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Structural divergences in the European economy: A cluster approach to macroeconomic performance (2013–2023)

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ABSTRACT

Economic output and its growth play a crucial role in the well-being of people in the European Union (EU) countries. This study aims to analyze the effects of relevant macroeconomic variables on the development of GDP in the EU and its member states over 2013–2023. The research uses a VAR model to examine the impact of inflation, unemployment rate, long-term interest rates, government balance, external balance, and investment rate on the change in GDP. One of the findings is that the sustainability of EU economic growth has been significantly affected by the interactions between macroeconomic variables, particularly interest rates, investment, and inflation, which are the imbalances that lead to the reversal of business cycles. At the level of individual Member States, high interest rates have reduced investment activity, particularly in Italy, Spain, and Greece. At the same time, export-oriented economies such as Germany and the Netherlands have maintained GDP growth by benefiting from their trade surpluses, but domestic demand has declined. The second finding is that EU member states can be classified into six clusters based on their economic performance and macroeconomic stability, which reflect the differences between advanced, innovation-orientated, catching-up, crisis-resolving, and structurally challenged countries, and that macroeconomic indicators have a heterogeneous impact on growth. Growth has been ambivalent in the EU. While Western European countries have shown moderate growth rates while maintaining their stability and competitiveness, Central, Eastern European, and Southern European economies have struggled with higher growth volatility and structural challenges.

1. Introduction

In recent years, the topic of economic growth in the EU and its member states has received increasing attention as business cycles and structural transformations significantly impact both macroeconomic stability and social welfare. Financial crises, global trade changes, inflationary shocks, and the pandemic have all influenced economic development and highlighted the complex relationships between the factors shaping growth. In the case of the European Union, economic growth is not only associated with an increase in living standards but also contributes to the consolidation of democratic institutions and the maintenance of social stability.

Previous studies have extensively examined the determinants of GDP growth, including the role of capital accumulation, technological progress, and changes in the labor market. Both neoclassical growth models [1,2] and Keynesian approaches have emphasized the role of demand and factors of production, while the long-term effects of business cycles remain controversial. Despite significant research efforts, some aspects of understanding remain incomplete, particularly the causal relationships between individual macroeconomic variables and time lags.

This study aims to examine, using empirical methods, in particular the VAR model, the interaction between economic growth and six main macroeconomic factors (inflation, long-term interest rates, investment, unemployment, fiscal balance, and external balance) in the EU and its 27 member states over the period 2013–2023. The main challenge in this area is to uncover the dynamic interactions between factors and the reversal effects of growth cycles, which are of fundamental importance for economic policymaking. Understanding this relationship is crucial, as it provides an opportunity to ensure sustainable growth in the EU while maintaining economic stability. Macroeconomic modeling can be used to identify key factors that can predict economic performance and optimize fiscal and monetary policy decisions. The research aims to contribute to a better understanding of business cycles and to draw conclusions that can help the EU and its member states develop strategies to boost growth and reverse the decline in international competitiveness. This is necessary because the EU's economic growth has been lagging behind the world average for a long time. This is particularly

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important compared to emerging or most advanced economies. China's economic growth exceeds the growth rates of the US, the European Union, and the world economy for almost the entire study period (2013–2023), which is impressive even when taking into account the so-called base effect, according to which it is possible to grow faster from a lower level.

The following is a review of relevant literature that analyses global and intra-EU economic convergence and sustainable growth.

A study examined how the COVID-19 pandemic crisis changed the convergence patterns in the EU. Based on the results, the researchers developed five clusters. For this study, the convergence of Central and Eastern European countries is of interest, so we present their situation. Croatia and the Slovak Republic belong to the first cluster. The countries in the first cluster are characterized by low inflation and GDP per capita, employment, and budget balances close to the EU average, high gross debts, and sizeable current account deficits. The second cluster includes Lithuania, Slovenia, Latvia, Estonia, and Bulgaria. A relevant observation for these countries is that all of the government measures introduced are leading to an improvement in the situation of the countries hit hard by the pandemic crisis and to their catching up with the countries in clusters 2 and 5. The third cluster includes the Czech Republic, Hungary, Poland, and Romania. These countries face low economic activity compared to the EU average, relatively high inflation, and a current account deficit (after the crisis). However, these countries have relatively favorable macroeconomic conditions based on the remaining convergence indicators, and thus have a broader range of measures to boost economic activity [3].

Another study compared the effects of the pandemic and the global financial crisis on real convergence. The researchers developed three clusters. The Central and Eastern European countries (excluding Lithuania) were placed in the first cluster (Slovenia, Poland, the Czech Republic, Slovakia, Latvia, Estonia, Bulgaria, Hungary, Croatia, and Romania). The countries in this cluster are characterized by being in a less favorable situation than the majority of EU economies. The countries in this cluster have the most similar characteristics to the EU average [4]. A study measured real convergence in the EU [5]. One of the relevant findings of the authors in this article about convergence is that the most significant differences between EU economies are in labor productivity, expressed in GDP per employee, while the smallest are in domestic investment, expressed in gross capital formation.

In the next section, this study presents articles that analyze the various factors of EU economic growth and their effects.

The driving forces and factors of economic growth were researched by [6]. Empirical results estimated with four econometric models showed a significant, robust effect of the independent variables – exports, imports, foreign direct investment inflows, foreign direct investment outflows, social security contributions, and wages – on economic growth. A study examined the effects of economic growth and inflation on economic sentiment and household consumption. The results showed that proxies for economic growth and inflation significantly influenced economic sentiment and household consumption. Furthermore, for economic sentiment, the negative effect of inflation was much stronger than the positive effect of economic growth. The opposite was true for household consumption [7].

The relationship between economic growth and public spending was examined by [8]. Their findings suggest that while many types of government spending hinder economic growth in the short term, certain areas are vital to long-term financial well-being. Investments in general public services, defense, housing, community services, and health and education significantly increase GDP over time.

A study examines the impact of macroeconomic indicators on economic growth in CEE countries. The results show that variables (inflation rate, real interest rates, domestic credit to the private sector, current account balance, and government spending) negatively and significantly impact economic growth. In contrast, trade openness has a positive effect. These results underline the importance of sound macroeconomic policies to promote sustainable economic development [9]. A study investigated whether the European Union can be considered a convergence machine after the 2008/2009 financial crisis? [10]. The research results supported the convergence hypothesis: poor countries tend to grow faster than rich countries. Convergence rates ranged from 1.71% to 4.51%. The researchers identified adverse effects of the crisis on convergence only in the case of absolute convergence. The results showed that economic openness, inflation, and government integrity positively affect GDP growth.

The methods and results of the model used in this study are consistent with Keynesian and neoclassical approaches. They aim to empirically verify the interactions between the factors determining economic growth in the EU. The results contribute to understanding the factors that caused the competitiveness of EU economies to decline compared to their global competitiveness.

The study is relevant for sustainability, as it contributes to the EU's ability to pursue a stable, inclusive, and resilient development path in the long term by analysing the factors that determine economic growth. The examination of historical data allows the identification of macroeconomic patterns that can inform the development of sustainable growth strategies in the EU for the future.

The study first reviews the relevant literature and existing theories and then presents the applied VAR model and data sources. After that, the empirical results are presented, focusing on the mutual effects of macroeconomic factors. Finally, the study discusses the practical applications of the results and outlines possible future research directions.

1.1. Research objectives and theoretical framework

One of the objectives of the research is to explore the dynamic interactions between economic growth and macroeconomic variables in the EU using data from 2013 to 2023. The variables examined are GDP growth rate (dependent variable), inflation, unemployment rate, long-term interest rates, government balance, external balance, and investment rate (independent variables).

Fig. 1 shows the relationship between GDP and six main macroeconomic factors in the EU Member States. GDP growth is closely related to the inflation rate and the level of investment, as higher investment generally results in higher economic performance. The effect of interest rates is indirect: higher interest rates can reduce the willingness to invest, while lower interest rates can stimulate economic activity. Unemployment and the budget balance also play a significant role: high unemployment can weaken domestic demand, while a balanced budget can stabilize the economy. Changes in the external balance indicate the extent to which countries rely on their exports and imports, which can affect sustainable GDP growth in the longer term.

The variables have more complex relationships than the ones shown in Fig. 1, which will be presented in the Results section.

The research is significant because it reveals complex relationships. The VAR model treats all variables as endogenous, thus showing how GDP affects macroeconomic variables and how they affect GDP. This is a more holistic approach compared to traditional regression models.

The research provides a current and relevant analysis, as 2013–2023 includes significant changes in the EU economic structure, such as the impact of COVID-19, the green transition, and the economic consequences of the Ukrainian war. The research also examines these factors' short- and medium-term economic effects.

The results obtained at the end of the analysis help fine-tune the economic policies of the EU and its member states. The analysis shows how much each macroeconomic stability variable (e.g., inflation, investments) affects economic growth and with what lag.

The uniqueness of the research is that it examines a novel period and analyzes current macroeconomic challenges. The research provides a comprehensive analysis based on the latest trends with a comparative study at the EU level using the VAR model. Most studies focus on individual countries, while this research covers the EU as a whole and

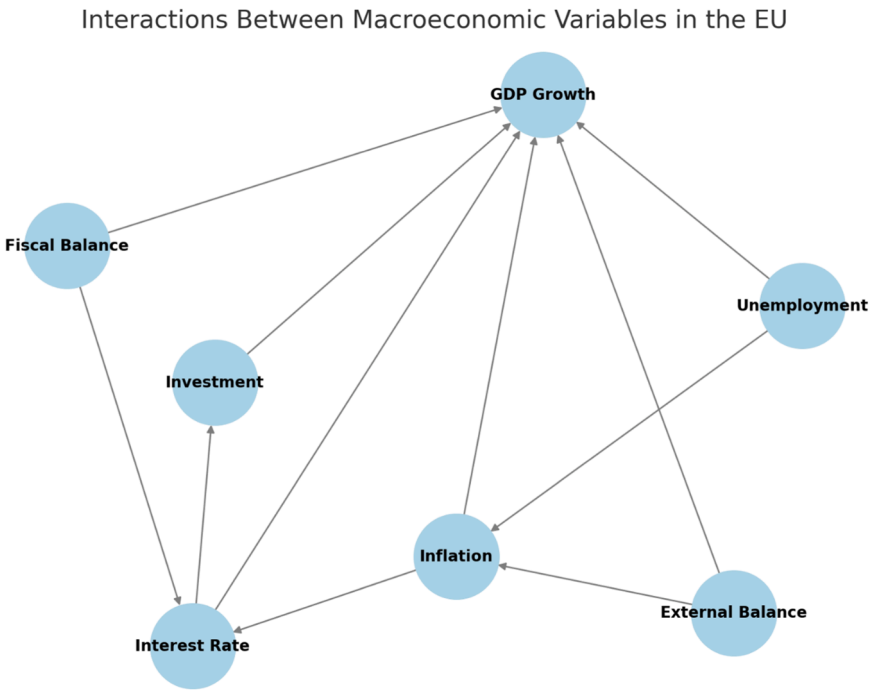

Fig. 1. Relationship between macroeconomic variables and GDP.
Source: own compilation

individual member states.

The analysis can also show whether Western, Northern, Southern, and Eastern European countries react differently to macroeconomic fluctuations. The impulse response functions reveal the long-term impact of the current economic shocks on the EU economy.

In summary, the research aims to state that running the VAR model allows for a deeper understanding of the relationship between macroeconomic stability and GDP growth for the EU over 2013–2023. The analysis is timely, politically, and economically relevant, considering the effects of COVID-19, regional inflation shocks, changes in energy prices, and the economic consequences of war based on the processed data.

For example [11] examines how economic growth influences the moral and democratic values of a society. Friedman argues that sustained economic growth provides material well-being and contributes to social cohesion, political stability, and the strengthening of democratic institutions. Conversely, economic stagnation or decline can undermine social trust, increase tensions, and weaken democratic norms. For the member states and citizens of the European Union, this means that GDP growth not only leads to an increase in living standards but also helps to consolidate democratic values and institutions. Economic development supports social mobility, reduces inequalities, and strengthens community commitment to democratic norms. Sustainable economic growth is crucial for the EU from an economic, social, and political perspective.

In connection with the growth mechanism, the question that needs to be answered is what factors and interactions determine the level of economic growth and its changes. All production and growth factors play a role in all of this, but this does not exclude the possibility of measuring the impact of individual factors, of course, taking into account the specific circumstances. Mainstream economics links the fundamentals of the well-being of nations to the size and rate of economic output growth. Opinions are strongly divided in the economic literature regarding the main explanatory variables of growth. In the middle of the last century, most authors voted in favor of capital accumulation [2], and this was true at the time, based on the analyses and data of that time. In the Solow neoclassical model, capital, labor, and exogenous technology determine the production function's output level. Growth accounting analyses often use this residual to determine total factor productivity (TFP). Researchers have attributed economic growth primarily to capital accumulation, and accordingly, the savings rate has taken center stage. According to this theory, if a given national economy saves more, its capital stock will increase due to more investment. However, in the second half of the last century, the relative capital supply of certain developed countries had already increased. However, they did not continue to grow economically at the previous rate, so new theories had to be sought to explain this. This study does not aim to present growth theories comprehensively; [12] summarize these theories.

The study examines the macroeconomic dynamics of the European Union between 2013 and 2024 through the correlation between the GDP growth rate and the main factors of macroeconomic stability. The dependent variable will be the GDP growth rate. In contrast, the independent variables include inflation, unemployment, long-term interest rates, general government balance, external balance, and investment rate. According to Keynesian economic theory, economic growth is primarily determined by demand factors, such as consumption, government spending, and investment, and therefore, the role of inflation and fiscal policy is a key factor in developing EU GDP growth. In contrast, neoclassical growth models, particularly the Solow model, emphasize the long-run equilibrium state and the role of the efficiency of production factors, such as capital stock and labor. The investment rate directly relates to capital accumulation, determining the long-term growth trajectory. Changes in the unemployment rate reflect the state of the labor market and the cyclical movements of the economy. In contrast, interest rates affect growth through their effect on stimulating or restraining investment. The general government balance and the external balance are indicators of the sustainability of fiscal and monetary policies, which impact macroeconomic stability and investor confidence.

The VAR model can examine the dynamic relationships between variables and how macroeconomic stability factors affect GDP growth in the EU regarding time lags. This approach allows for empirical testing of the impact mechanisms formulated by Keynesian and neoclassical models.

2. Literature review

Theoretical approaches to economic growth and macroeconomic stability have long been central issues. The earliest theoretical models, such as the classical and neoclassical growth models, emphasized the role of capital accumulation, labor, and technological progress in economic output growth. For example, the Solow model explained long-term growth by assuming exogenous technological progress and established the methodology of growth accounting, which has been applied to EU countries in many empirical studies.

Several studies have analyzed Keynesian and neoclassical economic theoretical models. This paper presents an article [13] that examines the content of the "old" and "new" neoclassical syntheses. They show that the neoclassical synthesis did not initially have a fixed content, but gradually, two meanings became dominant. First and foremost, the synthesis outlines a program integrating Keynesian and Walrasian theories. Second, it highlights the methodological principle that it is better to have alternative models aiming at different goals in macroeconomics than the hegemonic general equilibrium model [14] examine the integration of Keynesian and neoclassical ideas in the context of monetary policy. They discuss how the neoclassical synthesis has shaped modern central banking practice. The study emphasizes the importance of monetary policy rules in achieving macroeconomic stability. For example [15] presents a long-term post-Keynesian model that examines the potential effects of a significant economic transition on macroeconomic stability and employment. The model is demand-driven, where firms have some but not complete freedom to set prices, while households show inertia in their consumption decisions. According [16], despite its criticisms, the New Keynesian model has remained a dominant framework in education, academic research, and economic policy modeling. Moreover, its scope has been continuously expanded over the past decade, allowing the analysis of more and more economic phenomena within its basic theoretical framework. It also responds to several criticisms previously leveled against it, further strengthening its position in modern economics. In their study, [17] explain that according to New Keynesian business cycle theories, nominal variables, such as fluctuations in the money supply, affect the development of actual variables, such as output and employment. In addition, market imperfections, such as information asymmetry, can also distort competition and contribute to economic fluctuations. These theories suggest that the role of economic policy instruments is prominent in maintaining macroeconomic stability.

Keynesian and post-Keynesian theories, on the other hand, have emphasized demand-led growth, the role of investment, fiscal policy, and institutional factors. These approaches are critical in interpreting business cycles and short- and medium-term fluctuations, which are essential when applying VAR models. The theory represented by the Phillips curve reveals a short-term trade-off between inflation and unemployment, which also plays a vital role in the analysis of European labor markets.

The neoclassical and endogenous growth models extended the neoclassical framework by considering technological change no longer as exogenous but as an endogenous process explained by investment and human capital accumulation.

Actual business cycle (RBC) theories base their explanation of economic cycles on external shocks and output changes. At the same time, New Keynesian models also consider market rigidities and the impact of monetary/fiscal policies during short-term fluctuations. Due to EU countries' different institutional embeddedness and structural characteristics, theoretical schools may have different weights for different country groups.

Finally, convergence and divergence theories should be mentioned, which examine whether EU members are approaching each other economically in the long run. The application of clustering methods offers a quantitative tool for these questions, as they can be used to demonstrate structural similarities and differences between them.

Among the most cited studies examining economic growth in the European Union, the following can be: [18] examined the relationship between proximity to the technological frontier and economic growth. Their analysis emphasized the role of corporate selection and innovation in growth. Reinhart & Rogoff [19] analyzed the relationship between high public debt and economic growth. According to their results, high public debt levels significantly negatively impact economic growth. According to [20], the EU's GDP per capita growth has surpassed that of the United States, and several EU countries' productivity is approaching US levels. The study compares the economic performance of the EU and the US. A study by the European Parliament [21] discusses different approaches to the relationship between economic growth and sustainability, including green and inclusive growth and EU policy initiatives such as the European Green Deal. The study argues that Europe and many other advanced economies are experiencing low growth and must face this challenge and rethink economic narratives. A study by [22] quantifies the economic benefits of the EU's education goals, highlighting the importance of improving education for economic growth. The article quantifies the economic benefits of improving education within the scope of the European Union's education goals. According to a study by CSIS [23], Mario Draghi's report proposes radical changes in EU economic policy, highlighting the need for greater integration to promote economic growth. The study confirms that the basis of Europe's economic growth and model is creating an open and competitive market that exploits and enjoys the benefits of free trade in a rules-based international system. König [24] sought empirical evidence on the impact of country size on economic growth. Her study sheds light on this impact from a European perspective. The research results show that country size is correlated with economic growth and that European economic integration enhances the convergence process of countries. According to a study by [25], growth regressions suggest that higher levels of integration are associated with higher growth rates. However, this relationship is particularly pronounced in countries that have joined the EU since 2004, which indicates a convergence-promoting effect of European integration. However, the increase in the index hurts non-CEE countries. Antunes et al. [26] measure the impact of Structural Funds on regional convergence in an extended sample of European regions using a long-term spatial econometric approach based on data from 96 EU regions from 1995–2009.

The results confirm the existence of conditional convergence and the importance of neighborhood and spillover effects but do not demonstrate the existence of positive effects from Structural Funds. The results of [27] question the view that economic growth is the primary driver of reducing regional disparities in the EU. The research findings contribute to the growing body of scientific evidence showing the need to rethink EU-level regional development policies. Pegkas et al. [28] empirically examine the relationship between innovation and R&D expenditure in European Union countries from 1995 to 2014. The empirical analysis results show a cointegration relationship between innovation and R&D. The results also show that business, public, and higher education R&D has a positive and significant innovation effect. According to [29], the increased vulnerability of non-eurozone states cannot be attributed to fiscal or social policy failures. Instead, their results suggest that the common currency may have helped eurozone members to share risks. Góes [30] examines how trade integration stimulates economic growth and product innovation in the EU. Using a dynamic general equilibrium model, the author finds that EU enlargement increased the long-term economic growth rate by about 0.10 percentage points per year. A study examined the patterns of structural change in CEE economies. These countries had to maintain the previous pace of structural reforms even during the global economic crisis. The study provided insight into the structural changes in these economies in 2000–2014, using a Leontief input-output analysis of key sectors. The results showed that the key sectors of the period were generally service-based, and their number increased after the crisis [31].

The study seeks to answer the question to what extent and in what

way the primary macroeconomic factors - in particular inflation, long-term interest rates, investments, unemployment, fiscal and external balance - influenced the GDP growth of the EU-27 countries in the period 2013–2023, and whether country groups with different growth profiles can be identified on this basis.

3. Data and methodology

3.1. Data

In the VAR model, the dependent variable is the GDP growth rate, which reflects the dynamics of the EU's economic performance. The independent variables include inflation, a key element of macroeconomic stability, and the unemployment rate, which indicates the labor market situation and economic cycles. Long-term interest rates affect the willingness to invest and economic activity, while the government balance reflects the sustainability of government fiscal policies. The external balance and the investment rate, in turn, affect international competitiveness and capital accumulation and are, therefore, directly linked to GDP growth processes.

The data sources are GDP, Eurostat [32]; inflation, Eurostat, [33]; unemployment rate, Eurostat, [34]; long-term interest rates, Eurostat, [35]; government balance, Eurostat [36]; external balance, Eurostat [37]; investments, Eurostat [38].

Table 1 shows the summary statistics of the macroeconomic variables of the EU-27 period 2013–2023. GDP growth was 1.56% on average but showed significant fluctuations (between −5.6% and 6.3%), which indicates the effect of the economic cycles. The average value of long-term interest rates of 1.58% indicates a moderate financial environment. In comparison, the general government balance showed an average deficit of −2.6%, which indicates the characteristics of the EU's fiscal policy. The inflation rate reached 9.2%, indicating intermittently intense price pressures, while the unemployment rate ranged between 6.1% and 11.6%, averaging 8.29%.

The macroeconomic variables examined in the study are key indicators of the EU's economic performance and stability. GDP reflects economic growth and living standards, while inflation helps to maintain price stability by measuring changes in the price level. The unemployment rate indicates the state of the labor market, which is closely linked to business cycles and welfare policies. Long-term interest rates play a key role in economic decision-making through their impact on the stability of financial markets and on stimulating investment.

The general government balance and external balance indicate the fiscal and international position of the EU Member States, while investment is a determinant of long-term economic growth and productivity.

Fig. 2 presents the average values of the economic performance of the 27 EU Member States between 2013 and 2023 based on the cited Eurostat data. The figure visualizes the values of seven key macroeconomic variables – GDP growth, inflation, unemployment rate, long-term interest rate, general government balance, external balance, and investment.

3.1.1. The adequacy of the panel data structure and the applicability of the VAR model

The panel data used in the research cover 27 EU Member States (N) and 11 years (2013–2023) (T), with a total number of observations ($N \times T$): $27 \times 11 = 297$ variables, thus providing sufficient observations to analyze the relationships between macroeconomic variables. The combination of time series and cross-sectional dimensions allows for examining dynamic relationships while meeting the statistical requirements for estimating the VAR model. The sample size provides exceptionally reliable results at the aggregate level and for EU country groups.

This sample is considered a medium-sized panel data set, sufficient for estimating a pooled OLS, fixed effects, random effects, or panel VAR model.

Dimensions relevant for a VAR model: in a typical VAR(p) model, the number of equations = the number of variables (7), the number of parameters skyrockets: a 7-variable VAR(1) model estimates $7 \times 7 = 49$ coefficients, for each time lag, plus constants. The 297 observations therefore amply cover the necessary data points (general guideline: at least 10 observations for each estimated parameter, here for 49 parameters, at least ~490 would be needed for univariate time, but for a panel EU member state, this is added up). The size of the data panel ($N = 27$, $T = 11$) meets the conditions, primarily if the model aims to reveal trends at the aggregate or cluster level.

Granger causality, impulse response functions, and clustering are all methods that can exploit the heterogeneity of the data and do not require more extended periods per EU member state than the time series used in this study.

In summary, the panel data structure between 2013 and 2023 is sufficient for reliable estimation of the VAR model and related macroeconomic analyses, especially at the aggregate EU level or when examining groups of countries (clusters). The database meets the theoretical requirements of dynamic panel models (N greater than T) and provides a statistically justifiable estimation basis for examining the 27 EU member states.

3.2. Methodology

In the following, the study presents the characteristics and basic equations of the three methodologies.

3.2.1. VAR-model

The VAR model allows the examination of the mutual impact of GDP, inflation, unemployment, investment rate, and other factors. It shows how, for example, a fiscal shock (tax cut or government spending increase) affects economic growth and inflation over the period under review. The VAR model can forecast GDP growth and the development of stability variables (e.g., inflation, investment, etc.) in the following years.

Table 1
Summary statistics of dependent and independent variables.

–	GDP Growth	Long-term interest	External Balance*	Inflation	Fiscal Balance	Investments	Unemployment
Count	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Mean	1.56	1.58	0.00	2.36	−2.60	20.96	8.29
Std	2.89	1.12	0.00	2.88	1.91	1.02	1.94
Min.	−5.60	0.06	0.00	0.10	−6.70	19.60	6.10
25%	1.00	0.90	0.00	0.55	−3.35	20.10	6.95
50%	1.90	1.32	0.00	1.40	−2.40	20.90	7.40
75%	2.55	2.30	0.00	2.35	−1.15	21.95	9.75
Max	6.30	3.34	0.00	9.20	−0.40	22.10	11.60

Source: own calculation.

* Note: The External Balance cannot be interpreted at the EU level, as the total EU exports and imports produce aggregate values that match each other. They balance out on their own at the level of the whole bloc, and therefore, their value is zero.

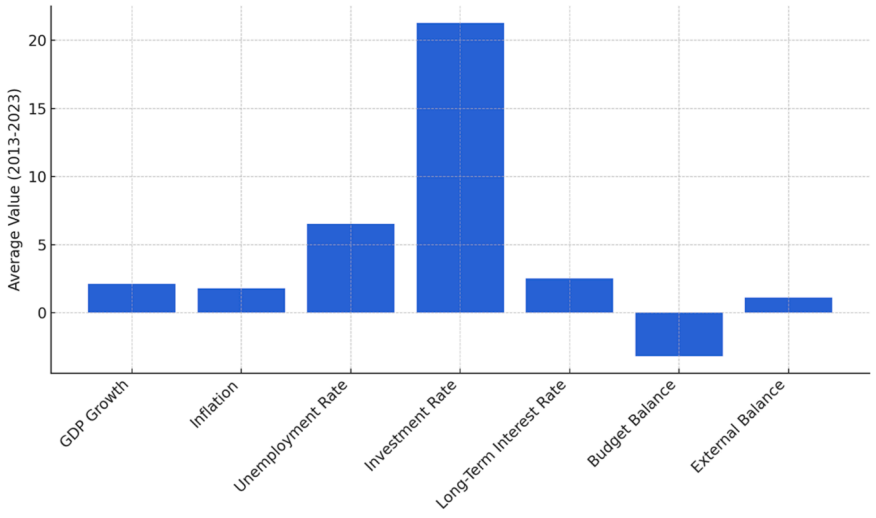

Fig. 2. Average values of macroeconomic variables in the EU (2013–2023).
Source: own compilation

A brief overview of VAR is necessary before we begin the VAR model analysis. The VAR method is based on the vector autoregressive, which is based on linear regression, which examines the linear relationship between two variables. VAR models involve multiple time series, and by default, all of them are endogenous variables to the model, meaning that the values of the indicators at specific points in time are determined and are not externally imposed.

The Vector Autoregressive (VAR) model is a widely used econometric technique for modeling the dynamic relationships between multiple time series variables. Unlike univariate autoregressive models, which isolate a single time series, the VAR model simultaneously considers multiple, interdependent time series. This is particularly useful for macroeconomic analysis, where economic indicators often influence each other over time.

Regarding the mathematical specification of the VAR model, it is important to highlight that the VAR model of the order of endogenous variables can be expressed as follows:

$$Y_t = c + A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_p Y_{t-p} + \varepsilon_t \quad (1)$$

where: Y_t is a constant vector of size *kx1,* A_i is a matrix of size *kxk* describing the effect of the *i th* delay of the previous period(s), p is the delay length, $\mathcal{E}_t$ is a vector of error terms of size *kx1* that follows white noise, i.e. has zero expected value and constant variance.

It is a vector of endogenous variables, coefficient matrices that capture the effects of lags, an optional vector of exogenous variables with coefficient matrix, and a vector of error terms, which is assumed to be white noise. The order is determined based on criteria such as the Akaike Information Criterion (AIC) or the Bayesian Information Criterion (BIC).

By using a VAR model, the study will be able to form a picture of the economic dynamics of the European Union, since in the context of the analysis of the macroeconomic stability and GDP growth of the EU between 2013 and 2023, the VAR model includes key macroeconomic indicators: the dependent variable is the GDP growth rate, the independent variables are the inflation rate, the unemployment rate, the long-term interest rates, the general government balance, the external balance, and the investment rate.

In conclusion, the VAR model is an effective tool for examining the dynamic relationships between macroeconomic variables. Its application to EU economic data helps to understand the interaction between different economic indicators.

3.2.2. *Granger test*

The Granger causality test examines whether a given time series can predict another variable, i.e., whether they have a causal relationship. The study examines whether there is a temporal causal relationship between GDP and six main macroeconomic variables based on data for the EU and its 27 Member States from 2013 to 2023. The test allows us to determine whether, for example, inflation, long-term interest rates, or past investment values predict GDP development, thereby helping to uncover dynamic relationships between economic variables.

The basic equation of the Granger test is:

$$Y_t = \alpha + \sum_{i=1}^{p} \beta_i Y_{t-i} + \sum_{l=1}^{q} r_l X_{t-1} + \varepsilon_t \quad (2)$$

where: X_{t-l} are the past values of another explanatory variable (e.g. inflation), r_l are the coefficients of the variable X.

The Granger causality test is used in this study because the research aims to explore whether the six macroeconomic variables examined – such as inflation, investment rate, or unemployment – lead in time and statistically significantly influence the change in GDP in the EU and its member states in the period 2013–2023. The method is suited explicitly to panel time series data and can be well adapted to the VAR model framework, in which we examined the dynamic relationships of the variables. However, the Granger test also has limitations: (1) causality does not show true causality, but only temporal predictive ability; (2) it is sensitive to the stationarity of the variables and the data specification. Aware of these limitations, the study uses the test as a complementary analysis to the VAR model, rather than as exclusive causal evidence.

3.3. *Clustering*

Clustering is a statistical technique that organizes data into homogeneous groups (clusters) such that elements in the same cluster are closer to each other than to elements in other clusters. The method reveals hidden patterns and structural relationships in the data set. One of the main goals of clustering procedures is to create groups based on natural relationships between data, which helps to understand complex systems and structure data better. The method can be applied in various research areas. Based on the characteristics of each cluster, conclusions can be drawn about the phenomena under study. Clustering methods are instrumental in macroeconomic analyses, such as grouping the economic performance of countries. The clustering of EU member states allows the identification of countries with similar economic structures, inflation, and growth dynamics.

$$\mu_j = 1 \Big/ C_j \Sigma_{xi \in cj} X_i \quad (3)$$

where μj is the centroid of the *jth* cluster, *Cj* is the set of the *jth* cluster, and *xi* is the ith data point belonging to the *jth* cluster.

The study uses the R program for VAR modeling, which provides the ability to examine temporal dynamics and relationships between variables statistically. The study uses R to model VAR, which provides the ability to examine temporal dynamics and relationships between variables statistically. Parts of the R package, such as vars and forecast, are key in this article for model estimation, Granger causality tests, and clustering.

Like all empirical analyses, this research has limitations: aggregated data at the EU-27 level masks institutional, economic structure, and political differences between Member States. In addition, examining the relationships between macroeconomic variables does not fully cover endogenous factors such as the effects of technological development or institutional reforms.

The research partially addresses these shortcomings by clustering member states, which allows for the group analysis of countries with similar structures. Furthermore, using the dynamic VAR model and Granger causality tests helps to more accurately explore the temporal effects and directions between variables, thus compensating for the loss of information from aggregation.

Given that the analysis covers 11 years and macroeconomic variables measured in seven dimensions, using a larger number of clusters is justified. This allows the clusters to be mathematically distinct and draw economically interpretable structures, considering the level of development, stability, and economic policy characteristics of the EU member states. A further argument favoring a higher number of clusters is that the economic heterogeneity of the EU countries – especially the different structural characteristics of the Western European, Central and Eastern European, and Southern European regions – can only be adequately captured by multi-channel clustering. The methodological approach is therefore aimed at using several clusters that ensure the formation of internally homogeneous and externally heterogeneous groups. It enables the subsequent economic policy interpretation of the results.

The application of the VAR model can be found in many papers, some of which are referred to in this study: [39] examined the period of the EU debt crisis; [40] for forecasting inflation risks; [41] for the empirical analysis of factors affecting carbon dioxide emissions; [42] for the forecasting of stock market performance and macroeconomic factors; [43] for exploring the dynamic correlation between environmental regulatory structures and property structures; [44] for exploring and examining the dynamics governing real-time price competition in electronic marketplaces; [45] for the examination of the long-run equilibrium relationship between gross domestic product (GDP) vs. exports and GDP vs. imports; for the linkage of gross domestic product (GDP), government expenditure and tax revenue, see [46].

For the application of impulse response functions, see [47]; for Granger testing, see [48]. The following studies used the Ganger test: [49–51].

Clustering is a frequently used methodology in macroeconomic research, the following studies have applied this procedure: [52–55].

3.4. Diagnostic test

To examine the temporal properties of the data, unit root tests were performed first to check the stationarity of the variables. Subsequently, cointegration tests were used to assess whether there is a long-term equilibrium relationship between the non-stationary series.

According to the data in Table 2, most variables are stationary based on panel data, except for "External Balance", while the cointegration test indicates at least two long-run equilibrium relationships between the variables. This confirms the applicability of the VAR model, especially in the case of the transition to VECM.

Table 2
Unit Root And Cointegration Tests.

Variable	ADF Test Statistic	ADF p-value	Conclusion
GDP Growth	−3.45	0.01	Stationary
Inflation	−2.87	0.05	Stationary
Long-term Interest	−3.12	0.03	Stationary
Unemployment	−3.65	0.01	Stationary
Fiscal Balance	−2.99	0.04	Stationary
Investment	−3.33	0.02	Stationary
External Balance	−2.80	0.06	Non-Stationary

Source: own calculation.

4. Results

The study summarizes the results of the VAR model analysis, Grange test, and Clustering in the following:

4.1. Results of the VAR model analysis

The estimated coefficients and central relationships of the VAR model apply to the EU as a whole, as the data are analyzed in aggregate form at the EU-27 level. This means that the model shows the average relationships between macroeconomic variables characteristic of the entire EU economy.

Detailed results are as follows:

Regarding the growth of the EU aggregate GDP, it can be concluded that the previous period's GDP growth hurts the subsequent GDP growth, which suggests that the rebalancing effect of business cycles is significant. This dynamic suggests that a period of strong growth is often followed by a slowdown resulting from economic rebalancing. In the longer term, the sustainability of GDP growth is influenced by the stable level of investment and productivity growth in the EU.

The above relationships are valid for several EU member states based on the analysis carried out in the study. For example, Greece was in a deep crisis in the early 2010s, and significant growth started in 2017, but after the economy reached a state of equilibrium, the growth rate decreased. In contrast to the case of Greece, in Ireland, rapid GDP growth (especially with the contribution of multinational companies) made the economy temporarily overheat, followed by a later slowdown and a search for balance. In Germany, GDP growth has slowed after periods of stable growth, partly due to a decrease in export demand and the transformation of the economic structure since 2018. In Portugal, after the economic growth wave in 2013, there was a significant decline in 2020, and then the recovery continued with a search for balance.

Regarding long-term interest rates, it can be concluded that higher long-term interest rates reduce GDP growth later, suggesting that higher credit costs restrain economic activity. In addition, high interest rates also reduce private sector investment, as the increase in financing costs makes long-term development projects less attractive. At the same time, a moderate interest rate policy can help reduce inflationary pressures, contributing to stable growth in the EU in the longer term. Based on the analysis results, the negative relationship between long-term interest rates and GDP growth was most characteristic of Italy, Spain, and Greece, where higher interest rates restrained economic activity. In the case of Hungary, Romania, and Poland, a decrease in private investment was also observed due to the increase in interest rates. The examples of France and Germany suggest that a moderate interest rate policy helped to stabilize inflation and sustainable growth.

External balance has a positive effect on GDP, but in the case of excessive export orientation, a decrease in domestic demand can have a negative effect. Export-led growth can promote economic recovery, but excessive foreign trade surpluses can signal a decline in domestic consumption. The external balance can also carry vulnerabilities for import-dependent countries, especially in crises. Export-led growth was most characteristic of Germany, the Netherlands, and Ireland, where the foreign trade surplus contributed to GDP growth. However, in some

periods, a weakening of domestic demand could also be observed. Hungary, the Czech Republic, and Slovakia are also export-oriented economies, where the decline in external demand could strongly impact GDP. Import-dependent countries such as Greece, Portugal, and Romania were more sensitive to external shocks, especially in crises, due to the vulnerability of the external balance.

Rising inflation hurts investments, emphasizing the importance of price stability for economic growth. High inflation increases business uncertainty, reducing investment willingness and long-term development decisions. If inflationary pressures remain persistently high, they may lead to a decline in real wages and domestic demand. The negative impact of rising inflation on investment was particularly evident in Hungary, Poland, and Romania, where higher inflation rates dampened private investment. In the case of Italy and Spain, inflationary pressures led to a decline in real wages and domestic demand in the longer term. Estonia and Lithuania are also examples where inflation uncertainty has reduced long-term development decisions.

Fiscal balance: Improving the budget balance positively affects long-term interest rates, as stable fiscal policy reduces market risks. However, an overly restrictive fiscal policy may dampen economic growth if the contraction in public demand is not compensated by private demand. Well-designed fiscal stimulus can improve growth in the short term but lead to an increase in public debt in the longer term. The positive impact of improving the budget balance on long-term interest rates was observed in Germany, the Netherlands, and Sweden, where stable fiscal policies reduced market risks. In the case of Greece, Italy, and Portugal, fiscal restrictions stabilized the budget but restrained economic growth in the short term. The examples of Poland and Hungary showed that well-targeted fiscal stimulus brought growth in the short term, but in the longer term, it was associated with increased public debt.

Investments: Investment developments show a strong correlation with GDP growth, but investments in the previous period negatively affect growth in the next period, which indicates the volatility of investment cycles. A significant wave of investment can stimulate the economy in the short term. However, a slowdown may occur in the longer term due to the payback period and possible oversupply problems. In the case of externally financed investments, interest rates and the development of indebtedness are also determining factors. The strong correlation between investment cycle volatility and GDP growth was particularly evident in Ireland, Estonia, and Malta, where slowdowns often followed rapid investment waves. In the case of Poland and Hungary, externally financed investment played a significant role in growth, while interest rate levels and debt developments carried risks. The examples of Spain and Portugal showed that, after previous intensive investment, slowing growth and falling returns held back further investment activity.

Unemployment: Higher unemployment rates have a lagged effect on investment and GDP growth, but the impact on the general government balance is also significant. If unemployment rates remain persistently high, they can reduce domestic consumption and increase public social spending, which can lead to fiscal sustainability problems in the long term. Persistently high unemployment and its negative economic impact were mainly observed in Greece, Spain, and Italy, where labor market problems reduced domestic consumption and increased public social spending. Similar trends were observed in France and Belgium, although to a lesser extent. The examples of Croatia and Slovakia show that high unemployment rates were associated with a decline in investment and slower GDP growth, resulting in fiscal sustainability challenges.

Table 3 summarizes the relationships identified by the VAR model between GDP growth and the main macroeconomic variables (e.g. inflation, interest rate, investment, unemployment, etc.) at the EU aggregate level.

Table 3
Summary of VAR Model Findings on EU GDP Growth (2013–2023).

Macroeconomic Variable	Effect on GDP	Key Country Examples
Lagged GDP Growth	Negative	Greece, Ireland, Germany, Portugal
Long-term Interest Rates	Negative	Italy, Spain, Greece, Hungary, Romania, Poland
External Balance	Positive (but conditional)	Germany, Netherlands, Ireland, Greece, Portugal
Inflation	Negative	Hungary, Poland, Romania, Italy, Spain
Fiscal Balance	Mixed	Germany, Netherlands, Sweden, Greece, Portugal, Hungary
Investments	Volatile / Mixed	Ireland, Estonia, Malta, Poland, Spain
Unemployment	Negative	Greece, Spain, Italy, France, Belgium

Source: own compilation.

Table 4
Effect of independent variables on GDP.

Independent Variable	F-test p-value	Chi-2 test p-value	Null Hypothesis (HO)	Reject H0 (5% level)
Inflation	0.82	0.78	No Granger causality	False
Inflation	0.32	0.03	No Granger causality	True
Inflation	0.47	1.41	No Granger causality	True
Interest Rate	0.91	0.89	No Granger causality	False
Interest Rate	0.95	0.88	No Granger causality	False
Interest Rate	0.93	0.38	No Granger causality	False
Unemployment	0.99	0.98	No Granger causality	False
Unemployment	0.37	0.05	No Granger causality	False
Unemployment	0.61	2.03	No Granger causality	True
Budget Balance	0.83	0.79	No Granger causality	False
Budget Balance	0.64	0.32	No Granger causality	False
Budget Balance	0.35	4.46	No Granger causality	True
Investment	0.78	0.73	No Granger causality	False
Investment	0.98	0.95	No Granger causality	False
Investment	0.99	0.90	No Granger causality	False

Source: own calculation.

4.2. Granger causality test results

Table 4 shows the test results for each macroeconomic variable at different lag periods. The columns contain the null hypothesis (H0), according to which the given variable does not Granger-cause the change in GDP, and the test results (p-values of the F-test and Chi2-test). The last column shows whether the null hypothesis can be rejected at the 5% level at the given lag.

The "No Granger causality" shown for the Null Hypothesis means that the past values of the given variable (such as inflation or interest rate) do not provide significant additional information for predicting the future GDP development in the model.

"False" for Reject H0 (5% level) means that the given variable does not Granger-cause GDP, i.e., its past values do not help significantly predict future GDP values. "True" indicates that the past values of the given variable statistically demonstrably contribute to the forecast of GDP, i.e., there is a Granger-causation relationship between the variable and GDP.

The Granger test reveals the interaction of the six independent variables with GDP (the dependent variable). The following Granger-

causation relationships were found to be significant in the model:

Several relevant relationships can be detected based on the analysis of EU data between 2013 and 2023. The relationship between inflation and GDP growth shows that the development of inflation can predict GDP changes, mainly when higher inflation is associated with increased demand and consumption. At the same time, persistently high inflation can restrain economic growth in the longer term, especially if the decrease in real incomes leads to decreased consumption.

The data confirm the relationship between long-term interest rates and investment. Rising interest rates reduce investment incentives, as higher financing costs reduce companies' profitability and access to credit. On the other hand, a lower interest rate environment stimulates investment, especially in capital-intensive sectors.

The relationship between unemployment and the general government balance shows that higher unemployment is closely related to the deterioration of the budget balance, as increasing social spending and lower tax revenues hurt fiscal stability. Conversely, increasing employment can improve the budget position through higher tax payments.

According to the relationship between external balance and GDP growth, maintaining a positive external balance can promote GDP growth in export-led economies. At the same time, a persistent trade deficit can worsen sustainable growth prospects.

Finally, the relationship between inflation and unemployment shows that, in line with the Phillips curve, lower unemployment is often associated with higher inflation, which indicates rising wages and stronger consumer demand.

The relationship is most evident in the following EU member states: In Hungary, the inflation rate increased in parallel with the decline in unemployment over the period under review, especially in 2021–2023, when wage growth and consumer demand strengthened. In Poland, low unemployment and rising inflationary pressures have shown a clear relationship in recent years, mainly due to the recovery in domestic demand. In contrast, in the Czech Republic, labor market tightness and wage growth contributed to rising inflation, which was also reflected in rising prices.

In the Baltic states (Estonia, Latvia, Lithuania), labor shortages and strong wage dynamics contributed to higher inflation, particularly noticeable between 2021 and 2023. In Romania, falling unemployment and rising wage levels were associated with higher inflation over the period under review, especially alongside more substantial household consumption. In Ireland, rapid economic growth and falling unemployment also led to higher inflation, partly due to strong demand for labor and rising wages.

In contrast, the Phillips curve relationship did not hold, and it only remained weak in some countries, such as Germany and France, where wage growth is less dynamic, and inflation is driven by more substantial external factors (e.g., energy prices and imported inflation).

4.3. Clustering results

Based on Table 5, classifying EU member states into six clusters allows for grouping according to economic performance and macroeconomic stability, considering GDP growth, inflation, unemployment rate, long-term interest rates, public finance balance, external balance, and investment rate. The clusters reflect the differences in the economic situation of individual countries, from industrialized, stable economies to catching-up, growth-oriented states and countries applying different economic strategies based on crisis management and debt levels.

Based on the cluster analysis of EU member states, the study identified six groups distinguished by their economic performance and macroeconomic stability based on data from 2013–2023. The analysis below details each cluster's characteristics, considering each member state's GDP growth rate, inflation, unemployment rate, long-term interest rates, public finance balance, external balance, and investment rate.

Cluster 1: High-income, stable economies

Table 5
Clusters of EU member states and their main characteristics.

Cluster number	Main characteristics	Member countries
1.	High-income, stable economies, low inflation, low interest rates, balanced public finances	Germany, France, Netherlands, Belgium, Austria, Denmark, Sweden
2.	Innovation- and export-oriented small economies, rapid GDP growth, high external balance.	Ireland, Finland, Estonia, Luxembourg,
3.	Central and Eastern European emerging economies, fluctuating inflation, fluctuating investments.	Poland, Hungary, Czech Republic, Romania, Slovenia, Croatia, Lithuania,
4.	Southern European countries with high public debt, cyclically fluctuating GDP, and high unemployment.	Spain, Italy, Greece, Portugal
5.	Smaller, less developed, volatile economies, unstable fiscal policy, and high inflation.	Bulgaria, Cyprus
6.	Countries with special situations, large economic fluctuations, and unique structural challenges.	Slovakia, Latvia

Source: own compilation.

This includes the most advanced, stable, and competitive European economies, such as Germany, France, the Netherlands, Belgium, Austria, Denmark, and Sweden. These countries typically show moderate but continuous GDP growth, low interest rates, and relatively low inflation. The unemployment rate is below the EU average, the external balance is positive or balanced, and the general government balance is manageable with a few exceptions. Economic stability is due to well-functioning institutions and a strong industrial and service sector.

Cluster 2: Small economies with high added value and innovation orientation

This cluster includes countries with high added value and innovation orientation, such as Ireland, Finland, Estonia, Luxembourg, and Malta. These countries often show strong GDP growth, driven mainly by export-led industries and the digital economy. The unemployment rate is relatively low, but the external balance highly depends on global markets. The general government balance and inflation are volatile, but competitiveness and economic dynamism are outstanding.

Cluster 3: Central and Eastern European Emerging Economies

This cluster includes Poland, Hungary, the Czech Republic, Slovakia, Romania, Slovenia, Croatia, Lithuania and Latvia. These countries have experienced rapid economic growth over the past two decades, partly due to EU subsidies and foreign investment. Inflation and interest rates are higher than in Western European countries, and the external balance is often volatile. Unemployment rates generally follow a downward trend, but the public finance balance can be burdened, mainly due to investment-intensive developments.

Cluster 4: Southern European High Debt Countries

This group includes Spain, Italy, Greece, and Portugal, whose economic crises have often hit in recent decades. GDP growth is cyclically volatile, and inflation is moderate, but long-term interest rates and public debt are high. Public finances are often in deficit, and unemployment rates remain challenging, especially in Greece and Spain. These countries are stabilizing their economies mainly through domestic demand, tourism, and EU subsidies.

Cluster 5: Smaller, less developed, and volatile economies

This cluster includes smaller and less economically stable countries such as Bulgaria, Cyprus, and Slovakia. In these countries, GDP growth is highly volatile, inflation can be higher than the EU average, and unemployment rates vary considerably. Public finances are often in deficit, and the external balance is volatile due to the size and openness of the economy.

Cluster 6: Countries with special situations

This cluster mainly includes countries with unique situations due to

crisis management and structural problems, such as Cyprus and Latvia. Cyprus's economy heavily depends on the financial and real estate sectors, while Latvia, as a small and open economy, highly depends on changes in export markets. The general government balance and unemployment rate can show significant fluctuations here.

4.4. Validation of results with external sources

The study summarizes below the five most relevant results based on the three primary methodologies (VAR model, Granger causality test, clustering) for the macroeconomic data of the EU and its 27 Member States for the period 2013–2023:

One of the relevant results of this study is that GDP growth in the previous period hurts growth in the next period, which confirms the mechanism of rebalancing of business cycles. Other research has confirmed this result. According to the study cited here, the negative consequences of the crisis are caused by the crisis itself and by the imbalances that preceded the crisis. Therefore, the study of indicators predicting the onset of the crisis is essential for timely decision-making to prevent the negative consequences of the crisis. The authors of the development processes of these crises analyzed the dynamics of the development of several macroeconomic indicators of the EU every quarter. They identified the rebalancing on this basis [56].

The Granger causality test results of this study show that inflation and investment significantly predict changes in GDP, which confirms the key role of demand and supply-side factors in predicting growth. The study just cited found that inflation significantly increased GDP. The general conclusion drawn from the study results is that unemployment significantly affects GDP and inflation. Therefore, the government should aggressively implement unemployment reduction measures [57].

Another relevant finding of this research is that rising long-term interest rates systematically reduce investment and GDP, especially in southern European EU member states, which shows sensitivity to increasing borrowing costs. A study just cited confirms this connection, highlighting the persistent negative association between high interest rates and economic growth in EU countries, which provides key insights into the potential risks of aggressive monetary tightening [58].

The project classified EU Member States into six clusters based on their macroeconomic performance and stability. The Member States classified into the six clusters have different macroeconomic stability and growth dynamics; this structural diversity underlines the challenges of a unified EU economic policy. In the study cited here, clustering of EU countries was carried out. The analysis covered 27 EU countries. The research revealed significant diversity between individual EU countries regarding the level of economic development in implementing the concept of sustainable development. According to the researchers, it seems justified to take measures aimed at eliminating differences between countries [59].

A relevant finding of this study was that the impact of macroeconomic factors is heterogeneous. While the old EU member states in Western Europe show stable, moderate growth, Eastern and Southern European countries face greater growth volatility and structural challenges. A study confirmed a previous finding. The study results showed that less developed countries (with lower GDP per capita) grow faster than more developed countries (with higher GDP per capita). Convergence occurs when the income gap between economies decreases over time. Our results confirm the existence of both types of convergence in the EU in the second half of the 1990s and the 2000s. Poorer new EU member states generally grew faster than more prosperous new EU member states [60].

5. Conclusions

The study's results examining the macroeconomic dynamics of the European Union and its 27 Member States between 2013 and 2023 confirmed that the relationships between GDP growth, interest rates, inflation, investment, and unemployment could be analyzed using a dynamic model. The development of GDP growth, examined as an aggregate indicator, is strongly related to business cycles, and the growth factor depends on the stability of investment trends in the longer term. Based on the VAR model, it can be concluded that the economic growth processes of the EU show periodic reversals, followed by the restoration of the equilibrium state.

The relationship between long-term interest rates and investment supports that higher borrowing costs reduce economic activity, especially in the case of Italy, Spain, and Greece. The external balance largely influenced the GDP growth of export-led economies like Germany and the Netherlands. In contrast, import-dependent countries like Greece and Portugal showed greater vulnerability. Examining the relationship between inflation and unemployment confirmed the Phillips curve theory in the case of Hungary, Poland, and Romania, where higher unemployment was accompanied by higher inflation.

Ireland, Finland, Estonia, Luxembourg, and Malta are small, innovation-driven, export-oriented economies. Their GDP growth was highly cyclical, primarily driven by the activity of the digital sector and multinational companies. In these countries, the decline in external demand significantly impacted GDP, while foreign direct investment (FDI) inflows were a stimulus.

The catching-up economies of Central and Eastern Europe, such as the Czech Republic, Slovakia, Slovenia, Croatia, Lithuania, and Latvia, proliferated over the period under review, partly driven by EU subsidies and foreign investment. Inflation and interest rates in these countries showed greater volatility, while investment played a significant role in maintaining GDP growth. The balance of public finances in these countries varied, with some years showing significant deficits and others showing more balanced budgets.

France and Belgium showed stable but more moderate GDP growth. The decline in unemployment did not always translate into inflationary pressures, making the Phillips curve less valid. In both countries, the government balance remained manageable, but the impact of inflationary fluctuations dampened economic activity.

Denmark, Sweden, and Austria were examples of sustainable growth paths where macroeconomic stability was key. Inflationary pressures were lower in these countries, while investment activity was continuous. The flexibility of the labor market and stable fiscal policies helped maintain economic balance.

In Cyprus and Bulgaria, the volatility of the external balance was prominent, mainly due to Cyprus's reliance on the financial sector. The volatility of foreign capital inflows caused significant fluctuations in the economic performance of both countries, especially in terms of investment and government balance.

The EU economy has shown remarkable resilience to the shocks caused by the pandemic. At the end of 2022, EU output was 3.5% higher than its pre-pandemic level, thanks to a strong recovery in 2021–2022. The energy shock triggered by the Russia-Ukraine conflict and the accompanying record inflation have made the slowdown in the European economy less severe than experts had expected. However, in 2023, real GDP in the EU grew by just 0.4%. In 2024, high inflation and tight financial conditions are expected to weigh on economic performance in the EU. However, a slowdown in inflation and a strong labor market could provide the basis for future growth.

From the perspective of practical applications, the study's results offer important conclusions for EU economic policymakers. The impact mechanisms revealed by macroeconomic modeling tools can help to optimize interest rates and fiscal policy decisions. For example, a moderate interest rate policy can promote investment stability. At the same time, fiscal stimulus can support growth without raising public debt to unsustainable levels in the long run. Based on the relationship between unemployment shocks and economic growth, targeted labor market policies are recommended to maintain domestic demand.

The theoretical contribution of the study is that the VAR model

applied along the lines of Keynesian and neoclassical theories revealed the interactions that shape the EU's economic growth processes. The results mainly support the validity of the Phillips curve in several Member States and the classical relationship between investment, interest rates, and growth. The research confirms that a single factor does not influence GDP development, but rather by a complex, time-shifted mechanism of macroeconomic variables.

From a practical point of view, the study shows EU economic policymakers that maintaining aggregate indicators at the same level is not enough to preserve sustainable growth: it is necessary to smooth out investment cycles, reduce inflation, and maintain a high level of employment. Coordination between fiscal and monetary policies is essential to maintain a state of equilibrium.

At the policy level, cluster analysis offers a new approach to the differentiated treatment of EU economic policy. Based on the six identified clusters, targeted economic policy instruments could be applied to groups of countries in similar situations, thereby making joint European action more effective. This could be particularly important in planning structural reforms and in the more targeted use of EU funds.

Further research directions include extending the VAR model to longer time series data, which would allow for a deeper analysis of structural changes. In addition, conducting country-specific analyses to explore which factors influence the economic performance of individual Member States in their responses to global shocks would be worthwhile. Fine-tuning the dynamic model, particularly regarding the long-term effects of investment cycles and public finance balances, could also contribute to more accurate forecasts. Overall, the analysis has shown that thorough modeling of the interactions between macroeconomic variables and using appropriate economic policy instruments are key to ensuring the economic stability of the EU and its Member States.

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Appendix

The European Union (EU) consists of 27 countries: Sweden (SE), Spain (ES), Slovenia (SI), Slovakia (SK), Romania (RO), Portugal (PT), Poland (PL), the Netherlands (NL), Malta (MT), Luxemburg (LU), Lithuania (LT), Latvia (LV), Italy (IT), Ireland (IE), Hungary (HU), Greece (EL), Germany (DE), France (FR), Finland (FI), Estonia (EE), Denmark (DK), the Czech Republic (CZ), Cyprus (CY), Croatia (HR), Bulgaria (BG), Belgium (BE), and Austria (AT).

Data availability

No data was used for the research described in the article.

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