Quantitative Methods for Business and Economics

Project - Part-1 Data Management For B&E

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Abstract: This comprehensive report presents a detailed analysis of the Constant GDP per capita for five prominent European countries— Portugal, Italy, Germany, Spain, and France - over the period of 01-01-1995 to 01-01-2024. The study aims to unravel the economic trajectories, identify patterns, and offer insights into the factors influencing the economic performance of these nations.

1. **Introduction**: Economic indicators play a pivotal role in understanding a nation's economic health. Constant GDP per capita serves as a crucial metric, accounting for inflation and population growth. This study explores the nuances of this indicator across five diverse economies.

2. **Data Collection and Preprocessing**: Data was meticulously gathered from the Federal Reserve Economic Data (FRED) repository, ensuring a consistent and reliable dataset.

3. **Time-series of Constant GDP per capita (1995-2024**) Upon importing the data into MATLAB, the first step plot annual time-series of Constant GDP per capita of Portugal, Italy, Germany, Spain, France from 1995to 2025 involved calculating the annual changes and rates of change for each country.

- ***The chart highlights significant economic trends in GDP per capita for five European countries over nearly three decades (1995–2024). Key conclusions.***

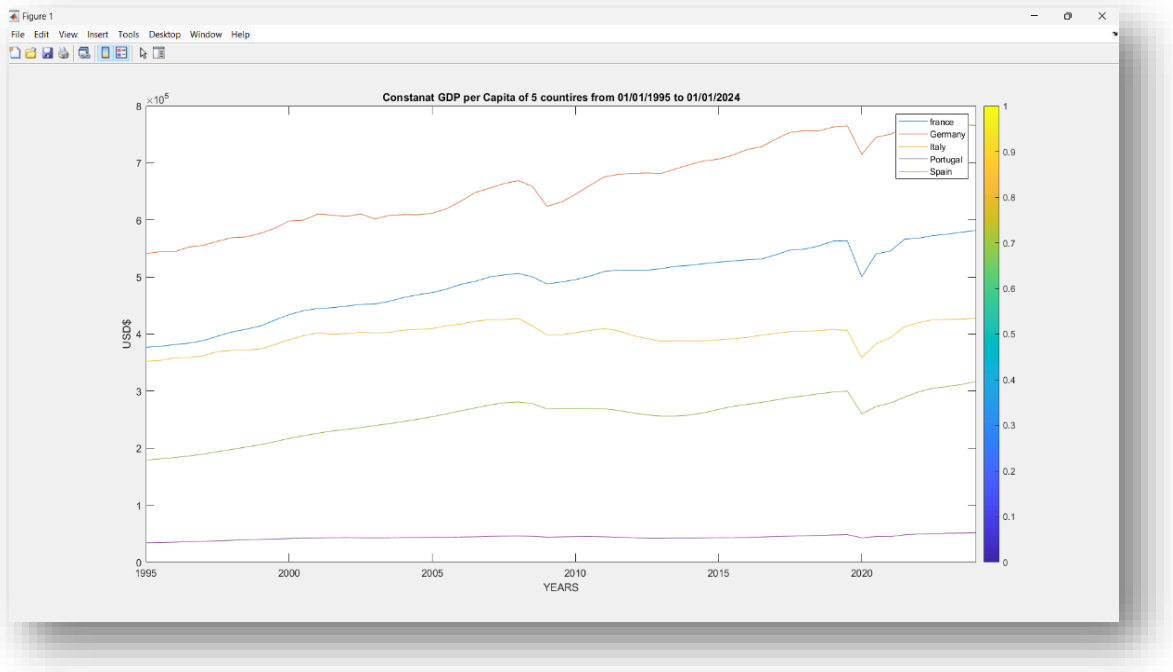

Figure – 1

- **Germany (orange)** consistently shows the highest GDP per capita among these countries, reflecting a steady upward trend and robust economic growth. **France (blue)** follows with the second-highest GDP per capita, exhibiting a similar upward trend, albeit at a slightly lower level than Germany. **Italy (yellow)** and **Spain (green**) trail behind, showing less pronounced growth and experiencing some fluctuations over the years. **Portugal (purple)**, while having the lowest GDP per capita among the group, demonstrates gradual and consistent growth throughout the period.

- ***This chart illustrates the rate of change in constant GDP per capita for five countries (France, Germany, Italy, Portugal, and Spain) over time. The rate of change indicates the percentage increase or decrease in GDP per capita from one year to the next.***

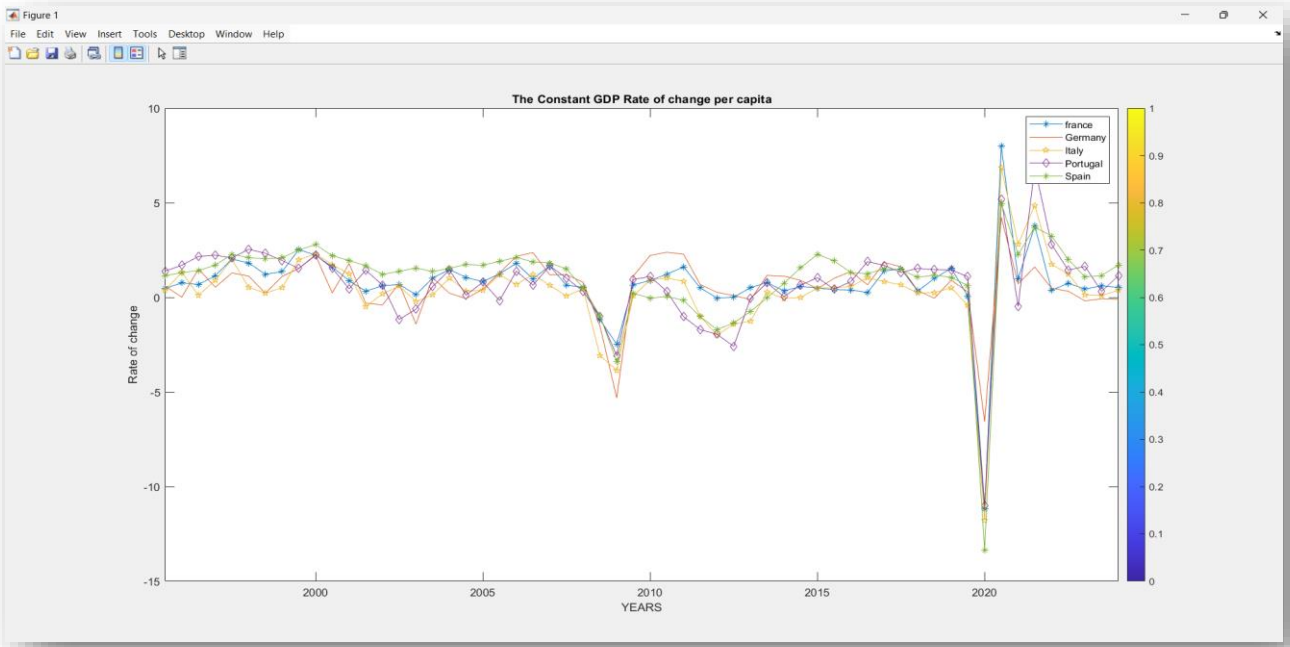

Figure – 2

- The figure-3 shows changes in GDP per capita for France, Germany, Italy, Portugal, and Spain. Most countries have stable fluctuations around zero, reflecting consistent growth. Major drops occurred during the 2009 financial crisis and the 2020 COVID-19 pandemic. Recovery rates since 2020 vary, with some countries rebounding faster. While trends are similar across countries, slight differences highlight unique recovery speeds and resilience to global shocks. The figure-3captures the impact of global events and short-term economic volatility.

- ***This figure - 3 consists of histograms representing the distribution of the percentage rate of change in GDP per capita for five countries. The purpose of creating these histograms is to analyse the variability and distribution of GDP growth rates over time, providing insights into the economic stability and growth dynamics of each country***.

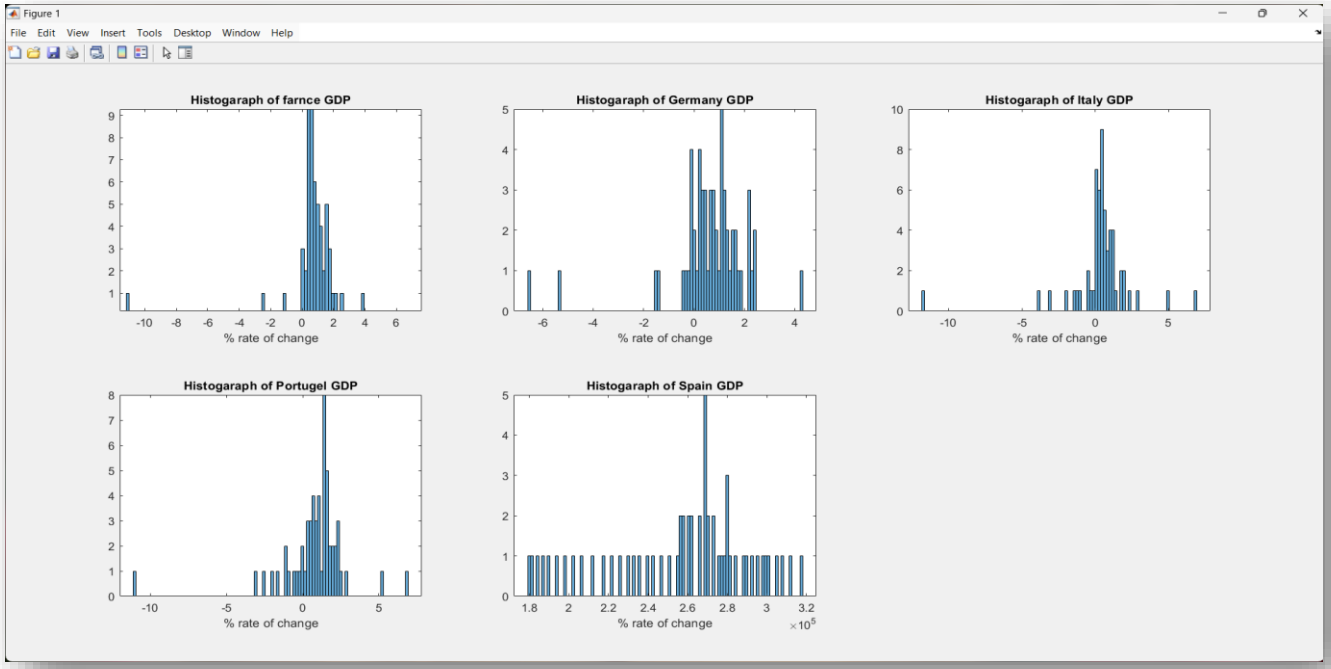

Figure – 3

- GDP growth rate distributions show economic stability and variability. France and Germany have stable growth near 0%, while Italy shows slightly more variation. Portugal has higher volatility, and Spain combines stability with occasional larger changes. This highlights differences in economic patterns and resilience.

- ***The figure-4 histograms comparing the standardized growth rates of GDP for five countries (France, Germany, Italy, Portugal, and Spain) against the standard normal distribution (red curve). Here's a breakdown and comparison***

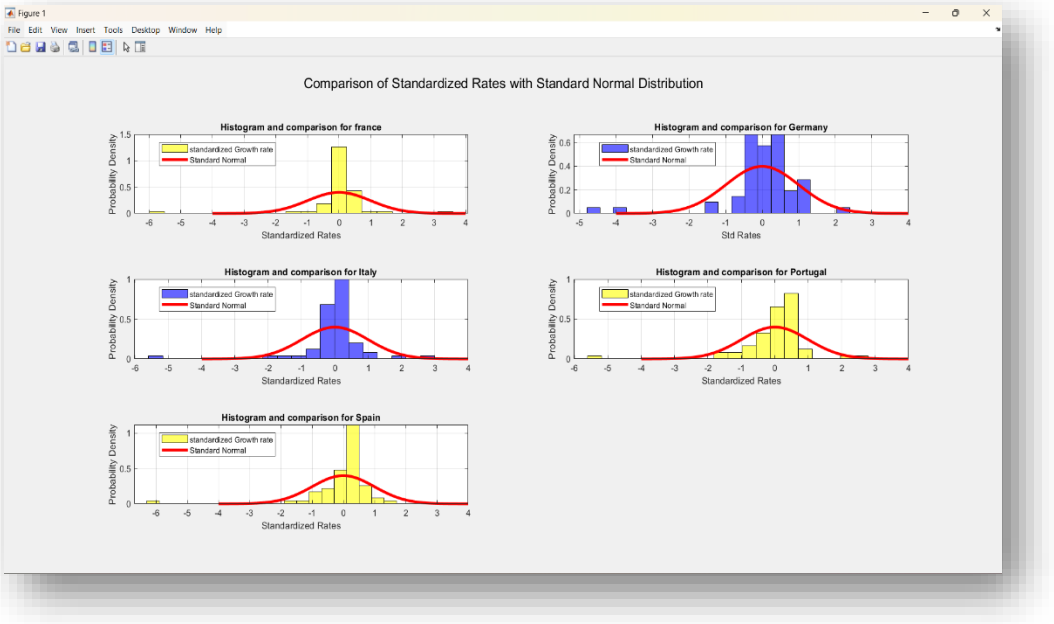

Figure – 4

- France and Germany exhibit more stable and consistent growth patterns, closely mirroring the standard normal curve.
- Italy shows moderate variability, lying between the stable patterns of France/Germany and the volatility of Portugal/Spain.
- Portugal and Spain demonstrate higher volatility, with distributions that deviate more from the standard normal, indicating less economic stability and resilience to shocks.

Note- This analysis helps us understand how stable or volatile the economies of these countries are, how they respond to economic crises, and how they compare to each other.

- ***This table-1 summarizes the mean, median, and mode of the GDP growth rate percentages for five countries: France, Germany, Italy, Portugal, and Spain. These statistical measures provide insights into the central tendency and distribution characteristics of each country's economic performance.***

country	mean	median	mode
{'france' }	0.77264	0.75815	-11.171
{'germany' }	0.61325	0.72096	-6.5702
{'italy' }	0.36083	0.49886	-11.786
{'portugal'}	0.7466	1.0675	-11.011
{'spain' }	1.0171	1.0171	-13.366

table-1

France:

Mean (0.77264) and median (0.75815) are close, indicating consistent growth.

Mode (-11.171) highlights an outlier representing a sharp contraction at some point.

Germany:

Mean (0.61325) and median (0.72096) are also similar, showing stable growth trends.

Mode (-6.5702) suggests a notable contraction as the most frequent value.

Italy:

Mean (0.36083) and median (0.49886) are the lowest among the group, reflecting weaker overall growth.

Mode (-11.786) highlights frequent negative growth, emphasizing economic struggles.

Portugal:

Mean (0.7466) and median (1.0675) show higher-than-average growth compared to Italy but more variability.

Mode (-11.011) indicates frequent sharp contractions.

Spain:

Mean (1.0171) and median (1.0171) are the highest, indicating robust growth.

Mode (-13.366) suggests Spain experienced more frequent extreme negative growth events despite having the highest average growth.

Category	Country	Explanation
Strongest Growth	Spain	Leads in both mean and median, reflecting the strongest average growth.
Most Stable Growth	France, Germany	Demonstrate consistent growth with minimal deviations between mean and median.
Weaker Growth	Italy	Shows the weakest growth trends with low mean, median, and frequent contractions.
Higher Volatility	Portugal, Spain	Display higher variability with modes showing large negative values.

table-2

- **Range:**

- France has the largest range of GDP rate of change at 19.156715, indicating the most significant variability and extreme values over time.
- Germany shows the smallest range at 10.801260, reflecting the most stable GDP changes.
- Italy (18.646484), Portugal (17.909151), and Spain (18.331728) fall between these two extremes, showing moderate variability.

- **Interquartile Range (IQR):**

- *France (0.92): Moderate variability in GDP changes.*
- *Germany (1.14): Higher variability than France.*
- *Italy (1.26): Highest variability, indicating significant fluctuations.*
- *Portugal (1.05): Moderate variability, between Italy and France.*
- *Spain (0.61): Lowest variability, showing the most stability.*

- ***boxplot visualization showing the percentage GDP rate of change for five countries: France, Germany, Italy, Portugal, and Spain.***

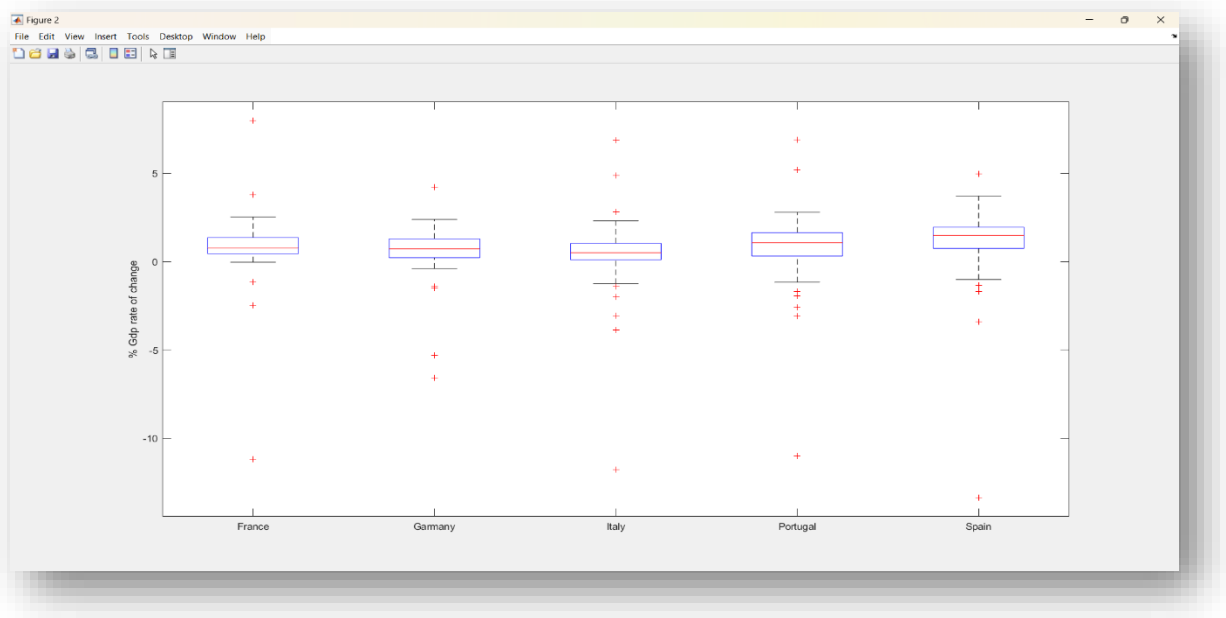

Figure – 5

- All countries have some outliers in their GDP rate changes, often in the negative direction.
- The medians for all countries are close to 0, indicating relatively stable GDP rates of change.
- The spread (IQR) is consistent across countries, but some, like Portugal and Spain, might show slightly wider whiskers, indicating more variability in their GDP rates of change.

- ***scatter plots showing pairwise comparisons of GDP rate changes between different countries. Each scatter plot visualizes the relationship between the GDP rate of change of two countries.***

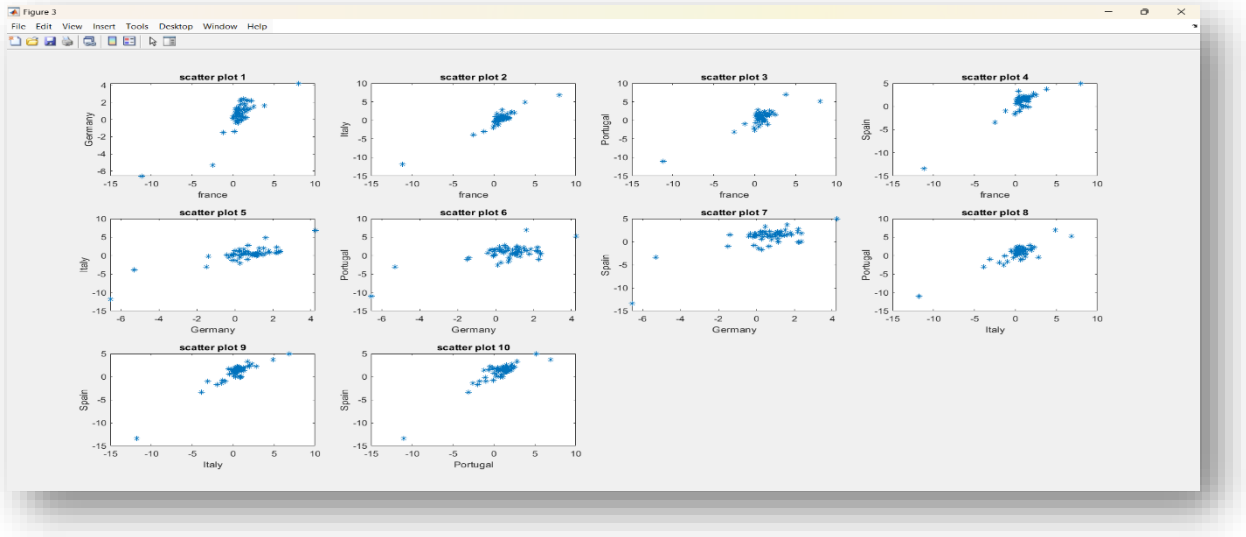

Figure – 6

- ***variance and standard deviation - Variance and standard deviation are critical statistical measures used to understand the variability and dispersion of GDP rate changes over time.***

country	variance	Standard deviation
{'france' }	4.1526	2.0378
{'germany' }	2.4904	1.5781
{'italy' }	4.9292	2.2202
{'portugal'}	4.944	2.2235
{'spain' }	5.4306	2.3304

table-3

- Germany has the most stable GDP rate of change (lowest variance and standard deviation).
- Spain shows the most variability in GDP rate changes (highest variance and standard deviation).

- Italy and Portugal exhibit similar levels of variability, both higher than France and Germany. France has moderate variability, between Germany and the other countries.

  - ***Covariance and correlation are statistical tools used to measure the relationship between two variables-in this case, the GDP rate changes of different countries.***

country	COR	COV
{'france_Germany' }	0.83233	2.6767
{'france_Italy' }	0.9439	4.2705
{'france_Portugal' }	0.85855	3.8901
{'france_Spain' }	0.89419	4.2463
{'Germany_Itlay' }	0.8231	2.8839
{'Germany_Portugal'}	0.70122	2.4605
{'Germany_Spain' }	0.74657	2.7455
{'Italy_Portugal' }	0.88092	4.3487
{'Italy_Spain' }	0.92631	4.7926
{'Portugal_Spain' }	0.89812	4.6537

table-4

- The weakest correlation is between Germany and Portugal (0.70122).
- The lowest covariance is also between Germany and Portugal (2.4605).
- The highest correlation is between Italy and Spain (0.92631), showing a very strong positive relationship in GDP rate changes.
- The highest covariance is also between Italy and Spain (4.7926).

- ***Analyzing GDP rates of change and confidence intervals is essential for understanding and interpreting economic stability and determine whether the null hypothesis is rejected or not.***

Country	Confidence Level	Mean Growth Rate ($\bar{x}$)	C.I.	Null Hypothesis ($\mu = 0$)
France	90%	0.77264	[0.325246, 1.220034]	Rejected
France	95%	0.77264	[0.236830, 1.308451]	Rejected
France	99%	0.77264	[0.059586, 1.485694]	Rejected
Germany	90%	0.61325	[0.266776, 0.959718]	Rejected
Germany	95%	0.61325	[0.198304, 1.028190]	Rejected
Germany	99%	0.61325	[0.061044, 1.204751]	Rejected
Italy	90%	0.36083	[-0.126606, 0.848269]	Not Rejected
Italy	95%	0.36083	[-0.222937, 0.944599]	Not Rejected
Italy	99%	0.36083	[-0.416044, 1.137707]	Not Rejected
Portugal	90%	0.74660	[0.258437, 1.234769]	Rejected
Portugal	95%	0.74660	[0.161962, 1.331243]	Rejected
Portugal	99%	0.74660	[-0.031434, 1.524639]	Not Rejected
Spain	90%	1.01714	[0.505515, 1.528766]	Rejected
Spain	95%	1.01714	[0.404404, 1.629877]	Rejected
Spain	99%	1.01714	[0.201714, 1.832567]	Rejected

table-5

- France, Germany, Spain: The null hypothesis is rejected at all confidence levels, indicating their mean growth rates are significantly different from zero.
- Italy: The null hypothesis is not rejected at any confidence level, suggesting no significant evidence of a non-zero mean growth rate.
- Portugal: The null hypothesis is rejected at 90% and 95% levels but not at 99%, showing borderline significance depending on the confidence level.

- **Concoction-** In this analysis of GDP growth rates from (01-01-1995) to (01-01-2024), we see that Germany had the most stable and strong economic growth, while France experienced steady growth. Italy had slower and more unpredictable growth, showing some challenges in its economy. Spain and Portugal showed growth too, but their economies were more unstable at times.

The statistical measures such as the average growth, range of values, and variability helped us understand these differences. Germany's economy was more consistent, while Italy’s was more uncertain.