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Evaluation on the effect of Poverty to Intelligence

I. Abstract

In the book IQ and the Wealth of the Nation, Richard Lynn and his colleagues established a study examining the factors that influence the distribution of IQ points across nations. He implemented a meta analysis on this relationship and concluded that the gap of income does dictate the gap of IQ points between groups (Lynn et al, 208). Around 10 years later, in 2013, The Environmental Science committee of Princeton University conducted their own study version on this subject and claimed that people who live under chronic poverty tend to have 13 IQ points lower than those who have average life. This study will inherit the data set of nations' IQ from Lynn's study then resemble with the educational expense, income, and climate of the listed countries. A thorough research about the significance of poverty on IQ point by using linear regression and logarithm regression is illustrated in this paper.

II. Introduction

IQ or Intelligence Quotient represents the score deducted from a set of standardized tests that indicates the cognitive ability of a person in relation to the average score of the groups. IQ has long been perceived as an indicator of intelligence, which is a powerful component that might dictate one's socioeconomic status.Thus, a tremendous amount of study has been established to identify the possible factors that might contribute to the differences of IQ points between countries. The reason behind these studies is to determine a method to optimize nationwide intelligence in order to boost efficiency and prosperity of such nations. These studies examine a variety of determinants, especially delve into the relationship between average income and intelligence. A numerous amount of study then implied that poverty might negatively affect one's cognitive ability while high income might correlate with one's ingenuity.

Lee Kuan Yew, the first ever Prime Minister of Singapore, the godfather of the so-called "Asian's Dragon" has brought Singapore from an underprivileged, tiny , newly liberated country to one of the most powerful countries in the world. Lee Kwang Yew took over Singapore when its income per capita was approximately 400$; by the time Lee left office, that number sky-rocketed to 50,000$. In the dataset collected from 2010,

Singapore is the country with the highest average IQ points with a relatively high average income. Hence, the successful story of Singapore is a compelling exemplar of Lynn's study outlier. Such story expand the scope of this study to not only (1) evaluate the causation relationship between IQ and poverty, but also (2) discover in depth the story behind the outliers, then (3) measure the influence of other factors on IQ, and finally (4) determine the bias factors that need to be considered in this study. From the four named purposes, this study only focuses on evaluating the impact of relevant variables on IQ instead of investigating the reverse causality.

In this study, the main data set that will be used is a combination of Lynn's data and World bank data, as the average IQ result of 109 countries and territories will be adopted from Lynn's study from 1990 to 2010. On the other hand, three other matrices present in this data set are average educational expenditures, average income (GDP per capita), and the average maximum daily temperature of the corresponding countries from 1990 to 2010. Noted that in Lynn's study, he and his colleagues were only able to measure IQ from 82 countries and predict the rest based on the model of their studies; hence, a possible random variable might arise from this prediction. Hence, this study is classified under the meta analysis category due to the large amount of samples and the conclusion will be deducted from the combination of prior studies . The result of this study covers the big picture of the subject so countries may adapt to be able to control the factors that affect IQ instead of providing a detailed explanation on any nation's case.

Prior to the implementation of the analyzing method, the null hypothesis of this study is (H0): There is no significant, non random relationship between average income and IQ, insisting that poverty will not exacerbate cognitive ability and vice versa.

III. Methods

III.1: Analyze the relationship between income and IQ

The initial approach to test such relationships is using cor() command to predict the correlation and then plot a scatter graph with smooth lines from the raw data, with x-axis of income (independent variable) and y-axis of IQ(dependent variable).

+ Plot command:

```
ggplot(data = dat) + geom_point(mapping = aes(x = `Income ( )`, y = IQ)) + geom_smooth(mapping = aes(x = dat$`Income ( )`, y = dat$IQ))
```

As income represents a large number (4 to 6 figures) compared to IQ(2 to 3 figures) so instead of using normal linear regression of two variables, this study examines such relationships using the linear regression of the logarithm base 10 to reduce the Residual standard error.

+ Regular linear regression command:
  lm.model = lm(dat$IQ ~ dat$`Income ( )`, data = dat)

+ Logistic base 10 in form of linear regression command:
  lm_log.model = lm(log1p(dat$IQ) ~ log1p(dat$`Income ( )`), data = dat)

III.2: Discover prevailing outliers from III.1

The outliers that this research wants to study further are the countries with high IQ points but low income. In 2008, the World Bank set the threshold for the extreme poverty line at income per capita of 1.25$ per day ~ 480$ per year. In order to expand the scale of this study and examine different abnormal stories of these outliers, this study defines outliers as countries that have average income fall below 1500$ with IQ not smaller than 94 points.

+ Filter command:
  outlier <- filter(dat, dat$`Income ( )` < 1500, dat$IQ >= 94)

III.3: Examine effects of other factors on IQ and compare

As this section only wants to examine which factor has the strongest correlation to the global dependent variable IQ; thus, cor() command run between the logarithm base 10 value of IQ and 3 factors: Income, Education expenditures, and daily max temperature will be examined.

+ Correlation command:
  cor(log1p(dat$IQ), log1p(dat$`Income ( )`), use = "complete.obs")

cor(log1p(dat$IQ), log1p(dat$`Education expenditures per capita ( )`), use = "complete.obs")

cor(log1p(dat$IQ), log1p(dat$`Daily max temperature(Celcius Degree)`), use = "complete.obs")

III.4: Identify random variables and bias

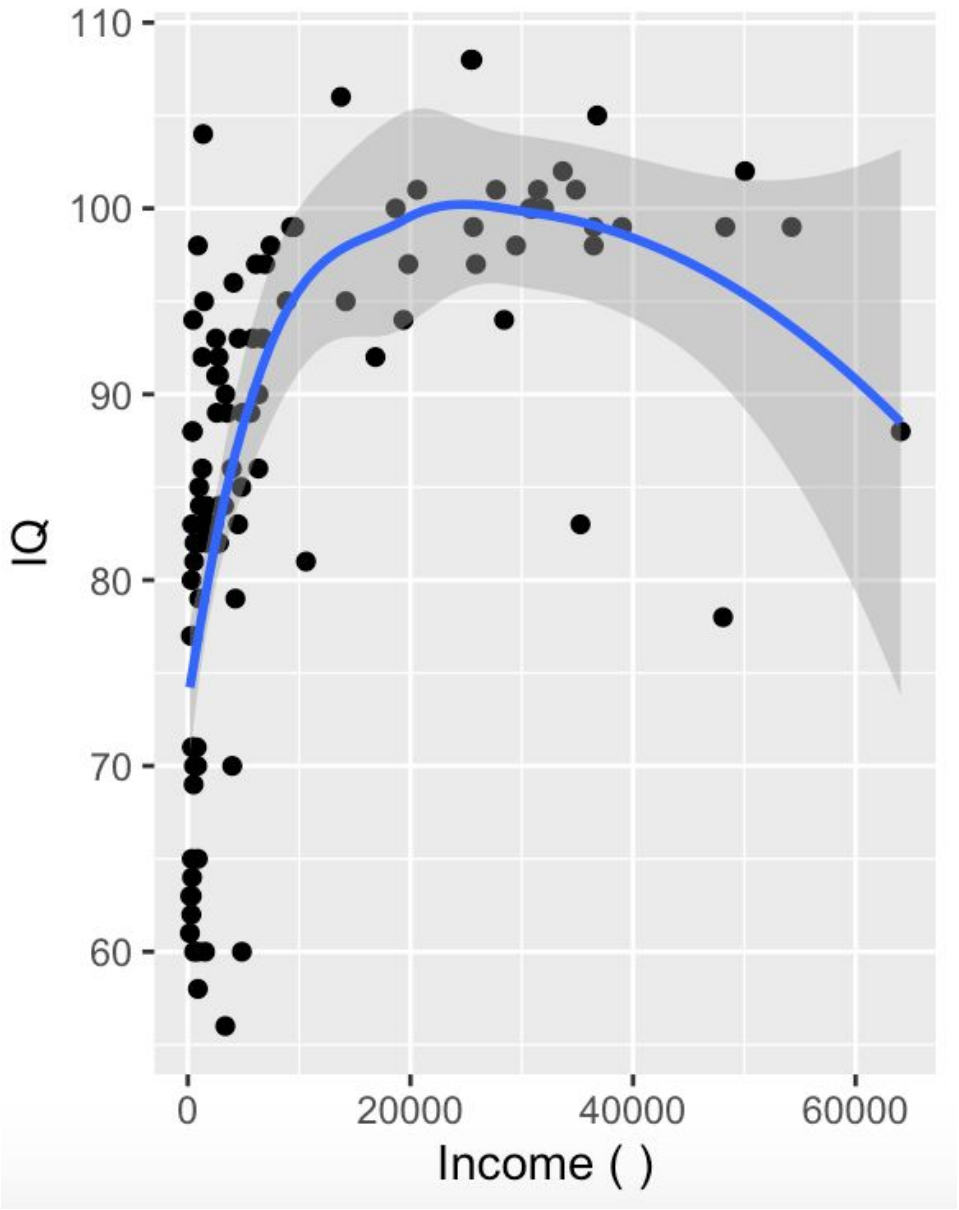
Random variables and possible bias will be manually discovered later in this study based on the result of sections **III.1,2,3.**

IV. Results

IV.1: Relationship between income and IQ

IV.1.1: Relationship by graph:

a. IQ vs Income

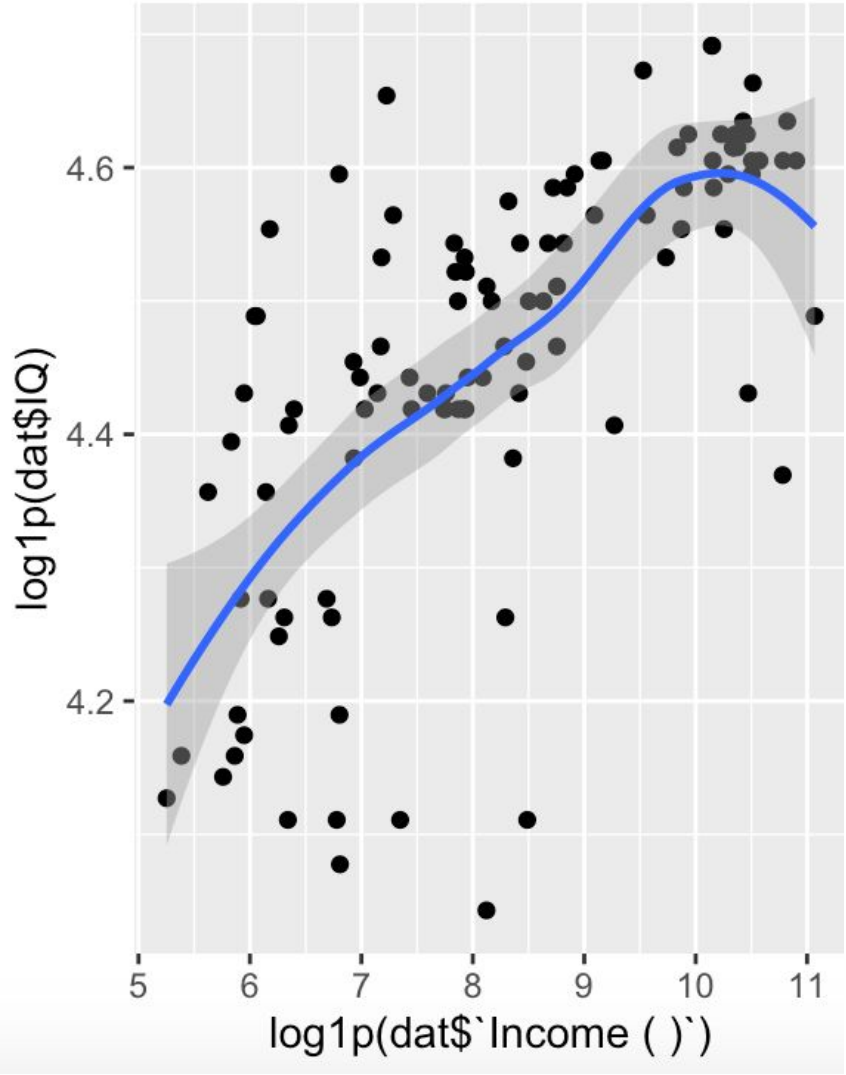


The above graph represents the relationship between IQ and Income across countries. However, since the scale of Income is much bigger than IQ, the scatter points represented for countries with low income seems clustered to each other that might lead to a misinterpretation of data.

From this graph, one conclusion can be drawn is countries with high income almost always have high IQ points, yet, the countries with low income do not always have a low IQ point. The lowest IQ points belong to the countries with lower income.

b. log10(IQ) vs log10(Income)

In order to reduce the amount of errors and misinterpretations from the graph, a graph between logarithm base 10 of IQ and Income will be drawn, resulting in:



From this graph, a clearer correlation between Income and IQ is represented. Even though a high amount of outliers are distributed far apart from the smooth line, the clear, nearly linear, positive slope smoothline goes across most of the scattered points. Hence, by observing this graph only, this study can speculate that Income and IQ have a positive correlation to each other. The strength and significance of such relationships will be examined further by regression analysis.

IV1.2: Relationship by regression (logarithm based linear regression)

Due to the plotted graph, regular linear regression will produce a large Residual Standard Error due to the enormous difference between scales of the two variables. Hence, a logarithm based linear regression is used instead, resulting in:

```
Call:
lm(formula = log1p(dat$IQ) ~ log1p(dat$`Income ( )`), data = dat)

Residuals:
     Min       1Q   Median       3Q
-0.40689 -0.02970  0.01528  0.07434
     Max
 0.26464

Coefficients:
                        Estimate
(Intercept)             3.900683
log1p(dat$`Income ( )`) 0.067620
                        Std. Error
(Intercept)               0.059538
log1p(dat$`Income ( )`)   0.007087
                        t value Pr(>|t|)
(Intercept)              65.516  < 2e-16
log1p(dat$`Income ( )`)   9.542 6.54e-16

(Intercept)             ***
log1p(dat$`Income ( )`) ***
---
Signif. codes:
  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’
  0.1 ‘ ’ 1

Residual standard error: 0.1174 on 105 degrees of freedom
  (2 observations deleted due to missingness)
Multiple R-squared:  0.4644,    Adjusted R-squared:  0.4593
F-statistic: 91.05 on 1 and 105 DF,  p-value: 6.542e-16
```

From the result of the log based linear regression above, one of the most prevalent values is p-value = 6.542e-16. As p-value is << 0.05, null hypothesis should be rejected, indicating that there’s a non random relationship between IQ and Income. Residual standard error of 0.1174 represents a low deviation between the predicted value and the actual value from the model. However, the Multiple R-squared only yields a value of 0.4644, showing that only 47% of the variance of IQ might be explained by this model.

This model demonstrates a sufficiently precise pattern of IQ and Income; it also proves that alternative hypotheses should be conceded. However, the result only shows that IQ and Income has a positive correlation, since the model's slope ~ 9.5; such result is inadequate to conclude that Income is an absolute determinant of IQ.

IV.2: Prevailing outliers from III.1:

By using the filtration command, a table of countries with income lies under poverty line or close to poverty line but achieve a high score of IQ is represented by this outliers table:

	Rank	Country	IQ	Income ( )	Education expenditures per capita ( )	Daily max temperature(Celcius Degree)
1	6	China	104	1374	27	19.4
2	29	Mongolia	98	897	50	8.0
3	36	Ukraine	95	1458	83	14.1
4	39	Vietnam	94	481	26	29.3

China, Mongolia, Ukraine, and Vietnam are the countries with the IQ results that differ significantly from other observations of low income nations in the model . These countries yield an extraordinarily high IQ result in accordance with their low income. Ironically, these countries also belong to the group that spend the least on education expenditures. Neither these countries has a good standard of living nor has good educational resources, yet, they were able to go against these adversities and expressed a high level of cognitive ability.

Demographically, these countries are all East Asian countries, Ukraine belongs to Europe yet located right next to China. Trace back to the history, China, Mongolia, and Vietnam are amongst the oldest countries on this Earth, with roughly 5000 years of history. With this length of time, these countries are able to accumulate intellectual resources, culture, and constantly expand these values. Moreover, these three countries are under influences of the Confucianism ideology, which treasure the importance of literacy and educators. Thus, these countries are capable of exercising and achieving high levels of intellect without the assistance of prosperity.

On the other hand, Ukraine is one of the most compelling outliers in this data set, as this country suffered from the Chernobyl disaster in 1986, just a few years before this data set was established. Unfortunately, due to the lack of prior study on cognitive ability of Ukrainian, this study is incapable of finding any reasoning for the case of this country.

IV.3: Effects of other factors on IQ and the most significant factor:

The correlation between IQ and three independent variables: education expense, income, and daily temperature is demonstrated from the following table (Note that these value are taken from the cor() command on the log base 10 value of each variable) :

	Income	Education expenditures	Daily max temperature
IQ	0.6814808	0.6586108	-0.6323529

The result from this table shows that Income and Educational expenses have a fairly strong positive relationship with IQ while temperature, on the contrary, is inversely proportional to IQ. The strength of correlation between IQ and other three factors are quite similar to each other, indicating that these three variables yield the same significance in the study of IQ , and none of them are an absolute determinant factor of IQ.

IV.4: Random variables and bias

As stated in the introduction section, the dataset in this research is a combination of prior meta analysis from different researchers. Hence, the context and method of each research are inconsistent to each other. Such a discrepancy might extend the amount of bias (each researcher has their own bias factor) and decrease the accuracy of this study.

Overall, some possible random variable in this research might include: the content of IQ test in each country (since the composition of each test might be different), the sample population and the demographic of the sample in each country (since there might be a chance that only people from a specific group were being tested in each country).

These random variables can have a strong effect on the accuracy and reliability of the study. However, the actual number of participants and the actual test have never been reported by these prior studies; this study is incapable of investigating these possible bias and random variables.

V. Conclusion

In conclusion, this study shows that there is a non random relationship between intelligence and income across countries, such relationship is identified as a positive correlation by graph and logarithm based linear regression. The center of this study is examining if poverty might negatively affect cognitive ability. By interpreting the graph and the model, this study shows that the lowest IQ group are also the group with the lowest average income. Thus, poverty and IQ are inversely proportional to each other.

Nevertheless, the outliers group has shown that even though poverty might affect intelligence, it's not an absolute determinant factor. Impoverished nations are still able to obtain literacy effectively with some extraneous conditions such as rich culture, meritocratic ideology, genetics, etc.. Hence, countries with low IQ tend to live near to the poverty line, yet, countries of lower wealth do not necessarily have substandard cognitive ability.

Finally, income, educational expense, and temperature do have a non random relationship with a fair impact on IQ points. Each of these three factors can influence the distribution of intelligence similarly but is not strong enough to determine the IQ result by itself.

VI. Further discussion

The (4) purpose of this study is to come up with a better methodology that can diminish the fallout of bias and random variables in the subject of IQ and poverty.
As discussed in IV.4, the possible inaccuracy of this study is due to the inconsistency of different methodologies conducted in meta analysis. In order to avoid such a situation, a meta study should be planned between a big group of researchers. The plan should list out the global steps, tests, and sample for each researcher group from each country. The content of the test , the demographic of the sample, and the population must act as control variables and must be similar from one country to another country. This scheme will not only improve the reliability of the study but also increase its efficiency.

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