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MODERN DETERMINANTS OF ECONOMIC GROWTH: DESCRIPTIVE AND CROSS-SECTIONAL DATA ANALYSIS

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ABSTRACT

This paper examines the determinants of economic growth in the post globalism setup. It provides descriptive analysis on modern determinants of economic growth and uses cross-sectional country data regressions to estimate the determinants of economic growth and discusses their statistical significance and coefficients.

Keywords: Economic growth, cross-sectional regression analysis, descriptive analysis, human capital, trade openness, financial capital, investment rates, population growth, Solow growth model, sectoral shifts.

1. INTRODUCTION

Economic growth has always been an important subject in the field of economics. Many academicians and researchers studied the determinants of economic growth and the differences between developed and underdeveloped countries. Studying economic growth is important for several reasons. Firstly, understanding the determinants of growth would allow a nation to optimize their production, and increase production possibilities. A consensus measure of economic growth is per capita GDP, thus increase in aggregate production is directly related to the economic growth. Secondly, economic growth is a measure of one's life quality. We typically observe high per capita GDP in developed countries, and their citizens have access to clean water, medicine, etc.

While we are discussing economic growth we must not confuse it with economic development. Economic growth can be defined as expansion of a nation’s wealth, while considering not only short-term but also long-term expansion (Cornwall, 2024). On the other hand, Economic development is generally used to describe both quantitative and qualitative advancements (Myint & Krueger, 2024). We emphasize this distinction, as this paper aims to formulate a theory regarding the modern dynamics of economic growth. Therefore, in our estimations we will only consider real GDP per capita as regressand.

This paper aims to contribute to the economic growth literature in two important ways. First one is that our descriptive analysis section will provide descriptive statistics, how the independent variables changed in the last 27 years (1996 - 2022), and data distributions. This analysis is crucial to understand the changing trends and behavior of variables in the post-globalism era. Second important contribution is that we will use cross-sectional data to estimate our growth equations and find the significance and direction of selected variables. We will be analyzing the pre 2008 crisis and post 2008 crisis separately. We will also discuss the efficiency of estimations.

This paper first discusses the previous researches conducted in the economic growth literature. After this discussion, we will introduce our dataset in detail. Then, we will discuss our research methodology briefly. Then, we will move on to presenting descriptive and cross-sectional analysis results. Finally, we will finish our discussion with concluding remarks and policy suggestions.

2. LITERATURE REVIEW

One of the most important and early contributions in the economic growth literature belongs to the 1987 economics Nobel prize winner Robert Solow. Therefore, we will introduce and discuss his model in detail. Solow's growth model put emphasis on the savings rate, technological progress, and population growth. Equation (2.1) shows the production function of the Solow model.

$$Y = A \cdot K^{\alpha} \cdot L^{(1-\alpha)} \tag{2.1}$$

$Where,$

Y: $total\ output\ (GDP),$

A: $total\ factor\ productivity\ (TFP),\ representing\ technology\ and\ efficiency,$

K: $the\ stock\ of\ capital,$

L: $the\ labor\ force,$

α: $the\ output\ elasticity\ of\ capital,\ indicating\ the\ share\ of\ income\ going\ to\ capital.$

Model uses per capita variables for better comparison between countries, thus we divide both sides by L and obtain equation (2.2), where small letters y and k denote per capita output and capital stock respectively.

$$y = A \cdot k^{\alpha} \tag{2.2}$$

Higher population would result in smaller y, hence, according to Solow growth model population growth rate plays an important role. Solow assumes that Y is only determined by consumption and investment. In other words, countries have no government intervention and they are closed economies. Equation (2.3) shows GDP according to the Solow model.

$$GDP = C + I \tag{2.3}$$

$Where,$

GDP: $gross\ domestic\ product$,

C: $total\ consumption\ by\ private\ households$,

I: $total\ investment\ by\ private\ businesses$.

From equation (2.3), we derive per capita savings rate as follows with the assumption that households always:

$$i = s \cdot y \tag{2.4}$$

$Where,$

i: $per\ capita\ investment\ on\ physical\ capital$,

s: $savings\ rate$,

y: $per\ capita\ income$.

Change in capital stock is given by equation 3:

$$\frac{\dot{K}}{L} = i - \delta \cdot k \tag{2.5}$$

$Where,$

$\dot{K}: \ change\ in\ capital\ with\ respect\ to\ time,$

$L: \ the\ labor\ force,$

$s: savings\ rate,$

$y: \ per\ capita\ income,$

$\delta: \ physical\ capital\ depreciation\ rate.$

We take derivative of $\frac{\dot{K}}{L}$ with respect to time and obtain $\dot{k} = \frac{\dot{K}}{L} - nk$, where n is the population growth rate, which is assumed to be constant. We will now denote both sides of equation 2.5 in terms of per capita variables. Please note that "dot" adobe variables indicate that they are differentiated with respect to time, that is $\frac{\partial k}{\partial t} = \dot{k}$. Plugging $\dot{k} + n \cdot k$ for $\frac{\dot{K}}{L}$ we arrive at equation 2.6:

$$\dot{k} = i - (n + \delta) \cdot k \tag{2.6}$$

We can further improve equation 2.6. From equation 2.4, we know that $i = s \cdot y$ and from equation 2.2; we also know that $y = A \cdot k^{\alpha}$, hence we can finalize fundamental capital accumulation equation in 2.7 as follows:

$$\dot{k} = s \cdot Ak^{\alpha} - (n + \delta) \cdot k \tag{2.7}$$

Capital accumulation (2.7) depends on only k as other variables are constants. Higher savings rate (s) would indicate higher capital accumulation and higher economic growth. Moreover, better technology is affecting the production in a positive way, hence higher technology would result in more income, and ultimately more savings. On the other hand, higher population growth rate and depreciation rate would reduce the net capital accumulation. Furthermore, the model assumes that the production function exhibits constant returns to scale as it is in the cobb-douglas form. Due to depreciation every country would reach a steady state at some point. Equation (2.8) is the steady state condition:

$$s \cdot Ak^{\alpha} = (n + \delta) \cdot k \tag{2.8}$$

Indeed, equation 2.8 implies that $\dot{k} = 0$. In case of reaching a steady state, technological improvements are the only way to increase capital accumulation (Solow, 1956). Solow's growth model provides a simplified yet powerful approach to economic growth. It prompted us to include investment on physical capital as one of the determinants of economic growth in our research.

While the Solow Model argues that an increase in population is detrimental to economic growth, it is also argued that high population density in cities can lead to better specialization, production, and transmission of knowledge. This is because the benefits of these factors can outweigh the diminishing returns generated by high population within the economy (Becker, Glaeser & Murphy, 1999).

Indeed the importance of human capital is studied in various researches. The Solow model did correctly predict the coefficients of investment and population growth. However Mankiw, Romer, and Neil argued that the magnitude of the predictions were misleading due to missing components in the model. Therefore, they added human capital factor into the original model. Equation (2.9) shows the enhanced production function.

$$y_t = A \cdot k_t^{\alpha} \cdot h_t^{\beta} \tag{2.9}$$

$Where,$

$y: \ per\ capita\ income,$

$k^{\alpha}: \ physical\ capital\ per\ capita,$

$h^{\beta}: \ human\ capital\ per\ capita.$

Human capital accumulation function can be derived similarly to the capital accumulation function given in equation 2.8. Mankiw, Romer and Weil, first estimated cross-country data using textbook Solow model, which resulted in coefficient signs that were inline with the Solow's model. However, the model had bias as it was missing human capital. Using secondary education attainment (% of working population) as proxy they constructed another regression which improved the R-squared value from 0.70 to almost 0.80. (Mankiw et al., 1992). Their research proved that human capital is an important element in economic growth as it enhances the production efficiency and income.

One of the most important article that studied long-run economic growth was written by Acemoglu, Johnson, and Robinson. Their article shed light on the importance of economic institutions. They claimed that a society with no sound property rights, individuals of that society would have no incentive for investing. Their argument was that political institutions and economic resources would ultimately be determining the economic institutions and economic performance of a nation. In addition to the economic institutions, they argued that geography and culture would cause differences in economic growth. Geography would affect technological development. They give for example plow machines which were developed in temperate climates rather than tropical ones (as the soil would not allow the usage of them in the latter) as an example in their publication. (Acemoglu et al., 2005).

We would like to only consider economic institutions as one of the explanatory variables in our research. To support this claim we would like to provide a case study from Acemoglu, Johnson and Robinson. In their article, they studied the separation of Korea. Note that both countries are very similar in terms of culture and geography however, after separation of North Korea and South Korea, we only observe divergence in the economical and political institutions. In their paper, they have found almost no difference in per capita income before separation. However, after separation we can observe that North Korea falls behind South Korea in terms of per capita income (Acemoglu, Johnson, & Robinson, 2005). Therefore, by considering only economical institutions we will be able to capture the highest variability in economic growth across the countries. Many researches in the literature carried out to find this relationship. Dawson (1998) studied the effect of economic freedom on growth and found that it had a direct effect on total factor productivity and indirect effect on investment. Knack and Keefer (1995) also found that the institutions that protected property rights promoted economic growth and investment in their cross-sectional regression analysis.

While we aim to build a model that explains the economic growth dynamics of the modern world, we cannot ignore the importance of international trade. A cross-country empirical analysis carried out by Halit Yanikkaya in order to investigate the impact of international trade on economic growth. In his paper, Yanikkaya argued that international trade optimizes a nation's resource utilization as locally producing might be inefficient than importing as discussed in theory of comparative advantage. In his research, he observed that higher trade openness resulted in higher economic growth. He also argued that international trade allows technologically backwards countries to import it from developed countries. To prove this claim, he analyzed countries who trade with the US, and concluded that those who traded with the US would grow faster than others (Yanikkaya, 2003). A similar research carried out by Tahir and Azid for 1990-2009 developing country panel data. Estimations have shown that international trade positively affected economic growth. Furthermore, they argued that developing countries must focus on importing technologies and physical capital instead of consumer goods (Tahir & Azid, 2015). Another panel research with a simultaneous equations model that uses 63 country data between 1960-2007 conducted by Kim, Lin and Suen found that trade had a positive effect on economic growth in high-income and low inflation countries. However, countries with opposite setup suffers from the trade. (Kim et al., 2012)

Similar to trade openness, international financial integration (IFI) has gained popularity in the economic growth literature especially after 1990. Edison, Hali J., et al. studied the impact of IFI on economic growth using various econometric techniques. While their research did not prove a definite causal relationship between economic growth and IFI, it has shown that developed countries tend to have higher IFI (Edison, Hali J., et al., 2002).

Another research, and also a dataset by Lane and Milesi-Ferretti also showed that there is a significant increase in the financial asset trading. Moreover, they argue that developed countries started to diverge from emerging markets in terms of assets to liabilities ratio. In other words, developed countries became creditors and emerging markets became debtors (Lane, Milesi-Ferretti, 2006). Moreover, financial openness has a positive impact on both physical capital stock growth and total factor productivity according to Bekaert, Harvey, and Lundblad (Bekaert et al., 2011).

The increase in the financial openness globally raises the question of sectoral shifts; more specifically, shifting from industrial to services sector or deindustrialization. Services sector, or tertiary sector, therefore, is closely related to financial openness and understanding sectoral shifts will provide more insights on economic growth. Sultan showed that there is a positive relationship between per capita income and services sector share. Economies that have higher services sector share had low service sector growth, and the opposite is observed for countries with low services sector share. While income and share of services sector is related, contribution of services sector remained ambiguous (Sultan, 2008). On the other hand, Attiah conducted a panel analysis with 50 countries over the period 1950-2015 and found that the manufacturing sector had more impact on economic growth compared to the services sector. However, this impact of manufacturing was more pronounced in poor countries and the services sector still played a role in economic growth (Attiah, 2019).

3. DATA

Since this paper will include descriptive analysis and cross-section regression analysis, we will collect the data in panel form. Data sources such as World Bank, Penn World Table. and External Wealth of Nations Dataset presents their data in panel format, and they are reliable data sources.

Our dependent variable will be GDP per capita. We will use real GDP per capita data provided by the World Bank, which is given in constant 2015 USD (World Bank, GDP per capita constant 2015 USD). These values are adjusted to reflect prices in the base year 2015 for all available countries. Using real money eliminates the effects of inflation, and allows us to only focus on economic growth. We use gross capital formation (formerly known as gross domestic investment) for our investment variable. For relative and comparable measurement across countries we use it as a percentage of GDP, and transform investment into investment rate (World Bank, Gross capital formation % of GDP). Population and population growth rate data is straightforward. We use World Bank datasets for population (World Bank, Population, Total), and population growth rate (World Bank, Population growth annual %). For human capital, we will use PWT 10.01 human capital index by Feenstra, Inklaar, and Timmer (2015). This index is between 0 and 5, where 5 being the highest education level possible. This scale will reduce errors that might arise when we use a proxy such as percentage of tertiary education attained similar to Mankiw et al. research (1992) where secondary education attainment percentage is used. A sound institutional quality proxy is the rule of law index (World Bank, Rule of Law Estimate). Values given in this index have a small range (approximately from -2.5 to 2.5 where higher values indicate higher rule of law estimate). We obtain a trade openness index directly from World Bank Data (Trade % of GDP). This index is calculated using the sum of total values of exports and imports as share of GDP, which will give comparable (relative) results across countries. Last important data for our research is a proxy for financial openness. We will use Lane and Milesi-Ferretti's External Wealth of Nations Database (2018). A similar approach to the calculation of the trade openness index will be used to calculate financial openness. We use the sum of total assets and liabilities divided by GDP. Then, we multiply the results by 100 to obtain values on a percentage scale.

4. METHODOLOGY

In this section, we will discuss the data cleaning and modeling approach for both descriptive analysis and cross-sectional regression analysis.

Before we start these analyses we must improve our dataset for better results. We remove countries that have less than 1 million population from the dataset. Such countries might generate outliers, and cause inefficiencies in regression estimations. Moreover, we consider countries such that data available from World Bank, PWT 10.01 and External Wealth of Nations Database in order to ensure consistency. We detect countries with missing data for all columns excluding rule of law (INST) and human capital index (HC) and remove those countries from the dataset. Rule of law index contains missing data for years 1997, 1999, and 2001, whose values are estimated using linear interpolation (since these data points are inner values). For HC, we drop countries with missing data for years before 2020. HC data from PWT 10.01 is available till 2019. We extrapolate the last 3 years values for each country in the panel by using linear regression. Lastly, we add a dummy variable OECD to further capture the differences between real GDP per capita. OECD countries considered in this dummy variable are OECD countries before 1997. Recent members will not be considered as OECD countries in this research. A detailed description of countries that are present in our data is given in appendix A.

In the descriptive analysis part, we will show a descriptive statistics table for our finalized dataset, 5 year interval averages dataset and OECD non-OECD groups. We plot sample averages from the panel as a time series plot for each variable, in order to study their changes over time. We extend this analysis by splitting the data into OECD and non-OECD countries to study their differences. Moreover, we plot marginal regression analysis for each independent variable for the OECD and non-OECD countries' and their distributions in the dataset to further study each variable's impact on development. Lastly, we provide a correlation matrix table in order to study comovement between variables.

In the cross-sectional data analysis section, we will estimate our economic growth model using an ordinary least squares estimator, and interpret the signs and statistical significance of coefficients. We will also conduct diagnostic tests and plots to assess the efficiency of the estimation. Our economic growth model is given in (4.1):

$$\ln(y_{it}) = \beta_o + \beta_1 \cdot I_{it} + \beta_2 \cdot n_{it} + \beta_3 \cdot HC_{it} + \beta_4 \cdot INST_{it} + \beta_5 \cdot TRADE_{it} + \beta_6 \cdot FINANCIAL_{it} + \beta_7 \cdot OECD_{it} + \epsilon_{it} \quad for\ t = T\ and\ i \in C \tag{4.1}$$

$Where,$

$\ln(y)$: $natural\ logarithm\ of\ real\ GDP\ per\ capita,$

I: $investment\ on\ physical\ capital\ (as\ \%\ share\ of\ GDP),$

n: $population\ growth\ rate\ (\%),$

HC: $human\ capital\ index,$

$INST$: $rule\ of\ law\ index\ (estimate),$

$TRADE$: $trade\ openness\ index\ (\%\ of\ GDP),$

$FINANCIAL$: $financial\ openness\ index\ (\%\ of\ GDP),$

$OECD$: $OECD\ dummy\ variable.\ 1\ indicates\ OECD\ countries\ and\ 0\ otherwise,$

ϵ: $error\ term$

T: $target\ year\ for\ cross\ sectional\ data,$

C: $set\ of\ countries\ in\ the\ dataset.$

In order to capture the long term relationships and minimize the variance caused by the business cycles,we modify cross-sectional model analysis to use pre 2008 crisis and post 2008 crisis averages. Dependent variables and independent variables will be averaged over these given intervals.

5. DESCRIPTIVE ANALYSIS

In this section, we present descriptive statistics tables, time series plots, partial regression plots and distribution plots in order to investigate time trends of variables as well as relationships between them.

DESCRIPTIVE STATISTICS OF PANEL DATA (1996 -2022)

	count	mean	std	median	min	max
y	2646	13952.6192	17996.0819	5751.6042	262.1848	97316.8775
I	2646	23.1834	6.7791	22.6501	-2.4244	58.1507
n	2646	1.2342	1.2583	1.2066	-14.257	16.6255
HC	2646	2.554	0.7236	2.6034	1.0533	4.8561
INST	2646	0.1121	0.9858	-0.1285	-1.87	2.1248
TRADE	2646	76.6849	46.8344	64.5309	2.6988	437.3267
FINANCIAL	2646	288.9295	651.4233	138.8401	6.7903	9683.7045

Table 5.1: Descriptive Statistics of Panel Data

Table 5.1 shows the descriptive statistics of our dataset. We have a total of 2646 observations (98 countries over the period 1996-2022). y, TRADE, and FINANCIAL exhibit high variability and skewness, indicating a diverse set of observations. HC and INST are relatively more centered around their means, suggesting less extreme variability and more stability. We group our data by intervals and take the means as an aggregation method. For each interval group, we present the descriptive statistics in table 5.2

SAMPLE MEAN BY INTERVALS

	1996-2001	2001-2006	2006-2011	2011-2016	2017-2022
y	11522.9984	12886.2244	14079.3731	14777.5315	16245.39
I	21.8112	22.4961	24.3415	23.7097	23.6477
n	1.3392	1.26	1.29	1.23	1.07
HC	2.3414	2.44	2.54	2.64	2.78
INST	0.1135	0.09	0.10	0.13	0.12
TRADE	69.0677	75.01	79.79	80.37	79.96
FINANCIAL	156.3478	216.62	298.03	355.30	401.14

Table 5.2: Interval Sample Mean Statistics

Table 5.2 allows us to study the changing trends for these variables. We can see that GDP per capita, human capital, trade openness and financial openness have increased overtime. In fact, financial openness has shown a dramatic increase relative to others. On the other hand, the population growth rate has fallen slightly. Rule of law index did not change at all.

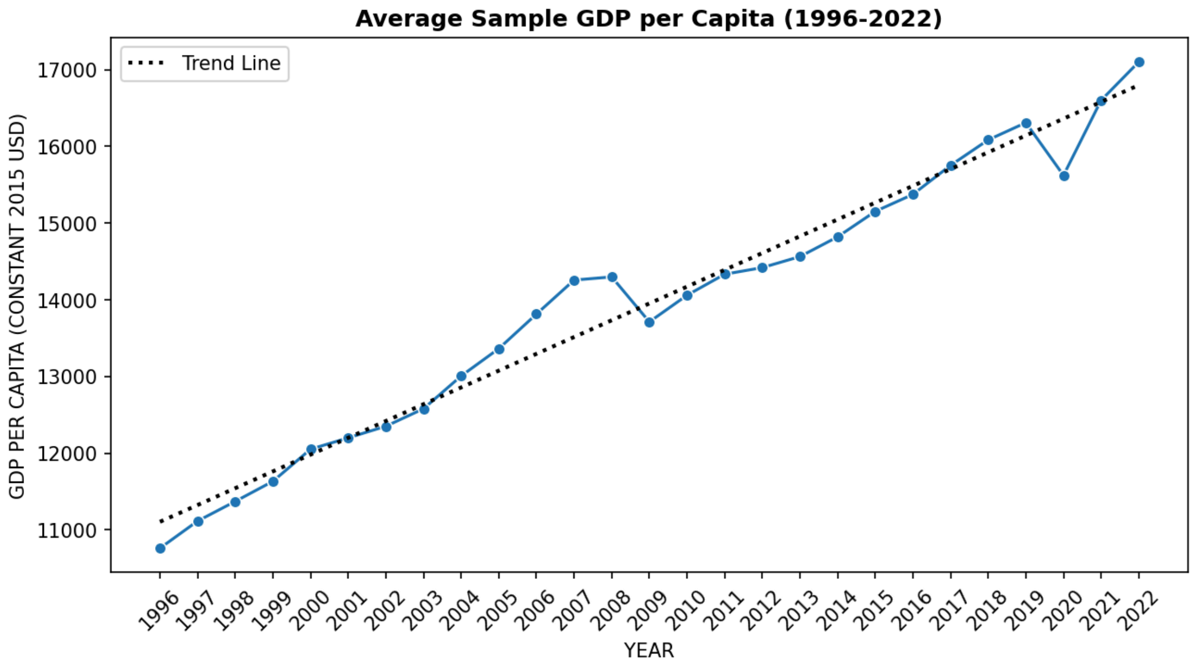

Figure 5.1: Average Sample GDP per Capita (1996-2022)

Figure 5.1 shows the average sample GDP per capita in our dataset year range. We observe that the 2008 recession and COVID-19 pandemic had a negative impact on GDP per capita; however, the general trend is positive.

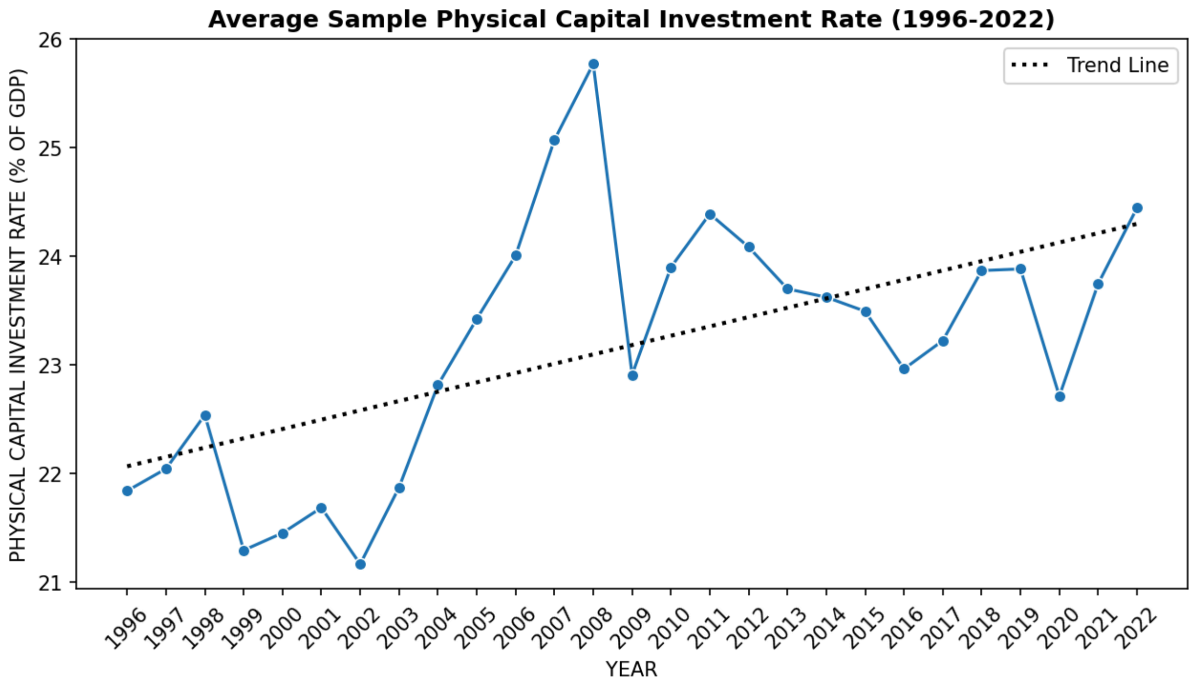

Figure 5.2: Average Sample Investment Rate (1996-2022)

Figure 5.2 shows the sample average investment rate over the period 1996-2022. We observe a very steep climb until the 2008 recession. After the recession, its value alternates between 24% and 23%. During COVID-19 pandemic, value has fallen below 23%, but after the pandemic it returned to its original post recession trend.

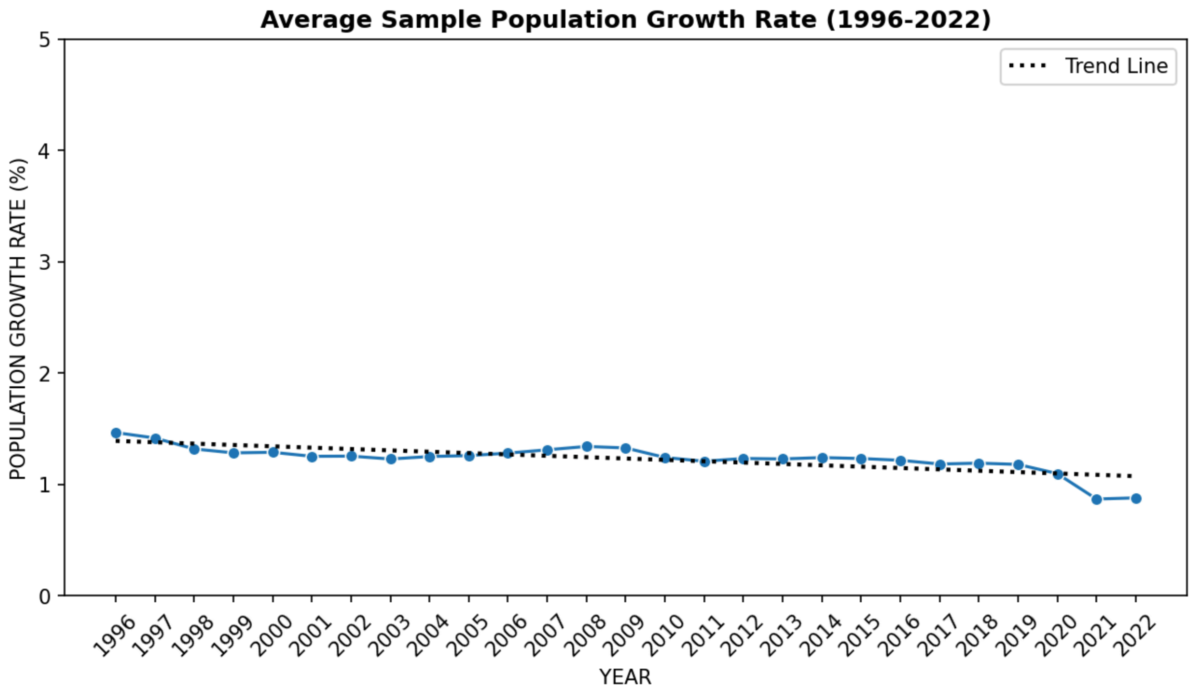

Figure 5.3: Average Sample Population Growth Rate (1996-2022)

Figure 5.3 shows the average sample population growth rate. Trend line shows a very little decreasing trend for population growth rate. Generally, it is stable; however during COVID-19 pandemic, it has fallen under 1%.

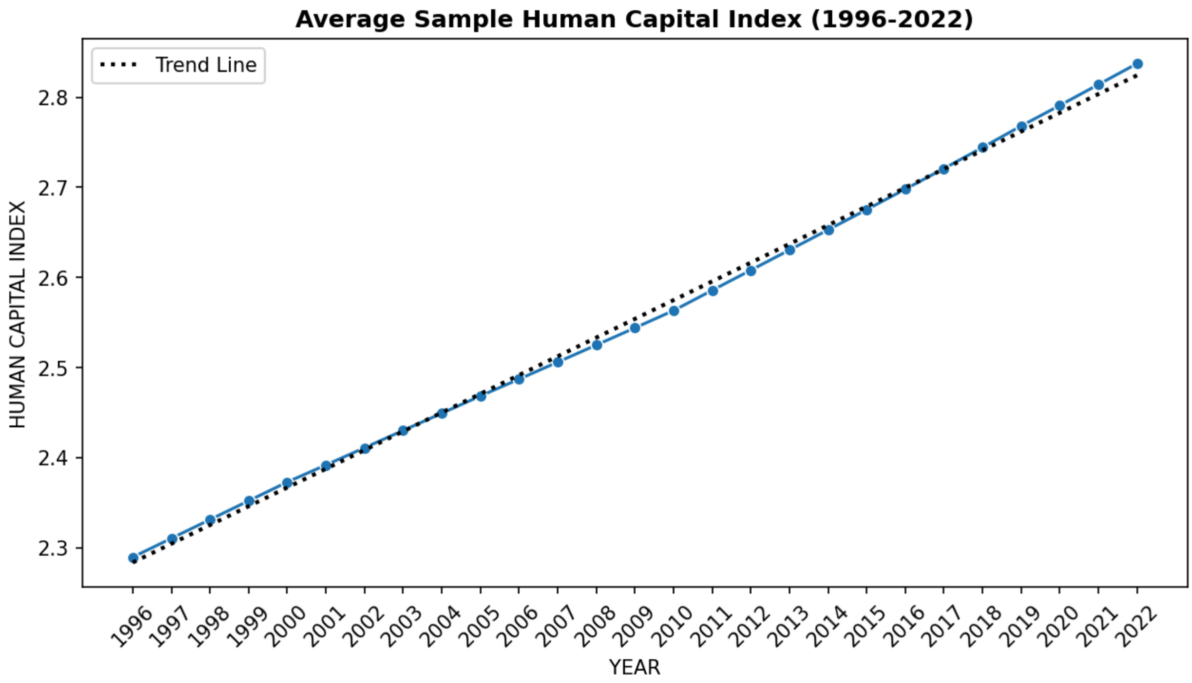

Figure 5.4: Average Sample Human Capital Index (1996-2022)

Figure 5.4 shows the sample average human capital as a time series plot. One can argue that human capital has a positive linear growth. This is also shown by the trend line.

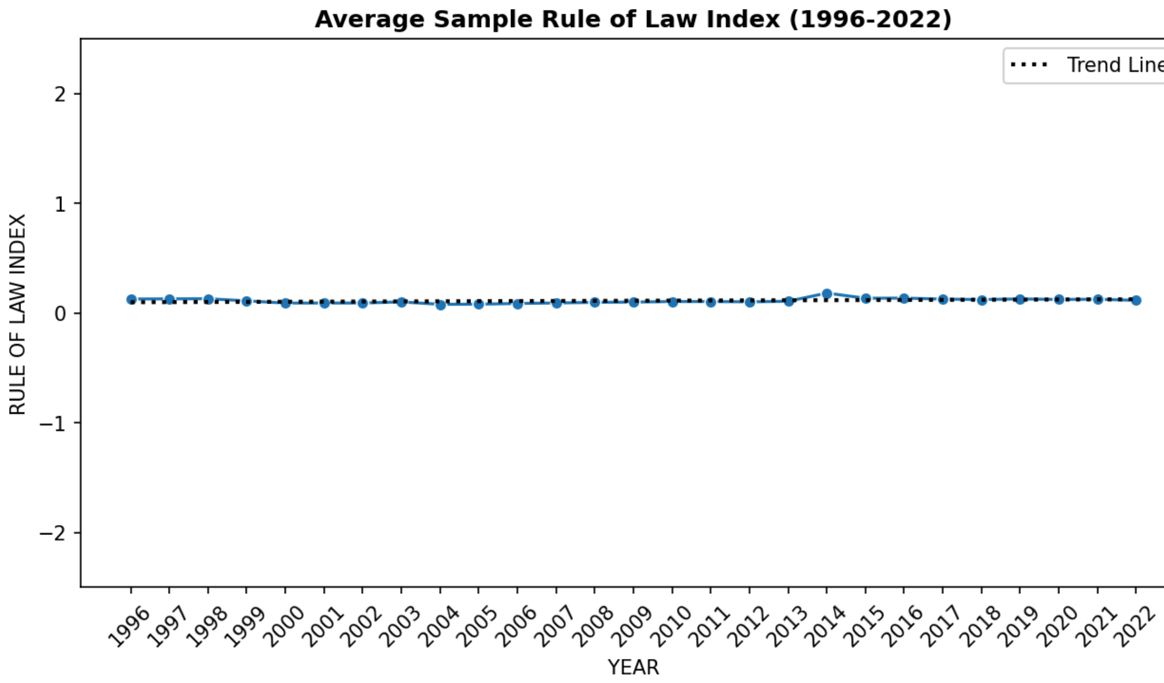

Figure 5.5: Average Sample Rule of Law Index (1996-2022)

Figure 5.5 shows the mean for the rule of law index over the period 1996-2022. Trend line slope coefficient is nearly zero, which indicates that there has been no improvement globally.

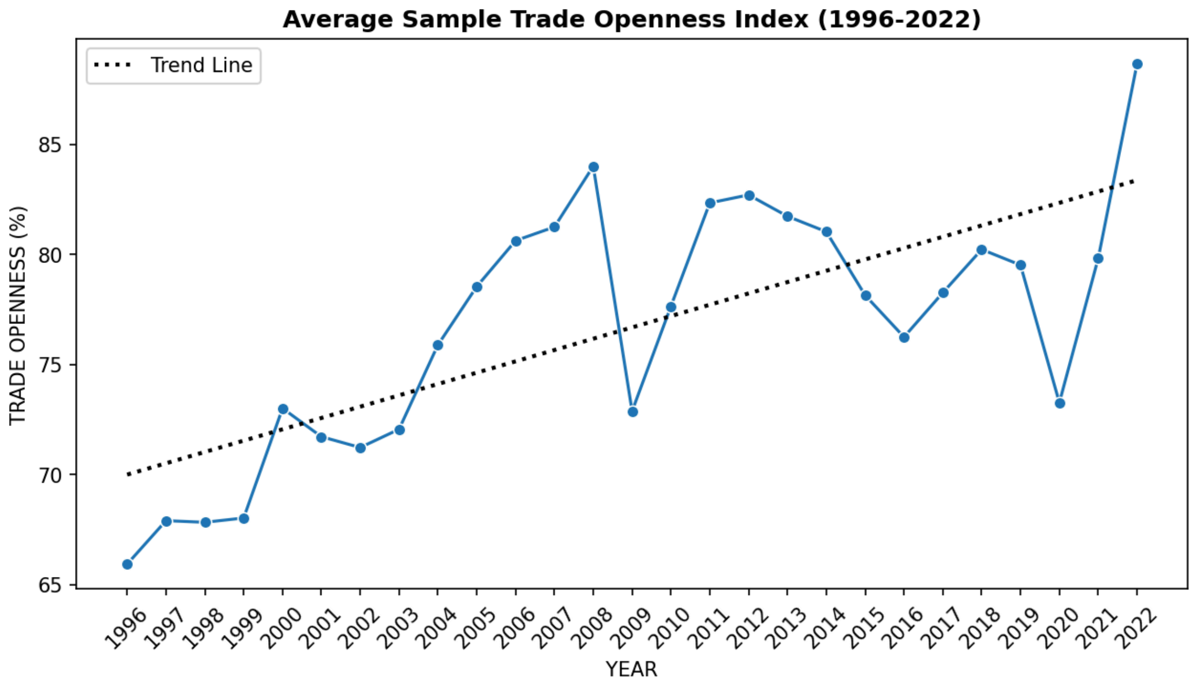

Figure 5.6: Average Sample Trade Openness Index (1996-2022)

Figure 5.6 shows the average trade openness for countries that are present in our dataset. We observe a positive trend over time which shows the impact of globalism. During the 2008 recession and COVID-19 pandemic, trade openness has fallen dramatically. However, after each crisis it got back on track; in fact, the sample world average was the highest in 2022.

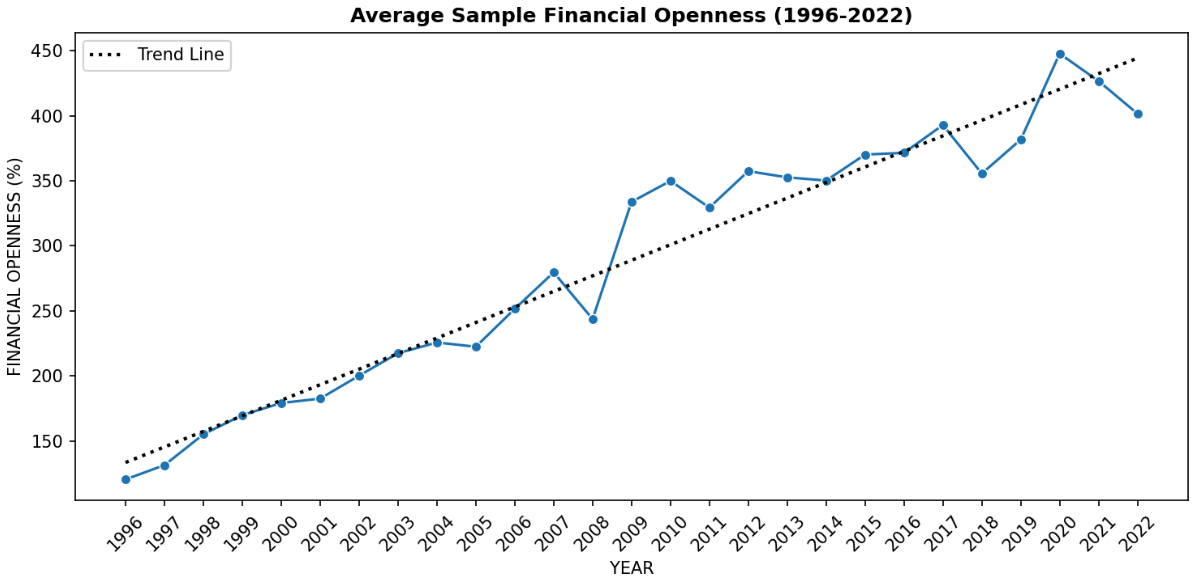

Figure 5.6: Average Sample Financial Openness Index (1996-2022)

Figure 5.6 illustrates the sample average financial openness index in the data year range. We observe that it has a high slope positive trend. During the 2008 recession, financial openness has fallen; however, we observe the exact opposite for COVID-19. During COVID-19, financial openness was the highest. Recall that financial openness is calculated as a sum of assets and liabilities divided by the GDP multiplied by 100. During the COVID-19, governments needed borrowing in order to manage the pandemic lockdowns and slow economic activity. Moreover, quantitative easing policies during the time of crisis tend to generate bubbles in the stock market. (Jomo & Chowdhury, 2020). These reasons can be attributed to the increase in financial openness index during the pandemic.

In order to understand the differences between developed and developing countries, we split our dataset into OECD and non-OECD countries. Table 5.3 shows average values (for all panel data) for dependent variable and independent variables for OECD and non-OECD countries.

SAMPLE MEAN FOR OECD and NON-OECD GROUP

	OECD	
	FALSE	**TRUE**
y	6043.345	41275.566
I	23.204	23.113
n	1.412	0.622
HC	2.360	3.223
INST	-0.278	1.461
TRADE	76.419	77.603
FINANCIAL	203.611	583.667

Table 5.3: Sample Mean for OECD and non-OECD Group (for OECD and non-OECD 1996 -2022)

Table 5.3 clearly shows differences in real per capita income, human capital, rule of law index, population growth rates, and financial openness index for OECD and non-OECD countries. On the other hand, we observe close average values for investment rates and trade openness index.

We explain the relationship between dependent variable, y, and independent variables by introducing partial regression plots. All of the values per country is the average of our data year range. For detailed information of country codes and OECD countries that are present in our dataset please see the appendix A. Furthermore, for better visualization, we transform y into natural logarithm space.

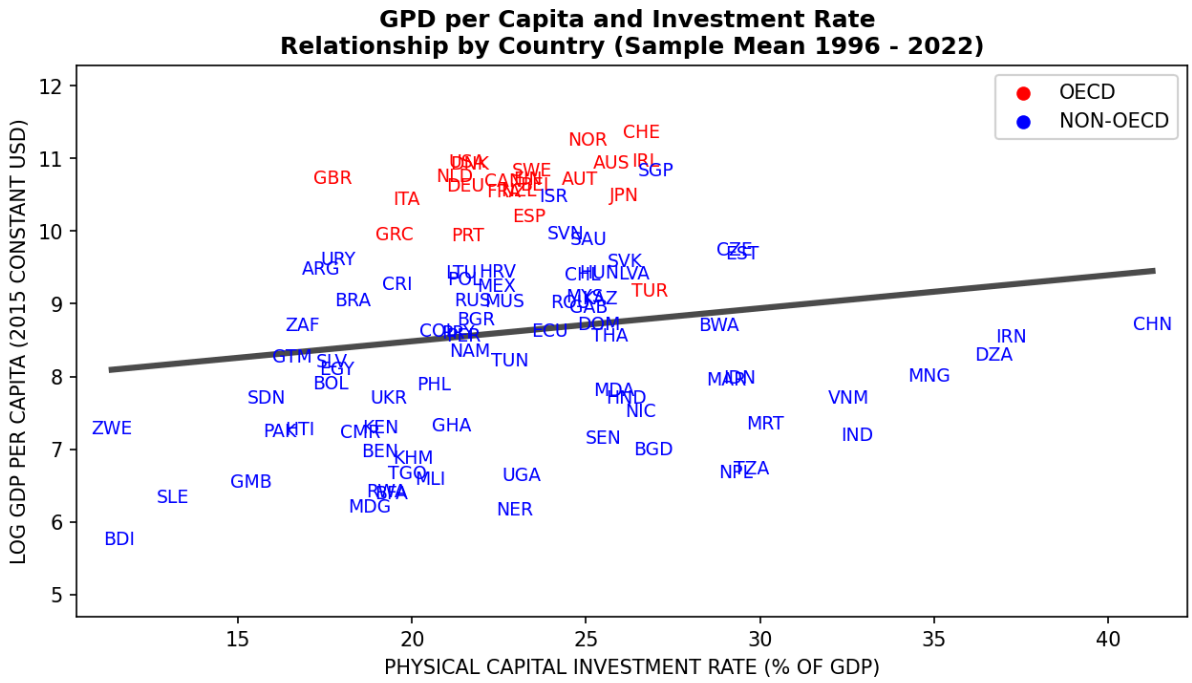

Figure 5.7: log(y) and I Relationship by Country (Sample Mean 1996-2022)

Figure 5.7 shows the average relationship between ln(y) and I. On average, the impact of I to economic growth is positive. We observe OECD countries' average investment rates are between 20% - 27%. However, non-OECD countries are more spread. For example, on average, CHN has the highest physical capital investment rate, whereas ZWE and BDI has the lowest.

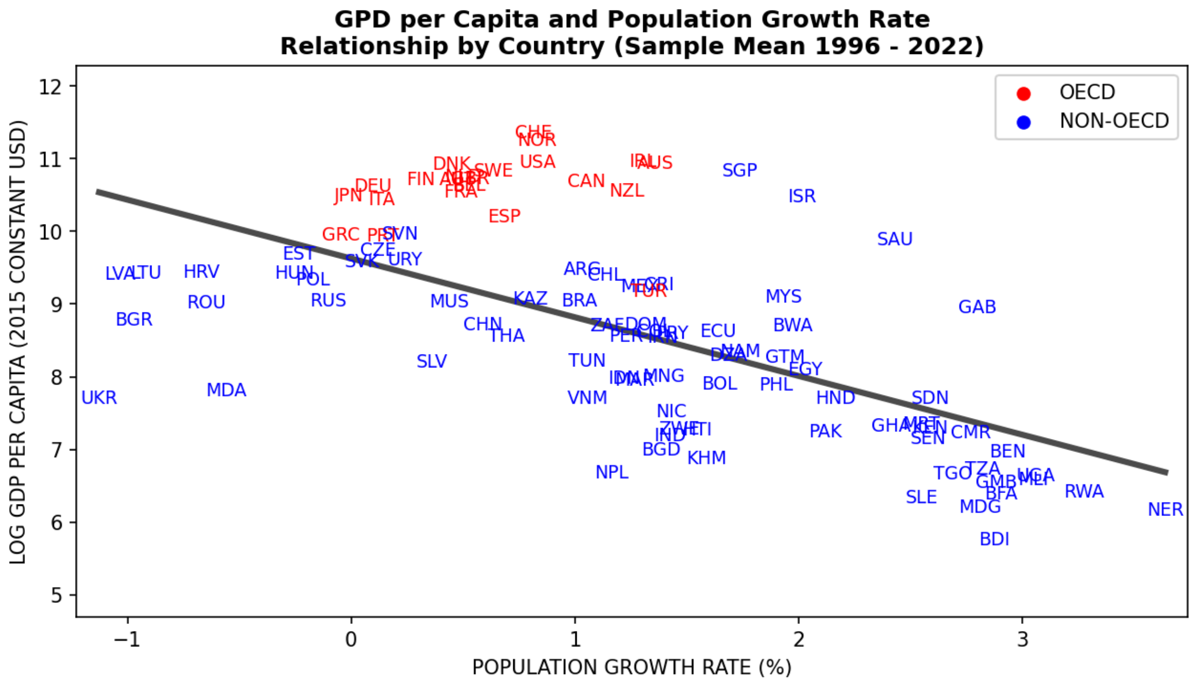

Figure 5.8: log(y) and n Relationship by Country (Sample Mean 1996-2022)

Figure 5.8 shows the average relationship between ln(y) and n. We observe OECD countries average values are between 0% - 1.5%. There is clearly a negative relationship between GDP per capita and population growth rate. While some non-OECD countries exhibit high population growth rates on average, such as NER, RWA and UGA, some of them show negative population growth rates; for instance, UKR, BGR and LVA.

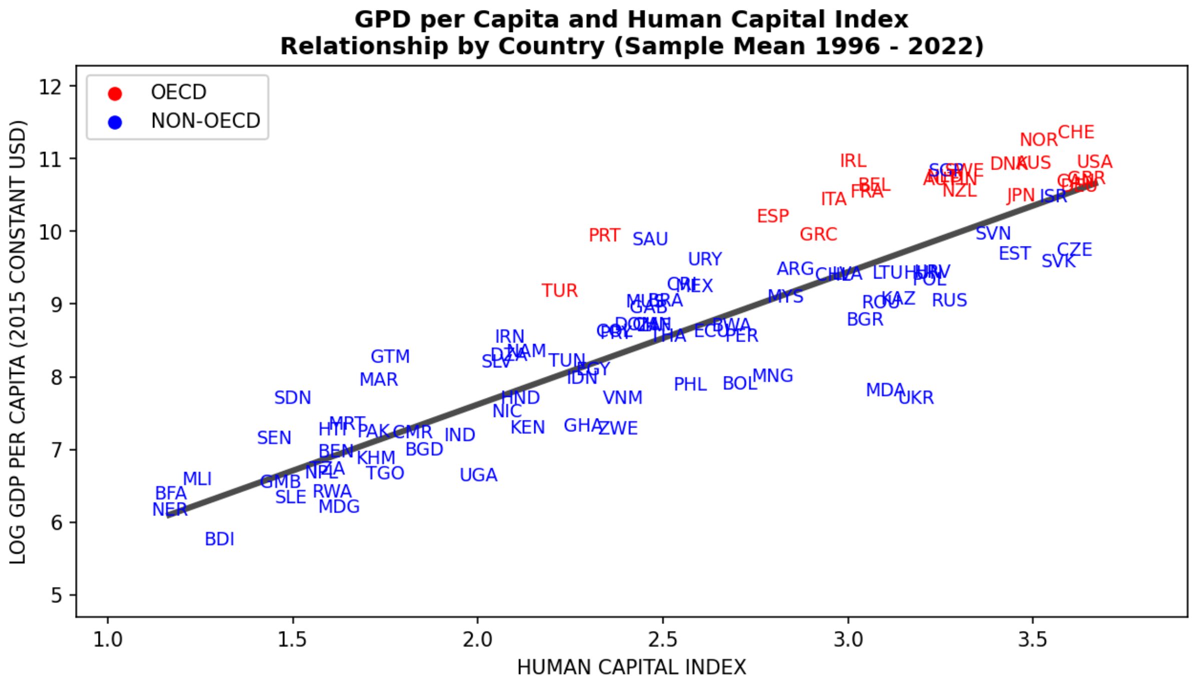

Figure 5.9: log(y) and HC Relationship by Country (Sample Mean 1996-2022)

The average relationship between human capital and real GDP per capita is given in the figure 5.9. We see a clear positive relationship. Most of the OECD countries have the highest value of human capital on average. TUR and PRT have the smallest index value among OECD countries. Non-OECD countries, similar to the investment rate case, exhibit high variance. Among non-OECD countries, ISR, SGP and CZE have high human capital index on average. On the other hand, NER, BFA, BDI and MLI have average index values below 1.5.

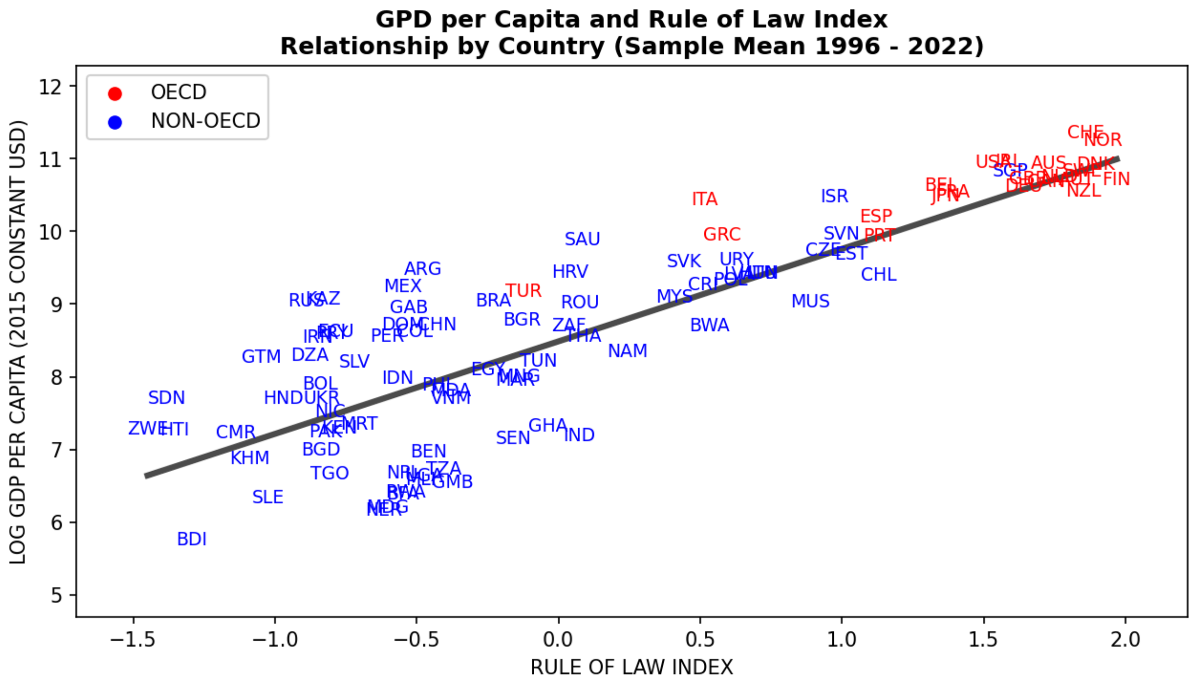

Figure 5.10: log(y) and INST Relationship by Country (Sample Mean 1996-2022)

Average Relationship between rule of law and real GDP per capita is investigated in figure 5.10. There is a clear positive relationship between these two variables. OECD countries have the highest values on average except TUR, ITA and GRC. Generally, non-OECD countries perform poorly in terms of their institutional quality. However, SGP, ISR, SVN, CZE, EST, EST and CHL are exceptional counties for previous statement.

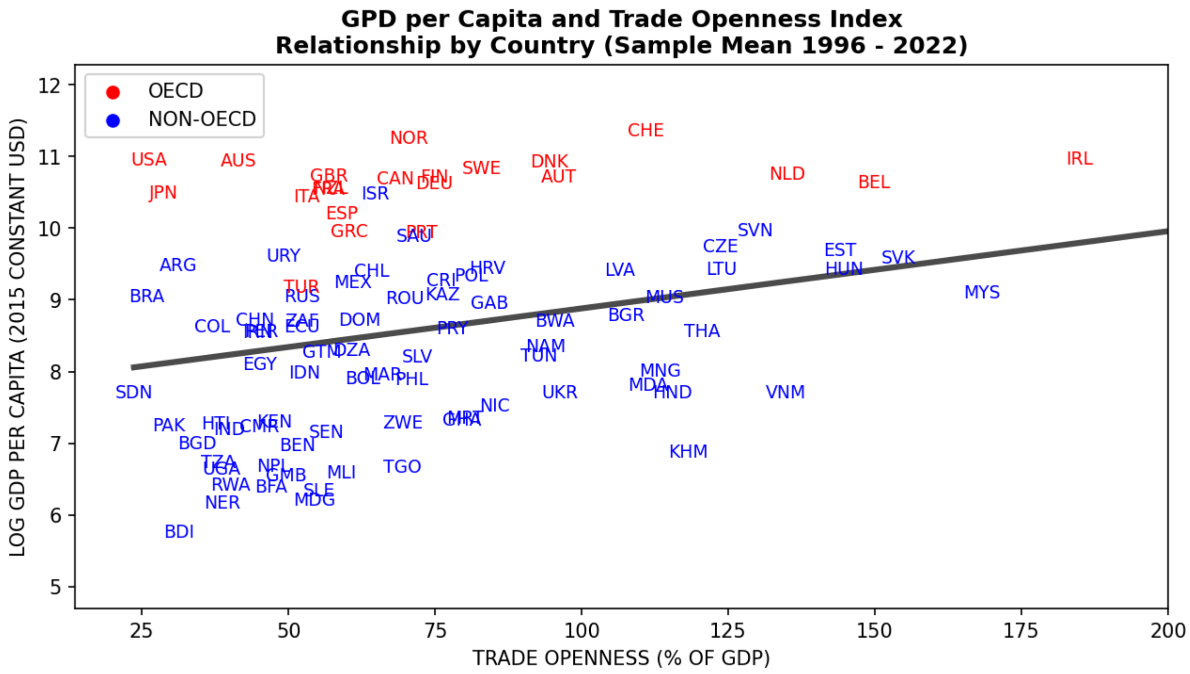

Figure 5.11: log(y) and TRADE Relationship by Country (Sample Mean 1996-2022)

Figure 5.11 analyzes the average relationship between trade openness and real GDP per capita. There is a weak positive relationship between the variables. SGP is not present in the figure 5.11 for better visualization purposes; it has an average value of 200%. We do not observe a clear distinction between OECD and non-OECD countries.

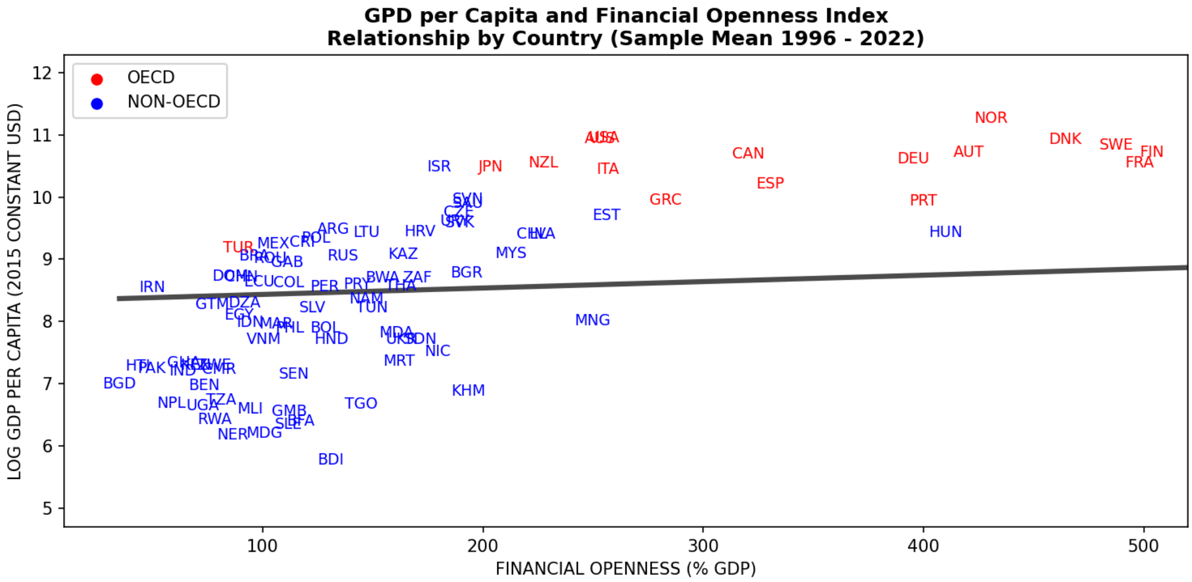

Figure 5.12: log(y) and FINANCIAL Relationship by Country (Sample Mean 1996-2022)

Figure 5.12 shows the average relationship between GDP per capita and financial openness. For better visualization, this figure does not include MUS, SGP, NLD, CHE, GBR and BEL whose average values are around 4000%, 1750%, 1500%, 1000%, 900% 770% respectively. There is a clear distinction between OECD and non-OECD countries. We observe that OECD countries tend to have higher financial openness, with the exception of TUR. Generally, non-OECD countries are below 200%. MUS, SGP and HUN are the exceptional countries for non-OECD group.

As done previously, we plot time series figures for OECD and non-OECD sub groups for comparison. In all of the figures, the solid line denotes non-OECD countries' sample average and the dashed line denotes OECD countries' sample average.

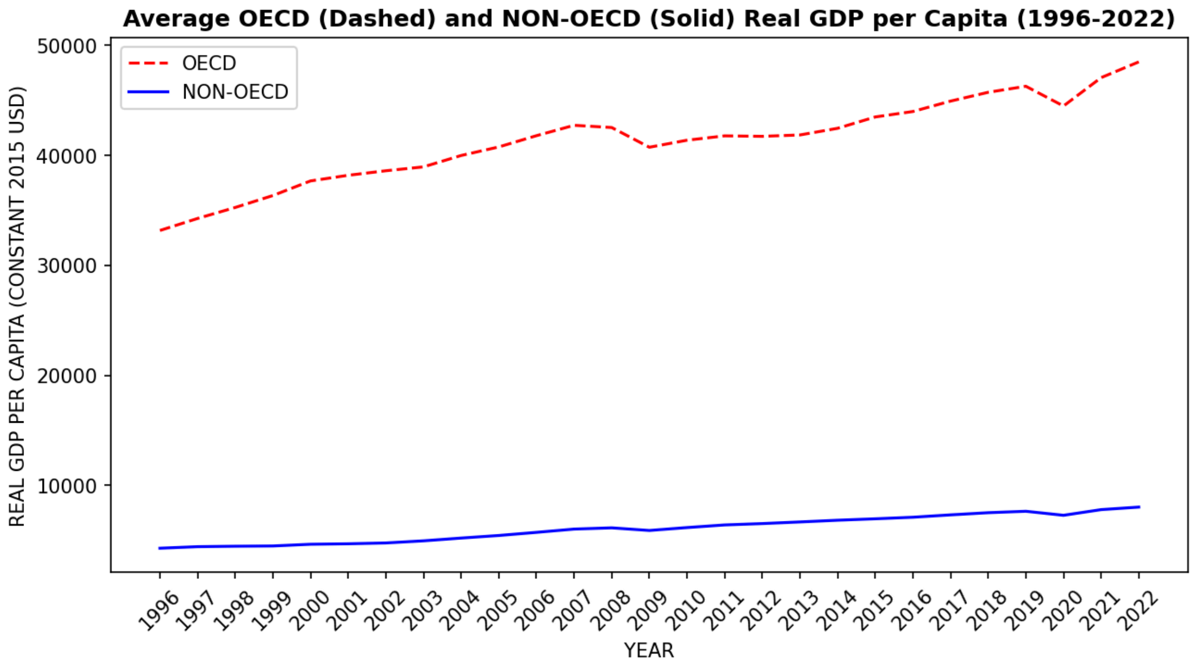

Figure 5.13: Average Sample GDP per Capita for OECD and non-OECD (1996-2022)

Figure 5.13 shows the sample average time series plot for real GDP per capita by OECD groups. There is a clear gap between OECD and non-OECD countries. Also, we see that OECD countries are more sensitive to the economic crises as we can see from the impact of 2008 recession and COVID-19 pandemic on OECD countries.

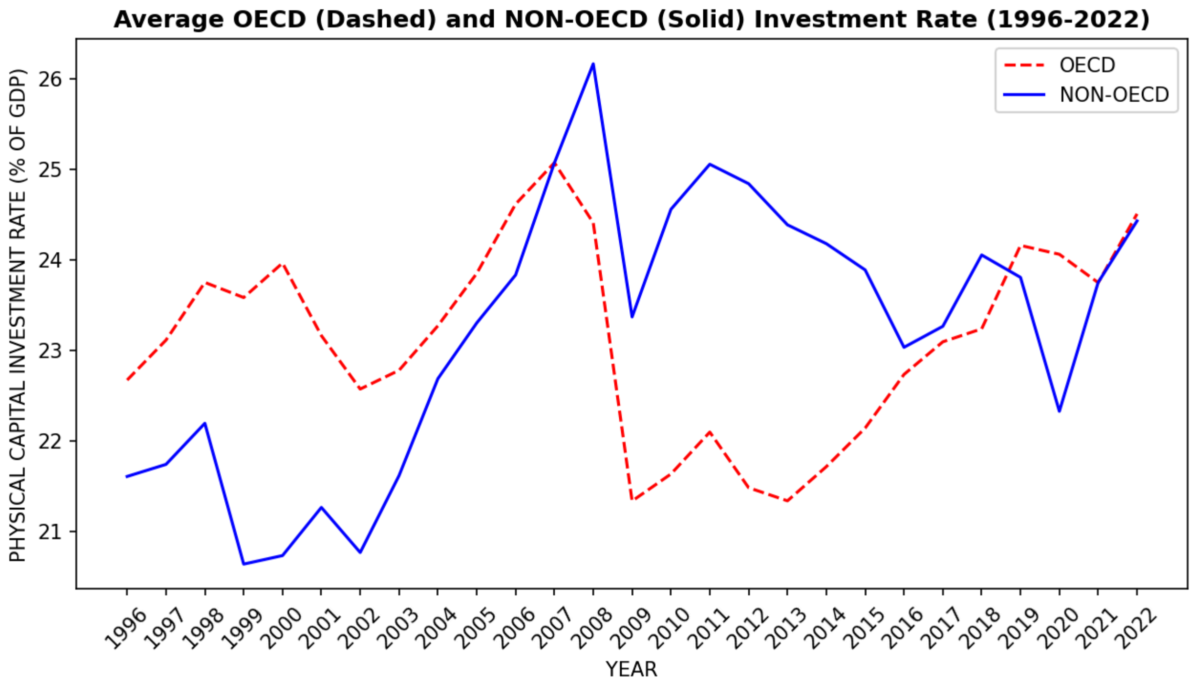

Figure 5.14: Average Sample Physical Capital Investment Rate for OECD and non-OECD (1996-2022)

Figure 5.14 shows the average investment rate on physical capital. On average OECD had higher investment rates until the 2008 recession. In fact, OECD countries suffered more during the 2008 recession. During the post recession period we see that on average non-OECD countries had higher investment rates until COVID-19 pandemic. During COVID-19 pandemic there was a very little decrease in the average investment rates for OECD countries, while non-OECD countries had a drastic decrease. In recent years, both OECD and non-OECD countries' average investment rate values are similar.

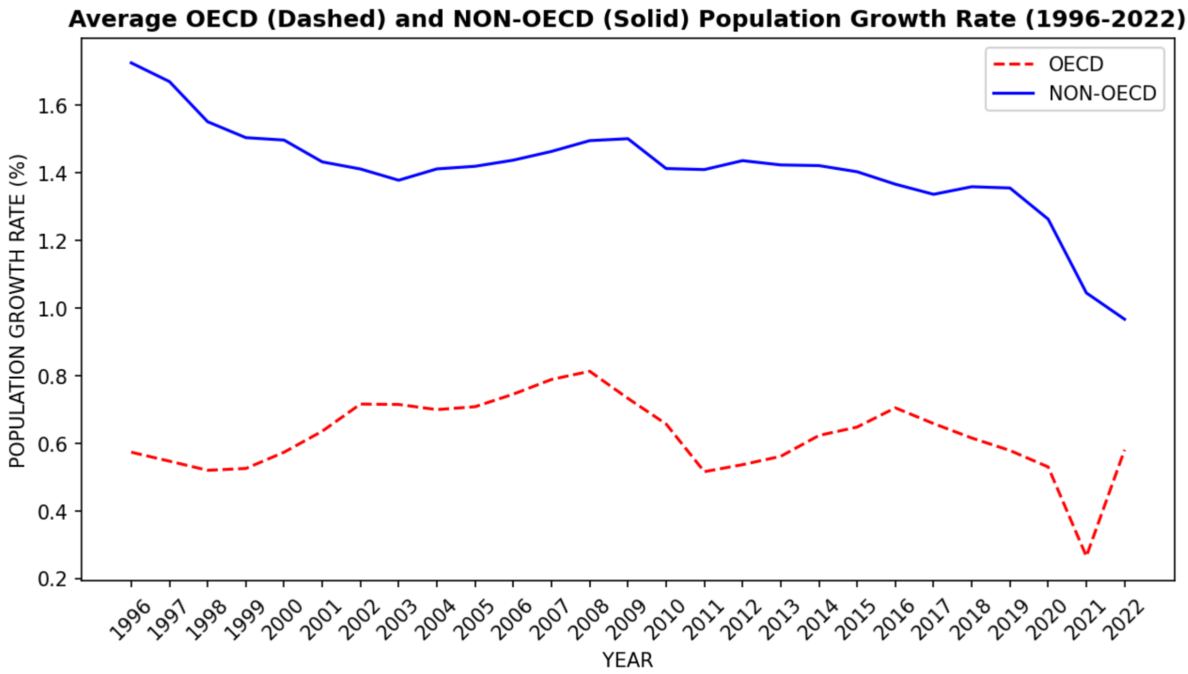

Figure 5.15: Average Sample Population Growth Rate for OECD and non-OECD (1996-2022)

In figure 5.15, we compare the average population growth rates for OECD and non-OECD countries. On average, non-OECD countries have almost 1% higher population growth. Also, we observe that in 2021, average population growth rates have fallen for both OECD and non-OECD countries. While OECD countries returned to their original trend, non-OECD countries' population growth rates kept falling.

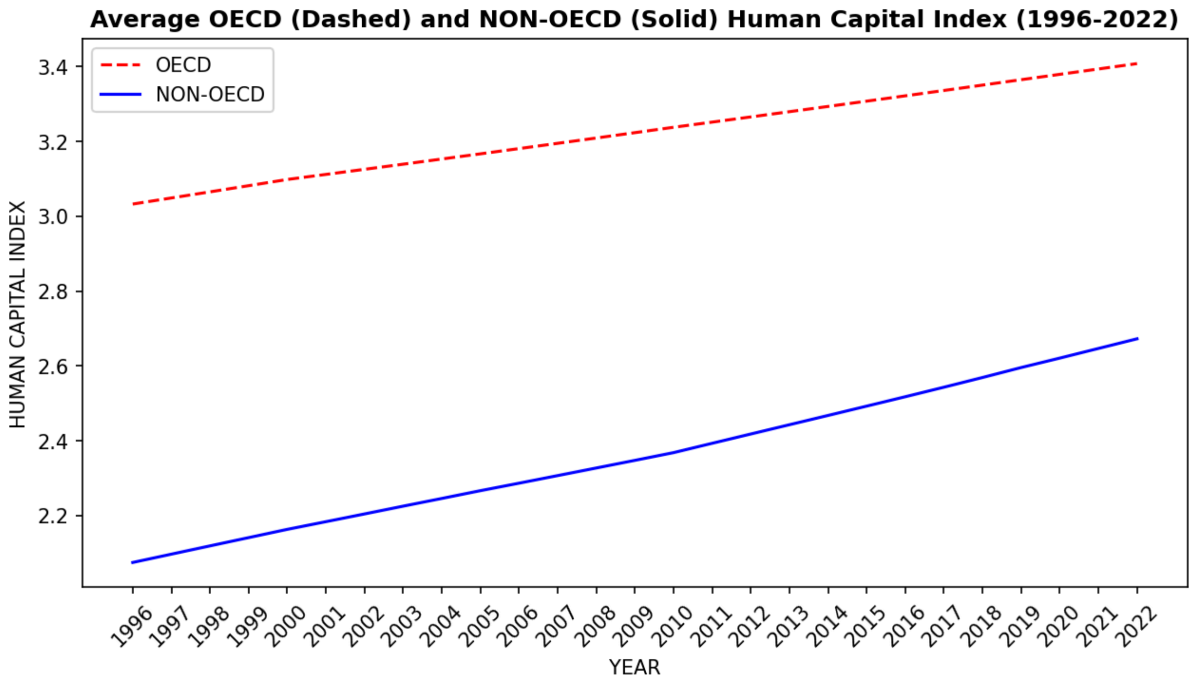

Figure 5.16: Average Sample Human Capital Index for OECD and non-OECD (1996-2022)

Figure 5.16 compares the average human capital index over the period 1996-2022 for OECD and non-OECD country groups. While both country groups indicate a positive trend, we see that OECD countries have always had very high levels of human capital compared to non-OECD countries. This figure fails to show any convergence for human capital for underdeveloped countries.

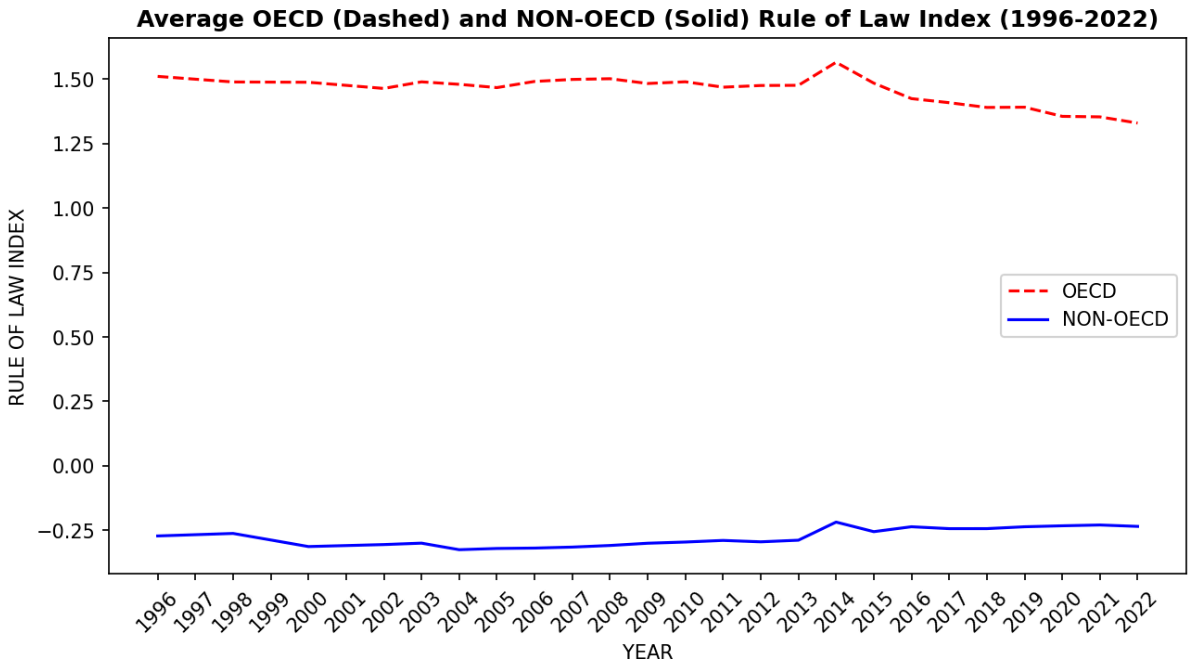

Figure 5.17: Average Sample Rule of Law Index for OECD and non-OECD (1996-2022)

In figure 5.17, we plot the average rule of law index between 1996-2022 for OECD and non-OECD country groups. There is a clear difference between OECD and non-OECD in the matter of institutional qualities. OECD countries average is around 1.50 and non-OECD countries average is around -0.25. Recall that this index is roughly between -2.5 and 2.5 (as a normal distribution).

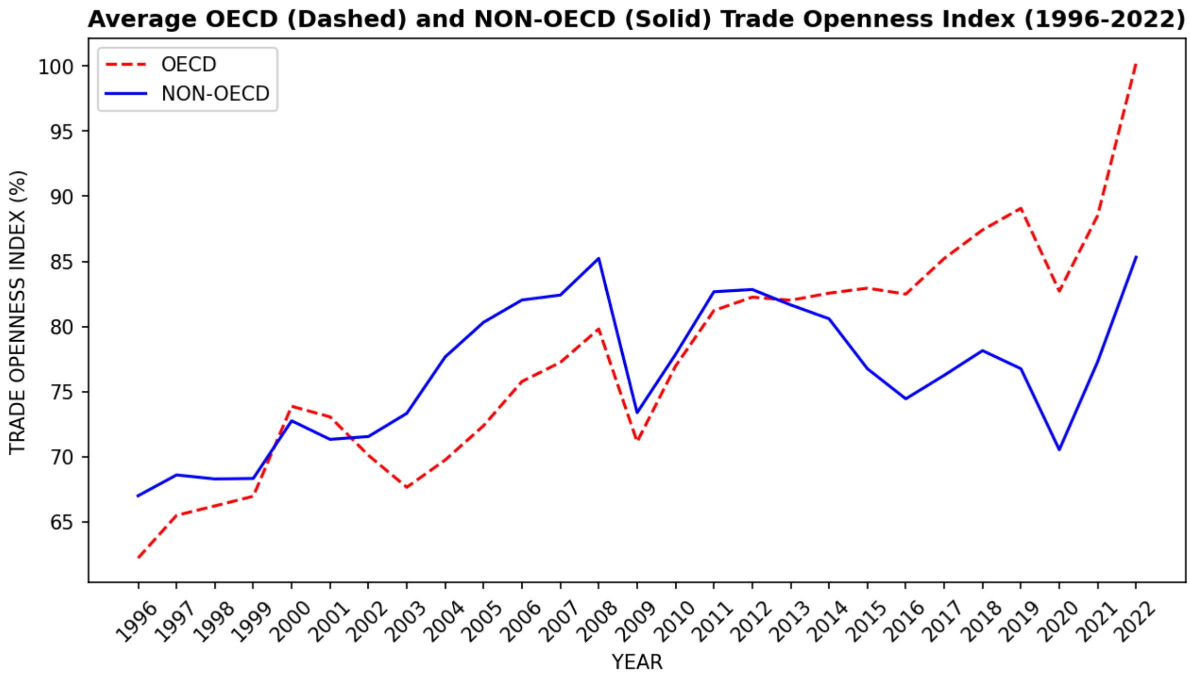

Figure 5.18: Average Sample Trade Openness Index for OECD and non-OECD (1996-2022)

In figure 5.18, we compare the average trade openness index values. Until the 2008 recession, we observe that both OECD and non-OECD averages were close to each other, but generally, non-OECD countries had higher trade openness. However, the post recession period paints a different picture. While both OECD and non-OECD countries suffer from the recession, 2014 and onwards OECD countries start to diverge and have higher trade openness.Similar to the 2008 recession, during COVID-19 both OECD and non-OECD countries' trade openness index values have fallen. But in recent years, they have increased dramatically.

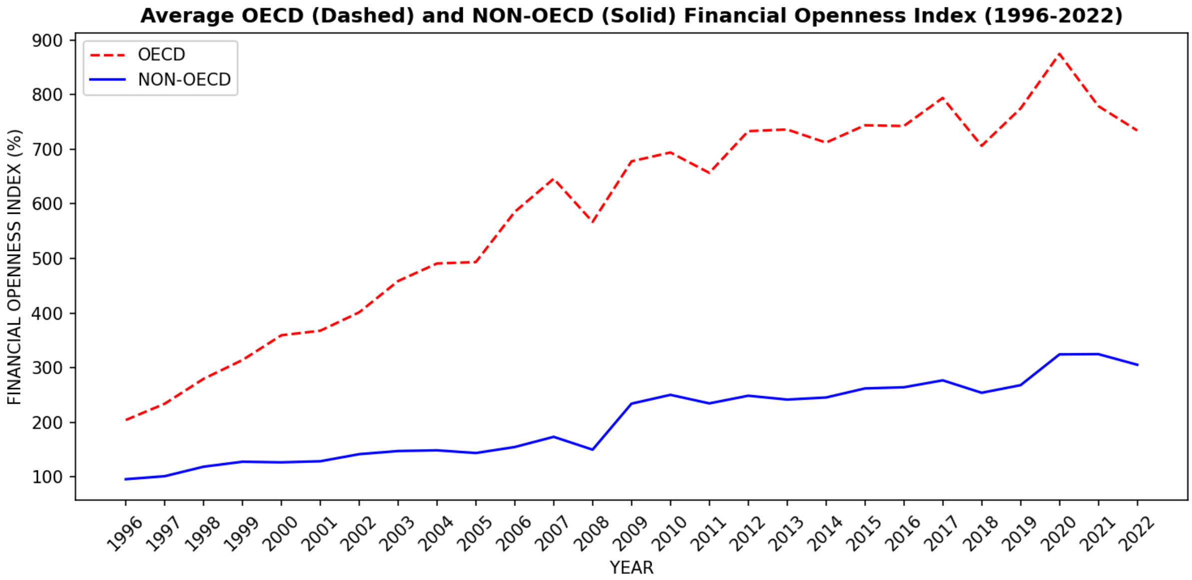

Figure 5.19: Average Sample Financial Openness Index for OECD and non-OECD (1996-2022)

Figure 5.19 shows the average financial openness index for OECD and non-OECD countries as a time series plot. In 1996, OECD countries had twice as much financial openness compared to non-OECD countries. In time, this gap widens and OECD countries start to diverge from non-OECD countries. We see that OECD countries are more volatile and sensitive. Both country groups have suffered during the 2008 recession. However, during COVID-19 pandemic, financial openness increased for both country groups. This phenomenon was previously discussed in figure 5.6.

We further study independent variable distributions using kernel density estimation (KDE) plots. KDE plots allow us to assess the normality of the distributions for each independent variable.

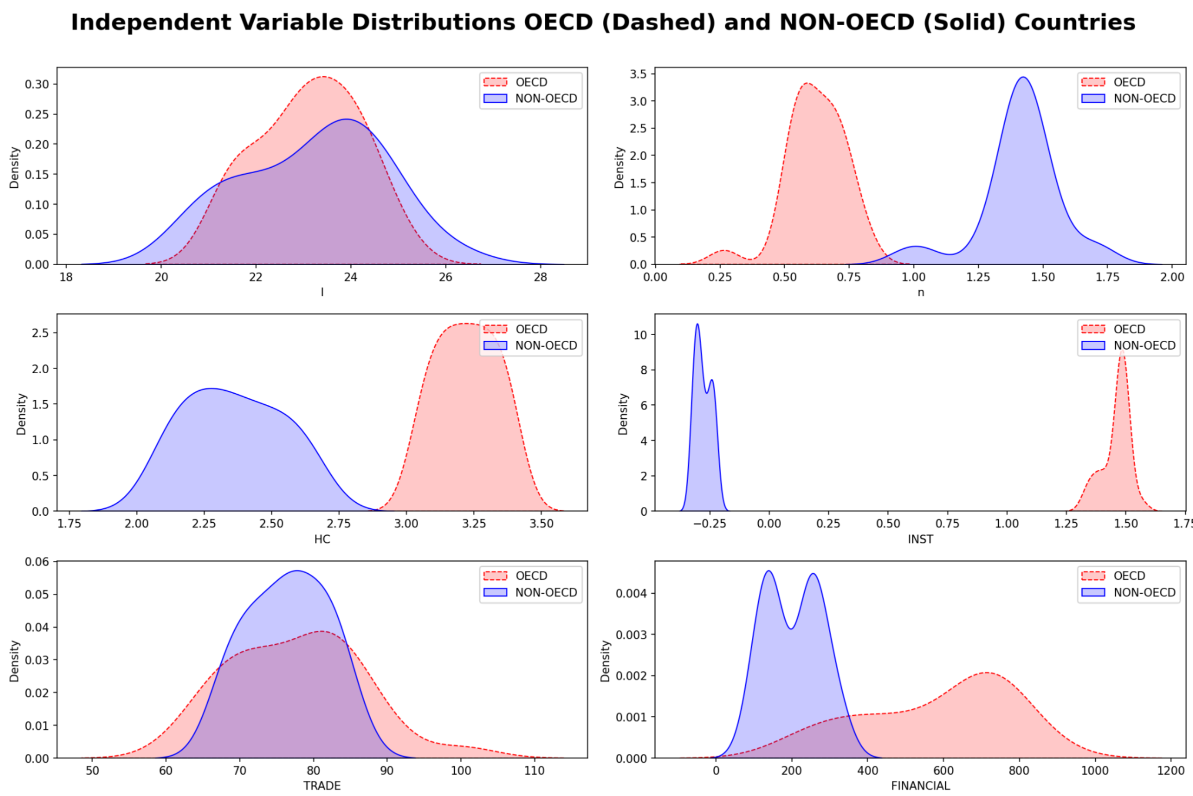

Figure 5.20: KDE plots for independent variables (OECD and non-OECD)

Figure 5.20 shows the KDE plots for each independent variable data. We also split data into OECD and non-OECD subgroups in order to compare them. We see that the distribution of variables I, TRADE overlaps. For variable I, non-OECD countries exhibit high variance. The opposite can be observed for variable TRADE, where OECD countries exhibit high variance. Distributions of the variables n, HC, INST show clear distinction between OECD and non-OECD countries. Financial variable distribution has high variance for OECD groups. Moreover, for non-OECD group it follows a binormal (not binomial) distribution. This distribution is a result of combining data from two independent distributions. Therefore, within the non-OECD group, there are more financially open countries, and less financially open countries. This raises the question whether the OECD dummy variable is a good split for capturing variances.

Lastly, we discuss the correlation matrix between variables. Table 5.4 shows the correlation matrix between our panel data variables. A typical rule of thumb for strong correlation is that absolute value of the correlation coefficient (ρ) is bigger than 0.75. We must note that the correlation should not be confused with causation. A high correlation simply indicates that comovement of variables either in the same or opposite direction depending on their sign. For causality analysis, one must build a regression model.

CORRELATION MATRIX

OECD	1								
y	0.9876	1							
ln_y	0.9927	0.9934	1						
I	-0.0357	0.0034	0.0282	1					
n	-0.9498	-0.9482	-0.9624	-0.017	1				
HC	0.9461	0.9716	0.9771	0.0898	-0.9602	1			
INST	0.9987	0.9826	0.9916	-0.0421	-0.9482	0.9444	1		
TRADE	0.0819	0.2137	0.157	0.4242	-0.169	0.2858	0.0552	1	
FINANCIAL	0.798	0.8744	0.8416	0.0174	-0.8029	0.9024	0.7877	0.51	1
	OECD	**y**	**ln_y**	**I**	**n**	**HC**	**INST**	**TRADE**	**FINANCIAL**

Table 5.4: Correlation Matrix

For OECD membership, we observe strong positive correlations with y, HC, INST, and FINANCIAL and a strong negative correlation with n. We can make a similar observation for y. n has strong negative correlation with y, HC, INST and FINANCIAL, hence, we observe that countries with high population growth also have lower gdp per capita, human capital index, institutional quality and financial openness. Investment rate, I, has negligible correlations with most of the variables. Its highest value correlation coefficient is observed with the TRADE variable. TRADE is also similar to I. It does not have many remarkable correlations. It has the highest correlation with FINANCIAL. However, it is weak. We see that other than I and TRADE, every other variable is strongly correlated with each other. This might indicate a multicollinearity problem; however, econometric papers tend to ignore this problem, and so this research will.

6. CROSS-SECTIONAL REGRESSION ANALYSIS

In this section, we will estimate two cross-section models in order to gain insights regarding modern determinants of economic growth. Our cross-section data for models will be the averaged values of dependent variable and independent variables for 1996-2008 and 2009-2022 respectively. In other words, we aim to analyze the coefficients and statistical significance of estimators for these two sub periods. This research will avoid pooled panel OLS as panel data generates serious heteroskedasticity and autocorrelation problems and the estimated values are no longer BLUE (Beck & Katz, 1995).

The main purpose of using averaged variables in these sub periods is to explain the growth trend and reduce noise caused by business cycles. Similar approaches taken by (Barro & Sala-i-Martin, 1992) and (Quah, 1992) in their empirical researches. In fact, Quah (1992) argues that reasons for using averaged cross-section analysis by stating that "The idea underlying this procedure is that the conditioning variables explain the permanent growth component or trend, while the initial condition controls for transitory dynamics." (p. 1).

In the both cross-sectional OLS regression results for 1996-2008 and 2009-2022, we use non robust covariance type; in other words, we assume that $\epsilon \sim N(0,\ \sigma)$, where σ is some constant. We prove this using White's heteroskedasticity test (1980).

Let,

$y_i = \beta_0 + \beta_1 \cdot x_{1i} + \beta_2 \cdot x_{2i} + \dots + u_i$, where u_i is the residuals.

After estimation we have

$\hat{u}_i = y_i - \hat{y}_i$, where $\hat{y}_i$ is the estimated equation.

Compute the squared residuals as:

$$(\hat{u}_i)^2 = (y_i - \hat{y}_i)^2$$

$$= \alpha_0 + \sum_{j=1}^{k} \alpha_j \cdot x_{ji} + \sum_{j=1}^{k} \alpha_{k+j} \cdot x_{ji}^2$$

$$+ \sum_{j=1}^{k-1} \sum_{l=j+1}^{k} \alpha_{2k+j+l-1} \cdot (x_{ji} \cdot x_{li}) + v_i \qquad (6.1)$$

Where,

v_i: *error term of the auxiliary regression,*

k: *the number of independent variables in the original regression model,*

j: *index for denoting independent variables from the original regression,*

l: *index used for the interaction terms in the auxiliary regression.*

Then, if null hypothesis holds, $N \cdot R^2$ from auxiliary regression 6.1 is distributed as χ^2(Chi-square) with $2k + 1$ degrees of freedom. If test statistic $N \cdot R^2$ is significant; we conclude that error terms are related to at least one independent variable and heteroskedasticity is present. In more mathematical terms,

$$H_0: \alpha_1 = \alpha_2 = \dots = \alpha_{2k+p-1} = 0$$

$$H_1: \exists \alpha_j \neq 0$$

Another diagnostic test that we will use to assess the efficiency of estimation is the Durbin-Watson test. The Durbin-Watson (Durbin and Watson, 1950) test statistic is also calculated using residuals.

$$DW = \frac{\sum_{i=2}^{N} (\hat{u}_i - \hat{u}_{i-1})^2}{\sum_{i=1}^{N} (\hat{u}_t)^2} \quad (6.2)$$

Interpretation of DW test value is not so direct. We must find d_l (lower critical value) and d_u (upper critical value), and see if DW value between them:

$d_l < DW < d_u$

If DW value is between lower and upper bound, then we conclude that there is no autocorrelation between residuals. DW distribution requires linearity assumptions of the regression model and normality assumptions of error terms. Moreover, it depends on sample size, number of independent variables, and having an intercept value. (Woolridge, 2019). We use Savin and White's DW table (Savin & White, 1977) and find that $d_l \approx 1.489$ and $d_u \approx 1.852$ at %95 confidence interval.

Both White's heteroskedasticity test and Durbin-Watson autocorrelation test will be the only diagnostic tests we will use to determine the efficiency of the estimation.

Before we present regression results, we will transform y, I, TRADE and FINANCIAL variables into natural logarithm space. There are several reasons for logarithmic transformation as discussed by Woolridge. First reason is that logarithmic scale reduces error for high numbers, hence the estimate does not suffer from the outliers. For example, variable real GDP per capita is a very big integer, hence we will use $\ln(y)$ to reduce error and improve the R^2 value. Second reason is that such a transformation allows us to interpret coefficients easily. For example, consider a generic regression equation in 6.3:

$$\ln(y) = \beta_0 + \beta_1 \cdot \ln(x_1) + \beta_2 \cdot x_2 \quad (6.3)$$

After the estimation, we interpret $\hat{\beta}_1$ as the percentage increase in y, when x_1 increases by %1, and we interpret $\hat{\beta}_2$ as $(\hat{\beta}_2 \cdot 100)$ percentage increase in y when x_2 increases by 1 unit. While logarithmic transformation is a very desirable approach in regression modeling, we must carefully consider which variables can be logarithmically scaled. Typically, non-negative (since logarithm function domain is the set of all positive real numbers.) high numerical values are transformed. Also, it is possible to transform variables that are measured in percentages. However, one must be careful when interpreting these variables after the transformation because such variables after logarithmic transformation, are interpreted as percentage point change, which is just the numerical change in percentages[1]. (Woolridge, 2019).

Furthermore, in the cross-sectional estimations we remove MUS and SGP as they have extreme outliers and potentially disturb the estimation results. Thus, in the finalized cross section dataset, we have 96 countries.

1. To further clarify this, let us consider a change from 30% to 45%. In this example, percentage point change is 15% and percentage change is 50%.

1996-2008 YEAR AVERAGE CROSS-SECTIONAL OLS

Dep. Variable:	ln_y	R-squared:	0.863
Model:	OLS	Adj. R-squared:	0.852
Method:	Least Squares	F-statistic:	79.19
Date:	Thu, 06 Jun 2024	Prob (F-statistic):	3.09E-35
Time:	1:39:04	Log-Likelihood:	-7.83E+01
No. Observations:	96	AIC:	172.7
Df Residuals:	88	BIC:	193.2
Df Model:	7		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	4.0405	1.102	3.666	0	1.85	6.231
ln_I	0.4455	0.244	1.829	0.071	-0.038	0.929
n	-0.0038	0.081	-0.047	0.963	-0.164	0.157
HC	1.1183	0.171	6.534	0	0.778	1.458
INST	0.267	0.128	2.086	0.04	0.013	0.521
ln_TRADE	-0.2298	0.177	-1.297	0.198	-0.582	0.122
ln_FINANCIAL	0.2301	0.164	1.405	0.163	-0.095	0.555
OECD	0.7668	0.271	2.832	0.006	0.229	1.305

Omnibus:	1.175	Durbin-Watson:	1.83
Prob(Omnibus):	0.556	Jarque-Bera (JB):	0.79
Skew:	0.211	Prob(JB):	0.674
Kurtosis:	3.142	Cond. No.	148

Notes:

[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Table 6.1: Cross-sectional OLS Regression for 1996 - 2008 Average Values

Table 6.1 summarizes the cross-sectional regression results for 1996-2008 averages. We observe that intercept, HC, INST, and OECD dummy variables are statistically significant as p-values are less than 0.05. For this period, TRADE, FINANCIAL and I did not have a significant impact on economic growth; in fact, we can conclude that their coefficient is 0 as they are not statistically significant. Coefficient of human capital, HC, is positive and it is the highest among other significant variables. For each 1 unit increase in the human capital index, real GDP per capita increases by approximately 111.83%. Similarly, the INST variable has a positive coefficient. For each 1 unit increase in rule of law index, real GDP per capita increases by approximately 26.7%. Coefficients if significant variables are inline with the previous studies in literature and theory.

Model R^2 value is very high. It explains 86.3% of the variance on real GDP per capita. F statistic p-value is less than 0.05, which indicates estimators are jointly significant. We conduct White's test and results are as follows:

WHITE'S TEST RESULTS (1996-2008)

Lagrange Multiplier statistic	39.4204
p-value	0.2403
f-value	1.25
f p-value	0.2209

Table 6.2: White's Test Results for 1996 - 2008 Average Values

Test results show that we do not have significant evidence to conclude there is heteroskedasticity. Moreover, Durbin-Watson test statistic reported in table 6.1 is between d_l and d_u. Therefore, we can conclude that there is no autocorrelation between the residuals. Figure 6.1 illustrates some diagnostic plots for the results of table 6.1.

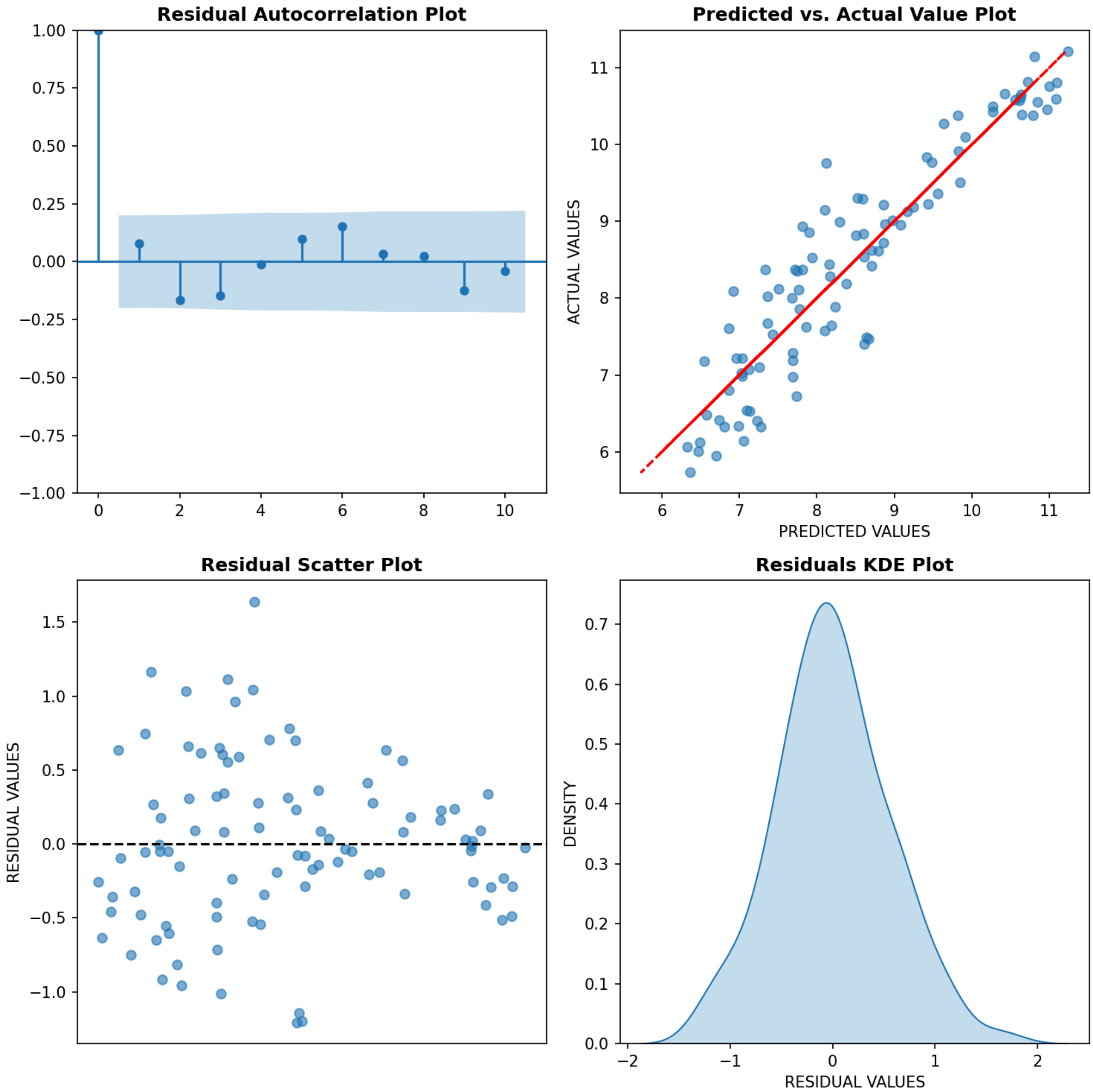

Figure 6.1: OLS Diagnostic plots 1996 - 2008 Average Values

Residual autocorrelation plot shows that there is no autocorrelation between residuals. Shaded area is 95% confidence interval, and values within this interval are statistically insignificant (excluding 0th value since residuals are perfectly correlated with each other for the same observation). Predicted vs actual value plot and residual distribution plot shows that residual variance is constant. Residual distribution plot also shows that residual distribution are very close to normal distribution. Thus, we conclude that estimation is efficient.

2009-2022 YEAR AVERAGE CROSS-SECTIONAL OLS

Dep. Variable:	ln_y	R-squared:	0.892
Model:	OLS	Adj. R-squared:	0.884
Method:	Least Squares	F-statistic:	104.2
Date:	Thu, 06 Jun 2024	Prob (F-statistic):	0
Time:	15:13:25	Log-Likelihood:	-63.748
No. Observations:	96	AIC:	143.5
Df Residuals:	88	BIC:	164
Df Model:	7		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	4.7213	0.966	4.886	0	2.801	6.641
ln_I	0.3134	0.215	1.455	0.149	-0.115	0.741
n	-0.098	0.068	-1.451	0.15	-0.232	0.036
HC	1.0855	0.136	8.006	0	0.816	1.355
INST	0.3112	0.114	2.737	0.007	0.085	0.537
ln_TRADE	-0.3694	0.153	-2.418	0.018	-0.673	-0.066
ln_FINANCIAL	0.3202	0.132	2.419	0.018	0.057	0.583
OECD	0.4967	0.222	2.242	0.027	0.056	0.937

Omnibus:	2.378	Durbin-Watson:	1.845
Prob(Omnibus):	0.305	Jarque-Bera (JB):	1.835
Skew:	-0.18	Prob(JB):	0.399
Kurtosis:	3.574	Cond. No.	158

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Table 6.3: Cross-sectional OLS Regression for 2009 - 2022 Average Values

Table 6.3 summarizes the cross-sectional OLS for 2009-2022 average values for 96 countries. Unlike in the previous sub-period, FINANCIAL and TRADE variables are now statistically significant. HC and INST variables preserve their statistical significance, while variables n and I are still statistically insignificant. 1 unit increase in the human capital index causes a 108.55% increase, 1 unit increase in the rule of law index would result in 11.4% increase, and 1 percentage point change in financial openness causes 32.02% increase in real

GDP per capita. While HC, INST, and FINANCIAL are inline with economic literature and theory, we cannot say the same for the TRADE variable. Though it is statistically significant, its coefficient is negative. In fact a 1% point increase in TRADE, reduces real GDP per capita by 36.94%. Figure 5.11 has shown that there is a weak relationship between TRADE and log(y). Also, it shows developed countries do not necessarily have high trade openness. Therefore, the coefficient sign is consistent with our dataset.

We observe high R^2 value for this sub period as well, which is 0.892. The P-value for F test also shows that variables are jointly significant. We test for heteroskedasticity using White's test. Results are summarized in table 6.4:

WHITE'S TEST RESULTS (2009-2022)

Lagrange Multiplier statistic	35.5732
p-value	0.3941
f-value	1.0562
f p-value	0.4173

Table 6.4: White's Test Results for 2009- 2022 Average Values

For this period, we also do not find evidence for heteroskedasticity. Moreover, we do not find evidence for autocorrelation as well since DW test statistic is 1.845, which between d_l and d_u values. Similar to the previous period we show diagnostic plots in figure 6.2.

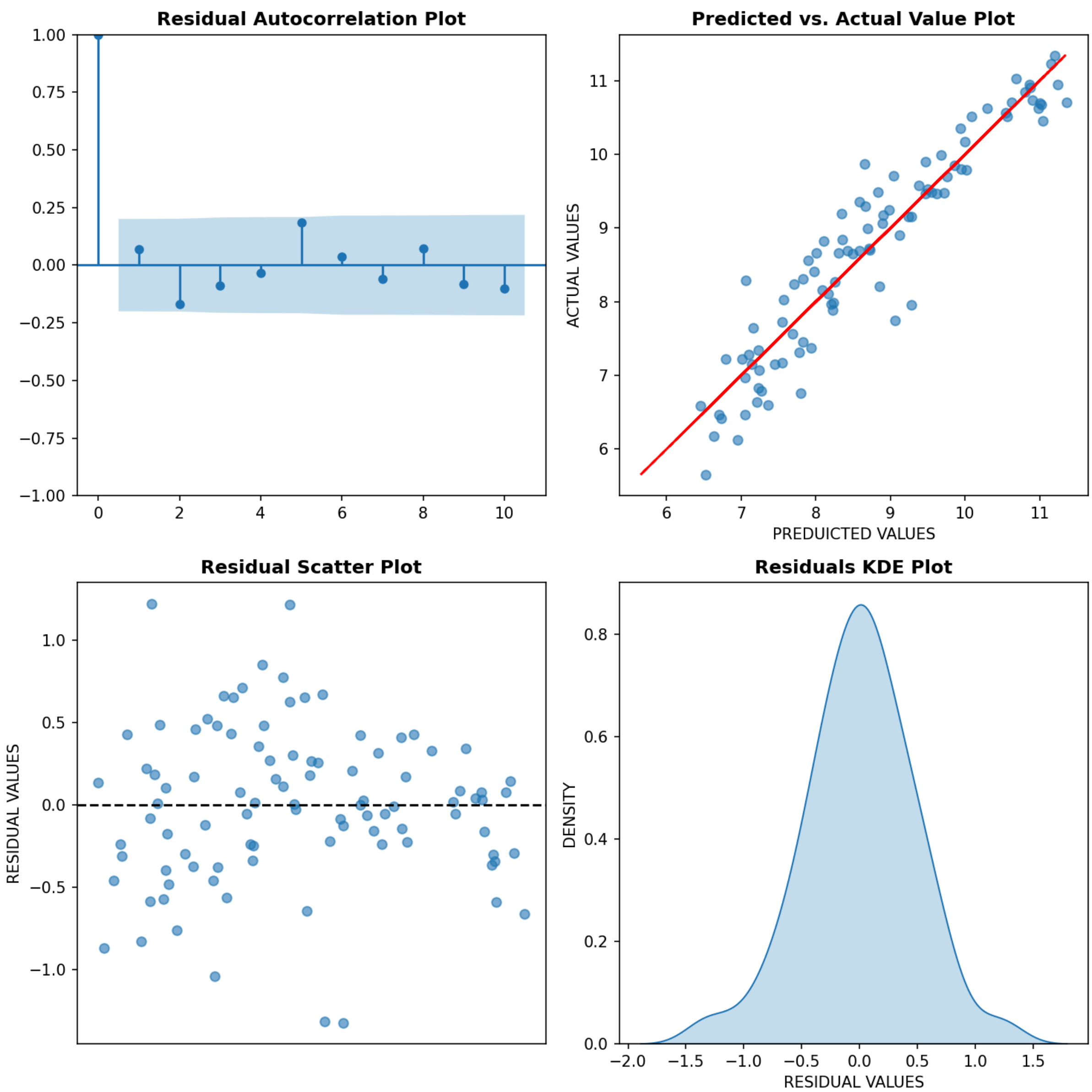

Figure 6.2: OLS Diagnostic plots 2009 - 2022 Average Values

Residual autocorrelation plot shows that there is no autocorrelation. Predicted vs actual value plot, and residual scatter plot shows that there is constant variance across residuals. Residual distribution is very close to normal distribution. We conclude that estimation is efficient.

7. CONCLUSION

The main aim of this study was to provide empirical evidence regarding the modern determinants of economic growth. Our methods have included descriptive data analysis and cross-section OLS regression for 1996-2008 and 2009-2022.

The results of descriptive analysis have shown that there are significant differences in human capital, institutional quality and financial openness between developed and underdeveloped countries. On the other hand, investment on physical capital and trade openness levels were close to each other. We have also observed that human capital, financial openness and trade openness levels have increased over time. However, there is no improvement in institutional quality for underdeveloped countries, and population growth rates have fallen slightly. All of the variables have strong correlation with each other, except investment rate of physical capital and trade openness. Only the population growth rate had a strong negative correlation with growth.

Cross-sectional regression results have shown that investment rate on the physical capital population is not a relevant determinant of economic growth in the post-globalism setup. On the other hand, trade openness and financial openness gained importance in economic growth for recent years. However, we found that trade openness does not positively affect economic development. We concluded that human capital and institutional quality is very important for economic development as their coefficient is positive and they are statistically significant in both sub-period regressions.

To further investigate these variables, we suggest using advanced panel estimation models. In fact, such models are more likely to capture short-run growth variances; therefore, such models will consider the impact of business cycles. Moreover, we suggest that researchers should focus on the financial openness, human capital and institutional quality using better time range and proxies because this paper underlines their importance, and consider a better dummy variable for splitting high income and low income countries.

As a policy suggestion we suggest that in order to achieve high levels of economic growth in the modern world, a country must have a solid educational system and institutional framework that promotes economic stability and activity. Moreover, having more financially integrated and open markets will also promote economic growth within the country.

APPENDIX A: COUNTRY LIST

COUNTRY LIST

COUNTRY	CODE	OECD
Algeria	DZA	FALSE
Argentina	ARG	FALSE
Australia	AUS	TRUE
Austria	AUT	TRUE
Bangladesh	BGD	FALSE
Belgium	BEL	TRUE
Benin	BEN	FALSE
Bolivia	BOL	FALSE
Botswana	BWA	FALSE
Brazil	BRA	FALSE
Bulgaria	BGR	FALSE
Burkina Faso	BFA	FALSE
Burundi	BDI	FALSE
Cambodia	KHM	FALSE
Cameroon	CMR	FALSE
Canada	CAN	TRUE
Chile	CHL	FALSE
China	CHN	FALSE
Colombia	COL	FALSE
Costa Rica	CRI	FALSE
Croatia	HRV	FALSE
Czech Republic	CZE	FALSE
Denmark	DNK	TRUE
Dominican Republic	DOM	FALSE
Ecuador	ECU	FALSE
Egypt	EGY	FALSE
El Salvador	SLV	FALSE
Estonia	EST	FALSE
Finland	FIN	TRUE
France	FRA	TRUE
Gabon	GAB	FALSE
Gambia, The	GMB	FALSE

Germany	DEU	TRUE
Ghana	GHA	FALSE
Greece	GRC	TRUE
Guatemala	GTM	FALSE
Haiti	HTI	FALSE
Honduras	HND	FALSE
Hungary	HUN	FALSE
India	IND	FALSE
Indonesia	IDN	FALSE
Iran	IRN	FALSE
Ireland	IRL	TRUE
Israel	ISR	FALSE
Italy	ITA	TRUE
Japan	JPN	TRUE
Kazakhstan	KAZ	FALSE
Kenya	KEN	FALSE
Latvia	LVA	FALSE
Lithuania	LTU	FALSE
Madagascar	MDG	FALSE
Malaysia	MYS	FALSE
Mali	MLI	FALSE
Mauritania	MRT	FALSE
Mauritius	MUS	FALSE
Mexico	MEX	FALSE
Moldova	MDA	FALSE
Mongolia	MNG	FALSE
Morocco	MAR	FALSE
Namibia	NAM	FALSE
Nepal	NPL	FALSE
Netherlands	NLD	TRUE
New Zealand	NZL	TRUE
Nicaragua	NIC	FALSE
Niger	NER	FALSE
Norway	NOR	TRUE
Pakistan	PAK	FALSE
Paraguay	PRY	FALSE
Peru	PER	FALSE
Philippines	PHL	FALSE

Poland	POL	FALSE
Portugal	PRT	TRUE
Romania	ROU	FALSE
Russia	RUS	FALSE
Rwanda	RWA	FALSE
Saudi Arabia	SAU	FALSE
Senegal	SEN	FALSE
Sierra Leone	SLE	FALSE
Singapore	SGP	FALSE
Slovak Republic	SVK	FALSE
Slovenia	SVN	FALSE
South Africa	ZAF	FALSE
Spain	ESP	TRUE
Sudan	SDN	FALSE
Sweden	SWE	TRUE
Switzerland	CHE	TRUE
Tanzania	TZA	FALSE
Thailand	THA	FALSE
Togo	TGO	FALSE
Tunisia	TUN	FALSE
Turkey	TUR	TRUE
Uganda	UGA	FALSE
Ukraine	UKR	FALSE
United Kingdom	GBR	TRUE
United States	USA	TRUE
Uruguay	URY	FALSE
Vietnam	VNM	FALSE
Zimbabwe	ZWE	FALSE

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Table A.1: Country List

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