | -10.736 |
| | (2.904) | (-2.153) | (1.870) | (-1.465) |
| 2011.Year | 9.226*** | -29.182** | 6.638** | -16.066 |
| | (3.251) | (-2.266) | (2.102) | (-1.564) |
| 2012.Year | 10.057*** | -11.967** | 6.833** | -6.474 |
| | (3.501) | (-2.276) | (2.152) | (-1.525) |
| 2013.Year | 10.528*** | -4.708* | 7.511** | -2.452 |
| | (3.615) | (-1.885) | (2.367) | (-1.189) |
| 2014.Year | 11.734*** | | 6.607** | |
| | (4.062) | | (2.100) | |
| 2015.Year | 12.726*** | | 6.836** | |
| | (4.425) | | (2.183) | |
| Constant | 75.759*** | 85.407*** | -85.629*** | 45.447*** |
| | (30.738) | (13.637) | (-11.090) | -5.084 |
| | | | | |
| Observations | 2,385 | 1,595 | 1,013 | 859 |
| R-squared | 0.465 | 0.772 | 0.523 | 0.792 |
| T-statistics in parentheses | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | |

There is greater statistical significance for the independent variables when substituting *ENROLL*, or gross secondary enrollment percentages, for PISA mean exam scores. In Main Regression II, increases in gross secondary enrollment percentages are associated with decreases in renewable energy consumption. A one percentage point increase in gross secondary enrollment decreases renewable energy consumption by .092 percentage points, which is quite surprising and is contrary to my initial hypothesis. If gross secondary enrollment is truly indicative of education quality, countries with higher quality education systems do not consume more renewable energy, a conclusion reinforced by mean PISA science and math scores in Main

Regression I. Interestingly, the coefficient on gross secondary enrollment percentages (-.092) nearly matches the coefficient on mean PISA mathematics scores in Main Regression I (-.096). As more control variables are added in Specifications (2) – (4), the size of the effect of gross secondary enrollment on renewable energy consumption decreases considerably. According to Appendix J, many countries with high gross secondary enrollment percentages consume less renewable energy than average, including many European countries, which helps explain the negative coefficient on the gross secondary enrollment variable.

Indeed, according to Appendix P, which displays regression results specifically for European countries, the coefficient on gross secondary enrollment, *ENROLL*, is negative and statistically significant at the 99% confidence level, and the size of this effect is substantial (-.177). This coefficient is also negative for Latin America in Appendix S, although it is not statistically significant. In addition, the size of the effect is much smaller than that of Europe. Conversely, this coefficient is positive for Africa, Asia, and North and South America, as shown in Appendices N, O, Q, and R, respectively. This supports the idea that the negative sign on this coefficient is being driven by Europe.

The crude oil and coal data of $ENPRICE_g$ exhibited the same general relationships in Specification (4) as in Main Regression I. Notable is that the coal price index is positively correlated with renewable energy consumption. One dollar (USD$) increases in the yearly mean of the weighted average of the coal price index increase renewable energy by .211 percentage points, a sizeable effect, although this is not a statistically significant relationship. This indicates that national renewable energy consumption tends to increase when non-renewable energy sources, such as coal, become more expensive. Countries may indeed marginally increase their consumption of renewable energy when coal prices rise.

It is important to note that all elements of $POP_e$ are positively correlated with renewable energy consumption in Specification (4) of Main Regression II, which is the opposite of the finding in Main Regression I. This suggests that increases in the 0-14-year-old and 64-year-old and above percentages of countries' populations increase renewable energy consumption more than the base group of 15-64-year-olds. This is logical because the base group is likely the portion of the population that would consume the most energy for employment, transportation, and other needs. The cause of this difference between Main Regression I and II is not clear.

Main Regression III employs degree attainment percentages of the 25-years-old and above population as a proxy for quality of education. In Specifications (1) - (4), I regress renewable energy consumption on primary, bachelor's, tertiary, and doctorate degree attainment percentage variables separately. Specifications (5) and (6) include natural resource and demographic-related variables, respectively. Specification (7) includes all controls in addition to the degree attainment variables.

**Table 4: Main Regression III**

Dependent Variable: Renewable Energy Consumption as a Percentage of Total Final Energy Consumption

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| VARIABLES | RENEW | RENEW | RENEW | RENEW | RENEW | RENEW | RENEW |
| | | | | | | | |
| PRIMARY | -0.647*** | | | | -0.109 | 0.239 | 0.15 |
| | (-18.697) | | | | (-1.269) | (1.256) | -0.731 |
| BACHELORS | | -1.395*** | | | 0.276 | 0.178 | 0.605** |
| | | (-9.859) | | | (0.877) | (0.477) | -2.189 |
| TERTIARY | | | -0.831*** | | -0.356 | -0.363 | -0.846*** |
| | | | (-12.645) | | (-1.336) | (-1.049) | (-3.040) |
| DOCTORATE | | | | -6.932** | -2.739 | -16.882** | -0.501 |
| | | | | (-2.028) | (-0.654) | (-2.449) | (-0.105) |
| FOSFUEL | | | | | -0.706*** | | -0.479*** |
| | | | | | (-11.870) | | (-7.648) |
| CRUDEDOIL | | | | | 0.031 | | 0.003 |
| | | | | | (0.632) | | -0.088 |
| COAL | | | | | -0.043 | | -0.095 |
| | | | | | (-0.286) | | (-0.799) |
| TRDOPEN | | | | | -0.040 | | -0.023 |
| | | | | | (-1.571) | | (-0.912) |
| LAND | | | | | -0.000 | | 0.000*** |
| | | | | | (-0.547) | | -3.537 |
| POPURB | | | | | | -0.897*** | -0.637*** |
| | | | | | | (-7.166) | (-5.341) |
| UNEMP | | | | | | 0.169 | -0.016 |
| | | | | | | (0.888) | (-0.073) |
| GDPUSD | | | | | | 0.000 | -0.000** |
| | | | | | | (1.608) | (-2.035) |
| GDPCAP | | | | | | 0.000*** | 0.000*** |
| | | | | | | (4.077) | -4.245 |
| POP014 | | | | | | 2.349*** | 0.652 |
| | | | | | | (4.653) | -0.945 |
| POP65PLUS | | | | | | 1.910** | 0.206 |
| | | | | | | (2.618) | -0.248 |
| POPTOTAL | | | | | | -0.000 | -0.000** |
| | | | | | | (-1.308) | (-2.524) |
| LABOR | | | | | | 1.112*** | 0.510** |
| | | | | | | (5.712) | -2.614 |
| 1999.Year | -19.705 | -7.211 | -35.755** | | | | |
| | (-1.446) | (-0.307) | (-2.300) | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2000.Year | -23.911** | -1.783 | -40.214*** | | | | |
| | (-2.119) | (-0.066) | (-3.339) | | | | |
| 2001.Year | -18.359* | 0.533 | -31.617*** | | | | |
| | (-1.663) | (0.024) | (-2.661) | | | | |
| 2002.Year | -11.315 | -2.999 | -18.314 | | | | |
| | (-1.011) | (-0.111) | (-1.529) | | | | |
| 2003.Year | -21.023* | -8.227 | -33.312*** | | | | |
| | (-1.770) | (-0.350) | (-2.621) | | | | |
| 2004.Year | -19.037* | -3.997 | -27.427** | | | | |
| | (-1.750) | (-0.180) | (-2.362) | | | | |
| 2005.Year | -22.399** | 10.794 | -29.308** | | | | |
| | (-2.062) | (0.460) | (-2.540) | | | | |
| 2006.Year | -21.584** | 19.356 | -25.287** | | | | |
| | (-2.029) | (0.921) | (-2.233) | | | | |
| 2007.Year | -17.919* | 4.183 | -26.468** | | | | |
| | (-1.686) | (0.205) | (-2.334) | | | | |
| 2008.Year | -18.955* | 10.338 | -28.102** | | | | |
| | (-1.790) | (0.511) | (-2.488) | | | | |
| 2009.Year | -16.283 | 11.789 | -24.141** | | | | |
| | (-1.535) | (0.586) | (-2.135) | | | | |
| 2010.Year | -17.925* | 6.860 | -26.531** | -50.954*** | | | |
| | (-1.696) | (0.348) | (-2.354) | (-3.194) | | | |
| 2011.Year | -14.723 | 10.137 | -22.891** | -36.374** | 0.422 | 4.749 | 8.122 |
| | (-1.395) | (0.516) | (-2.032) | (-2.199) | (0.037) | (0.428) | (0.826) |
| 2012.Year | -13.011 | 23.734 | -20.158* | -14.688 | 4.043 | 6.849 | 2.206 |
| | (-1.231) | (1.211) | (-1.786) | (-0.948) | (0.674) | (0.744) | (0.426) |
| 2013.Year | -16.792 | 13.424 | -23.406** | -33.185** | -0.892 | 6.675 | 3.155 |
| | (-1.581) | (0.690) | (-2.063) | (-2.203) | (-0.273) | (0.885) | (1.207) |
| 2014.Year | -10.689 | 21.434 | -18.255 | -25.870* | | 3.773 | |
| | (-1.011) | (1.105) | (-1.617) | (-1.728) | | (0.499) | |
| 2015.Year | -14.168 | 17.460 | -19.769* | -30.713** | | 8.865 | |
| | (-1.338) | (0.899) | (-1.747) | (-2.042) | | (1.184) | |
| Constant | 92.579*** | 32.017* | 64.282*** | 58.162*** | 92.487*** | -87.463*** | 54.219 |
| | (8.896) | (1.668) | (5.845) | (4.001) | (6.684) | (-2.660) | -1.627 |
| | | | | | | | |
| Observations | 653 | 256 | 725 | 150 | 76 | 86 | 65 |
| R-squared | 0.382 | 0.352 | 0.216 | 0.184 | 0.835 | 0.748 | 0.92 |
| T-statistics in parentheses | | | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | | | |

Specifications (1) – (4) demonstrate that all degree attainment variables have negative coefficients without including controls, which is similar to the mean PISA scores in

Specifications (1) – (3) of Main Regression I, but the sign of bachelor's degree attainment flips when the regression employs natural resource and demographic-related controls. The results of Specification (7), then, indicate that increases in bachelor's degree attainment increase renewable energy consumption substantially more than similar increases in other degree attainment percentages.

According to Main Regression III, increases in the percentage of countries' 25-years-old and above populations attaining at least bachelor's degrees were positively correlated with renewable energy consumption, while similar increases in the percentage of this population attaining at least short-cycle tertiary[21] or at least doctorate degrees were negatively correlated with renewable energy consumption. The primary and doctorate attainment level variables were not statistically significant in this regression, however. Despite the lack of statistical significance, these results indicate that ensuring high levels of bachelor's degree attainment may have a greater effect on increasing a country's renewable energy consumption than attainment of other degrees. This conclusion is supported by the positive coefficient of *LABOR*, or the percentage of the labor force with intermediate education. A bachelor's degree is classified as intermediate education[22]. One percentage point increases in *LABOR* increase renewable energy consumption by .5 percentage points. This is a substantial and statistically significant finding, and it reinforces the idea that attainment of bachelor's degrees is much more consequential in determining renewable energy consumption than attainment of other degrees. According to Appendix K, which plots bachelor's degree attainment and renewable energy consumption, countries with higher-than-average bachelor's degree attainment generally consume more renewable energy. The most significant outliers are Russia, Saudi Arabia, Singapore, the United Kingdom, and the United States.

Interestingly, coefficients on educational degree attainment variables for European countries, which is displayed in Appendix P, are all positive, although none are statistically significant. The coefficient on the percentage of the 25-years-old and above population percentage receiving at least doctorate degrees is 13.879, which is the opposite of its negative coefficient in Main Regression III. Although higher percentages of the population receiving doctorate degrees may drive renewable energy consumption in Europe, this effect does not seem strong enough to counteract that of the other continents in the panel data.

Main Regression IV employs government spending on education as a proxy for quality of education. In Specifications (1) - (4), I regress renewable energy consumption on government spending on education as a percentage of GDP and government expenditures for primary, secondary, and tertiary public institutions as a percentage of total public education expenditures variables separately. Similar to specifications in Main Regression I, II, and III, these quality of education variables by themselves are negatively correlated with renewable energy consumption. Specifications (5) and (6) include natural resource and demographic-related controls, respectively, while Specification (7) includes all controls and quality of education variables.

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[21] Short-cycle tertiary is community college

[22] According to The World Bank, intermediate education is upper-secondary or post-secondary education, excluding terminal degrees.

**Table 5: Main Regression IV**

Dependent Variable: Renewable Energy Consumption as a Percentage of Total Final Energy Consumption

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| VARIABLES | RENEW | RENEW | RENEW | RENEW | RENEW | RENEW | RENEW |
| | | | | | | | |
| GOVEDGDP | -3.125*** | | | | -0.792*** | 0.857* | 0.593* |
| | (-8.537) | | | | (-3.034) | (1.770) | -1.945 |
| EDEXPRIMARY | | -0.614*** | | | -0.051 | 0.244 | 0.196 |
| | | (-5.543) | | | (-0.557) | (1.245) | -1.566 |
| EDEXSECOND | | | -0.683*** | | -0.097 | -0.213 | -0.113 |
| | | | (-7.184) | | (-1.174) | (-1.302) | (-1.085) |
| EDEXTERT | | | | -0.112 | -0.125*** | 0.025 | -0.085* |
| | | | | (-1.599) | (-2.633) | (0.353) | (-1.730) |
| FOSFUEL | | | | | -0.767*** | | -0.625*** |
| | | | | | (-44.331) | | (-28.416) |
| CRUDEDOIL | | | | | 0.041 | | -0.066 |
| | | | | | (0.511) | | (-1.008) |
| COAL | | | | | -0.040 | | 0.292 |
| | | | | | (-0.191) | | -1.644 |
| TRDOPEN | | | | | -0.057*** | | -0.046*** |
| | | | | | (-7.062) | | (-5.297) |
| LAND | | | | | 0.000 | | 0 |
| | | | | | (1.502) | | -1.287 |
| POPURB | | | | | | -0.372*** | -0.184*** |
| | | | | | | (-8.520) | (-5.845) |
| UNEMP | | | | | | -0.102 | -0.079 |
| | | | | | | (-1.486) | (-1.377) |
| GDPUSD | | | | | | -0.000*** | -0.000*** |
| | | | | | | (-3.568) | (-3.563) |
| GDPCAP | | | | | | 0.000** | 0.000*** |
| | | | | | | (2.074) | -3.33 |
| POP014 | | | | | | 2.636*** | 0.646*** |
| | | | | | | (14.834) | -4.159 |
| POP65PLUS | | | | | | 2.711*** | 0.129 |
| | | | | | | (9.794) | -0.557 |
| POPTOTAL | | | | | | 0.000*** | 0.000** |
| | | | | | | (3.621) | -2.04 |
| LABOR | | | | | | 1.162*** | 0.302*** |
| | | | | | | (12.744) | -4.301 |
| 1999.Year | 0.210 | 2.614 | 1.777 | 2.311 | 1.456 | 2.847 | 5.292 |
| | (0.051) | (0.423) | (0.296) | (0.377) | (0.368) | (0.533) | (1.281) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2000.Year | 2.555 | 5.663 | 3.876 | 0.986 | 1.253 | 4.074 | 8.782* |
| | (0.621) | (0.933) | (0.660) | (0.167) | (0.244) | (0.789) | (1.764) |
| 2001.Year | -0.010 | 4.145 | 1.472 | -0.265 | -0.739 | 3.361 | 2.475 |
| | (-0.002) | (0.694) | (0.254) | (-0.045) | (-0.234) | (0.665) | (0.765) |
| 2002.Year | -2.340 | 0.619 | -0.660 | -2.045 | 0.457 | 5.207 | 8.196* |
| | (-0.572) | (0.109) | (-0.119) | (-0.363) | (0.101) | (1.073) | (1.844) |
| 2003.Year | -2.715 | -0.884 | -1.694 | -1.943 | -0.520 | 6.517 | 6.613 |
| | (-0.648) | (-0.146) | (-0.288) | (-0.325) | (-0.124) | (1.358) | (1.622) |
| 2004.Year | -0.112 | 8.298 | 6.553 | 4.595 | 0.452 | 7.657 | -3.222 |
| | (-0.028) | (1.475) | (1.189) | (0.813) | (0.106) | (1.612) | (-0.938) |
| 2005.Year | 0.197 | 6.037 | 3.684 | 0.496 | -2.313 | 7.677 | 2.746 |
| | (0.047) | (1.042) | (0.648) | (0.086) | (-0.890) | (1.579) | (1.089) |
| 2006.Year | -2.124 | 5.998 | 4.922 | 5.077 | -0.864 | 7.849* | 3.216 |
| | (-0.507) | (1.048) | (0.883) | (0.905) | (-0.279) | (1.651) | (1.129) |
| 2007.Year | -3.321 | 9.745* | 9.842* | 3.487 | -1.678 | 9.345* | -1.697 |
| | (-0.795) | (1.776) | (1.844) | (0.633) | (-0.681) | (1.958) | (-0.794) |
| 2008.Year | -0.452 | 9.789* | 10.719** | 7.318 | 4.479 | 9.027* | -25.561* |
| | (-0.111) | (1.813) | (2.037) | (1.356) | (0.257) | (1.902) | (-1.717) |
| 2009.Year | -0.455 | 13.465** | 11.467** | 7.870 | 4.000 | 10.920** | -3.865 |
| | (-0.111) | (2.504) | (2.192) | (1.478) | (0.834) | (2.357) | (-0.981) |
| 2010.Year | 4.261 | 18.820*** | 17.219*** | 12.736** | 4.993 | 12.384*** | -12.195 |
| | (1.041) | (3.534) | (3.324) | (2.432) | (0.492) | (2.709) | (-1.424) |
| 2011.Year | 2.558 | 17.151*** | 16.575*** | 13.205** | 5.338 | 14.594*** | -19.161 |
| | (0.621) | (3.246) | (3.218) | (2.508) | (0.376) | (3.187) | (-1.577) |
| 2012.Year | 1.067 | 18.841*** | 16.756*** | 12.602** | 2.481 | 14.354*** | -8.681* |
| | (0.255) | (3.554) | (3.259) | (2.399) | (0.427) | (3.124) | (-1.717) |
| 2013.Year | 1.814 | 14.835*** | 15.154*** | 12.127** | 0.385 | 13.041*** | -4.122* |
| | (0.443) | (2.821) | (2.967) | (2.324) | (0.137) | (2.828) | (-1.682) |
| 2014.Year | 3.278 | 14.549*** | 13.420*** | 8.765* | | 12.796*** | |
| | (0.792) | (2.735) | (2.582) | (1.665) | | (2.791) | |
| 2015.Year | 1.282 | 13.701** | 11.861** | 10.635** | | 14.213*** | |
| | (0.306) | (2.563) | (2.273) | (2.005) | | (3.055) | |
| Constant | 46.132*** | 75.531*** | 82.114*** | 31.277*** | 109.762*** | -<br>139.570*** | 28.301** |
| | (13.420) | (6.860) | (8.382) | (4.104) | (10.982) | (-8.618) | -2.004 |
| | | | | | | | |
| Observations | 1,942 | 1,147 | 1,158 | 1,118 | 704 | 558 | 493 |
| R-squared | 0.041 | 0.069 | 0.087 | 0.042 | 0.801 | 0.563 | 0.843 |
| T-statistics in parentheses | | | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | | | |

In Main Regression IV, which employs government expenditure on education as a proxy for the quality of a country's education system, there is a clear positive relationship between government expenditures on education and renewable energy consumption. In addition, this is a statistically significant relationship at the 90% confidence level. A one percentage point increase in a government's expenditure on education as a percentage of GDP increases renewable energy consumption by .593 percentage points. If government spending on education is an acceptable proxy for education quality, there does appear to be a positive relationship between education quality and renewable energy consumption. The sign of government spending on education as a percentage of GDP flips when the regression controls for demographic-related variables in Specifications (6) and (7), suggesting that increases in overall government spending on education increase renewable energy consumption substantially more than government spending on particular public education levels when accounting for population demographics.

The only other component of the government spending on education proxy that is statistically significant is the government expenditures for tertiary public institutions as a percentage of total public education expenditures, *EDEXTERT*, and this is significant at the 90% confidence level. *EDEXTERT* is negatively correlated with renewable energy consumption. A one percentage point increase in *EDEXTERT* decreased renewable energy consumption by .085 percentage points. This finding contradicts that of Main Regression III, but the effect of *EDEXTERT* is relatively small, indicating that government spending on undergraduate institutions may be a positive effect that is canceling out the negative impact of spending on other tertiary institutions on renewable energy consumption. Appendices L and M plot renewable energy consumption and government expenditure on education as a percentage of GDP. Appendix L plots countries that have both higher-than-average government spending on education as a percentage of GDP and higher-than-average renewable energy consumption. Appendix M plots countries that have higher-than-average government spending on education and renewable energy consumption above 70%. As Appendix M reveals, there are many countries that consume more than 70% renewable energy as a percentage of total final energy consumption. These countries are almost all in Africa. From these graphs, it's apparent that the positive government expenditure on education coefficient (*GOVEDGDP*) is predominantly influenced by African countries rather than by Europe.

According to the regression for South American countries in Appendix R, government expenditure on education as a percentage of GDP (*GOVEDGDP*) is negatively correlated with renewable energy consumption, although this is not statistically significant, and this is similar to the negative coefficient on *GOVEDGDP* in Specification (1) of Main Regression IV. In regressions for other continents[23] and in Main Regression IV, this coefficient is positive. This finding suggests that there is a direct relationship between education spending and renewable energy consumption for African countries, while South American countries that spend more on education tend to consume less renewable energy. The reasons behind and implications of these relationships are beyond the scope of this work.

[23] Appendices N-S

**Conclusion**

The linear regression models provide interesting insights into the relationship between quality of education and renewable energy consumption. Quality of education, which is proxied by mean PISA exam scores, gross secondary enrollment, government expenditures on education, and educational attainment levels, is not clearly correlated with renewable energy consumption in any general way. Although there is not a tangible relationship between quality of education and renewable energy consumption, the educational attainment and government expenditure on education proxies for quality of education indicate that increases in the percentage of a country's population with bachelor's degrees are more consequential in raising the national renewable energy consumption level than corresponding increases in the percentage of the population holding primary, secondary, or terminal degrees. The positive coefficient (.213) on mean PISA reading scores suggests that higher quality reading educational programs may produce more environmentally conscious populations. I cannot discern why science and mathematics scores are negatively correlated with renewable energy consumption, however.

In all regressions, the percentage of the working age population with intermediate education is statistically significant at the 95% confidence level or above, and its coefficient ranges from .302 to .510. This is a sizeable effect that suggests that the average education level of the labor force plays a significant role in determining national renewable energy consumption and is more consequential than a nation's education quality in this regard. Considering both the quality of education and labor force coefficients in each regression, it seems reasonable to conclude that there is a 'sweet spot' for the education of countries' populations regarding renewable energy consumption: High percentages of bachelor's degree holders and high-quality reading educations.

The regressions' demographic-related results generally matched the hypothesized outcome. Increases in the percentage of countries' populations between 0-14-years-old and above 64-years-old increased renewable energy consumption substantially more than the base group in three of the four regressions, which is logical because the base group, which includes 15-64-year-olds, is the most likely to be utilizing energy for work and travel.

Contrary to my initial hypothesis, GDP and GDP per capita did not play a statistically significant role in predicting national renewable energy consumption. This result may be influenced by outlier nations such as Burundi, Ethiopia, Bhutan, Nepal, and Paraguay, which had high levels of renewable energy consumption despite having relatively lower GDP and GDP per capita compared to other nations in the dataset. These relationships could be explored in greater detail in further work.

A notable discovery is that trade openness is negatively correlated with renewable energy consumption in all regressions. Although trade openness may convey a nation's level of economic development, it does not necessarily result in higher levels of renewable energy consumption. Therefore, First World countries should not take for granted that renewable energy adoption is inevitable, or that it will be facilitated by market forces and the 'Invisible Hand' (Stewart and Smith, 1892).

A significant limitation of the datasets employed by this paper is that some variables were missing observations for several countries and years. The government spending on education and mean PISA exam score variables in particular were missing observations for a large percentage of countries, which limited the regression using the PISA dataset to only 77 countries. This was significantly less than the 194 countries in the Main Regressions II-IV. Further studies could study the effects of nations' general attitudes towards renewable energy rather than relying on quality of education to proxy for environmental awareness.

**Appendix A: Countries in Main Regression I Panel Data, 1-39.**

| | | | | | |
|---|---|---|---|---|---|
| 1 | Albania | 14 | Colombia | 27 | Greece |
| 2 | Algeria | 15 | Costa Rica | 28 | Hong Kong SAR, China |
| 3 | Argentina | 16 | Croatia | 29 | Hungary |
| 4 | Australia | 17 | Cyprus | 30 | Iceland |
| 5 | Austria | 18 | Czech Republic | 31 | Indonesia |
| 6 | Azerbaijan | 19 | Denmark | 32 | Ireland |
| 7 | Belgium | 20 | Dominican Republic | 33 | Israel |
| 8 | Brazil | 21 | Estonia | 34 | Italy |
| 9 | Bulgaria | 22 | Ethiopia | 35 | Japan |
| 10 | Burundi | 23 | Finland | 36 | Jordan |
| 11 | Canada | 24 | France | 37 | Kazakhstan |
| 12 | Chile | 25 | Georgia | 38 | Korea, Rep. |
| 13 | China | 26 | Germany | 39 | Kosovo |

**Appendix B: Countries in Main Regression I Panel Data, 40-77.**

| | | | | | |
|---|---|---|---|---|---|
| 40 | Kyrgyz Republic | 53 | North Macedonia | 66 | Spain |
| 41 | Latvia | 54 | Norway | 67 | Sweden |
| 42 | Liechtenstein | 55 | Panama | 68 | Switzerland |
| 43 | Lithuania | 56 | Peru | 69 | Thailand |
| 44 | Luxembourg | 57 | Poland | 70 | Trinidad and Tobago |
| 45 | Macao SAR, China | 58 | Portugal | 71 | Tunisia |
| 46 | Malta | 59 | Qatar | 72 | Turkey |
| 47 | Mauritius | 60 | Romania | 73 | United Arab Emirates |
| 48 | Mexico | 61 | Russian Federation | 74 | United Kingdom |
| 49 | Moldova | 62 | Serbia | 75 | United States |
| 50 | Montenegro | 63 | Singapore | 76 | Uruguay |
| 51 | Netherlands | 64 | Slovak Republic | 77 | Vietnam |
| 52 | New Zealand | 65 | Slovenia | | |

**Appendix C: Countries in Main Regression II-IV Panel Data, 1-102.**

| | | | | | |
|---|---|---|---|---|---|
| 1 | Afghanistan | 35 | Chad | 69 | Greece |
| 2 | Albania | 36 | Chile | 70 | Greenland |
| 3 | Algeria | 37 | China | 71 | Grenada |
| 4 | Andorra | 38 | Colombia | 72 | Guatemala |
| 5 | Angola | 39 | Comoros | 73 | Guinea |
| 6 | Antigua and Barbuda | 40 | Congo, Dem. Rep. | 74 | Guyana |
| 7 | Argentina | 41 | Congo, Rep. | 75 | Haiti |
| 8 | Armenia | 42 | Costa Rica | 76 | Honduras |
| 9 | Aruba | 43 | Cote d'Ivoire | 77 | Hong Kong SAR, China |
| 10 | Australia | 44 | Croatia | 78 | Hungary |
| 11 | Austria | 45 | Cuba | 79 | Iceland |
| 12 | Azerbaijan | 46 | Curacao | 80 | India |
| 13 | Bahamas, The | 47 | Cyprus | 81 | Indonesia |
| 14 | Bahrain | 48 | Czech Republic | 82 | Iran, Islamic Rep. |
| 15 | Bangladesh | 49 | Denmark | 83 | Iraq |
| 16 | Barbados | 50 | Djibouti | 84 | Ireland |
| 17 | Belarus | 51 | Dominica | 85 | Isle of Man |
| 18 | Belgium | 52 | Dominican Republic | 86 | Israel |
| 19 | Belize | 53 | Ecuador | 87 | Italy |
| 20 | Benin | 54 | Egypt, Arab Rep. | 88 | Jamaica |
| 21 | Bermuda | 55 | El Salvador | 89 | Japan |
| 22 | Bhutan | 56 | Equatorial Guinea | 90 | Jordan |
| 23 | Bolivia | 57 | Eritrea | 91 | Kazakhstan |
| 24 | Bosnia and Herzegovina | 58 | Estonia | 92 | Kenya |
| 25 | Botswana | 59 | Eswatini | 93 | Kiribati |
| 26 | Brazil | 60 | Ethiopia | 94 | Kosovo |
| 27 | Bulgaria | 61 | Fiji | 95 | Kuwait |
| 28 | Burkina Faso | 62 | Finland | 96 | Kyrgyz Republic |
| 29 | Burundi | 63 | France | 97 | Latvia |
| 30 | Cabo Verde | 64 | Gabon | 98 | Lebanon |
| 31 | Cambodia | 65 | Georgia | 99 | Lesotho |
| 32 | Cameroon | 66 | Germany | 100 | Liberia |
| 33 | Canada | 67 | Ghana | 101 | Libya |
| 34 | Central African Republic | 68 | Gibraltar | 102 | Liechtenstein |

**Appendix D: Countries in Main Regression II Panel Data, 103-194.**

| | | | | | |
|---|---|---|---|---|---|
| 103 | Lithuania | 137 | Panama | 171 | Tanzania |
| 104 | Luxembourg | 138 | Papua New Guinea | 172 | Thailand |
| 105 | Macao SAR, China | 139 | Paraguay | 173 | Timor-Leste |
| 106 | Madagascar | 140 | Peru | 174 | Togo |
| 107 | Malawi | 141 | Philippines | 175 | Tonga |
| 108 | Malaysia | 142 | Poland | 176 | Trinidad and Tobago |
| 109 | Maldives | 143 | Portugal | 177 | Tunisia |
| 110 | Mali | 144 | Qatar | 178 | Turkey |
| 111 | Malta | 145 | Romania | 179 | Turkmenistan |
| 112 | Mauritania | 146 | Russian Federation | 180 | Tuvalu |
| 113 | Mauritius | 147 | Rwanda | 181 | Uganda |
| 114 | Mexico | 148 | San Marino | 182 | Ukraine |
| 115 | Moldova | 149 | Saudi Arabia | 183 | United Arab Emirates |
| 116 | Monaco | 150 | Senegal | 184 | United Kingdom |
| 117 | Mongolia | 151 | Serbia | 185 | United States |
| 118 | Montenegro | 152 | Seychelles | 186 | Uruguay |
| 119 | Morocco | 153 | Sierra Leone | 187 | Uzbekistan |
| 120 | Mozambique | 154 | Singapore | 188 | Vanuatu |
| 121 | Myanmar | 155 | Slovak Republic | 189 | Venezuela, RB |
| 122 | Namibia | 156 | Slovenia | 190 | Vietnam |
| 123 | Nauru | 157 | Solomon Islands | 191 | West Bank and Gaza |
| 124 | Nepal | 158 | Somalia | 192 | Yemen, Rep. |
| 125 | Netherlands | 159 | South Africa | 193 | Zambia |
| 126 | New Caledonia | 160 | South Sudan | 194 | Zimbabwe |
| 127 | New Zealand | 161 | Spain | | |
| 128 | Nicaragua | 162 | Sri Lanka | | |
| 129 | Niger | 163 | St. Kitts and Nevis | | |
| 130 | Nigeria | 164 | St. Lucia | | |
| 131 | North Macedonia | 165 | Sudan | | |
| 132 | Northern Mariana Islands | 166 | Suriname | | |
| 133 | Norway | 167 | Sweden | | |
| 134 | Oman | 168 | Switzerland | | |
| 135 | Pakistan | 169 | Syrian Arab Republic | | |
| 136 | Palau | 170 | Tajikistan | | |

## Appendix E: Variable List

| Variable | Variable Group | Unit | Explanation |
|---|---|---|---|
| *RENEW* | *RENEW* | Percentage | Country's renewable energy consumption as a percentage of total final energy consumption |
| *MATH* | *SCHOOL* | Mean Score | Country's mean performance on PISA mathematics exam taken by 15-year-olds |
| *READ* | *SCHOOL* | Mean Score | Country's mean performance on PISA reading exam taken by 15-year-olds |
| *SCIENCE* | *SCHOOL* | Mean Score | Country's mean performance on PISA science exam taken by 15-year-olds |
| *ENROLL* | *SCHOOL* | Percentage | Country’s gross secondary school enrollment percentages |
| *PRIMARY* | *SCHOOL* | Percentage | Country's percentage of the 25-years-old and above population that has attained a primary degree |
| *BACHELORS* | *SCHOOL* | Percentage | Country's percentage of the 25-years-old and above population that has attained a bachelor's degree |
| *TERTIARY* | *SCHOOL* | Percentage | Country's percentage of the 25-years-old and above population that has attained a short-cycle tertiary degree |
| *DOCTORATE* | *SCHOOL* | Percentage | Country's percentage of the 25-years-old and above population that has attained a doctorate degree |
| *EDEXPRIMARY* | *SCHOOL* | Percentage | Government expenditures for primary public institutions as a percentage of total public education expenditures |
| *EDEXSECOND* | *SCHOOL* | Percentage | Government expenditures for secondary public institutions as a percentage of total public education expenditures |
| *EDEXTERT* | *SCHOOL* | Percentage | Government expenditures for tertiary public institutions as a percentage of total public education expenditures |

| | | | |
|---|---|---|---|
| *GOVEDGDP* | *SCHOOL* | Percentage | Government expenditure on education as a percentage of total GDP |
| *LABOR* | *LABOR* | Percentage | Country's percentage of the total working age population with intermediate education |
| *GDPUSD* | *GDPUSD* | Current USD$ | Country's GDP in current USD$ |
| *GDPCAP* | *GDPCAP* | Current USD$ | Country's GDP per capita in current USD$ |
| *TRDOPEN* | *TRDOPEN* | Percentage | Sum of country's exports and imports as a percentage of GDP |
| *CRUDEOIL* | *ENPRICE* | USD$, 2016=100 | Yearly mean of the weighted average of the crude oil price index, USD$, 2016 base year |
| *COAL* | *ENPRICE* | USD$, 2016=100 | Yearly mean of the weighted average of the crude oil price index, USD$, 2016 base year |
| *FOSFUEL* | *FOSFUEL* | Percentage | Country's fossil fuel energy consumption as a percentage of total final energy consumption |
| *POPURB* | *POPURB* | Percentage | Country's percentage of population living in urban areas |
| *LAND* | *LAND* | Square Kilometers | Size of country's land area |
| *UNEMP* | *UNEMP* | Percentage | Percent of country's labor force with basic education that is unemployed |
| *POP014* | *POP* | Percentage | Percentage of country's population between 0-14-years-old |
| *POP1564* | *POP* | Percentage | Percentage of country's population between 15-64-years-old |
| *POP65PLUS* | *POP* | Percentage | Percentage of country's population above 64-years-old |
| *POPTOTAL* | *POP* | Count | Population count of country |

## Appendix F: Summary Statistics

Table 1: Summary statistics for independent variables of interest.

| Variable | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **MATH** | 334 | 466.9278 | 57.2806 | 292 | 612.6755 |
| **READ** | 337 | 464.611 | 51.0552 | 284.7066 | 569.5884 |
| **SCIENCE** | 337 | 471.2904 | 51.59742 | 322.0316 | 580.1178 |
| **ENROLL** | 2,763 | 79.4719 | 29.86181 | 5.29104 | 163.9347 |
| **BACHELORS** | 388 | 16.91792 | 9.350665 | 0 | 59.26088 |
| **PRIMARY** | 780 | 81.96967 | 20.27894 | 5.16848 | 100 |
| **TERTIARY** | 865 | 20.39965 | 11.75452 | 0 | 73.91028 |
| **DOCTORATE** | 256 | 0.553852 | 0.559675 | 0 | 2.97441 |
| **EDEXPRIMARY** | 1,342 | 92.28348 | 6.908066 | 44.07443 | 100 |
| **EDEXSECOND** | 1,353 | 91.75715 | 8.023374 | 13.09703 | 100 |
| **EDEXTERT** | 1,295 | 88.62011 | 11.52694 | 17.12292 | 100 |
| **GOVEDGDP** | 2,234 | 4.456573 | 1.754344 | 0 | 14.05908 |
| **TRDOPEN** | 3,393 | 88.62633 | 53.07386 | 1.861819 | 441.6038 |

Table 2: Summary statistics for dependent variable.

| Variable | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **RENEW** | 3,412 | 31.45768 | 30.30579 | 0 | 98.3426 |

Table 3: Summary statistics for natural resource-related control variables.

| Variable | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **FOSFUEL** | 2,389 | 65.14088 | 30.21517 | 0 | 100 |
| **CRUDEDOIL** | 4,074 | 127.765 | 59.60595 | 31.27922 | 222.451 |
| **COAL** | 4,074 | 98.35634 | 47.14585 | 37.31276 | 1.92E+02 |
| **LAND** | 4,025 | 661613.1 | 1843577 | 2 | 1.64E+07 |

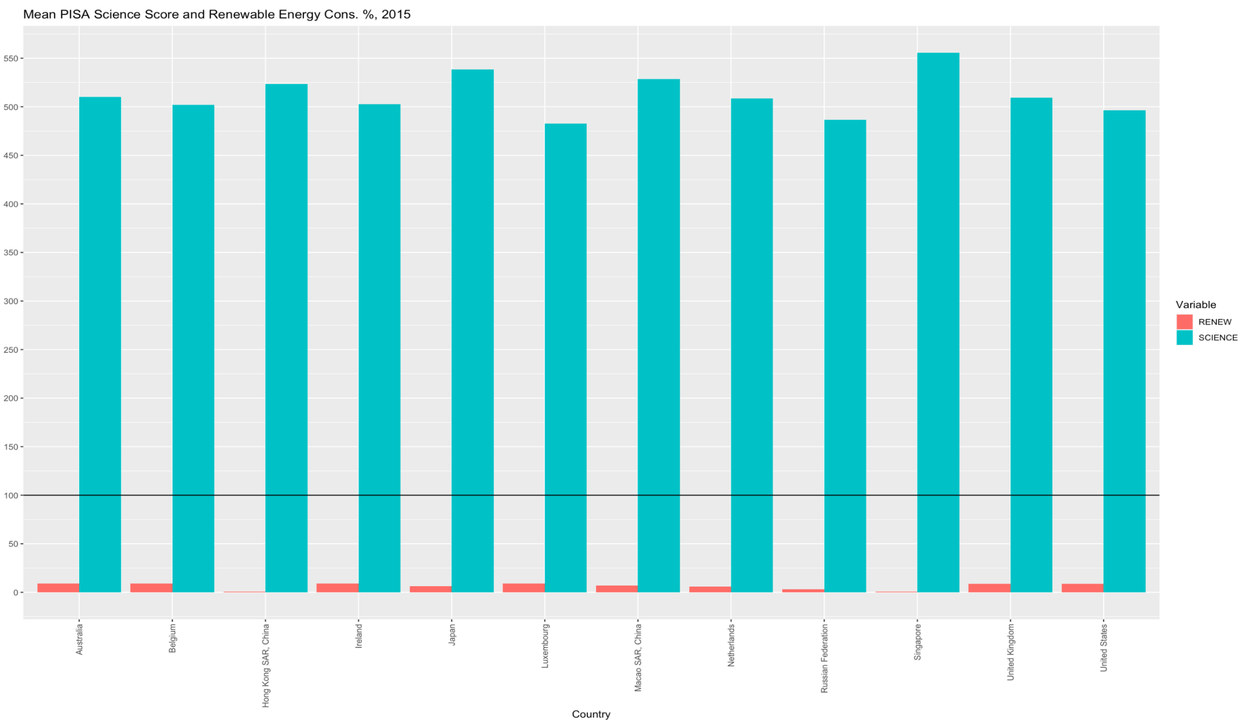
Table 4: Summary statistics for demographic and economic-related control variables.

| Variable | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **POPURB** | 4,046 | 57.26136 | 24.04212 | 7.83 | 100 |
| **POP014** | 3,752 | 29.83048 | 10.83543 | 11.0484 | 50.38519 |
| **POP1564** | 3,752 | 62.50823 | 7.025553 | 47.05716 | 86.39825 |
| **POP65PLUS** | 3,752 | 7.66E+00 | 5.34E+00 | 0.6855916 | 2.76E+01 |
| **POPTOTAL** | 4,067 | 3.43E+07 | 1.32E+08 | 9332 | 1.39E+09 |
| **GDPUSD** | 3,926 | 3.01E+11 | 1.30E+12 | 1.28E+07 | 2.06E+13 |

| | | | | | |
|---|---|---|---|---|---|
| **GDPCAP** | 3,926 | 13748.94 | 22602.73 | 102.598 | 189422.2 |
| **UNEMP** | 1,583 | 1.13E+01 | 8.62E+00 | 1.20E-01 | 5.49E+01 |
| **LABOR** | 1,443 | 66.37328 | 9.220473 | 30.06 | 100 |

# Appendix G

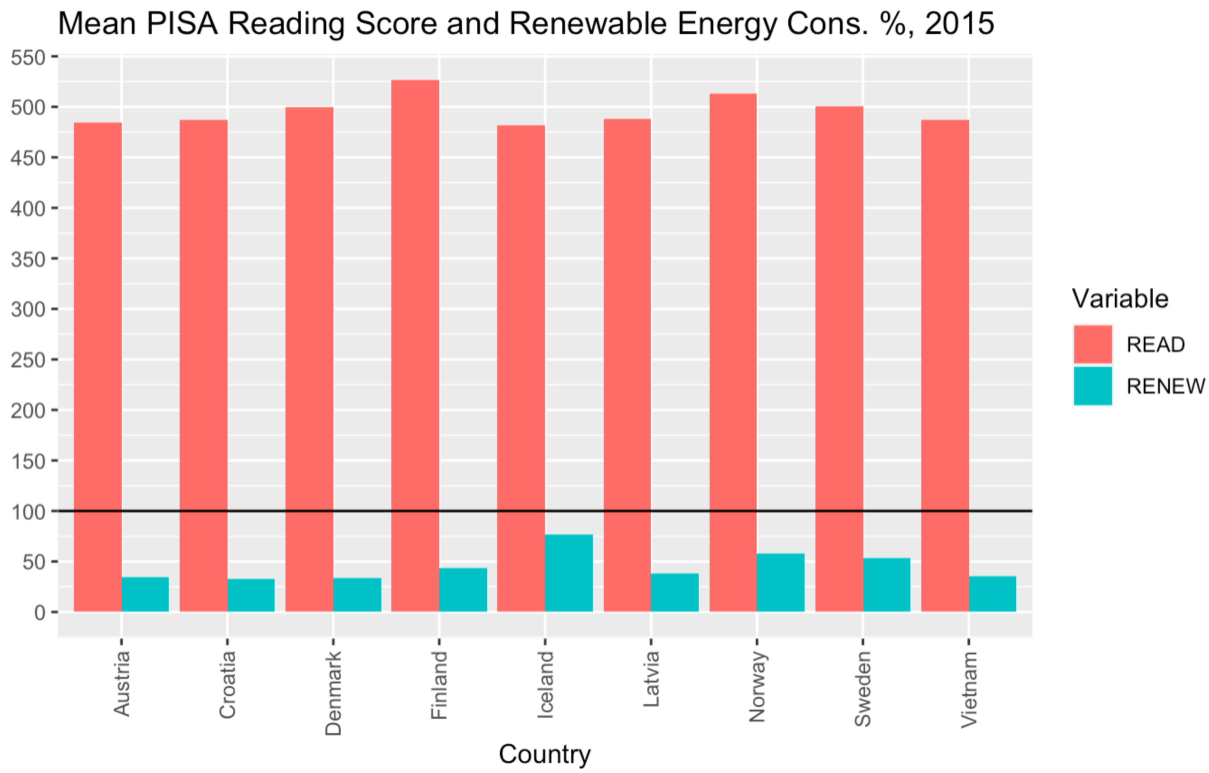
Mean PISA Science Score and Renewable Energy Consumption Percentage, 2015




Sources: The World Bank: World Development Indicators, and Our World in Data

**Appendix H**

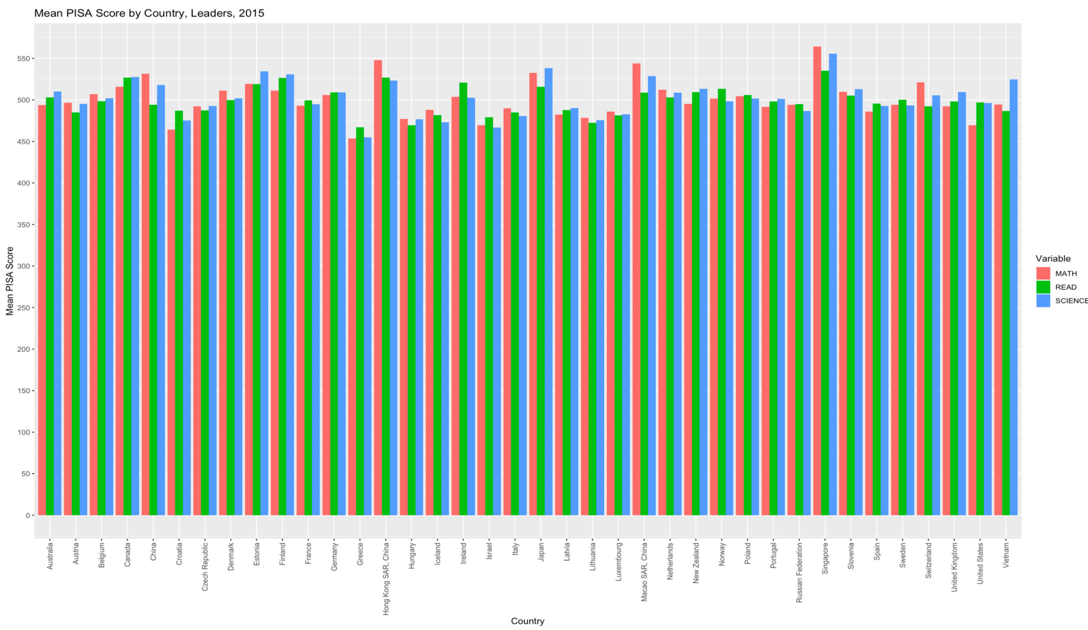
Mean PISA Reading Scores and Renewable Energy Consumption Percentage, 2015



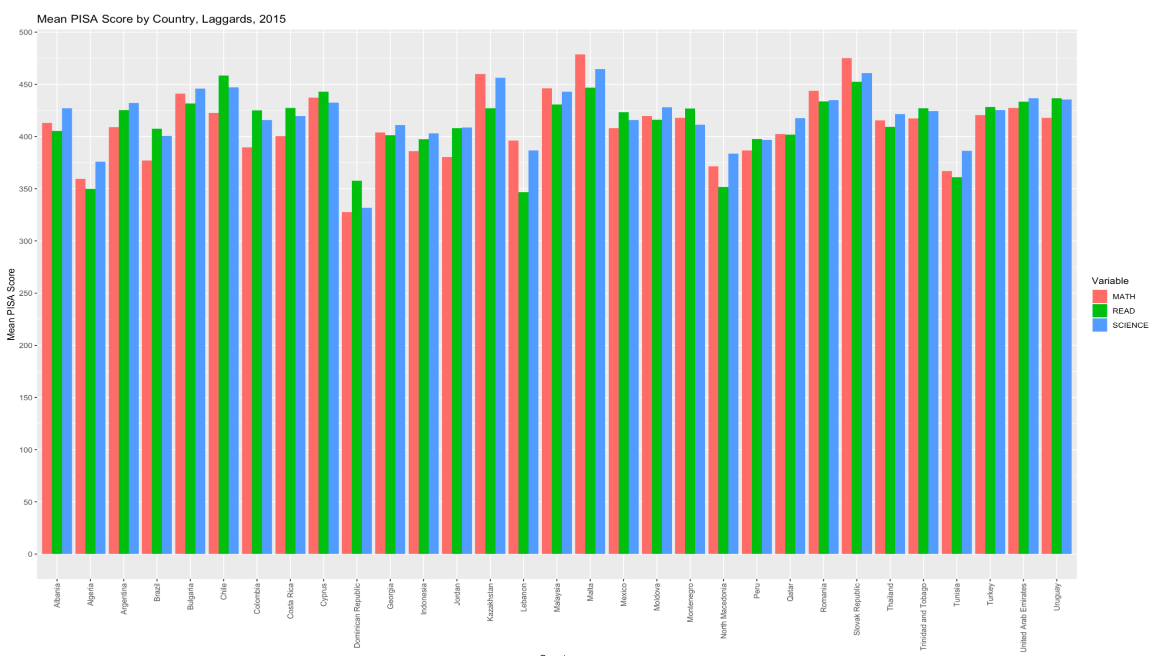

Sources: The World Bank: World Development Indicators, and Our World in Data

# Appendix I

## Mean PISA Score by Country, Leaders, 2015



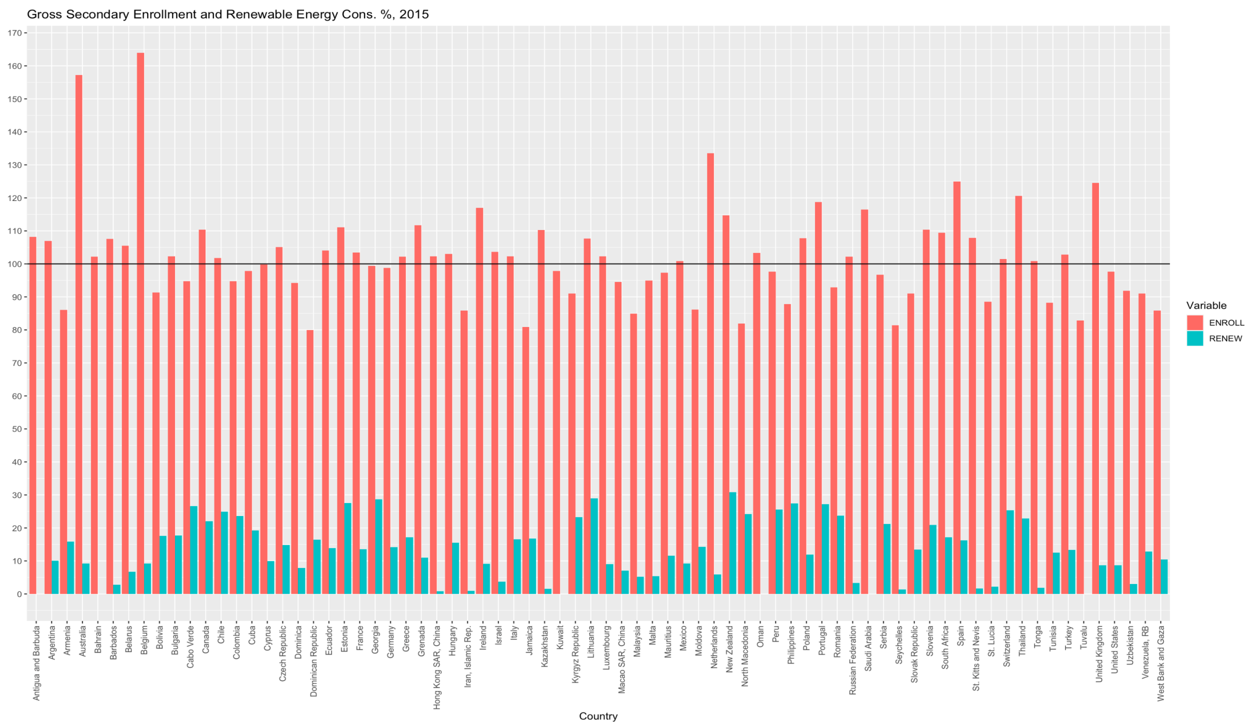

## Mean PISA Score by Country, Laggards, 2015




Source: Our World in Data

## Appendix J

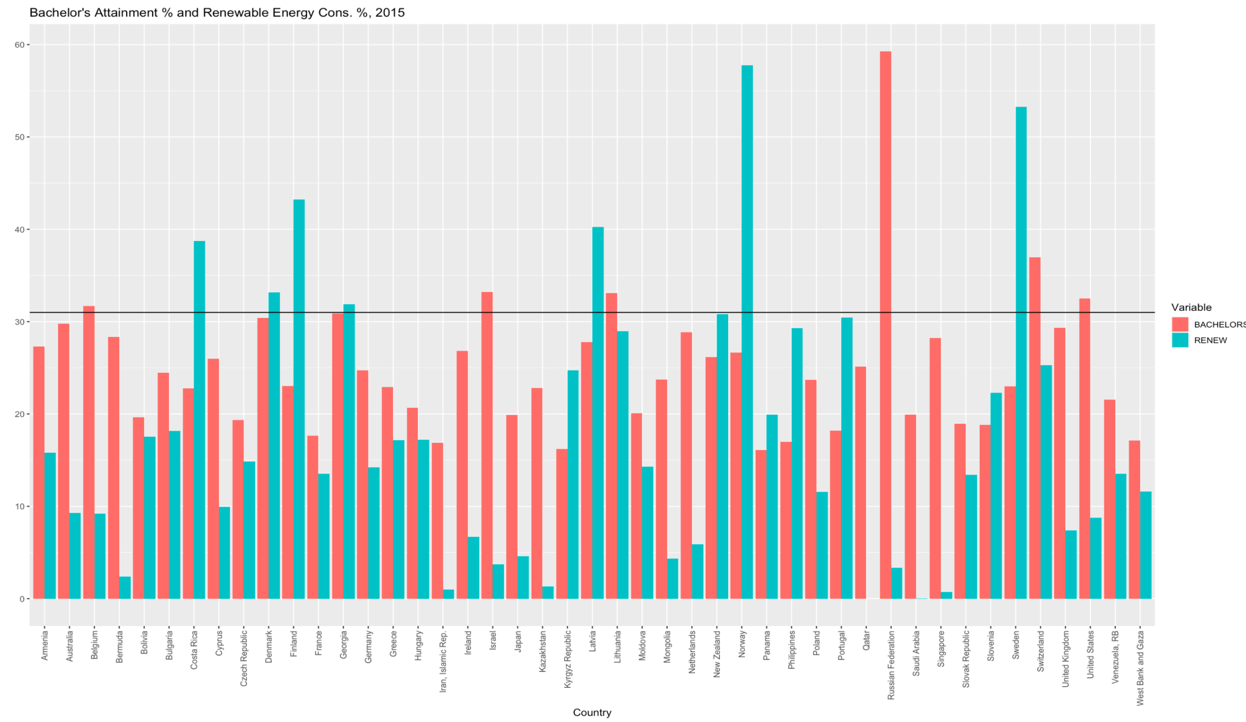
Gross Secondary Enrollment and Renewable Energy Consumption Percentage, 2015




Source: The World Bank: World Development Indicators

# Appendix K

Bachelor's Degree Attainment and Renewable Energy Consumption Percentages, 2015[24]




Source: The World Bank: World Development Indicators

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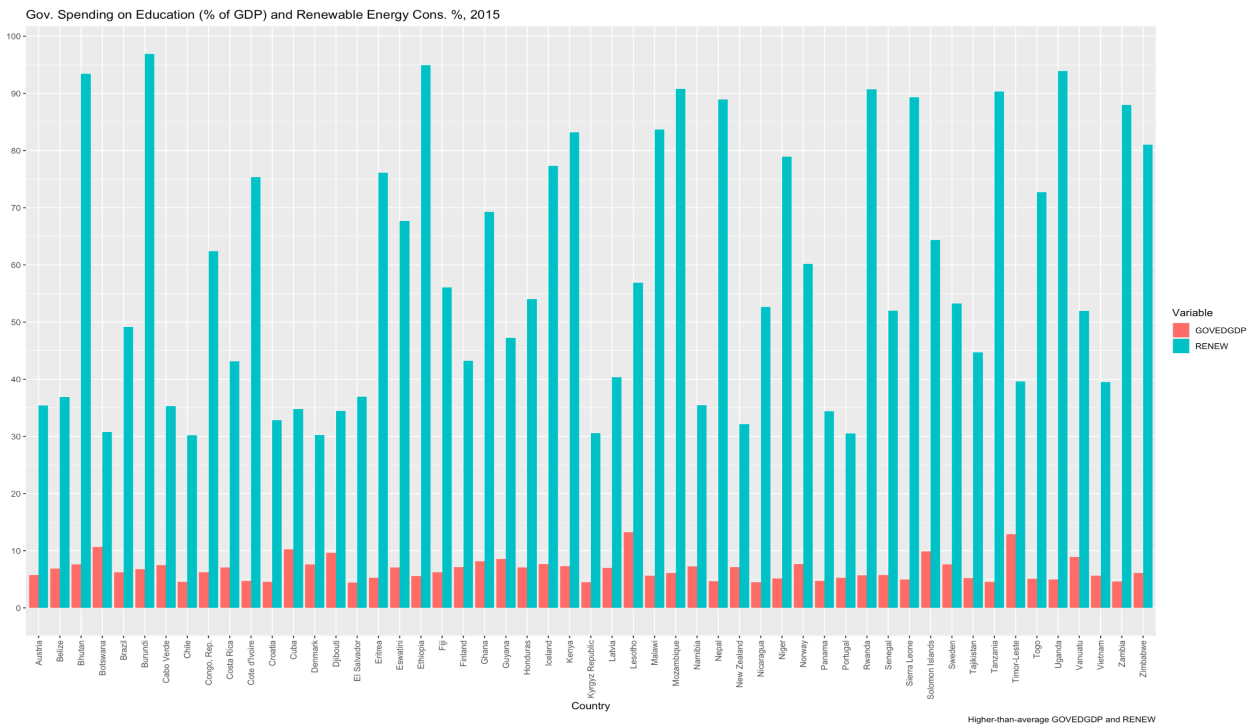
[24] The horizontal line represents mean renewable energy consumption in 2015 (30.46%)

# Appendix L

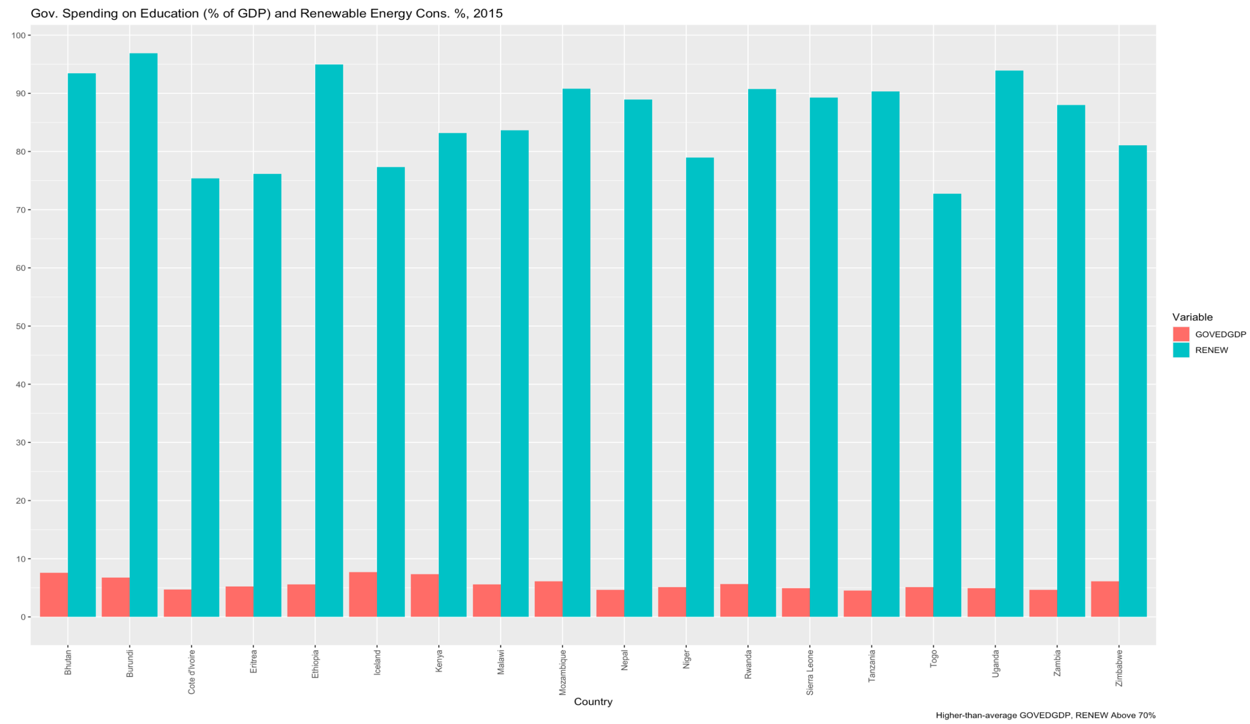
Government Spending on Education as a Percentage of GDP and Renewable Energy Consumption Percentage, 2015 – (Higher-than-average, both variables)




Source: The World Bank: World Development Indicators

# Appendix M

Government Spending on Education as a Percentage of GDP and Renewable Energy Consumption Percentage, 2015 – (Higher-than-average gov. spending on education, renewable energy cons. above 70%)




Source: The World Bank: World Development Indicators

## Appendix N: Africa - Regression

Dependent Variable: Renewable Energy Consumption as a Percentage of Total Final Energy Consumption. Quality of Education Variable**:** Gross secondary enrollment percentages.

| | (1) |
|---|---|
| VARIABLES | RENEW |
| | |
| ENROLL | 0.209 |
| | (1.037) |
| FOSFUEL | -0.354 |
| | (-1.610) |
| CRUDEDOIL | 0.351 |
| | (1.188) |
| COAL | -0.779 |
| | (-1.282) |
| TRDOPEN | -0.066 |
| | (-0.666) |
| LAND | 0.000 |
| | (0.824) |
| POPURB | -0.042 |
| | (-0.237) |
| UNEMP | -0.899* |
| | (-1.846) |
| GDPUSD | 0.000 |
| | (0.045) |
| GDPCAP | -0.002* |
| | (-1.737) |
| POP014 | 1.813 |
| | (1.301) |
| POP65PLUS | 4.964 |
| | (1.225) |
| POPTOTAL | 0.000 |
| | (0.924) |
| LABOR | 0.417** |
| | (2.074) |
| 2000.Year | -15.578 |
| | (-1.473) |
| 2001.Year | -1.158 |
| | (-0.150) |
| 2002.Year | -9.210 |
| | (-1.039) |
| 2003.Year | -7.451 |
| | (-0.950) |

| | |
|---|---|
| 2004.Year | 12.849 |
| | (0.716) |
| 2005.Year | -1.739 |
| | (-0.362) |
| 2006.Year | -4.253 |
| | (-0.677) |
| 2007.Year | 11.956 |
| | (1.549) |
| 2008.Year | 62.933 |
| | (1.263) |
| 2009.Year | 17.064 |
| | (0.998) |
| 2010.Year | 38.908 |
| | (1.280) |
| 2011.Year | 48.822 |
| | (1.238) |
| 2012.Year | 13.721 |
| | (0.958) |
| 2013.Year | - |
| | |
| 2014.Year | - |
| | |
| Constant | -32.277 |
| | (-0.400) |
| | |
| Observations | 54 |
| R-squared | 0.973 |
| T-statistics in parentheses | |
| *** p<0.01, ** p<0.05, * p<0.1 | |

## Appendix O: Asia - Regressions

Dependent Variable: Renewable Energy Consumption as a Percentage of Total Final Energy Consumption. Quality of Education Variable**:** Gross secondary enrollment percentages (Specification 1) and government spending on education (Specification 2).

| | (1) | (2) |
|---|---|---|
| VARIABLES | RENEW | RENEW |
| | | |
| ENROLL | 0.085* | |
| | (1.916) | |
| GOVEDGDP | | 0.916 |
| | | (0.827) |
| EDEXPRIMARY | | -0.348 |
| | | (-1.530) |
| EDEXSECOND | | 0.250 |
| | | (1.117) |
| EDEXTERT | | -0.036 |
| | | (-0.325) |
| FOSFUEL | -0.440*** | -0.813*** |
| | (-5.909) | (-4.016) |
| CRUDEDOIL | 0.067 | 0.012 |
| | (0.491) | (0.181) |
| COAL | -0.163 | -0.037 |
| | (-0.440) | (-0.259) |
| TRDOPEN | -0.006 | 0.123*** |
| | (-0.223) | (3.424) |
| LAND | 0.000*** | 0.000 |
| | (6.459) | (1.486) |
| POPURB | -0.894*** | -0.508** |
| | (-9.321) | (-2.749) |
| UNEMP | 0.008 | 0.202 |
| | (0.054) | (1.147) |
| GDPUSD | 0.000 | 0.000** |
| | (0.833) | (2.062) |
| GDPCAP | 0.000*** | 0.000 |
| | (5.176) | (0.965) |
| POP014 | 1.972*** | 1.637*** |
| | (7.121) | (3.918) |
| POP65PLUS | 3.610*** | 3.004** |
| | (6.107) | (2.256) |
| POPTOTAL | -0.000*** | -0.000 |
| | (-4.276) | (-1.442) |
| LABOR | 0.178** | -0.298*** |

| | | |
|---|---|---|
| | (2.032) | (-2.868) |
| 1999.Year | -3.706 | |
| | (-0.810) | |
| 2000.Year | -3.803 | |
| | (-0.699) | |
| 2001.Year | -4.422 | -0.843 |
| | (-1.377) | (-0.319) |
| 2002.Year | -4.863 | -0.059 |
| | (-0.942) | (-0.022) |
| 2003.Year | -5.800 | -0.918 |
| | (-1.223) | (-0.368) |
| 2004.Year | -2.301 | -1.028 |
| | (-0.478) | (-0.263) |
| 2005.Year | -1.319 | -2.647 |
| | (-0.528) | (-1.350) |
| 2006.Year | -0.650 | 0.429 |
| | (-0.217) | (0.189) |
| 2007.Year | 0.728 | 1.478 |
| | (0.296) | (0.722) |
| 2008.Year | 8.180 | 1.712 |
| | (0.408) | (0.179) |
| 2009.Year | -1.009 | 1.267 |
| | (-0.188) | (0.374) |
| 2010.Year | 3.695 | -0.040 |
| | (0.318) | (-0.007) |
| 2011.Year | 7.901 | 0.296 |
| | (0.485) | (0.040) |
| 2012.Year | 4.432 | -0.113 |
| | (0.666) | (-0.036) |
| 2013.Year | 3.182 | 0.580 |
| | (1.173) | (0.376) |
| 2014.Year | - | - |
| | | |
| 2015.Year | - | - |
| | | |
| Constant | 3.046 | 59.178*** |
| | (0.143) | (2.901) |
| | | |
| Observations | 83 | 56 |
| R-squared | 0.980 | 0.995 |
| T-statistics in parentheses | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | |

**Appendix P: Europe - Regressions**

Dependent Variable: Renewable Energy Consumption as a Percentage of Total Final Energy Consumption. Quality of Education Variable**:** Mean PISA exam scores (Specification 1), gross secondary enrollment (2), educational degree attainment (3), and government spending on education (4).

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| VARIABLES | RENEW | RENEW | RENEW | RENEW |
| | | | | |
| MATH | -0.074 | | | |
| | (-0.989) | | | |
| READ | 0.159* | | | |
| | (1.832) | | | |
| SCIENCE | -0.217** | | | |
| | (-2.456) | | | |
| ENROLL | | -0.177*** | | |
| | | (-5.756) | | |
| PRIMARY | | | 0.672 | |
| | | | (1.554) | |
| BACHELORS | | | 0.192 | |
| | | | (0.426) | |
| TERTIARY | | | 0.608 | |
| | | | (1.139) | |
| DOCTORATE | | | 13.879 | |
| | | | (1.535) | |
| GOVEDGDP | | | | 2.332*** |
| | | | | (4.364) |
| EDEXPRIMARY | | | | 0.202 |
| | | | | (0.919) |
| EDEXSECOND | | | | -0.019 |
| | | | | (-0.088) |
| EDEXTERT | | | | -0.225** |
| | | | | (-2.294) |
| FOSFUEL | -0.455*** | -0.325*** | -0.024 | -0.415*** |
| | (-9.477) | (-13.669) | (-0.172) | (-12.999) |
| CRUDEDOIL | -0.174* | -0.114* | 0.006 | -0.156** |
| | (-1.876) | (-1.893) | (0.161) | (-2.249) |
| COAL | 0.324** | 0.486*** | 0.116 | 0.613*** |
| | (2.278) | (3.115) | (1.256) | (3.276) |
| TRDOPEN | -0.102*** | -0.119*** | 0.050 | -0.091*** |
| | (-5.202) | (-11.956) | (1.059) | (-6.406) |
| LAND | 0.000 | 0.000*** | 0.000* | 0.000** |
| | (1.026) | (4.168) | (1.981) | (2.455) |

| | | | | |
|---|---|---|---|---|
| POPURB | -0.082 | 0.035 | -1.073*** | -0.096 |
| | (-1.020) | (0.764) | (-4.259) | (-1.599) |
| UNEMP | -0.038 | -0.130** | -0.602 | -0.141* |
| | (-0.292) | (-2.224) | (-1.553) | (-1.802) |
| GDPUSD | -0.000 | -0.000 | -0.000 | -0.000 |
| | (-0.545) | (-1.496) | (-0.820) | (-0.033) |
| GDPCAP | 0.000*** | 0.000*** | 0.000 | 0.000 |
| | (3.432) | (4.976) | (1.554) | (1.152) |
| POP014 | -0.721 | 0.746** | 2.193 | 0.967* |
| | (-1.094) | (2.352) | (1.041) | (1.718) |
| POP65PLUS | -0.898 | 0.260 | 5.982** | 0.277 |
| | (-1.284) | (0.795) | (2.599) | (0.605) |
| POPTOTAL | -0.000* | -0.000*** | -0.000 | -0.000** |
| | (-1.788) | (-5.575) | (-1.252) | (-2.194) |
| LABOR | 0.498*** | 0.322*** | -0.202 | 0.281* |
| | (3.136) | (3.998) | (-0.730) | (1.872) |
| 1999.Year | | 3.841 | | 7.399* |
| | | (1.205) | | (1.758) |
| 2000.Year | | 7.283* | | 11.841** |
| | | (1.789) | | (2.279) |
| 2001.Year | | 1.931 | | 4.441 |
| | | (0.754) | | (1.320) |
| 2002.Year | | 6.419* | | 12.561*** |
| | | (1.742) | | (2.696) |
| 2003.Year | -1.401 | 5.104 | | 9.591** |
| | (-0.588) | (1.500) | | (2.236) |
| 2004.Year | | -11.432*** | | -9.991*** |
| | | (-3.449) | | (-2.657) |
| 2005.Year | | -1.174 | | 2.416 |
| | | (-0.531) | | (0.868) |
| 2006.Year | 2.065 | -0.149 | | 3.980 |
| | (0.700) | (-0.057) | | (1.249) |
| 2007.Year | | -9.011*** | | -5.730** |
| | | (-4.384) | | (-2.275) |
| 2008.Year | | -45.423*** | | -53.721*** |
| | | (-3.411) | | (-3.420) |
| 2009.Year | -7.388** | -11.991*** | | -10.508** |
| | (-2.181) | (-3.228) | | (-2.452) |
| 2010.Year | | -24.185*** | | -28.259*** |
| | | (-3.133) | | (-3.125) |
| 2011.Year | | -35.136*** | | -42.850*** |
| | | (-3.249) | | (-3.350) |
| 2012.Year | | -14.468*** | 40.140*** | -17.745*** |
| | | (-3.214) | (3.489) | (-3.292) |

| | | | | |
|---|---|---|---|---|
| 2013.Year | | -5.432** | 1.559 | -7.799*** |
| | | (-2.287) | (0.791) | (-2.693) |
| 2014.Year | | - | - | - |
| | | | | |
| 2015.Year | - | - | - | - |
| | | | | |
| Constant | 120.823*** | 11.746 | -133.350 | -11.101 |
| | (4.292) | (0.927) | (-1.565) | (-0.559) |
| | | | | |
| Observations | 156 | 511 | 40 | 326 |
| R-squared | 0.813 | 0.780 | 0.958 | 0.816 |
| T-statistics in parentheses | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | |

## Appendix Q: North America - Regression

Dependent Variable: Renewable Energy Consumption as a Percentage of Total Final Energy Consumption. Quality of Education Variable**:** Gross secondary enrollment.

| | (1) |
|---|---|
| VARIABLES | RENEW |
| | |
| ENROLL | 0.233*** |
| | (3.018) |
| FOSFUEL | -0.352*** |
| | (-7.899) |
| CRUDEDOIL | -0.111 |
| | (-1.578) |
| COAL | 0.401** |
| | (2.020) |
| TRDOPEN | -0.096*** |
| | (-4.477) |
| LAND | 0.000*** |
| | (3.316) |
| POPURB | -1.529*** |
| | (-8.480) |
| UNEMP | 0.179 |
| | (0.700) |
| GDPUSD | 0.000 |
| | (0.570) |
| GDPCAP | -0.000 |
| | (-0.438) |
| POP014 | -0.807** |
| | (-2.323) |
| POP65PLUS | -2.418*** |
| | (-3.299) |
| POPTOTAL | -0.000*** |
| | (-2.743) |
| LABOR | -0.109 |
| | (-0.777) |
| 1999.Year | 5.039 |
| | (1.226) |
| 2000.Year | 6.114 |
| | (1.205) |
| 2001.Year | 2.761 |
| | (0.770) |
| 2002.Year | 3.446 |
| | (0.695) |

| | |
|---|---|
| 2003.Year | 6.354 |
| | (1.309) |
| 2004.Year | -6.991* |
| | (-1.856) |
| 2005.Year | 2.300 |
| | (0.938) |
| 2006.Year | 4.063 |
| | (1.380) |
| 2007.Year | -3.851* |
| | (-1.796) |
| 2008.Year | -33.975** |
| | (-2.032) |
| 2009.Year | -8.204* |
| | (-1.820) |
| 2010.Year | -19.780** |
| | (-2.053) |
| 2011.Year | -29.095** |
| | (-2.118) |
| 2012.Year | -13.336** |
| | (-2.322) |
| 2013.Year | -5.633** |
| | (-2.230) |
| 2014.Year | - |
| | |
| 2015.Year | - |
| | |
| Constant | 173.361*** |
| | (6.053) |
| | |
| Observations | 99 |
| R-squared | 0.975 |
| T-statistics in parentheses | |
| *** p<0.01, ** p<0.05, * p<0.1 | |

## Appendix R: South America - Regressions

Dependent Variable: Renewable Energy Consumption as a Percentage of Total Final Energy Consumption. Quality of Education Variable**:** Mean PISA exam scores (Specification 1), gross secondary enrollment (2), and government spending on education (3).

| | (1) | (2) | (3) |
|---|---|---|---|
| VARIABLES | RENEW | RENEW | RENEW |
| | | | |
| MATH | -22.291 | | |
| | (-5.799) | | |
| READ | 1.725* | | |
| | (7.119) | | |
| SCIENCE | 9.441 | | |
| | (5.356) | | |
| ENROLL | | 0.094** | |
| | | (2.183) | |
| GOVEDGDP | | | -0.043 |
| | | | (-0.074) |
| EDEXPRIMARY | | | -0.016 |
| | | | (-0.141) |
| EDEXSECOND | | | -0.075 |
| | | | (-0.668) |
| EDEXTERT | | | 0.043 |
| | | | (1.442) |
| FOSFUEL | -2.906* | -0.909*** | -0.855*** |
| | (-9.847) | (-20.043) | (-11.069) |
| CRUDEDOIL | 41.033 | 0.019 | -0.069 |
| | (5.863) | (0.225) | (-1.160) |
| COAL | -67.836 | -0.091 | 0.015 |
| | (-5.861) | (-0.410) | (0.128) |
| TRDOPEN | -6.215 | 0.133*** | 0.096* |
| | (-5.677) | (3.486) | (1.730) |
| LAND | 0.000 | -0.000*** | -0.000*** |
| | (5.687) | (-5.433) | (-4.757) |
| POPURB | -184.798 | 0.583*** | 0.155 |
| | (-5.828) | (5.106) | (0.532) |
| UNEMP | -34.246 | -0.383*** | -0.313* |
| | (-5.854) | (-2.932) | (-1.961) |
| GDPUSD | 0.000 | -0.000 | -0.000*** |
| | (5.844) | (-0.680) | (-2.954) |
| GDPCAP | -0.009 | 0.000** | 0.001** |
| | (-5.438) | (2.080) | (2.191) |
| POP014 | -123.118 | 1.570*** | 0.448 |

| | | | |
|---|---|---|---|
| | (-5.800) | (4.329) | (0.844) |
| POP65PLUS | 433.048 | 0.293 | 0.252 |
| | (5.871) | (1.000) | (0.361) |
| POPTOTAL | -0.000 | 0.000*** | 0.000*** |
| | (-5.655) | (4.918) | (4.023) |
| LABOR | -32.185 | -0.063 | 0.018 |
| | (-6.111) | (-0.590) | (0.130) |
| 1999.Year | | 4.125 | 0.410 |
| | | (1.331) | (0.181) |
| 2000.Year | | 3.778 | -0.867 |
| | | (0.838) | (-0.324) |
| 2001.Year | | 3.624 | -1.715 |
| | | (1.590) | (-0.817) |
| 2002.Year | | 1.583 | -2.233 |
| | | (0.408) | (-0.952) |
| 2003.Year | -16.833 | 0.819 | -2.524 |
| | (-3.764) | (0.234) | (-1.126) |
| 2004.Year | | 2.921 | -2.882 |
| | | (0.621) | (-1.042) |
| 2005.Year | | 1.503 | 0.682 |
| | | (0.900) | (0.354) |
| 2006.Year | -832.653 | 0.818 | 0.419 |
| | (-5.846) | (0.350) | (0.193) |
| 2007.Year | | 2.033 | 0.132 |
| | | (0.797) | (0.080) |
| 2008.Year | | 9.300 | -0.276 |
| | | (0.489) | (-0.031) |
| 2009.Year | 1,383.978 | 4.478 | -2.147 |
| | (5.871) | (0.859) | (-0.765) |
| 2010.Year | | 5.332 | -1.970 |
| | | (0.484) | (-0.367) |
| 2011.Year | | 7.430 | 0.456 |
| | | (0.485) | (0.064) |
| 2012.Year | | 3.315 | 0.956 |
| | | (0.531) | (0.385) |
| 2013.Year | | 0.870 | |
| | | (0.343) | |
| 2014.Year | | - | - |
| | | | |
| 2015.Year | - | - | |
| | | | |
| Constant | 22,700.223 | -5.292 | 70.174 |
| | (5.912) | (-0.209) | (1.700) |
| | | | |

| | | | |
|---|---|---|---|
| Observations | 21 | 111 | 60 |
| R-squared | 1.000 | 0.984 | 0.997 |
| T-statistics in parentheses | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | |

## Appendix S: Latin America - Regressions

Dependent Variable: Renewable Energy Consumption as a Percentage of Total Final Energy Consumption. Quality of Education Variable**:** Mean PISA exam scores (Specification 1), gross secondary enrollment (2), and government spending on education (3).

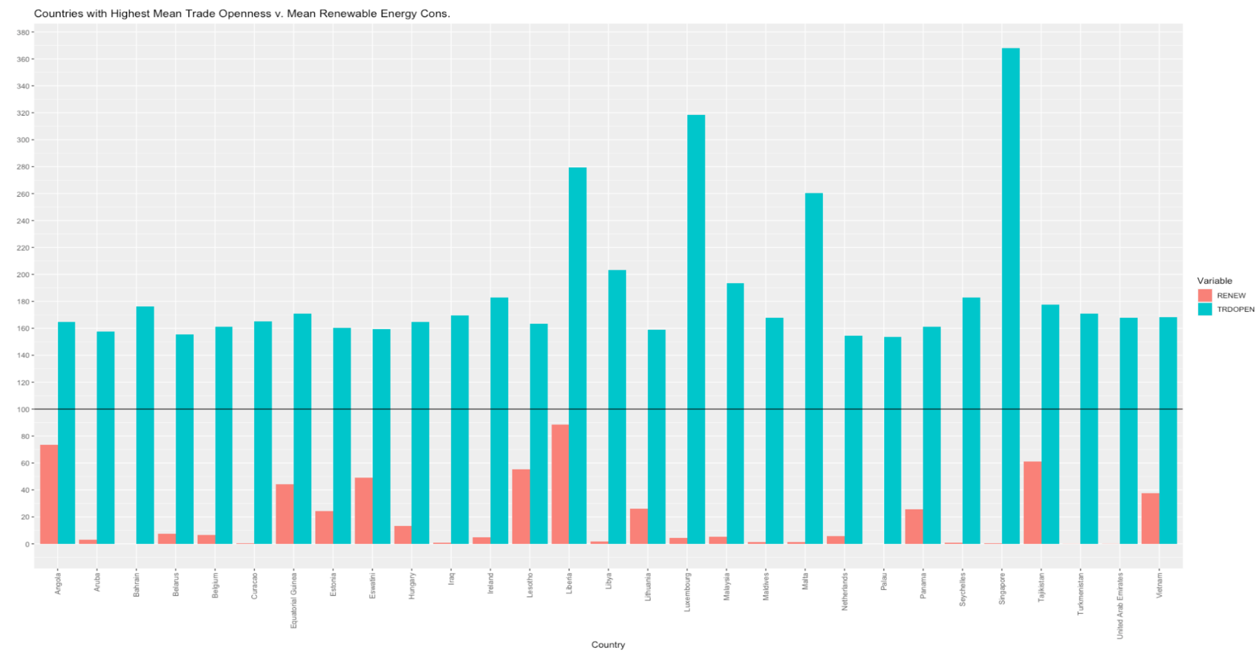
| | (1) | (2) | (3) |
|---|---|---|---|
| VARIABLES | RENEW | RENEW | RENEW |
| | | | |
| MATH | -0.151 | | |
| | (-0.957) | | |
| READ | 0.12 | | |
| | -0.76 | | |
| SCIENCE | 0.048 | | |
| | -0.19 | | |
| ENROLL | | -0.036 | |
| | | (-0.849) | |
| GOVEDGDP | | | 0.072 |
| | | | -0.143 |
| EDEXPRIMARY | | | -0.342* |
| | | | (-1.902) |
| EDEXSECOND | | | 0.264 |
| | | | -1.611 |
| EDEXTERT | | | 0.038 |
| | | | -0.759 |
| FOSFUEL | -0.811*** | -0.775*** | -0.916*** |
| | (-5.350) | (-26.696) | (-13.795) |
| CRUDEDOIL | 0.042 | -0.08 | 0.01 |
| | -0.295 | (-1.093) | -0.099 |
| COAL | -0.1 | 0.213 | -0.076 |
| | (-0.440) | -1.102 | (-0.274) |
| TRDOPEN | 0.122 | 0.032* | -0.026 |
| | -1.004 | -1.805 | (-0.775) |
| LAND | 0 | 0 | 0 |
| | (-0.653) | (-0.334) | (-1.232) |
| POPURB | 0.719* | 0.250*** | -0.07 |
| | -1.782 | -3.244 | (-0.386) |
| UNEMP | -0.054 | 0.23 | 0.266 |
| | (-0.182) | -1.628 | -1.442 |
| GDPUSD | 0 | 0 | 0 |

| | | | |
|---|---|---|---|
| | (-0.050) | -0.003 | (-1.670) |
| GDPCAP | 0 | 0.000* | 0.001** |
| | -1.484 | -1.864 | -2.439 |
| POP014 | 0.656 | 0.675*** | -0.738** |
| | -0.696 | -4.14 | (-2.482) |
| POP65PLUS | -1.247 | -0.489 | -1.656*** |
| | (-0.918) | (-1.589) | (-2.824) |
| POPTOTAL | 0 | 0 | 0 |
| | (-0.425) | (-1.384) | (-0.720) |
| LABOR | 0.727** | 0.522*** | 0.396*** |
| | -2.324 | -6.221 | -2.978 |
| 1999.Year | | 3.113 | 0.245 |
| | | (0.874) | (0.045) |
| 2000.Year | | 6.750 | 1.082 |
| | | (1.483) | (0.158) |
| 2001.Year | | 2.287 | 0.254 |
| | | (0.833) | (0.057) |
| 2002.Year | | 2.825 | -1.059 |
| | | (0.702) | (-0.179) |
| 2003.Year | -0.894 | 3.963 | 0.293 |
| | (-0.338) | (1.061) | (0.054) |
| 2004.Year | | -4.923 | 1.998 |
| | | (-1.243) | (0.376) |
| 2005.Year | | 1.346 | 2.394 |
| | | (0.683) | (0.807) |
| 2006.Year | -0.202 | 2.417 | 1.919 |
| | (-0.058) | (0.966) | (0.542) |
| 2007.Year | | -1.025 | 1.385 |
| | | (-0.478) | (0.499) |
| 2008.Year | | -17.253 | 6.678 |
| | | (-1.059) | (0.283) |
| 2009.Year | 3.493 | -3.282 | 0.977 |
| | (0.641) | (-0.733) | (0.157) |
| 2010.Year | | -10.642 | 2.703 |
| | | (-1.123) | (0.199) |
| 2011.Year | | -14.778 | 5.125 |
| | | (-1.114) | (0.267) |
| 2012.Year | | -7.126 | -1.018 |
| | | (-1.314) | (-0.130) |

| | | | |
|---|---|---|---|
| 2013.Year | | -2.920 | 0.894 |
| | | (-1.232) | (0.280) |
| 2014.Year | | - | - |
| | | | |
| 2015.Year | - | - | - |
| | | | |
| Constant | -44.133 | 5.57 | 111.844*** |
| | (-0.506) | -0.428 | -4.213 |
| | | | |
| Observations | 38 | 210 | 88 |
| R-squared | 0.97 | 0.948 | 0.984 |
| T-statistics in parentheses | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | |

## Appendix T

Countries with the Highest Mean Trade Openness v. Mean Renewable Energy Consumption

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