Yakup DURMAZ, PhD
yakup.durmaz@hku.edu.tr
Hasan Kalyoncu University, Gaziantep, Turkiye

Esra ATABAY, PhD
esra.atabay@comu.edu.tr
Çanakkale Onsekiz Mart University, Çanakkale, Turkiye

Mikail EROL, PhD
mikailerol@esenyurt.edu.tr
Istanbul Esenyurt University, İstanbul, Turkiye

İbrahim Bora ORAN, PhD
ibrahimoran@esenyurt.edu.tr
Istanbul Esenyurt University, İstanbul, Turkiye

Aybike Esra ŞAHIN, PhD (corresponding author)
aybikeesratetik@esenyurt.edu.tr
Istanbul Esenyurt University, İstanbul, Turkiye

Necessary Fiscal Measures to Increase Productivity in Developing Countries: Comparison of Turkish Automotive Sector with BRICS Countries

Abstract. *Productivity is defined as the relationship between the inputs used in the production process and the outputs generated, and it also refers to the quantity of goods or services produced per unit of input. An increase in productivity is a crucial indicator of the development level and market value of both countries and businesses. Enhancing productivity is vital for managers, as it helps to reduce costs and effectively use scarce resources, thereby contributing to the economic development of businesses and countries. This study addresses the measures needed at both macro and micro levels to enhance productivity in developing countries, specifically comparing Turkiye with the BRICS countries in the automotive sector. The identification of income as the primary driver of productivity highlights the critical role that financial performance plays in the overall productivity of the sector, guiding stakeholders to focus their efforts on improving this metric. Furthermore, according to the entropy-weighted TOPSIS method, China emerged as the most productive country, followed by India in second place and Turkiye in third. The findings provide a strategic roadmap for policymakers and business leaders in developing countries to refine their strategies to enhance productivity, thereby ensuring a competitive edge in the global market.*

Keywords: *entropy, TOPSIS, automotive sector, BRICS countries, productivity.*

JEL Classification: M, O3, O57.

DOI: 10.24818/18423264/58.4.24.18

1. Introduction

Productivity, in its most general sense, is the relationship between an output produced by a production or service system and the input used to create this output. The resources planned to be used in production or service delivery are not unlimited. The production or service process must be completed with scarce resources. Due to the increasing population, constantly evolving age, and economic factors, it has become inevitable for businesses to use their resources more carefully and carefully. The effective use of scarce resources in the production or service process expresses the concept of efficiency. Productivity shows how effectively production resources are used in a business. It is extremely important to measure the proportion of resources spent by the business in achieving its goals. Businesses aim to achieve maximum profit with minimum input, rather than making profit under all circumstances. Therefore, it is of great importance for the business to identify the factors that cause excessive resource consumption while achieving the goal and to take the necessary steps to keep them under control. Because there is a constantly changing and developing global trade. Businesses must consider their efficiency to keep up with this global trade and compete with other businesses. Keeping productivity under control or increasing productivity plays an effective role in the development of the business, the sector, and the country. Therefore, businesses must identify the problems that slow down or prevent productivity increases and seek the necessary solutions.

The current age has become a technology-oriented digital age. Between the productivity differences between developed countries and developing countries, the share of delay in creating an economic structure with opportunities provided by great knowledge and advanced technology is quite important (Gömleksiz, 2018). At the same time, productivity can be increased by ensuring balance and unity in labour-capital-social environment relations (Özçelik, 2010). It contributes to the increase in the standard of living with the effect of increased productivity of businesses. On the other hand, low productivity levels lead to high inflation, balance of payments deficits, lower levels of economic development, and increased unemployment (Özbek, 2007).

This study, which discusses productivity increase in developing countries and the comparison of the Turkish automotive sector with the automotive sector in BRICS countries, has been examined in three parts. In the first part of the study, general concepts and explanations about productivity and productivity increase, in the second part, the financial measures to be taken for productivity increase, and in the third part, analysis and findings regarding the comparison of the Turkish Automotive Sector and BRICS countries in terms of productivity are included.

2. General concepts related to productivity

The concept of efficiency appears to be an extremely general concept that concerns many branches of science. Science and technology, economy, physics,

nature, etc. It is seen that the concept of efficiency is used in many areas. The concept of efficiency is evaluated differently by operators and economists, who look at it from an economic perspective, and by engineers, who look at it from a technical perspective. Managers and economists define efficiency as the monetary relationship between inputs and outputs, while engineers define it as the modernity of the management techniques used and their ability to increase the production level by applying them (İleri, 1999). In another definition of productivity, the relationship between the results obtained and the time spent to achieve this result is explained as productivity (Prokopenko, 1998). In 1974, the Annual Programmes and Financing Branch of the Economic Planning Department of the Prime Ministry State Planning Organisation in Turkiye conducted a trial study on the concept of productivity. In this study, productivity was defined as the art of deriving goods and services from available resources. Additionally, productivity was described either as the relationship between the total output obtained in a specific period and the inputs used, or as the increase in total production resulting from a unit increase in a particular production factor.

The subject of this study is the concept of business efficiency. As Krugman (1994) states, efficiency becomes the most important issue, especially in the long run. Improving people's living standards in the country over time depends on increasing the production output per worker in the production process (Krugman, 1994). Productivity is a concept used to measure how efficiently production inputs, such as labour and capital, are used to produce a certain level of output in an economy.

Many concepts can be used instead of the concept of productivity and have truly different meanings. These concepts, which are indicators of the performance of businesses, include the concepts of efficiency and effectiveness. When looking at the difference between the concepts in question and efficiency; First of all, in terms of effectiveness, it is obvious that the relevant factors must be used effectively to ensure efficiency. In other words, both concepts cover activities aimed at aligning what is done with what needs to be done to maximize the profit or revenue obtained on a business basis and in general economic terms (Özbek, 2007). Various studies have been conducted to address and explain the confusion between the concepts of efficiency and effectiveness (Yükçü & Atağan, 2009; Cavlak, 2021; Altıntaş, 2020). The common point obtained from the studies is that effectiveness is the achievement of plans, efficiency is the production of outputs at the least cost, and efficiency is the combination of effective and effective activities.

2.1 Increased efficiency

Productivity increase is important for national economies as well as for businesses. Increasing efficiency in businesses results in production at the lowest cost, and businesses can reduce the prices of products by increasing the profit margin. In addition, increasing the profitability of the business in the long term

increases its competitiveness. In public companies, the income of business partners and shareholders increases due to the increase in market value (Bao & Bag, 2006).

In terms of country economies, the increase in productivity contributes both to increasing the national income per capita and to reducing the increase in prices, as an indicator of economic growth and development. At the same time, the trade deficit increases the competitiveness of foreign enterprises, which tends to decrease and determines the competitiveness of the country's goods in international markets. When countries that are not at the same productivity level as their competitors try to solve the problem by devaluing their markets, it is seen that real income decreases in these countries when inflation increases as a result of the increase in the prices of imported goods. Therefore, low productivity leads to high inflation, a deficit in the balance of payments, a decline in development, and an increase in unemployment (Prokopenko, 1998).

Labour productivity is an important development that shows the improvement in the production performance of enterprises and the increase in the competitiveness of sectors. It is an important indicator used as output when calculating labour productivity. However, there is no definitive opinion on whether gross or net value should be used in value-added analysis, and it is being debated. Net added value is obtained by subtracting depreciation from gross added value. Depreciation items can be viewed as undistributed reserves in the business and belong to the partners or shareholders. Therefore, it is argued that the gross value added should be used (Bao & Bag, 2006).

Many factors will affect the level of productivity in businesses. For example, the size of the financial performance level of the enterprise, debt structure, ownership, and foreign capital ratio, level of institutionalisation, export and innovation activities are considered factors affecting the efficiency of a business. In addition to these factors, the capacity utilisation rate also has an important role. Economists define productivity as the measurable ratio between production and production factors. Businesses, on the other hand, approach productivity in terms of effect and result and take into account production inputs instead of production factors. Thus, efficiency is defined as the ratio of physical outputs to physical inputs (İslamoğlu, 1991).

In terms of the concept of ergonomics, efficiency means ensuring production at the highest level by providing continuous inputs without leaving any gaps in the production process. For engineers, efficiency is the ratio of the achieved output to the desired output. (Alpugan, 1991). It is the ratio of the physical amount of output obtained from production activities to the physical amount of production of inputs subject to these production activities. Increasing productivity means producing more from production factors such as labour, capital, and land than before. Today, the concept of productivity is an essential indicator for evaluating the development activities of countries. It is generally accepted that productivity plays a very important role in increasing national welfare. Efficiency has become the most important development for countries where it is predicted that the goal of societies that want to increase the level of economic development will be to maximise

production by using existing resources in the most beneficial way (Aydın, 1992). Productivity growth shows the real increase in added value produced to a certain extent over time. Productivity increase is examined in three separate groups: efficiency (micro efficiency), technology (macro efficiency), and horizontal productivity increase (Toffler, 1992). Productivity growth is the main determinant of a country's future living standards (Drucker, 1981).

As a result, productivity plays an important role as a tool toward the aim to be achieved in the country's economies and is also defined as the power of production. Productivity also shows the relationship between output and the tools used to produce this output, and it is the real increase in value added (Sumanth, 1984). It is explained as an important function and result of management effectiveness. It is a system approach that takes into account the system elements and their relationships with their environment to increase efficiency, and this approach both explains the performance of the system and maintains balance while considering the necessary change (Drucker, 1981).

2.2 Financial measures to be taken

The main measures that can be taken at macro and micro levels against economic crises can be explained as follows (Şen & Aktan, 2001).

2.2.1 Macro measures

Gross National Product, Net National Welfare, Value Added, etc. These factors are the macro level outputs of productivity (Bayraç, 1997). One of the main reasons for the decline in these outputs is economic crises. Economic crises generally occur as a result of macroeconomic instability, and therefore macroeconomic stability is important. One of the most important conditions for ensuring macroeconomic stability is ensuring political stability. At the same time, it is deemed useful to make institutional arrangements that will establish and maintain monetary and fiscal discipline. The necessary discipline in public debts must be ensured, and provisions similar to the "ratio of public debts to GDP should not exceed 60%", which is implemented according to the Maastricht Treaty in European Union member countries, must be guaranteed by the constitution.

It is deemed necessary to organise the tax system within the framework of the principles of impartiality, simplicity, justice, generality, and efficiency. It is envisaged to avoid heavy tax burdens and to alleviate the tax burden on the workforce. The flexible exchange rate system acts as a buffer against speculation attacks that may occur in the foreign exchange market. For the flexible exchange rate system to continue its function, interest and exchange rate changes must be created most healthily in the long term.

When it comes to productivity increase at the macro level, total factor productivity is the first concept that comes to mind. The main determinants of this concept are education, research and development expenditures, foreign direct capital

investments, openness, institutional structure, and infrastructure investments (Suiçmez, 2008; Yiğiteli & Öztürk, 2022). In this sense, beyond the effective use of existing resources, it is also necessary to keep up with technological developments, increase the quantity and quality of resource stocks, and thus ensure social welfare. Considering that the available resources are scarce, it is necessary to ensure that these scarce resources are used in sectors appropriate to the requirements of the changing and developing age, to accelerate capital accumulation, to address the important economic, social, and institutional elements as a whole in the growth process, and to create a dynamic growth environment in all sectors (Suiçmez, 2008).

As the gross national product increases and the unemployment rate decreases; Reducing the unemployment rate can be possible by increasing the level of quality education and ensuring industrialisation. In this regard, it is necessary to make improvements in the education system, to reinclude vocational education institutions that will train vocational and technical personnel in the education system, and to train human resources interested in research. For this purpose, increasing practical training, intertwining education-industry cooperation, eliminating unnecessary and process-prolonging procedures of the state, ensuring the effective establishment of companies, increasing state incentives in all matters that will increase the country's productivity, encouraging and supporting investments in areas with high added value, encouraging individuals to It is necessary to provide government support and organise the necessary free training to raise the necessary awareness to keep up with the changing age. By ensuring improvement in education, a direct increase in productivity is achieved. The primary step in increasing productivity at the macro level should undoubtedly be to consider the education system as a whole and to train a workforce that is a researcher, analytical, creative, critical, has strong communication skills, is digitally literate, innovative, and qualified.

Another macro factor that is effective in increasing productivity is the level of openness. More open economies are aware of the technological innovations produced by developed countries and may be more advantageous for access (Tauqir & Bhatti, 2020). Therefore, in order to increase productivity, it is necessary for a country to engage in commercial activities in foreign markets.

2.2.2 Micro measures

In addition to the macro measures taken against possible exchange rates, there are micro measures that are deemed necessary to be taken on a company basis. It is envisaged that it would be beneficial for companies to take some precautions in order to be least affected by possible negative consequences.

Businesses can use various techniques to increase their efficiency (Özbek, 2007);

- Engineering techniques and analyses (work-study analysis, process management, job simplification, reengineering, just-in-time production management) in increasing efficiency at the business level,

- Techniques to increase productivity through quality (continuous improvement philosophy, total quality management, and quality circles)
- It can benefit from techniques such as behavioural techniques (creating a culture of productivity, ensuring motivation and participation, productivity training, work organisation, and performance management).
- It is deemed necessary to ensure that total quality management, one of the modern management approaches, is implemented in businesses. The need for effective leadership comes to the fore in this regard, and senior management has a responsibility in this regard.
- Contemporary costing techniques should be used in costing systems.
- New management techniques (such as Strategic Management or Human Resources Management) should be implemented.
- By using the re-engineering technique, changes and restructuring should be implemented in the business for low-cost and high-quality service purposes.
- Work study analyses should be made and reports should be prepared regarding the work done by each unit.
- It is necessary to eliminate unnecessary procedures and save time and processes.
- The demand to increase efficiency should not belong only to the top management of the business.

Personnel at all levels must have a sense of belonging to the business to increase the efficiency of the business. In this context, it is inevitable for each department within the business to set goals within themselves to increase their motivation and contribute positively to the efficiency of the business. The degree of achievement of the determined targets, investigation of the reasons if they are not achieved, weekly, monthly, quarterly, etc. It is necessary to prepare unit reports, to redetermine the next target at an achievable level if the determined target is achieved, and thus, each department should have a target cycle. Repeating internal motivation-enhancing activities at regular intervals, keeping employee satisfaction strong, and giving importance to in-service training are also important elements in increasing productivity.

Productivity is a measurement obtained by dividing the total output amount by the total input. The formula for this is shown below:

Efficiency = Output/Input

To increase productivity, in the most general sense, to reach the maximum output amount to provide more output with the same amount of input; To provide the same output with less input, it is necessary to reduce the amount of input to a minimum level, and to provide more output with less input, it is necessary to reach the minimum loss level (Onaylıgil, 2015).

Input →System →Output

Loss → Waste

Creating an increase in output with the same amount of input may require additional costs. Switching to technology-based production techniques may require

new investments, such as the purchase of new and faster production machines. In addition, when new investments cannot be made, businesses begin to look for other ways to increase efficiency. The amount of output can be increased by increasing the labour utilisation rate, improving production planning and control functions, and researching new methods and techniques for faster work. In cases where the amount of output cannot be increased, the amount of input must be reduced in order to increase productivity. In this regard, it is necessary to make improvements in the amount of raw materials used in production, to prefer less costly raw materials, or to switch to alternative production methods that will enable the same result to be achieved with less raw materials. In the cases where a change in the amount of input and output cannot be achieved, methods and techniques should be developed to reduce wastage and losses in the process as much as possible. For example, reducing the time between successive products on the production line or, in cases where it cannot be reduced, extending the start time of the process in the next production stage, can minimise the loss of raw materials that may occur.

3. Methodology

In this study, 5 criteria were selected to evaluate the automotive sector of Turkiye and BRICS countries in terms of efficiency using entropy weighted TOPSIS method based on the data from 2011 to 2020.
The study aims to compare and rank efficient decision-making units based on the results of efficiency measurement. In the study, the weights of the criteria expected to measure the efficiency of the countries were determined using the entropy method and then ranked using the TOPSIS method. The entropy method, TOPSIS method, data, and variables used in the study are explained below.

3.1 Data Collection

The 5 criteria selected to evaluate the automotive sector of Turkiye and BRICS countries in terms of efficiency are 'Production Amount', 'Export', 'Employment', 'Market Share', and 'Income'. The years 2011-2020 were taken as the basis, and the data was tabulated and presented in this section.
Production data of the automotive sector of 5 countries (BRICS Countries and Turkiye) for the years 2011-2020 have been accessed and shown in Table 1. These data will be analysed later for comparison.

Table 1. Production Data from BRICS Countries and Turkiye's Automotive Sector 2011-2020 (in Millions)

Country/ Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brazil	3.408	3.403	3.712	3.146	2.429	2.156	2.700	3.408	3.403	3.712
Chinese	18.419	19.272	22.117	23.73	24.50	28.119	29.015	27.809	25.721	25.225
India	3.927	4.175	3.898	3.845	4.126	4.489	4.783	5.175	4.516	3.394

Country/ Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Russia	1.990	2.233	2.192	1.887	1.384	1.304	1.551	1.768	1.720	1.435
Turkiye	1.189	1.073	1.126	1.170	1.359	1.486	1.696	1.550	1.461	1.297

Source: https://www.oica.net/production-statistics/.

Definition: Passenger cars included in the table are motor vehicles with at least four wheels, used to transport passengers, with a maximum of eight seats other than the driver's seat. Light commercial vehicles are motor vehicles with at least four wheels that are used to transport goods. They are minibuses derived from light commercial vehicles, used for passenger transportation, with more than eight seats in addition to the driver's seat, and a maximum weight between 3.5 and 7 tons. Commercial vehicles include light commercial vehicles, heavy trucks and buses.

Automotive Sector 2011-2020 export data was accessed via trademap.org and presented as in Table 3. To represent the automotive industry, 5 product groups have been selected, and their HS codes and definitions are given in Table 2:

Table 2. Product groups and HS Codes

HS CODE	DEFINITION
8702	Motor vehicles for the transport of >= 10 persons, incl. driver
8703	Motor cars and other motor vehicles principally designed for the transport of <10 persons
8704	Motor vehicles for the transport of goods, incl. chassis with engine and cab
8708	Parts and accessories for tractors, motor vehicles for the transport of ten or more persons, motor cars and other motor vehicles principally designed for the transport of persons, motor vehicles for the transport of goods and special purpose motor vehicles of heading 8701 to 8705
8709	Works trucks, self-propelled, not fitted with lifting or handling equipment, of the type used in factories, warehouses, dock areas or airports for short distance transport of goods; tractors of the type used on railway station platforms; parts of the foregoing vehicles

Source: www.trademap.org.

Table 3. Automotive Sector Export Data Between 2011-2020 (In Million Dollar Basis)

Country/ Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brazil	10.771	9.881	11.297	7.491	7.520	8.840	11.934	9.959	7.325	5.260
Chinese	29.546	34.094	36.357	40.022	38.467	38.385	43.805	49.120	48.343	47.896
India	7.499	9.327	10.379	10.731	10.322	11.372	12.239	13.850	13.224	9.453
Russia	1.132	2.125	2.758	2.581	1.907	1.851	2.310	2.327	2.700	1.896
Turkiye	14.864	13.883	16.299	17.336	16.152	18.308	22.369	24.082	23.941	19.781

Source: https://www.trademap.org.

World automotive market data by country was collected as shown in Table 4 in order to be included in the analysis:

Table 4. World Automotive Market by Country in Millions (Car + Commercial Vehicle)

Country/ Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brazil	3.648	3.645	3.756	3.422	2.569	2.050	2.239	2.566	2.788	2.058
Chinese	19.436	20.757	23.111	24.485	24.598	28.028	29.123	28.081	25.769	25.311
India	3.303	3.703	3.202	3.217	3.425	3.669	4.018	4.400	3.817	2.939
Russia	2.748	3.049	2.883	2.534	1.437	1.404	1.602	1.821	1.778	1.631
Turkiye	0.911	0.818	0.893	0.807	1.011	1.008	0.980	0.642	0.492	0.796

Source: Automotive Industry Association, OSD Publications: https://www.osd.org.tr/osd-yayinlari/istatistikler.

Employment data of the automotive sector of the countries, which is another criterion, is shown in table 5:

Table 5. World Number of Employment in Motor Vehicles, Trailers, Semi-Trailers Sector by Country (in millions)

Country/ Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brazil	0.540	0.539	0.541	0.499	0.440	0.412	0.424	0.439	0.435	0.424
Chinese	3.651	4.319	4.323	4.580	4.656	4.834	4.878	4.588	4.849	4.914
India	0.791	0.764	0.792	0.892	0.932	0.986	1.017	1.094	1.081	0.944
Russia	0.365	0.368	0.357	0.337	0.302	0.279	0.282	0.290	0.290	0.280
Turkiye	0.133	0.140	0.147	0.155	0.166	0.174	0.182	0.188	0.184	0.190

Source: United Nations, Industrial Development Organization: https://stat.unido.org/database/INDSTAT%202%202023,%20ISIC%20Revision%203;jsessionid=642EFE28344BF30D6564C3E99FCF91B1.

The last criterion, income data from product sales and provision of labor services, is shown in table 6:

Table 6. World-by Country Income obtained from product sales and provision of labor services, which are the main business in the motor vehicles, trailers, and semi-trailers sector (Million Dollar Basis)

Country/Year	Brazil	Chinese	India	Russia	Turkiye
2011	151.040	739.845	81.666	48.322	32.558
2012	126.741	822.535	74.497	54.779	30.081
2013	131.237	974.080	67.639	54.983	32.471
2014	108.027	1.115.548	76.573	46.279	33.631
2015	66.598	1.151.611	81.270	24.858	33.855
2016	60.468	1.224.282	83.720	26.544	34.515
2017	78.705	1.252.259	95.590	38.341	39.211

Country/Year	Brazil	Chinese	India	Russia	Turkiye
2018	79.701	1.260.174	104.261	43.047	40.467
2019	79.052	1.312.588	89.239	45.361	38.698
2020	51.233	1.363.871	78.968	38.068	36.753

Source: United Nations, Industrial Development Organization: https://stat.unido.org/database/INDSTAT%202%202023,%20ISIC%20Revision%203;jsessionid=642EFE28344BF30D6564C3E99FCF91B1.

3.2 Entropy Method

The entropy method calculates weights based on the information entropy of attributes (Shannon, 1948).

In this section, the steps of the entropy method, which is the method chosen to weight the criteria, are explained:

Step 1: Creating the Decision Matrix (D): The mxn dimensional decision matrix to be created for a decision-making problem is created as in Equation (1) to show the m alternatives and n criteria:

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{in} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Step 2: Normalizing the Decision Matrix: The normalized value of each element of the decision matrix expressed in Equation 1 in Step 1 is determined using equation 2. The normalized decision matrix consisting of normalized values is obtained as $R = [r_{ij}]_{mxn}$

$$r_{ij} = \frac{x_{ij}}{\sum_{p=1}^{m} x_{pj}}, (i = 1,2,3, \dots, m \; and \; j = 1,2,3, \dots, n) \quad (2)$$

Step 3: Calculation of Entropy Values: In this step, the Entropy value for each criterion is calculated and the general form of the equation used is given in Equation 3.

$$e_j = -k \sum_{i=1}^{m} r_{ij} \ln r_{ij}, j = 1,2, \dots, n. \quad (3)$$

k: Entropy coefficient r_{ij}:Normalized value e_j: Entropy value

The value k in the formula is a constant coefficient defined by $k = \frac{1}{\ln m}$ and $0 \leq e_j \leq 1$ is guaranteed.

Step 4: Calculation of Weight Values: Depending on the e_j value calculated with the help of the formula specified in Step 3, the uncertainty d_j is calculated as d_j = 1 - e_j and the weight values for each criterion are calculated with the formula in Equation 5.

$$d_j = 1 - e_j \quad (4)$$

$$W_j = \frac{d_j}{\sum_{p=1}^{n} d_j},\ j = 1,2,\dots,n. \tag{5}$$

The value of w_j found in Equality 4 represents the weight of criterion j, where the sum of weight values equals 1.
The importance level of the criterion with the highest weight is determined to be the highest according to the magnitude of entropy weight values.

3.3 TOPSIS (Technique for Order Preference by Similarity to the Ideal Solution)

Step 1: A decision or evaluation D matrix is created. The matrix consists of m alternatives $(A_1, \dots, A_{m)}$ and n criteria $(X_1, \dots, X_n)$ and its element is x_{ij};where $i = 1, \dots, m$ and $j = 1, \dots, n$.

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccccc} X_1 & X_2 & \cdots & X_3 & \cdots & X_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1j} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2j} & \cdots & x_{2n} \\ \vdots & \vdots & \cdots & \vdots & \cdots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \vdots & \cdots & \vdots & \cdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix}_{m\,x\,n} \end{array} \tag{6}$$

Step 2: The normalized decision matrix R is created.
Matrix D is normalized to matrix R with m alternatives and n criteria and where $i = 1, \dots, m$ and $j = 1, \dots, n$ its element is r_{ij}, $r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$ happens.

$$R = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccccc} X_1 & X_2 & \cdots & X_3 & \cdots & X_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1j} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2j} & \cdots & x_{2n} \\ \vdots & \vdots & \cdots & \vdots & \cdots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \vdots & \cdots & \vdots & \cdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix}_{m\,x\,n} \end{array} \tag{7}$$

Step 3: The weighted normalized decision matrix V is created.
$w = (w_1, \dots, w_n)$ and $\sum_{j=1}^{n} w_j = 1$ set of weights; where $w_j > 0$, j=1,…, n is given to the corresponding criterion X_j, where $j = 1, \dots, n$. The matrix $V = [w_j r_{ij}]$ is calculated by multiplying the elements in each column of the matrix R by their respective weights $w_j, j = 1, \dots, n$.

$$\begin{array}{cccccc} X_1 & X_2 & \cdots & X_3 & \cdots & X_n \end{array}$$

$$V = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1j} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2j} & \cdots & x_{2n} \\ \vdots & \vdots & \cdots & \vdots & \cdots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \vdots & \cdots & \vdots & \cdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix}_{m\,x\,n} \quad (8)$$

Step 4: The positive ideal and negative-ideal solutions V^+ (PIS) and V^- (NIS) are determined, respectively.
PIS and NIS respectively:
$V^+ = \{v_1^+, \dots, v_n^+\} = \left\{\left(\max_i v_{ij} \middle| j \in J\right), \left(\min_i v_{ij} \middle| j \in J'\right)\right\}$ and
$V^- = \{v_1^-, \dots, r_n^-\} = \left\{\left(\min_i v_{ij} \middle| j \in J\right), \left(\max_i v_{ij} \middle| j \in J'\right)\right\}$ It is defined; where J is related to the benefit criteria and J' is related to the cost criteria according to criterion X_j, where $j = 1, \dots, n$ for all alternatives $A_i, i = 1, \dots, m.$ (9), (10)

Step 5: The separation measure between ideal and negative-ideal solutions is calculated with alternative A_i, S_i^+ and S_i^- respectively.
The measure of separation or distance between alternative A_i and PIS can be measured by the $n-$dimensional Euclidean distance as follows:

$$S_i^+ = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^+)^2} \quad for\ alternative\ A_i\ , i = 1, \dots, m. \quad (11)$$

Likewise, the separation measure or distance between alternative i and NIS can be represented as follows:

$$S_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2} \quad for\ alternative\ A_i\ , i = 1, \dots, m. \quad (12)$$

Step 6: The relative closeness C_i^* of the alternative $A_i, i = 1, \dots, m$ is calculated. The relative closeness or ranking index of alternatives $A_i, i = 1, \dots, m$ is defined as:

$$C_i^* = \frac{S_i^-}{S_i^+ + S_i^-} \quad (13)$$

where $0 \leq C_i^* \leq 1$. The larger the index value, the better the performance of the alternative. In TOPSIS, the judging rule for the decision is relative closeness. We observe that $C_i^* = 0$ is the alternative ideal solution and $C_i^* = 1$ is the alternative non-ideal solution. In the real world, both are imaginary alternatives.
Step 7: The order of preference of all alternatives is listed.
The set of alternatives $A_i, i = 1, \dots, m$ can now be preference-ordered in decreasing order of C_i^* value. In general, the choice should be the alternative with the highest value of relative closeness.

4. Comparison of Turkiye and BRICS Countries in Terms of Productivity

The Entropy weighting and TOPSIS ranking method of 5 countries was applied to 5 criteria and new rankings of the countries were obtained. Criteria used in the study; They are listed as "Production Amount", "Export", "Employment", "Market Share" and "Income". These data used cover the period between 2011 and 2020. For this reason, the main decision matrix was obtained by taking the geometric mean of each year. Data on the 5 indicators by which the productivity of countries are evaluated are shown in Table 7 in the main decision matrix.

Table 7. Decision Matrix showing the values of countries according to 5 indicators in the automotive sector (in millions)

Country/ Criteria	Production Amount	Export	Employment	Market Share	Income
Brazil	3.102	8.786	2.801	0.466	87.974
Chinese	24.140	40.112	24.683	4.543	1.101.689
India	4.205	10.684	3.546	0.922	82.751
Russia	1.719	2.099	2.004	0.313	40.763
Turkiye	1.327	18.380	0.818	0.165	35.078

Source: Authors.

First, the normalization process of the decision matrix was done with the help of equation 2 (Table 8).

Table 8. Normalized Decision Matrix

Country/ Criteria	Production Amount	Export	Employment	Market Share	Income
Brazil	0.090	0.110	0.083	0.073	0.065
Chinese	0.700	0.501	0.729	0.709	0.817
India	0.122	0.133	0.105	0.144	0.061
Russia	0.050	0.026	0.059	0.049	0.030
Turkiye	0.038	0.230	0.024	0.026	0.026

Source: Authors.

Entropy values were obtained from the indicator scores as in the 2nd step of the Entropy method from the normalized decision matrix and are shown in Table 9.

Table 9. Entropy values according to 5 indicators in the automotive sector of the countries

Country/ Criteria	Production Amount	Export	Employment	Market Share	Income
Brazil	-0.217	-0.242	-0.206	-0.191	-0.178
Chinese	-0.250	-0.346	-0.230	-0.244	-0.165
India	-0.257	-0.269	-0.236	-0.279	-0.171
Russia	-0.149	-0.095	-0.167	-0.147	-0.106
Turkiye	-0.125	-0.338	-0.090	-0.094	-0.095

Source: Authors.

In the next stage, the Ej value was calculated with the help of equation 3 by taking the sum of the values in Table 10.

K=1/ln.n ensures that $0 \leq ej \leq 1$, being a constant number. In this study, since n = 5; It was calculated as k=1/ln(m) = 0.621.

Table 10. Calculation of Entropy Values (e_j)

e_j	**0,620**	**0,802**	**0,578**	**0,593**	**0,444**

Source: Authors.

By subtracting each calculated Ej value from 1, the Dj value is obtained with the help of equation 4 and shown in the table 11.

Table 11. Calculation of d_j Value

d_j	0.380	0.198	0.422	0.407	0.556

Source: Authors.

In the last step, each dj value is divided by the total dj value and the criterion weights are calculated with the help of equation 5 and presented below (Table 12).

Table 12. Entropy Criterion Weight Values (w_j)

w_j	0.194	0.101	0.215	0.207	0.283

Source: Authors.

Using the weights obtained by the entropy method, the TOPSIS method was applied to reach the optimum solution from the decision matrix and to determine the rankings of the countries. The TOPSIS method also uses the decision matrix containing variable values such as Entropy. The normalized decision matrix was obtained by normalizing the indicator scores as in the 2nd step of the TOPSIS method. The normalized decision matrix is shown in Table 13.

Table 13. Normalized decision matrix obtained from countries' indicator scores

Country/ Criteria	Production Amount	Export	Employment	Market Share	Income
Brazil	0.125	0.190	0.111	0.100	0.079
Chinese	0.973	0.866	0.980	0.972	0.992
India	0.169	0.230	0.140	0.197	0.074
Russia	0.069	0.045	0.079	0.066	0.036
Turkiye	0.053	0.397	0.032	0.035	0.031

Source: Authors.

The weighted decision matrix was obtained by multiplying the normalized values of the indicators in the data with the weights obtained by Entropy as in the 3rd step of the TOPSIS method. The weighted decision matrix is shown in Table 14.

Table 14. Weighted decision matrix obtained with entropy weights

Country/ Criteria	Production Amount	Export	Employment	Market Share	Income
Brazil	0.024	0.019	0.023	0.020	0.022
Chinese	0.188	0.087	0.210	0.201	0.281
India	0.032	0.023	0.030	0.040	0.021
Russia	0.013	0.004	0.017	0.013	0.010
Turkiye	0.010	0.040	0.006	0.007	0.008

Source: Authors.

Ideal and negative ideal values were determined with the values in the columns of the weighted decision matrix. These values are optimization values for the criteria and alternatives of the decision matrix. The ideal and negative values of the countries' indicators are shown in Table 15.

Table 15. Ideal and negative ideal solution scores of countries' indicators

V+	0.188	0.087	0.210	0.201	0.281
V-	0.010	0.004	0.006	0.007	0.008

Source: Authors.

The criteria in the decision matrix, that is, the 5 indicators that determine the efficiency of the countries' automotive sectors, are reflected in the ranking as positive ideal, that is, benefit criteria. The closeness values of the country indicators to the ideal solution from the ideal and negative ideal scores were calculated as in the 5th step of the TOPSIS method, and the distances calculated according to these Euclidean distances and their relative closeness to the ideal solution are shown in Table 16.

Table 16. Relative closeness scores of countries to the ideal solution and their new rankings

Country/ Criteria	S+	S-	Pi	Rank
Brazil	0.407	0.032	0.073	4
Chinese	**0**	**0.438**	**1**	**1**
India	0.392	0.051	0.116	2
Russia	0.428	0.012	0.028	5
Turkiye	0.432	0.035	0,075	3

Source: Authors.

In this study; 5 (BRICS and Turkiye) 2011-2020 Production Amount, Export, Employment, Market Share, and Income data were used to measure productivity. The importance of the criteria affecting the productivity of the countries was determined by the Entropy method and their rankings were obtained again according to the TOPSIS method. For countries to increase their productivity, they need to be able to determine where they are in which indicator and to improve their rankings.

5. Conclusions

When the productivity of five countries was evaluated based on indicators such as Production Amount, Export, Employment, Market Share, and Income, variable selection was conducted using the Entropy method, and "income" was determined as the most effective variable. Based on this finding, it has been revealed that the income generated by countries in the automotive sector plays a key role in their productivity. According to the entropy weighting results, the other significant indicators, in order, are employment, market share, production amount, and exports.

Upon re-evaluating the ranking of five countries with Entropy-weighted TOPSIS, it was determined that China is ranked first in productivity according to these criteria, followed by India in second place and Turkiye in third. Brazil and Russia follow Turkiye, respectively.

Productivity, in general terms, involves establishing proportional relationships between the amount of production and the factors used to achieve this production. In this study, correct proportional relationships among productivity rates were found, but productivity factors vary across sectors. Here, the most critical productivity factor was identified as income.

It should not be forgotten that, in addition to market and financial strategies, capital structures, and management and production configurations implemented to achieve financial success in the automotive industry, some macro factors also play a role. Determining the degree of impact of each indicator or a combination of several indicators among those that affect the financial success of companies in the automotive sector is of great importance both for the national economy and for businesses and the investments that will provide them with resources. Furthermore,

the results of this study provide countries and companies the ability to benchmark their own performance and determine areas in need of improvement, offering a critical guide. This study's findings are of strategic importance for decision-makers and policy-makers in the automotive sector. Understanding productivity ratios and the factors affecting them is fundamental to developing sustainable growth strategies and enhancing international competitiveness. In addition, the study contributes methodologically to the academic literature by proposing a framework for similar sectoral analyses. This framework can be adapted for productivity analyses in different sectors, thus laying the groundwork for productivity measurement and improvement efforts across various industries.

References

[1] Alpugan, O. (1991), *Hastanelerde verimlilik sorunu*. 1. verimlilik kongresi, Ankara, Turkiye.

[2] Aydın, A. (1992). *İmalat sanayii ve alt kollarında verimlilik, üretim, istihdam göstergeleri.* Milli Prodiktivite Merkezi, Ankara, Turkiye

[3] Bao, B.-H., Bag, D. (2006), *An Empirical Investigation of the Association Between Productivity and Firm Value. Journal of Business Finance & Accounting*, 16, 699-717, https://doi.org/10.1111/j.1468-5957.1989.tb00048.x.

[4] Bayraç, H. (1997). *İşletmelerde İşgücü Verimliliğini Etkileyen Faktörlerin Analizi ve Bir Uygulama. Anadolu Üniversitesi Sosyal Bilimler Enstitüsü Yüksek Lisans Tezi*. Eskişehir, Turkey.

[5] Cavlak, H. (2021), *Etkinlik, Etkililik, Verimlilik, Karlılık, Performans: Kavramsal Bir Çerçeve ve Karşılaştırma. Journal of Research in Business*, 6(1), 99-126.

[6] Drucker, P.F. (1981), *Toward the Next Economics, and Other Essays*. Harper & Row Publishers, New York, USA.

[7] Gömleksiz, M. (2018), Doktora Tezi. *Uluslararası Bilgi Taşmaları, Verimlilik Ve Ekonomik Büyüme İlişkisi: Gelişmekte Olan Ülkeler Üzerine Ekonometrik Bir İnceleme.* Konya, Turkey.

[8] Hwang C.L., Yoon K. (1981), *Multiple Attribute Decision Making: Methods and Applications.* Springer-Verlag, Berlin, Germany.

[9] Hung C.C., Chen L.H. (2009), *A Fuzzy TOPSIS Decision Making Model with Entropy Weight under Intuitionistic Fuzzy Environment. Proceedings of the International Multi-Conference of Engineers and Computer Scientists IMECS, Hong Kong.*

[10] İleri, H. (1999), *Verimlilik, Verimlilik İle İlgili Kavramlar ve İşletmeler Açısından Verimliliğin Önemi. Selçuk Üniversitesi Meslek Yüksekokulu Journal,* 1(2).

[11] İslamoğlu, H. (1991), *I. Verimlilik Kongresi—Bildiriler, Ankara, Turkey.*

[12] Jahanshahloo G.R., Lofti F.H., Izadikhah M. (2006), *An Algorithmic Method to Extend TOPSIS for Decision Making Problems with Interval Data. Applied Mathematics and Computation,* 175, 1375-1384.

[13] Krugman, P. (1994), *The Age of Diminishing Expectations*. Cambridge, MA: MIT Press, USA.

[14] Onaylıgil, S. (2015). *Enerjide verimlilik enerji yönetimi ve tasarrufu. Ulusal verimlilik kongresi,* Ankara, Turkiye. 6th- 7th of October, 2015.

[15] Özçelik, S. (2010), *Yüksek Lisans Tezi. Küçük ve Orta Büyüklükteki İşletmelerde Verimliliği Etkileyen Faktörlerin İncelenmesi - Erzincan İlinde Bir Uygulama -. Erzurum, Turkiye.*

[16] Özbek, Ç. (2007), *Verimlilik Arttırma Teknikleri. Yıldız Teknik Üniversitesi Sosyal Bilimler Enstitüsü Yüksek Lisans Tezi,* İstanbul, Turkiye.

[17] Prokopenko*, J.* (2001), *Verimlilik yönetimi: Uygulamalı el kitabı. Milli Prodüktivite Merkezi, Ankara, Turkiye.*

[18] Roszkowska, *E.* (2011), *Multi-Criteria Decision Making Models by Applying the TOPSIS Method to CRISP and Interval Data. Multiple Criteria Decision Making,* (6), 200-230.

[19] Shannon, C.E. (1948), *A Mathematical Theory of Communication. Bell System Technical Journal,* 27(3), 379–423, DOI:10.1002/j.1538-7305.1948.tb01338.x.

[20] Suiçmez*, H.* (2008), *Ekonomik Büyümede Toplam Faktör Verimliliğinin Rolü (Verimlilik Odaklı Büyüme). Ankara: Yenigün Matbaacılık, Turkiye.*

[21] Sumanth, D.J. (1984), *Productivity Engineering and Management: Productivity Measurement, Evaluation, Planning, and Improvement in Manufacturing and Service Organizations. McGraw-Hill, New York, USA.*

[22] Şen, H., Aktan, C.C. (2001), *Ekonomik Kriz: Nedenler ve Çözüm Önerileri. Yeni Türkiye Journal, Ekonomik Kriz Özel Sayısı:* 42/2*,* 1225-1230.

[23] Tauqir, A., Bhatti, A.A. (2020), *Measurement and Determinants of Multi-Factor Productivity: A Survey of Literature. Journal of Economic Surveys,* 34(2), 293-31

[24] Toffler, A. (1992), *Yeni güçler yeni şoklar. Altın Kitaplar: İstanbul, Turkiye.*

[25] International Trade Centre, Trade Map. Retrieved on August 13, 2024, https://www.trademap.org/.

[26] Organisation Internationale des Constructeurs d'Automobiles. Production statistics. *Retrieved from: https://www.oica.net/production-statistics/ https://www.oica.net/ production-statistics/Retrieved on* August 13, 2024.