GINI INDEX AND OTHER MEASURES OF INCOME INEQUALITY

By

Ei Ei Maw

Thesis submitted to University of Plymouth

In partial fulfilment of the requirements for the degree of

MSc Data Science and Business Analysis

University of Plymouth

Faculty of Science & Engineering

September 2024

Table of Contents

Abstract

This thesis analyses more than four decades of annual income share data to understand income distribution and income inequality between 38 OECD member countries and within the population of the countries. The Lorenz Curve, Gini Coefficient, Hoover Index, and other measures of income inequality have been utilised to generate results by using R Studio. We observed that from 1980 to 1997, Colombia had the highest income inequality among OECD countries, with Mexico surpassing it from 2003 onward. Chile also maintained high levels of inequality, while Denmark, Sweden, and Norway exhibited the lowest. As of 2022, 24 OECD countries had income inequality below the OECD average of 0.36, while 14 countries were above it. Notably, all six American OECD countries were above the average, whereas Western, Central and Northern European countries were below it. In Southern and Eastern Europe, Greece, Hungary, Slovakia, Poland, and Slovenia were below the average, while the rest were above. In the Asia-Pacific and Middle East regions, only Australia and Korea reported lower-than-average inequality.

The study also found that, in countries with rising inequality, such as Mexico and Chile, low-income groups saw a reduced share of income in 2022 compared to 1980. A strong positive correlation was observed between the Gini Coefficient and the income redistribution needed for equality (the Hoover Index). However, the analysis on the relationship between unemployment rate and the Gini Coefficient of selected five countries varied by country, with showing a negative correlation, except for Japan, which showed a positive correlation. Further research should explore additional factors affecting income inequality to better understand its underlying drivers.

Declaration of the word count

I hereby declare that the total word count of this thesis is 9,000 words.

List of Tables

Page

List of Figures

Acknowledgements

I would like to express my deepest gratitude to my supervisor, Dr. Tom Heinzl, from the University of Plymouth, an Associate Professor in Theoretical Physics, School of Engineering, Computing and Mathematics, for his unwavering guidance and insightful suggestions throughout the journey of my dissertation. His expertise, encouragement, and patience have been invaluable to me, and I am truly grateful for the support he has provided at every stage of this research. Dr. Heinzl's dedication to helping me achieve my academic goals has been a constant source of inspiration, and I am honored to have had the opportunity to work under his supervision. Thank you for your mentorship and for always challenging me to think critically and strive for excellence.

1. Introduction

1.1 Background Motivation

According to Kus (2012) the increase in income inequality is not just an isolated issue in a few places but a broader and more significant trend affecting many regions and countries. Likewise, income inequality has increased in most OECD countries over recent decades. Twenty-five years ago, the disposable income of the top 10% of earners was, on average, approximately seven times greater than that of the bottom 10%. By 2010, this disparity had expanded to about 9.5 times (OECD, 2014). Income and wealth inequality impacts both economies and societies, with increasing evidence suggesting that extreme inequality could hinder economic growth. Additionally, there are worries that inequality might limit access to education and reduce social mobility. Some even claim that it contributes to rising crime rates and negatively affects public health (Keeley, 2015). Examining income inequality across four decades in OECD countries can provide insights into the evolution of between and within-countries income disparities, which reflects the effectiveness of policies and economic changes. Understanding these trends helps policymakers evaluate the impacts of different interventions and adapt strategies to foster more equitable economic growth and social stability.

1.2 Literature Review

According to the OECD (n.d.), income inequality is characterized by the disproportionate distribution of income within a population. Income is defined as the disposable income available to a household within a specific year, encompassing earnings from employment, self-employment, capital income, and public cash transfers. This figure is calculated after

subtracting income taxes and social security contributions paid by households. The inequality is also known as the gap between the rich and the poor, wealth disparity, or the wealth and income gap. Chancel and Piketty (2021) offer an extensive examination of global inequality trends spanning from 1820 to 2020. Their analysis reveals that inequality rose both between and within countries from 1820 to 1910. However, between 1910 and 1980, while inequality between countries continued to increase, inequality within countries saw a decline. This trend reversed between 1980 and 2020, as within-country inequality increased once again, whereas between-country inequality began to decrease. Over the entire period from 1820 to 2020, the global top 10% consistently held between 50% and 60% of total income, whereas the bottom 50% controlled only 5% to 10%. Notably, the income share of the global top 1% has remained three to four times larger than that of the bottom 50%. Kharas and Seidel (2018) also revealed that over the past decades, the global elite, particularly the top 1 percent, have experienced substantial income growth. In contrast, the global extreme poor have remained largely marginalized, with many countries trapped in persistent cycles of poverty and violence.

The World Inequality Report (2022) corroborates these findings, revealing that the global bottom 50% currently holds 8.5% of total income, while the global top 10% captures 52%. On a regional level, income inequality is most pronounced in the Middle East and North Africa (MENA), where the top 10% hold 58% of the region's income. Conversely, Europe stands out as the most equitable region, with the top 10% holding only 36% of the total income. According to Seisembay *et al.* (2022) the current level of inequality is almost as severe as it was during the period when Western countries were most dominant. Since

the mid-1990s, approximately 1% of the wealthiest individuals accumulated 38% of the total additional wealth generated.

According to Schneider (2021) measuring inequality is a challenging task within the field of statistics. The challenge of how to measure inequality was explored by Max Lorenz, an American economist in his 1905 article, "Methods of Measuring the Concentration of Wealth". He examined various methods used to assess where a community falls between two extremes: perfect equality and the total concentration of wealth in a single individual. He noted that a simple graphical representation plotting wealth on one axis and population on the other was inadequate. This approach failed to accurately reflect changes in the distribution of wealth and its impact on different segments of the population

To address this issue, Lorenz introduced a novel method for quantifying income or wealth inequality, known as the Lorenz Curve. This graph shows the cumulative share of the population, ordered from the least wealthy to the most wealthy, against the cumulative percentage of total wealth owned by these groups. In a scenario of perfect wealth equality, the Lorenz Curve would be a straight diagonal line, indicating an equal distribution of wealth. However, when wealth distribution is unequal, the curve deviates from this diagonal, bowing further away as inequality increases. The extent of this deviation reflects the degree of wealth concentration: the more the curve bends away from the diagonal, the greater the concentration of wealth. This graphical approach provides a clear and comparative visualization of wealth distribution across different communities, independent of their specific circumstances (Lorenz, 1905).

The Gini coefficient, as we know it today, is the result of three distinct works by Gini coming together: “Indices of concentration and dependence”, “Dispersion and qualitative variates”, and “On the measurement of concentration and variability of characters”. An Italian statistician Corrado Gini (1884-1965) noted that whether the inequality coefficient rises or falls between any two years often depends on the specific value of *m* used to measure it (Schneider, 2021). The Gini coefficient quantifies inequality on a scale from 0 to 1, where higher values denote greater inequality (Our World in Data, 2024).

Since the early 1980s, income distribution has grown more unequal in the majority of OECD countries. Although real disposable household incomes in OECD countries grew by an average of 1.7 percent per year in the last two decades, the incomes of the wealthiest 10% increased at a faster rate than those of the poorest 10% in most of these countries (Kus, 2012). According to Tridico (2017) by recent estimates, the richest 10% now earn approximately ten times the income of the poorest 10%, compared to about seven times in the late 1980s. Concurrently, the Gini coefficient has risen from an average of 27% to 33%.

The 2009 OECD report identified Chile as having persistently high-income inequality from 1987 to 2006, with a Gini coefficient around 0.5 during this period—significantly above the OECD average of 0.31 (Paredes, Iturra, and Lufin, 2014). Lopez and Miller (2008) also suggest that Chile is among the countries with the most unequal wealth distribution globally, with an estimated household income Gini coefficient of approximately 0.57. The income share of the top 20% of earners was 17 times greater than that of the bottom 20%. Despite significant economic growth, Chile's high-income inequality has remained

largely unchanged (Paredes, Iturra, and Lufin, 2014). In USA, significant disparities persist among racial and ethnic groups in wages, employment, homeownership, arrests, and health outcomes. Whites are overrepresented in higher income brackets, while other racial groups are disproportionately concentrated in the bottom 10% and 1% of the income distribution. Specifically, Blacks, American Indians, and Hispanics consistently occupy the lower end of the income spectrum compared to Whites, Asians, and those categorized as Other (Akee, Jones, and Porter, 2019).

2. Aim and Objectives

The aim of this research is to analyze and compare income inequality trends in 38 OECD countries from 1980 to 2022. By applying quantitative measures such as Lorenz curves, Gini coefficients, and the Hoover Index, the study seeks to identify significant patterns, shifts of income inequality across different nations throughout more than 4 decades.

The objectives include measuring income inequality using these key indices, comparing changes in income distribution between the initial and final years of the study, and examining central tendency, variability, and skewness through beta distribution plots. Additionally, the research tests the correlation between the Gini and Hoover indices to determine if the Gini index can predict the Hoover Index, and it investigates the relationship between unemployment rates and the Gini index to understand the potential impact of unemployment on income inequality.

3. Methodology

According to OECD (2011), income inequality is calculated using household disposable income data. The Lorenz curve plots the cumulative share of income against the cumulative share of the population, with the 45-degree line representing perfect equality, where each population segment receives an equal share of income (United Nations, 2015). **Figure (1)** illustrates the income earned by each decile of the population and demonstrates how the Lorenz curve is derived from this income distribution.

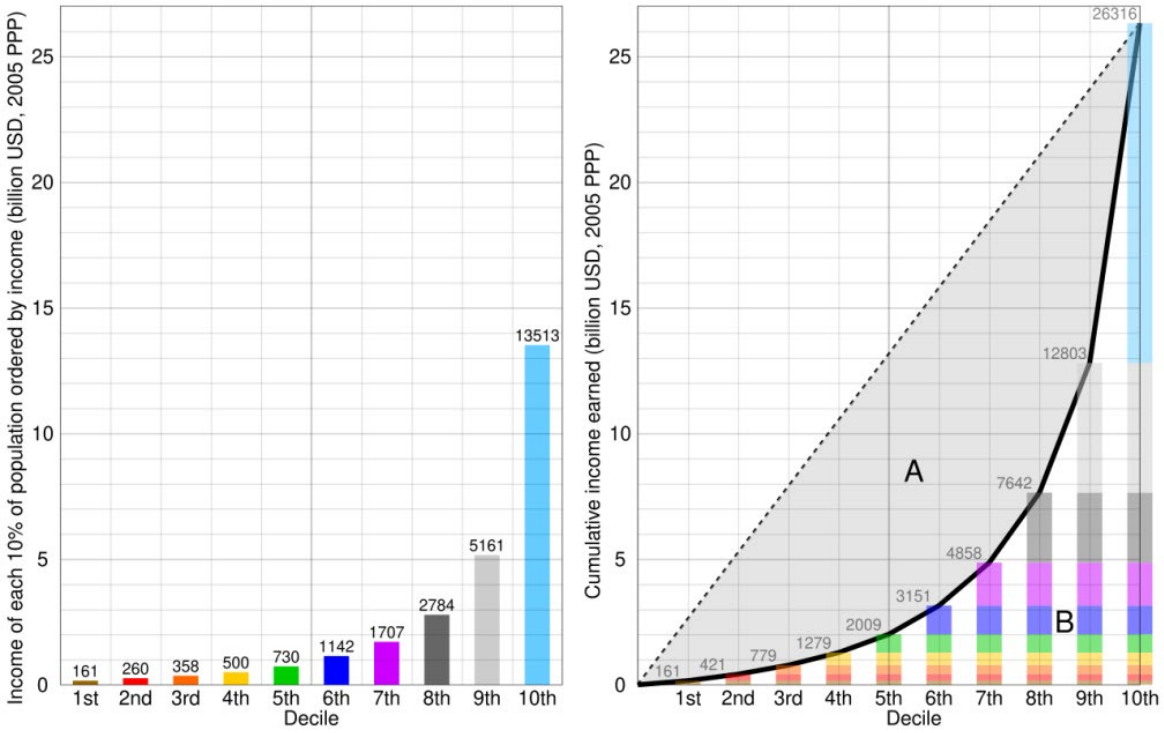


Figure (1) Absolute income of each decile and Lorenz Curve for the income distribution (WIKIPEDIA, 2024)

Besides the Lorez Cure, there are other measures for income or wealth inequality. The Gini Coefficient is one of those. The Gini coefficient is a measurement for income inequality, which is largely applied to examine the distribution of income of a nation (United Nations, 2015).

To calculate the Gini coefficient, one compares the area between the Lorenz curve and the line of equality (Area A) with the total area under the line of equality (A + B). The formulae for the Gini coefficient are as follows:

- Gini Coefficient = A / (A+B)

  Since the total area under the line of equality is always 0.5 (as it represents the area of a triangle with base and height equal to 1), the formula can be rewritten:

  A+B = 0.5.

  Thus, the formula becomes: Gini Coefficient = A/0.5 = 2A

- Gini Coefficient = 1 – 2B (Here B means the area under the Lorenz Curve). We can see how the Gini Coefficient can be calculated from the graphical representation of income inequality (the Lorenz Curve) **(Figure 2)**. The area A is coloured by the light blue and the area B is coloured by the dark blue. In a perfectly equal society, where income is evenly distributed, the Lorenz curve coincides with the line of equality, making Area 'A'

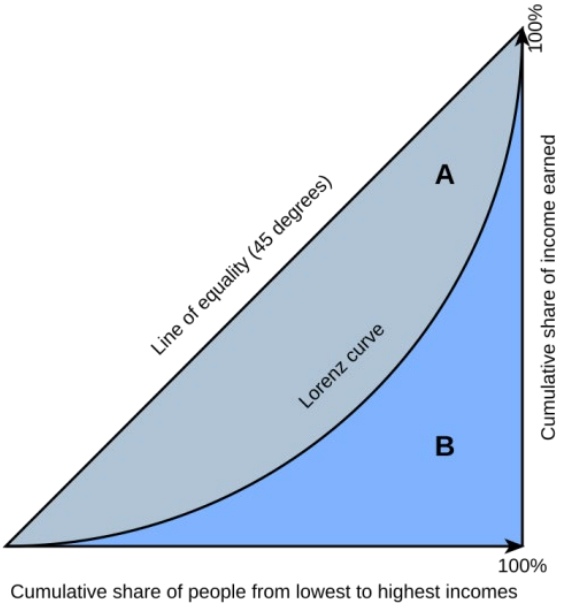


Figure (2) Lorenz Curve with Area A and Area B (WIKIPEDIA, 2024)

equal to 0, and consequently, the Gini coefficient is 0. Conversely, in a scenario where one person possesses all the income, the Lorenz curve lies along the horizontal axis until the last individual, resulting in Area B being 0 and the Gini coefficient being 1 **(Figure 2).**

Another well-known metric for measuring inequality is the Hoover index, introduced by economist Edgar Malone Hoover in 1936, which quantifies the amount of income that needs to be redistributed from the richer to the poorer half of the population to achieve equality. It ranges from 0 (perfect equality) to 1 (perfect inequality) (Wall Street Oasis, 2024). Graphically, The Hoover index measures the greatest vertical distance between the Lorenz curve and the 45-degree line representing perfect equality. (Heinzl, 2024).

We applied R Studio, especially the inequality package, to compute income inequality metrics. For the Lorenz curve, the cumulative income (L) and cumulative population (p) values are calculated using this package. To determine the Gini coefficient, L and p are first obtained, and then the area under the Lorenz curve is computed using the formula $Area\ under\ the\ Lorenz\ Curve\ (B) = \frac{1}{2}\sum_{i=1}^{n-1}\ (L_{i+1} + L_i) \times (p_{i+1} - p_i)$. The Gini coefficient is then calculated as $G = 1 - 2B$. The Hoover Index is also derived from the cumulative income (L) and cumulative population (p) values of the Lorenz curve, calculated as:

$$H = \max_{p}(p - L(p)).$$

4. Data and Data Analysis

4.1 Data

The income data for this research was sourced from the World Inequality Database (WID), which provides a comprehensive historical record of global income and wealth distribution. The database, managed by the World Inequality Lab (WIL) at the Paris School of Economics (PSE), aims to explain the increasing income inequality worldwide (WID.WORLD, n.d). With contributions from over 200 researchers from various institutions, the WID is continuously updated and is recognized as the most extensive open-access resource on global inequality trends (WID.WORLD, 2024).

The WID was inspired by the pioneering studies of Thomas Piketty in 2001 and 2003, as well as Piketty and Emmanuel Saez's 2003 research, which analyzed long-term income trends in France and the United States. The database offers different types of distribution data, including pretax income, post-tax income, and wealth, with income share data presented by percentiles (P0 to P100). For example, a top 1% share of 20% is represented as 0.2 (WID.WORLD, 2024).

The user-friendly design of the WID allows users to customize datasets according to specific needs. Through the menu bar, users can select indicators, such as post-tax national income share, and customize variable types (Share, Threshold, or Average Income), population (Equal-split Adults or Individuals), currency, and age group (WID.WORLD, 2024).

Another dataset, unemployment rate dataset originates from the World Bank, a leading global provider of funding and knowledge for developing nations (The World Bank Group, 2024). This organization offers an extensive range of databases, including the unemployment rate dataset, which is modelled based on estimates from the International Labor Organization (The World Bank Group, 2024).

The study utilizes post-tax national income shares from 1980 to 2022 for 38 OECD countries. Post-tax national income represents the total income available to households or individuals after taxes. The dataset divides each country's income data into vigintiles (5% segments) for each year, resulting in 20 data points per country annually. The reason for choosing vigintile is that it allows for a more granular examination of income distribution of the very rich or the very poor groups. Income share is calculated per individual aged 20 years and older, equally distributed among household members. All income shares were standardized to 2023 US Dollars using Purchasing Power Parity (PPP) for cross-country consistency.

The income share dataset has no missing data points, while some gaps in the unemployment rate dataset were addressed by imputing the mean values for each respective country. The constructed income dataset comprises 32680 rows and 5 columns. The variables included are Vigintile, Year, Country, Geographical Region, and Post-Tax National Income. To facilitate the grouping of countries according to their respective geographical regions, the Geographical Region variable was created, grouping 38 OECD member countries into 5 groups: American countries,

Central/Northern European countries, Southern/Eastern European countries, Asia Pacific/Middle East countries, and Western European countries.

4.2 Exploratory Data Analysis

Table (1) Summary Statistics of Income Share

Min	1st Qu	Median	Mean	3rd Qu	Max
0.0000	0.0271	0.0409	0.0500	0.0561	0.5199

The summary statistics of income shares across all 38 OECD countries and years indicate significant income inequality, with a highly skewed distribution. The minimum income share of 0% suggests that some vigintiles have negligible income in certain cases. The first quartile (2.71%) and median (4.09%) show that most data points are concentrated in lower income shares. The mean income share of 5% is slightly higher than the median, reflecting a right-skewed distribution where a few higher income shares raise the average. The maximum value of 51.99% highlights instances of extreme income concentration, where a single vigintile controls more than half of the total income **(Table 1).**

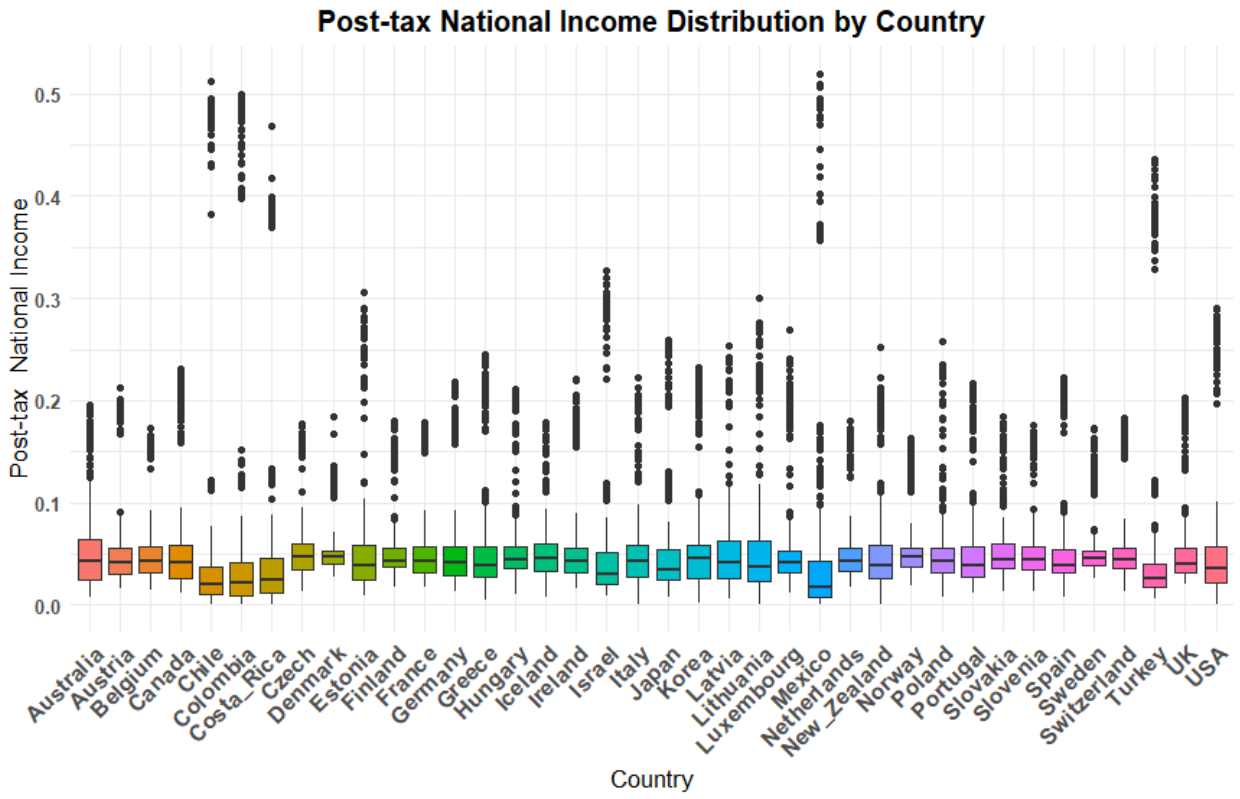


Figure (3) Box plot of Post-tax National Income Distribution across all years (1980-2022)

Chile demonstrates the highest income inequality, with a maximum income share of 51.25% and a minimum of 0%, indicating extreme concentration among a few groups. Colombia and Costa Rica also exhibit significant inequality, with maximum shares nearing 50%. In contrast, Denmark, the Czech Republic, Finland, and France show more equitable distributions, with maximum shares generally below 25% and narrower interquartile ranges. Israel and Mexico reveal substantial income concentration, with maximum shares of 32.64% and 51.99%, respectively, while Turkey also exhibits high inequality with a maximum of 43.57%. Conversely, the Netherlands, New Zealand, and Norway display more moderate distributions, with maximum shares under 25%. Overall, while some OECD countries exhibit severe income concentration, many maintain

relatively balanced distributions, though Turkey and Mexico indicate higher levels of disparity **(Figure 3) and (Appendix 1)**.

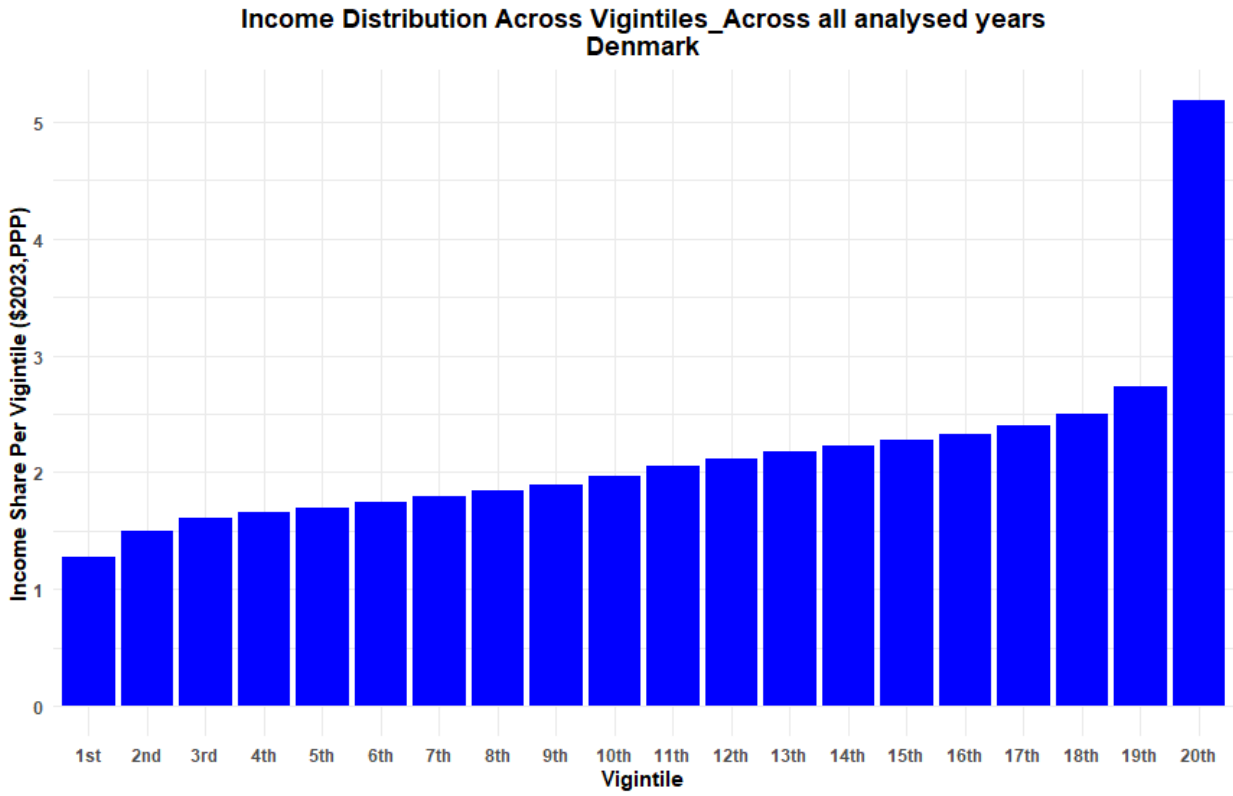


Figure (4) Income distribution across vigintiles (1980 to 2022) Denmark

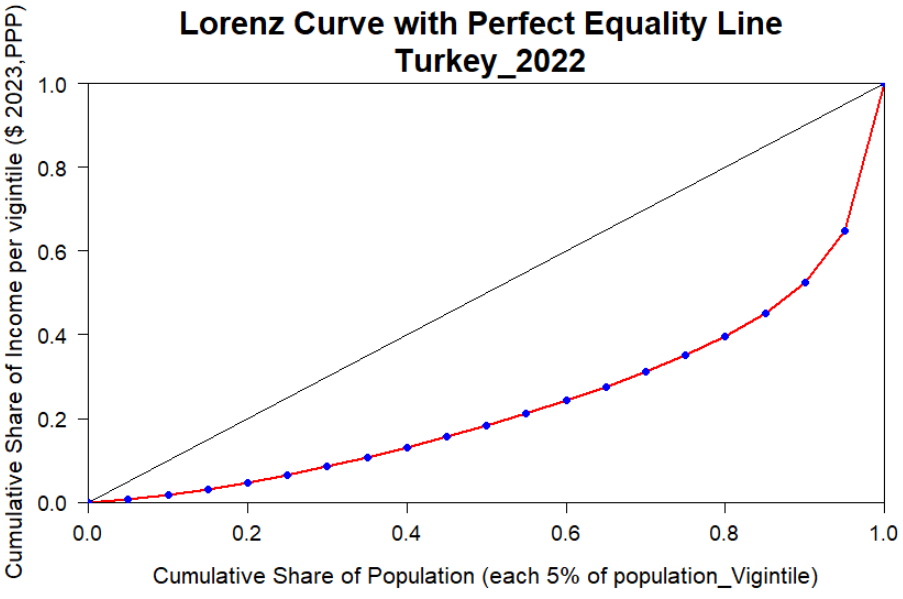
Exploring the income distribution across 20 vigintiles in Denmark from 1980 to 2022 reveals income inequality. In a scenario of perfectly equal income distribution, each vigintile, representing 5% of the population, would capture 5% of the total income annually. However, in Denmark, the bottom 5% of the population accumulated an income share of only 1.27 over the entire 42-year period, while the top 5% (20th vigintile) captured 5.18 of the total income shares. This translates to an average annual income share of approximately 3.02% for the bottom 5%, in contrast to 12.3% for the top 5% **(Figure 4).**

4.3 Data Analysis

4.3.1 Lorenz Curve

The Lorenz curve shows how income is distributed. It plots the cumulative share of income earned by different segments of the population. A curve farther from a straight line indicates more inequality.

To understand the general trend of income disparity across 5 geographical groups of 38 OECD countries, Lorenz curves of 20-years intervals and 2022 are visualized. The graph **(Figure 5)** is the Lorenz Curve with equality line of Turkey in 2022. The x-axis is denoted as the cumulative share of population (each 5% of population=Vigintile). The y-axis is denoted as the cumulative share of income per vigintile. The share of income is in the unit of Dollar $ (2023).



In the graph, the Lorenz curve is denoted as a red solid line with blue data points. The line of equality is demonstrated by a 45-degree, upward-sloping line, which is a black solid line in the graph **(Figure 5).**

Figure (5) Lorenz Curve of Turkey_2022

Table (2) %of population and % of income_2022

Population	Turkey_Income(%)	Canada_Income(%)	Mexico_Income(%)	Lithuania_Income(%)
5	0.79	1.1	0	0.22
10	1.72	2.5	0	0.57
15	3.04	4.1	0.009	0.93
20	4.72	6.1	0.42	1.37
25	6.56	8.2	1.09	1.88
30	8.6	10.8	1.96	2.5
35	10.8	13.7	3	3.6
40	13.1	16.9	4.2	5.5
45	15.6	20.5	5.7	7.9
50	18.3	24.5	7.3	10.8
55	21.1	28.7	9.2	14.2
60	24.2	33.4	11.3	18.1
65	27.6	38.4	13.8	22.6
70	31.2	43.8	16.7	27.9
75	35.2	49.7	20.1	34
80	39.7	56.2	24.4	41.1
85	45	63.3	29.9	49.5
90	52.6	71.3	37.6	59.6
95	64.8	80.8	49.4	72.4
100	100	100	100	100

The curve of Turkey bows below the line of perfect equality, reveals that the share of income is not equally distributed across the population **(Figure 5).** With the bottom 50% of the population holds only 18.3% of the total income share, while the top 10% of the population holds 51.6 % of the total income share **(Table 2),** it was the highest income inequality country among Asia Pacific and Middle East OECD countries over the study period. The other countries: Australia, Israel, Japan, Korea and New Zealand show lower levels of income inequality compared to Turkey. In 2000, New Zealand displays the lowest income inequality in the group, while the Lorenz curves of Japan and Israel moved further from the equality line compared to those of 1980, indicating that income distribution become unequal over time in these countries **(Figure 6).**

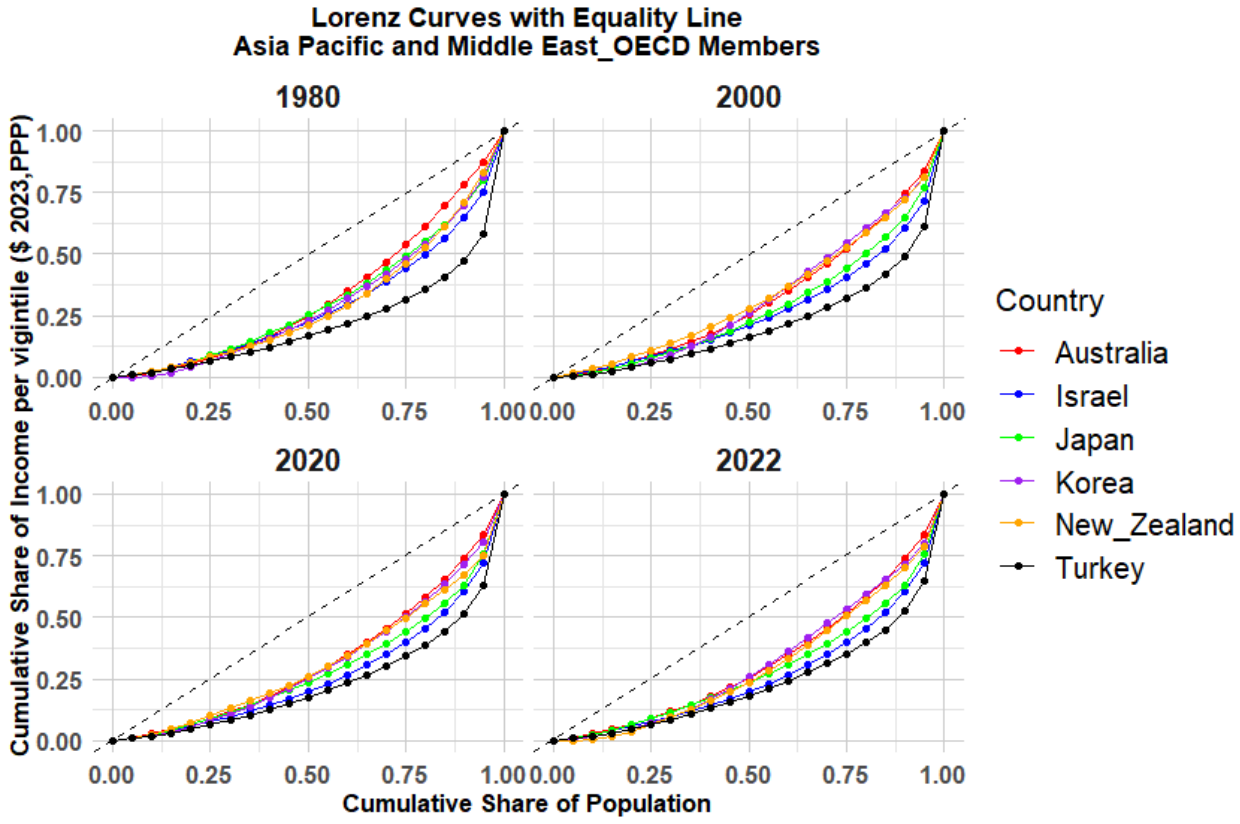


Figure (6) Lorenz Curve Asia Pacific / Middle East_ OECD (1980,2000,2020,2022)

When analyzing income inequality among American countries of OECD members, the Lorenz curves for all nations demonstrate significant deviation from the line of perfect equality, indicating substantial income inequality. Among these countries, the USA and Canada exhibit relatively lower inequality, showing through their Lorenz curves were closer to the perfect equality line compared to Chile, Colombia, Costa Rica, and Mexico throughout the different four years: 1980, 2000,2020 and 2022 **(Figure 7).**

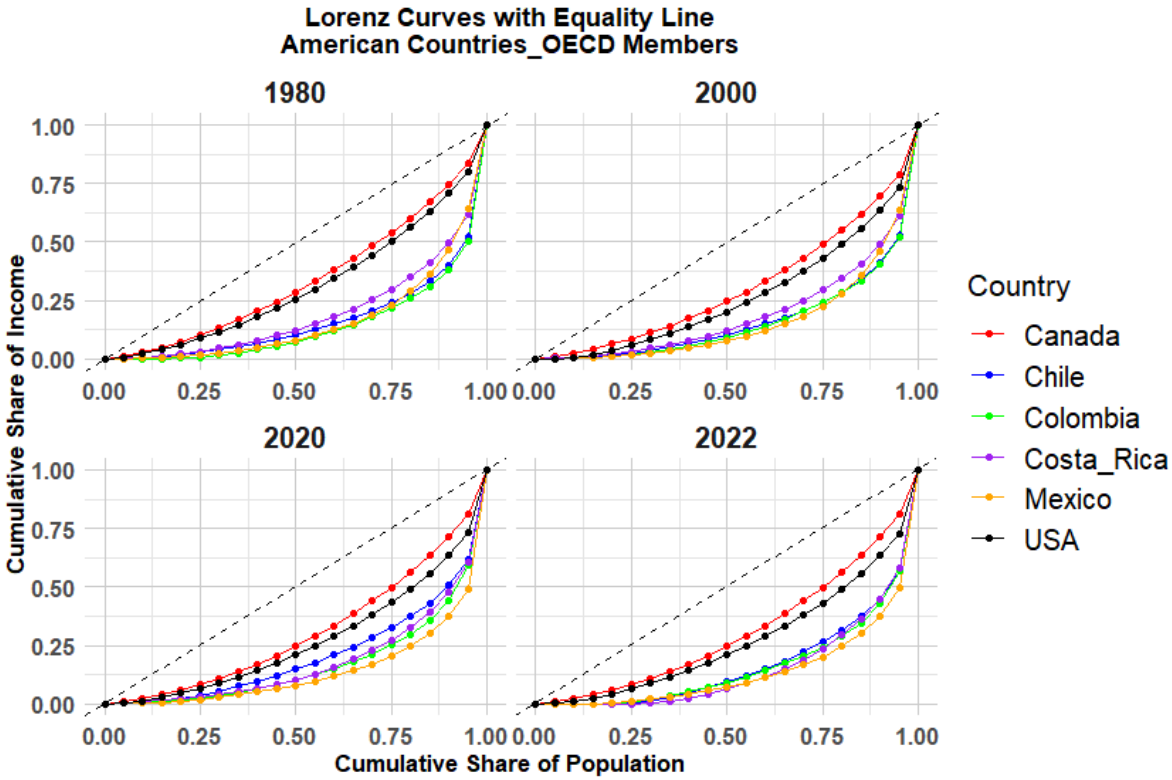


Figure (7) Lorenz Curve_ American Countries_ OECD (1980,2000,2020,2022)

Canada consistently shows the lowest income inequality along different years. In 2022, its bottom 50% of the population owned 24.5% of total income while Mexico's bottom 50% of the population held only 7.3% of total income share **(Table 2).** Chile experienced a sharp reduction in income inequality from 2000 to 2020 by indicating its Lorenz curve was

closer to the perfect equality line. However, by 2022, its inequality rose again, aligning with the levels of Costa Rica and Colombia, which displayed higher income inequality throughout the entire period. In 2022, bottom 50% of Colombia's population owned only 9.1 % of the total income share, and in Costa Rica, bottom 50% held a mere 6.2%. The relative positioning of these countries in terms of income inequality has remained largely consistent, with Canada and the USA generally showing lower levels of inequality compared to their regional counterparts: Colombia, Mexico, Chile, and Costa Rica **(Figure 7).**

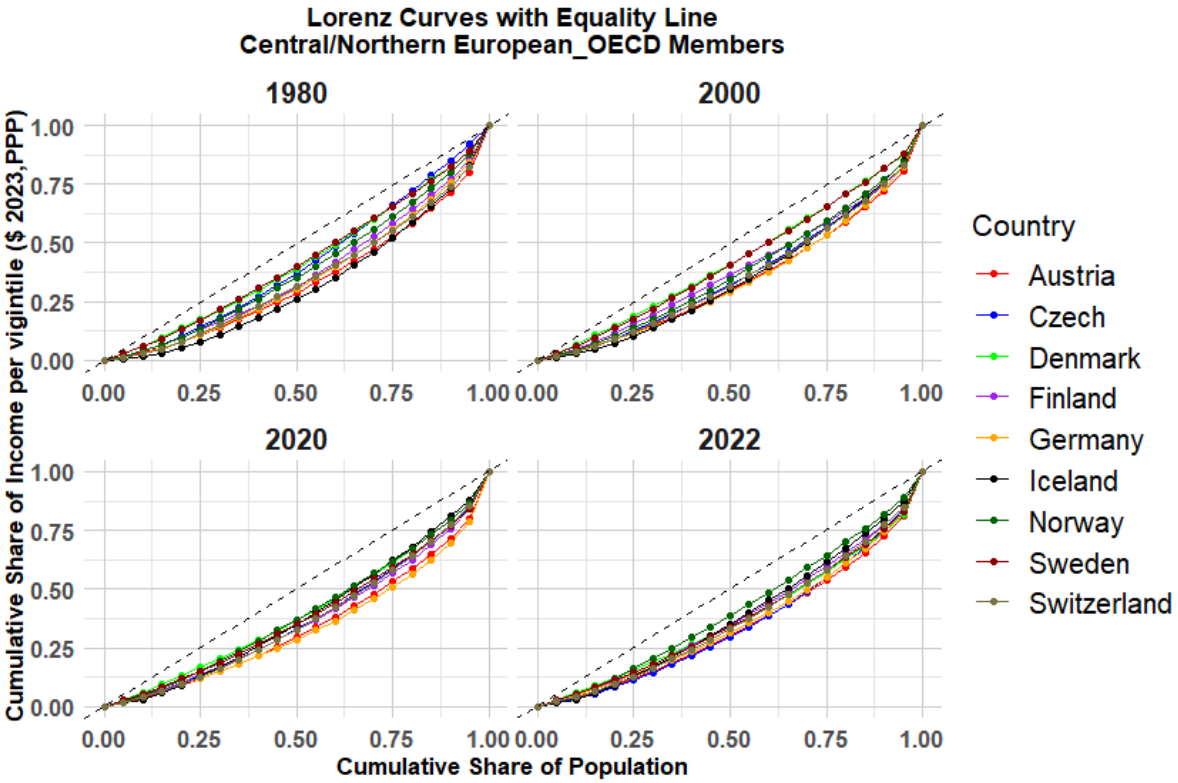


Figure (8) Lorenz Curve Central/Northern European_ OECD (1980,2000,2020,2022)

In Central and Northern European OECD countries, income inequality along twenty-year intervals period shows just slight deviation from the line of perfect equality, with no single

country appears to significantly deviate from the others in terms of income distribution, suggesting that income inequality was quite low in these nine nations. In 2020 and 2022, the curves slightly more bowed than in previous decades, indicating a minor increase in income inequality. Nevertheless, the curves remain close to the equality line, demonstrating that income inequality in these countries is still low **(Figure 8).**

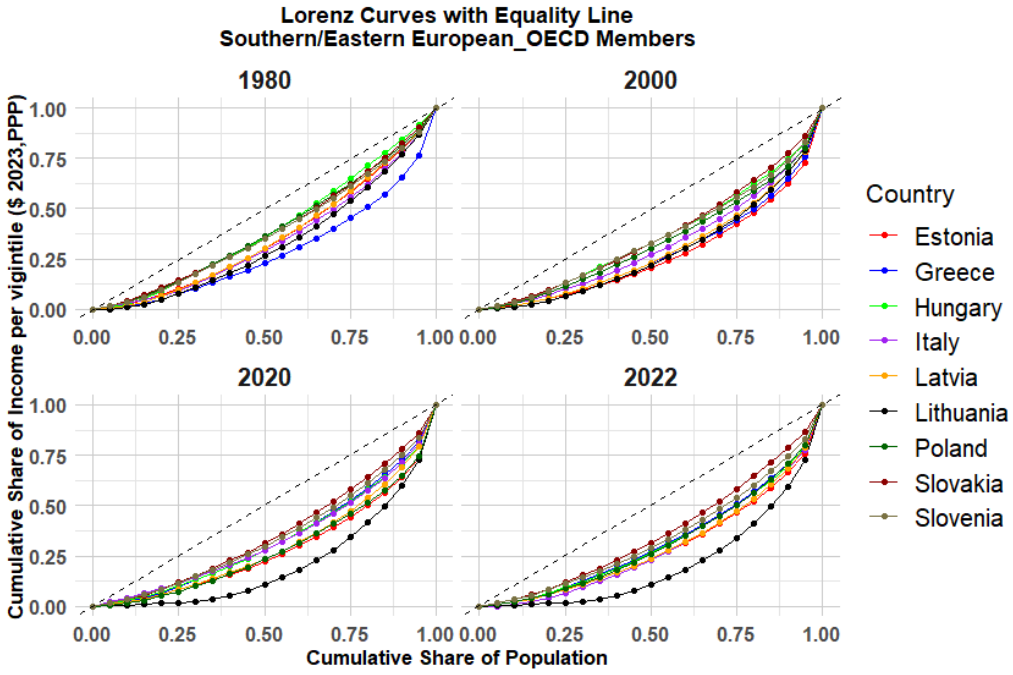


Figure (9) Lorenz Curve Southern/Eastern European_ OECD (1980,2000,2020,2022)

In 1980, the income inequality in Greece was the highest among Southern and Eastern European countries. However, its income inequality gradually went down while the income inequality in Lithuania rose along the period. The Lorenz curves of 2000,2020 and 2022 show a slight increase in inequality compared to 1980. In 2000, Estonia exhibited the highest income inequality, while countries like Slovakia, Hungary and Slovenia were closer to the equality line, indicating lower inequality among the nations.

In 2020 and 2022, the curve of Lithuania become significantly more bowed, signaling an increase in income inequality **(Figure 9).** The bottom 50% in Lithuania held only 10.8% of total income while its top 10% owned 40.4 % of total income in 2022 **(Table 2).**

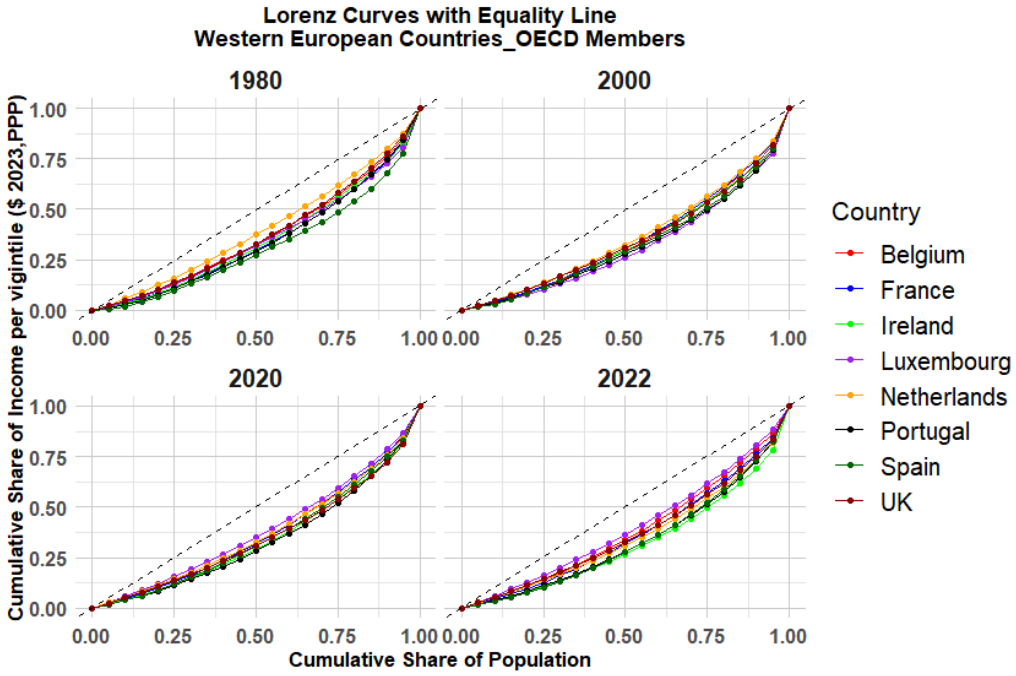


Figure (10) Lorenz Curve Western European_ OECD (1980,2000,2020,2022)

In Western European countries of OECD members, the Lorenz curves for most countries moved slightly away from the line of equality, indicating a small increase in income inequality from 1980 to 2000. Netherlands had the lowest income inequality among countries in two years (1980 and 2000), while Luxembourg has become the lowest income inequality countries in the years of 2020 and 2022. Netherlands' Lorenz curve in 1980 was closer to the perfect equality line compared to that of 2000, which indicates that even though the country stays stabled as the lowest income inequality country among the group, the unequal distribution of income has risen within the country. In 1980, Spain was

the country which had the highest income inequality among peers, and after four decades, in 2022, Ireland has become the country which has the highest income inequality, showing its Lorenz curve was the farthest from the line of equality **(Figure 10).**

Overall, Colombia had the highest inequality in 1980 and 1997, while Mexico and Chile led in 2000. By 2020 and 2022, Mexico became the most unequal. Conversely, Sweden, Denmark, and Norway consistently exhibited the lowest inequality. The most unequal countries were largely in the Americas, while the least unequal were in Central and Northern Europe. To gain granular insights, time series plots of the Gini Coefficient for all 38 OECD countries from (1980 to 2022) were created.

4.3.2 Gini Coefficient

The Gini coefficient measures income inequality on a scale from 0 (perfect equality) to 1 (complete inequality). Higher values mean more inequality.

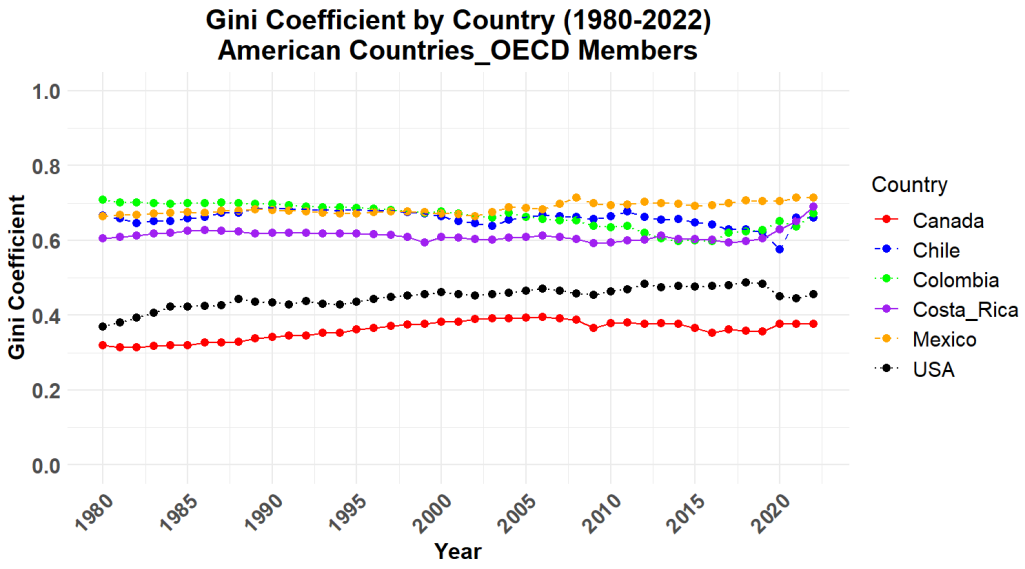


Figure (11) Gini Coefficient_ American Countries_ OECD Members (1980-2022)

The above plot **(Figure 11)** illustrates time series of Gini coefficient across American OECD countries from 1980 to 2022. The x-axis is denoted as the years of observation and the y-axis is denoted as the values of Gini coefficient. Colombia has consistently exhibited high income inequality from 1980 to 1997, with its Gini coefficient fluctuating between 0.69 and 0.71. Although Colombia experienced a temporary slight reduction in inequality (ranging from 0.60 to 0.62) from 2012 to 2016, its Gini coefficient climbed back to 0.67 by 2022. Costa Rica also exhibits consistently high Gini coefficient around 0.61 for four decades, and it saw a recent surge to 0.68 from 2020 to 2022. Similarly, Chile's Gini coefficient, which ranged from 0.62 to 0.68, briefly dropped to 0.57 in 2020 before reverting to higher levels. Mexico, meanwhile, saw a gradual increase in its Gini coefficient, starting from 0.66 to 0.68 between 1980 and 2002, and reaching 0.71 by 2022, marking it as the country with the highest inequality among the six. In contrast, the USA and Canada demonstrate lower levels of income inequality compared to other countries in the region, albeit with different trajectories. The USA's Gini coefficient rose from 0.36 in 1980 to 0.48 in 2019, reflecting growing inequality, though it slightly decreased to between 0.44 and 0.45 from 2020 to 2022. Canada's Gini coefficient also rose from 0.31 in 1980 to 0.38 in 2008, after which it stabilized around 0.36, with a value of 0.37 in 2022 **(Figure 11).**

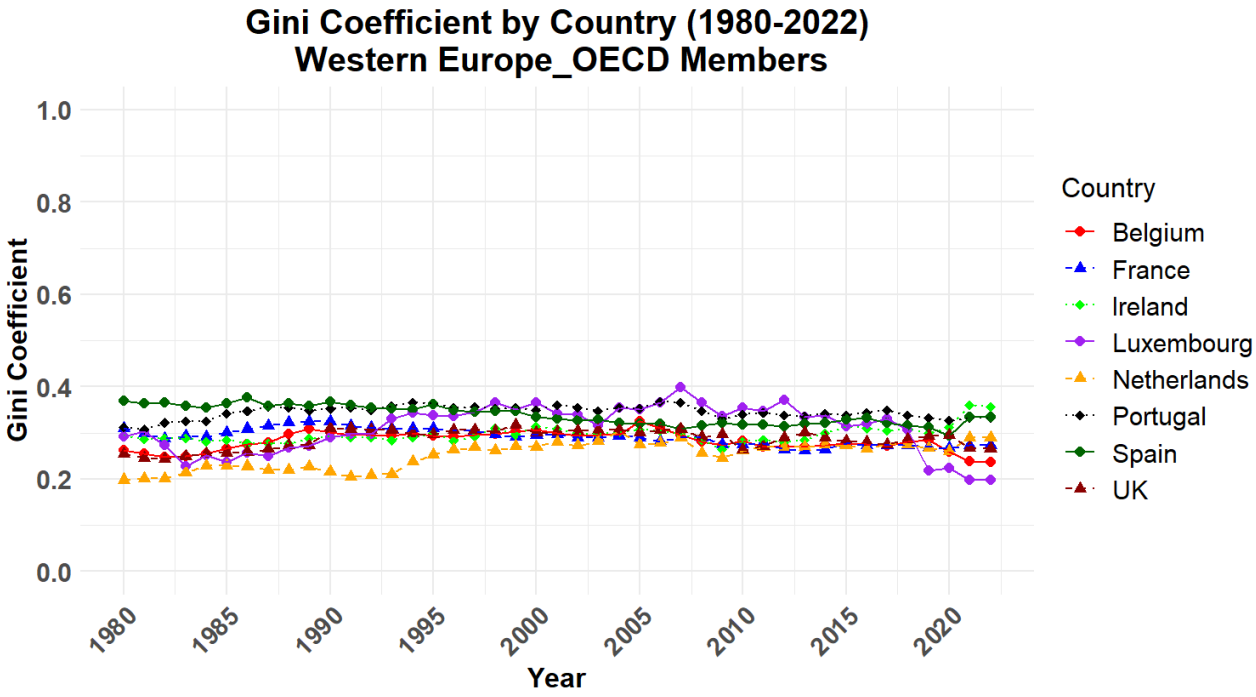


Figure (12) Gini Coefficient_ Western Europe_ OECD Members (1980-2022)

In Western European countries, the Gini coefficients for all countries range between 0.2 and 0.4. From 1980 to 1993, Spain exhibited the highest Gini coefficient among the countries. In contrast, the Netherlands maintained the lowest Gini coefficient, fluctuating between the range from 0.2 to 0.3, until 2009. Notably, in 2007, Luxembourg had the highest Gini coefficient among the group with the Gini coefficient of 0.39, but starting from 2019, it has become the country with the lowest Gini coefficient, around 0.2. Belgium, France, Portugal, and the UK fall in the intermediate range among Western European countries of OECD members, with Gini coefficients fluctuating around 0.3. Although Ireland fell in between two extremes from 1980 to 2020, it became the highest income inequality country in the most recent years (2021 and 2022), with a Gini value of 0.36 **(Figure 12).**

From 1999 to 2020, Germany had the highest Gini coefficient among Central and Northern European countries, ranging from 0.31 to 0.36, indicating elevated income inequality. Before this period, Iceland held the highest inequality from 1980 to 1997, with Gini values between 0.32 and 0.36. In contrast, Denmark and Sweden consistently had the lowest Gini coefficients, with Sweden's slightly higher after 1994, yet still among the lowest in the region. Finland, Switzerland, and Norway also maintained low and stable Gini coefficients, fluctuating between 0.2 and 0.3, reflecting sustained low-income inequality **(Figure 13).**

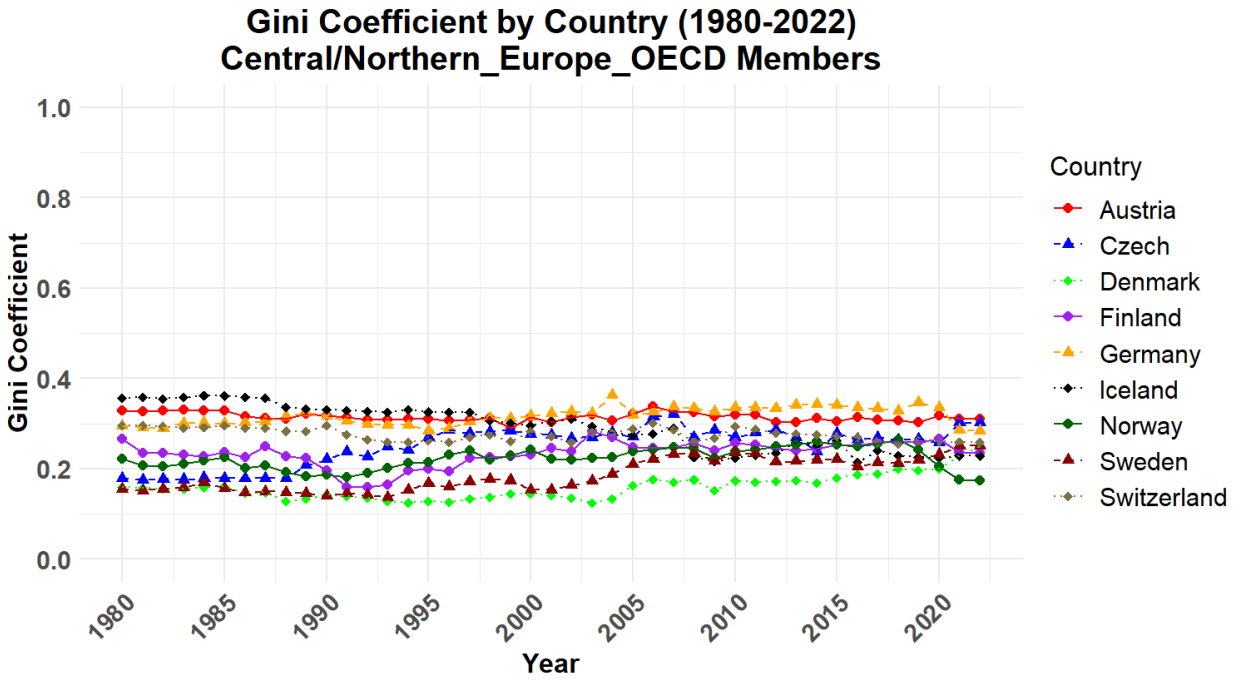


Figure (13) Gini Coefficient_ Central / Northern Europe_ OECD (1980-2022)

Austria's Gini coefficient remained between 0.29 and 0.33, making it the second highest in inequality within this group, though still lower than Germany and Iceland at their peaks. By 2022, Iceland had shifted to having the second-lowest Gini coefficient, marking a

significant change from its earlier status. Meanwhile, the Czech Republic saw a notable increase in income inequality, with its Gini coefficient rising from around 0.20 in the 1980s to 0.28 by 1999 **(Figure 13).**

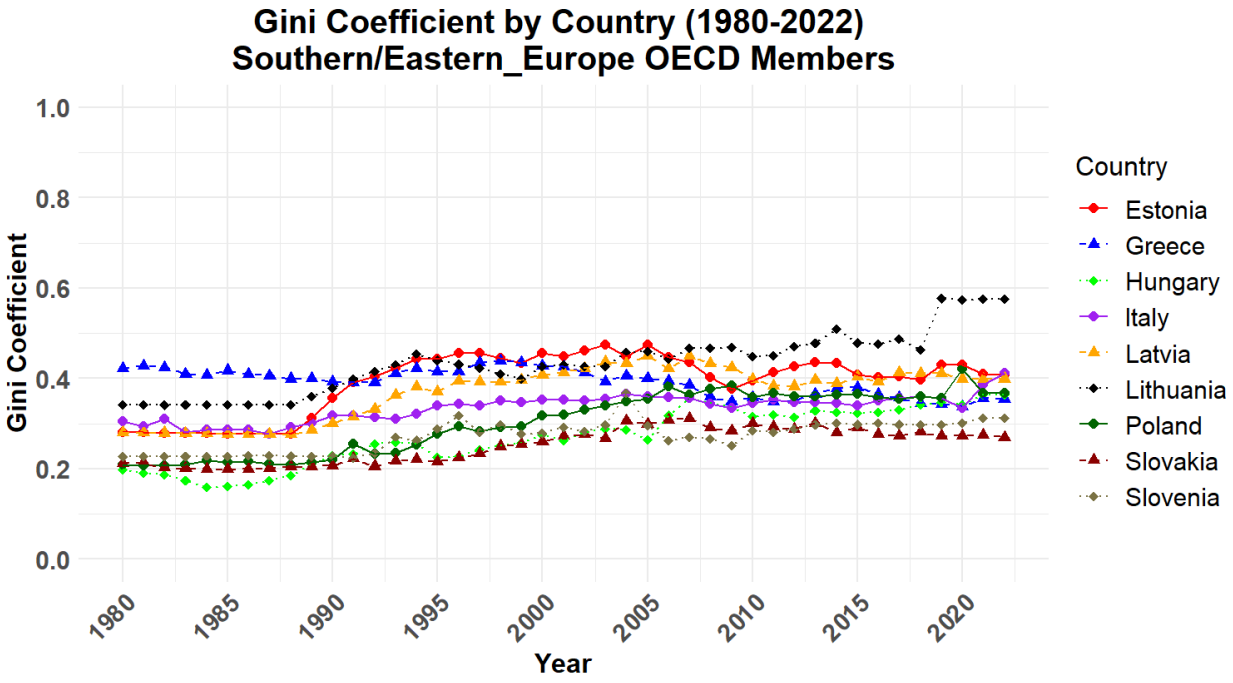


Figure (14) Gini Coefficient_ Southern and Eastern European_ OECD (1980-2022)

In Southern and Eastern Europe, Estonia showed the highest Gini coefficients from 1996 to 2005, with values between 0.43 and 0.47. Greece initially had the highest inequality from 1980 to 1990, but its Gini coefficient gradually declined to 0.35 by 2022. Conversely, Lithuania's Gini coefficient sharply increased from 1990 onwards, reaching 0.57 by 2022, making it the most unequal among its peers. Latvia also experienced rising inequality during this period. Hungary had the lowest Gini coefficient from 1980 to 1988, ranging from 0.16 to 0.20, but Slovakia took over this position from 2014 onwards, showing the lowest income disparities. Slovenia's Gini coefficient fluctuated until stabilizing between

0.30 and 0.31 from 2014 to 2022. Poland and Hungary showed increasing inequality trends, while Italy maintained relatively stable inequality until 2020, followed by a sharp rise in its Gini coefficient to 0.41 by 2022 **(Figure 14).**

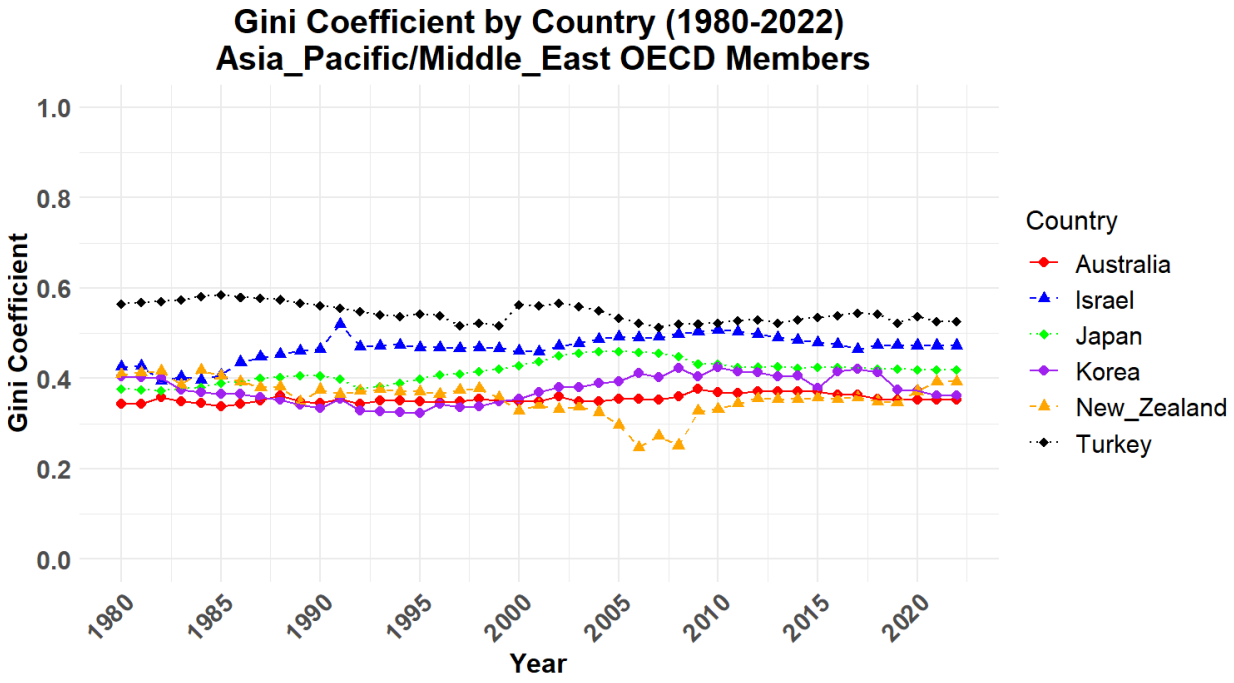


Figure (15) Gini Coefficient_ Asia Pacific and Middle East_ OECD (1980-2022)

Among the OECD countries from Asia Pacific and Middle East, the Gini coefficient of Turkey is the highest with the range of the Gini coefficient from 0.51 to 0.56, indicating that the country has the highest income inequality compared to its counterparts. Israel follows as the second highest of income inequality with the Gini coefficient of 0.39 to 0.52, with a peak in the early 1990s and maintaining relatively high levels throughout the period compared with the other countries in the group. Conversely, Australia shows the most stable and lowest Gini values in the group, ranging from 0.34 to 0.38. Japan has the third-highest Gini coefficients, while Korea and New Zealand exhibit similar trends with

moderate Gini coefficients that fluctuate slightly but generally remain in the middle range of Asia Pacific and Middle East countries. Notably, New Zealand's Gini coefficient drops sharply in the early 2000s but quickly returns to levels comparable to Australia's **(Figure 15).**

Overall based on the times series of Gini coefficient, income inequality varies significantly across regions. American countries show stark contrasts, with Canada and the USA exhibiting lower Gini coefficients, while Colombia, Mexico, Costa Rica, and Chile experience much higher inequality. In Western Europe, Gini coefficients are generally low, with the Netherlands and Luxembourg showing the least inequality, although Luxembourg had fluctuations. Central and Northern Europe display diverse trends, with rising inequality in Germany and the Czech Republic, while Denmark and Sweden maintain lower levels. Southern and Eastern Europe show increasing inequality in countries like Lithuania and Latvia, though Greece has seen a decrease. In the Asia Pacific and Middle East, Turkey has the highest inequality, while Australia demonstrates the lowest and most stable levels. Among all 38 OECD countries, Colombia has consistently exhibited the highest income inequality, holding this position from 1980 to 1997. Starting in 2003, Mexico took the lead in income inequality. During this period, Denmark and Sweden were noted for having the lowest levels of income inequality.

In 2022, 24 of the 38 OECD countries reported income inequality below the OECD average of 0.36, while 14 countries reported levels exceeding this average. Specifically, all six American OECD countries were above the average. In contrast, all OECD countries from Western Europe, as well as Central and Northern Europe, were below the OECD

average. Among Southern and Eastern European countries, Greece, Hungary, Slovakia, Poland and Slovenia fell below the average, whereas the remaining four were above it. In the Asia-Pacific and Middle East regions, only Australia and Korea reported income inequality below the average, with the other four countries exceeding it **(Figure 16).**

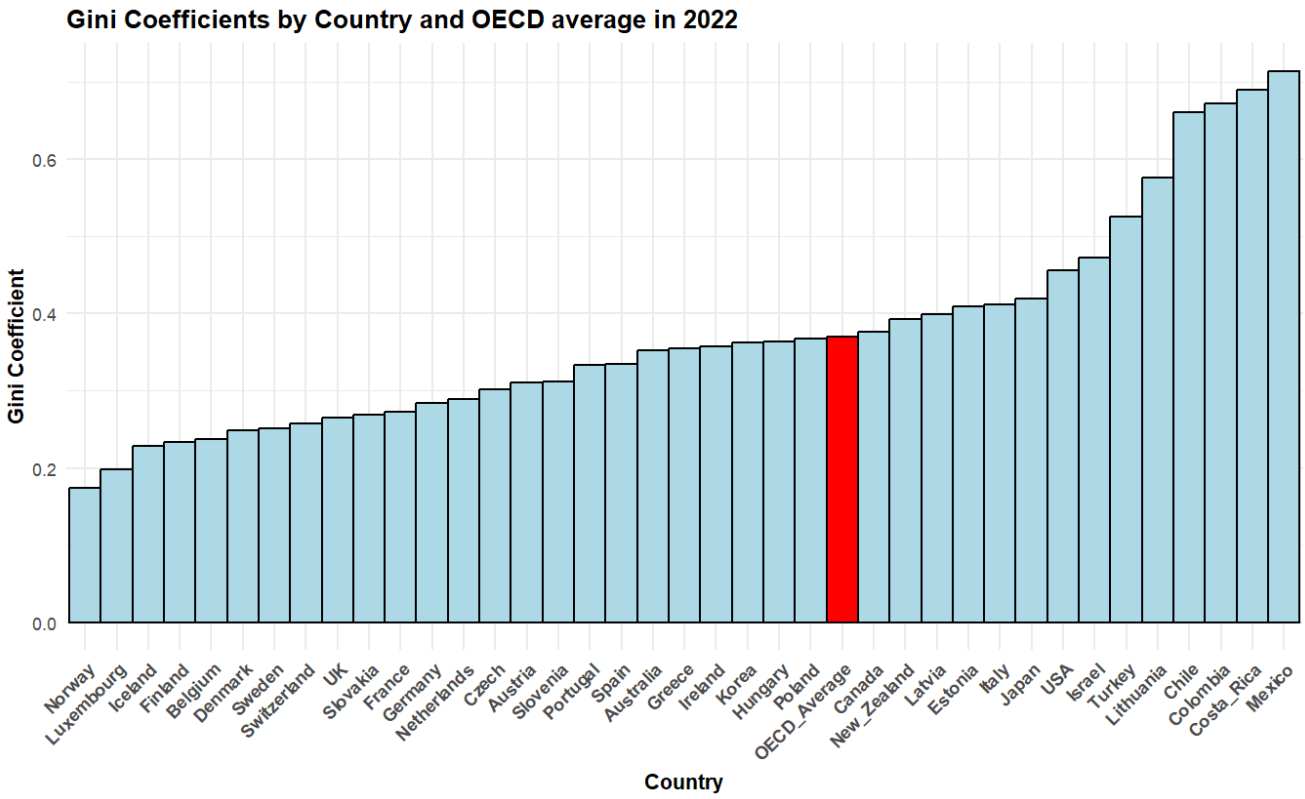


Figure (16) Gini Coefficients by Country and OECD average in 2022

Based on historical Gini coefficient trends, ten OECD countries were selected: five countries with high Gini coefficients, two with moderate income inequality, and three with low Gini coefficients. The goal is to examine and compare the difference in the percentage of total income that would need to be redistributed among population to achieve perfect equality. Therefore, the inequality measurement called Hoover Index is applied as follows.

4.3.3 Hoover Index

The Hoover Index shows how much income needs to be redistributed to make everyone's income equal. Higher values mean more inequality.

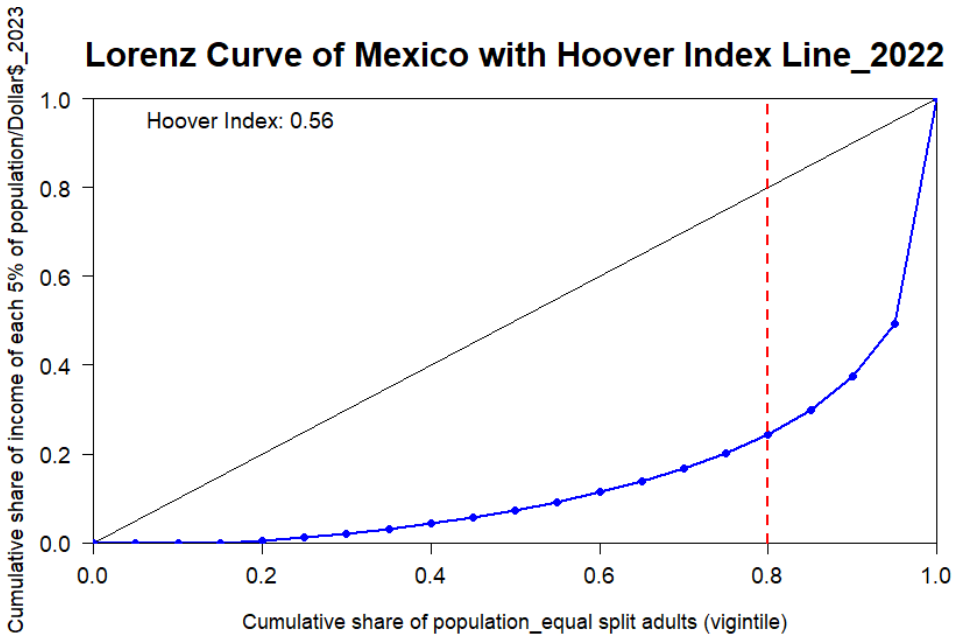


Figure (17) Lorenz Curve with Hoover Index Line (Mexico_2022)

The **(Figure 17)** shows Mexico's Lorenz curve for 2022 with the Hoover Index line. The Lorenz curve, depicted in blue, represents the cumulative income share held by the population, from poorest to richest. The red dashed line indicates the Hoover Index, which measures the amount of income redistribution needed for equality. With a Hoover Index of 0.56, the bottom 80% of the population held 24.4% of the total income, while the top 20% held 76%. In other words, the income share of the top 20% was over three times greater than that of the bottom 80% **(Figure 17).**

Along the entire period, from 52% to 57% of total income is needed to be reallocated from the richest to the poorest in Mexico, while only from 8% to 18% of total income would have to be redistributed among the society to achieve perfect equality in Denmark and Sweden. In Costa Rica, the income inequality stabled at the higher level with a range of Hoover Index from (0.44 to 0.51) along the period before it slightly increased starting from 2020 onwards. Chile and Colombia also display higher level of income inequality with a range of Hoover index from 0.43 to 0.55 **(Figure 18)**. In USA, 26% to 35% of total income needs to be reallocated among the population to gain perfect equal income society throughout the observed periods, which was found mostly at 13th vigintile. Notably, although Denmark and Sweden have consistently maintained the lowest levels of income inequality among OECD countries throughout the study period, their within-country income inequality began to increase from 2005, reaching a Hoover Index of 0.18 by 2022, compared to approximately 0.10 in 1980, the starting year of the study **(Figure 18)**.

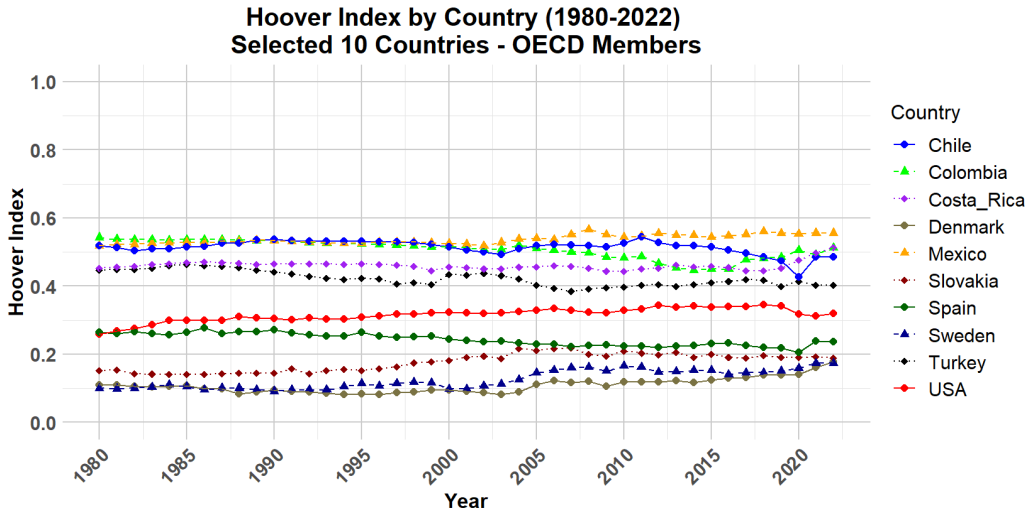


Figure (18) Hoover Index_ Selected 10 Countries_ OECD members (1980-2022)

4.3.4 Time Series of Gini and Hoover Indexes

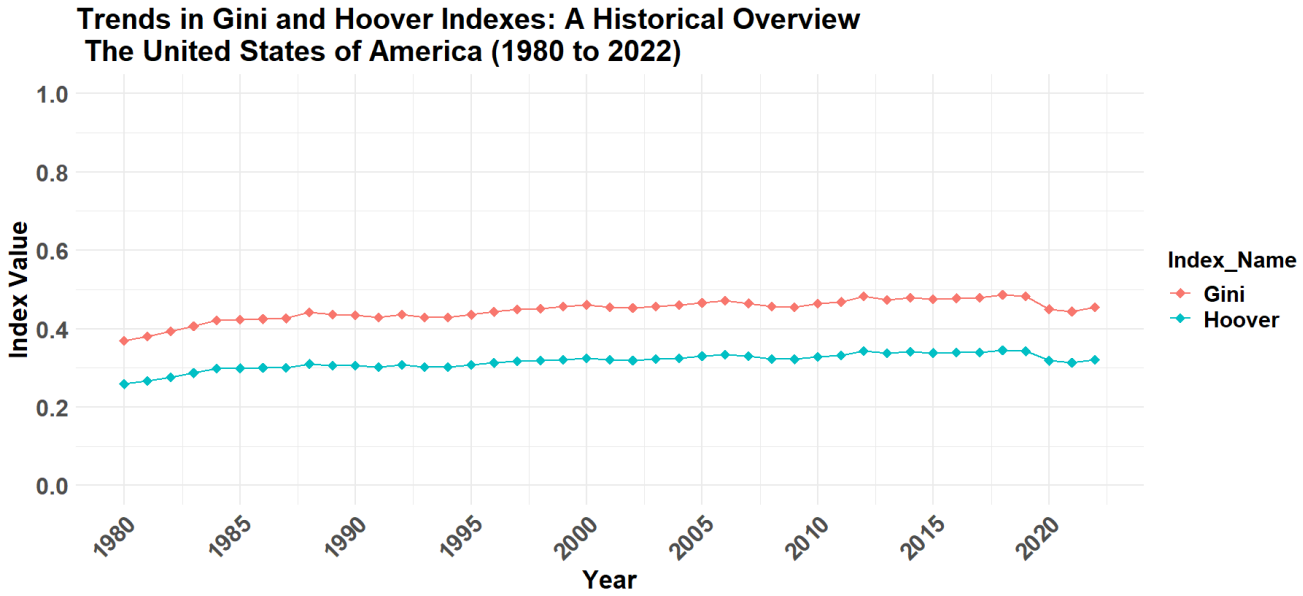


Figure (19) Time Series of Gini and Hoover Indexes (1980_2022) USA

The time series plot **(Figure 19)** depicting the Gini and Hoover indices for the United States mentioned above indicates that both indices exhibit consistent trends over the analyzed period (1980 to 2022).

This observation suggests **A Hypothesis I:** There is a positive correlation between the Hoover Index and the Gini Coefficient. Therefore, the statistical model is H = a + b*G. Based on the trend lines of both indices in **Figure (19)**, we infer that $H_t = G_t + a$ (where a is the (approximately constant) difference between G and H. This suggests that the gradient or slope (b) should be close to 1. To further investigate this hypothesis, the following session **(4.3.5)** was undertaken. Each data point on the graphs is a pair of $((G_t), (H_t))$ for a given year (t). The resulting data provides a comprehensive overview of the relationship between these indices across OECD member countries as follows.

4.3.5 Correlation between Gini Coefficient and Hoover Index

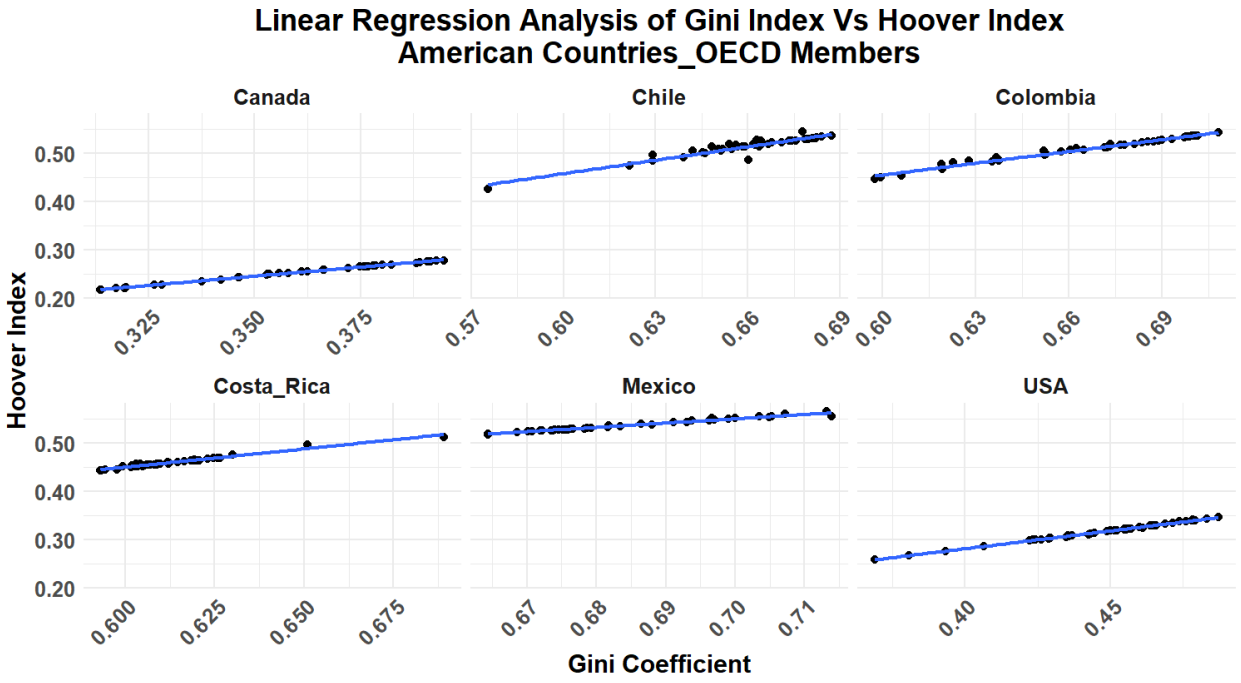


Figure (20) Regression Analysis of Gini and Hoover (American countries_ OECD)

The linear regression analysis of the relationship between the Gini coefficient and Hoover index in six OECD American countries reveals significant and robust correlations. Canada and the USA exhibit exceptionally strong fits, with adjusted R-squared values of 0.9975 and 0.9978, respectively, indicating that over 99.75% of the Hoover index variability is explained by the Gini coefficient. These countries also have the lowest residual standard errors, 0.0009466 for Canada and 0.000934 for the USA, indicating minimal deviation from the fitted values. Colombia, Costa Rica, and Mexico also show strong fits, with adjusted R-squared values of 0.9848, 0.9748, and 0.9744, respectively. Chile, while still showing a reliable correlation with an adjusted R-squared value of 0.8502, has a higher residual standard error (0.007981), indicating more variability in the residuals. Slope

coefficients are highest in Chile (0.9337) and lowest in the USA (0.7394). The P-value across all countries is less than 2e-16 (= 2×10^{-16}) **(Figure 20).**

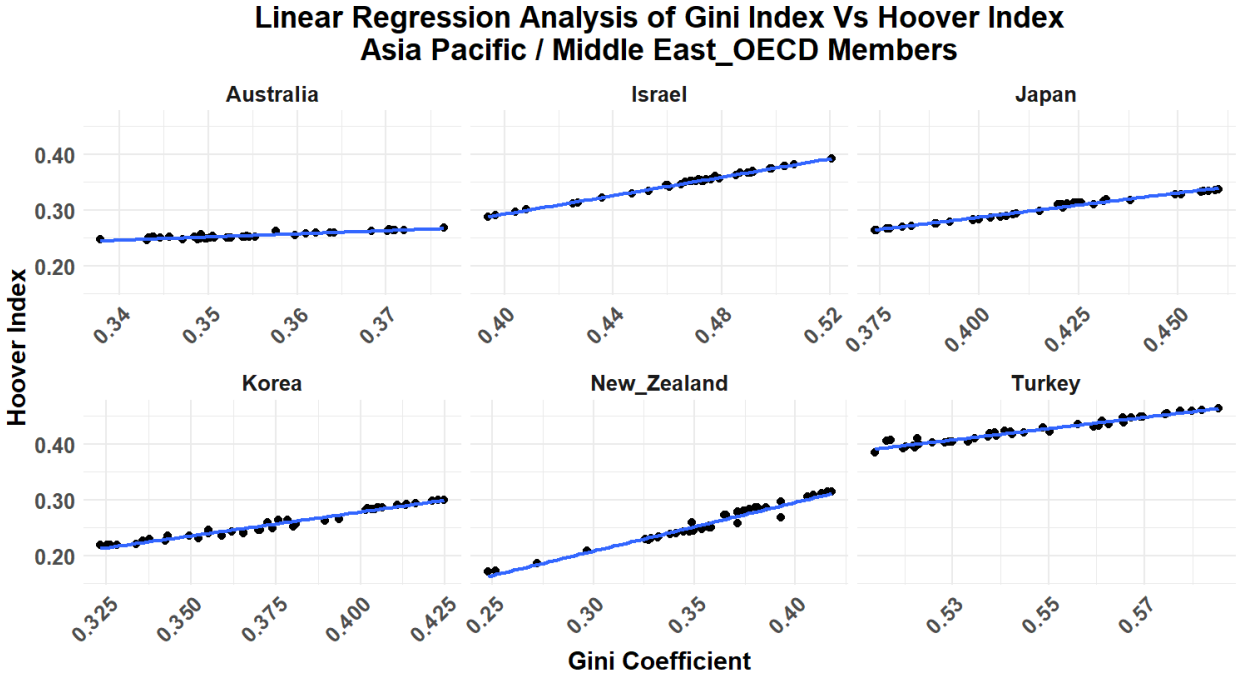


Figure (21) Regression Analysis of Gini and Hoover (AsiaPacific/MiddleEast OECD)

In the Asia Pacific and Middle East OECD countries, Israel shows the strongest fit between the Gini coefficient and Hoover index, with an adjusted R-squared of 0.9958, explaining 99.58% of the Hoover index variability. Japan (0.9771) and Korea (0.9678) also demonstrate high explanatory power, followed by Turkey (0.9554). New Zealand (0.9494) and Australia (0.8253) exhibit relatively lower, but still strong fits. Turkey's slope coefficient is the highest at 1.01, while Australia's is the lowest at 0.57, reflecting different correlation magnitudes. Israel and Japan have very low residual standard errors (0.0015 and 0.0033) and high F-statistics, reinforcing their strong model fits. Korea and New Zealand also show strong fits, though with slightly higher residual errors. Australia,

despite being statistically significant, has the lowest adjusted R-squared and slope coefficient, indicating a weaker correlation relative to other countries **(Figure 21).**

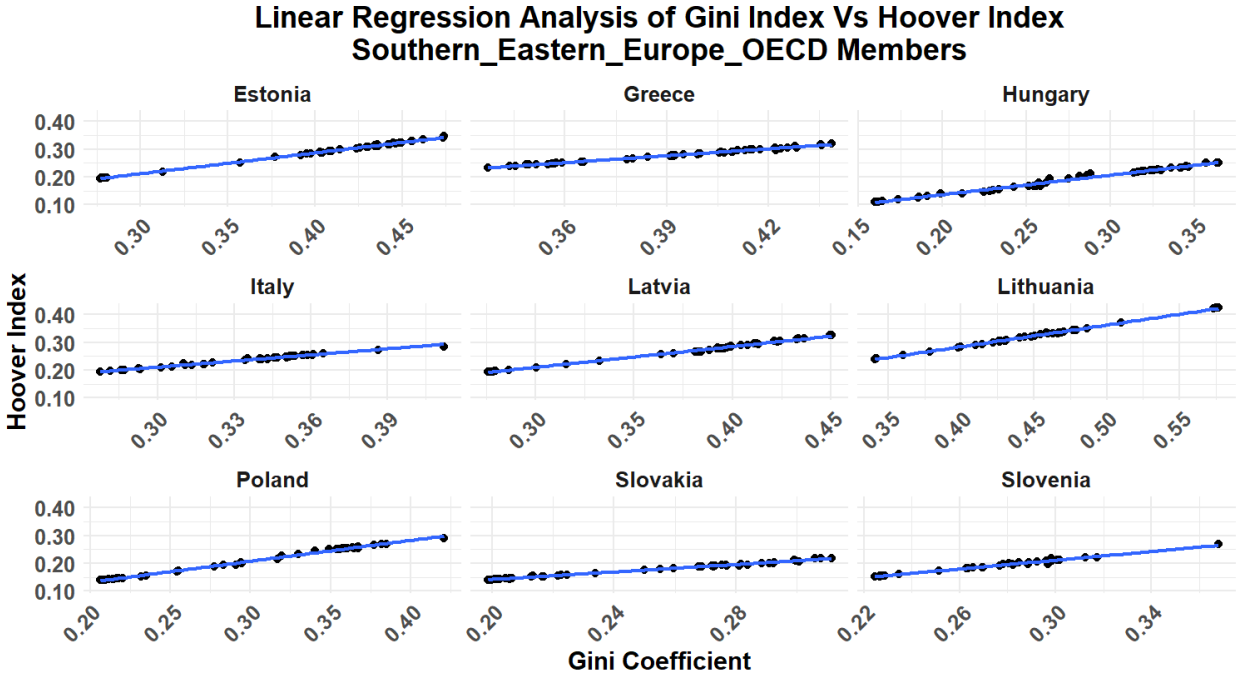


Figure (22) Regression Analysis of Gini and Hoover (Southern/Eastern Europe OECD)

In Southern and Eastern European countries, positive and highly significant slope coefficients indicate that as the Gini coefficient rises, so does the Hoover index, reflecting increased income redistribution. Greece (0.83) and Slovenia (0.79) have the highest slope coefficients, showing a strong impact of income inequality on redistribution, while Slovakia has the lowest (0.67), indicating a smaller increase in the Hoover index per unit increase in the Gini coefficient. The models exhibit excellent fit, with adjusted R-squared values exceptionally high in Lithuania and Estonia (0.9986) and Poland (0.9969), suggesting most Hoover index variability is explained by the Gini coefficient. Residual

standard errors are low, particularly in Estonia, Greece, Lithuania, and Slovakia, indicating minimal deviation from predicted values. Although Hungary, Poland, and Slovenia have slightly higher residual errors, the overall model performance remains strong, supported by high F-statistics and p-values below 2e-16 (= 2×10^{-16})**(Figure 22).**

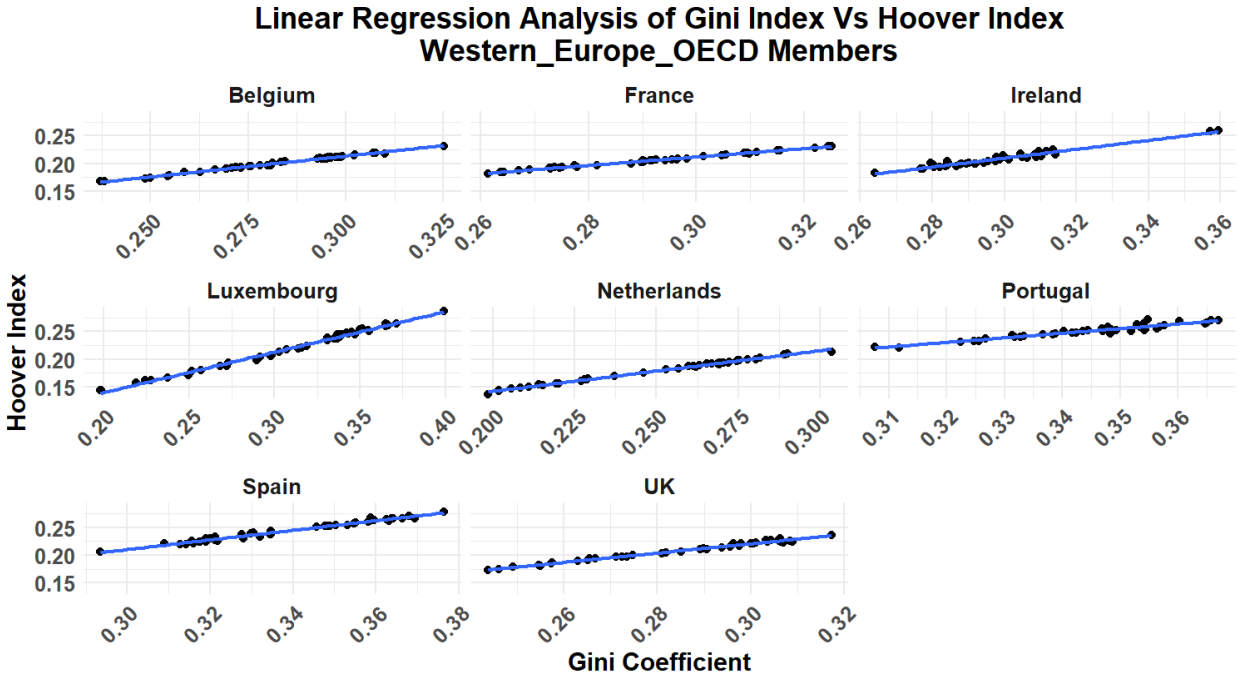


Figure (23) Regression Analysis of Gini and Hoover (Western Europe OECD)

In Western European OECD countries, the relationship between the Gini coefficient and the Hoover index is generally robust but varies in strength. France (0.9945) and the Netherlands (0.9959) exhibit extremely high explanatory power, with adjusted R-squared values indicating that over 99% of the Hoover index variability is explained by the Gini coefficient. These countries also show very low residual standard errors, reflecting minimal deviations from predicted values and strong F-statistics. Portugal has a lower adjusted R-squared of 0.9109 and a higher residual standard error of 0.0036, indicating

a less precise but still significant model. Ireland (0.9444) and Luxembourg (0.9925) also show strong fits, though slightly lower than France and the Netherlands. Spain (0.9781) and the UK (0.9855) have high explanatory power with minor deviations in residuals. Within the group, Luxembourg and the Netherlands demonstrated the lowest slope values, each at 0.73, indicating a more modest increase in the Hoover index relative to changes in the Gini coefficient. In contrast, Spain exhibited the highest slope value at 0.87, reflecting a stronger relationship between the two variables **(Figure 23).**

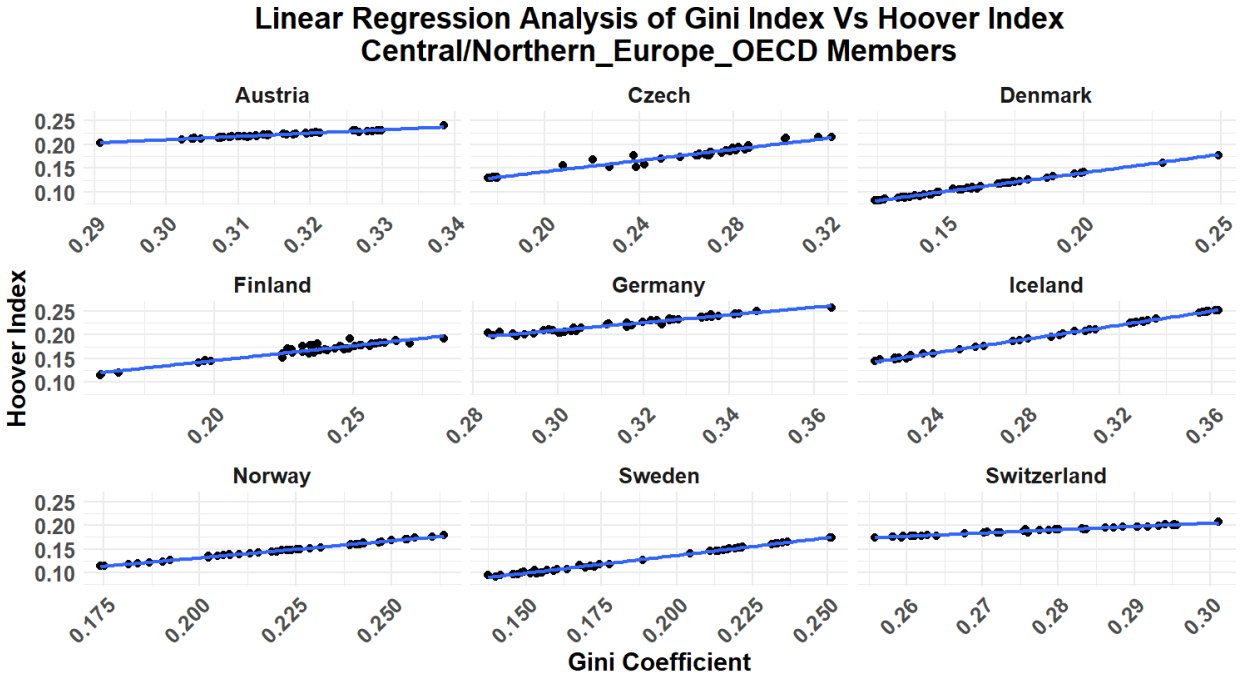


Figure (24) Regression Analysis of Gini and Hoover (Central/Northern Europe)

In Central and Northern European OECD countries, linear regression analyses reveal both commonalities and variations in the relationship between the Gini and Hoover indexes. All countries show a statistically significant positive relationship, indicating that higher income inequality correlates with increased redistribution. Germany exhibited the

highest slope value, with a coefficient of 0.80, while Czech showed the lowest slope value with a coefficient of 0.59. This indicates that for each 1-unit increase in the Gini coefficient, the Hoover index is expected to increase by approximately 0.80 units in Germany. Denmark, Iceland, and Norway have high slope values (0.782, 0.740, and 0.720) and adjusted R-squared values (99.71%, 99.82%, and 99.63%), reflecting a near-perfect model fit. In contrast, the Czech Republic, Austria, and Finland exhibit slightly lower slope values and adjusted R-squared values (95.79%, 97.49%, and 90.22%), indicating a strong but less pronounced relationship. Switzerland and Sweden also show robust correlations, with coefficients of 0.69 and 0.75 and adjusted R-squared values of 98.28% and 99.47% **(Figure 24).**

Overall, the linear regression analysis reveals that while the relationship between the Gini coefficient and the Hoover index differs for each country, there is generally a positive correlation across all OECD countries. In other words, income inequality is linked to the proportion of total income that requires redistribution among the population. In North and Latin America, especially the USA and Canada, this relationship is highly robust, with the Gini coefficient reliably predicting the Hoover index. In the Asia Pacific and Middle East, countries like Israel, Japan, and Korea also show a strong and dependable link. Western European countries exhibit a significant relationship, though with some variation in model fit. Southern and Eastern European countries demonstrate a robust connection, confirming the Gini coefficient's effectiveness in predicting redistribution. In Central and Northern Europe, while the models are statistically strong, there is greater variation in coefficient magnitudes and explanatory power, indicating differing impacts of income inequality on redistribution.

4.3.6 Beta Distribution

The beta distribution is a continuous probability distribution defined on the [0, 1] interval, with two shape parameters, α and β. These parameters enable the distribution to adopt various forms, from uniform to bell-shaped, and to be skewed in either direction. This versatility makes the beta distribution ideal for modelling proportions and probabilities, where values are constrained between 0 and 1 (Wikipedia, 2024). Its mathematical properties allow for easy calculation of mean, variance, and other moments, making it valuable in statistical analysis. Given that the Gini coefficient, a measure of income inequality, ranges from 0 (perfect equality) to 1 (perfect inequality), the beta distribution is an ideal model. The distribution of Gini coefficients across OECD countries has been modelled using the beta distribution for the years 1980, 2000, and 2022. This approach aids in understanding the central tendency, variability, and skewness of income inequality of OECD countries.

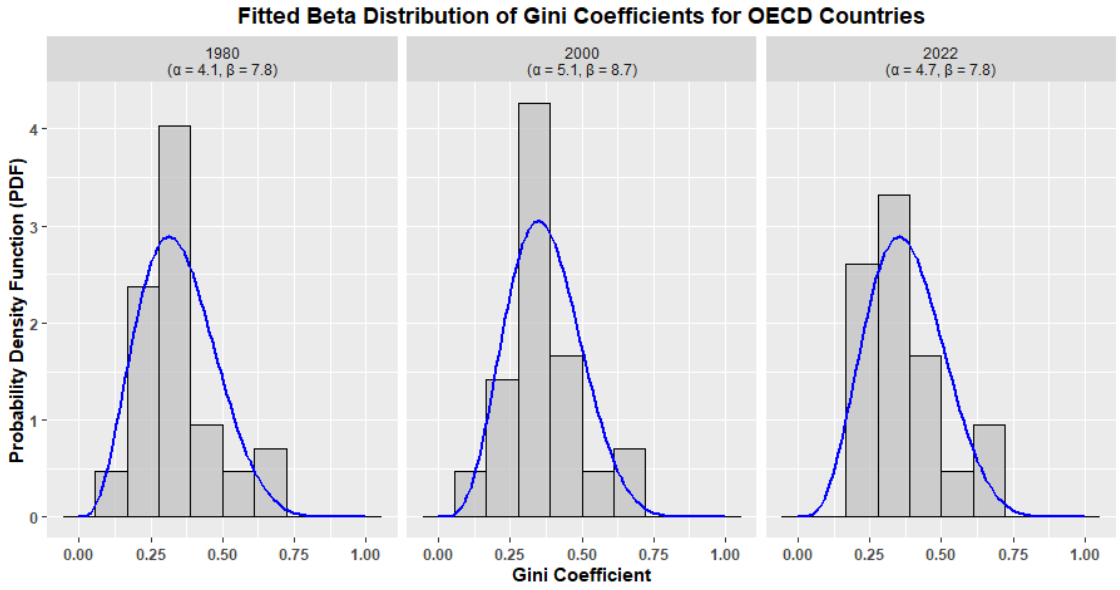


Figure (25) Beta Distribution of Gini Coefficients for OECD countries (1980,2000,2022)

The beta distribution parameters for the Gini coefficient across the years 1980, 2000, and 2022 highlight evolving patterns of income inequality among OECD countries. In 1980, with α=4.1 and β=7.8, the right-skewed distribution indicates that most countries had lower Gini coefficients, reflecting lower income inequality, though a few countries exhibited higher inequality. The variance of this distribution, calculated as $Var(X) = \frac{\alpha\,\beta}{(\alpha+\beta)^2(\alpha+\beta+1)}$, is 0.018. This variance suggests a relatively wide spread of Gini coefficients, indicating significant diversity in income inequality levels across OECD countries in 1980. This trend continues into 2000, where α=5.1 and β=8.7 also result in a right-skewed distribution. The mean Gini coefficient, calculated as $Mean(X) = \frac{\alpha}{\alpha+\beta}$ is slightly higher at approximately 0.37 compared with the mean of 1980 (which was 0.35), suggesting a slight increase in overall inequality. The variance in 2000 is approximately 0.014, pointing to a more clustered distribution of Gini coefficients, indicating that while inequality was still generally low, the gap between countries with low and high inequality had narrowed compared to 1980 **(Figure 25).**

In 2022, the parameters α=4.7 and β=7.8 still produce a right-skewed distribution, similar to previous years, with a mean Gini coefficient of about 0.38 reflecting moderate income inequality among OECD countries. The variance is around 0.015, showing a slightly wider spread than in 2000 but more concentrated than in 1980. This variance suggests a trend towards lower inequality compared to 1980 and 2000, though high Gini coefficients persist, keeping a long right tail in the distribution. Despite slight increases in the mean Gini coefficient, many OECD countries have managed to maintain relatively low-and stable income inequality with fewer extreme variations over time **(Figure 25).**

4.3.7 Microscopic View for Income Distribution

The following **(Table 3)**, generated by R Studio, shows that between 1980 and 2022 in the United States, income share decreased for the 1st through 18th vigintiles, while the top 5% (20th vigintile) saw a 37.6% increase. The top 5%'s income share rose from 19.7% in 1980 to 27.1% in 2022, indicating income disparity is greater in 2022 compared to 1980 over the period **(Table 3).**

Table (3) Relative Change in income share per vigintile (between 1980 and 2022) USA

Vigintiles	Country	InitialYear	FinalYear	Income_Share_Change	Relative_Change
<ord>	<chr>	<dbl>	<dbl>	<dbl>	<dbl>
1st	USA	0.0058	0.0018	-0.004	-69.0
2nd	USA	0.0152	0.0068	-0.0084	-55.3
3rd	USA	0.0194	0.0135	-0.0059	-30.4
4th	USA	0.0218	0.0191	-0.0027	-12.4
5th	USA	0.0252	0.0218	-0.0034	-13.5
6th	USA	0.0287	0.0235	-0.0052	-18.1
7th	USA	0.0312	0.0263	-0.0049	-15.7
8th	USA	0.0333	0.0294	-0.00390	-11.7
9th	USA	0.0362	0.032	-0.00420	-11.6
10th	USA	0.0393	0.0345	-0.0048	-12.2
11th	USA	0.0421	0.0376	-0.00450	-10.7
12th	USA	0.0449	0.041	-0.0039	-8.69
13th	USA	0.0484	0.0443	-0.0041	-8.47
14th	USA	0.0524	0.0479	-0.00450	-8.59
15th	USA	0.0567	0.0525	-0.00420	-7.41
16th	USA	0.0616	0.0583	-0.00330	-5.36
17th	USA	0.0679	0.0657	-0.00220	-3.24
18th	USA	0.0775	0.0764	-0.00110	-1.42
19th	USA	0.0955	0.0966	0.00110	1.15
20th	USA	0.197	0.271	0.074	37.6

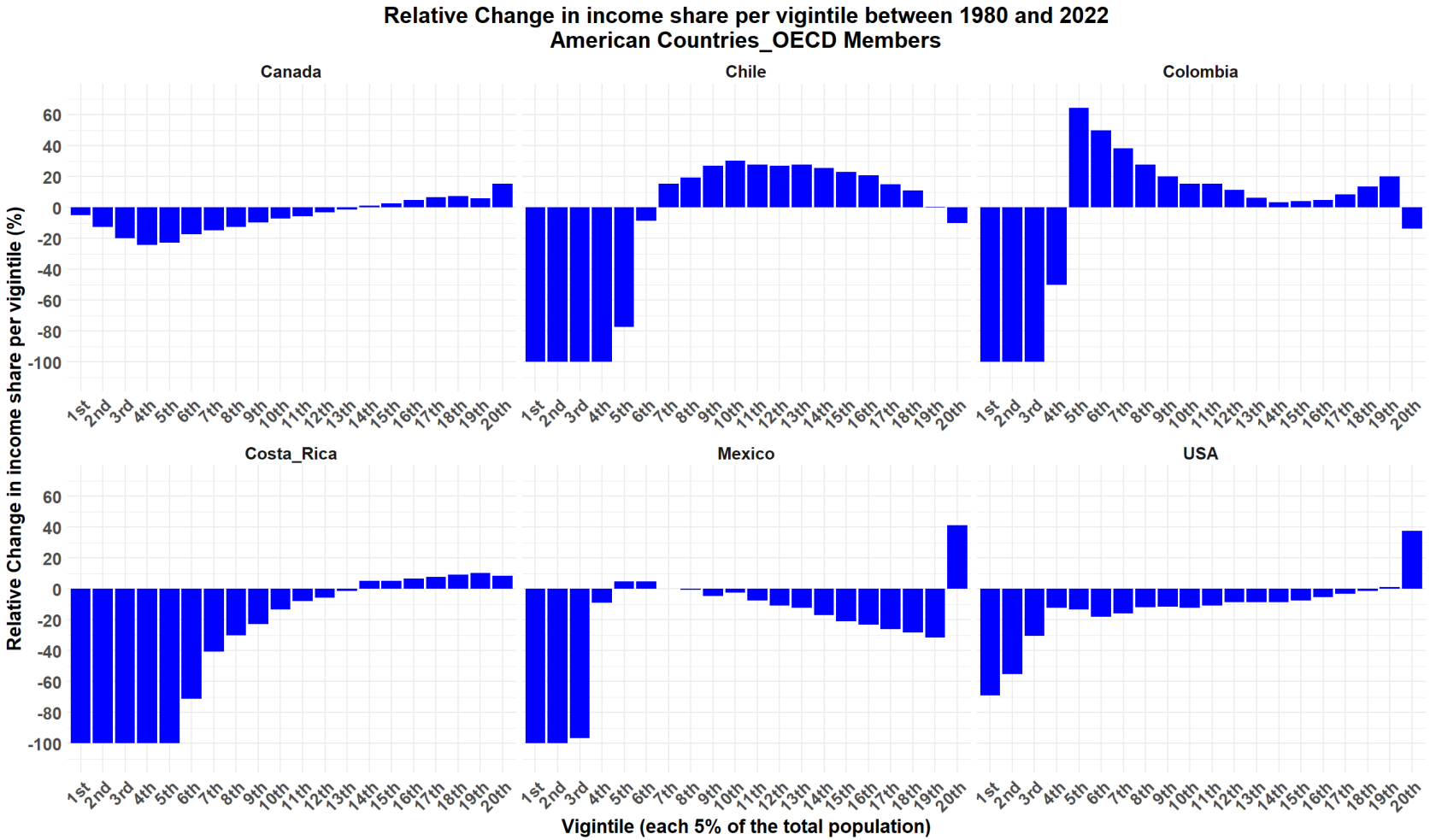


Figure (26) Relative Change in Income Share per vigintile between 1980 and 2022 (American Countries_ OECD Members)

the x-axis is the vigintile of population, ranked from the poorest to the richest. The y-axis is denoted as the relative change in income share for each 5% of population.

The analysis of income distribution across Canada, Chile, Colombia, Costa Rica, and Mexico reveals varied patterns. In Canada, lower and middle-income groups (1st to 13th vigintiles) experienced moderate declines, with the 4th vigintile seeing a 24.3% drop, while higher income groups (17th to 20th vigintiles) saw increases, especially the top 5% of the population (= 20th vigintile) with a 15.4% rise, indicating growing inequality **(Figure 26).**

Chile saw a dramatic shift, with the lowest income groups (1st to 4th vigintiles) losing all their income share by 2022, while middle-income groups (7th to 16th vigintiles) gained between 14.9% and 30.2%. The highest income group (20th vigintile) experienced a slight decrease of 10.2%, reflecting some redistribution **(Figure 26).**

In Colombia, the bottom 15% also lost their entire income share, while middle-income groups (5th to 8th vigintiles) saw gains ranging from 27.8% to 64.4%, and the top income group (20th vigintile) declined by 13.7%. Costa Rica followed a similar trend, with the bottom 25% (1st to 5th vigintiles) losing all their income share, and the top 20% (17th to 20th vigintiles) seeing increases between 7.78% and 10.3%. In Mexico, the bottom 10% lost their income share completely, while the top 5% (20th vigintile) gained 41.4% **(Figure 26).**

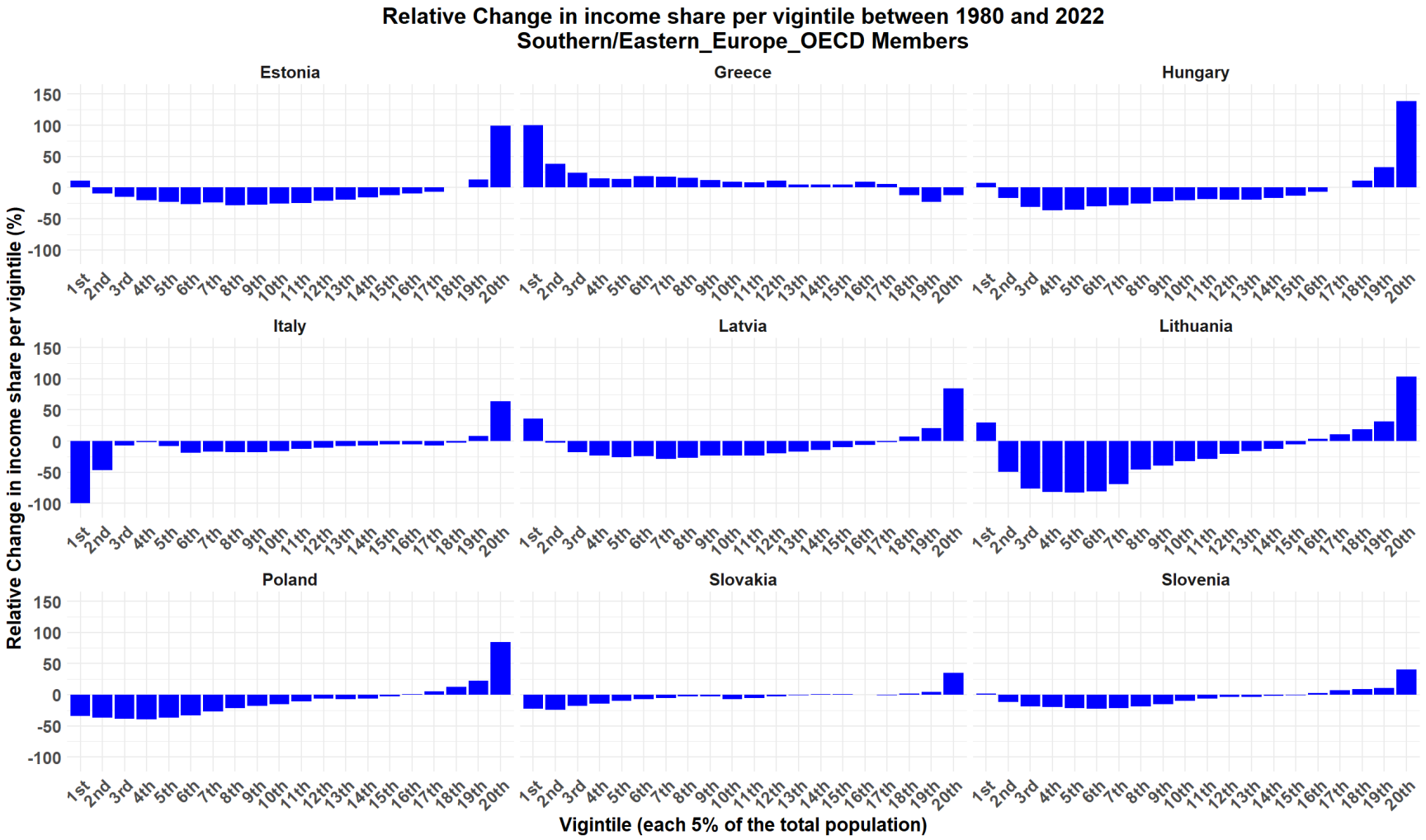


Figure (27) Relative Change in Income Share per vigintile between 1980 and 2022 (Southern/Eastern Europe_ OECD Members)

Analysis of income share changes in Southern and Eastern European OECD countries from 1980 to 2022 reveals diverse trends. In Estonia, the lowest income group (1st vigintile) increased by 10.8%, while the highest (20th vigintile) saw a substantial 100% rise, indicating significant income concentration at the top. Greece experienced a 100% increase in the lowest income group (1st vigintile) and a 12.1% decrease in the highest income group (20th vigintile), suggesting some redistribution towards lower income groups **(Figure 27).**

Hungary saw declines in lower and middle-income groups, with the 4th vigintile dropping by 36.2%, while the 20th vigintile surged by 139%, indicating rising inequality. Italy's income distribution showed a broad decline across most vigintiles, with the 20th vigintile increasing by 63.7%, highlighting growing inequality. Latvia experienced a 36.1% increase in the lowest income group and an 84.3% gain in the highest group, reflecting growing disparities. Lithuania saw the most significant increase in the 20th vigintile (103%), while lower and middle-income groups, especially the 4th and 5th vigintiles, saw substantial decreases of 82% **(Figure 27).**

In Poland, the bottom 75% of the population saw declines, with the 4th vigintile dropping by 39.8%, while the top 5% (20th vigintile) rose by 84%. Slovakia and Slovenia showed smaller changes overall, with Slovakia’s 20th vigintile increasing by 34.6% and Slovenia’s by 40.7%, indicating less dramatic shifts in income distribution compared to other countries **(Figure 27).**

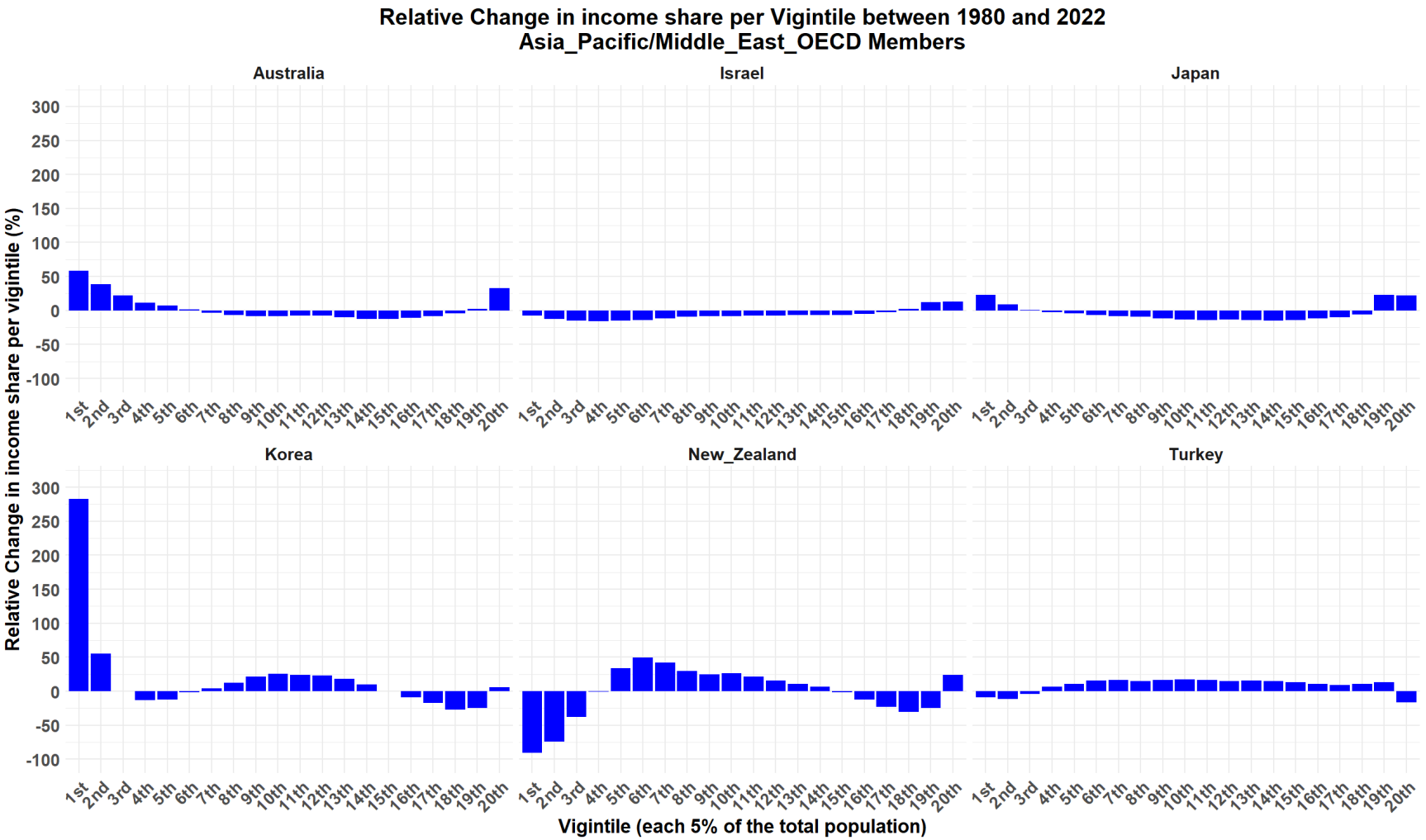


Figure (28) Relative Change in Income Share per vigintile between 1980 and 2022 (Asia Pacific / Middle East_ OECD)

In Australia, the lower income groups (1st to 6th vigintiles) saw increases in income share, particularly the 1st to 4th vigintiles, with relative changes ranging from 11.7% to 58.5%. Meanwhile, the highest income group (20th vigintile) also experienced a notable increase of 32.5%, while middle-income groups (8th to 17th vigintiles) saw slight decreases. In contrast, Israel displayed a more uniform trend where lower and middle-income groups (1st to 16th vigintiles) experienced moderate decreases, whereas the highest income group (top 10%) saw increases of 11.9% and 12.8%, respectively, highlighting a shift towards higher income concentration **(Figure 28).**

Japan and Korea both exhibited increases in income shares for the lowest and highest income groups, though with varying magnitudes. In Japan, the poorest 5% (1st vigintile) saw a 22.8% increase, while the top 5% (20th vigintile) saw a 22.3% rise, with most of the other income groups experiencing slight decreases. Korea showed a more dramatic shift, with the lowest income group (1st vigintile) experiencing a substantial 282% increase in income share, despite its small absolute value, and a smaller increase of 5.63% for the top 5% (20th vigintile). New Zealand, however, had a different pattern where the lowest income group (1st vigintile) saw a drastic 90.7% decrease in income share, while the middle-income groups (5th to 14th vigintiles) generally observed increases, with the 6th vigintile rising by 49.1%. Conversely, Turkey showed increases for most middle-income groups (4th to 17th vigintiles), with the 10th vigintile seeing a 17% rise, but the highest income group (20th vigintile) faced a moderate decrease of 16.2%, indicating a slight redistribution away from the top earners **(Figure 28).**

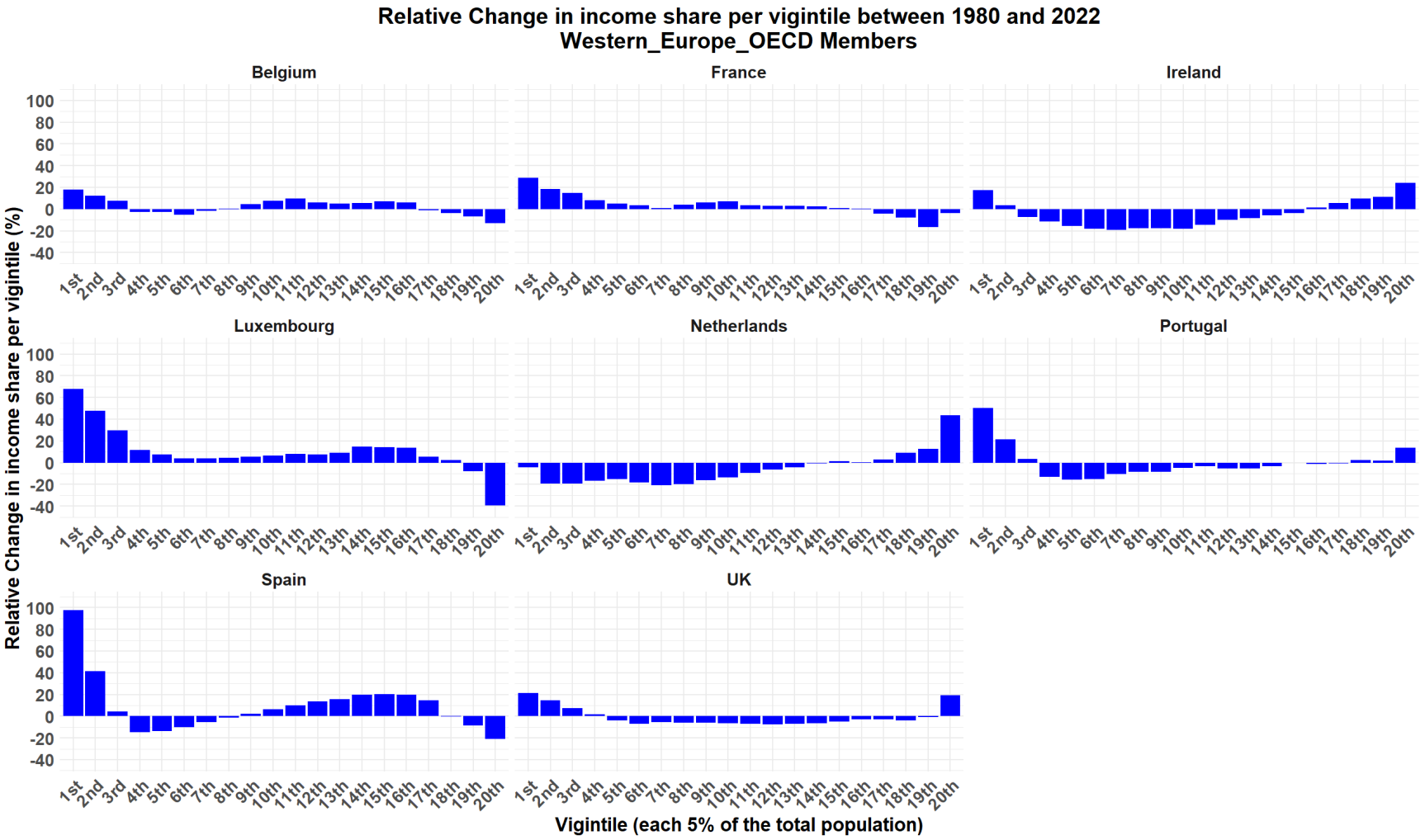


Figure (29) Relative Change in Income Share per vigintile between 1980 and 2022 (Western Europe_ OECD Members)

Analysis of income distribution in Western European countries reveals diverse trends. In Belgium and France, lower and middle-income groups saw increases—Belgium's 1st vigintile rose by 18% and France's by 28.8%—while higher-income groups declined, indicating a trend towards more equitable distribution. Luxembourg followed a similar pattern, with the top 10% experiencing significant decreases (20th vigintile down by 39.3%) and the bottom 5% increasing by 67.6% **(Figure 29).**

Ireland saw increases in both the poorest 10% and wealthiest 20%, particularly a 24% rise in the 20th vigintile, while middle-income groups declined. The Netherlands mirrored this, with gains in the top 30% (notably a 43.3% increase in the 20th vigintile) and decreases in lower and middle-income groups, including a 21% drop in the 7th vigintile. Portugal experienced a dramatic 50.4% increase in the 1st vigintile and a 13.7% increase in the 20th vigintile **(Figure 29).**

Spain and the UK showed mixed trends: Spain's lower income groups gained significantly (1st vigintile up by 97.5%), while the top 5% decreased moderately (20th vigintile down by 21.1%). The UK saw increases in both the bottom 20% and top 5% (1st and 20th vigintiles up by 21.1% and 19.4%, respectively), with slight declines in middle-income groups **(Figure 29).**

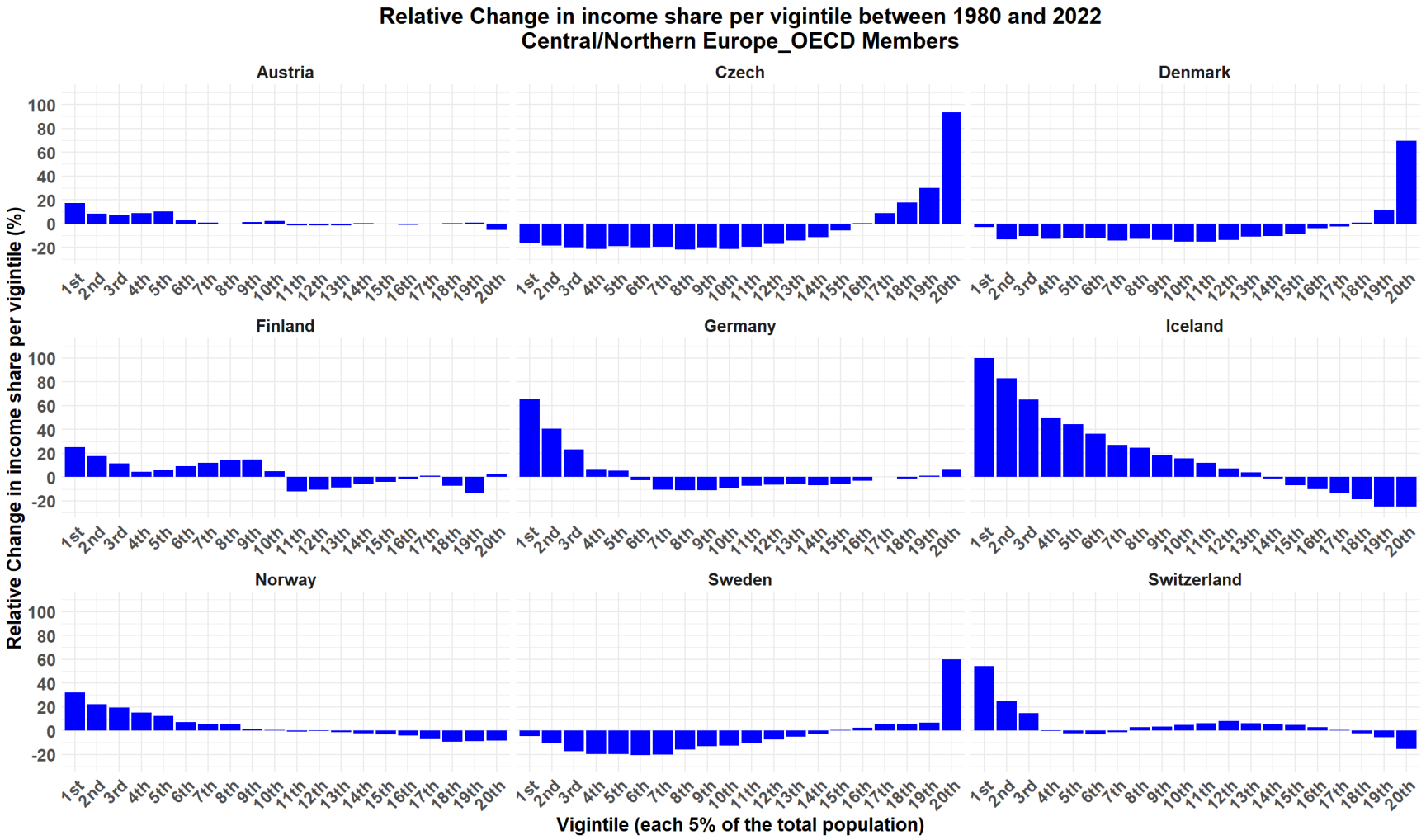


Figure (30) Relative Change in Income Share per vigintile between 1980 and 2022 (Western Europe_ OECD Members)

In Austria, lower income groups (1st to 7th vigintiles) saw modest gains, with the 1st vigintile increasing by 17.3%, while the top 5% (20th vigintile) experienced a 5.29% decrease. In contrast, the Czech Republic and Denmark saw significant increases in the top income groups, with the 20th vigintile rising by 93.2% in the Czech Republic and 69.5% in Denmark, while lower and middle-income groups declined. This indicates a concentration of wealth at the top in these countries, unlike Austria, where gains were more evenly distributed **(Figure 30).**

In Finland and Germany, both the lowest and highest income groups saw increases. Finland's 1st vigintile rose by 25.1%, and the 20th vigintile by 2.61%, while in Germany, the 1st vigintile surged by 65.5% and the 20th by 6.99%. Iceland and Norway also saw increases in lower and middle-income groups, with Iceland’s 1st vigintile doubling and Norway’s rising by 32.1%, while higher-income groups decreased. Conversely, Sweden's upper-middle and higher-income groups (15th to 20th vigintiles) gained significantly, with the 20th vigintile increasing by 59.7%, while lower and middle-income groups declined. Switzerland saw a 54.3% increase in the 1st vigintile, but a 15.2% decrease in the top 5%, reflecting a redistribution favoring lower-income groups **(Figure 30).**

4.3.8 Correlation between Gini Coefficient and Unemployment Rate

Hypothesis II: there is a positive correlation between Gini Coefficient and the Unemployment Rate. The hypothesis is built to investigate the potential impact of the unemployment rate on the Gini Coefficient. Only five countries from different five geographical regions, out of 38 OECD members are selected to test the hypothesis: Chile, Czech, Ireland, Israel, and Greece. Each data point on the graphs is a pair of $((G_t), (UR_t))$ for a given year (t). The statistical model is G = a+b*UR.

The linear regression analyses across selected countries reveal diverse relationships between unemployment rates and income inequality. In Japan, a country from Asia Pacific and Middle East OECD members, there is a significant positive correlation, with a coefficient of 0.015, indicating that higher unemployment is associated with increased income inequality (p-value = 0.000468). The R^2 value is 0.26, which means that approximately 26% of the variability in the Gini coefficient can be explained by the unemployment rate. This model explains 24.3%

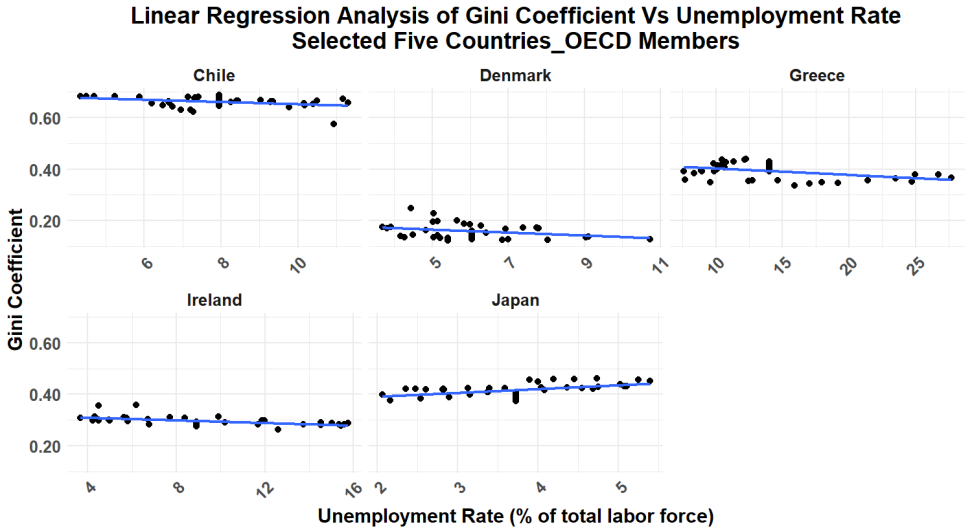


Figure (31) Regression Analysis of Gini Coefficient and Unemployment Rate

of the variance in the Gini coefficient, suggesting a robust relationship. In contrast, Chile, Greece, Ireland, and Denmark all show significant negative correlations. In these countries, higher unemployment is associated with lower income inequality, though the strength and explanatory power of these relationships vary. Chile's coefficient is -0.004 (p-value = 0.016), Greece's is -0.0025 (p-value = 0.0036), Ireland's is -0.0025 (p-value = 0.00031), and Denmark's is -0.0057 (p-value = 0.0493). These models explain 6.9% to 25.7% of the variance, with varying degrees of residual variability **(Figure 31).**

5. Conclusion

The study examined income inequality across 38 OECD countries, with a focus on five geographic regions. It employed widely recognized measures of income inequality, including the Lorenz Curve, Gini Coefficient, Hoover Index, and other relevant metrics. Additionally, the study tested two hypotheses: first, that there is a positive correlation between the Gini and Hoover indices, and second, that a positive relationship exists between the unemployment rate and the Gini Coefficient.

First, through Lorenz curves analysis and trends of Gini Coefficient throughout more than four decades, we have seen that among the 38 OECD countries, Colombia consistently had the highest income inequality from 1980 to 1997. From 2003 onward, Mexico took the lead in income inequality. Chile also remained among the countries with the highest Gini coefficients throughout the study period. During this time, Denmark, Sweden and Norway were recognized for having the lowest levels of inequality. As of 2022, 24 OECD countries reported income inequality below the OECD average of 0.36,

while 14 exceeded it. Notably, all six American OECD countries were above the average, whereas all Western European, Central, and Northern European countries fell below it. In Southern and Eastern Europe, Greece, Hungary, Slovakia, Poland, and Slovenia were below the average, while the other four were above it. In the Asia-Pacific and Middle East regions, only Australia and Korea reported inequality below the average, with the remaining four countries surpassing it.

Second, a microscopic analysis of income distribution provided granular insights into income inequality within population segments, examining each 5% of the population from 1980 to 2022. In countries with rising income inequality in recent years, such as Mexico, Chile, Colombia, and Costa Rica—known for consistently high inequality—low-income groups (specifically the bottom 25% = the 1st to 5th vigintiles) experienced a loss in their share of income.

Third, there is a strong positive relationship across all OECD countries between income inequality (Gini Coefficient) and the proportion of total income that must be redistributed to achieve perfect equality (Hoover Index). However, the relationship between the unemployment rate and the Gini coefficient varies significantly by country. Four out of five selected countries demonstrated a negative relationship, while Japan uniquely showed a positive correlation between unemployment and income inequality. Further research should explore additional variables related to the Gini Coefficient to identify the factors most strongly associated with income inequality. This analysis could help in developing strategies to reduce income inequality both within OECD countries and globally.

List of References

Akee, R., Jones,M.R and Porter, S.R (2019) 'Race matters: income shares, income inequality, and income mobility for all U.S. races', *Demography,* 56(3), pp. 999-1021. Available at: https://www-jstor-org.plymouth.idm.oclc.org/stable/45199437?sid=primo&seq=1 (Accessed: 17 Aug 2024)

Bishop, J.A, Formby, J.P and Smith, W.J (1991) 'Lorenz dominance and welfare: changes in the US distribution of income, 1967-1986'. Available at: https://www.jstor.org/stable/2109695 (Accessed: 26 Feb 2024)

Chancel and Piketty (2021) 'Global income inequality, 1820-2020: the persistence and mutation of extreme inequality', *Journal of the European Economic Association,* 19 (6), pp. 3025-3062. Available at: https://academic-oup-com.plymouth.idm.oclc.org/jeea/article-abstract/19/6/3025/6408467?redirectedFrom=fulltext. (Accessed 25 Feb 2024)

Chancel and Piketty (2021) 'Global income inequality, 1820-2020: the persistence and mutation of extreme inequality', *Journal of the European Economic Association,* 19 (6), pp. 3025-3062. Available at: https://academic-oup-com.plymouth.idm.oclc.org/jeea/article/19/6/3025/6408467?login=true&token=eyJhbGciOiJub25lIn0.eyJleHAiOjE3MTMzNzIxMTcsImp0aSI6ImQ1NDFkMjU4LTMyYTktNDAxYS1iOWQzLTk1MjIxNzhlYmI0YSJ9. (Accessed 25 Feb 2024)

Chancel, L., Piketty, T., Saez, E and Zucman, G (2022) *World inequality report 2022.* Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://wir2022.wid.world/www-site/uploads/2021/12/WorldInequalityReport2022_Full_Report.pdf (Accessed: 15 Mar 2024)

Dahl, E., Elstad, J. I., Hofoss, D and Mollard, M.M (2006) 'For whom is income inequality most harmful? A multi-level analysis of income inequality and mortality in Norway', *Social Science & Medicine,* 63(10), pp. 2562-2574. Available at: https://www-sciencedirect-com.plymouth.idm.oclc.org/science/article/pii/S0277953606003054 (Accessed: 14 Mar 2024).

Heinzl, T. (nd) *Wealth inequality and the Lorenz curve.* University of Plymouth. Unpublished.

Howard, M.W and Carter, V.J (n.d) *Income inequality.* Available at: https://www.britannica.com/money/income-inequality (Accessed: 7 Mar 2024).

Keeley, B (2015) *Income inequality: The gap between rich and poor, OECD insights,* OECD Publishing, Paris. Available at: https://books.google.co.uk/books?hl=en&lr=&id=kUpqDwAAQBAJ&oi=fnd&pg=PA3&dq=Income+inequality:+The+gap+between+rich+and+poor&ots=_lgwWWJS99&sig=z1rsKbOh-wmvmOZXitypVzNhR4Y#v=onepage&q=Income%20inequality%3A%20The%20gap%20between%20rich%20and%20poor&f=false (Accessed: 5 July 2024)

Kharas, H. and Seidel, B. (2018) *What's happening to the world income distribution?* Global Economy & Development Working Paper 114. Washington DC: Brookings. Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.brookings.edu/wp-content/uploads/2018/04/workingpaper114-elephantchartrevisited.pdf (Accessed: 5 June 2024).

Kus, B (2012) 'Financialisation and income inequality in OECD Nations: 1995-2007', *The Economic and Social Review,* 43(4), pp. 477-495. Available at: https://web-p-ebscohost-com.plymouth.idm.oclc.org/ehost/pdfviewer/pdfviewer?vid=0&sid=8e9d95d0-93da-477c-8720-5f5e8089f0fc%40redis (Accessed: 17 Aug 2024)

Lopez, R and Miller, S.J (2008) 'Chile: The unbearable burden of inequality', *World Development*, 36(12), pp.2679-2695. Available at: https://www-sciencedirect-com.plymouth.idm.oclc.org/science/article/pii/S0305750X08001691 (Accessed: 5 Aug 2024).

Lorenz, M.O (1905) 'Methods of measuring the concentration of wealth', *Publications of the American Statistical Association,* 9(70), pp.209-219. Available at: https://www-jstor-org.plymouth.idm.oclc.org/stable/2276207?sid=primo&seq=11 (Accessed: 24 July 2024).

OECD (2011) *Equity Indicators*. Available at: https://www.oecd.org/berlin/47570121.pdf. (Accessed: 10 Feb 2024)

OECD (2014) *Focus on inequality and growth,* Paris, OECD Publishing. Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/growth/growth-pdfs/Focus-Inequality-and-Growth-2014.pdf (Accessed: 17 Aug 2024)

Organisation for Economic Co-operation and Development (n.d) *Income inequality.* Available at: https://data.oecd.org/inequality/income-inequality.htm (Accessed: 1 Aug 2024).

Organisation for Economic Co-operation and Development (n.d) *Income inequality.* Available at: https://data.oecd.org/inequality/income-inequality.htm (Accessed: 19 Mar 2024).

Our World in Data (2024) *Measuring inequality: what is the Gini coefficient?* Available at: https://ourworldindata.org/what-is-the-gini-coefficient (Accessed: 24 July 2024).

Paredes, D., Iturra, V and Lufin, M (2014) 'A spatial decomposition of income inequality in Chile', *Regional Studies,* 50 (5), pp. 771-789. Available at: https://www-tandfonline-com.plymouth.idm.oclc.org/doi/full/10.1080/00343404.2014.933798 (Accessed: 15 Mar 2024).

Schneider, M (2021) 'The discovery of the Gini Coefficient: was the Lorenz Curve the catalyst?', 53(1), p 115. Available at: https://web-p-ebscohost-com.plymouth.idm.oclc.org/ehost/pdfviewer/pdfviewer?vid=0&sid=93c5ef49-c5c2-4154-a069-1ce1fd00638c%40redis (Accessed 9 Aug 2024)

Seisembay, J. *et al.* (2022) 'Global income inequality- a case study of OECD countries and Kazakhstan', *Comparative Economic Research,* 25(4), pp. 179-203. Available at: https://czasopisma.uni.lodz.pl/CER/article/view/15757/15256 (Accessed: 5 Aug 2024)

The World Bank Group (2024) *Unemployment, total (% of total labor force) (modeled ILO estimate).* Available at: https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS (Accessed: 15 June 2024).

The World Bank Group (2024) *Who we are.* Available at: https://www.worldbank.org/en/who-we-are (Accessed 17 Aug 2024)

Tridico, P (2018) 'The determinants of income inequality in OECD countries', *Cambridge Journal of Economics,* 42(4), pp.1009-1042. Available at: https://academic-oup-com.plymouth.idm.oclc.org/cje/article/42/4/1009/4621985?login=true&token=eyJhbGciOiJub25lIn0.eyJleHAiOjE3MjY1MTg1ODEsImp0aSI6IjBhN2IxYTRjLWJjN2EtNDkwYy1iOGZkLTU5YzczOTAyNTZhMCJ9. (Accessed: 17 Aug 2024)

United Nations (2015) *Inequality measurement*. Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.un.org/en/development/desa/policy/wess/wess_dev_issues/dsp_policy_02.pdf (Accessed: 25 Feb 2024)

WID.WORLD (2024) *Codes Dictionary.* Available at: https://wid.world/codes-dictionary/ (Accessed: 7 June 2024)

WID.WORLD (2024) *Distributional National Accounts Guidelines.* Available at: WorldInequalityLab-Guidelines.2021.pdf (Accessed: 8 Mar 2024).

WID.WORLD (n.d) *World Inequality Database.* Available at: https://wid.world/data/ (Accessed: 8 Mar 2024)

WID.WORLD (n.d) *World Inequality Database.* Available at: https://wid.world/wid-world/ (Accessed: 7 Jun 2024)

WIKIPEDIA (2024) *Beta Distribution.* Available at: https://en.wikipedia.org/wiki/Beta_distribution (Accessed: 5 July 2024).

WIKIPEDIA (2024) *Lorenz Cure.* Available at: https://en.wikipedia.org/wiki/Lorenz_curve (Accessed: 1 July 2024).

World Street Oasis (2024) *Hoover Index*. Available at: https://www.wallstreetoasis.com/resources/skills/economics/hoover-index (Accessed: 24 July 2024).

Appendices

Appendix (1)

Chile

```
> summary(chile$postTaxIncome)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.00000 0.01107 0.02050 0.05000 0.03798 0.51250
```

Colombia

```
> summary(colombia$postTaxIncome)
    Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
0.000000 0.008975 0.021900 0.050001 0.041575 0.499900
```

Costa Rica

```
> summary(costarica$postTaxIncome)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.00000 0.01137 0.02430 0.05000 0.04627 0.46820
```

Czech Republic

```
> summary(czech$postTaxIncome)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.01330 0.03520 0.04775 0.05000 0.05983 0.17760
```

Denmark

```
> summary(denmark$postTaxIncome)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 0.0274  0.0403  0.0467  0.0500  0.0532  0.1848
```

Finland

```
> summary(finland$postTaxIncome)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 0.0172  0.0369  0.0432  0.0500  0.0555  0.1802
```

France

```
> summary(france$postTaxIncome)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.01700 0.03110 0.04305 0.05000 0.05760 0.17840
>
```

Israel

```
> summary(israel$postTaxIncome)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.00880 0.02030 0.03090 0.05000 0.05215 0.32640
```

Mexico

```
> summary(mexico$postTaxIncome)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.00000 0.00760 0.01700 0.05000 0.04283 0.51990
```

Netherlands

```
> summary(netherland$postTaxIncome)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.01710 0.03358 0.04230 0.05000 0.05585 0.18050
```

New Zealand

```
> summary(newzealand$postTaxIncome)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.00100 0.02630 0.03915 0.05000 0.05883 0.25150
```

Norway

```
> summary(norway$postTaxIncome)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.01950 0.03780 0.04745 0.05000 0.05532 0.16260
```

Turkey

```
> summary(Turkey$postTaxIncome)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.00590 0.01810 0.02600 0.05000 0.04063 0.43570
```

Appendix (2)

The following appendix table (1) is the sample Gini Coefficient results of the UK from the function we applied in R Studio for the research project.

Appendix table (1)

	Country	Year	geographical_region	Gini
	<chr>	<chr>	<chr>	<dbl>
1	UK	1980	Western_Europe	0.255
2	UK	1981	Western_Europe	0.246
3	UK	1982	Western_Europe	0.244
4	UK	1983	Western_Europe	0.249
5	UK	1984	Western_Europe	0.255
6	UK	1985	Western_Europe	0.257
7	UK	1986	Western_Europe	0.257
8	UK	1987	Western_Europe	0.265
9	UK	1988	Western_Europe	0.273
10	UK	1989	Western_Europe	0.273
11	UK	1990	Western_Europe	0.309
12	UK	1991	Western_Europe	0.309
13	UK	1992	Western_Europe	0.307
14	UK	1993	Western_Europe	0.306
15	UK	1994	Western_Europe	0.298
16	UK	1995	Western_Europe	0.296
17	UK	1996	Western_Europe	0.306
18	UK	1997	Western_Europe	0.306
19	UK	1998	Western_Europe	0.304
20	UK	1999	Western_Europe	0.317

The following two tables are Gini Coefficient calculated by Wid.World for the same dataset.

Appendix table (2)

Percentile	Year	**Post-tax national income** Gini coefficient | adults | equal split **United Kingdom**
pall	1980	0.26
pall	1981	0.25
pall	1982	0.24
pall	1983	0.25
pall	1984	0.26
pall	1985	0.26
pall	1986	0.26
pall	1987	0.27
pall	1988	0.27
pall	1989	0.27

Appendix table (3)

Percentile	Year	**Post-tax national income** Gini coefficient | adults | equal split | **United Kingdom**
pall	1990	0.31
pall	1991	0.31
pall	1992	0.31
pall	1993	0.31
pall	1994	0.30
pall	1995	0.30
pall	1996	0.31
pall	1997	0.31
pall	1998	0.31
pall	1999	0.32