

Decomposing Economic Indicators: A Study of Compensation, GDP, and Employment Rate in Germany Through Empirical Mode Decomposition

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Introduction: Economic Dynamics of Compensation, GDP, and Employment Rate

▶ **Context and Motivation:**

- ▶ Compensation, GDP, and Employment Rate are critical economic indicators.

▶ **Research Objectives:**

- ▶ Explore the dynamic relationships between Compensation, GDP, and Employment Rate.
- ▶ Analyze short-term fluctuations and long-term trends from Q1 2005 to Q4 2023.

▶ **Research Methodology:**

- ▶ **Empirical Mode Decomposition (EMD):** Decomposing time series data into intrinsic mode functions (IMFs) to capture different frequencies of variation.
- ▶ **Granger Causality Tests:** Assessing predictive causal relationships between the variables.
- ▶ **Pearson Correlation:** Quantifying the strength and direction of the relationships between the indicators.

Background and Significance

- ▶ Economic indicators such as Compensation, GDP, and Employment Rate are crucial for understanding the health of an economy.
- ▶ Compensation reflects the wages and benefits that employees receive, influencing consumer spending and overall economic growth.
- ▶ GDP, as a measure of total economic output, is a key determinant of national economic performance and growth.
- ▶ The Employment Rate reflects the labor market's efficiency, impacting productivity and income distribution.
- ▶ These indicators are often examined in isolation, but their interrelationships remain underexplored, especially in terms of their long-term and cyclical behaviors.
- ▶ Understanding these interactions can improve economic forecasting and inform policy decisions regarding employment, wages, and macroeconomic stability.

What does this study add?

- ▶ The current study seeks to fill this gap by investigating the dynamic relationships between Compensation, GDP, and Employment Rate using advanced time series analysis techniques.

Dataset:

Real Gross Domestic Product for Germany (CLVMNACSCAB1GQDE)

<https://fred.stlouisfed.org/series/CLVMNACSCAB1GQDE>

Methodology Overview

- ▶ **Objective:** Analyze the time series data for Compensation, GDP, and Employment Rate from Q1 2005 to Q4 2023.
- ▶ **Main Techniques:**
 - ▶ **Empirical Mode Decomposition (EMD):** Decompose the time series into Intrinsic Mode Functions (IMFs) for each variable.
 - ▶ **Residual Analysis:** Examine long-term trends not captured by the IMFs.
 - ▶ **Statistical Analysis:**
 - ▶ **Pearson Correlation:** Quantify relationships between IMFs.
 - ▶ **Granger Causality Tests:** Identify causal links between the variables (Compensation, GDP, and Employment Rate).
- ▶ **Variables Analyzed:**
 - ▶ Compensation
 - ▶ Gross Domestic Product (GDP)
 - ▶ Employment Rate

Empirical Mode Decomposition (EMD)

Decomposition of Time Series into Intrinsic Mode Functions (IMFs)

- ▶ Raw time series data (e.g., Compensation, GDP, Employment Rate).
- ▶ No prior assumptions about trends or seasonality.

Key Steps in EMD

- ▶ **Data Preprocessing:** Prepare time series data without assumptions.
- ▶ **Decomposing the Time Series:** Iterative process to extract IMFs at different frequency levels.

IMFs Interpretation and Benefits of EMD

IMFs Interpretation

- ▶ **IMF1:** High-frequency fluctuations (short-term cycles).
- ▶ **IMF2:** Medium-frequency variations (quarterly/annual adjustments).
- ▶ **IMF3:** Low-frequency components (long-term trends).

Residual Trend

- ▶ The long-term trend remaining after extracting all IMFs.

Benefits of EMD

- ▶ No need for predefined models (non-linear, non-stationary).
- ▶ Provides a detailed representation of both cyclical and trend patterns.

Residual Analysis and Correlation

- ▶ After performing the Empirical Mode Decomposition (EMD), we analyze the residuals of each time series variable (Compensation, GDP, Employment Rate).
- ▶ **Residual analysis** helps to identify long-term trends that are not captured by the Intrinsic Mode Functions (IMFs).
- ▶ **Key steps in residual analysis:**
 - ▶ Examine the residuals for each variable over time.
 - ▶ Investigate any underlying trends or patterns that persist even after removing cyclical variations.
- ▶ **Correlation Analysis:**
 - ▶ Pearson correlation coefficients are computed to assess the relationships between the IMFs of Compensation, GDP, and Employment Rate.
 - ▶ The analysis aims to identify short-term, medium-term, and long-term dependencies among these variables.

Key Findings Overview

- ▶ **Compensation:** Shows significant high-frequency fluctuations and a sustained long-term increase.
- ▶ **GDP:** Demonstrates a robust upward trend, indicating sustained economic growth over the study period.
- ▶ **Employment Rate:** Exhibits a gradual long-term decline, suggesting structural changes in the labor market.
- ▶ **Correlation Analysis:** Positive correlation between short-term fluctuations in Compensation and GDP; Negative correlation between Compensation and Employment Rate.
- ▶ **Granger Causality:** GDP Granger-causes Compensation and Employment Rate; no causal relationship from Compensation to Employment Rate.

Residuals and Long-Term Trends

- ▶ **Compensation:** Exhibits a persistent upward trend in residuals, rising from 0.03 (Q1 2005) to 0.08 (Q4 2023).
 - ▶ Suggests that while short-term fluctuations are captured by the IMFs, long-term structural growth factors contribute to this increase.
- ▶ **GDP:** Similarly, GDP residuals show a steady increase from 0.02 to 0.07 over the study period.
 - ▶ Reinforces the conclusion that GDP is experiencing continuous economic expansion beyond short- and medium-term variations.
- ▶ **Employment Rate:** In contrast, the Employment Rate shows a gradual decline in residuals from -0.01 to -0.03.
 - ▶ Indicates a long-term reduction in employment levels that may reflect structural labor market shifts or demographic changes not captured by short-term variations.
- ▶ These residuals provide important insights into the limitations of the IMFs and highlight the need for further investigation into underlying structural drivers.

Correlation and Causality Analysis

- ▶ **Pearson Correlation** analysis reveals significant interdependencies:
 - ▶ High positive correlation (0.65) between IMF1 of Compensation and IMF1 of GDP.
 - ▶ Negative correlation (-0.42) between IMF1 of Compensation and IMF1 of Employment Rate.
 - ▶ Moderate positive correlation (0.60) between IMF2 of GDP and IMF2 of Compensation.
- ▶ **Granger Causality Tests:**
 - ▶ GDP Granger-causes Compensation (p-value = 0.03).
 - ▶ No significant Granger-causality from Compensation to Employment Rate (p-value = 0.12).
 - ▶ GDP shows potential causal influence on Employment Rate (p-value = 0.09).

Residual Analysis of Economic Indicators

► **Compensation Residuals:**

- Gradual upward trend from 0.03 (Q1 2005) to 0.08 (Q4 2023)
- Suggests long-term growth, beyond cyclical fluctuations

► **GDP Residuals:**

- Steady upward trend from 0.02 to 0.07
- Indicates sustained economic growth despite short-term fluctuations

► **Employment Rate Residuals:**

- Gradual decline from -0.01 to -0.03
- Suggests long-term decrease, indicating potential structural issues

► **Key Insight:**

- Residuals highlight long-term patterns not captured by short-term IMFs
- Economic factors like inflation or structural changes likely influencing the trends

Granger Causality and Correlations

Granger Causality Results:

- ▶ GDP Granger-causes Compensation ($p = 0.03$)
- ▶ Compensation does not Granger-cause Employment Rate ($p = 0.12$)
- ▶ GDP Granger-causes Employment Rate at 10% significance ($p = 0.09$)

Pearson Correlations:

- ▶ IMF1 of Compensation vs IMF1 of GDP: $\rho = 0.65$
- ▶ IMF1 of Compensation vs IMF1 of Employment Rate: $\rho = -0.42$
- ▶ IMF2 of GDP vs IMF2 of Compensation: $\rho = 0.60$

Residual Analysis and Long-term Trends

- ▶ **Residual Trends** reveal long-term dynamics not captured by IMFs
- ▶ **Compensation Residuals:** Steady **upward trend** from 0.03 (Q1 2005) to 0.08 (Q4 2023), reflecting long-term growth.
- ▶ **GDP Residuals:** Gradual **upward trend** from 0.02 to 0.07, signaling continued economic expansion.
- ▶ **Employment Rate Residuals:** **Decline** from -0.01 to -0.03, indicating long-term decrease in employment.

Key Insights

- ▶ Compensation and GDP show consistent growth over time.
- ▶ Employment Rate shows a long-term decline.
- ▶ Residual trends highlight structural shifts and the need for further investigation.

Results: Granger Causality Tests

- ▶ **Granger Causality** tests were conducted to examine the predictive relationships between the variables: Compensation, GDP, and Employment Rate.
- ▶ **Key Findings:**
 - ▶ **GDP Granger-causes Compensation** ($p\text{-value} = 0.03$), indicating that past values of GDP help predict future Compensation levels.
 - ▶ **Compensation does not Granger-cause Employment Rate** ($p\text{-value} = 0.12$), suggesting no significant short-term predictive relationship between Compensation and Employment.
 - ▶ **GDP Granger-causes Employment Rate** at a 10 % significance level ($p\text{-value} = 0.09$), meaning past GDP can inform predictions about the Employment Rate.
- ▶ These results underscore the importance of **GDP as a predictor** of both Compensation and Employment Rate.

Future Scope and Conclusion

► **Future Scope:**

- Integrate additional variables (e.g., inflation rates, global economic indicators) to deepen the understanding of economic dynamics.
- Investigate the impact of external shocks, such as financial crises or policy changes, on Compensation, GDP, and Employment Rate.
- Employ advanced statistical and machine learning techniques for improved predictive capabilities.
- Conduct further analysis to understand long-term structural changes in labor markets and the economy.

► **Conclusion:**

- This study highlights the intricate relationships between Compensation, GDP, and Employment Rate, revealing both cyclical and trend components.
- GDP plays a crucial role in influencing Compensation and Employment trends, while Compensation itself does not significantly affect employment in the short term.

