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The Nexus Between Economic Complexity and Economics Activity: Evidence Based on A Panel Vector Autoregression Model

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Abstract

Objective: The objective of this study is to analyze the relationship between economic complexity, as measured by the Economic Complexity Index (ECI), and economic performance, represented by GDP per capita.

Theoretical framework: The study builds upon the existing theoretical framework that suggests a positive relationship between economic complexity and economic growth. It examines the impact of economic complexity on economic performance and productivity in countries.

Method: The study utilizes a Vector Autoregression (VAR) framework and panel data from 1998 to 2020 for 134 countries. The VAR model allows for the analysis of the dynamic interactions between economic complexity and GDP per capita. The Economic Complexity Index (ECI) is used to measure economic complexity.

Result and conclusion: The results of the study indicate a direct and significant correlation between economic complexity and economic performance. Countries with higher levels of economic complexity tend to have higher levels of GDP per capita. The findings suggest that fostering economic complexity through targeted policies can potentially enhance overall economic performance. These results have important implications for policymakers and stakeholders in developing countries.

Keywords: *complexity, GDP per capita, PVAR, Economic Complexity Index (ECI).*

1. Introduction

"Economic complexity" is intricate interrelationships and interdependencies within an economy. Diversity in production and exports increases sustainability and reduces vulnerability to shocks. In contrast, economic simplicity refers to concentrating on producing and exporting specific goods. The question at hand is twofold: firstly, to what extent does economic complexity impact economic growth? And secondly, does economic complexity contribute to enhanced productivity in countries?

Countries have higher levels of economic vulnerability when public debt burdens are at high levels, which are the result of high levels of deficit in the general budget, and they also suffer from low levels of foreign reserves (Mohamed, 2023). Furthermore, dependence on a small number of products and a small number of Exports, therefore, and considering the above, are more vulnerable to economic shocks such as recessions (Abdulkadir, Shettima, Abdullahi, & Abdulkadir, 2022), currency crises, or fluctuations in commodity prices (Fossati, 2013).

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Economists Ricardo Hausmann and César Hidalgo created the Economic Complexity Index (ECI) to measure economic complexity (Dzotsenidze, 2021). The ECI considers the complexity or pervasiveness of the exported goods in addition to the export basket's variety for each nation. It assesses the knowledge and prowess needed to manufacture and export a nation's commodities. Countries with a high Economic Complexity Index (ECI) export a wide range of goods, including complex products requiring advanced skills and technology. Because they are not unduly reliant on a few distinct products, these nations are seen to have more robust and sustainable economies. On the other hand, countries with a low ECI have a more limited export base and frequently rely on a small number of commodities or low-complexity items. These economies may be more exposed to external shocks and commodity price volatility. The ECI is frequently used in economic development and policy analysis to analyze a country's economic structure, identify possible growth prospects, and lead policy actions to improve economic complexity and diversity.

Although a theoretical relationship between economic complexity and economic activity growth exists, there is a requirement for further comprehensive and precise research to fully comprehend the nature of this relationship and assess the magnitude of the impact of economic complexity on economic growth. While valuable, previous studies in this domain may have limitations or be insufficient in terms of practical applications and quantitative analyses. Therefore, this study aims to empirically estimate the effect of the Economic Complexity Index on economic growth across 134 countries within the framework of the Economic Complexity Index.

2. Theoretical framework

Nearly studies addressed analyzing the relationship between economic complexity and several other variables Some of them found a strong relationship, and some of them found a weak relationship where (Lapatinas, 2016) found no causal effect of economic complexity on economic growth using dynamic panel data. On the contrary, (Zhu & Li, 2017) economic complexity and different levels of human capital positively affect long- and short-term growth. According to (Stojkoski & Kocarev, 2017), economic complexity is a statistically significant explanatory factor for long-term economic growth, indicating its substantial economic implications. However, in the short term, productive knowledge does not appear to have an impact on income changes in Southeastern and Central Europe. A study conducted by (Gala, Rocha, & Magacho, 2018) revealed that exports and production complexity play a substantial role in explaining the convergence and divergence patterns between countries. The research indicated that as complexity increases, countries that can narrow the income gap with developed nations also have the potential to reduce the overall income disparity.

A study conducted by (Buccellato & CorÃ, 2019) revealed that different levels of economic complexity contribute to disparities in economic growth among selected regions. Their analysis utilized a balanced panel of 191 regions and 55 economic branches from 2003 to 2015. In another study, (Lee & Lee, 2020) established a significant and robust relationship between the economic complexity index and economic growth in the United States. They examined variables such as the concentration of assignees, localization, originality, diversification, and cycle time of technologies. (Ikram, Xia, Fareed, Shahzad, & Rafique, 2021) demonstrated bidirectional causality between economic growth and economic complexity in Japan using Quantile Granger causality analysis.

(Laverde-Rojas & Correa, 2021) employed the Adaptive Neuro-Fuzzy Inference System (ANFIS) model, dynamic panel data techniques, and the Sasabuchi–Lind–Mehlum (SLM) test to comprehensively analyze data from 86 countries between 1971 and 2014. Their findings indicated a significant impact of the economic complexity index on economic outcomes. (Ajide, 2022) examined the causal relationship between natural resources and economic complexity using a panel of thirty-two African economies from 1995 to 2018. The study established the empirical regularity of the natural resource curse thesis on economic complexity, both in aggregate and disaggregated terms. Additionally, path-dependent effects of economic complexity were observed across the board. (Gnangnon, 2022) A study was conducted to examine the effect of economic complexity on the diversification of services exports. The study utilized a panel dataset of 109 countries from 1985-2014, demonstrating the importance of economic complexity in the diversification of countries' exports of services.

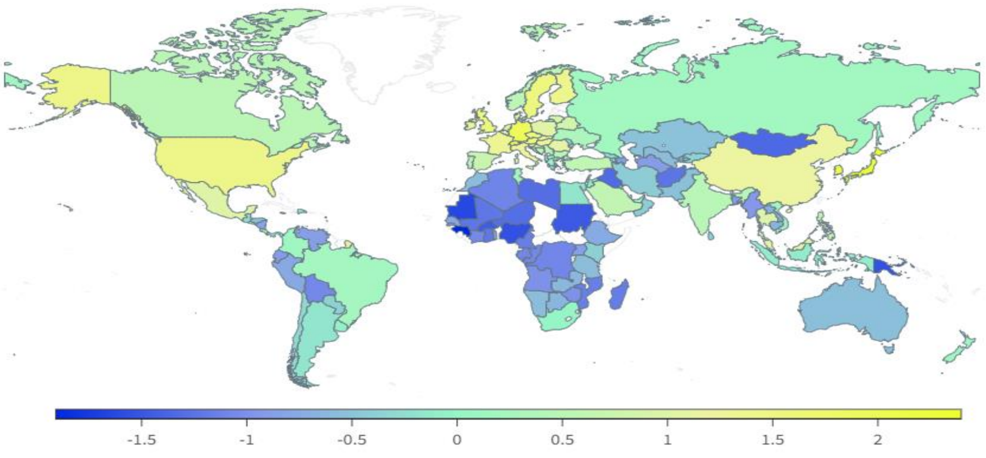
3. Methodology

The study utilized cross-sectional data for 134 countries from 1998 to 2020. The source of data for the Economic Complexity Index was the research lab at Harvard University, available at their website (www.atlas.cid.harvard.edu). The data for per capita Gross Domestic Product (GDP), which serves as a relative indicator of economic activity development in countries, was obtained from the World Bank database (www.worldbank.org).

The Economic Complexity Index (ECI) ranks countries based on the scale and complexity of their export portfolios. Figure 1 illustrates the distribution of countries based on the Economic Complexity Index. The yellow color represents higher levels of complexity, while the blue color represents lower complexity. It is notable that African and Middle Eastern countries exhibit lower levels of economic complexity compared to European, American, and East Asian countries, which demonstrate higher levels of complexity.

Countries with high complexity possess a wide scope of complex and specialized capabilities, allowing them to manufacture various products. Besides product knowledge, other factors play a role in determining a country's economic complexity. These include the number of products it produces, the ubiquity of those products (i.e., the number of countries exporting them), and the sophistication and diversity of the products made by other countries. Economic complexity reflects the variety and sophistication of the productive capabilities integrated into a country's exports. The Economic Complexity Index (ECI) has demonstrated its ability to elucidate income disparities among nations and outperform other singular metrics in predicting future growth (Breitenbach, Chisadza, & Clance, 2021).

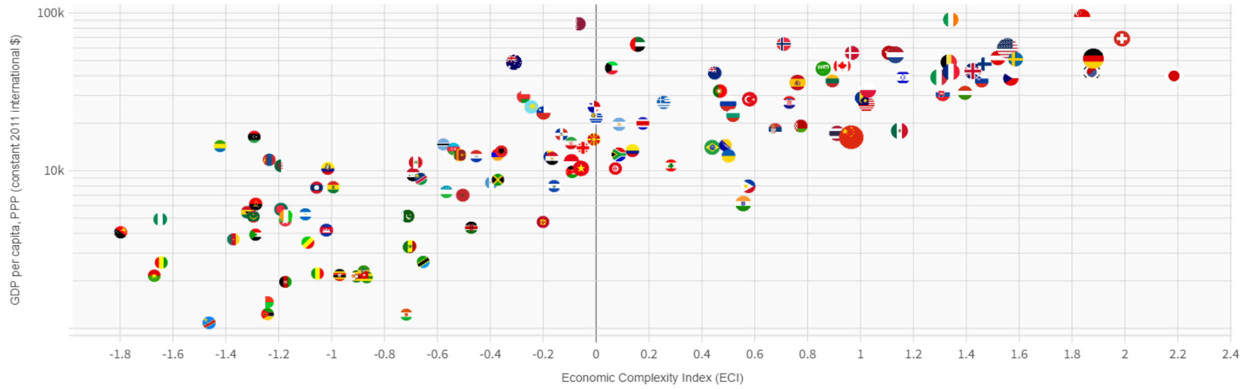
Figure 1: Economic Complexity Index (ECI) the World



Source: https://atlas.cid.harvard.edu/rankings.

In Figure 2, we can see how economic complexity is related to economic activity. High-complexity countries are generally those with higher per capita Gross Domestic Product (GDP). This clearly indicates a strong correlation between per capita GDP and the Economic Complexity Index.

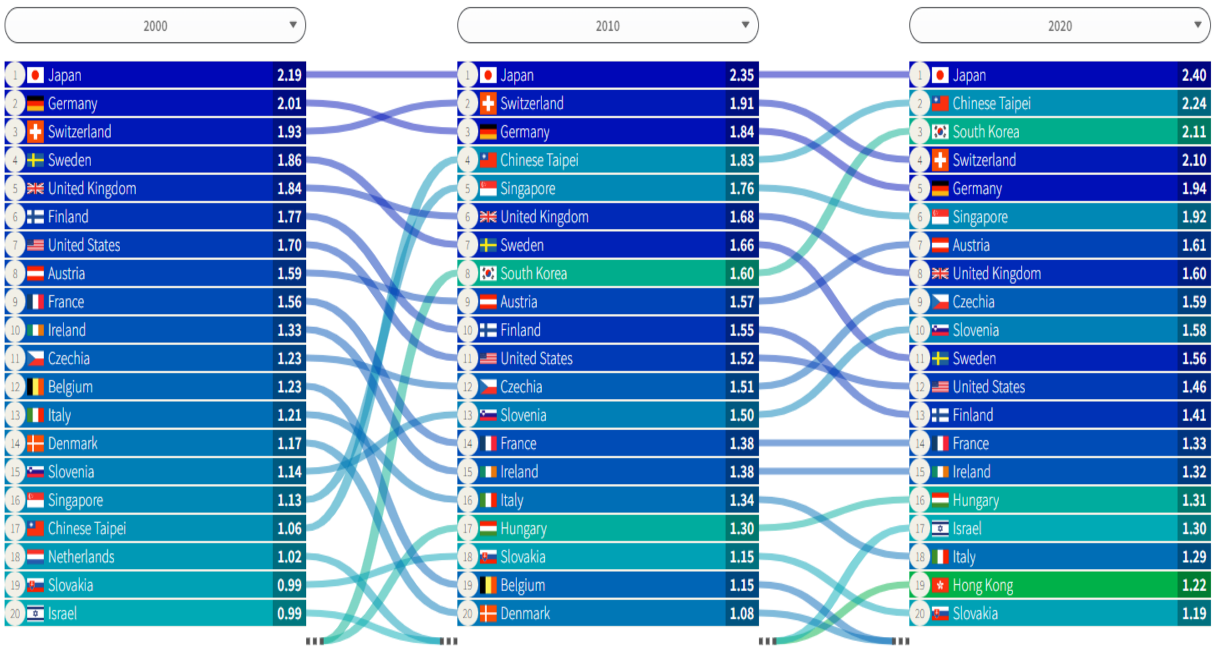
Figure 2: Economic Complexity Index (ECI) vs GDP per capita, PPP (constant 2011 international $) (2020)



Source: www.atlas.cid.harvard.edu.

The rankings of the countries included in the index have changed, as shown in Figure 3. Over time, the rankings of the countries in the index have changed. Rankings for some nations may have changed due to changes in the complexity of their economies. These modifications reflect changes in the economic and production activity of various nations.

Figure 3: Some changes in the rankings of countries



Source: ww.atlas.cid.harvard.edu.

The panel VAR model was employed in the study to test the relationship between Economic Complexity Index (ECI) and GDP-per capita. By including lag periods, accounting for both endogenous and exogenous factors, and maintaining the sequence of data within units (countries), this model offers a framework for dynamically assessing the interactions between variables. Both a stationary test and a co-integration test must be performed to estimate the data, Lag order is selected based on the Schwarz Bayesian information criterion (SBIC). The fundamental equation is a representation of the model's equation.

$$yi,t = \sum_{t=1}^{p} A_l y_{i,t-l} + Bx_{i,t} + \mu i + \epsilon i,t$$

where yi,t m×1 vector of an endogenous variable for i^{th} cross-sectional unit at time t, where m the number of variables in the vector. xi,t an n×1 vector of strictly exogenous variables, where n represents the number of exogenous variables. The term μi represents the fixed effect specific to the i^{th} cross-sectional unit. It is assumed that both A and B are independent of the cross-sectional units.

4. Results and Discussion

The table provides statistical measures for Gross Domestic Product per capita (GDP_PER) and Economic Complexity Index (ECI), The average value of GDP_PER is 13,787$, while the average value of ECI is -0.007186. and. The median GDP_PER is 5,394.269$, and the median ECI is -0.067182. The standard deviation for GDP_PER is 17,865.73, while for ECI, it is 0.987196. A positive skewness value (1.803790 for GDP_PER and 0.065070 for ECI) suggests a right-skewed distribution, meaning that there are more observations toward the lower values. A higher kurtosis value (5.965487 for GDP_PER and 2.307650 for ECI) indicates a more peaked distribution than a normal distribution. The probability Jarque-Bera statistic is 0.000 for both GDP_PER and ECI, indicating a significant deviation from normality, to avoid the issue, the natural logarithm was utilized.

Table. 1: Descriptive analysis

	GDP_PER	ECI
Mean	13787.21	-0.007186
Median	5394.269	-0.067182
Maximum	102913.5	2.262001
Minimum	113.5673	-2.936229
Std. Dev.	17865.73	0.987196
Skewness	1.803790	0.065070
Kurtosis	5.965487	2.307650
Jarque-Bera	2419.863	55.06691
Probability	0.000000	0.000000
Observations	2663	2663

Where GDP_PER: Gross Domestic Product per capita, ECI: Economic Complexity Index.

The outcomes of stationary testing (unit root test) are displayed in Table.2. The tests were conducted under different specifications, the inclusion or exclusion of a constant term, and a time trend. were performed at the level and the first difference of the variables. variables stationary at the first difference, therefore the terms of data using the difference in the data estimation.

Table. 2: Unit Root Test Results

		At Level	
		ECI	GDP_PER
With Constant	t-Statistic	0.0691	0.3655
	Prob.	0.5259	0.6947
		n0	n0
With Constant & Trend	t-Statistic	0.0033	0.9683
	Prob.	0.6553	0.8586
		n0	n0
Without Constant & Trend	t-Statistic	0.0836	0.5127
	Prob.	0.2782	0.5439
		n0	n0
		At First Difference	
		d(ECI)	d(GDP_PER)
With Constant	t-Statistic	0.0155	0.0402
	Prob.	0.1017	0.0074
		n0	***
With Constant & Trend	t-Statistic	0.0903	0.0594
	Prob.	0.0833	0.0344
		*	**
Without Constant & Trend	t-Statistic	0.0009	0.0029
	Prob.	0.0122	0.0003
		**	***

Notes:

a: (*) Significant at 10%; (**) Significant at 5%; (***) Significant at 1% and (no) Not Significant

b: Lag Length based on SIC.

c: Probability based on MacKinnon's (1996) one-sided p-values.

The results of the Panel Cointegration Test using the Johansen-Fisher method are shown in Table 3. The statistical analysis demonstrates that the Fisher statistics are highly significant at a 1% level for both the trace and max-eigen tests. Therefore, it can be said that the variables under examination have at least one cointegration relationship. This provides strong evidence of a long-term association among these variables.

Table. 3: Panel Cointegration Test (Johansen Fisher)

Hypothesized No. of CE(s)	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max-eigen test)	Prob.
None	663.4	0.0000	485.9	0.0000

At most 1	631.4	0.0000	631.4	0.0000

The results of the Panel Granger Causality Tests are shown in Table 4. The test findings show that ECI Granger Causes GDP_PER with a high level of statistical significance. The F-Statistic value of 13.3658 and the p-value of 2.E-06 indicate a substantial causal association between ECI and GDP_PER. On the other hand, the test finds no substantial evidence to support the claim that GDP_PER Granger causes ECI. The F-Statistic value of 2.11427 and the p-value of 0.1209 show that there is insufficient evidence to determine a causal association between GDP_PER and ECI.

Table. 4: Panel Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
ECI does not Granger Cause GDP_PER	2388	13.3658	2.E-06
GDP_PER does not Granger Cause ECI		2.11427	0.1209

The outcomes of the VAR stability tests are shown in Table 5. By looking at the roots of the characteristic equation, these tests evaluate the stability of the VAR (Vector Autoregression) model. Since no root sits outside the unit circle, this suggests that the VAR model satisfies the stability criterion. All the roots given in the table have moduli that are less than 1.

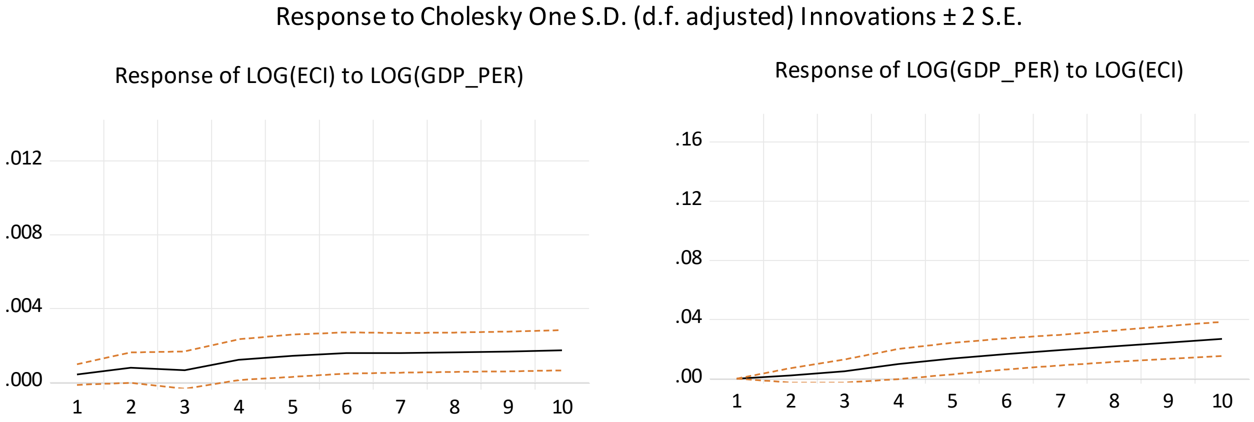
Table. 5: VAR stability Tests

Root	Modulus
0.992293	0.992293
0.957312	0.957312
0.306459 - 0.514514i	0.598868
0.306459 + 0.514514i	0.598868
-0.538655	0.538655
0.462052	0.462052
-0.096523 - 0.246311i	0.264548
-0.096523 + 0.246311i	0.264548

No root lies outside the unit circle. VAR satisfies the stability condition.

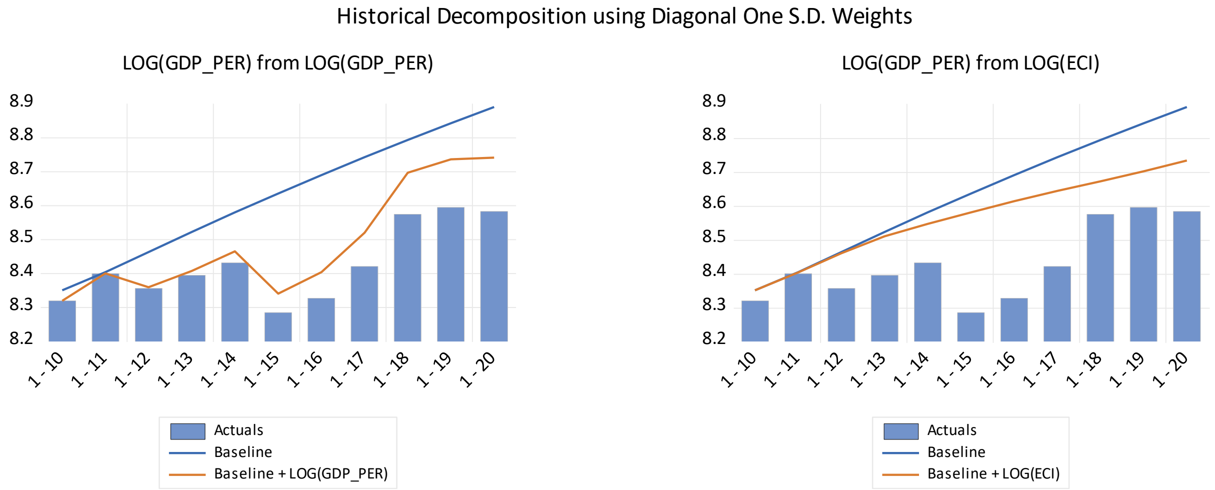
The outcomes of the investigation utilizing the Panel Impulse Response Function are shown in Figure 4. This function examines the dynamic response of variables to a shock or impulse in the system. The analysis reveals a significant and positive relationship between the Economic Complexity Index (ECI) and the per capita Gross Domestic Product (GDP). These results are in line with the theoretical framework that suggests a connection between economic complexity and economic development. Furthermore, these findings align with previous ones like (Laverde-Rojas & Correa, 2021), (Lee & Lee, 2019).

Figure 4: Panel Impulse Response Function



The study performed the Cholesky decomposition method for panel data to explain the relationship between GDP-per capita and the Economic Complexity Index (ECI). The results, as shown in Figure 4, indicate that there are positive effects within the basic scenario of economic complexity on the components of the variance in the per capita per GDP. Therefore, the presence of economic complexity in high proportions in countries created, in parallel, high levels of income because of the improvement in economic levels.

Figure 4: Panel Historical Decomposition using Cholesky.



5. Conclusion

The findings of this study present powerful evidence for the beneficial effect of economic complexity on economic performance, exactly in relation to per capita GDP. Using the Panel Impulse Response Function, the analysis shows a significant and positive relationship between the Economic Complexity Index (ECI) and the per capita Gross Domestic. Likewise, the Cholesky decomposition method for panel data analysis found a notable relationship between the Economic Complexity Index and per capita GDP. These results align with previous research and underscore the significance of fostering economic complexity as a pathway to sustainable economic development. Consequently, the implications of this study are of utmost significance for policymakers and stakeholders in developing countries, as they suggest that fostering economic complexity through targeted policies can potentially enhance overall economic performance.

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