The Determinants of Education

Research Question

What is the relationship between **educational attainment** of high school students and **GDP per capita**, **happiness level**, **money spent in education**, **inequality** and **teaching hours** per year in OECD countries?

Dependent Variable : Educational Attainment

<u>Programme for International Student Assessment (PISA)</u>
Variable name: *pisa*

- Conducted every 3 years by OECD
- Measure "15-year old's ability to use their reading, math and science skills"
- No max/ min score
- Results are scaled to fit normal distribution
- Mean score: 500 points
- This project uses PISA score from 2015 and 2018 (the most recent scores)

Independent Variable : Socioeconomic Indicators

GDP per capita
Variable name: gdp

Teaching hours per year
Variable name: teachhr

Money spent in education
Variable name: moneduc

Independent Variable : Socioeconomic Indicators

GINI Inequality

Variable name: ineq

- Proxy for inequality
- Measure to the extent to which the distribution of income in an economy deviates from a perfectly equal distribution
- 0 : perfect equality
- 100: perfect inequality

World Happiness Report

Variable name: hapind

- Proxy for happiness level
- By UN Sustainable Development Solutions Network, annually
- Based on survey results from Gallup World Poll
- Range from 0 to 10
- Higher number, higher happiness level

Motivation for the Project

Personally...

I have personally experienced high school education in different countries (US, Brazil, South Korea). I have observed how the education system differs vastly from country to country and would like to investigate the factors that influence educational decisions.

Education

Educational policy is often one of the most significant concerns of a country. Hence, factors that affect educational decisions may shed light to other fields of public service, along with each respective society and culture.

Literature Review

Spending & TIMSS Scores

(Woessman, 2001)

- Relationship between overall money spent per student in 39 countries & Third International Math and Science Study (TIMSS) exam results
- **No** significant correlation!
- BUT **number of books at home** significantly correlated with TIMSS scores

➢ Hypothesis:
moneduc to be **positively correlated** with PISA scores

PISA & GDP per Capita

DiCorrado et al., 2015

- **Positive** correlation b/n 2012 PISA score & GDP per capita
- 27 countries
- BUT small sample size
- Small R-squared value

OECD (2012)

- **No correlation** b/n country's wealth & educational attainment
- $35,000 **threshold** until which GDP per capita increases PISA scores
- Investment in teachers, attention for lower-achieving students more important

➢ Hypothesis:
Positive, diminishing correlation between PISA scores & GDP per capita

Inequality & Academic Excellence

(Philip, 2018)

- **Negative** relationship b/n average academic excellence & inequality
- Among OECD countries in 2000, except Mexico and Turkey

➢ Hypothesis:
Negative relationship between *ineq* and *pisa*

Happiness & Academic Excellence

(Duckworth, 2007)

- **Positive** correlation b/n happiness index & academic excellence
- Students with higher subjective well-being earn higher grades
- Happy students → perform well
- Performing well → happier students

➢ Hypothesis:
hapind to be **positively correlated** with *pisa*

My Project

- This project replicates previous studies in the methods employed to build a model.
- I expand upon the literature by combining multiple independent variables into one model
- I include OECD countries only, so the results may indicate an implication of the mission of OECD in the educational attainment of high school students

Methodology - Data Collection

World Happiness Report

OECD

World Bank

The data used in this research are collected from a variety of trustworthy sources including the World Happiness Report, OECD and the World Bank.

Methodology - Data Analysis

1. Multi Linear Regression Analysis with **Cross sectional data** from 2018

2. Further Multi Linear Regression Analysis with **Panel data** from 2015 and 2018

Cross Sectional Data Analysis

Data from 2018

Summary Statistics

Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
pisa	38	486.229	28.923	405.3	525.3
gdp	38	46055.238	19010.58	15256.201	116480.8
hapind	38	6.621	.696	5.358	7.632
moneduc	37	16669.112	8653.473	2862.727	47693.711
ineq	38	32.447	6.47	24.4	48.9
teachhr	31	655.696	154.307	471.91	1267.2

In total, I examined 38 countries. However, there were some missing data points for the variables *moneduc* and *teachhr.*

[redacted]

Why is *hapind* so high?

Descriptive Statistics

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OECD countries adhere to two requirements: (i) democratic societies committed to rule of law and protection of human rights; and (ii) open, transparent and free-market economies." They are developed countries with similar characteristics. Hence, he range in our sample is from 5.358 to 7.632, as the countries are likely to be relatively happier.

[redacted]

38 Countries Examined:

Australia	Finland	South Korea	Slovak Republic
Austria	France	Latvia	Slovenia
Belgium	Germany	Lithuania	Spain
Canada	Greece	Luxembourg	Sweden
Chile	Hungary	Mexico	Switzerland
Colombia	Iceland	Netherlands	Turkey
Costa Rica	Ireland	New Zealand	United Kingdom
Czech Republic	Israel	Norway	United States
Denmark	Italy	Poland	
Estonia	Japan	Portugal	

Initial Theoretical Model

$$pisa = \beta_1 gdp + \beta_2 hapind + \beta_3 moneduc + \beta_4 ineq + \beta_5 teachhr + \epsilon$$

Units:

pisa: point
gdp: USD
hapind: 1 unit
moneduc: USD
ineq: 1 unit
teachhr: 1 hour

First, I conducted a **multiple linear regression** with the dataset.

[redacted]

Multi Linear Regression 1

MLR 1

pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
gdp	0	0	0.92	.367	0	.001	
hapind	-13.868	6.529	-2.12	.044	-27.342	-.393	**
moneduc	.003	.001	2.71	.012	.001	.005	**
ineq	-1.57	.931	-1.69	.105	-3.492	.352	
teachhr	-.021	.03	-0.69	.497	-.082	.041	
Constant	584.658	39.334	14.86	0	503.476	665.84	***

Mean dependent var	484.643	SD dependent var	29.928
R-squared	0.750	Number of obs	30
F-test	14.383	Prob > F	0.000
Akaike crit. (AIC)	258.486	Bayesian crit. (BIC)	266.893

**** p<.01, ** p<.05, * p<.1*

Coefficient of *gdp* is too small to be indicated in the table.

→ I changed the units of *gdp* from 1 USD to 1000 USD (*gdp2)*. Another multiple linear regression was performed.

Multi Linear Regression 2

MLR 2

pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
gdp2	.333	.363	0.92	.367	-.415	1.082	
hapind	-13.868	6.529	-2.12	.044	-27.342	-.393	**
moneduc	.003	.001	2.71	.012	.001	.005	**
ineq	-1.57	.931	-1.69	.105	-3.492	.352	
teachhr	-.021	.03	-0.69	.497	-.082	.041	
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Multi Linear Regression 2

- **Happiness index is negatively correlated** with PISA scores, indicating that on average, ceteris paribus, the less happier the students are the higher their exam scores.
  - This may be due to the stress that high school students get when they spend hours studying for exams while losing sleep and social life.
- **Money spent on education is positively correlated** with exam scores, aligning with our hypothesis.
- 3 of the 5 variables have **insignificant p-values** (GDP per capita, number of teaching hours, inequality)

→ Check further for model validity

White's Test for Homoskedasticity

White's test for Ho: homoskedasticity
against Ha: unrestricted heteroskedasticity
chi2(20) = 21.37
Prob > chi2 = 0.3756
Cameron & Trivedi's decomposition of IM-test

Homoskedastic

Source	chi2	df	p
Heteroskedasticity	21.370	20	0.376
Skewness	7.890	5	0.163
Kurtosis	0.750	1	0.387
Total	30.000	26	0.268

The White's test shows a p-value bigger than 0.1
→ I **cannot reject the null hypothesis of homoskedasticity**
→ The model does not violate the Gauss-Markov assumption of homoskedasticity.

Variance Inflation Factor (VIF)

VIF	1/VIF
3.970	0.252
3.760	0.266
3.160	0.316
2.450	0.409
2.340	0.427
3.140	

Multicollinearity is not causing a big problem

The VIF is 3.14 overall & Individual VIFs are below 5.

→ **Multicollinearity is not presenting a problem**

→ With no clear violation of assumptions, further inspection was needed to see why 3 of the 5 variables were insignificant

Joint Hypothesis Testing

Joint hypothesis gdp ineq teachhr

```
( 1)   gdp = 0
( 2)   ineq = 0
( 3)   teachhr = 0
       F(  3,      24) =      4.28
            Prob > F =      0.0149
```

Statistically significant jointly
→ Enough evidence that *gpd, ineq, teachhr* are jointly significant

→ Further analysis needed to decide
whether or not to include these variables jointly

Reflections

- I realized that the number of observations was too small (38 countries) to obtain meaningful results.
- Need a wider database!
- Decided to expand the data to a panel dataset
- Used data from 2015

Panel Data Analysis

Data from 2018 & 2015

Panel Data Variable :

PISA
Variable name: Pisa

World Happiness Report
Variable name: happi

GDP per capita
Variable name: GDP

Money spent in education
Variable name: MonEdu

Teaching hours per year
Variable name: TeachHr

GINI Inequality
Variable name: Ineq

Panel Data Summary Statistics

Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Pisa	76	486.766	29.807	405.3	528.7
GDP	74	43171.373	18463.252	13330.6	116481
happi	75	6.598	.769	4.8	7.632
MonEdu	75	13193.757	8236.909	2159.7	47693.699
Ineq	73	33.714	7.104	24.4	51
TeachHr	68	693.491	177.535	471.91	1267.2
Year	76	2016.5	1.51	2015	2018

Panel dataset from 2015 & 2018 data
Same 38 countries examined

Regression with Panel Data (Base yr 2015)

Base year 2015

Pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
GDP	0	0	-0.28	.78	-.001	0	
happi	2.14	4.547	0.47	.64	-6.972	11.252	
MonEdu	.001	.001	1.65	.105	0	.003	
Ineq	-1.929	.589	-3.28	.002	-3.109	-.75	***
TeachHr	-.055	.025	-2.25	.029	-.105	-.006	**
2015b	0	.	.	.	.	.	
2018	-16.343	6.319	-2.59	.012	-29.007	-3.679	**
Constant	572.077	30.021	19.06	0	511.913	632.241	***

Mean dependent var	485.982	SD dependent var	31.304
R-squared	0.584	Number of obs	62
F-test	12.869	Prob > F	0.000
Akaike crit. (AIC)	561.587	Bayesian crit. (BIC)	576.477

*** $p<.01$, ** $p<.05$, * $p<.1$

→ Need to change the unit of GDP per capita to $1000 (*GDP2*)

Regression with Panel Data (Base yr 2015)

Base year 2015 with GDP2

Pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
GDP2	-.071	.253	-0.28	.78	-.579	.437	
happi	2.14	4.547	0.47	.64	-6.972	11.252	
MonEdu	.001	.001	1.65	.105	0	.003	
Ineq	-1.929	.589	-3.28	.002	-3.109	-.75	***
TeachHr	-.055	.025	-2.25	.029	-.105	-.006	**
2015b	0	.	.	.	.	.	
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Regression with Panel Data (Base yr 2015)

→ p-value for *GDP, happi,* and *MonEdu* are greater than the significance level of 10%
→ ***Ineq* and *TeachHr* have significant p-values**
→ compared to 2015, the GINI coefficient in 2018 is likely to be 1.929 lower
→ the number of teaching hours is likely to be 0.055 hours less

Regression with Panel Data (Base country Australia)

Base country Australia

Pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
GDP2	-.184	.254	-0.72	.476	-.709	.341	
happi	-.53	6.112	-0.09	.932	-13.175	12.114	
MonEdu	0	0	0.07	.947	-.001	.001	
Ineq	.269	.503	0.54	.598	-.771	1.31	
TeachHr	.01	.02	0.52	.61	-.031	.051	
: base Australia	0	.	.	.	.	.	
Austria	-5.397	7.887	-0.68	.501	-21.713	10.919	
Canada	19.981	7.759	2.58	.017	3.93	36.033	**
Chile	-72.318	12.008	-6.02	0	-97.159	-47.478	***
Colombia	-106.488	13.476	-7.90	0	-134.364	-78.611	***
Costa Rica	-100.128	14.02	-7.14	0	-129.131	-71.125	***
Czech Republic	-3.238	10.077	-0.32	.751	-24.083	17.607	
Denmark	5.606	7.989	0.70	.49	-10.921	22.133	
Estonia	21.712	12.267	1.77	.09	-3.664	47.088	*
Finland	22.366	8.761	2.55	.018	4.243	40.488	**
France	-5.725	8.353	-0.69	.5	-23.005	11.555	
Germany	4.839	7.482	0.65	.524	-10.638	20.317	
Greece	-48.241	14.32	-3.37	.003	-77.864	-18.618	***
Hungary	-26.056	13.918	-1.87	.074	-54.848	2.736	*
Iceland	-12.14	10.856	-1.12	.275	-34.598	10.318	

Regression with Panel Data (Base country Australia)

→ p-value of all of the independent variables are greater than the significance level of 10%
→ **None of the coefficients are statistically significant**
→ High p-values may be due to the **small number of observations** (38 OECD countries)
→ There may be omitted variables that have not been controlled for and are **confounding**.

→ Further examination of the dataset needed, as no conclusion can be drawn!

Panel Data without GDP

Maybe, GDP is highly correlated with money spent on education.

Correlation between MonEdu GDP

Variables	(1)	(2)
(1) MonEdu	1.000	
(2) GDP	0.755	1.000

→ Correlation coefficient : 0.755,
→ Strong positive correlation.
→ Including both variables may create **collinearity**

→ As money spent on education is more directly relevant to finding the determinants of educational attainment, I will proceed with the analysis **without GDP per capita** as an independent variable.

White's Test for Homoskedasticity

White's Test
White's test
H0: Homoskedasticity
Ha: Unrestricted heteroskedasticity
chi2(62) = 63.00
Prob > chi2 = 0.4407
Cameron & Trivedi's decomposition of IM-test

Homoskedastic

Source	chi2	df	p
Heteroskedasticity	63.000	62	0.441
Skewness	2.790	37	1.000
Kurtosis	2.490	1	0.115
Total	68.280	100	0.994

The White's test shows a p-value significant at 10% level
→ **Cannot reject the null hypothesis of homoskedasticity**
→ The model does not violate the Gauss-Markov assumption of homoskedasticity.

Variance Inflation Factor (VIF)

VIF of MLR		
Variable	VIF	1/VIF
happi	**1.69**	**0.592268**
MonEdu	**1.86**	**0.538937**
Ineq	**2.45**	**0.407470**
TeachHr	**2.42**	**0.413455**
Year		
2018	**1.23**	**0.816094**
Mean VIF	**1.93**	

The VIF is 1.93 overall & Individual VIFs are below 5.

→ **Multicollinearity is not presenting a problem**

→ No imminent violate of Gauss-Markov assumptions

→ proceed with regression analysis!

Regression (Base Year 2015, without GDP)

Base year 2015

Pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
happi	1.828	4.35	0.42	.676	-6.883	10.54	
MonEdu	.001	0	2.11	.039	0	.002	**
Ineq	-1.945	.579	-3.36	.001	-3.104	-.787	***
TeachHr	-.058	.023	-2.53	.014	-.104	-.012	**
2015b	0	.	.	.	.	.	
2018	-15.461	5.857	-2.64	.011	-27.189	-3.733	**
Constant	574.451	29.341	19.58	0	515.697	633.204	***

Mean dependent var	484.867	SD dependent var	32.289
R-squared	0.612	Number of obs	63
F-test	17.988	Prob > F	0.000
Akaike crit. (AIC)	567.934	Bayesian crit. (BIC)	580.792

**** p<.01, ** p<.05, * p<.1*

→ Coefficient of *MonEdu* too small

→ Change unit to $1000 per student (*MonEdu2*)

Regression (Base Year 2015, without GDP)

Base year 2015 with MonEdu2

Pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
happi	1.828	4.35	0.42	.676	-6.883	10.54	
MonEdu2	1.02	.483	2.11	.039	.053	1.988	**
Ineq	-1.945	.579	-3.36	.001	-3.104	-.787	***
TeachHr	-.058	.023	-2.53	.014	-.104	-.012	**
2015b	0	.	.	.	.	.	
2018	-15.461	5.857	-2.64	.011	-27.189	-3.733	**
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*** *p<.01*, ** *p<.05*, * *p<.1*

→ p-value for *MonEdu2, Ineq, TeachHr* significant at 10% level

→ Money spent in education is positively correlated with PISA scores

→ Inequality, Number of teaching hours are negatively correlated with PISA scores

Regression with Panel Data

(Base country Australia, without GDP)

Base country Australia with MonEdu2

Pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
happi	-1.529	5.732	-0.27	.792	-13.336	10.277	
MonEdu2	-.111	.229	-0.49	.631	-.582	.36	
Ineq	.207	.479	0.43	.67	-.781	1.194	
TeachHr	.012	.019	0.66	.514	-.026	.051	
: base Australia	0	.	.	.	.	.	
Austria	-5.659	7.645	-0.74	.466	-21.404	10.086	
Canada	21.863	7.091	3.08	.005	7.259	36.466	***
Chile	-68.796	10.665	-6.45	0	-90.761	-46.832	***

18 countries have significant coefficients!

→ Results analyzed further in implications

Implications of the Results

The previous result suggested the need for observing the regression results for each country. I investigate the determinants of PISA scores for 5 countries in the following section.

Canada

Pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Canada	21.863	7.091	3.08	.005	7.259	36.466	***

→ Results significant at 1% level
→ PISA result for Canada higher than Australia by 21.863 points, on average, ceteris paribus.

But why?

Canada & Australia are similar countries...

English
Developed country
Thinly dispersed population
Large immigrant population

Equity in Education!

90% of students in public schools
All schools are good
Low entry barriers in schools
Less socioeconomic divide in education

66% of students in public schools
Stratified school system
(only private schools are good)
Schools are highly selective
Difference of **3 years of schooling** between highest & lowest quartile

Students of lower socioeconomic status scored better in Canada, while they did very badly in Australia.

Finland

Pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Finland	23.689	8.308	2.85	.009	6.579	40.799	***

→ p-value significant at 1% level
→ Result was expected!

Finland is famous for quality education

- Ensure quality education **in all schools**
  - **Less work** outside of schools
- **Master's degree** required for teachers
  - **Cooperation** > Competition

Estonia

Pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Estonia	23.493	11.658	2.02	.055	-.517	47.503	*

→ p-value significant at 10% level
→ Estonia is also famous for good education!

- **Free** compulsory education
- Equal access to learning **technology**
- **Less selective** schools
- **Individual** achievement > Collective success

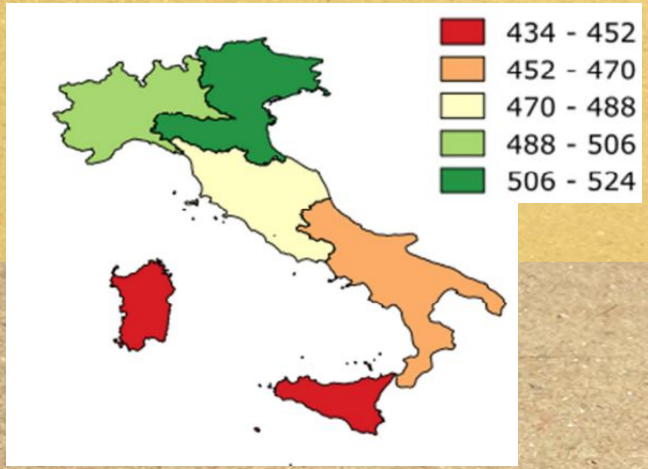
Italy

Pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Italy	-19.96	10.12	-1.97	.06	-40.802	.882	*

→ p-value significant at 10% level
→ PISA result for Italy is significantly lower than that of Australia
→ The average score in 2015 was 485.3, but...

Italy

2015 average: 485.3



- Clear evidence of **North-South divide**
- North had higher scores than South
- The difference is almost **2 years** of schooling
- **Immigrants** score lower
- Much learning outside of school (**tutoring**)
- So **socioeconomic status** determines amount of education received

South Korea

Pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
South Korea	20.095	10.467	1.92	.066	-1.462	41.653	*

→ p-value significant at 1% level
→ higher PISA results than Australia

- **Homogenous population** (95% of population are Korean)
  - Low immigration rate
- **Restrictive** immigration policies
- **Less** racial segregation in education

Equity as a Variable

→ Close examination of these countries suggest that **equity** might be a huge determinant of PISA scores. Hence, I decided to test the relationship between equity and PISA scores.

Socio-economic background affects probability of being a top performer

The higher the index value, the more advantaged students there are among top performers in reading (2018)

→ OECD index with the 2018 PISA reading test

- Higher value indicates that there are more students from higher socioeconomic backgrounds among the top performers
- Variable name: *Equity*

Equity as a Variable

Summary Statistics Equity

Variable	Obs	Mean	Std. Dev.	Min	Max
Equity	33	.407	.069	.29	.56

No data published for 5 countries
(Chile, Colombia, Costa Rica, Mexico, Spain)

Simple Linear Regression with Equity

Equity

Pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Equity	-141.795	37.632	-3.77	.001	-218.546	-65.045	***
Constant	552.355	15.536	35.55	0	520.669	584.042	***

Mean dependent var	494.606	SD dependent var	17.371
R-squared	0.314	Number of obs	33
F-test	14.198	Prob > F	0.001
Akaike crit. (AIC)	272.607	Bayesian crit. (BIC)	275.600

*** $p<.01$, ** $p<.05$, * $p<.1$

p-value significant at 1% level
→ *Equity* variable is negatively correlated with PISA scores
→ Hence, an increase in equity in education is associated with an increase in PISA scores

Evidence that socioeconomic status influences educational attainment

Equity in Education is Important!

Educational policies should focus on increasing equity in education!

Example from the US demonstrates this:

Policy in Education: US

2015

- **Inequitable funding** system in education
- 45% of high-poverty schools received less state & local funding than other schools → **low equity** in education

2018

- 2017: US govt gave **$15.4 billion grants** to local agencies to make sure students graduate high school, have access to job opportunities
- Boosted access to high-quality early learning + local innovation + more diverse schools

⇒ **increase in the PISA** test scores (487 to 495)

[redacted]

Conclusion

Conclusion

- Model has a better fit **without GDP per capita** as an independent variable
- **Equity** was not included in the original model, but is an important determinant of educational attainment
- Guideline for educational policy formation

Limitations

Small number of observations
(38 OECD countries)

Limitations

All countries examined are high-income countries (HICs)
→ results are not generalizable to all countries

Summary Statistics GNI

Variable	Obs	Mean	Std. Dev.	Min	Max
GNI	38	44099.474	15164.527	14480	74310

<u>GNI per capita</u>
HIC: >$12,746
MIC: $1,045< < $12,746
LIC: <$1,045

Limitations

If we use measures of wealth other than GDP per capita?

If wealth & PISA scores have none or negative correlation, then the proportion of the wealth invested in education & equity in education would be more important than the wealth per se.

→ I did a linear regression of GNI per capita & PISA scores

Further Research

GNI

Pisa	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
GNI2	1.11	.259	4.29	0	.586	1.634	***
Constant	437.287	12.039	36.32	0	412.87	461.703	***

Mean dependent var	486.229	SD dependent var	28.923
R-squared	0.339	Number of obs	38
F-test	18.429	Prob > F	0.000
Akaike crit. (AIC)	350.830	Bayesian crit. (BIC)	354.105

*** $p<.01$, ** $p<.05$, * $p<.1$

p-value significant at 1% level, positive correlation

→ Wealthier countries did have better PISA scores
→ Hard to differentiate effect of wealth from effect of equity
→ Further research can include **countries with varying levels of wealth** and observe the relationship with more countries

Limitations

PISA test only measures...

- 15 year olds
- Reading, Math, Science
- With technology
- Not all countries
- Every 3 years

Future Research

Include other forms of standardized test

- Every country's own standardized tests
- More past test results