Extent of the relationship between Economic Growth and its determinants in Europe from 2000 – 2021

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Resumo

O atual nexo entre energia, educação e crescimento económico leva a desenvolver modelos económicos teóricos, híbridos e integrados. Nesta pesquisa, tem-se em consideração variáveis que medem o conhecimento tecnológico (despesas do setor de I&D), o capital físico (formação bruta de capital fixo), o capital humano (população com ensino), o trabalho (população empregada), a política (índice de perceção de corrupção) e a energia (importações de produtos energéticos) de modo a verificar o seu impacto sobre o crescimento económico de diversos países.

Na validação do modelo teórico, consideraram-se diferentes equações, começando pela equação 1, que é considerada a mais básica do modelo de Solow, apenas com a presença dos fatores progresso técnico (A), capital físico (K) e trabalho (L). De seguida, a função 2 sofre uma evolução, tal como a teoria económica e por isso, é acrescentado o fator capital humano (H) na mesma. As equações 3 e 4 são iguais à anterior, mas nestas ocorre uma divisão dos fatores L e H em três níveis de educação. Por fim a última equação inclui também os fatores energético e político. Para além disso, optou-se pela utilização e estimação de uma série de técnicas econométricas, como, os testes de diagnóstico, que visam identificar a presença de dependência de cross section, heterocedasticidade e autocorrelação de primeira ordem, seguindo-se a estimação dos modelos de efeitos fixos e aleatórios mais clássicos e com correção ao enviesamento e por fim, estimou-se o método dos momentos generalizados quer às primeiras diferenças quer o robusto.

Esta investigação dá enfase à importância de variáveis económicas, políticas, sociais e energéticas e tem como principal objetivo, explicar o impacto das mesmas no comportamento do crescimento económico dos estados-membros da União Europeia. Assim, foi realizado um estudo tendo por base, dados em painel dos 27 estados pertencentes à UE, para o período temporal de 2000 a 2021.

Posto isto, esta análise procura responder a algumas questões de investigação, tais como: Qual o impacto do nível educacional da população e da mão-de-obra no crescimento económico da zona euro? Qual a influencia da dependência energética europeia no seu crescimento económico? De que forma a corrupção e criminalidade tem impacto no PIB dos membros da UE? O nível de inovação tecnológica de cada país terá impacto significativo e direto no seu crescimento?

Os resultados empíricos obtidos estão, maioritariamente, em consonância com a teoria económica atual. Como seria de esperar, na equação estendida 5, as variáveis Formação Bruta de Capital fixo, Mão-de-obra com ensino total, Dependência energética e Índice de Perceção de Corrupção têm um impacto positivo na maioria dos modelos estimados. Por outro lado, as variáveis Despesas em I&D e População com ensino total tiveram um impacto negativo nos estimadores de efeitos fixos e aleatórios com correção ao enviesamento, bem como no estimador GMM robusto.

De acordo com os resultados é necessário que as instituições governacionais europeias e de cada país, implementem políticas que visem o aumento do crescimento económico. Reduzir a dependência energética aumentando a produção doméstica através da utilização de fontes de energia mais limpas (ex: renováveis), reduzindo a poluição, criando mais emprego e melhorando o bem-estar da sociedade é imprescindível para melhorar a economia dos países da zona euro, visto que estes são ainda 60% importadores de matéria-prima energética. Para além disso, são também necessárias políticas que visem melhorar o conhecimento, a formação e as práticas institucionais em matéria de transparência e integridade de modo a manter não só, a transparência governacional, mas também reduzir a corrupção e a criminalidade. Assim, aumentar as penas para crimes de corrupção bem como a eficiência dos recursos no processo penal são também, algumas das medidas que podem ser implementadas. Para além disso, políticas que levem ao incentivo e ao aumento do nível educacional irão reduzir a corrupção e levar ao aumento da produtividade e do conhecimento da população. Este conhecimento terá impacto imediato no fator de progresso técnico que está diretamente ligado à função produção, uma vez que, mais conhecimento gera mais inovação e por isso, mais crescimento económico.

Sendo a União Europeia um dos principais blocos económicos a nível mundial e uma vez que, os seus estados-membros são guiados pelas mesmas diretrizes, metas e têm os valores e objetivos, então deverão ser implementadas políticas que promovam não só o seu crescimento económico sustentável, mas também, a paz e o bem-estar da sociedade.

Palavras-chave

Capital físico; Capital Humano; Conhecimento Tecnológico; Corrupção; Crescimento económico; Importações; Trabalho.

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Abstract

The current nexus between energy, education and economic growth leads to the development of theoretical, hybrid and integrated economic models. In this research, we take into consideration variables that measure technological knowledge (R&D sector expenditures), physical capital (gross fixed capital formation), human capital (population with education), labour (employed population), politics (corruption perception index) and energy (imports of energy products) to verify their impact on the economic growth of several countries.

Different equations were considered in the validation of the theoretical model and a series of econometric techniques were used and estimated, such as specification tests, basic and bias-corrected fixed and random effects models, and the generalized method of moments.

This research emphasizes the importance of economic, political, social and energy variables to explain their impact on the economic growth behaviour of the European Union member states. Thus, we conducted a study based on panel data for the 27 EU member states from 2000 to 2021.

The empirical results obtained are mostly in line with current economic theory. As expected, in the extended equation 5, the variables Gross Fixed Capital Formation, Total Education Labor, Energy Dependence and Corruption Perception Index have a positive impact in most of the estimated models. On the other hand, the variables R&D Expenditure and Total Education Population had a negative impact on the fixed and random effects estimators with bias correction, as well as on the robust GMM estimator.

Keywords

Corruption; Economic Growth; Human Capital; Imports; Labour; Physical Capital; Technological Knowledge.

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List of Acronyms

GDP - Gross Domestic Product
R&D - Research and Development
GFCF - Gross Fixed Capital Formation
CPI - Corruption Perception Index
FE - Fixed Effects
RE - Random Effects
GMM - Generalized Method of Moments
Y - GDP pc
A - Technical Progress (R&D Sector Expenditure as % of GDP)
K - Physical Capital (GFCF pc)
L - Labor (Total Education Labour Force)
L1 - Primary Education Labour Force
L2 - Secondary Education Labour
L3 - Tertiary Education Labour Force
H - Human capital (Total Education Population)
H1 - Primary Education Population
H2 - Secondary Education Population
H3 - Tertiary Education Population
E - Dependence on Energy Imports
P - Corruption Perception Index
pc - per capita

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1. Introduction

Economic growth consists of the quantitative increase of the productive capacity of an economy, so its theory seeks to find the factors that determine growth and identify policies that foster its increase. The production function of an economy relates the quantities of resources used in production, such as the physical capital, the human capital, the technological evolution, and the labour force, with the volume of production obtained. That said, GDP consists of the sum of household and corporate consumption and investments, plus the results of the balance of trade and government spending. The GDP per capita, however, is associated with the quantity of goods and services produced in the economy. In addition, one should take into account technical progress, which is observed, on the one hand, in the increase of productivity of production factors, and on the other hand, the human capital, which is the set of skills and productive skills of the population and translates into technical progress. Considering the factors that determine economic growth, policies that aim to increase a country's growth, such as reducing corruption, must be implemented. Energy is also one of the main influences on a country's economic and social growth, helping to develop an economy by allowing access to essential services used not only in the daily lives of citizens, but also in production. Therefore, having a lower dependency on other countries in terms of the need to import energy products, as well as increasing internal production, should be goals to be taken into account by the European Union.

The endogenous economic growth models of Romer and Lucas are an extension of the model proposed by Solow in 1956. The Romer model considers that knowledge creation is a side effect of investment, since, with the increase in physical capital, productivity becomes more efficient, Romer, (1990). On the other hand, the Lucas model, argues that human capital and physical capital are produced through different technologies and that, in turn, human capital (skills, educational or individual talent of each individual) is the only input of the educational sector, Lucas, (1988).

This study contributes to the literature by studying the relationship between economic growth and the variables, R&D sector expenditure, gross fixed capital formation, population with education (total, primary, secondary, and tertiary), employed population (total, primary, secondary, and tertiary), dependence on energy imports and the corruption perception index, through the production equations shown in the Solow, Romer and Lucas models. This study uses panel data for the 27 member states of the European Union for the period 2000 - 2021.

The econometric tests used were first the diagnostic tests of classical panel data models to check for cross-section dependence, heteroskedasticity and autocorrelation. Then the bias-corrected estimation of linear dynamic panel data models (fixed effects, FE, and random effects, RE) was calculated. Finally, the estimation of the Generalized Method for estimating moments of linear dynamic panel data models (GMM) was performed.

According the EF and ER estimators with correction for bias and in the GMM-robustness estimator, they present a positive influence on the economic growth of countries. the contrary, the GMM-One Step estimator presents negative coefficients for this variable. So, in this case, policies will be necessary to stimulate not only the participation of the labour force in economic activity to reduce skilled labour shortages in Europe but also to invest in education and rebalance the demographic structure as well as its judicious distribution at the territorial level.

In terms of structure, this dissertation after the introduction section presents a section with the literature review, and a section with the data and methodology used. The subsequent section shows the results. Section 5 exposes its discussion, and finally, the last section displays the conclusion. For its elaboration, the research of articles, papers, and literature via the internet was carried out, and the software "StataBE" was used.

2. Literature Review

The purpose of this dissertation is to analyze the relationship between economic growth, that is, the variation in Gross Domestic Product (GDP) per capita, and its economic, political, social, and even energy determinants. Capital accumulation plays a crucial social role in a country's growth process. The production function of an economy relates the quantities of resources used in production, usually capital, either physical (K) or human (H), technological knowledge (A) and labour (L), to the volume of production that is obtained. In addition, variables such as energy and corruption can also have an impact on the level of production of a country.

This paper combines elements from several economic growth models, such as the growth model developed by Solow (1956) and the endogenous growth models proposed by Lucas (1988) and Romer (1990). Since other variables are added at the regression stage, the functional form for aggregate production originally assumed in each model is not fully respected. The combination of these models is considered indispensable since the study is based on the economic growth of European countries and as such, it is necessary to address the basic growth models when forming equations to be used in the empirical part.

Robert Solow, in his article, Solow, (1956), proposed a neoclassical model, the exogenous long-run economic growth model that has become one of the most widely used theoretical and empirical tools in economic analysis. First, in this model, the production function uses physical capital (K), labour (L) and technical progress (A) as resources. Since without K and L no growth can be generated, these variables have a large productive input and are therefore included in all economic growth equations in this thesis. The successive use of one more unit of one of the productive factors leads to increases in the level of production (Y), but these increases are smaller and smaller. The characteristic of factor K - decreasing marginal returns - motivated the development of models that could accommodate the empirical evidence of positive and sustained economic growth in the long run.

Technological evolution has revolutionized entire economies and society and has encouraged all governments to implement ambitious R&D policies in order to promote and leverage innovation and economic growth in their nations. The Research and Development sector is considered one of the main determinants of technological development, and therefore plays a key role in determining the differences in growth between countries. That said, spending on R&D becomes an indicator that makes it possible to analyze the relevance that a country offers to science, technology, and innovation. The volume of spending on R&D reveals future competitiveness and wealth. Thus, spending in this sector becomes crucial in a knowledge-based economy since it aims to improve production technologies and stimulate economic growth.

According to Bilbao-Osorio & Rodríguez-Pose, (2004), R&D expenditure, as a whole, and investment in R&D in European countries, are positively associated with innovation and this, in turn, is directly linked to economic growth. So, investment in R&D, that is, in innovation, will generate economic growth. Simionescu et al., (2021), in their study on the 28 EU states for the period 2004-2018, conclude that R&D spending plays a positive and quite significant role in the GDP per capita of the eurozone countries.

In addition, with technological change, the differences between workers' skills began to be considered. According to Brugger & Gehrke, (2018), it was technological change that led to a polarization of labour, while at the same time there was a de-skilling of a large part of the workforce and an increase in demand for highly skilled workers. Education tends to keep up with technological change, but if there is still a shortage of highly skilled workers it is not possible to fully expand investment in R&D, creating an obstacle to growth, Abbritti & Consolo, (2022).

Acemoglu, (2000) argue that technical change and technological advances favour more skilled workers, replacing tasks previously performed by the unskilled and exacerbating inequality. Currently, there is a greater demand for skilled labour, which is one reason many unskilled workers choose to acquire specialized skills in order to move into skilled positions. Mello, (2008), through his study shows that economies with high substitutability between skilled and unskilled workers have high levels of capital, output, and a high proportion of skilled workers.

In this study, one must consider the primary difference between the two types of workers. On the one hand, skilled labour, which requires specialized training, and on the other, unskilled labour that does not require a particular skill set or formal education. The value of industrial production occupies a large portion of national income, Valero, (2021), and therefore, countries must increase their capital investment in education in order to stimulate their economic development and growth, Hanushek et al., (2017) and Marquez-Ramos & Mourelle, (2019).

The authors González-Sánchez et al., (2020) analyzed data for 31 European countries during the last decade (2010-2019), and the results obtained verify the positive effect of human capital on economic growth. Prada & Cimpoeru, (2019) investigated the influence of education and human capital on economic growth in European Union Countries from 2003 to 2016 and concluded that there is a strong link between economic growth and human capital and that the workforce with intermediate education has a significant impact on economic growth. With this, it can be seen that investment in human capital is central to the development of economies and therefore has a positive impact on the economic growth of countries, that is, their GDP per capita, Pelinescu, (2015) and Diebolt & Hippe, (2022). The efficient functioning of areas such as the education system and the R&D sector greatly impacts the development of human capital. Human capital, in turn, is a factor of great importance for the economy of eurozone countries and will impact the national economy as European countries are transitioning to post-industrial innovative development.

According to the existing literature, it is known that the level of education directly influences the level of employability, and that skilled workers (with a diploma) have more employability when compared to unskilled workers. That said, it is also essential to address the relationship between economic growth and labour, more specifically, employment. There are theoretical and empirical studies that have analyzed various countries and the impact that employability has on their economic activity. It is important to note that the relationship between employment and economic growth is bidirectional since employment contributes to an increase in GDP and vice versa, Dritsakis & Stamatiou, (2018). According to Herman, (2011), in his study of 27 European countries, only the process of economic growth generates new jobs, thus, ensuring the conditions for economic and human development, so it is crucial to act to increase the level of educated population and consequently, the intensity of employment and economic growth.

There is a dependency between the behaviour of economic growth and employment and that, therefore it is essential to implement measures that promote the increase in the educational level and employment and thus interrupt prolonged recessions. Soava et al., (2020) analyzed the evolution and influence of variables such as labour force and gross fixed capital formation, among others, on the economic growth of European Union countries during the time period from 1996 to 2019. They concluded that a decrease in the employed population and a reduction in investments are the main factors that lead to the reduction of the GDP growth rate.

With technological evolution, it became necessary to differentiate the levels of education, and therefore, another productive variable was added, called human capital (H). In his model of economic growth, Lucas, (1988) argued that physical and human capital are produced through different technologies; unlike the process of K accumulation, the process of H accumulation presents constant and non-decreasing marginal returns to scale. It then becomes possible to adjust and improve the growth model by including the H variable, that is, recognizing that the labour force in different economies has different levels of education, thus taking into account the average skill level of workers, which may be higher or lower, Jones, (1997). For Lucas, the human capital factor highly important since economic growth, in the long run, results mainly from the accumulation of human capital, Lucas, (1988). The authors Matousek & Tzeremes, (2021), who work in the same line of research, concluded that, in most cases, human capital could be one factor that explains the difference in growth between countries. Romer, (1990) argues that the effect of technical progress is endogenized and includes the output of the private R&D sector as well as the researchers working in that same sector. This model defines that technical progress allows increasing profits, since technology is considered a non-rival and partially exclusive good, since patents have a limited duration. Innovation is considered the main endogenous growth engine of modern economies, so the possibility of companies increasing profits via technical progress generated by R&D represents an important incentive for this type of investment in the economy and, therefore, for sustained economic growth.

Physical capital formation (K) is also considered an important factor of economic growth, both in theoretical and empirical literature, a direct and indirect impact on productivity. Gross fixed capital formation consists of the value of durable goods acquired by resident producing units to be used in the production process and the value of services embodied in fixed capital goods.

Trpeski & Cvetanoska, (2019) examined the impact of fixed capital investment on productivity in Southeastern European countries from 2000 to 2017 and concluded that increases in productivity are explained by increases in investment in gross fixed capital formation. According to ERKİŞİ & BOĞA, (2019) and Aslan & Altinoz, (2021), through their analyses, where they study the relationship between gross fixed capital formation and economic growth in some eurozone countries, they conclude that the level of gross fixed capital formation can positively influence economic growth. In the same vein, Lymonova, (2019) argues that gross fixed capital formation had a positive influence on the GDP of Eurozone countries from 2002 to 2017.

Subsequently, other lines of research arise in this study that consider not only the production factors mentioned above but also institutional and political variables. With regard to the energy factor, it is known that energy consumption plays an important role in the production process and, consequently, in economic growth, and can limit it. Thus, it is important to approach energy dependence based on the resource curse theory, which argues that countries that are exporters of natural resources, i.e., those with low energy dependence, are more likely to have not only negative social consequences, but also low economic performance and even a higher level of corruption, due to macroeconomic problems or even the absence of solid institutions Auty, (1994). Resource management becomes essential in natural resource importing countries that want to achieve sustainable economic growth. Thus, the authorities must create and implement economic policies to clearly establish the rights and duties of populations and institutions over resources, Singh et al., (2023).

In addition, it is currently essencial to understand the impact of energy variables on the economic growth of euro zone countries. It is vital to analyze in which types of production most energy is used, and which workers are employed in them in order to verify how energy dependence by EU countries can positively or negatively influence their economic growth. In the case of European countries, where energy products are traded with other countries, the stability of the energy supply can be threatened when a high proportion of imports are concentrated among relatively few external partners. Imports of energy products occur whenever a country is unable to produce a specific type of energy or when the amount it produces is insufficient to meet all needs. Thus, it is necessary to examine the energy dependence of each country in order to understand how the production of wealth and its growth may be affected.

That said, it is indeed essential that sufficient energy resources, whether imported or self-produced, are available to sustain a country's economic activity. Bildirici & Kayıkçı, (2022), through their study conclude that increases in energy imports generate increases in economic growth. Adams et al., (2000) and Çam Karakaş et al., (2019) also argue that energy imports increase GDP. Furthermore, they state that an increase in additional domestic energy production or improved energy efficiency can go some way to help alleviate the trend of energy imports. Carfora et al., (2022) conducted an in-depth analysis of the factors that determined the energy import demand of the 27 EU countries, and their results show that there are benefits to replacing energy imports with domestic energy production and thus reducing the energy dependency ratio.

Finally, regarding the institutional factor of corruption, Robinson, (1966) investigated why societies differ in the frequency of corrupt practices and argues that measures of institutional quality are correlated, and therefore the risk of corruption and expropriation are intertwined. Corruption reduces productivity and the effectiveness of economic policies. It also encourages individuals and companies to violate the law. Citizens and policy-makers have political, economic and social instruments to influence economic growth, so the economy should develop informal constraints that force citizens to restrict their behaviours in order to make political and judicial systems effective forces, (North, 1991). Good governance, which upholds democracy, decreases corruption, and attracts and increases foreign investment, coupled with low levels of corruption lead to economic growth, Gründler & Potrafke, (2019).

So it is essential in a study such as this one to address the corruption perception index in order to understand how it contributes to economic growth, especially in periods where the economy is threatened by increases in the inflation rate or recessions. Although corruption is correlated with political and moral degradation, there is no consensus on the impact of corruption on economic growth. Although in the literature, it is almost intuitive that corruption negatively affects economic growth: empirical evidence and counterarguments show that there may be positive implications for corruption.

Knowing that corruption has substantial and adverse effects on countries economic growth and that the costs of corruption are so high, why do economies not strive to improve their institutions and eradicate corruption? Mauro, (2004) tried to understand why corruption endures over time despite its negative impact on countries' economic growth. He used several models to explain this relationship, and he concludes that individuals do not have incentives to put an end to corruption even though societies would be better off without it. Popova & Podolyakina, (2014) analyzed how corruption can influence economic indicators and human capital indicators of eurozone countries and concluded that corruption is destructive to these economies, negatively influencing their economic growth. Herzfeld & Christoph, (2003) also argues that the lower the existence of corruption, the higher the economic growth because an increase in GDP results in an increase in the levels of the corruption perception index and lower the levels of corruption.

The corruption of each country is observed through a combination of corruption analysis sources developed by independent organizations and is directly correlated with its economic situation, reflected in its GDP and also in its employment rate. The authors Christos et al., (2018) conducted a study that aimed to investigate the phenomenon of corruption in relation to economic development and growth in Europe, where they conclude that there is a positive relationship between the growth rate of GDP per capita and the reduction of corruption levels for all European countries. Farrag & Ezzat, (2019) used 17 European countries and the period 1999-2012 as a sample to compare the impact of corruption on growth and their results indicate that for

European countries corruption tends to have an "efficiency-enhancing" effect, i.e., more corruption, more wealth. In the opposite direction, Pluskota, (2020) used economically developed countries in Europe from 1996 to 2017 as data and concluded that a low level of corruption can be beneficial to an economy. The study by Uberti, (2022), based on data from 1790 to 2010 for the countries in Europe, led to the conclusion that grand corruption (executive) is the most prevalent in less democratic regimes and is not related to economic growth after accounting for the prevalence of petty corruption (bureaucratic).

3. Data and Methodology

3.1. Data and Model Estimation Proposal

This study focuses on the twenty-seven countries directly committed to the supranational orientation of the European Union so one can evaluate the results obtained in a context of strong interrelation between the states' policies. Panel data were used for the period 2000 to 2021, thus making a total of 22 years, from all 27 states belonging to the EU: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden (Annex 1).

The main objective of this paper is to analyse the relationship between Economic Growth and its determinants using data suggested by the existing literature. To correspond to this objective, GDP per capita (Y), expressed in euros, was used as the dependent variable.

Several factors influence a country's economic growth. Therefore, to carry out this study, annual data and independent economic, political, social and energy variables were used: Expenditure in Research and Development activities (A) as a % of GDP, Gross Fixed Capital Formation (K) expressed in Euro currency, Primary (L1), Secondary (L2) and Tertiary (L3) Education Labour Force, the Primary (H1), Secondary (H2) and Tertiary (H3) Education Population, both in thousands of individuals, the Dependence on Energy Imports (E), in percentage and the Corruption Perception Index (P), in units (scale of 0 to 100). All data on these variables were taken from "The World Bank", "Pordata", and "Transparency International", as shown in Annex 2.

The GDP per capita variable (Y) presents the gross domestic product divided by the number of inhabitants of a country and is the most widely used measure of growth. It represents all the final goods and services produced in a country during a certain period of time, more precisely, in a given year. Social welfare is associated with the ratio between the number of goods and services produced in the economy and the number of people whose needs must be met. Thus, per capita GDP is used as an indicator of social welfare. This variable is directly related to the amount of wealth generated per person, i.e., it measures the Economic Growth of each country. Thus, the higher the GDP per capita, the higher the country's development.

The variable Expenditure on Research and Development Sector Activities (A) covers expenditure generated in this sector of the economy, regardless of the source of financing. Included here are all expenditures on R&D activities within a company or institution, such as facilities, materials, personnel, and others, and it excludes expenditures on outsourcing or financing R&D by other entities. The Research and Development sector is where new creative ideas are generated, and new discoveries based on original concepts or hypotheses are developed to produce results that can be freely transferred or traded on the market. The R&D sector is directly linked to the production function of an economy. Given that this variable is indexed to technical progress, it can be concluded that the greater a country's investment in the R&D sector, the greater its economic growth will be.

The Gross Fixed Capital Formation variable (K), consisting of the net acquisitions of valuable goods, is also considered investments by resident producers minus the disposal of fixed assets during a given period. It also includes land improvements, the purchase of plant, machinery and equipment, and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential housing, and commercial and industrial buildings. This macroeconomic indicator shows how current investments in fixed assets increase the productive capacity of an economy in the future. So for economic growth in a country, Gross Fixed Capital Formation should have an increasing share. Thus, increases in this indicator will positively stimulate GDP per capita.

The variables Primary (L1), Secondary (L2) and Tertiary (L3) Employed Population include the basic educated workforce (% of working age population with basic education), the intermediate educated workforce (% of total working age population with intermediate education) and the advanced educated workforce (% of total working age population with advanced education). Basic education includes primary or lower secondary education, and intermediate education comprises:

$$Y_{it} = \beta_0 + \beta_1 A_{it} + \beta_2 K_{it} + \beta_3 L_{it} + \varepsilon_{it} \quad \textbf{(1)}$$

The addition of one more unit of one of the productive factors increases the level of production (Y), but diminishing returns are experienced. Thus, economic growth based on physical capital accumulation is not sustainable, but it can result from permanent technical progress, Barro & Sala-i-Martin, (2004). Adjusting and improving this model by including the Human Capital variable is necessary.

Subsequently, additional moderator variables were added to the model, and further regressions were estimated. For this purpose, the labour force (L) and human capital (H) were split into three variables to capture their effect (employed population with L1: primary education, L2: secondary education, L3: tertiary education), (existing population with H1: primary education, H2: secondary education, H3: tertiary education), thus we have in these variables the ideals of the Lucas model.

$$Y_{it} = \beta_0 + \beta_1 A_{it} + \beta_2 K_{it} + \beta_3 L1_{it} + \beta_4 L2_{it} + \beta_5 L3_{it} + \beta_6 H_{it} + \varepsilon_{it} \quad \textbf{(3)}$$

$$Y_{it} = \beta_0 + \beta_1 A_{it} + \beta_2 K_{it} + \beta_3 L_{it} + \beta_4 H1_{it} + \beta_5 H2_{it} + \beta_6 H3_{it} + \varepsilon_{it} \quad \textbf{(4)}$$

Finally, a last equation was estimated, taking into account institutional variables. Access to energy is of strategic importance for the development and existence of societies. Hence, ensuring its uninterrupted supply is a priority for the economies of EU member states. Furthermore, a country's corruption tends to influence its growth directly and is, therefore, an institutional variable to be considered. Thus, the final output equation that will be estimated in this research is represented by the following:

$$Y_{it} = \beta_0 + \beta_1 A_{it} + \beta_2 K_{it} + \beta_3 L_{it} + \beta_4 H_{it} + \beta_5 E_{it} + \beta_6 P_{it} + \varepsilon_{it} \quad \textbf{(5)}$$

The econometric analysis was conducted using "StataBE", a complete and integrated statistical software that supplies everything for data analysis, especially panel data, as is the case of the study.

3.2. Methodologies

Firstly, an estimation of the panel data in complex error compositions was performed through the Pesaran, Frees, Friedman, Modified Wald, and Wooldridge tests. These tests were used as heteroscedasticity, panel autocorrelation, and contemporaneous correlation phenomena must be adequately treated because if this does not happen, there may be inefficiency in the coefficient estimation and/or bias in the estimation of the standard errors. After the estimation of the basic fixed and random effects models, the econometric tests used were the bias-corrected estimation of linear dynamic panel data models (fixed effects, FE and random effects, RE) and the generalized method for estimating moments of linear dynamic panel data models, (GMM estimation, a predominant estimation technique for models with endogenous variables, with short time horizon).

3.2.1. Diagnostic Tests

First, an estimation of the panel data in complex error compositions should be performed since heteroscedasticity, panel autocorrelation, and contemporaneous correlation phenomena must be dealt with properly because, if this does not happen, there may be inefficiency in the coefficient estimation and/or bias in the estimation of the standard errors.

Cross-sectional dependence depends on factors such as the magnitude of the correlations between cross-sections and the nature of the cross-sectional dependence itself. There are statistical procedures that allow the testing of cross-sectional dependence in panels when N (number of countries) > T (number of periods), such as Pesaran's (2004) cross-sectional dependence test, Friedman's statistic (1937) and the statistical test proposed by Frees (1995). If the correlation coefficients of the disturbances change sign (or if common time effects have been included in the model), only Frees' test can be used. It is necessary to calculate the mean absolute value of the off-diagonal elements of the cross-sectional correlation matrix of the residuals. If this is high, and the different tests provide contradictory results, in that the Pesaran and Friedman tests reject the null hypothesis, and the Frees test does not, the latter should be chosen. In dynamic panels, the Pesaran test remains valid in FE/RE estimation, even if there is bias in the estimated parameters, De Hoyos & Sarafidis, (2006).

Heteroscedasticity is considered present in linear regression models whenever the variance of the errors is not the same in all observations. The modified Wald test is used to verify the presence of group heteroscedasticity in the estimated regression model. This test rejects the null hypothesis that the residuals are homoscedastic and have constant variance. When there is heteroscedasticity, the error term is conceived as being drawn from a different distribution for each observation. The covariance matrix (Ω) of the errors is given by: $VAR\ (\varepsilon_i|X) = \sigma_1^2 = \begin{pmatrix} \sigma_1^2 & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & \sigma_n^2 \end{pmatrix}$. The main diagonal represents different variances for each observation. If all terms outside the diagonal are equal to zero, then the errors are uncorrelated. Thus, in repeated samples, it is known that the error associated with one observation is related to the error of any other observation. When this does not happen, it is said that there is an autocorrelation between the errors.

On the other hand, it is known that in the presence of autocorrelation between the residuals, biases will occur in the standard errors making the estimates less efficient. Here, it becomes necessary to perform the Wooldridge test, which aims to recognize the existence of a serial correlation between the residuals and can be applied in models with fixed and random effects, Drukker, (2003).

3.2.2. FE and RE models with bias correction

Regression models with panel data have temporal and spatial dimensions since the same cross-sectional unit (countries) is monitored over time. In the case of the current study, the period 2000-2021 was analysed, so there were 594 observations (27 countries x 22 years).

If cross-sectional dependence is caused by the presence of common factors, which are unobserved but are felt through the disturbance term and are not correlated with the regressors, then the standard fixed effects (FE) and random effects (RE) estimators are consistent but not efficient, and the estimated standard errors are biased. On the other hand, if the unobserved components that create interdependencies between cross-sections are correlated with the regressors, then the EF and ER estimators will be biased and inconsistent.

In the fixed effects model, the parameters are fixed quantities, and the group means are also fixed. The individual unit intercept may differ across individuals, and it may be necessary to use dummy variables. The disadvantage of this model is that when the number of cross-section units (N) is high, many degrees of freedom are required as it is necessary to include N dummy variables. The equation defined by fixed models is represented by $y_{it} = \beta_0 + \beta_1 \cdot x_{it} + \ldots + \beta_k \cdot x_{it} + \varepsilon_{it}$, being ε_{it} the error term. The x_{it} are assumed independent of the ε_{it} for all i and t. The β_0, β_1, β_k are the coefficients and the parameter β_0 corresponds to the idiosyncratic effect for the observational unit i.

On the other hand, the random effects model is considered a hierarchical linear model, which assumes that the analysed data are drawn from a hierarchy of different populations whose differences are related to that hierarchy. It is assumed that the intercept of an individual unit is a random extraction from a much larger population with a constant mean value. The advantage is that in this model, it is unnecessary to estimate N dummy variables because only the mean value needs to be estimated. This model allows for explanatory variables that do not vary in time to be included, and therefore the term: ${\beta_0}^*_{it} = ({\beta_0}_{it} - \beta)$, represents a random variable of zero mean and variance σ_β^2. Being $y_{it} = \beta_0 + \beta_1 \cdot x_{it} + \cdots + \beta_k \cdot x_{it} + {\beta_0}^*_{it} + \varepsilon_{it}$ the equation defined by the random models Baltagi (2005).

On the one hand, if the samples are drawn randomly from a population, the random effects estimator is more efficient. Conversely, if the observations represent a specific set of countries, the fixed effects estimator should be chosen, Baltagi, (2005). To make this choice between the two models (FE and RE), the Hausman Test should be used, which tests the null hypothesis, $HO\colon E(e_1|X) = 0$, that the unobservable individual effects are not correlated with the explanatory variables. If the null hypothesis is not rejected, then the random effects are consistently and asymptotically efficient and, therefore, the ones chosen.

Whenever the model under study presents a lagged dependent variable, a small number of periods and unobserved group-specific heterogeneity, the estimation of conventional fixed effects (FE) and random effects (RE) models for linear panel data models becomes inconsistent and biased. Therefore, the existing solutions to this problem include estimating dynamic linear panel data models, FE and RE, with bias correction or estimating the generalized method of moments, GMM.

3.2.3. Dynamic panel model - Generalized Method of Moments (GMM)

Whenever there is the presence of a lagged dependent variable, the strict exogeneity property of the regressors is not valid. Thus, the fixed and random effects estimators are inconsistent with large N (27 countries) and short T (22 years). In these cases, it is possible to resort to the GMM (Generalized Method of Moments) estimator to correct for the bias.

According to Kripfganz & Breitung (2022), the estimator with bias correction can correct the bias by adjusting the respective moment conditions. This process makes it easy to implement a method of bias correction of the estimator of moments (GMM) for linear dynamic panel data models with both fixed and random effects. It can be implemented even with available analytical standard errors, as they can be easily computed and adjusted to be robust across the board. It supports higher-order autoregressive models with finite samples, and in addition, this estimator performs specification tests to identify which model is best fitted between fixed effects and fixed effects. For residual autocorrelation, it uses the Arellano-Bond test to identify the presence of first and second-order autocorrelation. On the other hand, it uses the Hausman test or the Hansen overidentification test to choose between fixed and random effects.

The GMM estimator combines the conditions of moments of the equation in first differences with those of the equation in levels and is, therefore, the most consistent when the time series is persistent, Blundell & Bond, (1998). The function: $\Delta y_{t-1} = y_t - y_{t-1}$ presents the equation for differences and $y_t = y_{t-1}$, presents the equations in levels. The GMM-one step estimator is biased whenever the coefficient value is approximately one since, in the difference equation, the lagged value of the explanatory variable in levels is considered a weak instrument.

The equation gives the panel data autoregressive model $y_{it} = \delta y_{it-1} + u_{it}$ in which, $u_{it} = \mu_i + \varepsilon_{it}$ is the random error term, y_{it-1} is a lagged dependent variable, μi is the fixed effect of unobserved variables, and $\delta = L \times 1$ represents a vector of explanatory variables. The error terms μ_i and ε_{it} have the property $E(\mu_i) = E(\varepsilon_{it}) = E(\mu_i, \varepsilon_{it}) = E\left(y_{it}, \varepsilon_{i_t}\right) = 0$ thus, all elements of the endogenous variable, δ, are correlated with the error term ε_{it}. To solve this autocorrelation problem of the lagged dependent variable, instrumental variables were used in the model and that variable lagged 2 or more periods because, with only 1 period lag, there are still autocorrelation problems of the errors. Thus, it is known that the GMM-one step uses only the homoscedastic instrument matrix for estimation.

Bond & Temple (2001) define some of the advantages of this estimator concerning other estimators. Firstly, it is not biased by the omission of variables that are constant over time, and secondly, in the presence of models with endogenous explanatory variables, it allows consistent estimations even in the presence of errors.

4. Results

4.1. Estimation of Diagnostic Tests

Firstly, after verifying that the panel data was balanced, that is, there was variable data for all countries and years, the dynamic panel data models with fixed and random effects were estimated, and the results are shown in Annex 3. Considering the result obtained for the Hausman statistic with p-value lower than 1%, 5% and 10%, the null hypothesis that the estimators of the model with random effects are consistent and efficient so that the unobservable individual effects are not correlated with the explanatory variables was reject. In this model, all results are in line with the economic theory referred to in the literature review, except for the total education variable that in Equation 3 presents a negative sign, both in the FE and in the RE, contrary to what was expected, and the CPI variable that also presents a negative sign in the fixed effects. Nevertheless, both variables are insignificant in explaining the dependent variable (GDP pc). The adjustment quality was then analysed, and the diagnostic tests (Table 1) were performed to identify possible econometric problems associated with the model, such as cross-section dependence, heteroskedasticity and autocorrelation.

Table 1 – Diagnostic Tests

	Pesaran Test	**Fress Test**	**Friedman Test**	**Wald Modified Test (χ^2)**	**Wooldridge Test**	**Summary**
Eq. (1) (2) (3) (4) (5)	Rejection of the null hypothesis	Rejection of the null hypothesis	Rejection of the null hypothesis	Rejection of the null hypothesis	Rejection of the null hypothesis	- Cross-sectional dependence - Heteroscedasticity - Autocorrelation of 1st. Order Autocorrelation

The cross-section dependence was tested through the parametric tests of Pesaran, Frees and Friedman. In both models, FE and RE, there is unanimity in the tests because the probability values of the Pesaran, Frees and Friedman tests, expressed in the table in Annex 4, are both lower than the significance levels of 1%, 5% and 10%, so it was necessary to reject the null hypothesis of Cross Section independence. Thus, there is sufficient statistical evidence to conclude that there is Cross Section dependence in the data of this model. Therefore, there is a problem of contemporaneous correlation, that is, the observations of certain countries are correlated with the observations of others in the same time period.

The existence of heteroscedasticity in the model's residuals was tested through the modified Wald statistic, although this test only works for the Fixed Effects Estimator (FEE), and nothing can be concluded for the Random Effects Estimator (REE). As the probability value of the Modified Wald Test is lower than the significance levels of 1%, 5% and 10%, the null hypothesis that the variance of the residuals is constant was rejected, and, therefore, there is sufficient statistical evidence, to conclude that there is heteroscedasticity in the residuals of the model (var(ut) ≠ δ2it).

Finally, a serial correlation was investigated, and the Wooldridge Test for autocorrelation of panel data was performed. Based on the pooled test probability value, which is common for both estimators (FE, RE) and is lower than the significance levels of 1%, 5% and 10%, then the null hypothesis of no first-order autocorrelation in the model is rejected, so there is sufficient statistical evidence to conclude that there is first-order autocorrelation in the residuals of the model.

Globalisation, international commitments, and the guidelines of supranational institutions, such as the European Union guidelines, configure identical measures for countries, whether at the economic, political, or social level. Thus, it is confirmed that there is an interconnection of policies between the different member countries, which implies that errors are contemporaneously correlated between countries. One of the problems to be addressed associated with the perturbation terms is heteroscedasticity, where, when using the StataBE Software, it, by default, assumes homoscedastic standard errors, thus raising problems related to data selection bias. Moreover, when we are in the presence of finite data and small samples, data limitations occur, and consequently, problems in the specification of regressions can cause substantial bias. Thus, it was necessary to proceed with estimating panel data linear dynamic models, Fixed Effects and Random Effects, with correction for bias.

4.2. Estimation of Dynamic Panel Data (FE and RE) with Correction for Bias

Table 2.a shows the results of the estimators where we compared the results of fixed and random effects with bias correction.

Table 2.a – Estimator of dynamic linear panel data models (Fixed Effects (FE) and Random Effects (RE)) with correction for bias

	Eq. (1)	Eq. (2)	Eq. (3)	Eq. (4)	Eq. (5)	Eq. (1)	Eq. (2)	Eq. (3)	Eq. (4)	Eq. (5)
	Fixed Effects (FE)					Random Effects (RE)				
GDP *pc.* L1	0.991***	0.996***	0.994***	0.994***	0.997***	0.980***	0.987***	0.986***	0.986***	0.985***
A	-644.20	-633.08	-657.93*	-663.09*	-710.71*	-300.67***	-354.67***	-345.45***	-344.38***	-493.74***
K	0.2060	0.1967	0.2017	0.2020	0.1985	0.2563***	0.23295***	0.2438***	0.2414***	0.2341***
L	0.0429	0.0755	---	0.0430	0.0619*	-0.0101	0.0823***	---	0.0583***	0.0829***
L1	---	---	0.0129	---	---	---	---	-0.0077	---	---
L2	---	---	0.0488	---	---	---	---	0.0948***	---	---
L3	---	---	0.0947	---	---	---	---	0.0008	---	---
H	---	-0.0003***	-0.0003***	---	-0.0003***	---	-0.00007***	-0.00004***	---	-0.00007***
H1	---	---	---	-0.00035***	---	---	---	---	-0.00008***	---
H2	---	---	---	-0.00034***	---	---	---	---	-0.00002	---
H3	---	---	---	-0.00028**	---	---	---	---	-0.00009***	---
E	---	---	---	---	5.9329*	---	---	---	---	-1.2137
P	---	---	---	---	16.0279*	---			---	8.4854*
Const.	565.15**	2849.29***	3360.971***	3478.163***	1449.06*	418.8228***	463.1411***	427.0337***	419.1801***	255.6354

Note: GDP stands for Gross Domestic Product; R&D stands for Research and Development; GFCF stands for Gross Fixed Capital Formation; CPI stands for Corruption Perception Index. L1* is used to represent the lagged variable. The estimation of dynamic linear panel data models (FE and ER) with bias correction, the command "xtdpdbc" was used. ***, **, * denote significance of 1%, 5% and 10%, respectively.

In Table 2.a, it is possible to verify that in both estimators (FE and RE), the variables related to technology (R&D expenditure) and human capital (educated population) negatively influence GDP pc. In the fixed effects, the R&D expenditure variable has twice the impact compared to the random effects. On the other hand, the variables related to physical capital (gross fixed capital formation), labour (educated labour force) and politics (perceived corruption index) positively influence the economic growth of the countries under study, as expected. Although in the more traditional Equation 1, it can be seen that the labour variable shows a negative sign in the random effects contrary to what happens in the fixed effects. This result was one of the reasons why the remaining extended equations were estimated. As for the energy variable (dependence on energy imports), fixed effects have a positive influence, and random effects present a negative influence.

Table 2.b – Post-estimation specification tests

	Eq. (1)	Eq. (2)	Eq. (3)	Eq. (4)	Eq. (5)
Hansen Test	7.4981*	8.5458*	9.9744	10.6851*	12.9312**
Hausman Test	13.3803***	30.9918***	47.1670***	48.9729***	34.8571***
Arellano-Bond test for AR(1)	-2.6770***	-2.6679***	-2.6687***	-2.6697***	-2.6618***
Arellano-Bond test for AR(2)	-1.8678*	-1.9073*	-1.8800*	-1.8898*	-1.8660*

Note: Regarding post-estimation specification tests, the Hausman test tests the null hypothesis that the difference between the coefficients is not systematic. The command "estat hausman" was used. The Hansen test tests the null hypothesis that the overidentification restrictions are valid. The "stat overid" command was used. And finally, the Arellano-Bond test tests the null hypothesis of no existence of autocorrelation. The command "estat serial" was used.

After the Estimation of Fixed Effects (FE) and Random Effects (RE) with bias correction, we performed the post-estimation specification tests, namely, Hausman's test, Hansen's overidentification test and Arellano-Bond's serial correlation test. Based on Table 2.b and according to the conclusion of the Hausman test, as the value of the test statistics of the estimated equations is low and below the significance levels of 1%, 5% and 10%, the null hypothesis is rejected, there being sufficient statistical evidence to conclude that there is a correlation between the effects and the regressors and, consequently, the estimators of the random effects model will not be consistent, and the fixed effects should be used. Concerning Hansen's overidentification test, as the value of the test statistics of the estimated equations is low and below the 5% and 10% significance levels, the null hypothesis is rejected, leading to the conclusion that the overidentification restrictions are invalid. As for the Arellano-Bond test of serial correlation, for the 1st order, the value of the test statistics of the estimated equations is low and below the significance levels of 1%, 5% and 10% and for the 2nd order, it is lower only for the significance level of 10%.

4.3. GMM-One Step Dynamic panel data estimation

Subsequently, the dynamic panel data estimation, GMM-One Step, and the post-estimation specification tests were performed, and the results obtained are shown in Table 3.

Table 3 – GMM estimator of the dynamic linear panel data models - one-step difference

	Generalized Methods of Momments One Step				
	Eq. (1)	Eq. (2)	Eq. (3)	Eq. (4)	Eq. (5)
GDP *pc*. L1	0.6608***	0.6584***	0.6303***	0.6275***	0.6604***
A	1075.931*	1049.467**	744.2708	714.5376	1000.69*
K	-0.1352**	-0.1339**	-0.1239**	-0.1232*	-0.1380**
L	-0.2905**	-0.3447**	---	-0.4061*	-0.2857*
L1	---	---	-0.6358*	---	---
L2	---	---	-0.6996**	---	---
L3	---	---	0.8103***	---	---
H	---	0.0004*	0.0002	---	0.0004*
H1	---	---	---	-0.0003	---
H2	---	---	---	-0.0002	---
H3	---	---	---	0.0012***	---
E	---	---	---	---	31.9945
P	---	---	---	---	12.7879
Arellano-Bond test for AR(1):	-2.52**	-2.50**	-2.41**	-2.39**	-2.60***
Arellano-Bond test for AR(2):	1.30	1.34	1.10	1.08	01.35
Sargan Test	39.51***	39.04***	35.75***	35.42***	037.82***
Hansen Test	5.18**	5.13**	4.58**	4.56**	5.67**

Note: GDP stands for Gross Domestic Product; R&D stands for Research and Development; GFCF stands for Gross Fixed Capital Formation; CPI stands for Corruption Perception Index. L1* is used to represent the lagged variable. The command "xtabond2" by Roodman (2006) was used as the GMM test. Considering strictly exogenous variables, technological (x1), energy (x11) and political (x12), all other variables were considered predetermined in the variously estimated equations. The Arellano-Bond test tests the null hypothesis of no existence of 1st and 2nd order autocorrelation in first differences. The Sargan test tests the null hypothesis that the instruments are uncorrelated with the error term. The Hansen test tests the null hypothesis that the overidentification restrictions are valid. ***, **, * denote significance of 1%, 5% and 10%, respectively.

As expected, and in line with economic theory, the variables related to technology (R&D expenditure), human capital (educated population), energy (energy dependence) and politics (perceived corruption index) positively influence the economic growth of Euro area countries. On the contrary, variables concerning physical capital (gross fixed capital formation) and labour (educated labour force) influence negatively. Regarding the breakdown by the education level of the labour (L) and human capital (H) variables, the two lower levels of education negatively influence growth, and the upper level positively influences, as expected, GDP pc.

Regarding post-estimation specification tests, the Arellano-Bond test for serial correlation rejects the null hypothesis and concludes for all equations that there is 1st order autocorrelation but no 2nd order autocorrelation. Sargan's overidentification test does not reject the null hypothesis of the instruments' validity; therefore, the instruments are not correlated with the error terms. Finally, the value of Hansen's overidentification test statistic is low and below the 5% and 10% significance levels, so the null hypothesis is rejected, and there is statistical evidence to conclude that the overidentification restrictions are not valid.

4.4. Robust Dynamic panel data estimation, Robust GMM

We used another Stata command to perform an efficient GMM estimation of dynamic linear panel data models with non-linear moment conditions. This process allows combining the traditional linear moment conditions with the non-linear moment conditions suggested under the assumption of uncorrelated serial errors. These conditions can manage potentially considerable efficiency gains and improve performance in finite samples.

Looking at Table 4 and first analysing the results obtained in all equations for the variables related to technical progress (R&D sector expenditure) and human capital (total educated population), it can be seen that they do not follow economic growth in the same direction, contrary to expectations. On the other hand, the variables related to physical capital (gross fixed capital formation), labour (total educated labour force), energy (energy dependence) and politics (corruption perception index) positively accompany economic growth, thus having, as expected, a positive influence on it. Finally, when estimating Equations 3 and 4, where the labour force and population quantity variables are divided according to education levels (primary, secondary and tertiary), it can be seen that, as expected, the lowest education level in the labour force variable has a negative influence on the country's economic growth and is not significant in explaining economic growth. On the other hand, the variable population with primary, secondary, and tertiary education negatively influences GDP.

Table 4 – GMM Robustness Estimator

	Generalized method of moments estimation				
	Eq. (1)	Eq. (2)	Eq. (3)	Eq. (4)	Eq. (5)
GDP *pc*. L1*	0.9366***	0.9447***	0.9344***	0.9338***	0.9468***
A	-852.1672***	-765.4356**	-920.7959***	-921.4564***	-666.0713**
K	0.3096***	0.3009***	0.3230***	0.3235***	0.30299***
L	0.1499	0.2448**	---	0.0103	0.1965*
L1	---	---	-0.1860	---	---
L2	---	---	0.0778	---	---
L3	---	---	0.1762	---	---
H	---	-0.0006**	-0.0005***	---	-0.0006**
H1	---	---	---	-0.0007***	---
H2	---	---	---	-0.0006***	---
H3	---	---	---	-0.0004	---
E	---	---	---	---	4.7567
P	---	---	---	---	16.6644

Note: PIB is the name used to represent Gross Domestic Product; R&D is used to represent Research and Development; GFCF is used to represent Gross Fixed Capital Formation; CPI is used to represent Corruption Perception Index. L1* is used to represent the lagged variable. Following the author Sebastian Kripfganz, the command "xtdpdgmm" was used as a robustness test of the GMM. Considering strictly exogenous A, Dependency E and P, all other variables were considered predetermined in the various estimated equations. ***, **, * denote significance of 1%, 5% and 10%, respectively.

Finally, it is important to mention and emphasise that independent variables present coefficients with negative values, despite having, according to economic theory, a positive impact on economic growth. This outcome is because, we were looking at a finite sample with the 27 European states as a whole, and in the panel as a whole, some variables stand out with more negative than positive impacts. Even so, these variables evolved positively throughout the period under study and contributed to the economic growth of the countries under analysis.

5. Discussion

According to Article 3 of the EU Treaty, present in the Official Journal of the European Union (2016), all member states shall promote peace and well-being for their citizens by fostering sustainable development based on balanced economic growth. To this end, they should foster technological progress, as well as full employment, prevent and combat crime to provide an area of freedom, security, and justice to promote economic, social, and territorial cohesion among all countries.

To this end, the EU has defined several priorities to respond to the main challenges and opportunities raised by the current global situation, which puts all countries to the test. Building a more resilient economy to ensure that Europe is better prepared to face future shocks, investing in the education and skills of its citizens, assuming greater responsibilities for security and defence, helping the energy market to function correctly and provide sustainable, secure and affordable energy, as well as creating tools to achieve energy efficiency rapidly and the transition to renewable energies, thus reducing Europe's energy dependency are some of the main priorities that EU leaders want to achieve by 2024.

Brugger & Gehrke (2018) and Abbritti & Consolo (2022) argue that technological developments increase countries' educational levels and GDP. This situation can be revealed through the estimations of fixed and random effects in the GMM-One Step estimator. The FE and ER estimators with bias correction and the GMM robustness estimator, on the other hand, show the opposite sign, contrary to the studies of Bilbao-Osorio & Rodríguez-Pose, (2004) and Simionescu et al. (2021). Thus, policies encouraging innovation and increasing R&D spending can accelerate economic growth in EU countries.

Moreover, it is known that richer countries tend to invest more in education to increase the educational levels of the population. This educational evolution is directly related to technological changes, which inevitably depend on R&D activity. The greater this activity, the greater the capacity to innovate. Thus, it is crucial to mention that investing in innovation and research is synonymous with investing in the future of Europe and improving the quality of life of its citizens.

Concerning the variable underlying human capital (employed population with different levels of education), it is found, as expected, by the studies of González-Sánchez et al. (2020), Prada & Cimpoeru (2019) and Workie Tiruneh & Radvansky, (2011), that it has a positive influence on the economic growth of the countries under study, both in the fixed and random effects estimators and in the GMM- one Step estimator. On the other hand, the same is not true for FE and RE estimators with bias correction and the GMM robustness estimator. In addition, it is important to note that when dividing the population according to the level of education, it is possible to verify that the lower levels of education have a negative influence, while the higher level of education has a positive influence, as expected, in agreement with the authors, Acemoglu, (2000) and Da Silva, (2021).

To improve economic growth and employment, it is necessary to ensure that EU citizens have all the skills necessary to succeed in the labour market. Education is considered effective when it aligns the workforce's skills with the needs of the European economy. Thus, effective education and training policies should be implemented that contribute to personal development, enhancing equity, and promoting social integration and inclusion, Diebolt & Hippe, (2022).

Regarding the variables gross fixed capital formation and labour force with different levels of education, it is possible to verify that in the fixed and random effects estimators, in the EF and ER estimators with correction for bias and in the GMM-robustness estimator, they present a positive influence on the economic growth of countries, as it was expected through the studies of the authors Aslan & Altinoz, (2021). On the contrary, the GMM-One Step estimator presents negative coefficients for this variable.

In this case, policies will be necessary to stimulate not only the participation of the labour force in economic activity to reduce skilled labour shortages in Europe but also to invest in education and rebalance the demographic structure as well as its judicious distribution at the territorial level, Soava et al., (2020). On the other hand, measures are also needed to increase investments in Europe's gross fixed capital formation, Trpeski & Cvetanoska, (2019).

The corruption perception index is a reference of corruption analysis defined on a scale of 0 to 100, where 0 corresponds to very corrupt and 100 to very transparent. That said, the higher the corruption perception index of a country, the less corrupt it is. In agreement with the studies of Herzfeld & Christoph, (2003) and Popova & Podolyakina (2014), the estimations carried out show unanimously that the political variable dubbed CPI has a positive influence on economic growth. Therefore, on the contrary, corruption negatively affects the economy of the countries of Europe. Good governance accelerates economic growth. Citizens and policymakers have tools to influence economic growth: fighting corruption, improving governance, and defending democracy, Gründler & Potrafke (2019).

As expected, the fight against corruption in Europe continues to be weak and stagnant, as data shows that corruption risk levels continue to worsen progressively, thus demonstrating the lack of transparency and control by the defence and national security sectors. In this way, the solution is to implement policies aimed at improving transparency and helping to identify corrupt members of government to prevent and combat corruption and promote economic growth to safeguard EU values.

About the energy factor, more specifically the variable dependence on energy imports, it is possible to verify that all estimators agree; it has a positive impact on the economic growth of the countries under study, thus going along with the studies of Adams et al. (2000); Çam Karakaş et al. (2019), and of Carfora et al. (2022).

According to the European Commission Directorate-General for Energy and Transport., (2021), the EU should establish energy policy measures aimed at achieving a sustainable energy sector, an integrated energy market, and security of energy supply. It is becoming strictly necessary to improve energy efficiency and reduce dependence on energy imports, replacing these with domestic production and ensuring the functioning of the fully integrated European internal energy market, guaranteeing energy security and cooperation between EU countries.

6. Conclusion

The concept of economic growth is narrow and focuses on the quantitative increase in productive capacity rather than on the qualitative transformation of the economy's structure. The theory of economic growth seeks to find the determinants of the economic growth rate and identify policies that foster its increase. The measure of growth often used is the growth rate of Gross Domestic Product (GDP) per capita (income or wealth generated on average per inhabitant), which is the value of goods and services produced annually. Although the time horizon of the economic growth study is the long term (2000 - 2021), it is necessary to try to determine the short-term fluctuations (business cycles) and measure economic growth as the growth rate of the natural product.

This work estimates the effects of the main determinants of Economic Growth in the European Union countries. The choice of explanatory variables was based on the theoretical and empirical literature on the subject under analysis (Economic Growth of a Country). The variables used (GDP per capita, R&D sector expenditure, gross fixed capital formation, employment by education level, education level of the population, dependence on imports of energy products, corruption perception index) are common to most works related to the subject. However, they have never been analysed, using some of those considered most important.

After analysing all the work and the various regressions, it is possible to conclude that most of the empirical results obtained align with current economic theory. As expected, all the variables under study inevitably positively impact economic growth in European Union countries, some more significantly than others. Still, it is important to note that, as the analysis was conducted for a sample of 27 European Union member states, there are estimators where the coefficient values of some variables are negative, contrary to what was expected. This finding is because these variables had the most negative impact on the panel.

A larger sample size would be desirable for future work, as a larger number of observations and new estimators that can solve possible endogeneity problems (arising from simultaneity or the absence of theoretically relevant explanatory variables) could make the results more robust.

Bibliographic References

Abbritti, M., & Consolo, A. (2022). Labour market skills, endogenous productivity and business cycles. Working Paper Series, European Central Bank No 2651, https://doi.org/10.2866/388837

Acemoglu, D. (2000). Technical Change, Inequality, and The Labour Market. Journal of Economic Literature 40(1):7-72. http://doi.org/ 10.1257/0022051026976

Adams, F. G., Ichino, Y., & Prazmowski, P. A. (2000). Economic Growth and Energy Import Requirements: An Energy Balance Model of Thailand. Journal of Policy Modeling 22(2):219-254. https://doi.org/10.1016/S0161-8938(98)00015-5

Arellano, M., & Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. The Review of Economic Studies 58(2):277-297. https://doi.org/10.2307/2297968

Aslan, A., & Altinoz, B. (2021). The impact of natural resources and gross capital formation on economic growth in the context of globalization: evidence from developing countries on the continent of Europe, Asia, Africa, and America. Environmental Science and Pollution Research, 28(26):33794–33805. https://doi.org/10.1007/S11356-021-12979-7/TABLES/7

Auty, R. M. (1994). Industrial policy reform in six large newly industrializing countries: The resource curse thesis. World Development, 22(1):11-26. https://doi.org/10.1016/0305-750X(94)90165-1

Baltagi, B. H. (2005). Econometric Analysis of Panel Data - Third edition. John Wiley & Sons Ltd. https://doi.org/10.1007/978-3-030-53953-5

Bilbao-Osorio, B., & Rodríguez-Pose, A. (2004). From R&D to innovation and economic growth in the EU * From R&D to innovation and economic growth in the EU. Growth and Change: A Journal of Urban and Regional Policy, 35(4):434-455. https://doi.org/10.1111/j.1468-2257.2004.00256.x

Bildirici, M., & Kayıkçı, F. (2022). The relation between growth, energy imports, militarization and current account balance in China, Israel and South Korea. Energy, 242-122537 https://doi.org/10.1016/j.energy.2021.122537

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. In Journal of Econometrics 87:115-143. http://dx.doi.org/10.1016/S0304-4076(98)00009-8

Bond, S., Hoeffler, A., & Temple, J. (2001). "DP3048 GMM Estimation of Empirical Growth Models", CEPR Press Discussion Paper No. 3048. https://cepr.org/publications/dp3048

Brugger, F., & Gehrke, C. (2018). Skilling and deskilling: technological change in classical economic theory and its empirical evidence. Theory and Society (2018) 47:663–689. https://doi.org/10.1007/s11186-018-9325-7

Çam Karakaş, Ü., Üzümcü, A., & Karakaş, A. (2019). Energy Import and Economic Growth: an analysis on some energy importer countries. 20(2):317-334. https://orcid.org/0000-0001-6005-2556

Carfora, A., Pansini, R. V., & Scandurra, G. (2022). Energy dependence, renewable energy generation and import demand: Are EU countries resilient? Renewable Energy, 195:1262-1274. https://doi.org/10.1016/j.renene.2022.06.098

Christos, P., Eleni, K., Dimitrios, K., Zacharias, D., Athanasios, A., & Panagiotis, L. (2018). Corruption Perception Index (CPI), as an Index of Economic Growth for European Countries. Theoretical Economics Letters 08(03):524-537. https://doi.org/10.4236/tel.2018.83037

De Hoyos, R. E., & Sarafidis, V. (2006). Testing for cross-sectional dependence in panel-data models. In The Stata Journal 6(4):482-496. https://doi.org/10.1177/1536867X0600600403

Diebolt, C. & Hippe, R. (2022). The Long-Run Impact of Human Capital on Innovation and Economic Growth in the Regions of Europe. In: Human Capital and Regional Development in Europe. Frontiers in Economic History. https://doi.org/10.1007/978-3-030-90858-4_5

Dritsakis, N., & Stamatiou, P. (2018). Causal nexus between FDI, Exports, Unemployment and Economic Growth for the old European Union members. Evidence from panel data. International Journal of Economic Sciences, VII(2):36-56. https://doi.org/10.20472/es.2018.7.2.002

Drukker, D. M. (2003). Testing for serial correlation in linear panel-data models. In The Stata Journal 3(2):168-177. https://doi.org/10.1177%2F1536867X0300300206

ERKİŞİ, K., & BOĞA, S. (2019). High-Technology products export and Economic Growth: A panel data analysis for EU-15 countries. Bingöl Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 9(18):669-684. https://doi.org/10.29029/busbed.571892

European Commission. Directorate-General for Energy and Transport. (2021). EU energy in figures: statistical pocketbook. 2021 / European Commission, Energy. https://doi.org/10.2833/511498

Farrag, N. A., & Ezzat, A. M. (2019). The impact of corruption on economic growth: A comparative analysis between Europe and Mena countries. In Wealth Creation and Poverty Reduction: Breakthroughs in Research and Practice (pp. 266–290). IGI Global. https://doi.org/10.4018/978-1-7998-1207-4.ch015

González-Sánchez, V. M., Raya, A. M., & Ríos-Sastre, S. de los. (2020). An empirical study for european countries: Factors affecting economic growth and self-employment by gender. Sustainability (Switzerland), 12(22):1-15. https://doi.org/10.3390/su12229450

Gründler, K., & Potrafke, N. (2019). Corruption and economic growth: New empirical evidence. European Journal of Political Economy, 60-101810. https://doi.org/10.1016/j.ejpoleco.2019.08.001

Hanushek, E. A., Schwerdt, G., Woessmann, L., & Zhang, L. (2017). General education, vocational education, and labor-market outcomes over the lifecycle. Journal of Human Resources 52(1):48-87. https://doi.org/10.3368/jhr.52.1.0415-7074R

Herman, E. (2011). The Impact of Economic Growth Process on Employment in European Union Countries. Romanian Economic Journal 14(42):47-67. https://EconPapers.repec.org/RePEc:rej:journl:v:14:y:2011:i:42:p:47-67

Herzfeld, T., & Christoph W., (2003). Corruption and legal (In)- effectiveness: an empirical investigation. European Journal of Political Economy, 19(3):621-632. https://doi.org/10.1016/S0176-2680(03)00018-1

Jones, C. (1997). Introduction to economic growth. First Edition New York: W. W Norton & Company, Inc, 1998. ISBN 0-393-97174-0.

Kripfganz, S., & Breitung, J. (2022). Bias-corrected estimation of linear dynamic panel data models. London Stata Conference 2022 05, Stata Users Group (pp. 1–15). http://www.kripfganz.de/stata/

Lucas, R. E. (1988). On the mechanics of economic development*. In Journal of Monetary Economics, 22(1):3-42. https://doi.org/10.1016/0304-3932(88)90168-7

Lymonova, E. (2019). Estimation of the effect of taxes and gross fixed capital formation on economic growth of euro area. Academy Review, 1(50):5-14. https://doi.org/10.32342/2074-5354-2019-1-50-1

Marquez-Ramos, L., & Mourelle, E. (2019). Education and economic growth: an empirical analysis of nonlinearities. Applied Economic Analysis, 27(79):21-45. https://doi.org/10.1108/AEA-06-2019-0005

Mauro, P. (2004). The Persistence of Corruption and Slow Economic Growth. IMF Staff Papers, 51(1):1-18. http://www.jstor.org/stable/30035860

North, D. (1991). Institutions. Journal of Economic Perspectives 5(1):97-112. https://pubs.aeaweb.org/doi/pdfplus/10.1257/jep.5.1.97

Official Journal of the European Union. (2016). Treaty on European Union (consolidated version). https://eur-lex.europa.eu/resource.html?uri=cellar:9e8d52e1-2c70-11e6-b497-01aa75ed71a1.0006.01/DOC_3&format=PDF

Pelinescu, E. (2015). The impact of human capital on economic growth. Procedia Economics and Finance 22:184-190. https://doi.org/10.1016/s2212-5671(15)00258-0

Pluskota, A. (2020). The Impact of Corruption on Economic Growth and Innovation in an Economy in Developed European Countries. Annales Universitatis Mariae Curie-Skłodowska, Sectio H – Oeconomia, 54(2), 77. https://doi.org/10.17951/h.2020.54.2.77-87

Popova, Y., & Podolyakina, N. (2014). Pervasive Impact of Corruption on Social System and Economic Growth. Procedia - Social and Behavioral Sciences, 110:727-737. https://doi.org/10.1016/j.sbspro.2013.12.917

Prada, E.-M., & Cimpoeru, S. (2019). The impact of human capital on economic growth in EU-28: a Panel Data perspective. Proceedings of the International Conference on Applied Statistics, 1(1):398-406. https://doi.org/10.2478/icas-2019-0034

Robinson, J. (1966). An essay on Marxian Economics. 2:10-63. https://doi.org/10.1007/978-1-349-15228-5

Romer, P. M. (1986). Increasing Returns and Long-Run Growth. Journal of Political Economy, 94(5):1002–1037. http://www.jstor.org/stable/1833190

Simionescu, M., Pelinescu, E., Khouri, S., & Bilan, S. (2021). The main drivers of competitiveness in the EU-28 countries. Journal of Competitiveness, 13(1):129-145. https://doi.org/10.7441/joc.2021.01.08

Singh, S., Deep Sharma, G., Radulescu, M., Balsalobre-Lorente, D., & Bansal, P. (2023). Do natural resources impact economic growth: An investigation of P5 + 1 countries under sustainable management. Geoscience Frontiers. https://doi.org/10.1016/j.gsf.2023.101595

Soava, G., Mehedintu, A., Sterpu, M., & Raduteanu, M. (2020). Impact of employed Labour force, investment, and remittances on economic growth in EU countries. Sustainability (Switzerland), 12(23), 1–31. https://doi.org/10.3390/su122310141

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. In Source: The Quarterly Journal of Economics 70(1): 65-94. https://doi.org/10.2307/1884513

Trpeski, P., & Cvetanoska, M. (2019). Gross Fixed Capital Formation and Productivity in Southeastern Europe. Proceedings of FEB Zagreb International Odyssey Conference on Economics and Business; Zagreb, 1(1). https://doi.org/10.22598/odyssey

Uberti, L. J. (2022). Corruption and growth: Historical evidence, 1790–2010. Journal of Comparative Economics, 50(2), 321–349. https://doi.org/10.1016/j.jce.2021.10.002

Valero, A. (2021). Education and economic growth. Discussion Paper No.1764; ISSN 2042-2695 https://cep.lse.ac.uk/pubs/download/dp1764.pdf

Annexs

Annex 1 - Table of the 27 countries of the European Union used for the study

Country	it
Germany	DE
Austria	AT
Belgium	BE
Bulgaria	BG
Cyprus	CY
Croatia	HR
Denmark	DK
Slovakia	SK
Slovenia	SI
Spain	ES
Estonia	EE
Finland	FI
France	FR
Greece	EL
Hungary	HU
Ireland	IE
Italy	IT
Latvia	LV
Lithuania	LT
Luxembourg	LU
Malta	MT
Netherlands	NL
Poland	PL
Portugal	PT
Czech Republic	CZ
Romania	RO
Sweden	SE

Annex 2 – Synthesizing the variables

Abbrev.	Variable	Source	Expected impact on Y
Y	GDP per capita	Pordata	
A	R&D Sector Expenditure as % of GDP	Pordata	+
K	Gross Fixed Capital Formation per capita	Pordata	+
L	Total Education Labour Force	Pordata	+
L1	Primary Education Labour Force	Pordata	+
L2	Secondary Education Labour	Pordata	+
L3	Tertiary Education Labour Force	Pordata	+
H	Total Education Population	Pordata	+
H1	Primary Education Population	Pordata	+
H2	Secondary Education Population	Pordata	+
H3	Tertiary Education Population	Pordata	+
E	Dependence on Energy Imports	Pordata	+
P	Corruption Perception Index	Transparency Internationa	+

Note: ratios of own eLabouration using the sources mentioned. GDP stands for Gross Domestic Product and R&D stands for Research and Development.

Annex 3 – Estimator of dynamic linear panel data models (Fixed Effects (FE) and Random Effects (RE))

	Eq. (1)	Eq. (2)	Eq. (3)	Eq. (4)	Eq. (5)
			Fixed Effects (FE)		
A	3620.59***	3535.478***	2598.944***	2537.497***	3512.727***
K	2.2462***	2.2424***	2.2145***	2.2099***	2.2489***
L	0.7416***	0.6238**	---	-0.2338	0.6081**
L1	---	---	-0.7846	---	---
L2	---	---	-0.3292	---	---
L3	---	---	1.2766***	---	---
H	---	0.0007***	-0.0001	---	0.0008**
H1	---	---	---	-0.0003	---
H2	---	---	---	-0.0007	---
H3	---	---	---	0.0015***	---
E	---	---	---	---	13.8377
P	---	---	---	---	-6.5946
Const.	1822.914	-3857.664	9430.605**	10820.84**	-4144.466
			Random Effects (RE)		

A	4106.742***	4039.559***	3147.846***	3119.292***	3747.549***
K	2.4578***	2.4394***	2.3690***	2.3651***	2.4329***
L	0 .0557	0.2454	---	-0.1897	0.1959
L1	---	---	-0.5904	---	---
L2	---	---	-0.4711	---	---
L3	---	---	1.1463***	---	---
H	---	-0.0002	0.00002	---	-0.0001
H1	---	---	---	-0.00009	---
H2	---	---	---	-0.0004	---
H3	---	---	---	0.0014***	---
E	---	---	---	---	40.3091**
P	---			---	42.8795
Const.	4729.771***	5067.588***	7043.267***	7115.073***	495.6537

Note: ***, **, * denote the significance of 1%, 5% and 10%, respectively.

Annex 4 – Diagnostic Tests

		Grouped	Fixed Effects (FE)	Random Effects (RE)
Pesaran Test	Eq. (1)		48.599***	47.988***
	Eq. (2)		43.266***	48.218***
	Eq. (3)		30.198***	27.354***
	Eq. (4)		33.267***	29.038***
	Eq. (5)		43.754***	45.768***
Frees Test	Eq. (1)		9.141***	9.191***
	Eq. (2)		8.505***	9.091***
	Eq. (3)		9.152***	7.436***
	Eq. (4)		9.371***	7.990***
	Eq. (5)		8.618***	8.672***
Friedman Test	Eq. (1)		320.890***	316.073***
	Eq. (2)		289.451***	318.631***
	Eq. (3)		206.394***	193.271***
	Eq. (4)		232.168***	205.781***
	Eq. (5)		293.300***	299.673***
Modified Wald Test	Eq. (1)		89478.81***	
	Eq. (2)		1.9e+05***	
	Eq. (3)		33220.30***	
	Eq. (4)		28273.44***	
	Eq. (5)		1.7e+05***	
Wooldridge Test	Eq. (1)	146.335***		
	Eq. (2)	145.544***		
	Eq. (3)	119.616***		
	Eq. (4)	120.111***		
	Eq. (5)	146.006***		

Note: The Pesaran, Frees and Friedman tests test the null hypothesis of cross section independence. The Pesaran and Friedman tests follow a standard normal distribution. The Frees test uses a Frees' Q distribution. The "xtcsd" command was used. The Modified Wald test tests the null hypothesis that the variance of the error term (residuals) is constant. The "xttest3" command was used. The Wooldridge test tests the null hypothesis of no serial correlation, that is, there is no autocorrelation in the model. The command "xtserial" was used. ***, **, * denote the significance of 1%, 5% and 10%, respectively.