

Winners and Losers: Visualizing Global Economic Resilience During the COVID-19 Pandemic

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ABSTRACT

This project discusses analyzing the world economic resilience from 2010 to 2023, with a specific emphasis on their capacities for absorbing and recovering from the COVID-19 pandemic that ravaged the whole world from 2020-2022. With a set of data compiled from World Bank World Development Indicators in conjunction with data from other sources like the IMF and OECD, this report analyzes various key elements of a country's economy, including its GDP, unemployment rate, inflation, fiscal balance, and debt, with a comparative analysis of their economies for nearly 200 nations. Various preprocessing techniques like data filling for missing values, data normalization, and data segmentation, among others, help to facilitate a comparative analysis among nations. This report also aims to provide a solution for many of the world's economic issues, which are left uncovered in popular literature related to this topic, by offering a comprehensive, empirical, and visual analysis of economic data for nearly all nations. This report seeks to help with achieving SDG 1 as well as SDG 8 by providing easy access to macroeconomic data for all nations.

KEYWORDS

Economic Resilience; COVID-19 Recovery; Global Economy; Macroeconomic Indicators; World Development Indicators; GDP Growth; Fiscal Stability; Unemployment Trends; Inflation Dynamics; Cross Country Comparison; Resilience Index; Data Visualization; Regional Analysis; Economic Shocks; Sustainable Development

1. INTRODUCTION

The global economy experienced, perhaps, unprecedented challenges in the last two decades, with the COVID-19 pandemic being the latest. While some nations sprang back into growth quickly, others remained mired in long recessions. This divergence shows just how important the analysis of economic resilience—that is, the ability to absorb sudden shocks and recover growth—can be. Understanding these differences lets researchers uncover the structural, social, and policy-driven factors responsible for varying national outcomes. Such an analysis provides a backdrop against which future global disruptions could be expected to affect diverse economies.

This aligns with SDG 8: Decent Work and Economic Growth, centered on sustained, inclusive economic growth and productive employment. It also links to SDG 1: No Poverty, as resilience during and after the COVID-19 pandemic is inextricably linked to reducing economic vulnerabilities and preventing people from falling into poverty. The study of resilience patterns through a comparative visualization allows for an examination of whether countries are on track for stable and sustainable development. Such insights help demonstrate which regions need targeted interventions to get them on a path toward long-term economic stability. Thus, this study contributes to the greater global efforts toward monitoring development progress and identifying risks that will prevent recovery.

Resilience and fragility, seen together, explain how some nations recover more rapidly than others. Accessible visualization is also an effective way to make sense of complex macroeconomic data for wider audiences. Using interactive dashboards, maps, and comparative visuals, patterns are instantly available for policymakers, students, and the public that will be hard to decipher in raw data tables. These instruments will further develop an intuitive understanding of world economic performance and ease the process of finding out about regional disparities. Besides, accessible visualizations enable decision-makers to study scenarios, compare countries, and devise better-informed policies based on evidence.

2. STATEMENT OF THE PROBLEM

Research Question(s):

- How did countries differ in their resilience to the COVID-19 Pandemic?
- Which indicators best explain why some countries were resilient while others remained fragile?

- Are the regional patterns of resilience consistent across crises?

Objectives:

1. The first objective is to track and capture economic resilience to external shocks from 2010 to 2025. This involves keeping track of more than just how far or how deep the economies contracted or expanded during downturns, but also how fast they were able to regain growth.
2. The second objective is to categorize nations into distinct resilience classifications based on indicators, including GDP growth, unemployment rates, inflation levels, and fiscal stability. This method of grouping countries allows the analysis to illuminate which economies exhibit similar resilience characteristics and which ones continue to exhibit vulnerability.
3. The third objective is to distill regional trends and highlight case studies that reveal both vulnerability and strength. Through carrying out such an analysis, the project should be able to reveal longer continental trends while also highlighting individual nations that are either prime exemplars of having recovered or characteristic examples of continuing economic vulnerability.

Scope:

- **Countries:** Global coverage (~200).
- **Years:** 2010–2023.
- **Indicators:** Public Debt (% of GDP), Gross National Income (USD), Tax Revenue (% of GDP), Government Revenue (% of GDP), Government Expense (% of GDP), Current Account Balance (% GDP), GDP Growth (% Annual), Inflation (GDP Deflator, %), Interest Rate (Real, %), Unemployment Rate (%), GDP per Capita (Current USD), GDP (Current USD), Inflation (CPI %).

Limitations:

- Certain predictors, such as public debt and government spending, have missing values for selected nations and years. This omission limits the dataset's general coverage and could compromise the cross-comparison of nations with more unreliable reporting structures.
- In addition, World Bank data poorly reflects informal economies, which are especially significant in developing countries. For this reason, the transition patterns detected in regions with high informal components may be poorly captured or misunderstood.
- This project will only focus on the effects of the global pandemic caused by COVID-19 during 2020–2021.
- Ultimately, while the test zeroes in on economic disruptions, it is incapable of fully encapsulating the overall effects of the COVID-19 Pandemic.

3. BACKGROUND OF THE DATASET

Data Sources

This study leverages the World Development Indicators (WDI) from the World Bank Open Data as its primary data source. The WDI provides extensive coverage, encompassing over 200 countries, and a rich historical record. For the purpose of this research, the temporal scope is limited to the period from 2010 to 2025 to concentrate on recent economic developments and resilience patterns. This ensures that the analysis remains relevant to contemporary global economic trends.

Data Structure and Variables

The WDI dataset is structured in a wide format, with each row representing a country-year observation, including thirteen key macroeconomic indicators. These indicators encompass a range of fiscal, income, and economic stability measures. Fiscal metrics include Public Debt, Tax Revenue, Government Revenue, and Government Expense (all as a percentage of GDP). Income and economic activity are captured through Gross National Income (USD), Current Account Balance (% of GDP), GDP Growth (% Annual), total and per capita GDP (Current USD). Economic stability is monitored using Real Interest Rates, Unemployment Rate, and Inflation, using both GDP Deflator and CPI measures.

Data Integration and Validation

To broaden the scope of analysis and enhance the validity of the findings, this study incorporates regional aggregations defined by the United Nations, supporting a comparative study of continental economic trends. To ensure the robustness of the study, the WDI data is cross-verified against supplementary information from the OECD and IMF. These supplementary sources validate labor market trends and fiscal responses and contribute to the accuracy of the visualizations, ensuring that the study draws on a synthesis of statistical and institutional data.

4. LITERATURE REVIEW

The concept of economic resilience has evolved from a static measure of stability to a dynamic understanding of how economies absorb, recover from, and adapt to external shocks. This review synthesizes key theoretical frameworks and recent empirical studies on post-pandemic recovery to contextualize the global disparities in economic performance during the 2010–2023 period.

Distinguishing Vulnerability from Resilience

To measure resilience effectively, it is necessary first to distinguish it from economic vulnerability. Briguglio et al. (2009) provide a foundational distinction between the two, arguing that economic vulnerability arises from inherent, permanent features of an economy, such as openness to trade, export concentration, or dependence on strategic imports. These features expose nations to external shocks. In contrast, economic resilience is defined as the nurtured and policy-induced ability to recover from or withstand the effects of these shocks. This framework suggests that a country can be inherently vulnerable (e.g., a small island nation) but still economically resilient due to sound macroeconomic

management and market efficiency. This dichotomy is central to this study's objective of categorizing nations, as it implies that fragility is not solely a result of exposure to COVID-19, but of a lack of coping mechanisms.

Building on this, Hallegatte (2014) for the World Bank expands the definition by distinguishing between instantaneous resilience (the ability to limit the immediate magnitude of a loss) and dynamic resilience (the speed at which an economy reconstructs and recovers). Hallegatte emphasizes that resilience is not just about GDP aggregate numbers but includes microeconomic factors, such as the ability of households and firms to smooth consumption during disasters. This theoretical underpinning supports the inclusion of broader indicators in this project, such as unemployment and inflation, acknowledging that GDP growth alone does not fully capture an economy's capacity to protect its population from poverty during a downturn.

Current Policies and Structural Reform

While theoretical frameworks define the capacity for resilience, recent literature focuses on the mechanisms that enable recovery, particularly in the wake of the COVID-19 pandemic. The OECD (2021) emphasizes that resilience is not automatic; it relies heavily on "structural agility." Their report argues that economies with diversified supply chains, robust social protection systems, and higher levels of digital transformation were better positioned to absorb the pandemic shock. The OECD highlights that strengthening resilience requires a shift from short-term fiscal buffering to long-term structural changes, such as labor market flexibility and investment in innovation. This perspective validates this study's use of fiscal indicators (e.g., Tax Revenue, Government Expense) to measure how well nations can finance the interventions necessary for recovery.

However, the ability to implement these reforms is unevenly distributed globally. The IMF (2021) examines this divergence through a regional lens, specifically focusing on Sub-Saharan Africa. Their findings suggest that for developing regions, resilience is inextricably linked to fiscal space and external debt sustainability. The IMF notes that while advanced economies could deploy massive fiscal stimulus, many developing nations faced a "funding squeeze" that hampered their recovery. The report concludes that true resilience in these regions requires not just domestic reform but also international cooperation on debt relief and inclusive growth strategies. This highlights a critical geographical divergence in resilience patterns, reinforcing the need for this project's comparative visual analysis of how different regions (Global North vs. Global South) experienced the same shock differently.

Collectively, these works establish that economic resilience is a function of both inherent characteristics and policy choices. However, a significant gap remains in the literature. While Briguglio and Hallegatte provide the theoretical formulas, and the OECD and IMF provide regional or bloc-specific policy analysis, there is a lack of comprehensive, data-driven studies that visualize these resilience patterns across all nations simultaneously over the last decade. Existing studies often isolate specific regions or focus solely on OECD countries, potentially overlooking the "middle-ground" nations. This project addresses that gap by applying these theoretical definitions to a global

dataset (2010–2025), utilizing interactive visualization to reveal the comparative resilience of economies worldwide.

5. METHODOLOGY

Data Set

This study utilizes a comprehensive dataset derived from the World Bank's World Development Indicators (WDI) to evaluate global economic resilience. The analysis integrates thirteen critical macroeconomic metrics, categorized into fiscal health (including Public Debt, Tax Revenue, and Government Expense), economic performance (such as GDP, GNI, and Current Account Balance), and stability (monitored via Inflation, Real Interest Rates, and Unemployment). These indicators were selected for their direct relevance to SDG 8 (Decent Work and Economic Growth) and SDG 17 (Partnerships for the Goals). Specifically, fiscal metrics quantify the budgetary capacity for emergency response, while stability and performance indicators measure the real-time impact of exogenous shocks on national economies.

Data Preparation

To ensure analytical rigor, several preprocessing steps are applied to the raw data. The dataset is filtered to cover the period from 2010 to 2025 across over 200 countries, capturing the distinct phases of recent economic history. Missing values are managed through a hybrid imputation strategy, utilizing linear or spline interpolation for short gaps to preserve time-series continuity, while explicitly flagging extensive gaps to maintain data integrity. Furthermore, a derived temporal variable segments the data into Pre-pandemic (2010–2019), Pandemic (2020–2021), and Recovery (2022–2025) phases. Finally, to facilitate equitable comparisons between economies of vastly different scales, all indicators undergo normalization (e.g., Min-Max scaling) to standardize performance relative to economy size.

¹ Briguglio, L., Cordina, G., Farrugia, N., & Vella, S. (2009). Economic vulnerability and resilience: Concepts and measurements. UNU World Institute for Development Economics Research (UNU WIDER). <https://www.econstor.eu/bitstream/10419/45146/1/571437761.pdf>

² Hallegatte, S. (2014). Economic resilience: Definition and measurement (Policy Research Working Paper 6852). World Bank. <https://openknowledge.worldbank.org/handle/10986/18341>

³ International Monetary Fund. (2021). Post-COVID-19 recovery and resilience: Leveraging reforms for growth and inclusion in Sub-Saharan Africa (IMF Working Paper 2021/072). <https://www.imf.org/en/Publications/WP/Issues/2021/02/19/Post-Covid-19-Recovery-and-Resilience-Leveraging-Reforms-for-Growth-and-Inclusion-in-Sub-50103>

² OECD. (2021). Strengthening economic resilience following the COVID-19 crisis: A firm and industry perspective. <https://doi.org/10.1787/2a7081d8-en>

Construction of the Resilience Index

To quantify the capacity of nations to absorb and recover from exogenous shocks, this study constructs a composite Resilience Index grounded in the theoretical framework established by Briguglio et al. [2009]. The index operationalizes the concept of "nurtured resilience"—policy-induced capabilities that allow an economy to withstand external volatility—by synthesizing four critical dimensions: Fiscal Health, Economic Growth, External Stability, and Monetary Conditions. The composite score is calculated using a weighted summation approach, defined formally as:

Resilience Index = (Fiscal x 0.3) + (Growth x 0.3) + (External x 0.2) + (Monetary x 0.2)

In this model, higher weights (0.3) are assigned to the Fiscal and Growth components, reflecting their primacy in providing the immediate liquidity and structural absorption capacity necessary to mitigate the initial impact of a crisis. Conversely, External and Monetary factors are weighted at 0.2, serving as auxiliary stabilizing mechanisms that facilitate long-term adjustment and recovery (Briguglio et al., 2009).

Exploratory Data Analysis (EDA)

The Exploratory Data Analysis (EDA) phase establishes a baseline assessment of global economic health by generating descriptive statistics across regional aggregations. This process involves calculating distributions for growth, debt, and labor metrics to identify central tendencies and dispersion. Additionally, correlation analyses are conducted to examine the complex interplay between Public Debt, Inflation, and GDP Growth, elucidating how fiscal pressures interact with monetary conditions. Preliminary visualizations, including histograms and boxplots, are employed to detect outliers and map the regional variance of inflation and unemployment prior to more complex modeling.

Figure 5.1 displays linear correlations between key economic indicators, utilizing a color scale that ranges from -1.00 (strong negative, blue) to +1.00 (strong positive, red). Among the significant relationships revealed is a negative correlation of -0.42 between inflation (CPI %) and the real interest rate, while public debt (% of GDP) exhibits a moderate positive correlation of 0.33 with GDP per capita. Overall, these correlations provide a high-level view of the structural relationships within the dataset, indicating how fiscal variables (like public debt) and monetary variables (like inflation and interest rates) tend to move together across the observed countries.

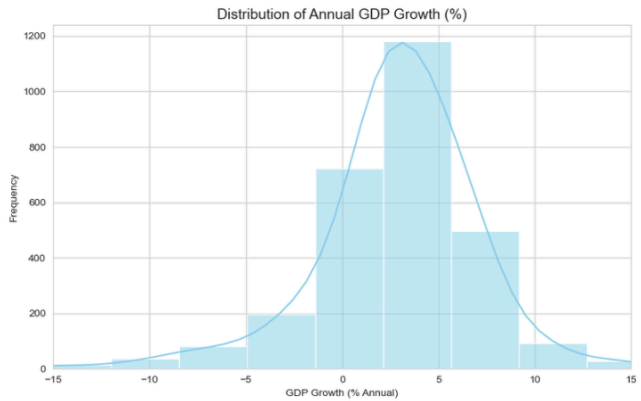


Figure 5.2 Distribution of Annual GDP Growth (%)

Figure 5.2 effectively illustrates the frequency distribution of annual GDP Growth (%) rates. The distribution is roughly bell-shaped (normal), with a noticeable peak in the 3% to 6% range. This central tendency indicates that moderate growth is the most frequent outcome across the countries and years observed, while the shape of the distribution confirms that extreme economic events, such as deep negative growth (recession) or exceptionally high growth rates, are comparatively rare occurrences.

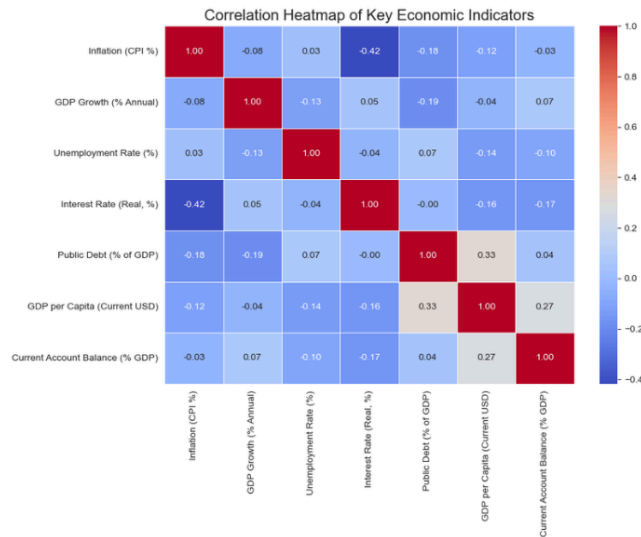


Figure 5.1 Correlation Heatmap of Key Economic Indicators

¹ Briguglio, L., Cordina, G., Farrugia, N., & Vella, S. (2009). Economic vulnerability and resilience: Concepts and measurements. UNU World Institute for Development Economics Research (UNU WIDER). <https://www.econstor.eu/bitstream/10419/45146/1/571437761.pdf>

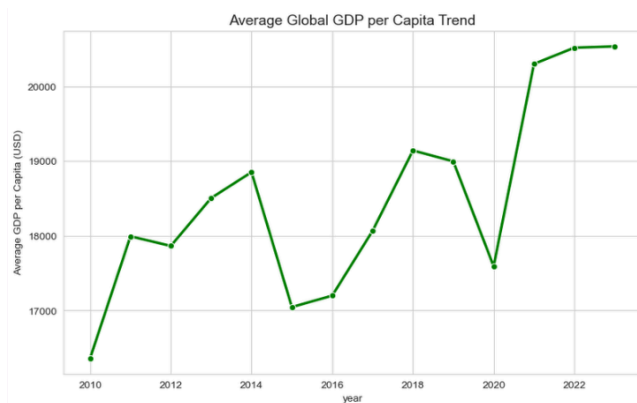


Figure 5.3 Line Graph of Average Global GDP per Capita Trend

The chart reveals a clear upward trend in the Average Global GDP per Capita (USD) from 2010 to 2023, signaling long-term economic improvement worldwide. Despite this general growth, the time series experienced notable fluctuations, specifically sharp declines observed around 2015 and again in 2020 (coinciding with the COVID-19 pandemic). The highest levels of GDP per capita, exceeding \$20,000, were ultimately achieved in the final years of the series, 2022 and 2023.

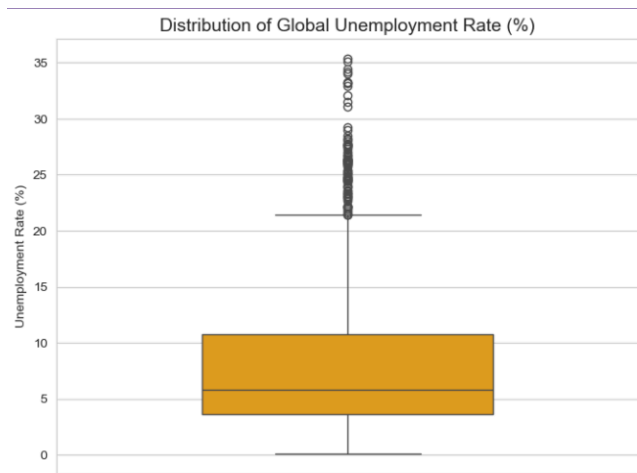


Figure 5.4 Box Plot Distribution of Global Unemployment Rate (%)

Figure 5.4 illustrates the distribution of global unemployment rates, revealing that the middle 50% of observations (the Interquartile Range) falls between approximately 4% and 10.5%. The distribution of the data is visually skewed to the right, indicating a longer tail toward higher unemployment figures. Furthermore, the plot highlights a significant number of outliers, represented by individual circles, which correspond to extremely high unemployment rates, with some nations reaching levels of nearly 35%.

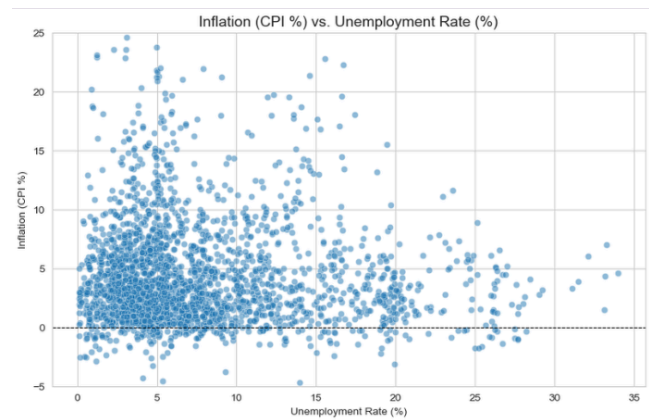


Figure 5.5 Scatter Plot of Inflation (CPI %) vs Unemployment Rate (%)

The scatter plot reveals no strong linear correlation between the Unemployment Rate (%) and Inflation (CPI %), as evidenced by the wide dispersion of the data points. The bulk of the observations indicates that Inflation (CPI %) remains below 10% and the Unemployment Rate (%) is under 15%, although the chart does include extreme values for both economic variables.

Data Visualization

The study presents findings through a multi-layered visualization framework designed to communicate resilience patterns effectively. Time series line charts track long-term trends in GDP and inflation, highlighting the volatility introduced by the COVID-19 crisis, while global choropleth maps provide a geospatial assessment of the "Resilience Index" across nations. To analyze distributional shifts, ridgeline plots illustrate how economic disparities widen during crisis periods, complemented by cluster scatterplots that visually distinguish "resilient" from "fragile" economies. These visual components are synthesized into an interactive dashboard (using tools like Tableau or Plotly), enabling users to filter data by time, region, or indicator for granular, comparative exploration.

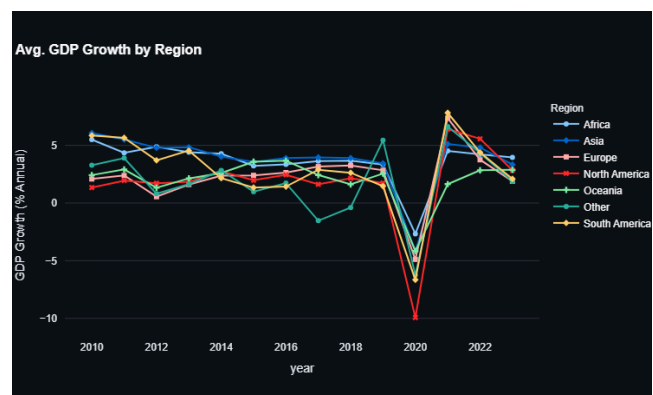


Figure 5.6 Time Series Line Chart of Avg. GDP Growth by Region

Figure 5.6 illustrates the divergent impact of the COVID-19 shock across global regions, while the accompanying histogram shows the overall distribution of annual GDP growth rates. The line chart reveals that all regions experienced a sharp and synchronized contraction in 2020, with North America

suffering the deepest drop, approaching -10% annual growth, followed closely by Europe. The period between 2010 and 2019 was characterized by relative stability, with most regions sustaining growth between 0% and 5%, primarily led by Africa and Asia. Furthermore, the recovery was equally sharp in 2021, especially for the regions that contracted most severely. The overall distribution of the underlying annual GDP growth data, shown in the histogram, is roughly bell-shaped (normal), peaking in the 3% to 6% range, which confirms that moderate growth rates are the most common outcome, while extreme negative or high growth rates are less frequent.

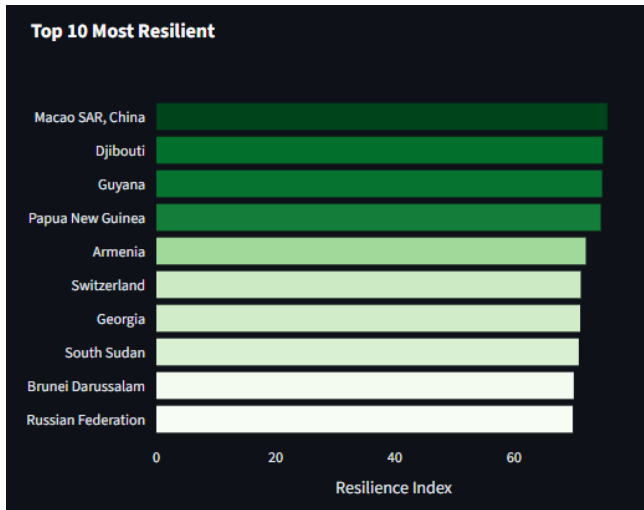


Figure 5.7 Bar Chart of The Top 10 Most Resilient Countries in 2023

Figure 5.7 identifies the nations with the highest Resilience Index scores for 2023. The top four are Macao SAR, China, Djibouti, Guyana, and Papua New Guinea, all achieving scores in the high 70s. The rest of the top ten includes Armenia, Switzerland, Georgia, South Sudan, Brunei Darussalam, and the Russian Federation. This diverse grouping clearly demonstrates that superior economic resilience, as measured by this index in 2023, is a heterogeneous trait, not confined to major economic or regional blocs. A major developed economy like Switzerland, for instance, ranks alongside much smaller, developing nations across different continents, indicating that factors other than sheer size or traditional wealth determine a country's ability to withstand economic shocks.

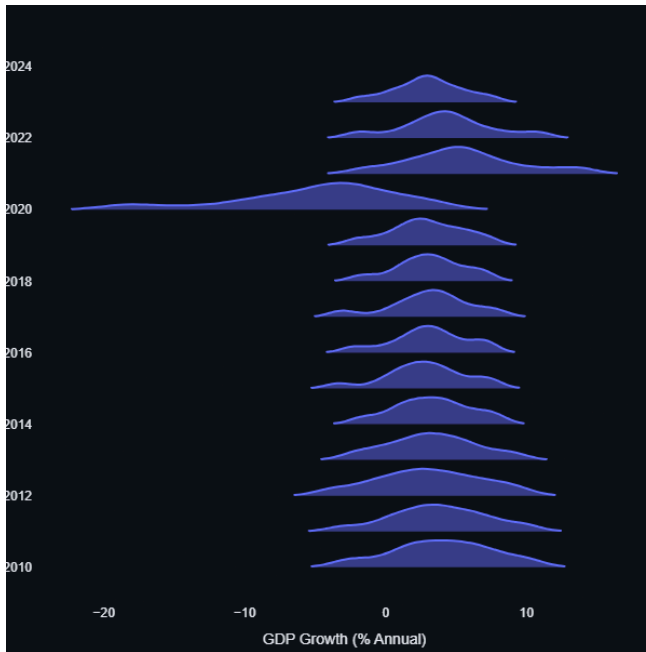


Figure 5.8 Ridgeline Plot of GDP Growth (% Annual)

Figure 5.8 illustrates the distribution of annual GDP growth rates over multiple years, showing how economic performance has shifted through time. Earlier years are characterized by relatively narrow distributions clustered around modest positive growth, indicating more stable economic conditions. As time progresses, the ridges widen, suggesting increased volatility in GDP growth. A pronounced leftward extension appears around 2020, reflecting a sharp economic contraction likely associated with a major global shock. In the most recent years, the distributions have shifted back toward positive growth, with peaks centered at higher values, signaling recovery and renewed expansion. Overall, the plot highlights a transition from stability to disruption and then toward gradual recovery, emphasizing how economic growth dynamics evolve in response to external shocks and subsequent rebound phases.

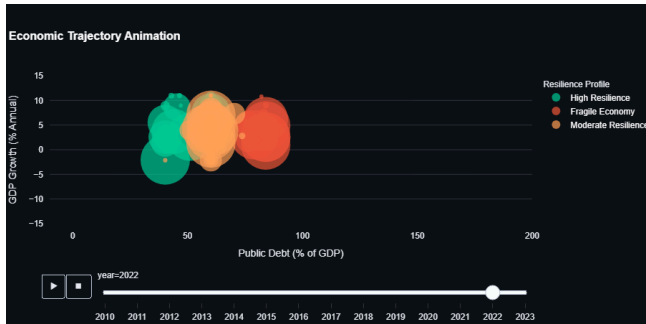


Figure 5.9 Economic Trajectories of Countries by Public Debt, GDP Growth, and Resilience Profile (2010–2023)

Figure 5.9 presents an economic trajectory visualization showing the relationship between public debt and annual GDP growth over time. Economies are grouped by resilience profiles: high resilience, moderate resilience, and fragile economies. High-resilience economies cluster at lower debt levels and generally maintain positive growth, indicating stronger capacity to absorb shocks. Moderate-resilience economies occupy the middle

range, with higher debt and more variable growth outcomes. Fragile economies are concentrated at higher debt levels and exhibit weaker or less stable growth performance. The animated timeline suggests how these groups evolve across years, highlighting divergence in fiscal sustainability and growth paths. Overall, the visualization emphasizes that lower public debt combined with consistent growth is associated with greater economic resilience, while high debt burdens tend to constrain growth and increase vulnerability to economic disruptions.

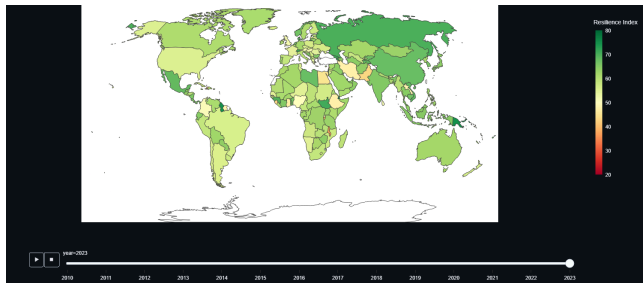


Figure 5.10 Global Choropleth Map of 2023 (Post-Pandemic)

Figure 5.10 presents a global choropleth map showing the distribution of the Economic Resilience Index across countries in 2023. Nations are color-coded according to their resilience scores, with greener shades indicating higher resilience and yellow to red tones representing lower resilience levels. The map reveals strong regional disparities, as many countries in Europe, North America, and parts of East Asia demonstrate relatively high economic resilience. In contrast, several countries in parts of Africa, South Asia, and the Middle East exhibit lower resilience scores, reflecting greater vulnerability to economic shocks. Overall, the figure highlights the uneven global capacity to absorb and recover from economic disturbances in 2023, emphasizing persistent structural differences in economic stability and adaptive capacity across regions.

6. DATA ANALYSIS

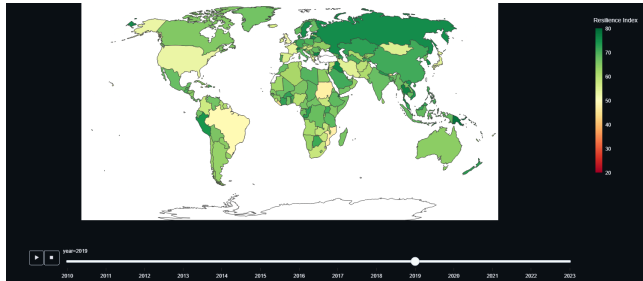


Figure 6.1 Global Choropleth Map of 2019 (Pre-Pandemic)

Figure 6.1 shows country-level resilience index values for the year 2019, before the COVID-19 pandemic struck. Countries are color-coded along a gradient, with darker greens indicating higher resilience and lighter or warmer tones representing lower resilience. The map provides a clear, comparative snapshot of how resilience varied across regions worldwide prior to the profound social, economic, and health disruptions caused by COVID-19. High resilience is concentrated in parts of Europe, East Asia, and Oceania, while lower scores are more prevalent across parts of Africa, Latin America, and the Middle East. By focusing on 2019, the map serves as an important pre-pandemic baseline, allowing viewers to understand global

disparities and contextualize how resilience levels may have influenced countries’ ability to respond to and recover from the pandemic that followed.

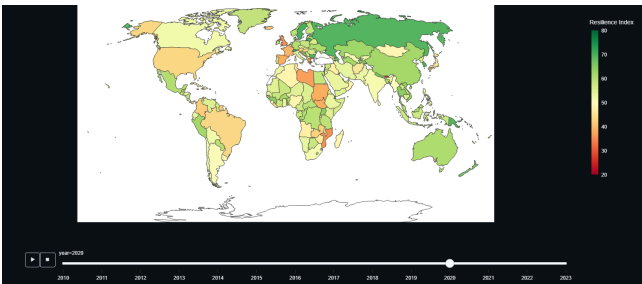


Figure 6.2 Global Choropleth Map of 2020 (During Pandemic)

Figure 6.2 shows country-level resilience index values during the first year of the COVID-19 pandemic. Countries are shaded from red and yellow, indicating lower resilience, to darker green, indicating higher resilience. Compared with 2019, more regions, particularly parts of Africa, Latin America, and South Asia, show reduced or moderate resilience, reflecting early economic, health, and institutional strain caused by COVID-19. Higher resilience remains concentrated in parts of Europe, East Asia, and Oceania, although some declines are visible. Overall, the map illustrates the uneven global impact of the pandemic in 2020 and highlights how resilience varied widely as countries responded to an unprecedented global shock.



Figure 6.3 Bar Chart of The Top 10 Most Resilient Countries in 2019

Figure 6.3 displays the top 10 most resilient countries in 2019, ranked by their resilience index. The horizontal bars show resilience scores on a scale from low to high, with darker green shades representing higher resilience. The Marshall Islands ranks highest, followed closely by Timor Leste, Eswatini, and Papua New Guinea. Estonia and Switzerland also show strong resilience levels, while Thailand, Kiribati, Bulgaria, and Djibouti complete the top ten with slightly lower but still comparatively high scores. Overall, the chart highlights that high resilience in 2019 was not limited to a single region, as countries from Oceania, Europe, Africa, and Asia are all represented, emphasizing the diverse

geographic distribution of resilience prior to the COVID-19 pandemic.

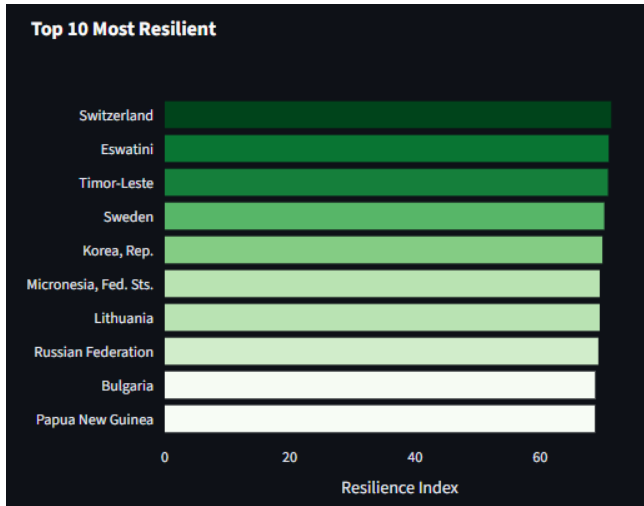


Figure 6.4 Bar Chart of The Top 10 Most Resilient Countries in 2020

Figure 6.4 presents the top 10 most resilient countries in 2020, a year marked by the height of the global COVID-19 pandemic. The resilience index scores reflect how well countries were able to withstand and adapt to severe health, economic, and social disruptions. Switzerland ranks highest, followed by Eswatini and Timor-Leste, demonstrating exceptional stability and adaptive capacity during an unprecedented global crisis. Sweden and South Korea also stand out, highlighting strong institutional frameworks and crisis response systems. The presence of countries such as Micronesia, Lithuania, and Papua New Guinea further underscores the remarkable diversity of resilience across regions and income levels. What makes this chart especially striking is that these high resilience scores were achieved during one of the most challenging periods in modern history. Despite widespread uncertainty, lockdowns, and economic shocks, these countries maintained strong resilience, showcasing effective governance, social cohesion, and adaptability in the face of extraordinary global pressure.

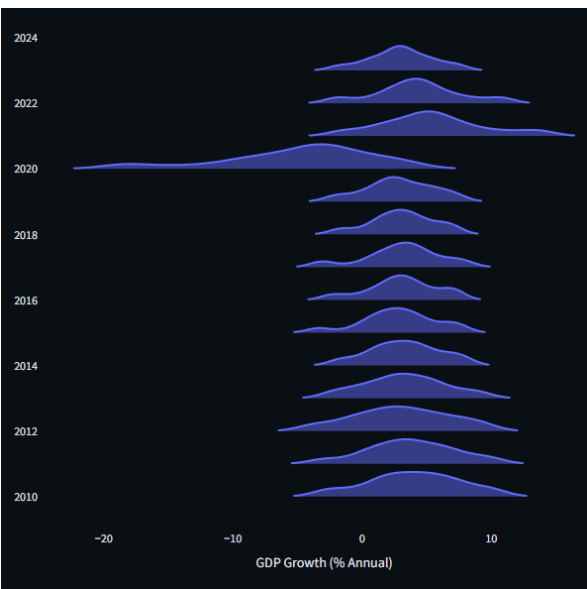


Figure 6.4 Ridgeline Plot of GDP Growth (% Annual)

Figure 6.4 visualizes the distribution of annual GDP growth rates over time, with each horizontal curve representing a different year from 2010 to 2024. The x-axis shows GDP growth as a percentage, while the stacked density curves highlight how growth outcomes are spread in each year. Most years display distributions centered around moderate positive growth, indicating relative economic stability. The curve for 2020 stands out sharply, stretching far into negative territory, reflecting the severe global economic contraction during the COVID-19 pandemic. In contrast, the years following 2020 show a noticeable rebound, with distributions shifting back toward positive growth. Overall, the plot effectively captures both long-term economic patterns and the dramatic disruption and recovery associated with the pandemic period.

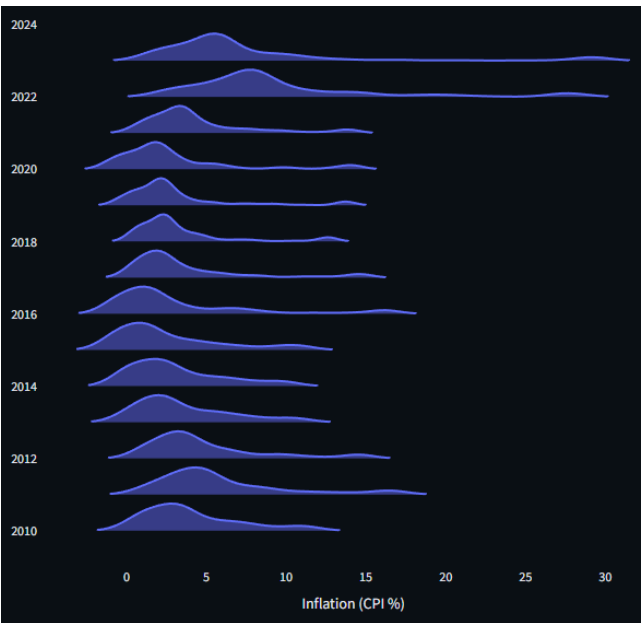


Figure 6.5 Ridgeline Plot of GDP Growth Inflation (CPI %)

Figure 6.5 illustrates the distribution of inflation rates measured by CPI percentage from 2010 to 2024, with each horizontal curve representing a different year. The x-axis shows inflation levels, while the shape of each ridge reflects how inflation outcomes are distributed across countries in that year. Earlier years generally show inflation clustered at lower and more stable values. Around 2020, the distributions began to widen, indicating increased variability during the pandemic period. In the years after 2020, especially 2022 and 2024, the curves shift noticeably to the right, showing higher and more dispersed inflation rates. This pattern highlights the global surge in inflation following pandemic-related disruptions, supply chain pressures, and policy responses, and clearly demonstrates how inflation dynamics changed over time.

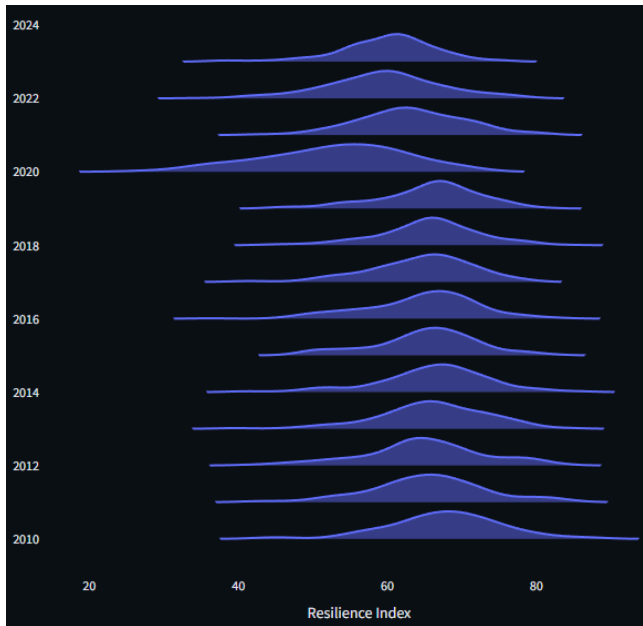


Figure 6.6 Ridgeline Plot of Resilience Index

Figure 6.6 shows the distribution of the Resilience Index from 2010 to 2024, with each horizontal curve representing a different year. The x-axis displays resilience index values, while the shape and position of each ridge illustrate how resilience levels are spread across countries over time. In earlier years, the distributions are more tightly clustered around mid-range values, suggesting relatively stable global resilience. Around 2020, the curve becomes wider and slightly shifts, reflecting increased variation and stress during the COVID-19 pandemic. In the years that follow, particularly 2022 and 2024, the distributions shift toward higher index values, indicating a gradual recovery and strengthening of resilience across many countries. Overall, the plot highlights long-term resilience trends, clearly capturing the disruption caused by the pandemic and the subsequent improvement as countries adapted and rebuilt capacity in the post-pandemic period.

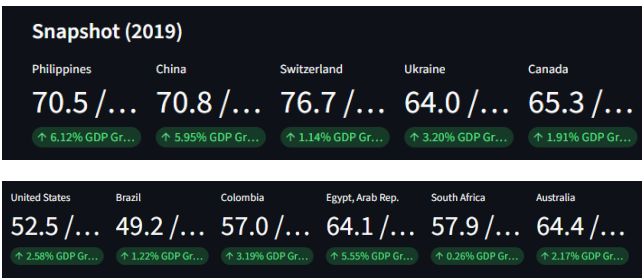


Figure 6.7 GDP Growth Rates Snapshot of 2019 (Pre-Pandemic)

Figure 6.7 highlights GDP growth rates in 2019 for a selection of countries. All listed economies show positive growth, indicating broad global expansion before the COVID-19 pandemic. China and the Philippines record the strongest growth, both above 5 percent, reflecting rapid economic momentum. Egypt and Colombia also demonstrate solid performance, while developed economies such as Switzerland, Canada, Australia, and the United States show more moderate but steady growth. Overall, the snapshot captures a period of widespread economic stability and growth across both emerging and advanced economies prior to the global downturn that followed.

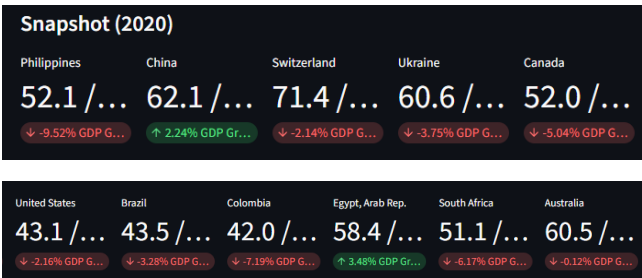


Figure 6.8 GDP Growth Rates Snapshot of 2019 (During Pandemic)

Figure 6.8 shows GDP growth rates in 2020, reflecting the economic impact of the COVID-19 pandemic. Most countries experienced negative growth, highlighted in red, including the Philippines, the United States, Canada, Brazil, and South Africa, indicating widespread contraction. China and Egypt stand out with positive growth, showing relative resilience during the global downturn. Overall, the snapshot illustrates the sharp and uneven economic disruption of 2020, marking a clear contrast with the broad expansion seen in 2019.

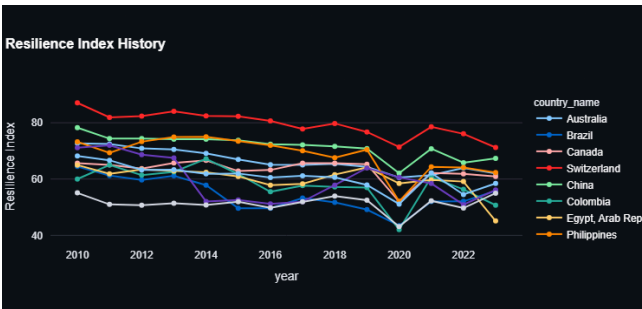


Figure 6.9 Time Series Line Chart of Resilience Index History

Figure 6.9 presents the Resilience Index history from 2010 to 2023 for selected countries, illustrating long-term trends

and country-level differences. Most countries show gradual fluctuations rather than abrupt changes during the pre-pandemic years, suggesting relatively stable resilience levels. A pronounced dip appears around 2020, reflecting the widespread shock caused by the COVID-19 pandemic, with nearly all countries experiencing a temporary decline. Following this disruption, several countries show partial recovery in subsequent years, though resilience levels do not always return to their earlier peaks. Canada and Switzerland generally maintain higher resilience scores across the period, while countries such as Brazil, Colombia, and the Philippines display greater volatility. Overall, the chart highlights how resilience evolved over time, emphasizing both the shared global impact of the pandemic and the differing capacities of countries to recover in the years that followed.

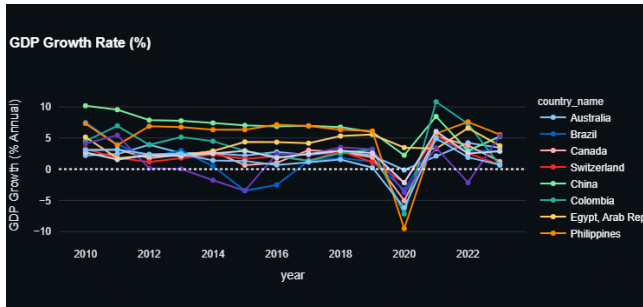


Figure 6.10 Time Series Line Chart of Avg. GDP Growth Rate (%)

Figure 6.10 shows annual GDP growth rates from 2010 to 2023 for selected countries. Growth is generally positive and stable in the years before 2020, with moderate differences across countries. A sharp and synchronized decline occurs in 2020, reflecting the severe economic impact of the COVID-19 pandemic, with several countries experiencing deep contractions. In the years that follow, most countries show a strong rebound, with growth returning to positive levels, though volatility remains. Overall, the chart highlights both the global shock of 2020 and the uneven pace of economic recovery afterward.

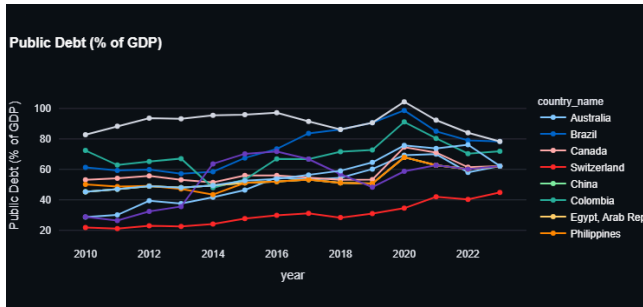


Figure 6.11 Time Series Line Chart of Public Debt (% of GDP)

Figure 6.11 illustrates public debt as a percentage of GDP from 2010 to 2023 for selected countries. Debt levels generally trend upward over time, with moderate increases before 2020. A sharp rise occurs around 2020, reflecting increased government borrowing during the COVID-19 pandemic. After 2020, some countries show gradual stabilization or slight declines, while others maintain elevated debt levels. Overall, the chart

highlights how the pandemic significantly intensified public debt burdens across countries.



Figure 6.12 Time Series Line Chart of Inflation Rate (%)

Figure 6.12 shows inflation rates from 2010 to 2023 across selected countries. Inflation remained relatively low and stable for most countries before 2020. During the pandemic period, inflation dipped slightly, followed by a sharp surge in 2022, particularly in some emerging economies. After this spike, inflation begins to ease but remains elevated compared with pre-pandemic levels. Overall, the chart highlights the significant inflationary pressures that emerged globally in the post-pandemic recovery period.

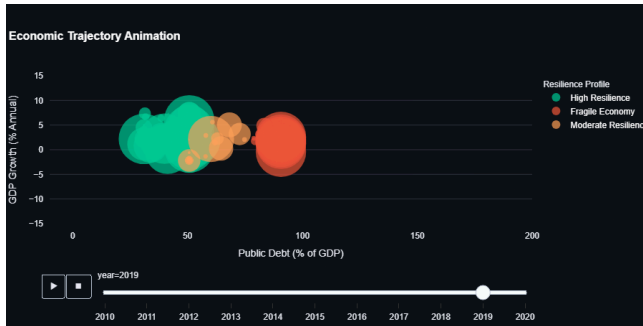


Figure 6.13 Economic Trajectories of Countries by Public Debt, GDP Growth, and Resilience Profile of 2010-2019 (Pre-Pandemic)

Figure 6.13 illustrates economic trajectories from 2010 to 2019, before the COVID-19 pandemic, plotting GDP growth against public debt as a share of GDP. Each bubble represents a country, with colors showing resilience profiles. High-resilience countries cluster around moderate debt and steady positive growth, while fragile economies tend to combine higher debt with weaker growth. The chart highlights clear pre-pandemic differences in economic stability and resilience across countries.

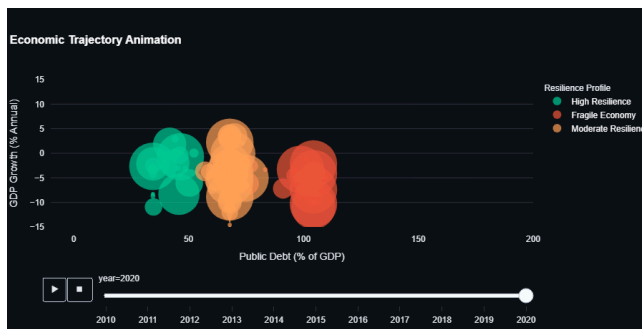


Figure 6.14 Economic Trajectories of Countries by Public Debt, GDP Growth, and Resilience Profile of 2010-2020 (Including Pandemic)

Figure 6.14 shows economic trajectories in 2020, during the COVID-19 pandemic, plotting GDP growth against public debt as a share of GDP. Compared with 2019, most countries shifted downward, reflecting widespread economic contraction. Public debt levels rise across all resilience profiles, with fragile economies showing the weakest growth and highest debt burdens. High-resilience countries perform relatively better but still experience negative growth. Overall, the chart highlights the severe and uneven economic shock of the pandemic year.

Differential Resilience to the COVID-19 Shock

The visualizations demonstrate a marked heterogeneity in how nations absorbed the pandemic shock, characterized by a distinct divergence between "High Resilience" and "Fragile" economies. As evidenced by the Economic Trajectory Animation (Scatter Plot), the onset of the pandemic in 2020 caused a universal contraction in GDP growth, effectively shifting the global cluster downward. However, the magnitude of this collapse varied significantly; resilient nations (represented by green bubbles, such as Switzerland and China) experienced milder contractions or maintained near-positive growth, whereas fragile economies (orange/red bubbles) suffered deep double-digit negative growth. The GDP Growth Rate time series further illustrates this uneven impact: while economies like China maintained a positive trajectory, others, such as the Philippines, experienced a sharp "V-shaped" plunge followed by a volatile recovery. The Resilience Index History confirms this disparity, showing that while the global average resilience score dipped in 2020, top-tier nations like Switzerland maintained a buffer that allowed for a faster return to stability compared to emerging markets.

Key Explanatory Indicators

The Public Debt (% of GDP) and Inflation Rate charts suggest that fiscal health was the primary determinant of resilience during the initial shock, while monetary stability defined the recovery phase. The scatter plots reveal a clear negative correlation between high public debt and resilience; the "Fragile Economy" cluster is predominantly populated by nations with high or rapidly expanding debt burdens (exceeding 80-90% of GDP). In contrast, the Top 10 Most Resilient bar charts consistently feature countries with strong fiscal buffers (e.g., Switzerland, Estonia, Sweden), implying that low leverage provided the necessary fiscal space to execute stimulus measures without destabilizing the economy. Furthermore, the Inflation Rate ridgeline and line plots indicate that while inflation was not the immediate driver of the 2020 crisis, it became the critical stressor in the recovery phase (2022–2023), differentiating

countries that could manage post-stimulus overheating from those that succumbed to purchasing power degradation (e.g., Egypt).

Consistency of Regional Patterns

Regional patterns of resilience appear robust and structurally consistent across the analyzed timeframe, though the gap between regions has widened during the crisis. The Choropleth Maps (2019 vs. 2020) display a persistent "resilience divide," where the Global North (North America, Western Europe) and select Asian economies (China, South Korea) consistently maintain higher resilience scores (green hues) compared to the lower scores observed in Latin America and South Asia (yellow/orange hues). The Ridgeline Plots for GDP Growth and Resilience Index offer a critical insight into this dynamic: in 2020 and 2021, the distributions flatten and widen, indicating that while the shock was global, the dispersion of outcomes increased. This suggests that crises exacerbate existing regional inequalities; established economic blocs with institutional strength recover to their pre-pandemic baseline quickly, while peripheral regions experience a prolonged period of "fragility," struggling to close the widening gap.

Implications for SDG 8 and Global Development Priorities

The empirical trends observed across the visualizations underscore a critical dependency between macroeconomic resilience and the successful realization of Sustainable Development Goal 8 (Decent Work and Economic Growth) and SDG 1 (No Poverty). The divergence illustrated in the Resilience Index History and Ridgeline Plots reveals that "fragile" economies—burdened by the high public debt and volatile inflation seen in the time-series analysis—faced significant barriers to the "sustained and inclusive economic growth" mandated by SDG 8. Unlike the resilient clusters that utilized fiscal buffers to protect employment and consumption, fragile nations experienced deep contractions that threatened to entrench poverty, directly undermining SDG 1. The geospatial persistence of low resilience in the Global South suggests that current development priorities must pivot beyond mere GDP targeting toward structural stabilization. Specifically, the data indicates that without addressing the systemic vulnerabilities of debt distress and inflationary pressure, the global development agenda risks a "K-shaped" recovery where the most vulnerable populations are left behind, effectively stalling progress on the 2030 Agenda.

7. CONCLUSION

Summary of Findings and SDG Implications

The empirical analysis reveals a distinct divergence in global economic resilience, characterized by a "resilience divide" that was significantly exacerbated by the COVID-19 pandemic. The visualizations demonstrate that nations with pre-existing fiscal buffers—specifically low public debt and stable inflation—were able to absorb the exogenous shock of 2020 with minimal long-term scarring, whereas highly leveraged economies experienced deep, prolonged contractions. These findings have profound implications for Sustainable Development Goal 8 (Decent Work and Economic Growth), as the inability of fragile economies to sustain growth directly undermines the creation of productive employment. Furthermore, this instability poses a critical threat to SDG 1 (No Poverty). The widening gap between the "High Resilience" and "Fragile" clusters suggests that without structural interventions, developing nations face a heightened risk of regression, where economic volatility translates directly into

income insecurity and reverses decades of progress in poverty reduction. The analysis underscores that building macroeconomic resilience is not merely a financial objective but a fundamental prerequisite for safeguarding the livelihoods of the world's most vulnerable populations.

Methodological Limitations

While this study provides a robust macro-level assessment, several methodological limitations must be acknowledged. First, the reliance on the World Development Indicators (WDI) introduces an inherent reporting lag; consequently, some 2024–2025 data points rely on projections or interpolations which, while statistically sound for trend analysis, may not fully capture sudden, recent policy shifts. Second, the normalization process, though necessary for comparing diverse economies, may mask absolute capacity differences; a small island nation and a G7 power might share similar "resilience scores" based on ratios, yet possess vastly different absolute capabilities to fund recovery. Finally, the exclusion of the informal economy—which constitutes a significant portion of GDP in developing nations—means that the calculated resilience metrics may understate the true extent of economic vulnerability in the Global South.

Policy Recommendations and Future Directions

In light of these findings, policymakers must prioritize counter-cyclical fiscal frameworks that build debt buffers during growth periods to ensure liquidity during crises. For international bodies, the clear correlation between high debt and fragility supports the case for targeted debt relief mechanisms as a tool for global stability. Future research should expand the scope of this analysis by integrating high-frequency, real-time data sources (e.g., trade flows or satellite imagery) to mitigate reporting lags. Additionally, there is significant potential in applying machine learning techniques, such as Long Short-Term Memory (LSTM) networks or Random Forest classifiers, to move from descriptive analysis to predictive modeling. Such approaches could identify early warning signs of fragility, enabling preemptive interventions before economic shocks crystallize into full-scale crises.

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