An innovative perspective on the impact of innovation on global competitiveness: Comparative analysis of EU13 and EU15 countries

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Abstract

This study examines the relationship between innovation and global competitiveness in European Union (EU28) member states and the differences between EU13 and EU15 countries categorised by wealth level from 1997 to 2019. The study employs the Parks–Kmenta panel data method considering heteroscedasticity, serial correlation and cross-section dependence to analyse the impact of innovation, income inequality, unemployment and labour force share in national income on global competitiveness. The results reveal that innovation has the highest positive effect on global competitiveness, with a 1% increase in the innovation index leading to 13.4% and 11.1% increases in global competitiveness for the EU28 and EU15–EU13, respectively; a 1% increase in income inequality leads to a 0.53% and 0.55% increase in global competitiveness for the EU28 and EU15–EU13, respectively; a 1% increase in unemployment causes a 0.12% and 0.13% decrease in global competitiveness for the EU28 and EU15–EU13, respectively; a 1% increase in labour's share in national income results in a 0.18% and 0.17% decrease in global competitiveness for the EU28 and EU15–EU13, respectively. The analysis also shows that EU15's global competitiveness is 11.7% higher than EU13. This study concludes that innovation is the primary determinant of global competitiveness; however, it may come at the cost of a decrease in labour's share in national income and income distribution equality.

Keywords: *Global Competitiveness, Innovation, Panel Data, Income Inequality, European Union*

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1 INTRODUCTION

The concept of global competitiveness has been a crucial issue in the world economy since the second half of the 20th century. Many factors influence nations' global competitiveness, of which the most significant are innovation and technological progress. A nation's capacity to innovate and upgrade technology is crucial for achieving and sustaining a competitive edge in today's interconnected global economy. In this context, this study investigates the influence of innovation on global competitiveness, adopting an innovative perspective to compare the circumstances in EU13 and EU15 countries.

Innovation and technological progress have been identified as crucial elements for countries to achieve sustainable economic growth and development, and it is essential for nations to leverage existing resources to create new economic value, using knowledge as a key factor. Traditional resources of capital and labour can no longer solely sustain a nation's competitive edge in today's global economy; therefore, assets based on knowledge are now the primary factors in determining global competitiveness. However, measuring global competitiveness and determining the criteria by which countries are ranked is not a straightforward process. This complexity has prompted investigations regarding which indicators are the most representative. Creating a solid, reliable system to measure global competitiveness is a crucial endeavour. Developing such a measurement can support informed decision-making regarding policies for a country's economy in a macro scale or individual firms in a micro scale.

This study examines the EU15 and EU13, which are clusters of countries within the European Union (EU) that have distinct levels of economic growth and innovation achievement. The EU13 represents the newer member states of the EU, and the EU15 includes older, more established EU members. The economic progress and innovation capabilities of these two groups differ substantially. Comparing these two sets of countries in terms of innovation outputs and global competitiveness can offer insights into the role of innovation in securing and sustaining a competitive edge. This study also investigates the welfare dynamics of the EU15 and EU13, which are directly related to innovation potential. This approach can contribute to understanding the relationship between innovation, welfare trends and global competitiveness, boosting the study's theoretical and practical importance.

2 THEORETICAL BACKGROUND

2.1 INNOVATION

Innovation has long been a key topic in economics research. Many economists have offered related definitions over the years. Schumpeter (1934) characterised innovation as the emergence of new consumer goods, production methods, trade routes, markets and industrial structures. Other economists have added various perspectives on innovation, some focusing on the initiating activity of innovation, some on the multi-stage process, while others have concentrated on the end results or outcomes (Drucker, 1954; Freeman, 1982; Rogers, 1998; Mulgan & Albury, 2003).

To unify the understanding of innovation, The Oslo Manual was developed by the EU's Statistical Office (Eurostat) and the Organization for Economic Co-operation and Development (OECD). This manual provides a comprehensive definition of innovation, which is structured on four pillars of product, process, marketing and organisational structure. The most commonly used definition is "the realisation of a new or significantly improved product (good or service), or process, a new marketing method or a new organisational method in internal business practices, workplace organisation or external relations" (OECD & Eurostat, 2018).

The phenomenon of innovation is almost as old as human history, but it has been a short time since it took its place in economics research in terms of theoretical foundations and became the subject of subsequent investigation. Therefore, a brief summary of innovation will be presented to make sense of the associated relationships and show how innovation is attributed to economic development and growth (Fagerberg, 2004; Aghion & Howitt, 2007).

According to classical economics, as formulated by Adam Smith (1776), the division of labour and specialisation increase productivity, leading to the creation of new knowledge and innovation. Ricardo (1817) considered technology to be embedded in capital, whereas Malthus (1798) argued that technological innovations reduce prices and contribute to economic development. Marx (1906) viewed technological progress as resulting from class relations, and Schumpeter (1934) argued that innovation is driven by entrepreneurial activities and resulted in creative destruction. When growth theories were proposed, particularly those in the pre-Solow period, the views of Marshall and Keynesian economists such as Harrod (1939) and Domar (1946) were presented, followed by the Solow model, which was the first to initiate a novel discussion on the basis of growth and innovation (Solow, 1956). However, the Solow model has been criticised for its inability to explain the origin of technological progress. While it was a major contribution to the field of economic growth, it was criticised for treating

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technological development as an external factor. This led to the development of endogenous growth models, which considered technological development to be an internal and endogenous aspect of the growth process. Endogenous growth models have significantly enhanced our knowledge regarding the impact of technological progress and human capital on economic growth. These models have also guided the formulation of more effective economic policies to stimulate growth (Lucas, 1998; Barro, 1990; Romer, 1986; Aghion & Howitt, 1992).

2.2 THE CONCEPT OF COMPETITIVENESS AND COMPETITIVENESS OF NATIONS

Competitiveness can be characterised as a country's or organisation's capacity to achieve sustainable economic growth by enhancing productivity and competitive capacities in internal and global markets. The concept of competitiveness has been thoroughly explored in scholarly literature and has been linked to a variety of elements such as innovation, human capital, market configuration and government policies. According to the World Economic Forum (WEF) Global Competitiveness Index (GCI), competitiveness is defined as "the collection of institutions, policies and factors that determine a country's productivity level" (WEF, 2018).

Put simply, national competitiveness refers to a country's ability to produce goods and services that can compete on a global scale, while elevating citizens' standard of living. It is a comparative term which has been assessed by how a country performs relative to others. This concept not only considers a country's economic performance, but also factors such as social conditions, environmental conservation and income distribution. The ultimate objective of advancing a nation's competitiveness should be to optimise its social welfare function, ensuring that the nation remains economically competitive while fostering citizens' well-being (Delgado et al., 2012).

Porter (1990) argued that a country's prosperity depends on the capacity to innovate and enhance productivity, emphasising that competitiveness is not solely determined by natural resources, but driven by industrial productivity. Porter's diamond model of competitiveness includes four integral factors: conditions, supporting industries and firm strategy, structure, and competition. Porter suggested that a country's creation and maintenance of competitive advantage depends on the interplay of these factors. Porter also highlighted the role of clusters, which were defined as groups of firms and relevant institutions that are geographically and functionally interconnected, arguing that these clusters support productivity and innovation by fostering an environment that promotes knowledge sharing and collaboration (Porter, 1990). Porter's contributions have significantly influenced economists' and policymakers' perspectives regarding competitiveness, resulting in extensive academic investigations. The model was first incorporated and expanded to multi-national companies by Dunning (1992). Rugman and D'Cruz determined that Porter's single diamond model was invalid for countries with foreign trade but small economies and proposed the double diamond model (Rugman & D'Cruz, 1993). Claiming that the diamond model is only applicable for developed countries, Cho (1998) proposed a new model called the nine factor model, which includes developing countries.

Measuring the competitiveness of nations remains controversial; however, the WEF and the International Institute for Management Development (IMD) assess the wealth created by nations and publish annual national competitiveness rankings. These rankings serve as benchmarks for policymakers and academics to assess countries' competitiveness in a global context. Since 1989, the IMD and WEF have produced national competitiveness rankings via the annual World Competitiveness Yearbook and Global Competitiveness Report, respectively.

2.3 COMPETITIVENESS FROM A NOVEL PERSPECTIVE AND GLOBAL COMPETITIVENESS INDICES

Measuring competitiveness has primarily focused on firms', countries' or economies' pricing, particularly when confronting new low-cost competitors. However, this narrow interpretation of competitiveness, which only considers cost reduction, has been criticised as misleading (Krugman, 1994). The success of firms in oligopolistic markets not only depends on cost levels but also competitive advantage and innovation capabilities. Firms' profitability and an industry's ability to compete internationally are determined by costs and efficiency (Grossman & Helpman, 1990). The concept of unit labour costs has been widely used to summarise relative costs. While some scholars such as Porter (2004) have argued that productivity is the sole significant aspect of competitiveness, others have advocated for a more balanced perspective that considers both costs and productivity. Studies focusing on cost benchmarking have analysed individual cost elements, whereas those examining total factor productivity have employed a production function approach to encompass all aspects of cost and productivity. The latest approaches to measure competitiveness have highlighted the significance of evaluating nations and businesses by examining structures and capabilities. An economy's structural composition includes primary inputs used in industries, the complex interplay of these inputs and the related services that are employed and provided. The consideration of capabilities provides information about firms' or industries' sources of success and failure and future prospects (OECD, 2021).

The concept of competitiveness is too intricate to be assessed solely on the basis of inputs. The ultimate aim of advancing a nation's competitiveness should be to produce higher living standards for its citizens, opportunities for employment and improved living conditions. To accurately investigate these considerations, it is crucial to consider economic and social outcomes, such as GDP per capita, job availability, poverty reduction and sustainability. The 'beyond GDP' approach evaluates societal progress using a broader set of objectives that encapsulate the elements that contribute to social well-being, assessing competitiveness in a manner that captures economic indicators as well as the aspirations and requirements of the citizens within an economy (Aiginger, 2006; 2015).

Traditionally, competitiveness has been defined by factors such as employment and unemployment rates, GDP per capita and labour productivity; however, this narrow perspective has been criticised for its limited applicability to a broader range of countries. As a result, investigations of competitiveness have shifted towards a more innovative perspective that encompasses new factors and employs a more comprehensive interpretation. This novel perspective suggests that enhanced living standards and quality of life will increase competitiveness, and the ultimate objective of an economy should be to provide its citizens with consistently increasing income, expanded employment opportunities and improved living conditions. The European Commission framed this results-oriented competitiveness as an economy's capacity to offer its population continuously improved living standards and high rates of employment sustainably (Ketels, 2006; Ulengin et al., 2011; Madzika et al., 2015).

The European Commission uses an outcome-focused definition of competitiveness, considering an economy's capacity to maintain and enhance the standard of living and sustained high long-term employment rates for its citizens. This conceptualisation of competitiveness goes beyond constructs of mere economic prosperity and emphasises the importance of ensuring that economic growth directly translates to improved living standards and job opportunities for its people. This broader perspective goes beyond the traditional metrics of competitiveness, which have primarily been focused on economic indicators such as GDP per capita, labour productivity and trade balances, emphasising the population's quality of life and overall well-being (EU Commission, 2001; Cassiers, 2007).

Several comprehensive indices have been established to quantify global competitiveness; most notably, the WEF GCI and the IMD World Competitiveness Ranking. While these indices offer valuable insights, the methodologies have been criticised and countries' placement can significantly vary between these indices.

Despite criticism, these indices offer essential benchmarks for international comparison and have continued to be extensively used to measure countries' competitiveness. The GCI developed by the WEF is a case in point, and evaluates the competitiveness of 140 economies referencing 12 pillars, which include institutions, infrastructure, macroeconomic stability, health and primary education, higher education and training, goods market efficiency, labour market efficiency, financial market development, technological readiness, market size, business sophistication and innovation. The GCI is routinely employed across governments, academia and the private sector to inform policymaking and track nations' progress towards enhancing competitiveness (WEF, 2018). The IMD's World Competitiveness Ranking evaluates the competitiveness of 63 economies by considering four principal factors of economic performance, government efficiency, business efficiency and infrastructure. Further considerations include sub-factors such as human capital, international trade and technology (IMD, 2019). Despite their distinct methodologies, both the GCI and the World Competitiveness Ranking commonly offer valuable insights into countries' competitiveness, supplying crucial data for governments, businesses and other interested parties.

As a result, theories of competitiveness such as Porter's (1990) diamond model and global competitiveness indices have significant weight for determining countries' competitiveness and providing inclusive measures of economies' competitiveness. These theories and indices provide guidance and valuable insights for governments, businesses and other stakeholders. Despite the criticisms, these remain key instruments for quantifying and comparing the competitiveness of different nations.

2.4 INNOVATION, GLOBAL COMPETITIVENESS AND CREATING WELFARE

Nations' competitiveness has long been a central topic in discussions regarding development. While many countries prioritise increasing competitiveness and economic growth to advance their positions in the global economy, the ultimate objective should be to enhance citizens' quality of life and prosperity (Aiginger, 2006; 2013). A country that offers a high standard of living is more appealing to businesses, investment and talent, leading to a positive cycle in which economic growth attracts investment, generates job opportunities and enhances the standard of living.

Innovation is widely recognised as a principal driver of worldwide competitiveness. Businesses can improve performance and efficiency by pioneering new products, methodologies and organisational frameworks, which translates into a larger market presence and enhanced profitability (Drucker, 1993). In addition, innovation prepares companies to adjust to shifting market dynamics, strengthens resilience and heightens the likelihood of weathering economic downturns. Numerous studies have demonstrated the positive association between innovation and competitiveness in various sectors and countries (Terzic, 2017; Szymańska, 2013; Fonseca & Lima, 2015; Petrakis et al., 2015). These results show that innovation is a crucial factor for increasing global competitiveness and the significant economic and social gains that can be achieved through investing in innovation.

Another critical indicator of a country's well-being is its unemployment rate. High unemployment rates can have significant societal, economic and political consequences, which may have a long-lasting destructive impact on a country's progression and growth (Aghion & Howitt, 1994). Increased unemployment rates can increase poverty, inequality and societal conflict and damage overall economic activities. This circumstance can downgrade people's quality of life; hence, it is essential for nations to emphasise economic expansion as well as stabilising unemployment rates. To effectively tackle unemployment, countries should cultivate an environment that is conducive to job creation. This can be accomplished by implementing strategies like extending critical assistance to businesses, which includes tax breaks, subvention and infrastructure development to encourage investment and stimulate job creation (Galbraith, 2009; Cahuc & Michel, 1996; Muscatelli & Tirelli, 2001).

Moreover, the allocation of resources towards human capital development (particularly education and skills training) is another pivotal factor which influences nations' competitive edge and overall prosperity. Equipping the workforce with the requisite expertise, education and training empowers individuals to overcome difficulties that emerge in the global market. A well-educated and skilled workforce is more likely to be employable and productive, enhancing competitiveness and prosperity. Education also plays a direct influence on cultivating innovation and equipping nations to sustain economic growth and development (Stiglitz, 1993; King & Rebelo, 1988; Stadler, 1990; Muscatelli & Tirelli, 1998). Another crucial aspect of competitiveness and socio-economic well-being is the provision of effective healthcare and education social services, which are important factors in determining the standard of living. A country with a well-developed healthcare system and quality education services establishes a more attractive environment for business investment. Nations supported by superior social services tend to have a highly efficient workforce, which uplifts the overall standard of living. In conclusion, it is essential to recognise that while economic growth is vital, it is not the sole definition of countries' competitiveness, and well-being and other relevant factors must be considered. A nation offering a high standard of living and lower unemployment rate is more likely to be competitive and prosperous; therefore, countries should focus on creating a vibrant environment for job creation, investing in human capital development and ensuring that basic social services like healthcare and education are easily accessible to all citizens.

As noted, nations' competitiveness is represented by proficiency in producing goods and services that meet global market demand while simultaneously ensuring that citizens' quality of life remains high by maintaining economic growth and job creation and reducing unemployment rates. Innovation is a key driver of competitiveness, as it allows nations to produce new and improved products, processes and services. A nation with robust innovation is expected to establish a place in the global market and better manage lower unemployment rates than less innovative counterparts. The interplay between competitiveness, unemployment and innovation is multi-faceted and dynamic, as corroborated by numerous studies. Several factors such as education, infrastructure and the business environment collectively impact nations' competitiveness and ability to innovate.

Another notable issue is the potential discrepancy between a country's competitiveness and its income distribution, which can distort competitiveness. The reason for this is the economic dynamics underlying competitiveness. A more competitive country tends to attract more investment, which raises income and elevates overall prosperity. However, the distribution of wealth may not always be equitable across the population; leading to disparities (Murphy et al., 1989). A primary factor of income inequality in a developing economy is the uneven distribution of skills and education. With rising competitiveness, countries often require a more skilled workforce to produce more complex and intricate goods and services. This demand could widen the earning gap between highly-skilled and less-skilled workers, and the former, being in higher demand, command higher wages. Another consideration is the influence of capital and technology. As firms compete more intensely, they tend to invest in innovative technologies and machinery that raise productivity and reduce costs. Such advancements often demand substantial capital, leading to the uneven distribution of benefits from rising productivity and profits, favouring those with capital. Furthermore, heightened competitiveness can be associated with increased market consolidation and monopoly power. When firms outcompete others, they can gain control over markets and enforce higher prices, leading to increased profits and income for owners and shareholders. Thus, despite the fact that competitiveness can enhance economic growth and employment, it could also aggravate income disparity, which is evident in widening wage gaps between high-skilled and low-skilled workers, favouring capital holders and leading to an enhanced concentration of market and monopoly power.

3 RESEARCH OBJECTIVE, METHODOLOGY AND DATA

This study employs a panel regression method, which is specifically designed to handle data that features both time-series and cross-sectional characteristics to facilitate the analysis of how independent variables correlate with a dependent variable, across different groups or individuals and over time.

Panel regression models typically incorporate both fixed and random effects. The former accounts for differences between individuals or groups that remain consistent over time, whereas the latter allows for changes over time. The models also account for various sources of heterogeneity, the possibility of endogeneity and the potential correlation between the independent variables and the error term. The linear panel data model is expressed as follows:

$$Y_{it} = \alpha_{0it} + \sum_{k=1}^{K} \beta_{kit} X_{it} + \varepsilon_{it} \quad (1)$$

alternatively, to elaborate, the following model is used:

$$Y_{it} = \alpha_{it} + \beta_{1it} X_{1it} + \beta_{2it} X_{2it} + \cdots \beta_{kit} X_{kit} + \varepsilon_{it}) \quad (2)$$

where *i* denotes the cross-sectional dimension, and the time dimension is denoted by *t*. Y_{it} is the dependent variable, X_{kit} is the independent variable, β_{kit} is slope parameter and α_{it} is the constant term.

EU countries are included in this study. EU28, EU15 and EU13 are groups of EU member states defined by the years of accession into the EU. EU15 refers to the first 15 member states to join the EU before its enlargement in 2004, which include Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom (which has since left the EU). These countries generally have more developed economies and per capita income than EU13 member states (UNDP, 2022). EU13 refers to the 13 member states that joined the EU in 2004 or later, which include Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia. These countries generally have less developed economies and per capita income levels than EU15 member states (UNDP, 2022). These groupings are useful for comparative analysis and policy investigations, as the economic and social characteristics of EU15 and EU13 countries may differ significantly.

The variables used in our model, along with the associated abbreviations and proxies for those variables, are presented in Table 1.

Table 1: Variables

Variables	Abbr.	Proxy	Source
Global Competitiveness	GCI	Global Competitiveness Index	IMD
Innovation	INO	Persons employed in science and technology	Eurostat
Innovation	INO	Gross domestic expenditure on R&D (GERD) by sector	Eurostat
Innovation	INO	Triadic patent families total, number	OECD

Unemployment	UMP	Unemployment, total (% of total labour force)	World Bank
Gini	GINI	Gini coefficient (adults), equal split	World Inequality Database (WID)
Labour's share of national income	LSH	Total population ratio (all ages), individual	WID

4 RESULTS AND DISCUSSION

Panel data analysis is employed in this study to investigate the relationships between the dependent variable of global competitiveness and the independent variables innovation, labour income share, income inequality and unemployment.

Considering the general panel data model presented in Eq.2, we are able to express the model that is used in empirical analysis as Eq. 3.

$$LnGCI_{it} = \alpha_{it} + \beta_1 INO_{it} + \beta_2 lnLSH_{it} + \beta_3 LnUMP_{it} + \beta_4 LnGINI_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

$$Countries\ (i) = 1, 2, \dots\dots\dots, 25 \qquad and \qquad Years\ (t): 1997, \dots\dots\dots, 2019$$

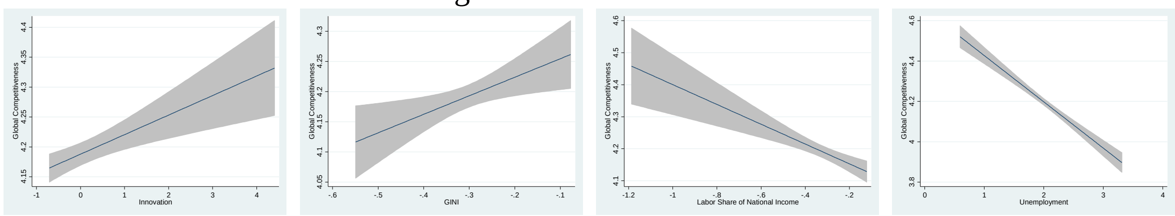
Table 2 presents the number of observations, mean, standard deviations, minimum and maximum values of the total 28 EU countries between 1997 and 2019, with 644 observations. The minimum value of the GCI series is 27.3, the maximum value is 97.534, and the standard deviation is 14.16. The principal component analysis method is employed to convert the three proxies for the innovation variable into a single index, which is then included in the model's INO series, the mean of which is 0.000, the standard deviation is 1,000 and the minimum and maximum values are −0.715 and 4.404, respectively. The income inequality proxy is the Gini coefficient, and the labour's share of national income (LSH) is considered as the control variable in the model. The mean value of the Gini series is 0.732, the standard deviation is 0.064, the minimum value is 0.577 and the maximum value is 0.925. The mean value of the LSH series is 0.457, the standard deviation is 0.042, and the minimum and maximum values are 0.36 and 0.63, respectively.

Table 2: Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
GCI	644	67.684	14.157	27.297	97.534
INO	644	0	1	-.715	4.404
GINI	644	.732	.064	.577	.925
LSH	644	.457	.042	.354	.628
UMP	644	8.7	4.314	1.81	27.47

The prediction of the theory establishes the direction of the relationship between the variables, and parameter estimations confirm, but the graphs give us a sense of what to expect. Therefore, before proceeding to the empirical model, it would be prudent to examine the relationship between the dependent variable and independent variables using graphs.

Fig. 1: Line Plot of the Variables



(a) GCI-INO (b) GCI-GINI (c) GCI-LSH (d) GCI-UMP

Figure 1 reveals that the slope of the graph between GCI and INO in panel (a) and the GCI and INO graph in panel (b) are positive, whereas the GCI and LSH graph in panel (c) and the GCI and UMP graph in panel (d) are negative.

The exact or nearly complete linear relationship between all or some of the explanatory variables indicates multi-collinearity in the panel regression model. The high degree of correlation between the explanatory variables may render the parameter calculation impossible and the least squares method inapplicable. The variance inflation factor (VIF) test is conducted to examine potential multi-collinearity between the independent variables, as presented in Table 3.

Table 3: Variance Inflation Factor

	LnUMP	LnLSH	INO	LnGINI	Mean VIF
VIF	1.012	1.011	1.004	1.002	1.007
1/VIF	.988	.989	.997	.998	.

One of the criteria for determining the multi-collinearity problem is VIF values, and the VIF values that are less than 10 indicate no multi-collinearity problem between the variables. Table 3 confirms that all VIF values for independent variables are ≅ 1, indicating no multi-collinearity between the independent variables.

In contemporary research using panel time series in the past decade, the concept of cross-sectional dependence (CD) in macro panel data has garnered a significant amount of attention. If CD is not considered when selecting unit-root tests and parameter estimation methods, this could lead to biased results. In the case of panel models with exogenous regressors, Paseran, Ullah and Yamagata (2008) proposed a bias-adjusted version of the Lagrange multiplier (LM) test statistic for error cross-sectional independence (CI). In this context, the null hypothesis of CI [$H_0\colon Cov\ (u_{\text{it}}, u_{\text{it}}) = 0$ for all t and $i = j$] is tested, and the outcomes are presented in Table 4. We failed to reject H_0 at a 1% significance level, confirming CD.

Table 4: Slope Homogeneity and Cross-sectional Dependence Tests

Bias Adj. CD Test	LM CD: 85.71***
Homogeneity (Delta)	Delta adj: 15.679***

Note: *** p<.01

It is essential to verify the assumption of slope homogeneity for model selection when conducting dynamic panel data analysis. Pesaran and Yamagata (2008) proposed the delta (Δ) test to determine whether slope coefficients are homogeneous under the null hypothesis ($H_0\colon \beta_i = \beta$; $H_1\colon \beta_i = \beta_j$). The testing procedure is predicated on the assumption that errors in dynamic models are not serially correlated. In this method, it is acceptable to have regression errors that exhibit heteroscedastic behaviour. Table 4 shows the outcomes of the Delta test. H_0 is rejected at the 1% significance level. This result demonstrates heterogeneity between nations; therefore, heterogeneity and CD will be considered when selecting an estimation method.

Since CD is confirmed in Table 4, the stationarity of the series will be examined referencing the panel unit-root tests of Im, Pesaran and Shin (2003) (IPS) and Levin, Lin and Chu (2002) (LLC), which account for cross-section dependence. LLC determines stationarity by first calculating the cross-sectional averages of the series of each country then subtracting these averages from the data for all of the series to calculate the difference between the cross-sectional averages. Similarly, IPS uses the difference between cross-section averages to reduce CD and permit heterogeneity in the autoregressive parameter. The results of the LLC and IPS tests are presented in Table 5.

Table 5: Unit-root Test

Method		GCI	INO	LSH	UMP	GINI
LLC t-stat. (prob.)	I(0)	-5.145***	2.9465	4.099	-5.082***	-0.3582
	I(1)	-	-26.421***	-2.357***	-	-12.34***
IPS W-t-bar stat. (prob.)	I(0)	-1.9706**	9.875	-0.066	-3.372***	1.141
	I(1)	-	-26.329***	-7.809***	-	-12.38***

Note: **** p<.01, ** p<.05*

Table 5 presents the LLC and IPS test statistics and p-values of the series used in the model in which the null hypothesis (H_0) of panel unit roots was tested. H_0 is rejected for GCI and UMP, as t-statistics with p-value are significant; therefore, the series of GCI and UMP are stationary in level [I(0)]. We failed to reject H_0 for INO, LSH and GINI, but in their first differences, they remain stationary [I(1)].

The study's dataset is compiled from a particular subset of the population in a particular time frame, and was not selected at random; therefore, the random effects model cannot be used to estimate our results.

Table 6: Appropriate Model Selection

Test statistics	Individual effect (H0: No individual effect)	Time effect (H0: No time effect)	Individual and/or time effect (H0: No time and individual effect)
LR	493.47***	39.17***	792.58***
F	44.70***	4.65***	
LM	2028.88***		
Hausman test statistics			χ^2 (4) = 12.68***

Note: **** p<.01, ** p<.05*

Table 6 presents the test statistics, including LR, F, LM and Hausman tests, which are used to determine the optimal estimation method and ascertain the existence of time and/or individual influences in the model. The LR and F tests reveal signs of both individual and time influences in the model. In addition, the findings of the Hausman test suggest that the fixed effects model offers greater efficiency than the pooled model. This conclusion is further reinforced by a lower p-value, prompting us to discard the null hypothesis, further confirming that the fixed effects model is most suitable. Prior to venturing into parameter estimations, we must validate the basic presuppositions of the model, encompassing heteroscedasticity, autocorrelation and CD. These tests identify the most fitting estimation technique. The results of these tests are presented in Table 7.

Before proceeding with parameter estimations, we first confirm the model's foundational premises, examining heteroscedasticity, autocorrelation and CD to help determine the optimal estimation method. The conclusions from these tests are presented in Table 7.

Table 7: Test Results of the Model's Basic Assumptions

Heteroscedasticity test H0: No heteroscedasticity	W0 = 7.682***
	W50 = 6.687***
	W10 = 7.33***
Autocorrelation test H0: No Autocorrelation	DW =.304 < 2
	LBI =.545 < 2
CD test H0: Cov(uit, ujt) = 0	Friedman test statistic = 111.070***
	Free test statistic = 4.042***
	Pesaran test statistic = 17.419***

Note: *** *p<.01*

The fixed effect model is used to analyse the data, and heteroscedasticity was tested using Levene (1960), Brown and Forsythe's (1974) tests. The test statistics (W0, W50 and W10) are compared to the Snedecor F table with degrees of freedom (26, 500). The null hypothesis that the variances are equal was rejected at a 1% significance level, indicating the presence of heteroscedasticity in the model.

Table 7 also presents the results of the autocorrelation test, which includes the DW test statistic proposed by Bhargava, Franzini and Narendranathan (1982), as well as the LBI test statistic suggested from Baltagi-Wu (1999). In the random effects model, the calculated values of these test statistics are compared to the critical value of 2. Since the calculated values are less than 2, the null hypothesis of no autocorrelation is rejected at a 1% significance level, indicating the presence of autocorrelation in the model.

Table 7 also shows the results of the CD test, presenting test statistics and probability values for Friedman (1937), Free (2004) and Pesaran (2004) tests, which are 111.070 with Prob. = 0.000, 4.042 with Prob. = 0.000 and 17.419 with Prob. = 0.000, respectively. In both tests, the null hypothesis of no CI was rejected at a 1% significance level; thus heteroscedasticity, CD and autocorrelation are present in the model.

Parks (1967) introduced a panel data analysis method that accounts for periodic and spatial correlations as well as heteroscedasticity. This approach involves estimating the model using least squares, calculating residuals to assess autocorrelation and heteroscedasticity and subsequently re-estimating the model. However, a notable limitation of this research is the assumption of immediate effects due to data constraints. In reality, time delays may occur between certain stimuli, such as changes in employment in technology sectors and associated impact on global competitiveness. To address these concerns, the Parks–Kmenta estimator, which accommodates heteroscedasticity, CD and autocorrelation, is employed to estimate the model parameters, as shown in Table 8.

Table 8: Parks–Kmenta Regression Outcomes

		EU28		EU15–EU13	
LnGCI		Coef.(S.E)	t- (p-) value	Coef.(S.E)	t- (p-) value
INO		.134*** (.018)	7.30 (.000)	.111*** (.018)	6.19 (.000)

LnGINI	.525*** (.151)	3.49 (.000)	.548*** (.148)	3.70 (.000)
LnUMP	-.121*** (.015)	-7.95 (.000)	-.125*** (.015)	-8.20 (.000)
LnLSH	-.180* (.097)	-1.86 (.062)	-.174* (.095)	-1.84 (.065)
Cons.EU28	4.53*** (.074)	60.84(.000)		
EU15–EU13				
EU15			.117** (.055)	2.12 (.034)
Cons.EU15			4.48*** (.076)	58.83 (.000)
EU13			-.117* (.055)	-2.12 (.034)
Cons.EU13			4.60* (.077)	4.60 (.077)
Wald χ^2 (Prob.)		194.98***(.000)		461.92*** (.000)

Note: **** p<.01, ** p<.05, * p<.1*

Table 8 presents the parameter estimates for EU28. Furthermore, EU nations are divided into EU15 and EU13 groups to calculate parameter estimates for these two groups. Table 8 shows the constant-slope parameters, t-values, p-values and standard deviation values for each of the three groups, with the following notable findings.

Regarding the estimation results for EU28:

a) A 1% increase in the innovation index increases global competitiveness by 13.4%.
b) A 1% increase in Gini coefficient increases global competitiveness by 0.53%.
c) A 1% increase in unemployment reduces global competitiveness by 0.12%.
d) A 1% increase in labour's share of national income reduces global competitiveness by 0.18%.

Similarly, regarding the estimation results for EU15 and EU13:

a) A 1% increase in the innovation index increases global competitiveness by 11.1%.
b) A 1% increase in GINI coefficient increases global competitiveness by 0.55%.
c) A 1% increase in unemployment reduces global competitiveness by 0.13%.
d) A 1% increase in labour's share of national income reduces global competitiveness by 0.17%.
e) The global competitiveness of EU15 is %11.7, which is higher than EU13.

The findings indicate that innovation is a key driver of global competitiveness; however, this could inadvertently lead to a lower share of national income for labour and result in a more uneven income distribution.

5 CONCLUSION

Innovation and global competitiveness are crucial for fostering sustainable economic growth and development. How a nation manages to convert its knowledge resources into innovative economic value is essential for maintaining a competitive edge in the global marketplace. This study explores the influence of innovation on the global competitiveness of EU member nations, with a specific focus on the distinctions between the EU13 and EU15 nations during the period from 1997 to 2019. Furthermore, welfare dynamics are incorporated, referring to changes in the distribution of benefits across different segments of society.

The findings from the Parks–Kmenta panel data regression indicate that innovation, income inequality, unemployment and labour's share of national income significantly impact global competitiveness. Innovation has the most potent positive effect on global competitiveness, indicating that a 1% rise in the innovation index translates into a 13.4% increase in global competitiveness for all EU28 nations, and an 11.1% increase for the EU15–EU13 segment. When the Gini coefficient (a measure of income inequality) increases by 1%, this leads to a rise of 0.53% and 0.55% in global competitiveness for the EU28 and the EU15–

EU13 groups, respectively. In contrast, a 1% rise in unemployment decreases global competitiveness by 0.12% and 0.13% for the EU28 and EU15–EU13, respectively. Finally, a 1% increase in labour's share of national income leads to a reduction of 0.18% and 0.17% in global competitiveness for EU28 and EU15–EU13, respectively.

The results also reveal that the global competitiveness of EU15 is 11.7% higher than that of EU13. The study also makes a unique contribution by investigating the welfare dynamics linked to the countries' innovative capabilities. The conclusions reveal that innovation significantly influences global competitiveness; however, it is crucial to recognise that the quest for innovation could lead to a downturn in labour's share of national income and an imbalance in income distribution equality, which can only happen at the expense of these losses in socio-economic well-being.

This study provides a comparative review of innovation and global competitiveness for two distinct EU country groups, each defined by disparate levels of economic advancement and innovation potential. By investigating these differences, this study adds to the research concerning innovation and global competitiveness, underscoring the value of innovation in achieving and maintaining a nation's competitive edge and its influence on a nation's welfare dynamics. Moreover, the findings reveal the varying degrees of global competitiveness between EU13 and EU15 nations, producing valuable insights that can guide policymaking to boost innovation and competitiveness, particularly for the EU's lesser developed members. This study enriches our comprehension of the dynamic interplay between innovation, competitiveness and policy considerations in fuelling economic growth and development.

The findings elicit several key policy suggestions. First, policymakers should elevate innovation and technology investment, as these factors significantly improve global competitiveness. It is also crucial to reduce income inequality and unemployment, because these problems are shown to reduce global competitiveness. Policymakers should also strive to maintain the balanced distribution of the advantages that stem from technological progress and innovation across the entire societal spectrum to avoid adverse welfare effects. Finally, this study underscores the need for strategies to encourage innovation and competitiveness in the less economically advanced EU countries, possibly through increased R&D funding and incentives for innovation.

In conclusion, this study offers a valuable addition regarding the interplay between innovation and global competitiveness, particularly within the context of EU13 and EU15 member states. The results reveal the function of innovation as a main factor for global competitiveness. Additionally, the research demonstrates the significance of formulating policies that cultivate innovation and boost competitiveness, while concurrently ensuring that benefits are spread fairly. These insights could prove essential to policymakers, guiding their strategies to increase the competitiveness of less advanced EU countries and augment overall global competitiveness.

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