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Performance Management Assessment Model for Sustainable Development

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Abstract: Achieving performance is the premise of an organization's existence on the market. Performance may be achieved by optimal administration of resources, in order to ensure not only short-term but also long-term efficacy. In this sense, performance and sustainability have common support. A sustainable enterprise is, implicitly, a performing enterprise. To be performing or to be able to support sustainable development implies the concern for simultaneous achievement of three categories of objectives: Economic-financial, social and environmental. Therefore, performance measurement requires a global vision of what the entity's performance means. Thus, the present paper has the major objective of determining the global performance within industrial systems, by indicators that are mainly used to assess the sustainability aspects of the manufacturing systems. Indicators, such as manufacturing costs, quality of manufacturing, energy consumption, personal motivation, and safety, were correlated by an advanced multicriterial analysis. The created model presents the novelty that it provides a total score for performance, allowing to highlight risk areas and to set up improvement measures. The model is an important tool for optimizing the planning processes in order to reduce the consumption of energy, materials or water.

Keywords: performance management; global performance; sustainable development; organizational performance; key performance indicators

1. Introduction

Economic development in the last century has led to increased pollution and consumption of natural resources. At the same time, as a result of the industrialization and increase in the production of goods, the materials that affect the environment have increased. Thus, the major concern of organizations is to minimize the negative environmental impact of their activity, while at the same time, achieving sustainable performance. Therefore, performance and sustainability are two concepts of major interest and echo for all socio-economic entities. The connection between sustainability and performance is an indestructible one, respectively a sine-qua-non condition to approach the concept of sustainability in an overall.

To be performing or to be able to support sustainable development implies the concern for simultaneous achievement of three categories of objectives: Economic-financial, social and environmental aspects. In other words, an enterprise with financial performance is not compulsory sustainable, meaning that the financial performance does not guarantee or not prove clear indications on the achievement of social or environmental objectives, in case they have been taken into account [1].

To be sustainable, an enterprise must manage its resources to have good results not only in the short term, during a financial year, but especially in the long term. Moreover, the performance of an enterprise does not indicate only the maximizing of results, but the contribution to the improvement of the couple's cost-value [2].

The profile literature and practical observations suggests that the performance is assessed only in terms of economic-financial indicators, and an enterprise is better rated for higher values of these indicators, without taking into account the impact on the natural and social environment or the enterprise attitude towards these issues [3].

In this sense, common support of performance and sustainability concepts can be identified, and resources and their optimal administration can be developed, in order to ensure not only short-term but also long-term efficacy. A sustainable enterprise is, implicitly, a performing enterprise. Sustainable development was defined nearly 30 years ago as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [4].

The sustainable development of an economy is a goal that brings performance and progress, is noticed by assessment methods, with new economic indicators, new reports and new audit procedures [5]. Studies show that organizations that pursue more environmentally friendly products and operations will recover costs quickly and contribute to competitive advantage rather than suffering a burden [6].

To achieve a sustainable manufacturing system, defining and implementing some practical aspects through the product, process, and system levels are required, such as [7]:

- Developing and planning of production processes to reduce the consumption of energy, materials, and water;
- Expanding the design concepts of using fewer resources and applying easy-to-repair techniques;
- Using efficient transportation and logistics systems.

It has been found from the open literature that five major elements are mainly used to assess the sustainability aspects of the manufacturing systems. These elements are as follows: Manufacturing costs, environmental impact, waste management, energy consumption, and personal health and safety, as has been mentioned in some previous studies [8]. Demartini et al. [9] confirm this statement. They showed that sustainable performance management should include aspects, such as industrial safety and client satisfaction, materials and packaging waste, water, and energy consumption, and emissions.

Based on some previous studies, the authors show that the expectations of a sustainable manufacturing process are:

- Energy consumption reduction;
- Waste elimination/reduction;
- Product durability improvement;
- Health hazards and toxic dispersion elimination;
- Higher quality of manufacturing;
- Recycling, reuse, and remanufacturing enhancement.

As mentioned above, sustainable development involves achieving performance for each process or product of the organization. The quality of industrial manufacturing is the premise of achieving performance. Thus, the performance of industrial systems has a fundamental role to play in sustainable development, in surviving and maintaining on the market, as fierce competition in the market has led to the disappearance of those who do not progress and therefore do not achieve high performance.

Organizational performance has been defined in the literature from different perspectives [9–13], but most commonly used dimensions of organizational performance are aspects of financial performance and non-financial performance. Financial performance includes indicators, such as return on investment, sales revenue, profit indexes, return on total assets and net profits. On the other hand, the non-financial performance includes factors such as market performance, investment in research and development, market development, customer satisfaction, productivity, time to launch new products and working environment. Other measures of organizational performance include innovation performance, quality performance and human resource results, such as low employee turnover rate, low employee absenteeism and job performance [14].

Therefore, it can be said that performance is the relative size that allows the multidimensional characterization of an organization using specific measurement indicators.

The multidimensional vision of performance is also suggested by Ciemleja [15], who states that performance evaluation should be based on the criteria associated with the field of activities of a particular enterprise and particular manufacturing technology. Liebetruth [16] reinforces the need for a multidimensional character of performance by defining sustainable performance as the performance of a company in all dimensions and for all drivers of corporate sustainability.

In order to be able to assess to what extent organizational goals are being achieved and business strategies are effective, it is absolutely necessary to define an integrated system of performance indicators that can analyze the company's current situation and its performance [17–20].

Osmania [21], Kaplan [22], Vujovic [23] and Berlec [24] show, that in order to manage their performance and to be able to improve their activity, organizations need to implement a performance measurement system.

In the literature, there are a number of models used to measure organizations' performance, but most of them seem to focus only on the quality dimensions [25,26]. For example, Parvadavardini [27] explored the relationship between quality management practices, quality performance and financial performance of the manufacturing firm, illustrating the direct impact of quality performance on financial performance. Khan [17] shows that quality practices improve service innovation and organizational performance. Jyoti [28] studied the impact of total quality services on financial performance, using indicators, such as internal quality services, employee satisfaction, employee commitment, employee loyalty, external quality services, customer satisfaction, and financial performance. Shafiq et al. [29] studied the impact of total quality management practices, such as leadership, strategy, people, partnership, and resources, process on organizational performance in the textile sector of a developing country.

Although there are more models for the evaluation of organization performance, some of these frameworks are quality-oriented, others are financially oriented, but only a few of them are environmentally oriented, as Vartiak [30] shows. Furthermore, environmental excellence models are mostly composed of criteria based on principles of leadership, strategy, processes, results, monitoring, and people.

For example, Moldovska [31] includes sustainable development as an indicator of organizational performance assessment by building a corporate sustainability assessment model. Kartadjumena [32] includes sustainability as a motivating factor, studying the impact of executive compensation, climate, and environmental concerns on company financial performance.

Some studies [33] have explored the possibility of using more than one model of performance assessment in the same organization. It seems that they can work successfully, with different effects.

This research has been carried out by identifying, following the study of the literature, that in the current economic environment, performance measurement is no longer limited to strictly economic performance objectives, but it requires a global vision of what the entity's performance means, viewing a multitude of financial and non-financial criteria to measure the performance of an organization [34]. For sustainable development, a good measurement process should consider the total performance of the organization. Business excellence models, such as Balanced Scorecard, European Foundation of Quality Management (EFQM) are good examples of business performance frameworks that address the total performance in organizations [35].

However, even these performance measurement systems have some limitations that are briefly analyzed as follows:

1. The performance pyramid technique is easy to use and can map the most important performance indicators of strategy hierarchically. However, the over-emphasis on hierarchy tends to only allow for a restricted analysis.
2. The EFQM excellence model tries to improve the performance of a business by learning from best practices and benchmarking deemed adequate in setting the corresponding service standards.

However, the nonprescriptive model is sometimes a problem by itself in benchmarking the structure because no two businesses are in exactly the same situation.

3. The performance prism method tries to satisfy the needs of different stakeholders to achieve success in the longer term. However, the satisfaction of the stakeholders is measured through the value co-created by them.
4. The Balanced Scorecard (BSC) approach considers four different perspectives: Financial, customer, internal business processes, and learning and growth perspective at the same time, and studies their dependencies [36–38]. Although BSC has been adopted widely by different industries, there is no formal implementation methodology. This lack of formal implementation methodology and subjective measures often leads to a focus on short-term financial measures.

The short analysis of the models presented in this section shows a number of deficiencies in their construction and use, such as: The lack of target values for performance levels, the lack of explicit methods to guide the efficient implementation of models, lack of objectivity in assessing performance, or a small degree of flexibility in their application.

The present paper proposes that the determination of total performance should be achieved by taking into account indicators that are mainly used to assess the sustainability aspects of the manufacturing systems, grouped into four functions: The quality of products and processes, manufacturing costs, deliveries and the motivation and satisfaction of the employees. Besides eliminating the presented deficiencies, the proposed model also delivers a measurable result of total performance, an absolute novelty in the field of performance measurement of the entity. The created model is an important tool for optimizing the planning processes in order to reduce the consumption of energy, materials or water, this being one of the essential conditions for sustainable development. The result of the work is the model including the methodology and the appropriate combination of methods and tools for assuring the sustainable performance of the business processes.

2. Materials and Methods

The objective of the research is to provide the industry with an approach which will allow determining the global performance of an industrial system. Performance management implies to create lean operations, reduce waste, and improve efficiency. Therefore, the global performance model requires using fewer resources and producing less waste to conserve valuable resources for the benefit of future generations.

The methodology for choosing the indicators was done in collaboration with specialists in the automotive industry within the company where the case study was carried out. The indicators monitored by the company that can influence directly or indirectly the global performance of the organization were taken into account. A six-step process was used to create the indicators: Conduct a needs assessment, conduct process planning, develop a draft set of indicators, test and adjust the indicators, implement the indicators, review and improve the indicators.

In extended system design it started from the following steps:

1. Indicators composing the global performance model were grouped into five categories: Quality, delivery, cost, motivation, and environment.
2. The weight of each indicator (quality, delivery, cost, motivation, environment) in the global performance model was determined by multi-criteria analysis.
3. Performance indicator—quality function (FQ) was determined using multiple regression and taking into account indicators such as: OEE (total equipment efficiency), staff qualification and non-quality costs.
4. Performance indicator—delivery function (FD)—was determined by taking into account indicators of performance, such as: On-time delivery, delays in product delivery, backlogs efficiency recovery, transports efficiency.

5. Determining performance indicator—cost function (FC)—taking into account the volume of sales, stock levels, replenishment times, employee productivity, production times, hours worked by all employees.
6. Determination of performance indicator—motivation and staff satisfaction (FMS)—taking into account indicators such as: Fluctuation of staff, absence due to illness, satisfaction of staff at work, matrix of risk.
7. Determination of performance indicator—environmental function (FE)—taking into account indicators such as: Energy and water consumption, waste and total emissions.
8. Determination of total performance (PT)—by replacing the four functions in the overall model.
9. Model validation—the applicability of the model has been proven with great success in the automotive industry on several segments of the industrial system in Romania.

2.1. Conceptual Framework and Support of Extended Set of Performance Indicators

The mathematical model proposed for calculating total performance in industrial systems was achieved by taking into account the key performance indicators that are mainly used to assess the sustainability aspects of the manufacturing systems. These indicators were grouped into five categories: Quality, delivery, costs, motivation, and environment.

The total performance function is considered to be dependent on five main variables: Product quality, deliveries, costs, employees' motivation, and environment.

Factors that can influence the overall performance of industrial systems are:

$$\text{Q (quality)} = f_1\text{(nonconformities, cost of non-quality)}, \quad (1)$$

$$\text{D (delivery)} = f_2\text{(on-time delivery, backlogs)}, \quad (2)$$

$$\text{C (costs)} = f_3\text{(costs, productivity)}, \quad (3)$$

$$\text{M (motivation)} = f_4\text{(safety, staff turnover)}, \quad (4)$$

$$\text{E (environment)} = f_5\text{ (waste, consumption)} \quad (5)$$

2.2. Determining the Weights of Indicators by Multi-Criteria Analysis

To determine the weight of each indicator in the overall performance formula, an advanced multi-criteria analysis was performed.

Variants of the multi-criteria analysis:

Q—total performance is given by the result of quality-related actions.

D—total performance is given by the result of delivery-related actions.

C—total performance is given by the result of costs-related actions.

M—total performance is given by the result of actions related to staff motivation and satisfaction.

E—total performance is given by the result of actions related to environmental factors.

Selected criteria:

1. Sustainable development (Dd);
2. The company's image on the market (Im);
3. Innovation (In);
4. Trust the brand (B);
5. Safety of the workplace (S);
6. Financial strength (Pf);
7. Product durability (Dp);
8. Market resilience (R);
9. Change management (flexibility) (F).

The weighting coefficients (γ_i) are calculated using the FRISCO formula F (Table 1):

$$\gamma_i = \frac{p + \Delta_p + m + 0.5}{\Delta_{p'} + \frac{Nr.crt}{2}}, \tag{6}$$

where:

p—is the sum of points obtained in the line by the item taken into account;
Δ_p—the difference between the item score took into account and the score of the element at the last level;
m—number of outclassed criteria by criteria taken into account;
N_{crt}—number of criteria considered;
$\Delta_{p'}$—the difference between the item score taken into account and the score of the element at the first level.

Table 1. Weighting coefficients calculated for each criterion.

	Dd	**Im**	**In**	**B**	**S**	**Pf**	**Dp**	**R**	**F**	**Score**	**Level**	γ_i
Dd	0.5	0	0	0	0	0	0.5	1	1	3	6	0.85
Im	1	0.5	0.5	0.5	0	0	1	1	1	5.5	4	2.067
In	1	0.5	0.5	0	1	0	1	1	1	6	3	2.5
B	1	0.5	1	0.5	1	0	1	1	1	7	2	3.417
S	1	1	0	0	0.5	0	1	1	0	4.5	5	1.47
Pf	1	1	1	1	1	0.5	1	1	1	8.5	1	5.44
Dp	0.5	0	0	0	0	0	0.5	0.5	1	2.5	7	0.619
R	0	0	0	0	0	0	0.5	0.5	0.5	1.5	8	0.217
F	0	0	0	0	0	0	0	0.5	0.5	1	9	0.125

The score is set * for the four functions in relation to each of the nine criteria listed in Table 2:

Table 2. Notes for each option.

	Q	**D**	**C**	**M**	**E**
Criteria	N_i	N_i	N_i	N_i	N_i
Dd	8	6	5	9	10
Im	10	10	7	10	10
In	8	9	8	9	10
B	10	10	9	10	10
S	9	6	10	10	10
Pf	9	9	10	10	9
Dp	10	10	10	7	10
R	9	9	9	8	8
F	8	7	7	7	10

* The scores were awarded taking into account the opinions of specialists representing the teaching staff and specialists of the company where the case study was conducted.

The total score for each function is calculated (Table 3) as a weighted arithmetic mean (sum of the products between the scores for each criterion and the criteria weights):

The weights calculated for each indicator by reporting the score of each function to the total score:

Q = 0.198,
D = 0.193,
C = 0.191,
M = 0.209,
E = 0.209.

Table 3. Total score for each function.

		Q		D		C		M		E	
Criteria	γ_i	N_i	$N_i \times \gamma_i$	N_i	$N_i \times \gamma_i$	N_i	$N_i \times \gamma_i$	N_i	$N_i \times \gamma_i$	N_i	$N_i \times \gamma_i$
Dd	0.85	8	6.8	6	5.1	5	4.25	9	7.65	10	8.5
Im	2.067	10	20.67	10	20.67	7	14.469	10	20.67	10	20.67
In	2.5	8	20	9	22.5	8	20	9	22.5	10	25
B	3.417	10	34.17	10	34.17	9	30.753	10	34.17	10	34.17
S	1.47	9	13.23	6	8.82	10	14.7	10	14.7	10	14.7
Pf	5.44	9	48.96	9	48.96	10	54.4	10	54.4	9	48.96
Dp	0.619	10	6.19	10	6.19	10	6.19	7	4.333	10	6.19
R	0.217	9	1.953	9	1.953	9	1.953	8	1.736	8	1.736
F	0.125	8	1	7	0.875	7	0.875	7	0.875	10	1.25
Total			152.973		149.238		147.59		161.034		161.176

Thus, the formula of total performance is:

$$P_t = 0.198 \times Q + 0.193 \times D + 0.191 \times C + 0.209 \times M + 0.209 \times E, \tag{7}$$

The five functions—quality–deliveries–costs–the motivation and safety of employees at the workplace–environment—will be expressed as absolute values, i.e., a score obtained by each of them, marked from 1 to 10. Scoring 1 means that the results were null and the goals were not reached, and the 10 score means that the results are in line with the set objectives, 10 representing the maximum performance that can be achieved for each of the four functions.

2.3. Determining the Performance Indicator—Quality Function (FQ)

The main expectation of a sustainable manufacturing system is a higher quality of manufacturing. Therefore, the quality function is considered to be determined mainly by two indicators: Nonconformities and non-quality costs, which can influence the quality of production and the products obtained. Keeping these two indicators under control will help to reduce the consumption of raw materials, materials, and scrap.

$$\text{Q (quality)} = f_1 \text{ (nonconformities, cost of non-quality)}, \tag{8}$$

The performance indicator—nonconformities—is also considered to be influenced by other indicators, such as:

1. OEE (total equipment efficiency)

Total equipment efficiency is a composite indicator that measures the efficiency of machine use, consisting of three factors: Availability, performance, and quality. The overall level of machine efficiency is calculated as the product of the three coefficients.

OEE gives a fair view of the performance of the equipment. At the same time, it is a tool for continuous improvement, one of the aims of the method is to reduce or eliminate losses, an essential aspect to be taken into account for sustainable development.

$$OEE = K_d \times K_t \times K_q, \quad (9)$$

$$K_d = \frac{Tl}{Td} = \frac{Td - In}{Ds - Ip}, \quad (10)$$

where:

K_d = coefficient of availability of machines;
T_d = the difference between the duration of the exchange and the planned interruptions [min];
T_l = the difference between Td and unplanned interruptions (loss of time) [min];
I_n = unplanned interruptions [min];
D_s = exchange time [min];
I_p = planned interruptions [min].

$$K_t = \frac{Tp}{Tr} => K_t = \frac{Tp * Nrt}{Te}, \quad (11)$$

where:

K_t = the coefficient of performance (productivity);
T_p = planned time for piece execution [min/piece];
T_r = achieved time (calculated by reporting the actual working time to the total quantity of pieces made) [min].
T_e = actual working time [min];
Nr_t = total number of pieces made [pieces].

$$K_q = \frac{Nrb}{Nrt}, \quad (12)$$

where:

K_q = quality coefficient;
Nr_b = number of good pieces made [pieces].;
Nr_t = total number of pieces made [pieces].

2. Machine wear

The wear of the machine is calculated by reporting the actual running time to the total running time.

$$K_u = \frac{Te}{Te + In + Ip}, \quad (13)$$

where:

K_u =durability coefficient (machine wear);
T_e = actual working time [min].
I_n = unplanned interruptions [min].
I_p = planned interruptions [min].

3. Staff qualification

The personal qualification indicator is calculated as the ratio between the defective pieces made and the total number of pieces.

The indicators will be calculated according to the formulas:

$$Cp = \frac{Pd}{Nrt}, \quad (14)$$

where:

Cp = personal qualification;
P_d = defective parts made [pieces];
Nr_t = Total number of pieces [pieces].

To analyze the correlations between the three variables: OEE, machine wear and staff qualification, and establishing the validity of the multiple regression model, the multivariate regression analysis was used as an explanatory method (Table 4).

Table 4. Regression table for the nonconformities function.

Summary Output						
Regression Statistics						
Multiple R		0.76				
R Square	0.57					
Adjusted R Square	0.41					
Standard Error	5.10					
Observations	12.00					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3.00	279.80	93.27	3.59	0.07	
Residual	8.00	207.87	25.98			
Total	11.00	487.67				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	−154,137.27	56,048.45	−2.75	0.03	−283,385.23	−24,889.30
OEE	4.35	35.73	0.12	0.91	−78.05	86.76
Machine wear	72.58	34.38	2.11	0.07	−6.69	151.85
Staff qualification	1540.88	560.53	2.75	0.03	248.29	2833.47

Table 4 presents the multiple regression results in covariance analysis between OEE, machine wear, staff qualification as the independent variables and nonconformities as the dependent variable nonconformities.

The model obtained was:

$$\text{Nonconformities} = -a_0 + a_1\text{OEE} + a_2\text{Machine wear} + a_3\text{Staff Qualification}, \quad (15)$$

Using the regression model obtained in Relation (15), the formula of the nonconformity indicator can be determined, thus:

$$\text{Nonconformities} = K_d \times K_t \times K_q \times K_u + Cp, \quad (16)$$

Replacing relationships (9)–(13) in Formula (15):

$$\text{Nonconformities} = \frac{Tl}{Td} \times \frac{Tp}{Tr} \times \frac{Nrb}{Nrt} + \frac{Te}{Te + St} + \frac{Pd}{Nrt}, \quad (17)$$

Using the connection between relationships and replacing these relationships in Formula (17) it will result:

$$\text{Nonconformities} = \frac{Tp \times Nrb}{Te + In} + \frac{Te}{Te + In + Ip} + \frac{Pd}{Nrt}\ (\text{pieces}), \quad (18)$$

The second factor of influence of the quality function is the cost of non-quality.

In the study, the cost of non-quality will be considered as having two terms: Internal cost of failure (IFC) and external failure cost (EFC).

Thus, the cost of non-quality can be calculated according to the formula:

$$\text{Nonconformities Cost} = \text{Internal cost of failure} + \text{External failure cost (RON)}, \quad (19)$$

Developing, by taking into account the composition of internal and external costs:

$$\mathrm{CN} = \mathrm{P_d} \times \mathrm{T_p} \times \mathrm{Ch_p} + \mathrm{P_r} \times \mathrm{Nr_r}\ (\mathrm{cost/min.}), \quad (20)$$

where:

CN = non-quality costs;
P_d = defective parts made [pieces];
T_p = time required to produce the piece [min/piece];
Ch_p = total cost per piece [RON/piece];
P_r = price per piece [RON/piece];
Nr_r = number of returned pieces [piece].

The estimation of the cost of non-quality is achieved by reporting the non-quality costs to the value of the production for the period:

$$\mathrm{CN_p} = \frac{\mathrm{CN}}{\mathrm{VP}}(\mathrm{RON}), \quad (21)$$

where:

CN_p = the share of non-quality costs;
CN = costs of non-quality;
VP = the value of the production for the period.

The formula of the quality indicator used to determine total performance will be composed of the sum of nonconformities and non-quality costs, both with a share of 50%.

$$\mathrm{Q} = 0.5 \times \mathrm{Nonconformities} + 0.5 \times \mathrm{Cost\ of\ Non-Quality}, \quad (22)$$

Replacing the relationships obtained above into the final form of the quality function:

$$\mathrm{FQ} = 0.5 \times \left(\frac{\mathrm{Tp} \times \mathrm{Nrb}}{\mathrm{Te} + \mathrm{In}} + \frac{\mathrm{Te}}{\mathrm{Te} + \mathrm{In} + \mathrm{Ip}} + \frac{\mathrm{Pd}}{\mathrm{Nrt}}\right) + 0.5 \times \frac{\mathrm{CN}}{\mathrm{VP}}(\%), \quad (23)$$

2.4. Determining Performance Indicator—Delivery Function (FD)

Determining the delivery function (D) was made by taking into account the following indicators showing sales performance:

1. On-time delivery (OTD)

This indicator measures the percentage of all delivered orders until the requested delivery date, as indicated in the contract over a defined time period.

$$\mathrm{OTD} = \frac{\mathrm{Nrct}}{\mathrm{Nrcl}} \times 100, \quad (24)$$

where:

OTD = orders delivered in time;
Nrc_t = number of orders delivered in time;
Nrc_l = total orders delivered.

2. Delays in product delivery (SLT)

This indicator is calculated as the average of absolute percentage differences (APD) between the supplier's delayed delivery time and the actual delivery time for each order placed by the supplier.

$$\mathrm{SLT} = \frac{\sum \mathrm{APD}}{\mathrm{Nrc}}, \tag{25}$$

$$\mathrm{APD} = \frac{\mathrm{Iprg} - \mathrm{Trl}}{\mathrm{Trl}}, \tag{26}$$

where:

SLT = the average level of delivery deviations;
APD = the share of deviations between the delivered and planned delivery times in relation to the planned delivery time;
Nr_c = number of orders;
I_{prg} = the predicted delay;
T_{rl} = actual delivery time.

3. Backlogs efficiency recovery (BE)

This indicator measures the effectiveness of the arrears recovery, comparing two consecutive months.

$$\mathrm{BE} = \frac{\mathrm{Rlc}}{\mathrm{Rt}} \times 100, \tag{27}$$

where:

BE = backlogs efficiency recovery.
R_{lc} = backlogs delivered the current month;
R_t = the total balance of the current month.

4. Transport efficiency (TE)

$$\mathrm{TE} = \frac{\mathrm{Crt} - \mathrm{Cpt}}{\mathrm{Cpt}} \times 100, \tag{28}$$

where:

TE = transport efficiency;
C_{rt} = real shipping cost;
C_{pt} = planned shipping cost.

Achieving high performance for these indicators will mean reducing the fuel consumption and emissions from the delivery process, with major implications for sustainable development.

The coefficients for each of the four indicators were established taking into account the opinions of some specialists representing the teaching staff and specialists of the company where the case study was conducted, as follows:

$$\text{Delivery function (FD)} = 0.5 \times \mathrm{OTD} + 0.15 \times \mathrm{SLT} + 0.25 \times \mathrm{BE} + 0.1 \times \mathrm{TE}, \tag{29}$$

$$\mathrm{FD} = 0.5 \times \frac{\mathrm{Nrct}}{\mathrm{Nrcl}} \times 100 + 0.15 \times \frac{(\mathrm{Iprg} - \mathrm{Trl}) \times \mathrm{Nrc}}{\mathrm{Trl}} \times 100 + 0.25 \times \frac{\mathrm{Rlc}}{\mathrm{Rt}} \times 100 + 0.1 \times \frac{\mathrm{Crt} - \mathrm{Cpt}}{\mathrm{Crt}} \times 100(\%), \tag{30}$$

2.5. Determining Performance Indicator—Cost Function (FC)

Manufacturing costs are also important aspects of the sustainable development of the organization. The high performance of the cost function contributes to reducing the cost of raw material, material, and stocks.

Defining a mathematical relationship that describes the performance of a financial entity from a financial point of view does not only reduce to the income and expense balance, it is necessary to take into account several factors.

Sales volume (V) is the number of products sold (B) multiplied by the equivalent value of a product (Pu).

$$V = Pu \times B, \tag{31}$$

where:

V = sales volume;
B = pieces sold;
Pu = unit price.

The sale price of the product is calculated according to the cost of its manufacturing, plus the profit margin. Product manufacturing costs can be categorized as direct (sensitive to the volume of work) or indirect (insensitive to the volume of work). Raw material usage, waste treatment, utilities are examples of direct costs. Capital depreciation, labor, plant maintenance, plan support are examples of indirect costs.

Hence, the product costs include unit costs (MPU), direct unit costs (CdU), indirect unit costs (Ciu), and unit cost (PRu).

$$Pu = MPu + Cdu + Ciu + PRu, \tag{32}$$

The proposed financial performance indicator starts from the Relationship (32).

If we consider that the profit obtained by the firm (after tax) may have two purposes: Allocation to investors in the form of dividends or reinvestment, in both cases we may consider that this profit can be treated as an expense (with dividends or investments of any kind).

Simplifying the Relation (31) and replace it in Relation (32),

$$V = B \times (MPu + CPu), \tag{33}$$

where:

CPu = the amount of process costs required to complete an entity, including the profit.

Regarding the Relationship (33) only financially, we will say that the sales volume (V) in monetary units is equal to the sum of the value of the raw material used (MP) and the process expenditures (CP).

$$V = MP + CP, \tag{34}$$

In order to create a mathematical relationship that defines the financial performance of a company that adds value to the raw material used, we consider that indicators such as:

- Planned and realized sales values;
- Planned and realized outputs of production stocks;
- Planned and realized values of average pass-through times;
- Planned and realized employee productivity figures;
- Planned and realized costs of production costs;
- Planned and realized values of supply times (frequency).

Using the Relationship (34) we can say that an economic entity is performing as the deviations to the plan (budget) will be lower.

We, therefore, define the planned value (b) of each indicator and the value achieved (i):

$$\begin{gathered} Vb = MPb + CPb, \\ Vi = MPi + CPi, \end{gathered} \tag{35}$$

Thus, we define the concept of performance indicator, cost function (FC) expressed as a percentage, taking into account the indicators presented above and the Relationship (35):

$$FC = 1 - \left\{ \frac{(V_i - V_b) - [(CP_i - CP_b) + (MP_i - MP_b)]}{V_b * 100} \right\}, \quad (36)$$

where FC represents the percentage deviation from planned financial performance.

Using the "productivity" indicator (Pr) as a determinant of financial performance, we define:

$$Pr_b = \frac{Va_b}{h_b}; Pr_b = \frac{Va_b}{h_b}, \quad (37)$$

where,

Pr_i = achieved productivity;
Pr_b = planned productivity;
Va_i = added value achieved;
Va_b = added value planned;
H_i = sum of hours worked by all employees (achieved);
H_b = sum of hours worked by all employees (planned).

Knowing that value added represents the difference between sales and the raw material used, we define relationships:

$$\begin{aligned} Pr_i &= \tfrac{(V_i - MP_i)}{h_i}, \\ Pr_b &= \tfrac{(V_b - MP_b)}{h_b}, \end{aligned} \quad (38)$$

Results,

$$V_i - Pr_i \times h_i = MP_i, V_b - Pr_b \times h_b = MP_b, \quad (39)$$

By replacing Relations (39) with Relation (36), it will result:

$$FC = 1 - \left[\frac{Pr_i \times h_i - Pr_b \times h_b - (CP_i - CP_b)}{V_b \times 100} \right], \quad (40)$$

The indicators for production and raw material stocks will be also introduced in the FC formula. The stock known as WIP (work in progress) reflects the value of the products in manufacturing. A product is required to arrive from the raw material stage to the finished product by a production time (lean throughput time), noted in the paper as Tt.

Thus, the relationships can be defined:

$$\begin{aligned} WIP_i &= Tt_i \times \tfrac{MP_i}{30} + Tt_i \times \tfrac{CP_i}{30}, \\ WIP_b &= Tt_b \times \tfrac{MP_b}{30} + Tt_b \times \tfrac{CP_b}{30}, \end{aligned} \quad (41)$$

Extracting CPi and CPb values from Relation (41) and replacing relationships them in Relation (40) and obtaining (42):

$$FC = 1 - \left[\frac{(Pr_i \times h_i - Pr_b \times h_b) - \left(\left(\tfrac{WIP_i}{Tt_i} \times 30 - \tfrac{WIP_b}{Tt_b} \times 30 \right) - (MP_b - MP_i) \right)}{V_b \times 100} \right], \quad (42)$$

According to the Relationship (38), MP represents the total raw material costs necessary to reach the sales volume (with their processing). The stock of raw material (SMP) is a function dependent on raw material consumption and raw material replenishment time (ta).

Thus, the relationships can be defined:

$$\begin{gathered} \mathrm{Smp_i} = \frac{\mathrm{MP_i}}{30} \times \mathrm{ta_i}, \\ \mathrm{Smp_b} = \frac{\mathrm{MP_b}}{30} \times \mathrm{ta_b}, \end{gathered} \tag{43}$$

Extracting MP_ișiMP_b values from Relations (43):

$$\begin{gathered} \mathrm{MP_i} = \frac{\mathrm{Smp_i}}{\mathrm{ta_i}} \times 30, \\ \mathrm{MP_b} = \frac{\mathrm{Smp_b}}{\mathrm{ta_b}} \times 30, \end{gathered} \tag{44}$$

By replacing Relationships (44) in Relation (42) the final cost Function (45) will be obtained. The Relationship (45) is a way of calculating the total financial performance (cost) of an economic entity, taking into account the volume of sales, stock levels, replenishment times, employee productivity, production times, hours worked by all employees. All these indicators were used both in terms of planning and achieving.

$$\begin{aligned} &\mathrm{FC} \\ &= 1 - \left[\frac{(\mathrm{Pr_i} \times \mathrm{h_i} - \mathrm{Pr_b} \times \mathrm{h_b}) - \left((\frac{\mathrm{WIP_i}}{\mathrm{Tt_i}} \times 30 - \frac{\mathrm{WIP_b}}{\mathrm{Tt_b}} \times 30) - (\frac{\mathrm{Smp_b}}{\mathrm{ta_b}} \times 30 - \frac{\mathrm{Smp_i}}{\mathrm{ta_i}} \times 30) \right)}{\mathrm{V_b} \times 100} \right] (\%), \end{aligned} \tag{45}$$

2.6. Determination of Performance Indicator—Motivation and Staff Satisfaction (FMS)

Sustainable development also involves employees, without which improvement could not be achieved. Staff motivation, satisfaction, and safety are indicators that are mainly used to assess the sustainability aspects of the manufacturing systems.

Job satisfaction is defined as all the feelings that an individual has about his/her job. Extensive literature reveals that job satisfaction is dependent on supervisor behavior, co-worker behavior, pay and promotion, job and working conditions, workplace safety, and organizational aspects [20,21]. Thus, the motivation and satisfaction of staff function have been calculated taking into account the following indicators that can influence it:

1. Fluctuation of staff (Fp)

$$\mathrm{Fp} = \frac{\mathrm{Nrlic}}{\mathrm{Nrang}} \times 100, \tag{46}$$

where:

Fp = fluctuation of staff;
Nr_{lic} = number of employees liquidated;
Nr_{ang} = number of employees.

In the final formula, the indicator is calculated by reporting the value of the fluctuation indicator to its planned value.

2. Absence due to illness

$$\mathrm{Abs} = \frac{\mathrm{Nrcm}}{\mathrm{Nr.zl} \times \mathrm{Nr.ang}} \times 100, \tag{47}$$

where:

Abs = absence due to illness;
Nrcm = number of working days of medical leave;
Nrzl = number of working days of that month;
Nr_{ang} = number of employees.

In the final formula, the indicator is calculated by reporting the value of the absenteeism indicator due to illnesses at the planned value.

3. Degree of participation with improved ideas, accepted ideas.

It is calculated as follows: The number of employees who have registered an idea accepted during the analyzed period, in relation to the number of employees in the team/segment/department analyzed.

$$\text{Gpi} = \frac{\text{Nrei}}{\text{Nr.ang}}, \tag{48}$$

where:

Gpi = degree of participation with improved ideas, accepted ideas;
Nr_{ei} = number of employees who have registered an accepted idea during the analyzed period;
Nr_{ang} = number of employees in the team/segment/department analyzed.

In the final formula, the indicator is calculated by reporting the value of the degree of participation indicator with ideas for improvement to the planned value.

4. Risk matrix (Mr)

The minimum of:

- Implementation of measures older than 12 months;
- Implement measures introduced over the last 12 months;
- Achieving risk-based measures 1.

If the score under condition 3 is less than 100%, the result is automatically multiplied by factor 0.5 (hazard factor), and under condition 1 below 100%, it is multiplied by a factor of 0.8 (factor of length).

In the final formula, the indicator is calculated by reporting the value of the risk matrix indicator to its planned value.

5. Days of incapacity to work due to an accident at work (Acc)

$$\text{Acc} = \frac{\text{Nr.inc}}{\text{Nr.lc}}, \tag{49}$$

where:

Acc = days of incapacity for work due to an accident at work;
Nr_{inc} = number of days of work incapacity resulting from an accident at work;
Nr_{lc} = number of days worked.

In the final formula, the indicator is calculated by reporting the value of the days of invalidity label due to an accident at work at its planned value.

6. Satisfaction of staff at work (SG)

Employees satisfaction at the workplace will be measured percentually through surveys or questionnaires.

The employee motivation and safety formula will contain the percentage deviation of staff satisfaction from the planned value.

The weight of these indicators in the formula of employees' motivation and safety performance was established following a meeting, thus:

$$\text{FMS} = 0.3 \times \text{Fp} + 0.15 \times \text{Abs} + 0.15 \times \text{Gpi} + 0.1 \times \text{SG} + 0.15 \times \text{Mr} + 0.15 \times \text{ACC}, \tag{50}$$

$$\begin{aligned} \text{FMS} = 0.3 \times \tfrac{\text{Nr.lic}}{\text{Nr.ang}} \times 100 + 0.15 \times \tfrac{\text{Nr.cm}}{\text{Nr.zl}*\text{Nr.ang}} \times 100 + 0.15 \times \tfrac{\text{Nr.ei}}{\text{Nr.ang}} + 0.1 \times \text{SG} + 0.15 \times \text{MR} \\ +0.15 \times \tfrac{\text{Nr.inc}}{\text{Nr.lc}} (\%), \end{aligned} \tag{51}$$

2.7. *Determination of Performance Indicator—Environmenal Function (FS)*

The indicators included in the global performance model concern the main environmental areas such as: Energy efficiency, material use efficiency, water, waste, and emissions. They are calculated as follows [39]:

1. Energy efficiency (electricity, diesel oil, gasoline, hard coal) expressed in gigajoules [GJ], calculated on the total amount of waste accepted in a given year.

$$\mathrm{EEF} = \frac{\mathrm{ACE}}{\mathrm{AW}}\%, \tag{52}$$

where:

EEF—energy efficiency indicator;
ACE—annual consumption of electricity and fuels expressed in GJ;
AW—total amount of waste accepted in a given year.

2. Water consumption—the total annual water consumption expressed in m3, based on the total amount of waste accepted in a given year.

$$\mathrm{WAC} = \frac{\mathrm{AW}}{\mathrm{AWT}}\%, \tag{53}$$

where:

WAC—indicator of water consumption efficiency;
AW—annual water consumption expressed in m3;
AWT—total amount of waste accepted in a given year.

3. Waste-concerning the 'annual mass-flow of different materials used' (excluding energy carriers and water), expressed in tones.

$$\mathrm{W} = \frac{\mathrm{UM}}{\mathrm{AMW}}\%, \tag{54}$$

where:

W—indicator of efficient use of materials;
UM—annual use of materials expressed in tones;
AMW—total amount of waste accepted in a given year

4. Emissions—Total annual air emission, including at least emissions of SO2, NOX and PM.

$$\mathrm{EM} = \frac{\mathrm{TAE}}{\mathrm{TAW}}\%, \tag{55}$$

where:

EM—indicator of emission to air;
TAE—total annual emission into air expressed in Mg;
TAW—total amount of waste accepted in a given year.

The weight of these indicators in the formula of environmental performance was established following a meeting, thus:

$$\mathrm{FE} = 0.2 \times \mathrm{EEF} + 0.2 \times \mathrm{WAC} + 0.3 \times \mathrm{W} + 0.3 \times \mathrm{EM}\%, \tag{56}$$

2.8. Determination of Total Performance (PT)

The five functions—quality–deliveries–costs–the staff motivation and satisfaction at the workplace–environment, as well as the final function of global performance—will be expressed as absolute values, i.e., a score obtained by each of them, from 1 to 10. The score will actually express the deviation of the results from the planned objectives. Total performance can take values between 1 and 10, the significance of which is shown in Table 5:

Table 5. Meaning of total performance.

Interval	Significance
1–5	Nonperformance
5–8	Average performance
Over 8	High performance

3. Results

The formula was validated within an industrial segment in which “outer ring” parts are produced.

3.1. Results for Quality Function (FQ)

The results obtained for the quality function are shown in Table 6.

Table 6. Results obtained for the quality function.

Month	Non-Quality Costs (Cost/Min.)	Nonconformities (pcs)	Quality Function %
January	0.0167	1.648	83.25%
February	0.0120	1.802	90.72%
March	0.0093	1.810	90.94%
April	0.0070	1.808	90.74%
May	0.0076	1.807	90.75%
June	0.0079	1.767	88.75%
July	0.0075	1.671	83.91%
August	0.0073	1.687	84.70%
September	0.0083	1.663	83.54%
October	0.0065	1.698	85.23%
November	0.0071	1.807	90.72%
December	0.0064	1.671	83.85%
		Average Q	87.26%

The evolution of the quality function for January–December is shown graphically in Figure 1.

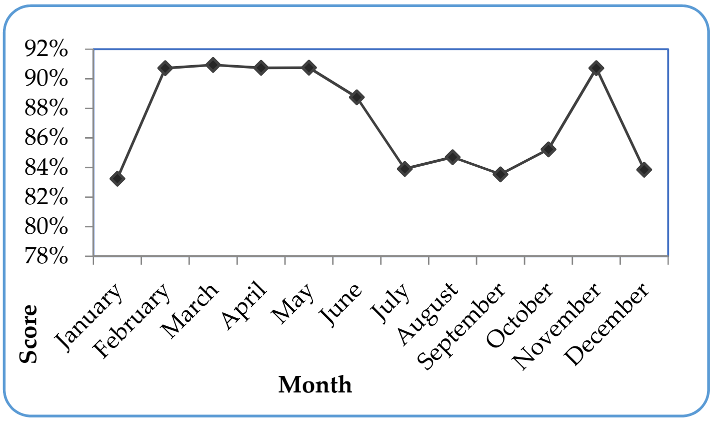

Figure 1. Evolution of quality function for January–December.

3.2. Results for Delivery function (FD)

The results obtained for the delivery function are presented in Table 7.

Table 7. Calculating the delivery function indicators.

Month	OTD	SLT	BE	TE	Delivery Function
January	70.588	94.714	90.75	−318.43	40.345
February	50.721	97.473	91.40	−425.02	20.329
March	51.111	99.408	95.76	−119.71	52.434
April	55.220	95.009	98.49	−126.42	53.841
May	63.725	99.202	96.68	−96.22	61.291
June	72.772	99.295	98.16	2.08	76.029
July	86.667	99.374	98.64	29.83	85.882
August	93.514	97.492	97.54	−96.37	76.127
September	88.041	95.761	98.76	−88.29	74.246
October	90.078	99.328	98.24	18.72	86.369
November	92.344	95.981	98.21	18.08	86.929
December	94.483	98.055	99.45	52.96	92.109
				Average D	77.748%

The evolution of delivery indicators OTD, SLT, BE and TE for the analyzed period is graphically presented in Figure 2.

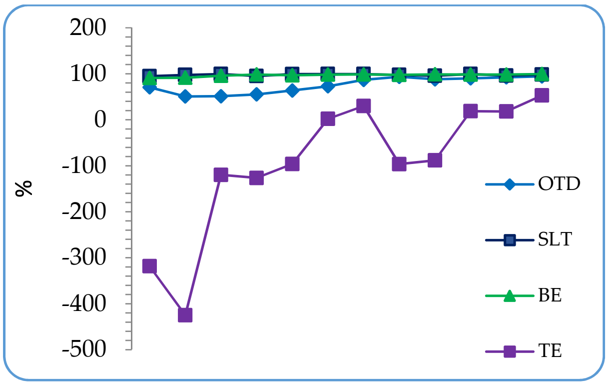

Figure 2. Evolution of delivery indicators on-time delivery (OTD), delays in product delivery (SLT), backlogs efficiency recovery (BE) and transport efficiency (TE) for January–December.

The evolution of the delivery function achieved by the industrial system for January–December is shown graphically in Figure 3.

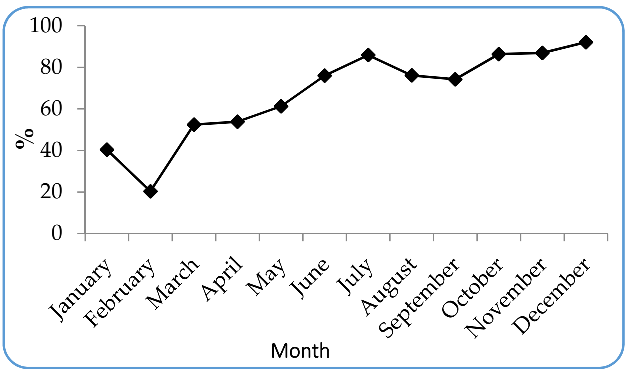

Figure 3. Evolution of delivery function for January–December.

3.3. Results for Cost Function (FC)

The results obtained by the multinational company in terms of cost performance between January and December are presented in Table 8.

Table 8. Results obtained for the Cost function.

Month	Cost Function
January	99.79%
February	99.77%
March	99.61%
April	99.36%
May	99.77%
June	99.94%
July	99.66%
August	99.87%
September	99.99%
October	99.91%
November	99.47%
December	99.99%
Average/year	99.76%

The evolution of the cost function of the company is graphically displayed in Figure 4.

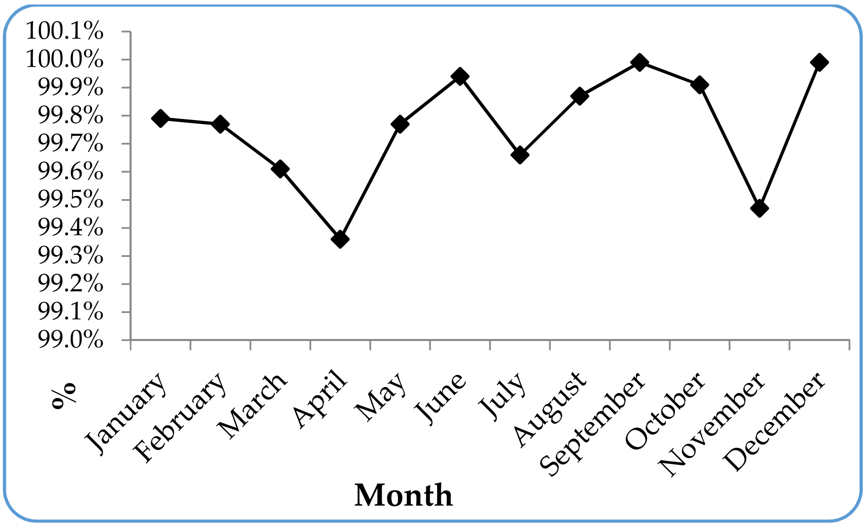

Figure 4. Evolution of cost function for January–December.

3.4. Results for Staff Motivation Function (FMS)

In Table 9, the results obtained for the motivation function of the multinational company can be analyzed.

Table 9. Calculating the staff motivation indicators.

Month	FP	ABS	Gpi	SG	Mr	Acc	FMS
January	100%	100%	76.92%	91.29%	81.90%	100%	92.953%
February	37.24%	100%	51.28%	91.29%	93.04%	25.50%	60.775%
March	36.60%	100%	100%	91.29%	100%	100%	80.110%
April	100%	100%	100%	91.29%	100%	100%	99.129%
May	100%	100%	100%	91.29%	100%	8.93%	85.469%
June	100%	100%	0%	91.29%	100%	13.50%	71.154%
July	100%	64.03%	0%	91.29%	100%	26.60%	67.724%
August	42.17%	76.64%	76.92%	91.29%	100%	26.40%	63.775%
September	100%	83.84%	0%	91.29%	100%	100%	81.705%
October	100%	100%	76.92%	91.29%	100%	25.80%	84.538%
November	100%	84.14%	100.00%	91.29%	46.77%	100%	88.766%
December	100%	100.00%	30.77%	91.29%	101.01%	100%	88.896%
						Average FMS	80.416%

The evolution of the motivation function obtained by industrial system is shown graphically in Figure 5.

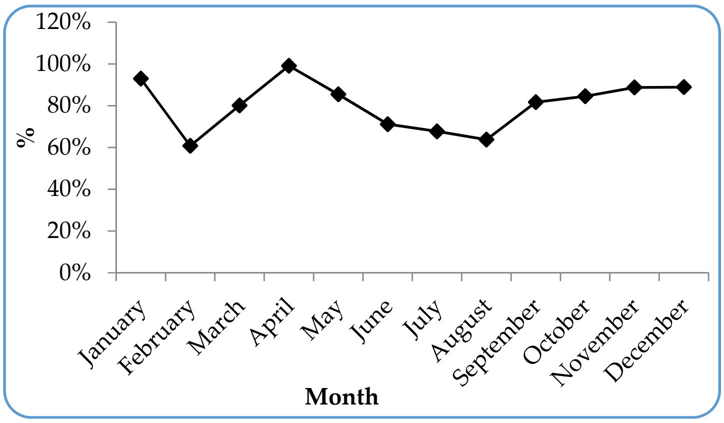

Figure 5. Evolution of the employees' motivation function for January–December.

3.5. *Results for Environmental Function (FE)*

The results obtained for the environmental function are presented in Table 10.

Table 10. Calculating the environmental function indicators.

Month	EEF %	WAC %	W %	EM %	FE %
January	86.915	99.2	96	96	94.823
February	89.641	96.923	97.979	94.827	95.155
March	98.090	90.666	91.428	94.285	93.465
April	94.806	93.432	98.654	90.312	94.338
May	93.227	83.598	92.672	92.672	90.968
June	98.226	97.058	99.056	95.862	97.532
July	87.405	88.260	98.297	98.297	94.112

Table 10. *Cont*.

Month	EEF %	WAC %	W %	EM %	FE %
August	88.190	92.592	97.777	97.777	94.823
September	87.369	82.105	95.967	96.308	91.577
October	86.255	96.715	96.363	93.288	93.489
November	89.710	89.6	95.588	96.438	93.469
December	93.7901	90.641	93.023	98.461	94.331
				Average	94.007%

The evolution of the environmental function obtained by the industrial system is shown graphically in Figure 6.

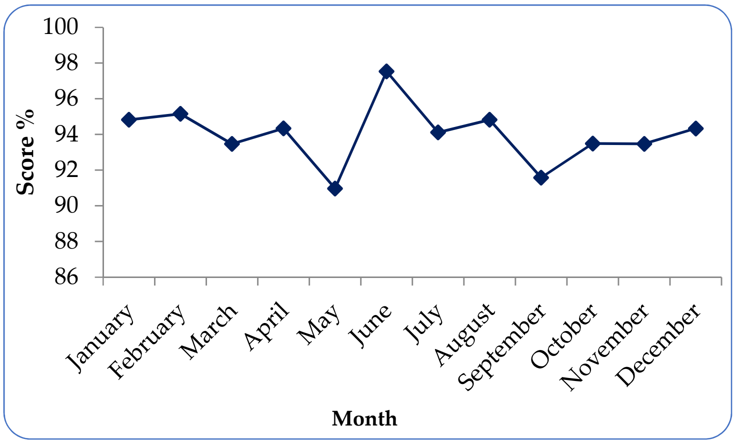

Figure 6. Evolution of the environmental function for January–December.

3.6. The Results Obtained for the Total Performance Function

Thus, knowing the results of each of the four indicators over the analyzed period, the total monthly performance of the multinational company is presented in Table 11.

Table 11. Calculation of total performance.

Month	Quality	Delivery	Cost	Motivation	Environment	Total Performance
January	8.325	7.219	9.979	9.295	9.482	8.872
February	9.072	6.283	9.977	6.077	9.516	8.173
March	9.094	6.441	9.961	8.011	9.347	8.574
April	9.074	6.648	9.936	9.913	9.434	9.021
May	9.075	7.091	9.977	8.547	9.097	8.759
June	8.875	7.603	9.994	7.115	9.753	8.659
July	8.391	8.588	9.966	6.772	9.411	8.605
August	8.47	8.576	9.987	6.378	9.482	8.555
September	8.354	8.307	9.999	8.171	9.158	8.789
October	8.523	8.637	9.991	8.454	9.349	8.984
November	9.072	8.693	9.947	8.877	9.347	9.183
December	8.385	9.211	9.999	8.890	9.433	9.177
Average	8.725	7.775	9.976	8.04	9.401	8.872

Figure 7 shows the evolution of performance for quality, cost, delivery, motivation and environmental functions in January–December.

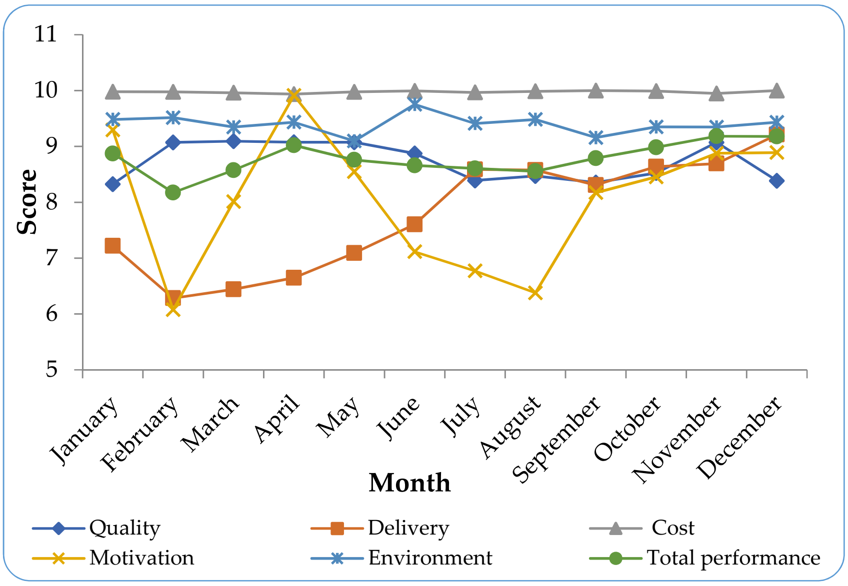

Figure 7. Evolution of the five functions and total performance for January–December.

Following the graphical evolution of the five functions, it can be noticed that in the first months delivery and motivation functions provide the lowest values, although they are of particular importance to customers.

There is also a very fluctuating evolution of employees' motivation, and its large variations since the beginning of the year are also reflected in other functions (delivery and quality).

Improvement measures should be focused on improving these three indicators: Quality, delivery, and employees' motivation and satisfaction. Even though costs function declined in the second part of the year, the other three functions increased, resulting in an increase in total performance.

It can be seen that the highest level of performance is achieved by the costs function with an average of 9.98 with a deviation of 0.02%, compared with the goal, followed by the environmental function with a score of 9.401. The last place in the order of the results obtained and one which is needed for improvement measures is the delivery function, with an average of 7.77 during the analyzed period. Optimizing the delivery process can have a major impact on sustainable development by increasing transport and logistics efficiency and reducing waste, materials and fuel consumption.

Analyzing the 8.872 value of the total performance obtained by the manufacturing system, and correlating with the interval of specific significance, it can be said that the industrial system analyzed is of high performance, reaching the planned goals will lead to sustainable development.

The statistical validity of the model has been demonstrated by the normal distribution of values and by the correlation of variables obtained with the multiple regression. It can be noticed that the results obtained for global performance follow a normal Gauss distribution (Figure 8). Thus, it can be said that the results obtained by the company for all 12 months are around the average of 8.779, corresponding to a high-performance score. Thus, the statistical validity of the results is demonstrated by confirming the hypothesis from which the research begun, namely: The total performance of the organization can be considered as the result of the action of the five functions: Quality, costs, deliveries, staff motivation, and the environment.

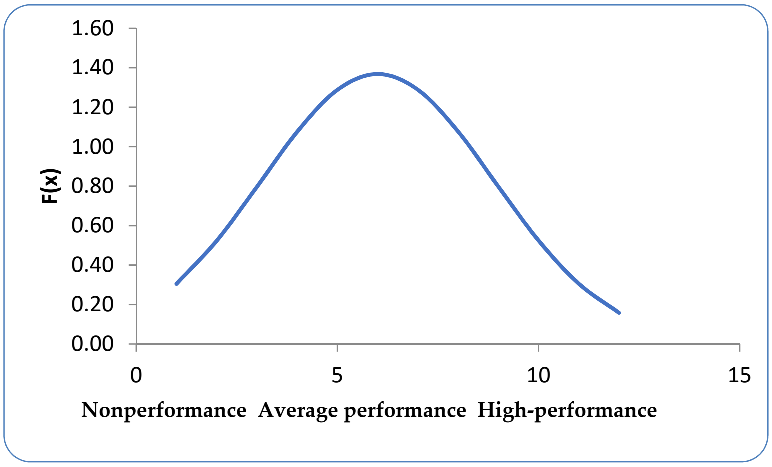

Figure 8. Distribution of global performance score.

The statistical validity of the model and the very strong correlation between the variables was also confirmed by regression analysis (Table 12). The regression model was achieved by considering the global performance as the dependent variable and as independent variables the five functions: Quality, costs, deliveries, staff motivation, and the environment.

Table 12. Results of regression analysis.

Regression Statistics	
Multiple R	0.999999685
R Square	0.999999371
Adjusted R Square	0.999998846
Standard Error	0.000313228
Observations	12
F	*Significance F*
1906950	1.63529×10^{-18}

The determinant coefficient (R2 = 0.99) showed a very good linear model, which explains the variation of the analyzed phenomenon (global performance) according to the five explanatory variables, in a ratio of 99.9%. The remaining approximately 0.01% is the influence of unregistered, unconsidered factors. Multiple correlation coefficient (Multiple R = 0.99) shows a very strong correlation of very strong intensity between the five variables: Global performance, quality, costs, deliveries, staff motivation, and the environment.

The regression is globally significant F * = 1906950 > F theoretically (4.38) at a very low significance threshold of 1.63529×10^{-18} practically equal to 0. The probability of the guarantee is 100%.

Therefore, it can be said that global performance is very strongly influenced by the five functions: Quality, costs, deliveries, staff motivation, and the environment. The chosen model is a valid one, with a direct and very strong correlation between all the variables.

4. Discussion

In this paper a mathematical model for the calculation of the total performance formula within an organization was developed, by taking into account the key performance indicators monitored by the entity, offering a global vision of what the entity's performance means. Indicators that are mainly used to assess the sustainability aspects of the manufacturing systems, such as manufacturing costs, quality of manufacturing, energy consumption, waste, personal motivation, and safety, were correlated by an advanced multicriterial analysis. Subsequently, these indicators were correlated by the multiple regression, which confirmed the hypothesis that total performance is the result of actions related to quality, deliveries, costs, staff motivation, and environmental aspects.

Numerous studies have shown that one of the main weaknesses of the performance measurement models used by many companies is that they have adopted single-dimensional focus.

Thus, the model created in this paper starts from a multidimensional vision of performance, being consistent with the current studies [15,16,27–32,40]. In fact, many authors define performance as a relative size that allows multidimensional characterization of the organization by using key performance indicators [21–27,38,40].

Existing models used to evaluate performance, such as the EFQM excellence model or the Baldrige model, reflect the performance of the organization in terms of customers, managers, shareholders or even employees, and performance appreciation is often subjective. However, these models are based on enablers that are restricted to quality management perspectives. There are other enablers that are considered to affect performance, as found in other studies, outside the total quality management framework. Also, the main drawback of these models is that they seem to focus more on the economic side of the organization, the sustainability factors being less or not at all considered, as Asif [41] showed.

For sustainable development, organizations need to adopt a global vision of performance that will include financial, economic, social, environmental or quality indicators. Thus, to eliminate all the shortcomings mentioned above, a mathematical model has been designed to provide a global vision of the organization's performance. The global performance model created attempts to cover all the factors that could influence the performance of the organization, from economic, social, to environmental factors. Therefore, the model is achieved by the objective calculation of the indicators monitored by the entity, making a clear distinction on five categories: Quality, costs, deliveries, the staff motivation, and the environmental factors, the correlation between them showing the overall performance of the organization.

Quality as an indicator of performance evaluation has been used in many studies [24–27]. Economic and financial performance is already presented in the specialty literature under various forms and indicators [18–21]. Employees' performance and job satisfaction are one of the main concerns of managers and specialists, with many studies trying to identify the factors that influence it [24].

Principles of sustainability are increasingly being applied by many organizations around the world [31,32,40,41]. Asif [41] confirmed the importance of introducing the sustainability criterion in excellence performance measurement models, proposing an integrated quality-sustainability framework. With increasing environmental concern, some models only focus on sustainability aspects. Environmental indicators, such as materials, energy, and waste, have been used in other performance evaluation models [42,43], but they have not been correlated with other factors that may affect the performance of the organization. Pinna et al. [43] developed a framework of indicators for sustainable performance management that includes environmental aspects, such as industrial safety and client satisfaction, materials and packaging, water, energy, and emissions, but economic metrics have not been included in the research.

In contrast to the above-mentioned works, global performance formula developed in this paper ensures a multidimensional vision, being achieved by the objective calculation of the main indicators monitored by the entity and that can affect the performance of the organization and its sustainable performance.

Although many studies suggest the criteria by which to conduct performance appraisal, those criteria are often subjective and unquantifiable. For example, Moldavska [31] includes sustainability in the performance assessment model, but the built model only allows highlighting the aspects that need to be improved, without providing any value for indicators. The global performance formula created in this paper proposes both the criteria for performance assessment and the manner of calculation for each of them, leading to quantifiable results. Achieving high-performance for each category of indicators will lead to sustainable development by reducing the consumption of raw materials and materials, fuel consumption, scrap and related costs, by offering high-quality products, on-time delivery of goods and increasing employees' motivation and satisfaction. In other words, applying the global performance model will ensure the satisfaction of customers, employees, shareholders and environmental requirements, thus ensuring the sustainable development of the organization.

Therefore, the new model developed in this paper presents the following novelties and advantages in its use:

- The determined mathematical model uses manufacturing-specific indicators;
- The developed model provides a true and fair view of the performance of the industrial system obtained by using a system of indicators that assess the sustainability aspects of the manufacturing;
- The indicators used in the model are indicators already monitored by the industrial systems, so there is no additional effort to calculate them;
- The model provides a measurable result and an overview of the overall performance of the industrial system;
- The global performance model is a management tool useful for managing the company, making comparisons and analysis between segments, groups, divisions.
- This model can also be a tool for controlling the way planning is done, highlighting the areas where the results obtained have significant deviations from what was planned.

Thus, it has been demonstrated through this work that the determination of the organization's overall performance implies sustainable development by accurately highlighting risk areas and optimizing processes that require improvement. The model developed in this paper was validated in the Romanian industrial system within a segment in which the "outer ring" parts are processed. Validation of the mathematical model led to a total score of 8.872. That shows an industrial system of high performance. The formula created was successfully validated within an automotive industrial system. The analysis of indicators helped the company discover its risk areas and by optimizing the deliveries process they increased its indicators up to 100%.

The created model is extremely useful in evaluating performance as it highlights both the performance gained for each indicator that compiles the quality, delivery, cost, motivation, and environmental functions, as well as the overall performance of the five functions. The correlation between the five functions will give the organization total performance overview. Thus, the risk areas can be easily seen and the improvement measures can be applied exactly where it is needed. At the same time, the tool created is useful for assessing the way planning processes are performed, showing the deviation to the planned objectives.

However, several limitations of this study must be highlighted. First of all, the applicability of the model has been proven in the automotive industry on several segments of a multinational company, but in other industries, the model may need adjustments in terms of the used indicators.

Second, the validity of the case study is limited to only two segments of the company, they could be not sufficient to cover all sustainable performance management behaviors, probably, more case studies would allow giving more precise directions for improvement.

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