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Unveiling the Linkages between Economic Complexity, Innovation and Growth: The Case of High-Income and Upper Middle-Income Economies

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Abstract

This article explores the essential variables of economic complexity, innovation, and growth by researching the relationships between imperative economic indicators in selected high-income and upper middle-income economies. The economic complexity and innovation of the observed economies are robustly linked to their economic growth. The goal of this article is to investigate the significance of economic complexity and innovation in encouraging economic growth in high-income and upper middle-income economies. Miscellaneous methodological measurement instruments have been applied towards exploring the linkages between the crucial variables of economic complexity, innovation, and economic growth. The empirical data necessary for conducting this exploration were accumulated from primary and auxiliary sources. Analysis of the observed economies was performed using the statistical software package SPSS 25. The exploration results reveal the essential determinants of economic complexity and innovation for economic growth in selected countries. The interrelated determinants supervised for enhancing innovation and growth are linked to synthesized indicators of economic complexity. Confirmation of the heterogeneity between essential variables and awareness of sensitivity is the foundation for the subsequent acceptance of convenient economic complexity indicators for improvement of the critical fields of national economies.

Keywords: unveiling the linkages; economic complexity; innovation; growth; high-income and upper middle-income economies.

JEL classification: C8; E0; O40; O57.

1. INTRODUCTION

Economic complexity, innovation, and economic growth have evolved into active fields of research in the globalised world in recent years (Card & DiNardo, 2002; Griffith *et al.*, 2006; Chong & Gradstein, 2007; Porter, 2008; Hidalgo & Hausmann, 2009; Gackstatter *et al.*, 2014; Hausmann *et al.*, 2014; Norris *et al.*, 2015; Lybbert & Xu, 2022). A modern theory of economics that interprets determinants of economic complexity, innovation, and growth

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per capita recognizes operations of increasing product and knowledge distribution at national or international levels that are additionally interrelated to the worldwide transmission of different economic performances. The ability to innovate has been identified as one of the primary concerns for most economies, with governments pledging appropriate resources to increase innovation and exports, which are identified as economic growth levers (Griffith *et al.*, 2006; Gackstatter *et al.*, 2014).

However, many scientists in the field of economics have already acknowledged national economies as complex systems (Smith, 1776; Beinhocker, 2006). The contribution of Adam Smith to economics theory and the wealth of nations has been related to knowledge and labour distribution. The empirical investigation of economic complexity has been spreading in recent years with the relevance of new indicators and methodological approaches.

Similarly to the literature's overview and economic theory, many surveys of economic complexity have focused on the duality between economic inputs and outputs. However, this is contradictory to traditional economic theory, which either accumulates outputs as GDP per capita undertakes, or estimates the nature of inputs, such as capital, labour, and knowledge, as economic complexity operates. Innovation represents one of the most essential drivers of an economy's future economic growth (Helpman, 2004; Aghion *et al.*, 2005; George *et al.*, 2012; Atkinson & Ezell, 2014; Castellacci & Natera, 2015; Petrakis *et al.*, 2015; Terzić, 2017).

Economists Hidalgo and Hausmann (2009) proposed the expression of economic complexity to illustrate the knowledge that has been accumulated in the community, widely recognized as productivity capability or production complexity. Established on the assumption that national economies are interrelated by their export of outputs, the concept of economic complexity intends to evaluate complexity by evaluating the competitiveness of economies and the quality of their exported outputs. Hidalgo and Hausmann (2009) developed the Economic Complexity Index (ECI), based on a concept of reflection, where ECI is presented over the measurement of economic outcomes.

The crucial global institutions use various indicators that are important for exploration of the significance of innovation for economic growth. Dutta, Lanvin and Wunsch-Vincent (Cornell University *et al.*, 2020) indicate the importance of the new Global Innovation Index (GII), developed by the World Intellectual Property Organization (WIPO), for every national economy. The GII provides new data on global innovation status, along with the period during the COVID-19 pandemic.

Despite the fact that superior business performance results in poverty devaluation and an impressive improvement in economic growth, elaborating innovation and economic complexity is becoming a concern. Many economists propose that increasing income disparities could slow down consumption, foreign direct investments, and economic growth by affecting economic and social uncertainty (Rajan, 2010; Acemoglu & Robinson, 2012; Atkinson & Ezell, 2014; Cingano, 2014; Kumhof *et al.*, 2015).

However, income disparities can accelerate underprivileged governmental and other community choices while ruining confidence and community cohesion, and that negatively affects future economic growth (Bourguignon, 2003). Although intervening income disparities is still an ambitious assignment for both advanced and emerging economies, recognizing the variables of economic complexity has been a focus for policy creators, economists, and authorities (Hidalgo & Hausmann, 2009; Norris *et al.*, 2015). An important segment of the research survey deals with answering the question: Do economic complexity and innovation play a significant role in encouraging economic growth in selected high-income and upper middle-income economies? There are several explorations that highlight the relationship between innovation and exports, indicating that the more innovative products are, the more likely for exportation they may be (Pla-Barber & Alegre, 2007; Lewandowska *et al.*, 2016). Despite the fact that innovative products are feasible as exports, that does not automatically mean that exports will increase (Ganotakis & Love, 2011). Several economists (Kuznets & Murphy, 1966; Corak, 2013) have examined relationships between economic development and income disparities. They concluded that income disparity rises continuously as long as a demanding income level is achieved, and afterwards inequality starts to decline.

On the contrary, Yang and Greaney (2017) argue that a relationship between economic growth and income inequality does not exist. Hidalgo and Hausmann (2009) suggest the approach of "economic complexity" to evaluate an economy's productive potential. Economic complexity can be understood through the distinction and pervasiveness of what a specific economy can produce. This stimulates the belief in investigating the linkages between economic complexity, innovation, and economic growth. The linkages between the national economy's productive system and its capability to aggregate and allocate income were found in the papers by Hirschman (1958) and Singer (1950). Furthermore, the literature revealed aspects of economic metamorphosis or structural adjustment in increasing total factor productivity, growth per capita, and allocating economic outputs (Dollar *et al.*, 2016)

This research article addresses the new response by exploring the relationships between economic complexity, innovation, and growth. Actually, the existing literature reveals insufficient consideration of the abovementioned relationships. Furthermore, Hartmann *et al.* (2017); Le Caous and Huarng (2020) found a negative relationship between economic complexity and income disparities. On the contrary, K. K. Lee and Vu (2020) found that economic sophistication has a positive influence on income disparities. Additionally, these authors reject the moderating influence of other factors on the relationship between economic complexity and income disparity. According to the authors, Hidalgo and Hausmann (2009), economic complexity represents a long-term and expensive process of realizing new potential. The ambition of the new Economic Complexity Index is to ensure a comprehensive outlook on economic complexity, innovation, and growth, a paradox that cannot be understood by individual variables beyond any examination. The primary goal of this article is to investigate the significance of economic complexity and innovation in encouraging economic growth in high-income and upper middle-income economies. Miscellaneous methodological measurement instruments have been applied towards exploring the linkages between the crucial variables of economic complexity, innovation, and growth. This article is restricted to five parts. The first section deals with the theoretical background of the literature focused on the new dimensions of economic complexity, innovation, and growth. The 2nd section reveals research methodological patterns related to the variables of the economic complexity index, the global innovation index, and growth per capita. The 3rd section of the article presents collected primary and secondary data along with applied research methodologies. The 4th part of the article presents research results and discussions. The 5th part presents the conclusions.

2. THEORETICAL BACKGROUND OF THE LITERATURE: ECONOMIC COMPLEXITY, INNOVATION AND GROWTH

Nowadays, economic complexity, innovation, and growth have developed into the most popular expressions in the concepts of the new economic theory, including each national economy and its economic performance. Although the whole academic community and government institutions are becoming interested in the unveiling of the significance of economic complexity and innovation for economic growth, an understandable explanation of these terms has not been absolutely determined in the existing literature. Commonly, the reasons for that depend upon a variety of the evaluation of the abovementioned expressions and their comparable variables. The numerous variables of economic complexity, innovation, and growth are identified, notably by the configuration of complexity and the additional obstacles that evaluate the supplementary effects among the components of the framework, such as the specific characteristics of the national economy (Freudenberg, 2003; Fagerberg & Godinho, 2004; K. Lee & Kim, 2009; Grossman & Helpman, 2015; K. K. Lee & Vu, 2020; Lybbert & Xu, 2022).

Subsequently, the contribution of Adam Smith's economic theory, wealth of nations has been attributed to knowledge and labour dispersion. Although scientists in the field of economics have previously acknowledged national economies as complex systems (Smith, 1776; Beinhocker, 2006), the empirical exploration of economic complexity has been expanded in the last decade, with the importance of new indicators and methodologies. Correspondingly to the literature's background and economic theory, many surveys of economic complexity have been focused on the duality among economic inputs and outputs. Nonetheless, this is contradictory to traditional theories of economics, that either accumulate outputs as GDP per capita undertakes, or estimate the nature of inputs, such as capital, labour, and knowledge, as economic complexity operates. Innovation has been acknowledged as one of the most relevant drivers of the national economy and its future economic growth (Helpman, 2004; Aghion *et al.*, 2005; George *et al.*, 2012; Atkinson & Ezell, 2014; Castellacci & Natera, 2015; Petrakis *et al.*, 2015; Terzić, 2017).

Hidalgo and Hausmann (2009) suggest the expression of economic complexity to explain the knowledge that has been aggregated in the community, widely recognized as productivity capability or production complexity. Established on the belief that economies are interrelated by their export of outputs, the economic complexity concept aims to evaluate complexity by measuring the competitiveness of national economies and the quality of their exported outputs. According to that, economists Hidalgo and Hausmann (2009) developed the Economic Complexity Index (ECI) based on an approach of contemplation where ECI is presented over the observation of economic outcomes.

Correspondingly, they constructed an economic complexity index based on the "method of reflections". According to the reflection method, economic complexity is evaluated over the reflection of economic outputs (Mariani *et al.*, 2015). Precisely, revealed comparative advantage (RCA), or the range where an economy effectively exports products, is handled to present the degree of economic complexity. Appropriately, the pioneers of economic complexity, Hidalgo and Hausmann (2009), underline two approaches related to the economic complexity concept: 1. "diversity" and 2."ubiquity". Diversity represents the number of products that an economy could export competitively, and ubiquity represents the number of economies that are capable of exporting a product competitively. In order to evaluate the two dimensions of complexity, the ECI applies a cross-country export matrix – a matrix of relatedness. Hidalgo *et al.* (2018) noted that the relationship between the ECI and GDP per capita is very robust, and they have also demonstrated that the ECI can forecast economic growth after significant control for other basic economic features. Therefore, economies with a higher economic complexity rank than their proposed GDP per capita rank can be anticipated to grow rapidly. When a certain economy tries to become more complex, it switches attention from low-value products that depend upon natural resources and low-competence knowledge to those demanding higher competence. This causes an increase in the income gap (Card & DiNardo, 2002; Corak, 2013; K. K. Lee & Vu, 2020).

Porter (2008) created the theoretical framework for determining the reasons why innovation-driven economies are more productive and increase their growth rate faster than efficiency-driven economies, restraining certain important factors. In the last decade, many scientists have progressively directed their attention to investigations of economic complexity, innovation, growth and auxiliary economic outcomes (Edquist, 2004; Fagerberg & Godinho, 2004; Howells, 2005; Malerba & Brusoni, 2007; Foray, 2009; Hidalgo & Hausmann, 2009; Atkinson & Ezell, 2014; Grossman & Helpman, 2015; Le Caous & Huarng, 2020; Pugliese & Tacchella, 2020; Sciarra *et al.*, 2020; Schetter, 2021). They determined various approaches and dimensions affecting economic complexity, innovation capability, and growth of countries.

Modern economics theory that defines, interprets, and discovers factors of economic complexity, innovation, and growth per capita is recognizing activities of increasing product and knowledge distribution at a national level that are additionally connected to the worldwide transmission of various economic activities. The respected economist Porter (2008) highlights that efficiency-driven economies, if they wish to accomplish a higher level of economic growth and development, should be oriented to business sophistication and innovation capability, which are relevant to their international position and their path to achieving an innovation-driven economy.

Innovation performances are very complex, demanding distinctive resources (Edquist, 2004; Howells, 2005; Fagerberg & Verspagen, 2009; Atkinson & Ezell, 2014). These involve the research and development sector (R & D), skilled human resources (George *et al.*, 2012), and technical instruments that result in new or improved products that accomplish exceptional performance in comparison to other countries, institutions, or enterprises (Griffith *et al.*, 2006; Gackstatter *et al.*, 2014). Innovation has been identified as a crucial determinant of national competitiveness (Porter, 2008), especially in mapping the way to new markets.

Many institutions and enterprises have begun to influence innovation by ensuring that the new technologies are efficiently created and applied (Acemoglu & Robinson, 2012; Acemoglu & Restrepo, 2020). Hence, the basic strategy for creating new value relies upon the development of new products and services, as well as their commercialization (Fagerberg & Verspagen, 2009). Foray (2009) recognizes innovation as playing an indispensable function in enforcing the economic activity and economic growth or inactivity of regions over time. Most economies regard innovation capability as one of their top priorities, with governments pledging to direct adequate resources toward stimulating innovation and exports, which are linked as economic growth alternators (Griffith *et al.*, 2006; Gackstatter *et al.*, 2014).

Certain investigations highlight the relationship between innovation and exports, indicating that the more innovative products are, the more likely for exportation they may be (Pla-Barber & Alegre, 2007; Lewandowska *et al.*, 2016). Despite the fact that innovative products are feasible as exports, that does not automatically mean that exports will increase (Ganotakis & Love, 2011). Accordingly, a country's capability of creating innovative products is essential for exports, ensuring the enterprise to achieve a better rank in the global market and to gain competitive advantages. Economic complexity also represents one of the determinants that affect exports, admitting that the complexity of a product is recognized by the capabilities needed for its development. The more capacity a product needs for its production, the more complex it is likely to be (Hausmann *et al.*, 2014).

For instance, products determined as the most complex include very sophisticated machinery and chemicals, while the least complex products involve raw products or very simple agricultural products (Harvard's Growth Lab, 2021). The ECI evaluates each economy's productive capability by exploring its export capacity and the knowledge used in its products, acknowledging that the overall products of a country have their basis in knowledge perception. Each product demands a reasonable quantity of non-market inputs, called capabilities. Capabilities ensure that products can be manufactured (Hidalgo *et al.*, 2018).

The complexity of each country is evaluated by the export competitiveness of their production systems and structures (Tacchella *et al.*, 2013). Nonetheless, not every one of the total manufactured products in a specific economy is exported; this refers to the incompetence to export the products, resulting in lower productivity. Hence, there is a knowledge insufficiency in product creation. The innovation indicators reveal that high-income economies export more complex products, which increases their income, while low-income economies export fewer complex products, resulting in less (Tacchella *et al.*, 2013). Economies competing in the global market with identical products have the same capabilities (Hausmann *et al.*, 2014).

Consequently, economies capable of responding to the turbulent business environment, economic complexity, and innovation requests that are the foundation for increasing Gross Domestic Product and prosperous future growth are recognized as innovation-driven economies. Economists Costanza *et al.* (2009) explored the historical aspects of how gross domestic product emerged as the most widely accepted indicator of economic growth. GDP per capita (measured by Purchasing Power Parity) has been identified as a reliable barometer for assessing economic growth (Raworth, 2017).

Many worldwide institutions also acknowledge GDP per capita as a promising gauge of economic growth (WIPO, 2021). Helpman (2004) and afterwards, Grossman and Helpman (2015) explored growth theory with the emphasis on the significance of innovation in increasing economic growth. They have investigated innovation capability and growth in the world economy and identified the factors that increase long-term economic growth. Innovation formulation and dispersion rely upon new high-tech knowledge, which is created by interrelations between different elements of innovation capability in the unique national innovation structure (Fagerberg & Verspagen, 2009; Dollar *et al.*, 2016).

The awareness of innovation origins could be explained as aggregated knowledge which companies apply to increasing innovation performance and establishing a strong market position. In regard to enhancing innovation, companies could collect various types of information from international organizations, governments, experts, universities, and innovation labs. The essential global institutions use different gauges that are crucial for exploration of the significance of innovation in boosting economic growth. Dutta *et al.* (2020) indicate the importance of the new Global Innovation Index (GII), constructed by the World Intellectual Property Organization (WIPO), for every national economy. The GII provides new data on global innovation status, including the period during the COVID-19 pandemic.

3. RESEARCH METHODOLOGY AND DATA

The factors associated with the Economic Complexity Index (ECI), the Global Innovation Index (GII) and growth were determined and evaluated over the SPSS 25 comparative analysis, including the application of primary and auxiliary data in observed high-income and upper middle-income economies. The countries' rankings according to the ECI are based on the diversification and complexity of their export structures. Economies with a diverse set of individually complex specialized know-how are capable of producing and developing a diverse set of business-sophisticated outputs.

The complexity of an economy's exports is related to highly anticipated actual income ranks, or where complexity surpasses forecasts for an economy's income ranks, the economy is expected to achieve future growth much faster. According to that, ECI represents a valuable indicator of economic growth and development.

The exploration of economic complexity evolved over the last decennium according to two augmentations. The first augmentation convoluted the inauguration of a relatedness matrix (Hidalgo *et al.*, 2007, pp. 428-437; Hidalgo *et al.*, 2018, pp. 451-457), which evaluates the comprehensive affection between a specific activity and a specific location. The matrix of relatedness demonstrates pathway interdependencies and anticipates which performances could increase or decrease in a specific location (e.g. country, region).

The second augmentation emphasizes the evolution of the complexity metric (Hidalgo *et al.*, 2018, pp. 451-457). The matrix of relatedness applies indicators to the performance of a specific country to measure the availability, variety, and sophistication of the variables or inputs present in the specific economies. Specifically, the economic complexity of a location representing an economy (e) can be presented as Cmpx (e). The complexity of an activity (p-product or industry) can be expressed as Cpmx (p) – that presents the matrix which includes total economic activities in a specific economy. Generally, Cpmx (ep) equals 1 when a location's output in economic activity is greater than what is expected for an area of the identical size and economic activity with the identical total output. That could be done by applying a measure such as a location indicator. Economic complexity is calculated from equations for "diversity" and "ubiquity" to express the recursion:

$$k(e,n) = \frac{1}{k_{e,o}} \sum_{p} M_{ep} \frac{1}{k_{p,o}} \sum_{e'} M_{e'p} * k_{e',n-2} \tag{1}$$

$$k(e,n) = \sum_{e'} k_{e'',n-2} \sum_{p} \frac{M_{e'p} * M_{ep}}{k_{e,0} * k_{p,0}} = \sum_{e'} k_{e',n-2} * \tilde{M}_{e,e'} \tag{2}$$

where it can be presented as:

$$\tilde{M}^{Cmpx}(e,e') = \sum_{p} \frac{M_{ep} * M_{e'p}}{k_{e,0} * k_{p,0}} \tag{3}$$

Therefore, in a vector identification, if $\vec{k}_n$ represents the vector, whose e-th element is $k_{e,n}$ then:

$$\vec{k}_n = \tilde{M}^{Cmpx} * \vec{k}_{n-2} \tag{4}$$

where:

$\tilde{M}^{Cmpx}$ is the matrix whose e-th elements present the final matrix.

The economic complexity index is the eigenvector corresponding to the second largest eigenvalue of the $\tilde{M}^{Cmpx}$. The second eigenvector of a stochastic matrix is the leading correction to the equilibrium distribution and represents a partition of the data. In economic terms, the ECI is the vector that best divides economies into groups based on the activities that are performed in them. The new ECI index is an "aggregated measure"; its calculation is based on the following scores' collections, from the indicator rank (the highest rank) to the total score value (the highest value). The ECI indicators are calculated by the average of the scores of their structural variables, as follows:

$$ECI(e) = \frac{Cmpx(e) - mean(Cmpx_{(e)})}{std(Cmpx_{(e)})} \tag{5}$$

which can also be presented as:

$$\mathrm{ECI}_e = (k_e - \mathrm{mean}(k_e))/\mathrm{stdev}(k_e), \tag{6}$$

where the complexity k*e* of a location *e* and the complexity of an activity *p* can be defined as a function of each other. ECI values > 0 represent locations with a complexity that is larger than the average location in the dataset. One of the features of ECI is relatedness ωep. Formally, a relatedness ωep that can be defined as a predictor of a matrix of specialization that satisfies:

$$R_{ep}(t + \mathrm{d}t) = R_{ep}(t) + B1\omega_{ep}(t) + B2\omega_{ep}(t) + B3\omega_{ep}(t) \tag{7}$$

where: R*ep* represents the relatedness of an economy, and *B* is a positive and significant coefficient at a given time (t). The literature groundwork regarding economic complexity started with a survey by Hidalgo and Hausmann (2009) confirming that the ECI can predict further economic growth. Specifically, they found that an economy's futuristic scope of income (e.g., GDP per capita) was correlated with the economic complexity index (ECI) in futurous controlling for its primary scope of income and other variables (Fc). This finding could be presented by a baseline model of the following form:

$$\log(\mathrm{GDPpc}_c(t + \mathrm{d}t)) = A \log(\mathrm{GDPpc}_c(t)) + B\,\mathrm{ECI}_c(t) + CF_e + CF_p \ldots + \varepsilon \tag{8}$$

where :

GDP pc denotes gross domestic product per capita in a given time period (t),

F_e and F_p present location-specific and activity-specific variables (for instance, the level of innovation of an economy) and

B_2 and B_3 are coefficients that measure the interaction between relatedness and specific innovation variables (for example, relatedness × level of innovation or business sophistication), and

ECI represents the economic complexity index.

Accordingly, the influence of relatedness in the presence of a variable F_e is, precisely, $(B_1 + B_2F_e)\omega_{ep}$, and B_2 could be comprehended as a coefficient modifying the influence of relatedness in the presence of F_e.This method has been applied, usually, to determine variables that mitigate the influence of relatedness to help identify path-breaking growth. Economic complexity methodologies encircle delicate indicators of numerous economic performances to enroll both the extracted variables of production functions and the methods that integrate them into numerous final outputs. Actually, the exploration of economic complexity could be applied as an extension of the endogenous economic growth theory (P. M. Romer, 1990).

The model that is generally used in examining economic growth was developed by the economist P. M. Romer (1986). It highlights the influence of high-tech knowledge on growth per capita. An empirical model can be illustrated by allocating economies into two categories. Precisely, the model may be applied to highlight innovation's influence, as a variable of economic complexity, on growth per capita. This model may be presented by dividing the analyzed countries into two sections. The first section (the high-income economies) demonstrates production of innovative outputs, and the second section (the upper middle-income economies) represents innovation capability that leads to higher countries' innovation capability.

The following equalization can be applied to two specific groups of countries:

$$Y = I_{RD} C^{\alpha} L_y^{\beta} HR_y^{1-\alpha-\beta} \; ; \; 0<\alpha<1; 0<\beta<1. \tag{9}$$

$$I_{RD} = I_{RD}{}^{\varpi} C_{I_{RD}}^{\varpi} L_{I_{RD}}^{\varpi} HR_{I_{RD}}^{1-\varpi-\chi} \; ; \; 0<\varpi<1; 0\ \chi<1. \tag{10}$$

where:

variable Y is the quantity of determinant used for production activities,

C represents capital,

L represents labour,

HR demonstrates human resources, and

the variable I_{RD} presents the quantity of measures implicated for innovation performance that are created by the Research & Development section.

The empirical model developed by D. Romer (2012) that is applied for constructing R & D section growth is based on the following: Innovation increases growth, Technology diversification can be the effect of innovation performance created by human resources. By excluding capital, labour, and human resources from the scope of GDP per capita, the productivity of the R&D sector in each selected economy can be measured. Consequently, it can be proposed that the production function acknowledge the Cobb-Douglas model as follows:

$$Y_{et} = B_{et} C_{et^{\alpha}} L_{et^{1-\alpha}} \tag{11}$$

where :

Y_{et} is GDP per capita (PPP) for selected economy (e) in time (t),

B_{et} is a coefficient that measures the interaction of relatedness and specific innovation variables,

C_{et} is the capital accumulation of a selected economy (e) in time (t),
L_{et} represents the human capital scope for a selected economy (e) in time (t), and
α is the capital dispersion ($1 - \alpha$ presents the share of labour).

Afterwards, the logarithms could be calculated by following the formula:

$$\ln(Y_{et}) = \ln(B_{et}) + \alpha\ln(C_{et}) + (1 - \alpha)\ln(L_{et}) \tag{12}$$

It is reasonable to determine an indicator of $\ln(B_{et})$ by extracting $\alpha\ln(C_{et}) + (1 - \alpha)\ln(L_{et})$ from each side to get the following formula:

$$\ln(B_{et}) = \ln(Y_{et}) - \alpha\ln(C_{et}) + (1 - \alpha)\ln(L_{et}) \tag{13}$$

By determining the cumulation of different variables and its features, each variable of the innovation is transformed into scores. The variables are ranked from 0 to 100 according to the lowest and highest scores. Precisely, each innovation indicator is re-scored by applying the following formula equation:

$$VariableScore_{e,t} = \left(\frac{Score_{e,t} - LowestScore_{i}}{HighestScore_{i} - LowestScore_{i}} \right) * 100 \tag{14}$$

The Global Innovation Index (GII) includes two sub-indicators, the Innovation Input Sub-Indicator and the Innovation Output Sub-Indicator, which both constitute innovation pillars. The five input innovation pillars include indicators of the national economy that assure innovative performance: (1) institutions; (2) human capital and research; (3) infrastructure; (4) market sophistication; and (5) business sophistication. Two output innovation pillars incorporate the current state of innovation outputs: (6) knowledge and technology outputs and (7) creative outputs. Every innovation pillar is separated into sub-pillars, and those sub-pillars are created based on particular indicators. Sub-pillar scores are calculated as the weighted average of individual indicators. Pillar scores are calculated as the weighted average of a sub-pillar score.

Correlation analysis using Spearman's statistician, which is used on ordinal variables in the absence of normality, is carried out to assess the link between chosen indicators. The rho-p hypothesis test is also used to determine the statistical significance of Spearman's correlations. In order to analyse the relationships between economic complexity, innovation, and growth, Spearman's rank-order correlations were used. When data is interpreted by rank order and when it is necessary to study the rankings of variables, the Spearman coefficient (p or rho) is the most commonly employed to assess the correlation between ordinary quantitative variables.

Indicators are sourced from MIT’s Observatory of Economic Complexity, Harvard's Growth Lab, the World Intellectual Property Organization (WIPO), and other international and academic institutions. The data used to calculate the ECI and GII for the observed countries came from the Central Intelligence Agency (CIA), the World Bank (WB), and the Eurostat national accounts database for high-income and upper middle-income economies. Inequalities in economic complexity, innovation, and growth have been the subjects of recent literature studies. However, less is known about the situation in high-income and upper middle-income countries, where innovation and growth per capita are rising quickly. Most of the existing classifications of countries were created on the basis of different analytical frameworks or for political reasons. The increasing diversity between high-income and upper-middle-income countries has not been taken into account in earlier analyses of countries' economic complexity, innovation, and growth. Therefore, the countries were selected and classified as 10 high-income and 6 upper-middle-income countries according to the values of gross domestic product per capita (measured by Purchasing Power Parity). The World Bank's income-based classification has been used.

4. RESEARCH RESULTS AND DISCUSSIONS

The comparative analysis was conducted in 16 economies, classified into two groups: high-income economies: Switzerland (CH), Germany (DEU), Czech Republic (CZE), Hungary (HUN), Estonia (EST), Lithuania (LTU), Latvia (LAT), Poland (POL), Slovenia (SVN), Slovakia (SLK), and upper middle-income economies: Romania (ROU), Bulgaria (BGR), Serbia (SRB), Bosnia and Herzegovina (BIH), North Macedonia (MKD), and Albania (ALB). The aggregated data for each country covers the period 2016-2021. Table no. 1 presents the global innovation index scores and rankings in observed high-income and upper middle-income economies.

Table no. 1 - The Global Innovation Index scores and rankings of high-income and upper middle-income economies in 2016-2021.

Economy	GII 2016		GII 2017		GII 2018		GII 2019		GII 2020		GII 2021	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
High-income economies												
CH	66,30	1	67,70	1	68,40	1	67,20	1	66,10	1	65,5	1
DEU	57,90	2	58,40	2	58,0	2	58,20	2	56,50	2	57,3	2
CZE	49,40	4	51,0	3	48,70	4	49,40	4	48,34	3	49,0	4
HUN	44,70	6	41,70	10	44,90	6	44,5	6	41,53	6	42,7	6
EST	51,70	3	50,90	4	50,50	3	50,0	3	48,28	4	49,9	3
LTU	41,20	10	41,20	11	41,2	11	41,5	9	39,18	11	39,9	10
LAT	44,30	7	44,60	6	43,20	7	43,2	7	41,11	7	40,0	9
POL	40,20	11	42,0	9	41,70	10	41,3	10	39,95	9	39,9	11
SVN	46,0	5	45,80	5	45,80	5	45,3	5	42,91	5	44,1	5
SLK	41,70	8	43,40	7	42,90	8	42,0	8	39,70	10	40,2	8
Upper middle-income economies												
ROU	37,90	12	39,20	12	37,90	12	36,8	12	35,95	12	35,60	12
BGR	41,40	9	42,80	8	42,60	9	40,3	11	39,98	8	42,4	7
SRB	33,80	14	35,30	14	35,50	13	35,7	13	34,33	13	35,0	13
BIH	29,60	15	30,20	15	31,10	15	31,4	14	28,99	15	29,6	15
MKD	35,40	13	35,40	13	29,90	16	30,3	15	33,43	14	34,1	14
ALB	28,40	16	28,90	16	30,0	14	30,3	16	27,1	16	28,0	16

Source: Cornell University, INSEAD & WIPO, The Global Innovation Index Reports, various editions (2016, 2017, 2018, 2019, 2020), WIPO (2021) and own calculations.

In terms of the innovation scores and rankings compared to other analysed economies for the studied period (2016–2021), Switzerland and Germany achieved the best results. According to the Global Innovation Index, Estonia and the Czech Republic made progress and sustained their positions in the rankings. Bulgaria improved its position from the 9th ranking position in 2016 to the 7th ranking position in 2021 by developing its potential for innovation. Latvia, on the other hand, has shown a decreasing position in innovation capability over the six years that have been examined, falling from the 7th ranking position in 2016 to the 9th ranking position in 2021.

In each field of innovation (new products, processes, and policies), different national economies have created their own individual innovation patterns, including at a more limited level in upper middle-income countries. This is illustrated by the range of economies from different income group levels ranking in the top 3 (Switzerland, Germany, and Estonia) of the Global Innovation Index 2021. Regardless of these positive tendencies, enormous gaps exist in innovation performance between the high-income economies and the upper middle-income economies.

The GII affirms the perceptive assumption that innovation and economic complexity scores and rankings increase with income levels. Enormous innovation divides also endure across geographic areas, especially when comparing innovation performance across high-income groups with those of other regions of upper-middle income countries. Many upper middle-income economies are lagging behind other regions that have almost identical GDP per capita levels. It can also be noticed that innovation capacity in upper middle-income economies is lagging behind the high-income economies, especially after Switzerland (CH), and Germany (DEU).

Figure no. 1 below shows that innovation capacity in high-income and upper middle-income economies is stagnant during the observed period (2016-2021).

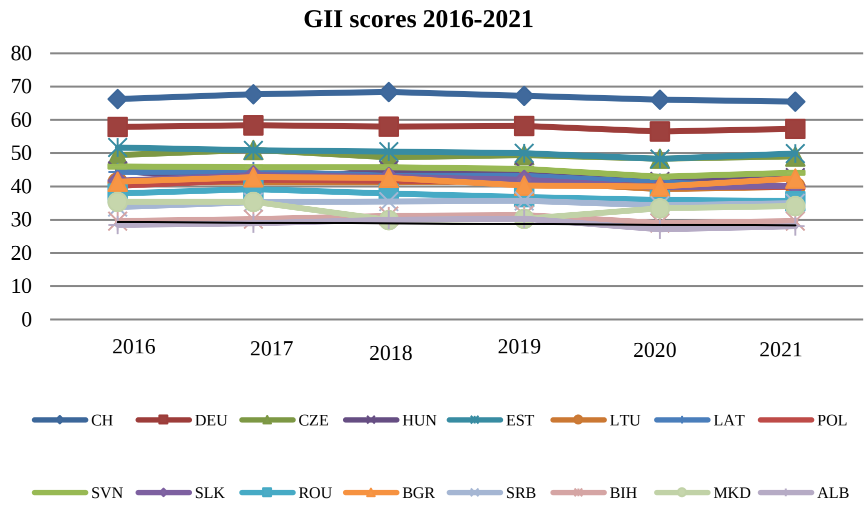


Figure no. 1 – The Global Innovation Index scores for selected high-income and upper middle-income economies in 2016-2021

Source: Author's own creation from the Global Innovation Index, 2016-2021.

Switzerland achieved the highest global innovation index (GII) scores and ranks during the observed 2016-2021 period compared to the other countries. Besides Switzerland, as the top innovative economy, Germany has obtained the 2nd ranking position in terms of innovation potential. Other economies have improved or settled into their ranking positions. Albania achieved the worst ranking position according to the global innovation index during the six years observed. Scores and ranks of the selected high-income and upper middle-income economies are presented in Table no. 2, based on various methodological approaches and measures of economic complexity, innovation, and economic growth.

Table no. 2 – Scores and rankings of selected high-income and upper middle-income economies based on various methodological approaches and measures of economic complexity, innovation, and growth in 2020-2021

Economy	Economic Complexity Index (ECI)		Global Innovation Index (GII)		GDP pc PPP	
	Score	Rank	Score	Rank	Value	Rank
	High-income economies					
CH	2,13	1	65,5	1	75,880	1
DEU	2,07	2	57,3	2	56,956	2
CZE	1,80	3	49,0	4	42,956	3
HUN	1,63	5	42,7	6	35,088	8
EST	0,92	9	49,9	3	39,729	6
LTU	0,79	10	39,9	10	40,784	5
LAT	0,67	11	40,0	9	33,394	10
POL	1,08	8	39,9	11	35,957	7
SVN	1,64	4	44,1	5	40,820	4
SLK	1,45	6	40,2	8	34,815	9
	Upper middle-income economies					
ROU	1,20	7	35,6	12	32,950	11
BGR	0,53	14	42,4	7	25,471	12
SRB	0,75	12	35,0	13	20,545	13
BIH	0,73	13	29,6	15	15,935	15
MKD	0,04	15	34,1	14	17,663	14
ALB	-0,04	16	28,0	16	15,225	16

Note: ECI – The Economic Complexity Index; GII – The Global Innovation Index; GDP pc (PPP)-Gross Domestic Product per capita (PPP-Purchasing Power Parity).

Source: Data from the MIT's Observatory of Economic Complexity (2022), Harvard's Growth Lab (2021), WIPO (2021), the World Bank (2021), Eurostat (2021), and the Central Intelligence Agency (2021) are used in the calculation.

Switzerland has achieved the highest scores and ranks in economic complexity (ECI). It is a dominant high-income economy by the global innovation index (GII) and a crucial economic growth measure - GDP per capita (evaluated by Purchasing Power Parity). Two groups of countries can be identified by their innovation performance in relation to their income levels. Among the innovation leaders are high-income economies, such as Switzerland, Germany, Estonia, the Czech Republic, and Slovenia. These economies have achieved progress in innovation through the contribution of human capital to productive and durable innovation infrastructures to develop impressive levels of innovation outputs. The group of innovative followers includes: Serbia, Bosnia and Herzegovina, North Macedonia, and Albania. Table no. 3 presents the selected high-income and upper middle-income economies' rankings according to different innovation measures in the 2020-2021 period. The innovation variables in observed economies include the following crucial innovation subindicators (pillars) for each country: 1. Institutions (INST), 2. Human Resources (HRM), 3. Infrastructure (INFR), 4. Market sophistication (MSO), 5. Business sophistication (BSO), 6. Knowledge and technology outputs (KTO), and 7. Creative outputs (CRO).

Table no. 3 - Rankings of selected high-income and upper middle-income economies according to innovation indicators in 2020-2021

Economy	INST	HRM	INFR	MSO	BSO	KTO	CRO
High-income economies							
CH	1	2	1	1	1	1	1
DEU	2	1	4	4	2	2	2
CZE	6	4	3	6	3	3	5
HUN	10	6	6	11	6	4	10
EST	4	5	2	3	5	5	3
LTU	7	8	10	9	7	10	8
LAT	5	9	12	5	1	13	7
POL	8	7	11	10	8	11	11
SVN	3	3	5	12	4	8	6
SLK	9	10	9	14	10	7	9
Upper middle-income economies							
ROU	14	15	8	15	12	9	13
BGR	11	12	7	13	9	6	4
SRB	12	11	13	8	13	12	12
BIH	16	13	15	7	16	15	16
MKD	13	14	14	2	14	14	15
ALB	15	16	16	16	15	16	14

Note: 1. Institutions (INST), 2. Human Resources (HRM), 3. Infrastructure (INFR), 4. Market sophistication (MSO), 5. Business sophistication (BSO), 6. Knowledge and technology outputs (KTO), 7. Creative outputs (CRO).

Source: The calculation is based on data published by the World Intellectual Property Organization (WIPO) for 2020-2021.

In 2020-2021, Switzerland realized the highest position (1st ranked) in the following innovation indices: Institutions (INST), Infrastructure (INFR), Market sophistication (MSO), Business sophistication (BSO), Knowledge and Technology Outputs (KTO), and Creative Outputs (CRO). Germany captured the highest rank according to Human Resources (HRM). Bosnia and Herzegovina represents the lowest ranked country (16th ranking position) by following the innovation pillars: Institutions (INST), Business sophistication (BSO), and Creative outputs (CRO). Albania is the lowest ranked country according to human resources (HRM), infrastructure (INFR), market sophistication (MSO), and knowledge and technology outputs (KTO). Germany achieved the first ranking position according to human resources and the second ranking position in the following innovation indicators: institutions, business sophistication, knowledge and technology outputs, and creative outputs. Latvia is the best ranked high-income economy according to business sophistication, with evidenced weaknesses in infrastructure and knowledge and technology outputs. Estonia achieved the third position according to market sophistication and creative outputs. Macedonia achieved the 2nd ranking position according to market sophistication, with evidenced weaknesses in all other innovation indicators. Bulgaria achieved the 4th ranking position according to creative outputs and 6th ranking position by knowledge and technology outputs.

Weaknesses in innovation achievement, shown by innovation indicators, are evident in most of the upper middle-income countries, as well as in several high-income economies.

Table no. 4 shows the relationships between the variables of economic complexity, innovation, and growth in observed high-income and upper middle-income economies. Utilizing Spearman's rank-order correlations, the relationships between the Economic Complexity Index (ECI), the Global Innovation Index (GII), various innovation sub-indices (pillars), and GDP per capita (PPP) were investigated. The data were gathered from primary and auxiliary sources. The empirical research was conducted by the execution of the statistical software package (SPSS 25).

Table no. 4 – Correlation matrix of the variables of economic complexity, innovation, and growth

	ECI	GII	GDP pc PPP	INST	HRM	INFR	MSO	BSO	KTO	CRO
ECI	1,000	,800**	,882**	,726**	,829**	,809**	,206	,721**	,824**	,624**
GII	,800**	1,000	,876**	,876**	,888**	,953**	,391	,859**	,932**	,935**
GDP pc PPP	,882**	,876**	1,000	,909**	,935**	,847**	,382	,852**	,812**	,809**
INST	,726**	,876**	,909**	1,000	,918**	,765**	,494	,930**	,691**	,882**
HRM	,829**	,888**	,935**	,918**	1,000	,800**	,476	,855**	,774**	,800**
INFR	,809**	,953**	,847**	,765**	,800**	1,000	,297	,752**	,950**	,859**
MSO	,206	,391	,382	,494	,476	,297	1,000	,453	,256	,371
BSO	,721**	,859**	,852 **	,930**	,855**	,752**	,453	1,000	,698**	,854**
KTO	,824**	,932**	,812**	,691**	,774**	,950**	,256	,698**	1,000	,826**
CRO	,624**	,935**	,809**	,882**	,800**	,859**	,371	,854**	,826**	1,000

Note: **. p<0.001.

Source: Author's own calculation

The following scatter plots show the Spearman's correlation coefficients results for selected high-income and upper middle-income economies in 2020-2021.

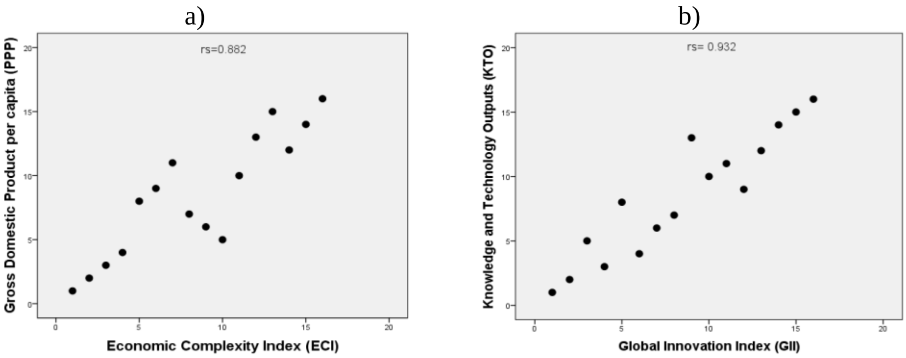


Figure no. 2 - Scatter plot showing the relationship between: a) ECI and GDP per capita (PPP); b) GII and KTO

Source: Created by the author using SPSS 25.

The scatter plot (2a), in Figure no. 2, shows a very strong positive and significant relationship between the Economic Complexity Index (ECI) and the economic growth measure – GDP per capita (PPP), as confirmed by Spearman's rank-order correlation coefficient rs = 0.882, p<0.001. A very strong positive relationship was revealed between the Global Innovation Index (GII) and Knowledge and Technology Outputs (KTO), as presented by the scatter plot (2b) and the correlation coefficient rs = 0.932, p<0.001.

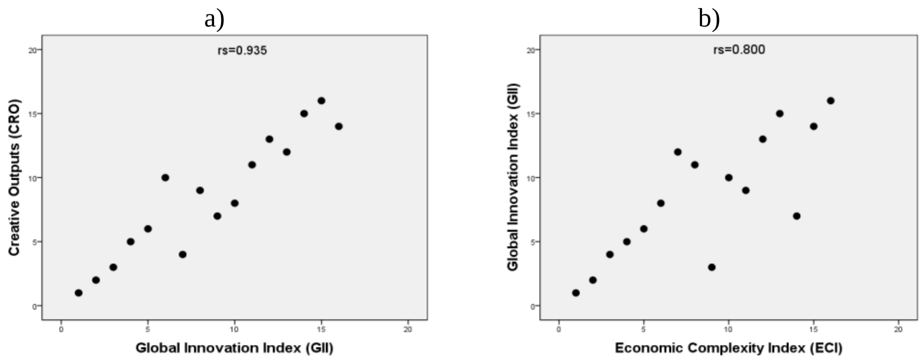


Figure no. 3 – Scatter plot showing the relationship between:
a) GII and CRO; b) ECI and GII
Source: Created by the author using SPSS 25

The scatter plot (3a), in Figure no. 3, reveals a very strong positive relationship between the Global Innovation Index (GII) and Creative Outputs (CRO), presented by a correlation coefficient rs = 0.935, p<0.001. The scatter plot (3b) shows a strong positive relationship between the Economic Complexity Index (ECI) and the Global Innovation Index (GII), with a correlation coefficient rs = 0.800, p< 0.001.

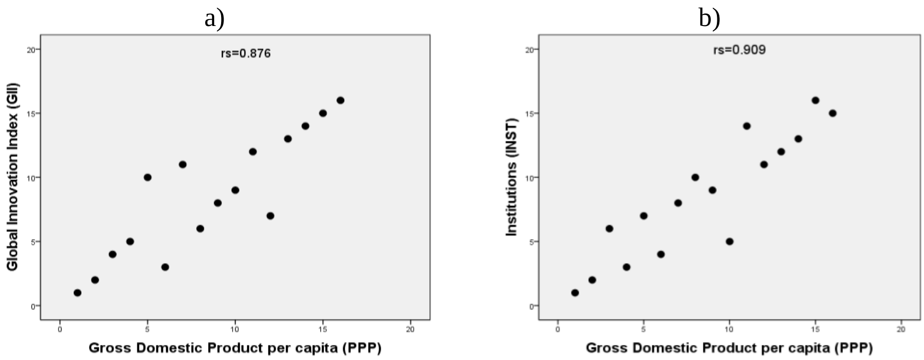
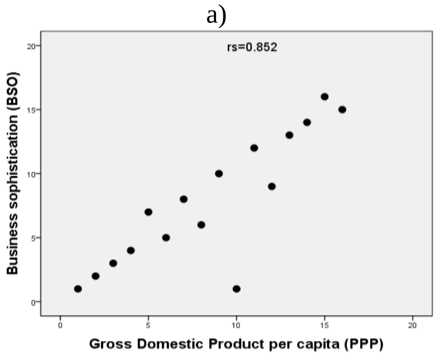


Figure no. 4 – Scatter plot showing the relationship between:
a) GDP per capita (PPP) and GII; b) GDP per capita (PPP) and INST.
Source: Created by the author using SPSS 25

The scatter plot (4a), in Figure no. 4, indicates the strong positive relationship between the GDP per capita (PPP) and the Global Innovation Index (GII), with a correlation coefficient rs = 0.876, p<0.001. A very strong positive relationship (scatter plot 4b) was revealed between GDP per capita (PPP) and the innovation subindicator institutions (INST), shown by the correlation coefficient rs = 0.909, p<0.001.

a)



b)

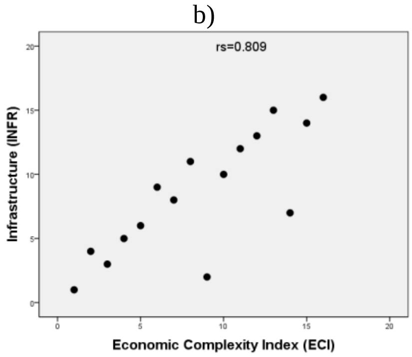
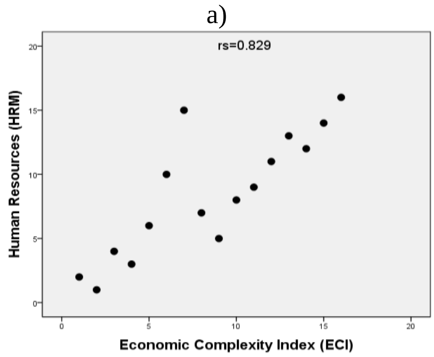


Figure no. 5 – Scatter plot showing the relationship between:
a) GDP per capita (PPP) and BSO; b) ECI and INFR.
Source: Created by the author using SPSS 25

A very strong positive relationship has been identified between GDP per capita (PPP) and the innovation pillar, business sophistication (BSO), as presented by Figure no. 5 (scatter plot 5a) and the correlation coefficient rs = 0.852, p<0.001. A strong positive relationship was determined between the Economic Complexity Index (ECI) and the innovation subindicator: infrastructure (INFR), as indicated by the scatter plot (5b) and the correlation coefficient rs = 0.809, p<0.001.

a)



b)

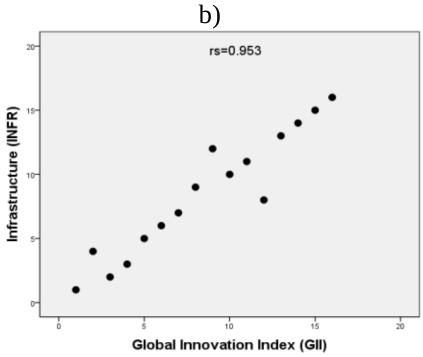


Figure no. 6 – Scatter plot showing the relationship between:
a) ECI and HRM; b) GII and INFR.
Source: Created by the author using SPSS 25

The scatter plot (6a) in Figure no. 6 shows a strong positive relationship between the Economic Complexity Index (ECI) and the innovation subindicator: Human Resources (HRM), with a correlation coefficient rs = 0.829, p<0.001. A very strong positive relationship was found between the GII and the innovation subindicator: infrastructure (INFR), as presented by the scatter plot (6b) and the correlation coefficient rs = 0.953, p<0.001.

a) b)

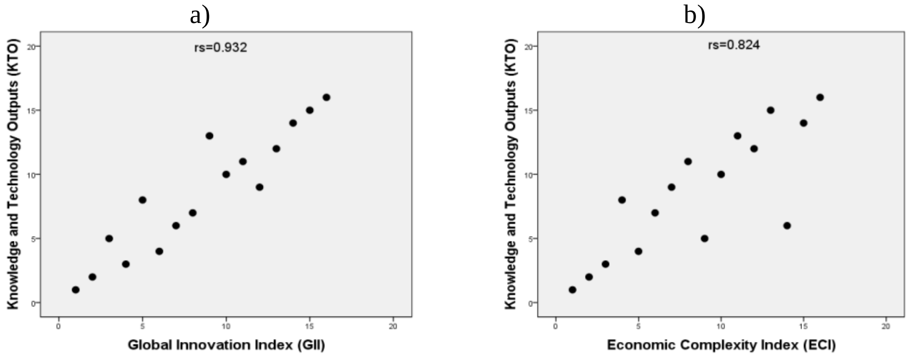


Figure no. 7 – Scatter plot showing the relationship between:
a) GII and KTO; b) ECI and KTO.
Source: Created by the author using SPSS 25

The scatter plot (7a) in Figure no. 7 shows a very strong positive and significant relationship between the GII and the innovation subindicator: Knowledge and Technology Outputs (KTO), confirmed by the correlation coefficient rs = 0.932, p<0.001. A significant positive relationship was found between the Economic Complexity Index (ECI) and the innovation indicator-Knowledge and Technology Outputs (KTO) as presented by the scatter plot (7b) and Spearman's correlation coefficient rs = 0.824, p<0.001.

a) b)

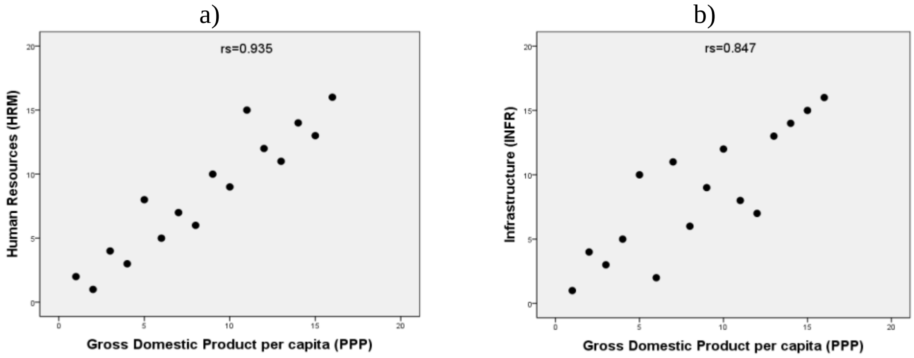


Figure no. 8 – Scatter plot showing the relationship between:
a) GDP per capita (PPP) and HRM; b) GDP per capita (PPP) and INFR.
Source: Created by the author using SPSS 25

The scatter plot (8a) in Figure no. 8 shows a very strong positive relationship between GDP per capita (PPP) and the innovation subindicator Human Resources (HRM), with a correlation coefficient rs = 0.935, p<0.001. A strong positive relationship was identified between GDP per capita (PPP) and infrastructure (INFR), as shown by the scatter plot (8b) and Spearman's correlation coefficient rs = 0.847, p<0.001.

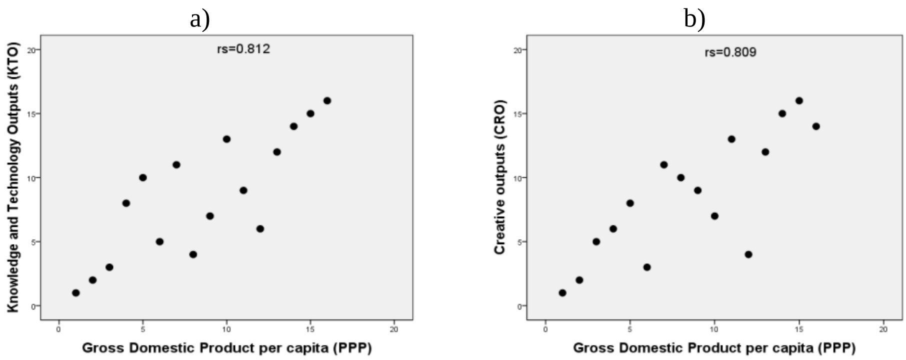


Figure no. 9 – Scatter plot showing the relationship between:
a) GDP per capita (PPP) and KTO; b) GDP per capita (PPP) and CRO.
Source: Created by the author using SPSS 25

The scatter plot (9a) in Figure no. 9 shows a strong positive relationship between the GDP per capita (PPP) and the following innovation subindicator: Knowledge and Technology Outputs (KTO), as presented by a correlation coefficient rs = 0.812, p<0.001. A very strong positive relationship was found between GDP per capita (PPP) and the innovation subindicator, creative outputs (CRO), as shown by the scatter plot (9b) and the correlation coefficient rs = 0.809, p<0.001.

Financing innovation in times of crisis has become an essential concern because the pandemic rise of COVID-19 has slowed down innovation processes and increased economic unpredictability. Attention to the allied dimensions of economic complexity and innovation in building strong linkages between the innovation pillars is becoming crucial. The interaction between the academic community and institutions, on the one hand, and the innovation process, on the other hand, in the creation, application, and dissemination of knowledge, technology, and human capital should be prioritized. Economic policy creators should pay attention to the diffusion of scientific results and their application to social questions in high-income and upper middle-income economies.

Innovation leaders like Switzerland and Germany have achieved an impressive innovation results, by interaction with universities, the government, and the private sector. The GII indicates that countries have to begin to invest in innovation infrastructure and human capital at a level on par with their GDP per capita level. Policy discussions in European countries have to be focused on innovation to bridge the gaps between high-income and upper-middle income group economies. A two-speed Europe is rising, with European innovation leaders (high-income economies) and upper middle-income economies that perform less well in economic complexity and innovation. European policy discussions require us to place priority on creating appropriate economic policies that encourage economic growth. Even if innovation cannot alleviate the most immediate financial obstacles, it is an essential element of long-term growth. Looking at indicators of economic complexity and innovation, some upper middle-income countries are the bridge spots of Europe, while countries such as Estonia and the Czech Republic have substantially increased their ECI and GII positions. The ECI and GII are not meant to be created as the definite scores and rankings of economies. The GII is focused on mapping the path to evaluating and comprehending innovation as well as identifying appropriate policies, successful practices, and other levers to enhance innovation and economic growth.

5. CONCLUSIONS

The goal of this article was to investigate the significance of economic complexity and innovation in encouraging economic growth in high-income and upper middle-income economies. Miscellaneous methodological measurement instruments have been applied towards exploring the linkages between the crucial variables of economic complexity, innovation, and growth. The research results have unveiled positive and significant correlations between the Economic Complexity Index (ECI), the Global Innovation Index (GII), Gross Domestic Product per capita (Purchasing Power Parity), Institutions (INST), Infrastructure (INFR), Human Resources (HRM), Business sophistication (BSO), Knowledge and Technology Outputs (KTO), and Creative Outputs (CRO). From the explored strong positive relationships between essential indicators, it can be concluded that economic complexity and innovation, in particular, have been very strongly positively correlated with economic growth, which demands building or strengthening institutions and infrastructure, high-skilled human resources, advancing business sophistication, enhancement of innovation and creative outputs through the usage of knowledge and technology in selected high-income and upper middle-income economies.

The observed high-income economies have acknowledged the significance of economic complexity, innovation performance, and economic growth expansion, and have already directed goals to map their ways to innovation-driven economies. The spotlight should be directed to effective economic instruments and practices that should encourage innovation, income, and growth by establishing stable institutional frameworks, creating infrastructure capacities, providing qualified human resources, implementing sophistication in business performances, and raising innovation outputs through the usage of knowledge and technology in the observed economies. The comparative analysis has recommended the wide-ranging theoretical background and factual exploration attributed to the significance of economic complexity for overall innovation capability and growth. As a result, the aforementioned could play a critical role in supporting and strengthening the foundation for affirming determinants of economic complexity, innovation, and growth, as well as creating future theoretical approaches for applicable economic and innovation performances or possibly individual analysis of each economy. Consequently, indices and subindices of innovation capability represent precious variables for broader exploration concerning the economic complexity and growth of countries.

This study makes a contribution by providing additional theoretical analysis and empirical investigation of the relationships between essential indicators of economic complexity, innovation, and growth in a number of high-income and upper middle-income economies. Furthermore, this analysis ensures a new, extensive dataset, which can be used for further empirical analysis of economic complexity, innovation, and growth. Conducted research provides new perspectives on the existing literature that seeks to measure the economic complexity and innovation of economies. The research results have important policy implications. The aforementioned may help to ensure a crucial basis for recognizing the importance of economic complexity and innovation variables for achieving economic growth, as well as to improve the anticipated theoretical foundation for suitable new economic policy in the high-income and middle-income economies' investigations.

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