The DJ-MC Equation for Measuring Income Inequality

Myra M. Beyene, Ciarese Guia Marie C. De Torres, Diana P. Liz, Jessie L. Willinghan

Notre Dame of Maryland University

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Income Inequality

Income inequality is one of the greatest issues facing the world today. Not only can income inequality depress demand, but it can also lead to economic instability. There are many factors that contribute to income inequality, however, there is not a mathematical formula that can calculate it. Economists have used the Gini coefficient for years to measure the degree of income inequality within countries (Gini Index, 2018). The sole dependent variable for income inequality use in this study is the Gini coefficient. The Gini coefficient is the most commonly used measure of inequality. This variable measures the statistical dispersion intended to represent the income or wealth of a country's residents (Gini Index, 2018). Unfortunately, the Gini coefficient only looks at wealth distribution, not the factors that cause this distribution. By looking at various factors across countries, this research hopes to derive a mathematical formula that correlates the Gini coefficient with these variables. This study began by determining what factors correlate with income inequality in a statistically significant way in hopes to create a mathematical formula that can be used to determine income inequality and direct policies regarding it.

Data Gathering Process

In order to create a mathematical formula for the Gini coefficient, multiple variables need to be identified that might contribute to income inequality in a qualitative way. The statistical significance of these variables would be determined by running a regression on Excel. The variables were chosen based on preliminary research and the researcher's personal inclinations as to the causes of income inequality across the globe. This research yielded 16 variables that our team believed would be statistically significant. The 16 variables chosen were:

- ➢ Literacy rate of people ages 15 and up who can read and write (literacy rate)
- ➢ 2014 government expenditures on education as a percentage of GDP
- ➢ GDP growth
- ➢ Global Gender Gap Ratio
- ➢ Life expectancy
- ➢ Incarcerated people out of 100,000 (incarceration rate)
- ➢ 2015 tax revenue as percentage of GDP

- ➢ Unemployment rate
- ➢ Healthcare cost as percentage of GDP
- ➢ Level of globalization (globalization)
- ➢ GDP
- ➢ GDP per capita
- ➢ Average inflation rate
- ➢ National/public debt as percentage of GDP
- ➢ Top income tax percentage
- ➢ Median age of the population

In order to increase the chances of data being available, 80 countries were chosen to be tested. The 80 countries with the highest GDP were chosen at the risk of bias. A list of the original 80 countries tested can be found in Appendix A. The next step was to find the data for all 16 variables for the 80 countries. Once this was done, an initial regression was run in order to determine what variables were correlated with income inequality.

Initial Regression

The first multiple regression done using Microsoft Excel showed that only six variables were statistically significant at a 95% confidence interval, having a t-statistic greater than +/-1. The adjusted R squared showed that about 39% of the data can be accounted for. The R-squared value shows how closely our data fits into the regression line of our model.

	Coefficients	Standard Error	t Stat	P-value
Intercept	30.8540112	23.9137211	1.29022209	0.2016892
Literacy Rate	20.1727129	13.7287771	1.46937436	0.14670752
2014 Govern	-39.60109	42.4967338	-0.931862	0.35496535
GDP growth	-84.535908	35.7343532	-2.3656762	0.02108714
Global gende	12.9687022	16.5835497	0.78202209	0.43713094
Lie expectan	0.20741025	0.31922675	0.64972703	0.51823064
incarceration	0.02093329	0.00870879	2.40369689	0.01918469
2015 Tax rev	-17.119135	7.37318338	-2.3218106	0.02348969
unemployme	21.0981125	20.2502363	1.04186994	0.30145373
healthcare cc	-0.0257873	0.29588697	-0.0871524	0.93082678
globalization	-0.0265154	0.10826782	-0.2449059	0.80732523
GDP (MILLIO	3.5619E-07	4.1239E-07	0.86372152	0.39101741
GDP per capi	-1.954E-05	6.6144E-05	-0.2954296	0.76863726
average infla	-0.2424127	0.27536404	-0.8803353	0.38202367
national/pub	-0.0037994	0.02947109	-0.1289209	0.89783097
top income t	-3.8616781	8.41634452	-0.4588308	0.64793476
average age	-0.8388933	0.20390924	-4.1140523	0.00011486

Values closer to 0 show little to no variability to the data, while values closer to 1 show

significant variability to our data. The following figures; literacy rate, GDP growth, number of

incarcerated people out of 100,000, tax revenue as a percentage of GDP for the year 2015,

unemployment rate, and the average age of the population, where to be continued with and the

rest that was not statistically significant were dropped. Some of the variables dropped were

surprising, especially top income tax bracket, healthcare cost, and inflation rate. These were

surprising given how much politicians and the news seem to correlate these variables with

income inequality.

These initial findings provided six statements regarding the correlation between the

variables and their relation to income inequality.

1. As the literacy rate increases, income inequality increases (positive correlation).

2. As GDP growth increases, income inequality decreases (negative correlation).

3. As the incarcerated people out of 100,000 increases, income inequality increases
    (positive correlation).

4. As tax revenue increases, income inequality decreases (negative correlation).

5. As the unemployment rate increases, income inequality increases (positive correlation).

6. As median age increases, income inequality decreases (negative correlation).

Regression of Continued Variables

For the six variables continued in this study, a

second linear regression was run. This second regression

yielded a more significant t-value for all variables except

for unemployment rate which became insignificant and

was therefore dropped from this study.

	Coefficients	Standard Erro	t Stat	P-value
Intercept	38.995522	7.5269156	5.1808103	1.888E-06
Literacy Rate	28.899185	10.652632	2.712868	0.0083148
GDP growth	-67.32008	28.221078	-2.3854538	0.0196544
incarceratior	0.0210846	0.007359	2.8651483	0.0054407
2015 Tax rev	-19.693576	6.4446234	-3.0558149	0.0031338
average age	-0.7655421	0.1461909	-5.2365921	1.517E-06
unemployme	16.345335	16.713767	0.9779564	0.3313258

Research on Statistically Significant Variables

The results from our data show that as GDP growth increases, by a percentage, income inequality decreases, as measured by the Gini coefficient. Researchers that have studied the effect of GDP growth on income inequality have concluded that there is a significant negative effect of income inequality on economic growth, especially in low-income countries (Kim, 2015, p. 511). This negative correlation between economic growth and income inequality may be due to multiple transmission channels. Income inequality has the ability to generate socio-political instability, causing people to undermine incentives to save and invest (Mo, 2000, p. 293). This can have a grave effect on the growth of the economy, because the less that one saves and invest, the less they will spend on human capital. Borrowing money can be difficult and costly, so people with lower incomes tend to not do so, resulting in less investment in human capital.

The data shows that as the median age of a population increases, income inequality decreases. The research was done by Edvinsson, Lundevaller, and Malmberg corroborates this finding. Their study, conducted in Sweden, came to the same conclusion as our data that "Lower individual income and lower average income in the municipality of residence were associated with significantly increased mortality" (Edvinsson, Lundevaller, & Malmberg, 2013, p. 1). The DJ-MC equation estimated that Sweden's Gini coefficient would be 40.48, as opposed to it's actually Gini coefficient of 24.9. This difference of almost 15 means that Sweden is an outlier to the DJ-MC equation. However, the research done in Sweden shows that the correlation generally applies.

The data reveals that the coefficient for the tax revenue variable is negative, showing a negative correlation. This indicates that as the tax revenue increases, income inequality

decreases. One article suggests that the progressivity of tax revenues factor in reducing income

inequality (Webber & Thomas, 2016). Though progressive taxes can reduce income inequality

but only in small amounts, they are not so effective in several cases. For instance, South Africa

has one of the most progressive tax systems in the world but the country also has the highest

income inequality (Ehrenfreund, 2017). It goes to show that progressive tax system are not the

only solution. Tax policies are another factor that can lower income inequality (Carter, 2018).

They are important in financing public expenditures such as health and education (Carter, 2018).

The findings from our research also show a positive correlation between incarceration

rate and income inequality. As incarceration rates increase, income inequality increases. Looking

further into the reasons why this might happen, research has shown that the increase of the

income gap between higher and lower incomes creates a higher incentive for individuals of lower

income to partake in criminal actions (Chiu, 1998, p. 124). While higher income households are

gaining more income, individuals who have lower incomes have a greater incentive to risk

engaging in criminal activities, like burglary, then richer individuals because these lower income

individuals see more rewards then risks when it comes criminal activities. High impunity and

high income inequality are shown to be linked to high homicide rates, further suggesting that

lower income inequality can help reduce crime rates (Nadanovsky & Cunha-Cruz, 2009).

According to our research, higher unemployment rates worsen income inequality.

Therefore, there is a positive correlation between unemployment rate and income inequality. The

coefficient for the unemployment rate is positive which indicates that as the unemployment rate

increases, income inequality increases as well. High unemployment indicates that the economy is

not using its available resources in the best way (EconomyWatch, 2010).

Third Regression

The third regression yielded t-values above

	Coefficients	Standard Erro	t Stat	P-value
Intercept	40.7566779	7.30615587	5.57840245	3.7752E-07
Literacy Rate	28.8357236	10.6492959	2.7077587	0.00840836
GDP growth	-69.756882	28.1025781	-2.4822236	0.01532475
incarceration	0.02081041	0.00735148	2.83077899	0.00597567
2015 Tax rev	-18.876074	6.38829657	-2.9547898	0.00419385
average age	-0.7841143	0.14490944	-5.4110639	7.3992E-07

+/-2 for all five variables, as well a P-values of well

below .05. Given the statistical significance of all

variables, a preliminary equation for income inequality was developed and tested against

countries in the study.

Building an Equation

Using the coefficients from the third regression, the following equation emerged:

$$x = 28.83572362L - 69.756882G + .02081041I - 18.876074T - .7841143A + 40.7566779$$

- x represents the Gini coefficient or income inequality.

- L represents the literacy rate as a percentage.

- G represents GDP growth over the span of one year.

- I represents number of incarcerated people out of 100,000.

- T represents tax revenue as percentage of GDP.

- A represents the median age of the population.

Testing Equation

By assigning each country in the study a number between 1 and 80, a random number

generator in excel choose 10 countries to test the equation on. The following countries were

chosen: Costa Rica, Indonesia, Kazakhstan, Slovak Republic, Ukraine, North Sudan, Malaysia,

Romania, South Africa, and Sweden. The data showed that on average, the test equation differed

from the Gini Coefficient by 10.74, suggesting a flaw in the equation, or too small of a sample

size. In order to increase the sample size, all countries were tested against the variables in order

to create a more accurate equation.
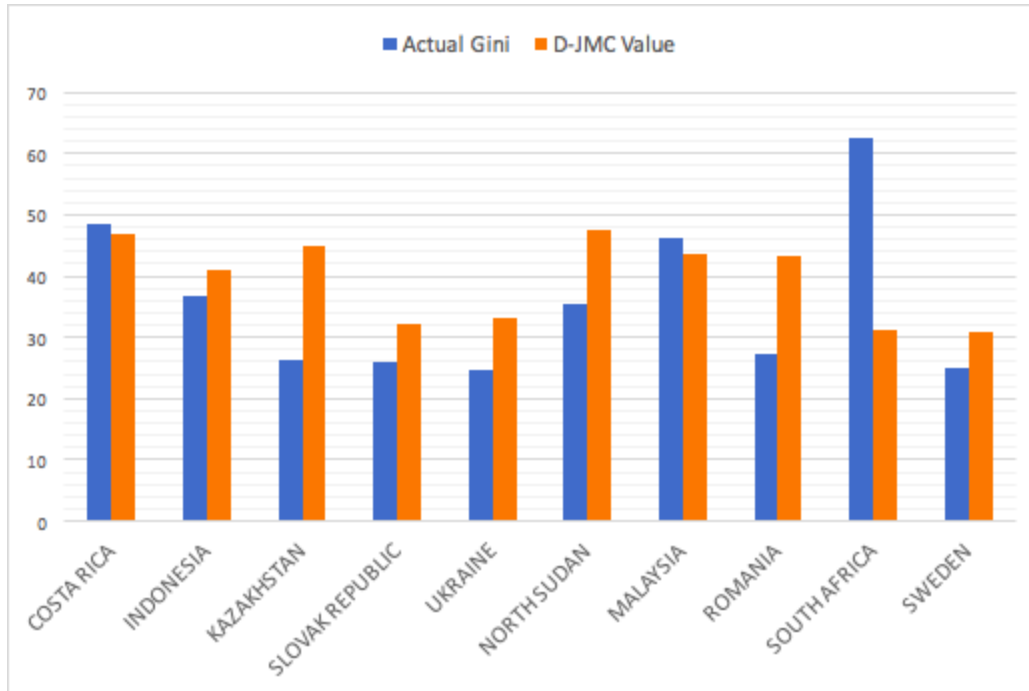
Strengthening Test

In order to strengthen the test equation, data on the five continued variables (literacy rate,

GDP growth, incarceration rate, tax revenue, and median age) was collected for as many

countries as possible. Complete data sets for the variables was able to be collected for 163

countries.

Once this data was collected, a regression was run in Excel that showed only

incarceration rate and the median age of the population were statistically significant (P<.05) with

p-values of 1.418-6 and 5.9367-10 respectively. Next, a regression was run with only these two

variables, and p-values of 1.7946-6 for incarceration rate and 9.4371-11 were produced.

Furthermore, this regression produced a y-intercept of 49.656417915285, a coefficient for

incarceration of 0.0265217, and a coefficient for the median age of -0.482076087260802. Given

the strength of the variables' significance, the test equation was rewritten as the DJ-MC equation

using the coefficients yielded from this regression.

D-MC Equation: y=.01326085I-.241038M+49.6564179

Testing the DJ-MC Equation

Using the data from the 165 countries, the estimated Gini value from the DJ-MC equation

was tested against the actual Gini coefficient for each country. This test showed that on average,

the DJ-MC equation predicted a Gini value that was 8.16 different from the actually Gini value.

A regression comparing the DJ-MC equation's estimated Gini value and the actual Gini value

produced an R-squared of .27899685, a standard error of 2.05789593, and a p-value of 4.289^{-13}

. This regression produced a 95% confidence interval, meaning that 95% of Gini coefficients can

be accounted for with the DJ-MC equation.
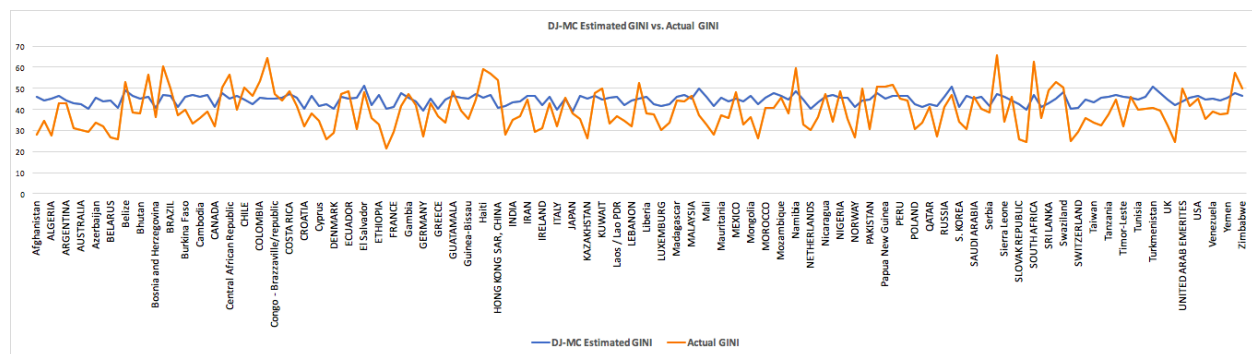
Factors That Contribute to Incarceration Rate

After running a regression analysis, our data shows that there is a positive correlation

between income inequality and incarceration rate. Proposing that as incarceration rate increases,

income inequality raises as well. Furthermore, our research has concluded that income inequality

is a factor that contributes to the increase of incarceration rate, rather than incarceration rate influencing income inequality. Regions of high-income inequality tend to have high incarceration rates due to the increase of incentives to perform criminal acts (Chiu, 1998, p. 124). Individuals and families with lower incomes see rewards, rather than the consequences, that source from their criminal actions (Nadanovsky & Cunha-Cruz, 2009). This increase in criminal activity would then lead to higher incarceration rate in countries of higher income inequality.

Incarceration Rate vs. GINI Coefficient
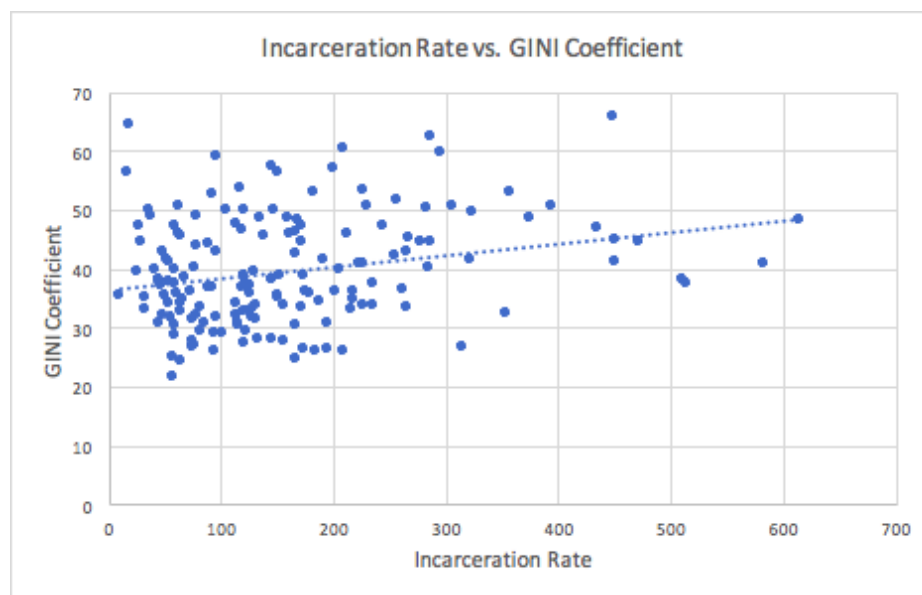
Factors That Contribute to Median Age

Our data showed that the correlation between income inequality and the median age is negative, meaning as income inequality increases, median age decreases. With further research, we can conclude that income inequality is associated with a decrease in life expectancy (Cohen, Balfour, Kaplan, Lynch, & Pamuk, 1996). A decline in life expectancy can lower the median age in a certain country because if individuals are not living long, there would be a large majority of younger people in that certain region. Affordable healthcare and fresh food can be hard to obtain

in places of lower income, making it especially difficult for families of lower income to acquire. Without these necessities, lower-income families may not be able to afford or have access to the goods and services they need in order to live a healthier lifestyle, lowering life expectancy.

Median Age vs. GINI Coefficient
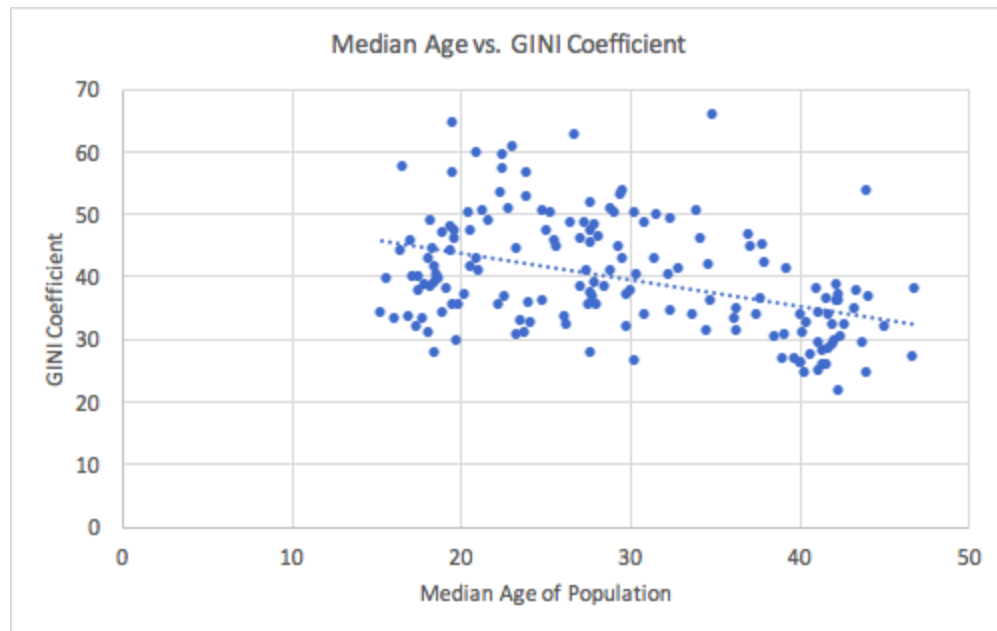
Issues Faced With This Study

While researching and gathering data to find the variables that influenced, or was a factor, of income inequality, a few issues were encountered. Some of the countries we looked at had data from slightly different years, but all were within the past five years, making our data still relevant for the time. In addition, some countries did not have the data we required for a particular variable, or did not report it every year. There were a few variables considered at the beginning of the project that had to be dropped, given that there was not enough data available to continue. Another barrier was that it was hard to standardize units across variables while constructing the final equation from our regression analysis. All in all, we are were able to gather

all the information a data needed by the end of our research, narrowing down the variables of income inequality.

Conclusion

This research began by trying to determine what factors contribute to income inequality. Through research and data analysis, it was found that incarceration rate and the median age of a population are highly correlated with income inequality. Median age has a negative correlation with income inequality, whereas incarceration rate has a positive correlation with income inequality. It is possible that high incarceration rate and the median age of a population are dependent on income inequality, as opposed to income inequality being systematic of high incarceration and a low median age. More analysis would be needed to determine which variables are dependent and which are independent.

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Appendix A

(North) SUDAN	GUATEMALA	PERU
ALGERIA	HONG KONG SAR,	PHILIPPINES
ANGOLA	CHINA	POLAND
ARGENTINA	HUNGARY	PORTUGAL
AUSTRALIA	INDIA	QATAR
AUSTRIA	INDONESIA	ROMANIA
BANGLADESH	IRAN	RUSSIA
BELARUS	IRAQ	S. KOREA
BELGIUM	IRELAND	SAUDI ARABIA
BRAZIL	ISRAEL	SINGAPORE
BULGARIA	ITALY	SLOVAK REPUBLIC
CANADA	JAPAN	SOUTH AFRICA
CHILE	KAZAKHSTAN	SPAIN
CHINA	KENYA	SRI LANKA
COLOMBIA	KUWAIT	SWEDEN
COSTA RICA	LEBANON	SWITZERLAND
CROATIA	LUXEMBURG	THAILAND
CUBA	MALAYSIA	TURKEY
CZECH REPUBLIC	MEXICO	UK
DENMARK	MOROCCO	UKRAINE
DOMINICAN REPUBLIC	MYANMAR	UNITED ARAB
ECUADOR	NETHERLANDS	EMIRATES
EGYPT	NEW ZEALAND	URUGUAY
ETHIOPIA	NIGERIA	USA
FINLAND	NORWAY	UZBEKISTAN
FRANCE	OMAN	VIETNAM
GERMANY	PAKISTAN	
GREECE	PANAMA	