Multiple Regression Analysis of Indicators that Determine Competitiveness

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Abstract

The correlation between Human Development Index (HDI), Sustainable Development Goals Index (SDG) and Competitiveness Index (CI) reflects how countries balance social progress, environmental sustainability and economic performance. Generally, countries with high scores of HDI perform well in the SDG Index because education, strong health and income levels support sustainable development. They are also competitive because education and health are key productivity drivers' factors.

The objective of the paper is to analyze the factors that determine competitiveness of countries such as human development and sustainable development. To study this interdependence were selected the most relevant indicators that measure competitiveness (Competitiveness Index), human development (Human Development Index) and sustainable development (Sustainable Development Goals Index). The statistical methods used are multiple regression and correlation coefficient.

Key words: Competitiveness Index, Human Development Index, Sustainable Development Goals Index, multiple regression
J.E.L. classification: C10, C30

1. Introduction

Multiple regression is a widely utilized statistical technique for analyzing the influence of multiple independent variables on a single dependent variable. It plays a crucial role in data analysis, decision-making and predictive modelling across various fields. The advantages of this method are: it allows the examination of multiple factors simultaneously, helps isolate the unique effect of each predictor by holding others constant, enhances the accuracy of conclusions about cause- effect relationships.

2. Theoretical background

Ordinary least squares regression examines the extent to which a dependent variable responds to changes in a single explanatory variable. However, when outcomes are influenced by multiple factors, there is required a more appropriate analytical method such as multiple regression.

Multiple regression models can be either linear or nonlinear. Linear multiple regression assumes a direct relationship between the dependent variable and the independent variables.

The model estimates how changes in each explanatory factor affect the outcome, holding the other factors constant.

Key assumptions underlying multiple linear regression include:

- A linear relationship between dependent independent variables
- Limited multicollinearity among predictors
- Independent and random sampling of observations from the population

The adjustment equation of the multifactor linear model is:

$$\hat{y}_i = a + b * x_{1i} + c * x_{2i}$$

The system of normal equations is:

$$\begin{cases} n*a+b*\sum x_{1i}+c*\sum x_{2i}=\sum y_i \\ a*\sum x_{1i}+b*\sum x_{1i}^2+c*\sum (x_{1i}*x_{2i})=\sum (x_{1i}*y_i) \\ a*\sum x_{2i}+b*\sum (x_{1i}*x_{2i})+c*\sum x_{2i}^2=\sum (x_{2i}*y_i) \end{cases}$$

This system is solved using Cramer's method.

The determinants are:

$$\Delta=\begin{vmatrix} n & \sum x_{1i} & \sum x_{2i} \\ \sum x_{1i} & \sum x_{1i}^2 & \sum (x_{1i}*x_{2i}) \\ \sum x_{2i} & \sum (x_{1i}*x_{2i}) & \sum x_{2i}^2 \end{vmatrix}$$

$$\Delta_a=\begin{vmatrix} \sum y_i & \sum x_{1i} & \sum x_{2i} \\ \sum (x_{1i}*y_i) & \sum x_{1i}^2 & \sum (x_{1i}*x_{2i}) \\ \sum (x_{2i}*y_i) & \sum (x_{1i}*x_{2i}) & \sum x_{2i}^2 \end{vmatrix}$$

$$\Delta_b=\begin{vmatrix} n & \sum y_i & \sum x_{2i} \\ \sum x_{1i} & \sum (x_{1i}*y_i) & \sum (x_{1i}*x_{2i}) \\ \sum x_{2i} & \sum (x_{2i}*y_i) & \sum x_{2i}^2 \end{vmatrix}$$

$$\Delta_c=\begin{vmatrix} n & \sum x_{1i} & \sum y_i \\ \sum x_{1i} & \sum x_{1i}^2 & \sum (x_{1i}*y_i) \\ \sum x_{2i} & \sum (x_{1i}*x_{2i}) & \sum (x_{2i}*y_i) \end{vmatrix}$$

The parameters of the model are calculated according to the following formulas:

$$a=\frac{\Delta_a}{\Delta}$$

$$b=\frac{\Delta_b}{\Delta}$$

$$c=\frac{\Delta_c}{\Delta}$$

The multiple regression model enables the analyst to forecast the resultative variable using data from several explanatory variables. However the model does not always achieve perfect accuracy, as each data point may vary slightly from the predicted outcome given by the model. The residual value (e) representing the difference between the actual result and the predicted result is incorporated in the model to accommodate these minor discrepancies.

The disadvantages of multiple regression are:

- Multicollinearity- if predictors are highly correlated, it becomes hard to determine their individual effects
- Requires large data sample – for more reliable results there are required large datasets
- Interpretation of the results can be complex and hard especially for non-experts.

For more than thirty years, the IMD Competitiveness Center has pioneered research on how countries and companies compete to lay the foundation for sustainable value creation. The competitiveness of nations is probably one of the most significant developments in modern management. The rankings of the country help attract investment, inform policy decisions and foster a competitive spirit among the nations. This can also lead to improved living standards, job creation and sustainable development, shaping the economic landscape for years to come.

In 2024 the WCC ranked the competitiveness of 67 economies across four factors: economic performance, government efficiency, business efficiency and infrastructure. These factors capture various aspects of competitiveness such as macroeconomic stability, fiscal policy, institutional quality, market openness, business dynamism, innovation, education, health and environmental performance. The 2024 ranking shows that the most competitive economies combine solid economic

performance with efficient and effective public and private sectors, high-quality infrastructure. These economies also balance productivity and prosperity meaning they can therefore generate elevated levels of income and quality of life for their citizens while preserving the environment and social cohesion. (IMD, 2024).

Sustainable development remains a central goal shared by governments, international organizations, and the private sector. Global efforts have been substantial in defining actionable goals and in mobilizing the resources and instruments necessary for their realization. Rather than focusing solely on financial gain, investments should prioritize generating measurable social and environmental benefits in parallel with economic returns—an approach aligned with the principles of impact investing. (Panait, M., Hysa, E. and Raimi, L., 2023).

Sustainable Development Goals Index (SDG) measures and ranks countries based on their progress towards achieving the 17 UN Sustainable Development Goals, which are a set of global goals aimed to end poverty, protecting the environment and ensuring people peace and prosperity by 2030.

SDG Index provides an annual assessment of SDG progress in all 193 UN member states. SDG Index incorporates 125 indicators including 98 global indicators and 27 additional indicators used for the OECD countries' dashboards.

"Human Development Index (HDI) is a composite Index measuring average achievement in three basic dimensions of human development:

- Life expectancy at birth- number of years a newborn infant could expect to live if prevailing patterns of age-specific mortality rates at the time of birth stay the same throughout the infant's life
- Expected years of schooling- number of years of schooling that a child of school entrance age can expect to receive if prevailing patterns of age-specific enrolment rates persist throughout child's life
- Mean years of schooling- average number of years of education received by people age 25 and older, converted from education attainment levels using official durations at each level
- Gross national income (GNI) per capita – aggregate income of an economy generated by its production and its ownership of factors of production, less the incomes paid for the use of factors of production owned by the rest of the world". (United Nations Development Programme, 2025)

3. Research methodology

The research utilizes datasets from public reports: Sustainable Development Report 2024, Human Development Report 2025, IMD World Competitiveness Booklet 2024. The analysis focuses on the top 10 ranking of countries according to the Sustainable Development Goals Index in 2024. To study this correlation there are used statistical methods like linear multiple regression and correlation coefficient. The independent variables are Sustainable Development Goals Index (SDG) and Human Development Index (HDI). The resultative variable is the Competitiveness Index (CI). The Cramer method is used to determine the regression equation of the linear model.

4. Findings

The following table presents the first ten ranked countries by the Sustainable Development Goals Index in 2024. For each country the Human Development Index and the Competitiveness Index in 2024 are presented to determine the correlation using multiple regression analysis.

Table no.1 Ranking of the countries

Rank	Country	SDG	HDI	CI
1	Finland	86.4	0.948	80.3
2	Sweden	85.7	0.959	90.3
3	Denmark	85	0.962	97.1
4	Germany	83.4	0.959	72.7
5	France	82.8	0.92	69.7

6	Austria	82.5	0.93	72.1
7	Norway	82.2	0.97	86.2
8	Croatia	82.2	0.889	52.8
9	U.K	82.2	0.946	70.8
10	Poland	81.7	0.906	61.7

Source: Sustainable Development Report 2024 https://dashboards.sdgindex.org/chapters,
Global Digitalization Index 2024 Report, https://www.huawei.com/en/reports/global-digital-economy

The independent variables are the Sustainable Development Goals Index (SDG) denoted by x_{1i} and the Human Development Index (HDI) denoted by x_{2i}. The resultative variable is the Competitiveness Index denoted by y_i. The following table contains processed data to study the multiple correlation between the indicators.

Table no. 2 Processed data

No.	x_{1i}	x_{2i}	y_i	$x_{1i}*x_{2i}$	$x_{1i}*y_i$	$x_{2i}*y_i$	x_{1i}^2	x_{2i}^2
1	86.4	0.948	80.3	81.9072	6937.92	76.1244	7464.96	0.898704
2	85.7	0.959	90.3	82.1863	7738.71	86.5977	7344.49	0.919681
3	85	0.962	97.1	81.77	8253.5	93.4102	7225	0.925444
4	83.4	0.959	72.7	79.9806	6063.18	69.7193	6955.56	0.919681
5	82.8	0.92	69.7	76.176	5771.16	64.124	6855.84	0.8464
6	82.5	0.93	72.1	76.725	5948.25	67.053	6806.25	0.8649
7	82.2	0.97	86.2	79.734	7085.64	83.614	6756.84	0.9409
8	82.2	0.889	52.8	73.0758	4340.16	46.9392	6756.84	0.790321
9	82.2	0.946	70.8	77.7612	5819.76	66.9768	6756.84	0.894916
10	81.7	0.906	61.7	74.0202	5040.89	55.9002	6674.89	0.820836
total	834.1	9.389	753.7	783.3363	62999.17	710.4588	69597.51	8.821783

Source: realized by the author

The system of normal equations is:

$$\begin{cases} 10*a+834.1*b+9.389*c=753.7 \\ 834.1*a+69597.51*b+783.3363*c=62999.17 \\ 9.389*a+783.3363*b+8.821783*c=710.4588 \end{cases}$$

The determinants obtained using Cramer method are:

$$\Delta=\begin{vmatrix} 10 & 834.1 & 9.389 \\ 834.1 & 69597.51 & 783.3363 \\ 9.389 & 783.3363 & 8.821783 \end{vmatrix}=1.228$$

$$\Delta_a=\begin{vmatrix} 753.7 & 834.1 & 9.389 \\ 62999.17 & 69597.51 & 783.3363 \\ 710.4588 & 783.3363 & 8.821783 \end{vmatrix}=-571.025$$

$$\Delta_b=\begin{vmatrix} 10 & 753.7 & 9.389 \\ 834.1 & 62999.17 & 783.3363 \\ 9.389 & 710.4588 & 8.821783 \end{vmatrix}=2.969$$

$$\Delta_c = \begin{vmatrix} 10 & 834.1 & 753.7 \\ 834.1 & 69597.51 & 62999.17 \\ 9.389 & 783.3363 & 710.4588 \end{vmatrix} = 443.049$$

The parameters of the model are:

$$a = \frac{\Delta_a}{\Delta} = \frac{-571.025}{1.228} = -465.004$$

$$b = \frac{\Delta_b}{\Delta} = \frac{2.969}{1.228} = 2.418$$

$$c = \frac{\Delta_c}{\Delta} = \frac{443.049}{1.228} = 360.789$$

The adjustment equation of the multifactor linear model is:

$$\hat{y}_i = -465.004 + 2.418 * b + 360.789 * c$$

The following table contains processed data to calculate the correlation coefficient, to study the intensity of the correlation between the indicators.

Table no. 3 Processed data

$\hat{y}_i$	$y_i-\hat{y}_i$	$(y_i-\hat{y}_i)^2$	$y_i-\bar{y}$	$(y_i-\bar{y})^2$
85.939172	-5.63917	31.8002608	4.93	24.3049
88.215251	2.084749	4.34617839	14.93	222.9049
87.605018	9.494982	90.1546832	21.73	472.1929
82.653851	-9.95385	99.0791497	-2.67	7.1289
67.13228	2.56772	6.593186	-5.67	32.1489
70.01477	2.08523	4.34818415	-3.27	10.6929
83.72093	2.47907	6.14578806	10.83	117.2889
54.497021	-1.69702	2.87988027	-22.57	509.4049
75.061994	-4.26199	18.1645929	-4.57	20.8849
59.421434	2.278566	5.19186302	-13.67	186.8689
754.261721		268.703767		1603.821

Source: realized by the author

The correlation coefficient is

$$R = \sqrt{1 - \frac{268.703767}{1603.821}} = 0.912$$

The value of correlation coefficient indicates a strong interdependence between Sustainable Development Goals Index , Human Development Index and Competitiveness Index (CI).

5. Conclusions

Investments in education, health and environmental goals help long term human development and foster innovation, social stability and skilled labor- all critical factors for competitiveness. Competitive economies have better infrastructure, strong institutions and a capacity for innovation which help implement sustainable and inclusive development policies.

Sustainable development continues to be a challenge for long-term investments. Reshaping the international financial system is more necessary than it has ever been. Addressing today's global challenges demands access to essential public goods that go beyond the jurisdiction of individual nation-states. To progress toward sustainable development, low- and middle-income countries have to secure affordable, long-term funding mechanisms that enable large-scale investment. Achieving

these goals will require reorganization of institutional frameworks, innovative financing models and a renewed global commitment to prioritize investments in education and human capital development.

An important milestone in global economic policy is the transition from mere productivity to a holistic dimension of competitiveness. True competitiveness is determined not only by productivity, but also by quality of life (economic prosperity, happiness, social inclusion, fairness and environmental sustainability). This perspective highlights that competitiveness is a polyvalent concept within which productivity is a crucial component, but not the only determinant.

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