Examining the Relationships between GII, HDI, Gini, and GDP per capita

A Comparative Analysis of Undeveloped and Developed Countries (1990-2021)

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Abstract:

This thesis examines and evaluates key measurements, namely the Gender Inequality Index (GII), Human Development Index (HDI), Gini coefficient (a measure of income and wealth inequality), and GDP per capita. Further, this study investigates the strengths and weaknesses of each measurement, providing a comprehensive background on previous research and their interrelationships. The study compares these measurements among undeveloped and developed countries, encompassing 193 countries from 1990 to 2021. The data section analyzes correlations between the measurements and explores the reasons behind these correlations. Notably, a strong positive correlation is found between GDP per capita and GII, which is the strongest correlation, while HDI and Gini exhibit the weakest correlation in the correlation matrix. The results and analysis section presents regressions that are connected to the literature review. It reveals that an increase in HDI is positively associated with GDP per capita, especially in undeveloped countries. Conversely, a higher GII indicates a negative relationship with GDP per capita, and an increased Gini suggests a positive association with GDP per capita. However, these relationships are weaker in developed countries, partly due to diminishing marginal returns. Lastly, a sensitivity analysis is conducted by imposing restrictions on the Gini coefficient and the time period to strengthen the findings.

1. Introduction

The study of socioeconomic disparities between nations has garnered significant research attention over an extended period. Variations in development, wealth distribution, and gender equality among countries constitute a multifaceted subject for investigation. Researchers commonly employ metrics like the Gender Inequality Index (GII), Human Development Index (HDI), Gini coefficient, and Gross Domestic Product (GDP) per capita to comprehend these disparities. This research focuses on the past three decades, a particularly intriguing era due to noteworthy technological advancements and transformations in numerous countries. Notably, this period encompasses significant events, such as the 2008 financial crisis. Therefore, the question that is investigated and attempted to be answered in this paper is the following: What are the differences in the relationships between GDP per capita and the indicators GII, GINI, and HDI when comparing undeveloped and developed countries between 1990-2021?

To provide a concise overview of the measurements, here's a summary of each measurement used in this paper: The GII measures disparities between men and women in three domains: empowerment, labor market participation, and reproductive health (UNDP, 2023); the HDI assesses progress in crucial aspects of human development, including GDP per capita in purchasing power parity (PPP), life expectancy at birth, and education (UNDP, 2022); the Gini coefficient serves as a measure of income or wealth distribution within a nation (World Bank, 2015); and GDP per capita reflects a country's economic output per individual. These metrics possess individual strengths and weaknesses, conveying diverse aspects of a nation's socioeconomic landscape. Although previous studies have examined the relationships among these metrics, understanding their complexities remains an ongoing endeavor.

In essence, this thesis attempts to examine these four measurements and their relationships, thereby shedding light on the disparities between undeveloped and developed countries. The study encompasses an extensive dataset spanning 193 countries. Additionally, the investigation evaluates the sensitivity of these relationships to changes in the Gini coefficient and the time period because of the Gini coefficient's missing values. Furthermore, it discusses the reasons behind variations in the strength of these relationships and draws comparisons with prior research. By the regressions made in this paper, the study aspires to contribute to the broader comprehension of these crucial socio-economic measures.

2. Background

This section presents an overview of the various metrics employed in the study: GDP per capita, HDI, GII, and the Gini coefficient. GDP per capita serves as a widely utilized indicator of economic growth, while HDI offers a more comprehensive assessment of a nation's development, encompassing factors such as education and health. The GII and Gini coefficient are dedicated measures designed to capture gender inequality and income inequality, respectively.

2.1 GDP per capita

The Gross Domestic Product (GDP) acts as a metric for quantifying the value derived from the production of goods and services within a specified time frame in a given country (OECD, 2023). Dividing the GDP by the population of that country enables the calculation of GDP per capita. A more precise definition of GDP per capita can be found in the World Bank's explanation: "GDP per capita is the sum of gross value added by all resident producers in the economy plus any product taxes (less subsidies) not included in the valuation of output, divided by mid-year population." By considering the value of output per individual within a particular economy, GDP per capita facilitates the study of economic growth across different nations (The World Bank, 2023).

GDP per capita is a widely used measurement to evaluate economies. However, it does have its limitations even though it correlates with many other factors outside the measurement. According to Oulton's research (2012), there exists a correlation between GDP and different factors of welfare, as outlined in Greve's paper (2008). Welfare, defined by the Oxford Dictionary, includes the happiness, health, and prosperity of individuals and communities, etc. For example, the number of products and services that the average person has access to has a link to welfare. Oulton's research paper shows that there's a strong positive correlation between GDP and life expectancy and a negative correlation between GDP and both inequality and infant mortality, which are connected to welfare (Oulton, 2012). However, the study recognizes certain limitations, such as the measurement's limitation to include factors like leisure, housework, carbon emissions, and pollution (Oulton, 2012).

The Gross Domestic Product (GDP) acts as a metric for quantifying the value derived from the production of goods and services within a specified time frame in a given country (OECD, 2023). Dividing the GDP by the population of that country enables the calculation of GDP per capita. A more precise definition of GDP per capita can be found in the World Bank's formal explanation: "GDP per capita corresponds to the aggregate sum of gross value added by resident producers in the economy, encompassing product taxes (excluding subsidies) that are not accounted for in output valuation, divided by the population count during the middle of the year." By considering the value of output per individual within a particular economy, GDP per capita facilitates the study of economic growth across different nations (The World Bank, 2023).

GDP per capita serves as a widely employed measure for evaluating economies. Nonetheless, it does possess limitations despite exhibiting correlations with numerous external factors. According to Oulton's study (2012) as presented in Greve's paper (2008), a relationship is observed between GDP and various indicators of well-being. Welfare, encompassing aspects such as happiness, health, and prosperity of individuals and communities, is defined by the Oxford Dictionary. For instance, the accessibility of goods and services to the average person influences welfare. Oulton's research reveals a strong positive correlation between GDP and life expectancy, as well as a negative correlation between GDP and both inequality and infant mortality, both of which are connected to welfare (Oulton, 2012). Nevertheless, the study acknowledges certain limitations, including the measurement's inability to incorporate factors like leisure, housework, carbon emissions, and pollution (Oulton, 2012).

2.2 HDI

The UN developed the Human Development Index (HDI) to highlight that evaluating a nation's progress should extend beyond the growth of a country's economy, and therefore the HDI focuses on the well-being and capabilities of its people. This measure contains four distinct statistics: GDP per capita in purchasing power parity (PPP), life expectancy at birth, adult literacy rate, and school enrollment ratio. It is a welfare indicator with three components consisting of four different statistics. The statistics are the following: GDP per capita in PPP, life expectancy at birth, adult literacy, and school enrollment ratio. Literacy and school enrollment are merged together to form an education index. In this merge, literacy accounts for two-thirds of the weight and school enrollment for the other third. The measure uses log

GDP per capita to reflect the decreasing marginal effect of income (UNDP, 2022). These three parts are put together, and each part represents one-third of the total weight. (Cahill, M.B. 2005).

A weakness within the HDI, according to UNDP, is that it ignores the allocation of human development to a population or country; in other words, the HDI does not provide information on the equality or inequality of development outcomes among individuals within a given country (UNDP, 2022). The UN recognizes that HDI alone does not encompass all dimensions of human development. To obtain a comprehensive understanding of a country's level of human development, it is necessary to examine additional indicators and information provided in the Human Development Report (HDR) statistical annex (UNDP, 2022). The HDI serves as a summary measure, but a more complete picture emerges when considering the supplementary data and analysis presented alongside it in the HDR statistical annex. The measurement can be employed to raise inquiries about a country's policy choices, such as how its human development outcomes may diverge from those of a similarly ranked GDP nation (UNDP, 2022).

2.3 The Gini Coefficient

The Gini coefficient measures how much income deviates between different households, starting from a totally equal distribution. Usually, the Gini coefficient is calculated for income but can also be calculated for consumption (World Bank, 2015). The Gini coefficient has a range between zero and one, where zero represents total equality and one is when one resident gets all the country's income (Janvry & Sadoulet, 2021). The Lorenz curve with the Gini coefficient is the predominant metric employed when measuring income inequality, as per Sloman (2000).
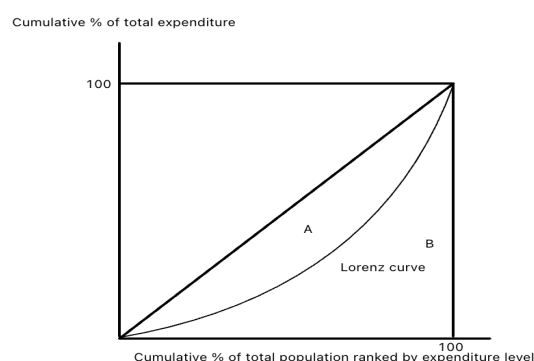
The Lorenz curve

Figure 1 from Janvry & Sadoulet (2021)

By arranging household income from lowest to highest, calculating the total income of an economy, and then calculating the fraction of income gained from each household, we get the Gini coefficient in the A-area of Figure 1. This is the area between perfect equality, where everyone earns the same income, and the Lorenz curve (Janvry & Sadoulet, 2021).

The Gini coefficient is a common and popular way of measuring income equality. However, the principal shortcoming of the Gini coefficient as an indicator of income distribution is its inability to discern distinct forms of inequalities (De Maio, F.G., 2007).

2.4 GII

This paper focuses on the Gender Inequality Index (GII) as the specific measure related to gender. It is important to note that the GII does not assess a country's overall development, allowing undeveloped countries with certain limitations on gender disadvantages to still perform relatively well. Further, GII is not dependent on imputations and reflects three underlying dimensions through an index (UNDP, 2010). These dimensions include empowerment (measured by education and political representation), labor market (measured by female labor force participation rate), and reproductive health (measured by adolescent fertility rate and maternal mortality ratio) (UNDP, 2023). Figure 2 provides an overview of the measurement and how the dimensions are related to each other.

Gender inequality index (GII)
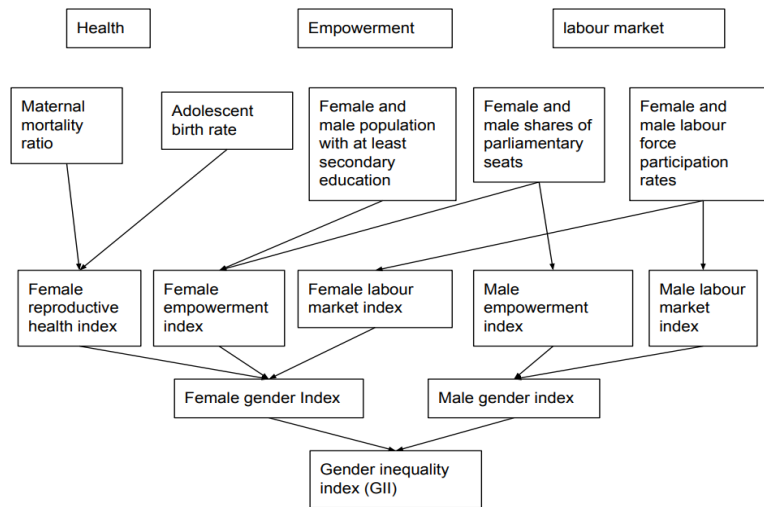
Note: Figure 2 from UNDP (2023)

The index has a scale between 0 and 1, where 0 implies that women and men are perfectly equal and 1 implies perfect inequality (UNDP, 2023). The dimensions in GII are connected with each other, and the higher the numerical value of the index, the stronger the correlation is across dimensions in gender differences. This shows that the dimensions are complementary to each other (United Nations Development Programme, 2010).

The GII does not account for all gender-related factors due to limited data availability. For example, data on how time is distributed between men and women is often unavailable. Also, data on women's asset ownership and violence against women is not documented in a comparable way. Despite efforts to establish more comprehensive data, these factors have yet to be adequately included in global measurements (United Nations Development Programme, 2010).

3. Literature Review

3.1 GDP and Welfare: Alternative Measures and Inequalities

Literature that researches differences between GDP and other welfare measures is broad. Cahill (2005) studies the redundancy of the Human Development Index (HDI), which, according to some researchers, is highly correlated with gross domestic product (GDP), raising the question of the necessity of having such an index. McGillivray (1991) argued that if any component of the HDI has a correlation coefficient greater than 0.7, it's considered redundant and cannot provide new information. Specifically, level 1 redundancy occurs when the correlation coefficient is above 0.9, while level 2 redundancy occurs when it is above 0.7. Cahill's study showed that each component of the HDI was highly correlated with each other, and therefore, according to McGillivray (1991), the HDI is a redundant composite intercountry index.

Figure 3: GDP and Human Development Index 1999
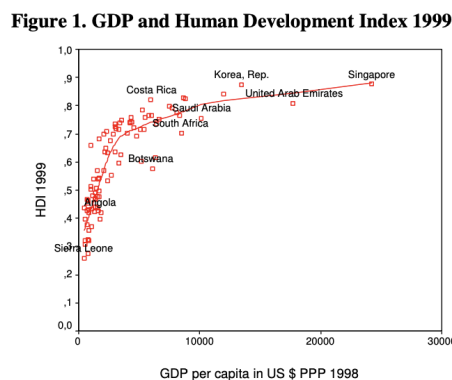
Note: Reproduced from Lane and Ersson (2004), Figure 1.

There exist various approaches to analyze welfare, as demonstrated by Jones and Klenow's (2016) calculation of consumption-equivalent welfare across different countries. Their index incorporates factors such as consumption, leisure inequality, leisure, consumption inequality, and age-specific mortality. Interestingly, their findings indicate that welfare inequality surpasses income inequality, although there remains a strong correlation between the welfare index and income per capita. They also found that, despite significant disparities in GDP per capita between Western Europe and the United States, the living standards in these regions are relatively similar. Western Europeans usually have more leisure time and similar

consumption across different incomes (Jones and Klenow, 2016). This shows that a broad index like HDI doesn't account for all definitions of welfare, and an index like Jones and Klenow's (2016) measurement suggests it might be better to investigate developed countries, while an index like HDI might be better to measure undeveloped countries. According to a study conducted by Lane and Ersson (2004), an examination of the correlation between GDP per capita and HDI in 1999 reveals a strong relationship between the two variables. Nonetheless, it is noteworthy to mention that certain outliers, such as Botswana, deviate significantly from the overall trend observed in the figure, displaying a high GDP per capita but a low HDI. We can also see that in countries that already have a GDP per capita of over $10,000, the HDI doesn't seem to improve much. A higher GDP per capita is necessary for a country to increase living standards in a poor country; however, political stability is also a must for a third-world country to "leave the poverty trap" (Lane and Ersson, 2004). Botswana constitutes a compelling subject of study, where the projected positive linkage between the HDI and GDP per capita has not materialized as anticipated. Botswana has for many years been one of the world's fastest-growing economies, at the same time as its HDI score has been declining. Even with well-handled economic policies, solid financial management, fiscal discipline, and commitment to a free market, they haven't managed to solve the big issue of inequality in the country, with huge differences in income and life expectancy between the population (Clover, 2003).

3.2 Economic Growth & Human Capital

Robert Barro (1991) denies the hypothesis that well-off countries grow slower than poor countries. The study employs school enrollment rates as a surrogate measure for human capital in order to examine the relationship between initial levels of human capital and subsequent economic growth rates in various countries. The findings indicate that, holding constant the initial value of GDP per capita, a country's growth rate is positively correlated with measures of its initial human capital. Additionally, when controlling for human capital variables, subsequent economic growth exhibits a substantial negative association with the initial level of GDP per capita. Hence, the results lend support to the convergence hypothesis posited by neoclassical growth regression. Specifically, the findings suggest that a poor country may grow more rapidly than a wealthy country, but only if the poor country's level of human capital surpasses what is typically observed at its low level of per capita income

(Barro, 1991). This shows us how important education and general welfare are to economic growth.

3.3 Income Inequality and Economic Growth

In the paper titled "Income Inequality and Economic Growth: Evidence from American Data" Ugo Panizza (2002) examined the correlation between inequality and growth in 48 US states from 1940 to 1980. The author observed some evidence of a negative relationship between growth and income inequality, but this correlation was not consistent for small variations in the economic model. Specifically, when examining the Gini index and growth over the period studied, In another article titled "Income Inequality is Not Harmful to Growth: Theory and Evidence," Li and Zou (1998) present their empirical findings on the relationship between income inequality and economic growth. Through an examination of data encompassing 46 countries, the authors find the opposite of Panizza's findings. They discovered that income inequality can actually promote growth. They found a generally positive correlation between income inequality and economic growth, which was statistically significant in most cases. Furthermore, they noted that undeveloped countries tend to experience greater income inequality than developed nations (Li and Zou, 1998).

3.4 Empowering Women for Economic Development: Addressing Gender Inequalities through Poverty Reduction and Education

The relationship between empowerment of women and economic development refers to increasing women's level of access to development in education, health, rights, opportunities, and more (Duflo, 2012). Esther Duflo (2012) explains that a low level of opportunity and existing poverty make the way for gender inequalities, which means that an increase in economic development would lead to a reduction in poverty, which would improve women's position in life and decrease gender inequality. Notably, the magnitude of gender inequality tends to be more pronounced in low-income countries. Moreover, Duflo reveals a bidirectional relationship between women's empowerment and economic development (Duflo, 2012). This implies that as women are empowered, societies experience positive

economic development, while advancements in economic opportunities for women further contribute to their empowerment.

Low-income households face complex situations where the lives of males are valued higher than those of females. By reducing poverty and therefore increasing household economic standards, women's positions will be improved (Duflo, 2012). Khanna et al. (2003) highlight that there was no big difference between girls and boys in India when examining different illnesses that were not treatable. The difference arises when examining death rates among boys and girls in the case of diarrhea, which is treatable (Khanna et al. 2003). Enhanced economic development alleviates the burdensome choices faced within households regarding the prioritization of boys' health over girls' health by mitigating the constraints imposed by poverty. Moreover, economic progress holds additional advantages for various health-related domains, encompassing a reduction in maternal mortality rates, improvements in childbirth outcomes, and an overall increase in life expectancy (Duflo, 2012). This showcases a relationship with economic development that reduces poverty and results in increased female empowerment and health.

Within the labor market, gender-based disparities in opportunity may contribute to distinct treatment and expectations within households, potentially leading to diminished prospects for females in terms of education and health when compared to males. Economic development increases work opportunities for females through an increase in jobs that are more favorable to women's work, which leads to better outcomes for women (Duflo, 2012). The lower expectations for females in education are shown in The PROBE Team report, which highlights parents' attitudes toward children's education in India. According to The PROBE Team's research, 89% of parents expressed belief in the importance of girls' education, while a higher percentage, 98%, affirmed the significance of boys' education. 10% of parents indicated that girls' education is not important, while a mere 1% expressed the view that boys' education lacks importance (The PROBE Team, 1999).

Gender inequality emerges, among various factors, due to divergent expectations and norms surrounding the allocation of time for females and males. This can manifest through women being more likely to engage in informal household work, limiting their full participation in careers. However, economic development plays a vital role in liberating women's time, resulting in a reduction of their home responsibilities and enabling increased engagement in the labor market. Both disparities in labor market opportunities and societal expectations concerning women's time allocation, which can influence their career trajectories, are subject to the influence of economic development (Duflo, 2012).

4. Method

4.1 Regression Analysis: Model Specification

In the current study, ordinary least squares (OLS) is used to relate GDP per capita to the three measurements of national welfare and equality. OLS can be used to investigate the different variables and their roles in output-making. The model requires a large amount of data to generate reliable results (IBNET, 2021), making it applicable on the current study's large data set. For all regressions, GDP per capita is in the natural log; to make the data more manageable, simplify understanding of the results, and create a better fit for our models, which makes the analysis more accurate and dependable. To investigate the relationship between the three measurements and GDP per capita for all countries, the following model is used:

$$ln(GDPpc) \ = \ \beta_0 \ + \ \beta_1 HDI \ + \ \beta_2 \ Gini \ + \ \beta_3 GII \ + \ u \qquad (1)$$

Where ln(GDPpc) represents the dependent variable and the independent variables include HDI, Gini, and GII, with the error term denoted as u. The coefficient β_1 represents the percentage change in ln(GDPpc) associated with a 0.1 unit increase in HDI, while β_2 and β_3 capture the effects of the Gini coefficient and GII, respectively. Furthermore, to determine how the relationship differs between developed and undeveloped countries, the following regression is used (column 2, table 5):

$$ln(GDPpc) = \beta_0 + \beta_1 HDI + \beta_2 Gini + \beta_3 GII + \beta_4 HDI * developed + \beta_5 Gini * developed$$

$$+ \beta_6 GII * developed + \beta_7 * developed + u \qquad\qquad (2)$$

Here the developed-variable is added. When this dummy variable is equal to 1, the country in the regression is developed, and when it's equal to 0, the country is undeveloped. The developed variable is an interaction variable that examines the difference between undeveloped and developed countries (for a detailed definition of the developed variable, see 5.3). For this regression, robustness is used to account for potential heteroskedasticity in the error term. Heteroskedasticity happens when the differences in errors in a regression model aren't the same for all the data points. This can violate one of the key assumptions of the ordinary least squares (OLS) regression, leading to biased standard errors and unreliable hypothesis testing, which can mess up the usual regression analysis and cause errors in our tests. By using robust standard errors, this study gets more reliable results and tests.

4.2 Sensitivity analysis: Model specification

In order to assess the robustness of the findings, the inclusion of the Gini coefficient in the analysis is restricted/excluded. This is because the Gini variable contains missing values, especially for the period 1990–2000, which could potentially impact the results. The sensitivity sensitivity of our model in relation to the Gini coefficient is tested through two ways. First, we omit the variable from the regression to observe how this affects HDI and GII in observations and coefficients. Second, we restrict our time frame to 2000–2021 in the purpose of limiting the number of observations. By reducing the time frame from 31 years to 21 years, the goal is to reduce the fraction of omitted country years by reducing the period of time investigated. The restriction may then lead to an increase in the representativeness and generalizability of the regression, which impacts the result and analysis.

5. Data

5.1 Data Sources

Data has been obtained from two main sources: the World Bank and the United Nations Development Program (UNDP, 2021). Based on these two sources, a unique dataset has been created specifically for this paper. GDP per capita and Gini were retrieved from the World Bank's World Development Indicators (WDI), which is the primary source of development data for cross-country comparisons (The World Bank, 2023). Data for GII and HDI is from UNDP's human development reports: "All composite indices and components time series (1990–2021) metadata" (UNDP, 2021).

5.2 Data Selection

The data is based on 193 countries from the time period 1990-2021. The goal is to include as many countries as possible but two countries were excluded from the study, these are Hong Kong and North Korea as they weren't included in the data from the sources mentioned in 5.1. Furthermore, the obtained data does not have information for all countries in all the years that are under investigation. In addition, there are some countries in the data that have missing values in some measurements for all the years between 1990-2021, which can affect the results. This limits the representativeness of the data, even though it comes from credible sources.

5.3 Developed Variable

To differentiate between countries categorized as undeveloped or developed, the World Bank has implemented an income classification system to assign countries to various income groups. This system comprises four distinct groups: low-income, lower-middle-income, upper-middle-income, and high-income nations (World Bank, 2022). For the purpose of regression analysis, the initial three variables (β_1-β_3) are considered representative of undeveloped countries, while the high-income category, denoted as developed in the regression(β_4-β_7), represents countries considered developed. Specifically, a high-income country is defined as a nation with a GDP per capita of \$13,205 or higher. Although the

World Bank utilizes GNI per capita to evaluate a country's income level, this study employs GDP per capita instead. This substitution is feasible due to the negligible disparity between these two measurements. By employing this model, countries that closely approach the high-income threshold can transition in and out of the "developed" classification over time.

5.4 Summary Statistics and Description of Variables

Table 1 is a description of the key variables used in the paper.

Table 1: Description of variables

Variable Name	Description
Log GDP per capita	GDP per capita in natural logs
GII	Gender inequality index
Gini	Measurement of income and wealth inequality
HDI	Human development index
Developed	Variable taking the value 1 if the country has a GDP per capita over or equal to 13205$

The second table presents a condensed overview of the variables analyzed in this study, showcasing key statistical measures. These statistics offer valuable information about the central tendencies and variations observed within the variables. Notably, the variables GDP per capita and the developed indicator exhibit the highest number of observations, while Gini displays the fewest. This limited number of observations for Gini may result in diminished data points when utilized in regression analyses.

Examining the GDP per capita variable, we observe a substantial range between its minimum value of 22.85 and maximum value of 234,315, indicating significant variability in per capita GDP across the dataset. Similarly, the variable GII also exhibits a wide range, with a minimum value of 0.013 and a maximum value of 0.822. Conversely, Gini does not demonstrate such an extensive range in its minimum and maximum values. Additionally, the maximum value for HDI aligns closely with the concept of "perfect welfare," standing at 1. On average, the mean values of the variables appear to be closer to their respective minimum values, except for HDI, where the mean value of 0.67 approximates the maximum value.

These statistics succinctly summarize the variables, providing valuable insights into the dataset as a whole.

Table 2: Summary Statistics

Variable	Obs	Mean	SD	Min	Max
GDPpc	5925	11359.5	20427.16	22.85	234315.5
gii	4857	0.41	0.2	0.013	0.822
gini	1787	0.38	0.89	0.207	0.658
hdi	5518	0.67	0.175	0.26	0.962
developed	5925	0.27	0.45	0	1

5.5 Correlation Matrix & Discussion

Table 3

	LOG GDPPC	HDI	GII	Gini
LOG GDPPC	1.0	0.3	-0.86	-0.39
HDI	0.3	1.0	-0.25	-0.009
GII	-0.86	-0.25	1.0	0.59
Gini	-0.39	-0.009	0.59	1.0

Table 3 summarizes the correlations between the variables of interest in this paper. Negative correlations exist between HDI and GII, as well as between HDI and Gini, this means that welfare and development are negatively correlated with more gender and income inequality. The weak correlation between HDI and Gini indicates that they are almost completely uncorrelated. The negative correlation is -0.009 where 0 is perfectly uncorrelated. Additionally, there is a negative correlation between log GDP per capita and GII, as well as between log GDP per capita and Gini. The strong correlation between log GDP per capita and GII indicates a strong negative correlation at -0.86. The correlations suggest that GDP per capita and HDI move in the opposite direction as Gini and GII.

The strongest correlation in the table is observed between the GII and log GDP per capita. The GII examines gender inequality in three dimensions: health, empowerment, and labor market, which are all influenced by economic development. It's important to note that if GII takes a smaller value, the lower the inequality. The health dimension is influenced by economic development by a reduction in poverty that can help lower the mortality rate during pregnancy and childbirth while increasing life expectancy (Dulfo, 2011). Future influence on the health dimension is shown by Khanna et al. (2003) that finds a reduction in difficult decisions related to women's health becomes less common with increased economic development. The labor market dimension is influenced by economic development, which increases job opportunities for women. Particularly in sectors that are more favorable to women's work, regarding the labor market dimension (Duflo, 2012). The dimension of female empowerment is also linked to economic development, as it involves improving women's access to education, health, rights, opportunities, etc. Furthermore, Duflo (2012) highlights that gender inequalities arise due to limited opportunities and poverty, and reducing poverty through economic development can enhance women's position in society and decrease gender inequality (Duflo, 2012). It's important to note that economic development has a direct connection to GDP per capita, which is highlighted in Goran Miladinov's (2020) article where he examined five former EU applicant countries from 1990 to 2017. The study concluded that an increase in GDP per capita promotes economic growth and development in a country and results in improved life expectancy at birth and an extension of lifespan.

The weakest correlation in the table is between HDI and Gini which are almost completely uncorrelated. This indicates that income and wealth distribution that comes from the Gini variable (The World Bank, 2015) and the components of HDI, which are GDP per capita in PPP, life expectancy at birth, adult literacy, and school enrollment ratio (UNDP, 2022) does not move along each other. Although HDI has a direct link to GDP per capita through one of its components (GDP per capita in PPP), it does not necessarily impact the very weak correlation between HDI and Gini even though GDP capita and Gini have a much stronger correlation.

Both Jones and Klenow (2016) and Lane and Ersson (2004) show that HDI is strongly correlated with GDP per capita. The correlation between the two studies is partly supported by our result of 0.3 correlation. The measurements are indeed positively correlated; however, the correlation would not be considered as strong as the other studies have indicated. A reason why HDI seems to be more correlated in other studies might be that this study has taken a lot more countries into account. It could also be that this study uses log for GDP per capita. The log-transformation is non-linear and affects the correlation, sometimes by a lot. It is, however, important to note that correlation does not equal causation. Why we get a positive correlation, however, is because GDP per capita is directly connected to one of HDI's three component indexes, which is GDP per capita in PPP (UNDP, 2022). This creates a direct link between the two measurements and creates a positive correlation.

6. Results & Analysis

6.1 Regression Results & Analysis

In the regression below, we present the results of the two regressions specified in Section 4. The results are shown in Table 4. All variables in Table 4 are significant at a 0.01 (1%) level except GII developed. The first regression (1) includes only the main independent variables, being: HDI, GII, and Gini, with robust standard errors. The second regression (2) incorporates interaction terms between the "developed" variable and the main independent variables; as mentioned in Section 4, the interpretation of the developed variable should be that it is the difference between undeveloped and developed countries (holding fixed the other regressors). Both of the regressions have the same number of observations, and GDP per capita is in the natural logarithm for all regressions, which allows us to interpret the coefficients in the regressions as percentage changes in GDP per capita.

In regression (1), we can see that a 0.1 unit increase in HDI increases GDP per capita by 6,35%. For the GII variable, the regression shows that a 0.1 unit increase in GII is associated with a GDP per capita change of -73.26%. For a 0.1 unit increase in the Gini coefficient, the dependent variable is associated with a 28% change. Furthermore, the constant is 9.692, which is the estimated value of the natural logarithm of GDP per capita if HDI, GII, and Gini are held constant.

Regression (2) showcases the difference between developed and undeveloped countries. As seen in the regression, the relationship between HDI and GDP per capita is -40% smaller in developed countries in comparison to undeveloped countries. This means that a 0.1 unit increase in HDI still has a positive relation to GDP per capita but is smaller for developed countries. Further in regression (2) we see that HDI has a coefficient of 0.96, which means that if HDI goes up by 0.1 unit, the GDP per capita relationship is 9.6%. For undeveloped countries, this number is expected to be bigger than regression (1), as model (1) accounts for all countries and regression (2) accounts separately for undeveloped countries. This is because of diminishing marginal returns, for a country with a low GDP per capita, we will see big differences in the standard of living. Developed countries will not see as great of an increase as the essential needs of a high standard of living are already met. Therefore, the coefficient for HDI-developed is negative. This is also what is observed in the graph reproduced by Lane and Ersson (2004), Figure 1.

While we see a strong relationship between the measurements for low-income countries, this relationship decreases for high-income countries. Cahill (2005) states that the HDI is a redundant measurement, as in his study, the HDI was shown to be highly correlated with GDP per capita. This shows not to be true in the correlation matrix, but the relation with GDP per capita and HDI for low-income countries does show a significantly strong relationship (Table 4, regression 2).

For GII-developed in regression (2) we have a non-significant result of a 3.6% difference in GDP per capita by a 0.1 unit increase in GII. This can potentially mean that there is no relationship between developed and GII. This could also indicate a too-small number of observations, high standard errors, coefficients that are imprecisely estimated or there's simply no difference between GII and GII-developed.

The negative sign of GII in regression (1) is stronger than in regression (2), it's important to note however that β_1-β_3 in regression (1) isn't the same regression as β_1-β_3 in regression (2) as regression (1) is the relationship for all countries and β_1-β_3 is the relationship for undeveloped countries in regression (2). The smaller value for GII in regression (1) suggests a stronger relationship between GII and GDP per capita compared to regression (2). Furthermore, regression (1) with the lower value of GII also shows that higher gender

equality is associated with higher GDP per capita. On the other hand, regression (2) shows a positive sign of GII-developed indicating that a 0.1 unit increase in GII is associated with a lower decrease in GDP per capita (Note: higher GII shows higher gender inequality, 0 is complete equality and 1 is complete inequality).

Esther Duflo (2012) explains many relationships between the empowerment of women and economic development in her paper. Duflo highlights that gender inequality is greater in low-income nations (Duflo, 2012). Duflo explains, among other things, that economic development leads to increased life expectancy, reduces the mortality rate during pregnancy, increases work opportunities for women, etc. (Duflo, 2012). These are some factors that are important for GII and can arise with economic development. The result that higher GDP per capita is associated with higher gender equality but has a weaker relationship among developed countries is supported by previous research.

Gini and GDP per capita relationship is 16% smaller in developed countries compared to undeveloped countries. This means that any unit increase in Gini won't be associated with as big a growth in GDP per capita as in undeveloped countries. When researching previous studies on income inequality and growth, there's a lot of indecision. Li & Zou (1998), like this study, found a positive correlation between growth and income inequality in 46 countries. Panizza (2002), who studied 48 of the 50 states in America, found evidence for a negative relationship between income inequality and growth (Panizza, 2002). As stated before, this study does not find a negative relationship between income inequality and GDP per capita, however, it finds a smaller positive relationship for developed countries. Therefore, a less positive relationship could be expected, as Panizza studied the USA, which is considered a developed country.

The developed constant suggests that developed countries have a 202% higher GDP per capita than undeveloped countries, holding all other variables constant.

Table 4

Variable	Coef	Std. err.	Coef	Std. err.
ln(GDPpc)	(1)		(2)	
HDI	0.635***	.112	0.96***	.15
GII	-7.326***	.137	-4.98***	.164
Gini	0.28***	.03	0.33***	.025
HDI-developed	0	0	-0.4***	.169
GII-developed	0	0	0.36	.296
Gini-developed	0	0	-0.16***	.048
Developed	0	0	2.02***	.198
Constant	9.692***	.107	8.03***	0.156
Observations	1550		1550	

6.2 Sensitivity Analysis

Table 5 showcases a sensitivity analysis that has been used in the paper to test the robustness of the results concerning changes in the Gini coefficient and time restrictions. Column 1 repeats column 1 in Table 4. Column 2 excludes Gini, and column 3 excludes Gini but keeps the sample as if Gini were not excluded. Column 4 restricts the time from 2000 to 2021.

Excluding the Gini coefficient from the regression, as shown in regression (2), leads to an increase in the number of observations from 1550 in regression (1) to 4345 in regression (1). The increase in the number of observations is due to more available data on HDI and GII for more countries compared to the Gini. This leads to a larger sample size that includes more countries in more years that would otherwise be excluded with missing data on the Gini.

In regression (3) we use the same regression, however, keeping the sample size to 1550, which is the same size as if Gini were included. However, not accounting for the Gini relation to the other variables. This results in HDI decreasing from 1.080 in regression (2) to 0.865 in regression (3), which means that if HDI increases by 0.1 units, in regression (3), GDP per capita will be associated with 8.65%. Which is lower than in regression (2) when all

observations are included. Gini seems to affect the relationship between GII and HDI because the coefficients for both GII and HDI increase when Gini is in the regression. Furthermore, if GII increases by 0.1 unit, the value goes from -62.1% in regression (2) to -65.24% in regression (3). Regression (1) and (4) have overall similar tendencies. Furthermore, Gini seems to affect the relationship between GII and HDI and seems to increase the coefficients for both of them when removing Gini.

Regression (4) restricts the time period from 1990-2021 to 2000-2021. This results in a reduction in the number of observations. Regression (4) does not omit any variables, and only focuses on time. This results in the HDI relationship increasing from 6.35% in regression (1) to 6.8% in regression (4) with a 0.1 unit increase. Furthermore, a change in GII from -73.26% in regression (1) to 73.2% in regression (4) for a 0.1 unit increase.

For both regression (1) and (4) we get the same Gini coefficient and similar overall results, even though the observations decreased by a third in regression (4). The results suggest that regression (2) and (3) give bigger coefficients for GII and HDI, which suggests that Gini affects the relationship between GDP per capita and GII and HDI. We see that in regression (2) we get the biggest coefficients, suggesting that HDI and GII have a more positive relationship with GDP per capita. As the coefficients for regression (2) are bigger than regression (3) it suggests that the countries with missing Gini are different from those without. The countries with missing Gini must have a weaker correlation between HDI and GDPpc, especially (1.08 is higher than 0.865 because removing countries where the relationship between those two variables is low). Information from these results might affect the main regressions for this paper because the inclusion of the Gini coefficient in regressions (2) and (3) reveals that Gini plays a crucial role in the relationship between GDP per capita and the GII and HDI in this data.

Table 5

Variable	Coef	Std. err.	Coef	Std. err.	Coef	Std. err.	Coef	Std. err.
ln(GDPpc)	(1)		(2)		(3)		(4)	
HDI	0.635***	0.112	1.080***	0.070	0.865***	0.109	0.68***	0.15
GII	-7.326***	0.137	-6.210***	0.062	-6.524***	0.091	-7.32***	0.148
Gini	0.28***	0.03	0	0	0	0	0.28***	0.031
Constant	9.692***	0.108	10.066***	0.060	10.325***	0.090	9.65***	0.138
Observations	1550		4345		1550		1068	
Time Period	1990-2021		1990-2021		1990-2021		2000-2021	

7. Conclusion

The purpose of this study was to examine the differences in the relationships between GDP per capita and HDI, GII, and Gini for developed and undeveloped countries. This has been done by researching 193 countries over 31 years. Previous research regarding relationships between economic growth and welfare measures is broad, and most of the earlier studies that have been done have been specific and taken fewer countries into account, usually studying one region, researching only one type of measurement in a scientific article. This study presents an attempt to do this with more measurements, countries, and updated data.

One of the findings of this study is that HDI and GDP per capita relationship decrease for developed countries in comparison to undeveloped countries. For a 0.1 unit increase in HDI in regression (2), table 4, GDP per capita is associated with a 9.6% change, and for the same increase in HDI, in regression (1), table 4, GDP per capita is associated with a change of 6.35%. Further, in regression (2), table 4 for HDI-developed there's a 4% decrease, which tells us that the relation for developed countries is 4% less in developed countries compared to undeveloped countries. This could be because, in the early stages of an economy, there'll be a fast growth in overall equality and standard of living, while this welfare growth slows down with a bigger GDP per capita.

Another finding of this study is the relationship between GII and GDP per capita, where GII has a smaller negative relationship with GDP per capita in developed countries. This indicates that higher gender equality is associated with a smaller relationship with GDP per capita in developed countries than in undeveloped countries. However, this result is insignificant and could be interesting to study further in future studies. The strongest correlation examined in this study was between GDP per capita and GII. Indicating a strong relationship and the importance of gender equality and GDP per capita.

For Gini and GDP per capita, an overall positive relationship can be detected. When Gini interacts with the developed variable, a negative coefficient appears. This indicates that with a 0.1 unit increase in Gini, there is a larger positive relationship to GDP per capita while developed countries are associated with a smaller positive association. This implies that an income inequality has a positive relationship with GDP per capita. The bigger the income inequality, the richer the country.

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