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AN INTEGRATED BALANCED SCORECARD (BSC)- GREY RELATION ANALYSIS (GRA) BASED ON ENTROPY METHOD FOR EVALUATION LOGISTICS PERFORMANCE

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Abstract.

This paper aims to investigate the appropriate measures and evaluate logistics performance of selected countries by using the Balanced Scorecard (BSC) and grey relation analysis (GRA) based on the entropy method to ensure comprehensive performance analysis. The BSC helps organizations and teams achieve their business objectives and make key decisions by identifying, measuring, and managing four main business perspectives: Financial, Customer, Internal business processes, and Learning and growth. The GRA is applied as an extension of the entropy method for performing prediction analysis and decision making. Particular importance has to be attached to the assignment of objectives in determining performance measures in logistics. Therefore, countries should focus on actions that lead to sustainable performance. Application results provide a reliable analytical tool and credible academic bases and references for evaluating logistics performance.

Keywords: Logistics performance, Balanced Scorecard, grey relation analysis, entropy

1. Introduction

Logistics is not a new concept. In the past, Logistics has served to supply soldiers in a world often marked by the military and commercial wars. Team logistics was used primarily in the military application (Pettit & Anthony, 2005; Southern, 2011). Before 1950, the supply, maintenance, and transport of equipment and personnel could only be done using military facilities (Ballou, 2007). After the Second World War, companies recognized the importance of logistics and began to take advantage of the services that logistics offered. Moberg et al. (2004) assert that the implementation of logistics management is a way to improve performance and achieve company objectives.

Improving logistics performance to achieve countries objectives has posed a significant challenge. Raballand et al. (2012) noted that the impact of dwell time on trade has recently been seen as a major hindrance to the development of low-income countries. They also notice that ports in Sub-Saharan Africa average more than two weeks, adding that it does not only affect the efficiency but also worsens the congestion situation with its cost implication on the economy. Therefore, the rise in bilateral trade in Asia could be explained by improving the exporting country's LPI performance (Kumar & Felipe,2010). The development of logistics sector is expected to impact increasing production, consumption, and trade positively, thus stimulating economic growth (Lean, Huang, & Hong, 2014).

Hence, a particular emphasis has been placed on the key factors affecting logistics performance. Murthy (2015) prioritized R & D's three main performance assessment functions, training, and education using a Balanced Scorecard (BSC). This Balanced Scorecard consists of three hierarchies to assess their potential contribution to organizational development goals, the likelihood of research success, and expected adoption rates. According to Chin et al. (2008), the prioritization of critical success factors and sub-factors helps practitioners understand their relative importance and develop an improvement plan. Sharma and Rajat (2007) integrated a balanced scorecard (BSC) analytical hierarchy process (AHP) approach for supply chain management (SCM) evaluation. The complexity of applying AHP to multi-objective analysis is the large number of pair-wise comparisons required of decision-makers.

Thus, the integrated entropy and other approaches such us Fuzzy, TOPSIS, have been applied to many processes. Xu and Xia (2012) developed two methods to determine the optimal weights of attributes and set two pairs of entropy and cross-entropy measures for intuitionistic fuzzy value. Sun, Miao and Yang (2017) developed the entropy-weighted TOPSIS method to assess the impact of green technology innovation on the environmental and economic efficiency of strategic emerging industries.

Although, the logistics performance index (LPI) is a very commonly used index for evaluating the logistics performance of 155 countries based on six areas: customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing, and timeliness (Arvis et al., 2018), the proposed contribution is to evaluate the logistics performance of selected countries by determining the weights of the criteria with entropy method and the ranking of the alternatives with the grey relation analysis. The rest of this paper is structured as follows. Section 2 provides a review of the recent literature relating to logistics performance. Section 3 describes the methodology and approaches used in the study. Section 4 presents the results and analyses. Section 5 concludes.

2. Literature reviews

Logistics is the practice of moving stocks or supplies from the point of origin to the end of use efficiently (Svensson, 2007). Manufacturers, retailers, and distributors are all involved in the logistics work, as well as the military, non-profit organizations, civil defense agencies, and public works agencies. The concept of logistics is one that has evolved the most over the years. Many approaches have attempted to measure logistics performance and its impact on economic activity. Puertas, Martí and García (2014) have argued that logistical performance is essential for competitiveness and supported the argument of Hausman, Lee and Subramanian (2013) according to which logistics performance can have a significant impact on bilateral trade relations between trading nations. Keh, Chu and Xu (2006) evaluate the performance of logistics in three aspect: productivity, efficiency and effectiveness, where productivity measures a prescribed output to the resources consumed; efficiency is the measurement for producing results by using available resources; while effectiveness is designed to correspond to the accomplishment of mission objectives and achievement of desired results.

Previous research on logistics performance provides an overview of the importance of productivity improvement and highlights the high cost of logistics process activities. Stainer, A. and Stainer, L. (1997) discuss the challenges of these integrated approaches by emphasizing the effectiveness of the productivity philosophy in logistics and offers a critique of the current state of productivity and performance measurement and management in logistics. They have developed analytical frameworks and models to assist management in planning and decision making, both operationally and strategically. As a result, they have identified quality, productivity, speed and innovation as key ingredients for strategic logistics performance. Zhao, and Tang (2009) attest that the cost of logistics is an important factor in measuring the level of development of the logistics industry. In addition to analyzing the current cost of logistics in China and the factors that affect the status of the logistics industry, they have subsequently proposed an effective strategy based on the vision of the logistics level that is appropriate for the current situation to reduce the cost of logistics. Indeed, reducing logistics costs is significant and represents the most direct way to extend third party benefits and increase competitiveness.

Mentzer and Konrad (1991) reviewed logistics performance measurement practices and suggested improvement methods from an efficiency and effectiveness perspective. They consider effectiveness and efficiency as the main measures of logistics performance. Wong et al. (2015) employed a triangular DEA to identify factors that affect efficiency and effectiveness; therefore, the performance of logistics companies and proposes ways to improve their competitiveness. The results show that increased investment, for example, in technologies such as RFID and human capital development, will improve performance. At the same time, a decrease in current liabilities (e.g., borrowings) will also bring an improvement in performance.

3. Methodology

3.1 Balanced Scorecard (BSC)

3.1.1 Characteristics and evolution of the Balanced Scorecard

Initially, the Balanced Scorecard model, developed by Kaplan and Norton in 1990 (Kaplan and Norton, 1998), is a method of formalizing company strategy and constructing prospective dashboards combining financial and non-financial indicators.

- The BSC approach proposes to rely on four axes of analysis covering respectively financial results, customer satisfaction, internal processes, and organizational learning.
- This interconnection allows a company to link its actions to its strategy and to evaluate the evolution of performance variables by adopting a global and balanced vision of its activities.
- This idea of globality and balance, present in the BSC approach, highlights the notion of the cause-and-effect model, underlying the relationship between the four identified dimensions.
- Likewise, learning enables the improvement of internal processes, which generates customer satisfaction, which in the longer or shorter-term enables the achievement of economic objectives and, therefore, shareholders' satisfaction.

3.1.2 Using of BSC in logistics performance

Using the Balanced Scorecard framework, each function has implemented actions and measures along the customer's four key dimensions, finance, internal, and innovation and learning. Each function's objectives and actions were designed to support the logistics organization selected a set of measures that would also support business objectives (Kaplan and Norton, 1998). What does the company need to do to achieve its strategy? This guideline has allowed us to have up to 13 measurable objectives. Concrete, tangible actions that support the achievement of the goals. Finally, the targets: expectations in terms of the level of performance against the strategic plan. For each measure, set a goal or plan to assess progress against the objective. Performance indicators include the total revenue (% of GDP), the exports of goods and services (% of GDP), the extent of staff training, etc.

Table 1: Strategy maps & Balanced scorecard

Perspective	Objectives	Measures
Financial	Financial result Growth ⇧	I1-Total revenue(%GDP) I2-Exports of goods and services (% of GDP) I3-GDP per capita
Customer	High quality service Increase customer satisfaction ⇧	I4-Expected delivery time I5-Degree of customer orientation
Internal process	Improve operation efficiency Fast business decisions ⇧	I6-International shipments I7-Logistics quality and competence I8-Quality of infrastructure I9-Efficiency of the clearance process
Learning & Growth	Align personal and compagnie objectives Proper knowledge management Align personal and compagnie objectives	I10-Ability to track and trace consignments I11-Cooperation in labor-employer relations I12-R&D expenditures (% of GDP) I13-Extent of staff training

3.2 Entropy method

In 1948, Shannon proposed a mathematical theory of communication widely employed in social and physical sciences. Generally, the entropy is described as a measure of randomness or disorder of a system. This entropy concept can be considered a criterion for the degree of uncertainty represented by a discrete probability distribution (Kuo, Yang & Huang, 2008). However, the entropy index represents an estimate of the difference between the average share of individual groups in the system.

Recently, the economics spectral analysis manager increasingly applies the concept of entropy in decision-making (Ye, 2010; Lotfi & Fallahnejad, 2010). In the present research, the entropy calculation procedure is presented as follow:

Step 1. *The decision matrix (X)*

We assume that $x_{ij} = (i = 1, 2, ..., m; j = 1, 2, ..., n)$ is the performance of different alternatives with respect to various criteria and the decision matrix is represented as follow:

$$X = [\mathrm{x}_{ij}]_{mn} = \begin{vmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & \cdots \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{vmatrix} \quad (i = 1, 2, ..., m; j = 1, 2, ..., n) \qquad (1)$$

When m=number of indicators (criterion)

n=number of respondents (countries, alternatives)

step 2. *Normalized matrix (X)*

For better comparison, matrix (X) should be normalized in the same scale of measurement using the formula:

$$p_{ij} = x_{ij} / \sum_{i=1}^{m} x_{ij} \qquad (i = 1, 2, ..., m; j = 1, 2, ..., n) \qquad (2)$$

Step 3. Entropy value (e_j)

The entropy value of jth criterion is determined as follow:

$$d_j = \qquad (i = 1, 2, ..., m; j = 1, 2, ..., n) \qquad (3)$$

Where $k = 1/\ln m$ and $0 < e_j < 1$

Step 4. Entropy weight w_j

The entropy weight of jth criterion is obtained as follow:

$$w_j = \frac{1 - e_j}{n - \sum_{j=1}^{n} e_j} \qquad (i = 1, 2, ..., m; j = 1, 2, ..., n) \qquad (4)$$

When $d_j = 1 - e_j \qquad (i = 1, 2, ..., m; j = 1, 2, ..., n)$ (5)

$$w_j = d_j / \sum_{j=1}^{n} d_j \quad \text{Were} \quad \sum_{j=1}^{n} w_j = 1 \qquad (i = 1, 2, ..., m; j = 1, 2, ..., n) \qquad (6)$$

$d_j =$ represent the degree of deviation (degree of diversification) of each criterion.

3.3 Grey relation analysis (GRA)

Developed by Deng in1989, GRA is used to solve the uncertainty problems under discrete data and incomplete information. The new concept of GRA is often applied as an extension of the entropy method for performing prediction analysis and decision making in many areas such as physics, mathematics, computer sciences (information theory), and other fields of science. In many cases, GRA is used for solving multiple decision making (Kuo, Yang & Huang, 2008; Wei, 2011). Kung and Wen (2007) used grey relational analysis and grey decision-making to evaluate the relationship between company attributes and its financial performance in Taiwan's venture capital enterprises. Therefore, GRA allows to manage relationships between objects from different contexts and establish links between concepts from other tables.

The steps for obtaining the final rank are as follows:

Step1. *Normalized*

Suppose that m=evaluation indexes, n=evaluating alternatives and the initial matrix (X): $X = \left[x_{ij}\right]_{m\times n}$; $(i = 1,2,...,m;\ j = 1,2,...,n)$

The standardization index can take the following form:

For benefices indexes (higher is better)

$$x_{ij}^{*} = \frac{x_{ij-}\min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})},\ (i = 1,2,...,m;\ j = 1,2,...,n) \tag{7}$$

For the cost indexes (lower is better)

$$x_{ij}^{*} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})},\ (i = 1,2,...,m;\ j = 1,2,...,n) \tag{8}$$

When $\max(x_{ij})$ and $\min(x_{ij})$ are the maximum and minimum respectively.

Step 2. Grey relational coefficient

The equation for calculating the grey relational coefficient is as follows:

$$\xi_i = \frac{\Delta\min + \zeta.\Delta\max}{\Delta_{oi}(k) + \zeta.\Delta\max},\ (i = 1,2,...,m;\ j = 1,2,...,n) \tag{9}$$

Where Δ_{oi} is the deviation sequence: $\Delta_{oi} = \left\| x_0^{*}(k) - x_i^{*}(k) \right\|$

A value of ζ is smaller and the distinguisher ability is the larger. $0 < \zeta < 1$ and $\zeta = 0.5$ is generally *used.*

Step 3*. Grey relation grade (GRG)*

The formula for calculating the gray relationship grade and determining top performer is as follows

$$\gamma_i = \frac{1}{n}\sum_{k=1}^{n} w_i x_i(k),\ (i = 1,2,...,m;\ j = 1,2,...,n) \tag{10}$$

4. Empirical study

The application of Entropy and GRA method is proposed to evaluate the logistics performance problem in the selected countries belonging to the lower-middle and upper-middle-income countries: Brazil (BRA), China (CHN), Cote d'Ivoire (CIV), Ghana (GHA), Nigeria (NGA), Pakistan (PAK) and Russian Federation (RUS). The objective is to measure logistics performance based on thirteen indicators constructed across the key dimensions of the BSC model.

The decision matrix is given by the table (2), and those data have been collected in various sources; the world bank database, the global competitiveness report, the IMF data, and LPI.

Table 2: Decision matrix

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13
BRA	30.110	15.497	9001.234	3.510	4.424	2.881	3.090	2.927	2.406	3.111	3.796	1.300	3.788
CHN	28.390	19.112	9976.677	3.840	4.607	3.536	3.595	3.753	3.286	3.648	4.578	2.100	4.496
CIV	19.190	22.596	2302.613	3.227	4.346	3.207	3.227	2.887	2.779	3.136	4.633	0.400	4.117
GHA	17.490	35.264	2202.312	2.871	4.709	2.534	2.507	2.443	2.452	2.571	4.418	0.400	4.213
NGA	6.200	15.497	2028.182	3.068	3.938	2.522	2.399	2.560	1.967	2.685	3.882	0.300	3.653
PAK	15.100	8.972	1482.306	2.663	3.936	2.629	2.587	2.197	2.122	2.265	3.933	0.300	3.958
RUS	33.290	30.517	11370.813	3.313	4.520	2.644	2.749	2.775	2.420	2.646	4.251	1.100	3.924

4.1 Application of entropy method

The normalization of the arrays of decision matrix (X) which is calculated according the formula (2) to obtained project outcomes is showed in table (3).

Table 3: Normalized matrix

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13
BRA	0.201	0.105	0.235	0.156	0.145	0.144	0.153	0.150	0.138	0.155	0.129	0.220	0.135
CHN	0.190	0.130	0.260	0.171	0.151	0.177	0.178	0.192	0.188	0.182	0.155	0.356	0.160
CIV	0.128	0.153	0.060	0.143	0.143	0.161	0.160	0.148	0.159	0.156	0.157	0.068	0.146
GHA	0.117	0.239	0.057	0.128	0.155	0.127	0.124	0.125	0.141	0.128	0.150	0.068	0.150
NIG	0.041	0.105	0.053	0.136	0.129	0.126	0.119	0.131	0.113	0.134	0.132	0.051	0.130
PAK	0.101	0.061	0.039	0.118	0.129	0.132	0.128	0.112	0.122	0.113	0.133	0.051	0.141
RUS	0.222	0.207	0.296	0.147	0.148	0.133	0.136	0.142	0.139	0.132	0.144	0.186	0.139

The entropy value of each index is calculated according to formula (4). The entropy is an absolute measure which provides a number between 0 and 1. The results shows a high entropy, the value of all criteria is approximately more than 0.80, which means a high level of disorder and low level of purity.

Table 4: Entropy value and entropy weight

Index	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13
Entropy (Hi)	0.950	0.958	0.856	0.997	0.999	0.996	0.995	0.993	0.993	0.994	0.999	0.864	0.999

Entropy Weight (Wi)	0.122	0.103	0.355	0.008	0.003	0.010	0.012	0.017	0.016	0.014	0.004	0.334	0.003

According to the table (3), the GDP per Capita (I3) is the most important criterion with the highest entropy weight (I3=0.355), following by R&D expenditures (I12=0.334), Total revenue (I1=0.122). The weight of the Extent of staff training (I13=0.003) is lower among all criteria showing that I13 is less important compared to other criteria.

4.2 Application of grey relation analysis method

The study applied the GRA method demonstrated in the equation (7), (8), (9) and (10) to rank the countries according to the level of their logistics performance.

Table 5: Normalized matrix

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13
BRA	0.883	0.248	0.760	0.720	0.631	0.354	0.578	0.469	0.333	0.612	0.000	0.556	0.160
CHN	0.819	0.386	0.859	1.000	0.868	1.000	1.000	1.000	1.000	1.000	0.934	1.000	1.000
CIV	0.480	0.518	0.083	0.479	0.530	0.676	0.693	0.443	0.616	0.630	1.000	0.056	0.550
GHA	0.417	1.000	0.073	0.176	1.000	0.011	0.090	0.158	0.368	0.221	0.743	0.056	0.664
NIG	0.000	0.248	0.055	0.344	0.003	0.000	0.000	0.233	0.000	0.303	0.103	0.000	0.000
PAK	0.329	0.000	0.000	0.000	0.000	0.106	0.157	0.000	0.118	0.000	0.164	0.000	0.362
RUS	1.000	0.819	1.000	0.552	0.755	0.120	0.293	0.371	0.344	0.275	0.544	0.444	0.321

Table 6 : Grey rational coefficient (GRC) matrix

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13
BRA	0.810	0.399	0.676	0.641	0.576	0.436	0.542	0.485	0.428	0.563	0.333	0.529	0.373
CHN	0.734	0.449	0.780	1.000	0.791	1.000	1.000	1.000	1.000	1.000	0.884	1.000	1.000
CIV	0.490	0.509	0.353	0.490	0.515	0.607	0.619	0.473	0.566	0.574	1.000	0.346	0.526
GHA	0.462	1.000	0.350	0.378	1.000	0.336	0.355	0.373	0.442	0.391	0.660	0.346	0.598
NIG	0.333	0.399	0.346	0.433	0.334	0.333	0.333	0.395	0.333	0.418	0.358	0.333	0.333
PAK	0.427	0.333	0.333	0.333	0.333	0.359	0.372	0.333	0.362	0.333	0.374	0.333	0.439
RUS	1.000	0.735	1.000	0.528	0.671	0.362	0.414	0.443	0.432	0.408	0.523	0.474	0.424

Table 7: Grey relational grade

	BRA	CHN	CIV	GHA	NIG	PAK	RUS
I1	0.062	0.056	0.038	0.036	0.026	0.033	0.077
I2	0.031	0.035	0.039	0.077	0.031	0.026	0.057
I3	0.052	0.060	0.027	0.027	0.027	0.026	0.077
I4	0.049	0.077	0.038	0.029	0.033	0.026	0.041

I5	0.044	0.061	0.040	0.077	0.026	0.026	0.052
I6	0.034	0.077	0.047	0.026	0.026	0.028	0.028
I7	0.042	0.077	0.048	0.027	0.026	0.029	0.032
I8	0.037	0.077	0.036	0.029	0.030	0.026	0.034
I9	0.033	0.077	0.044	0.034	0.026	0.028	0.033
I10	0.043	0.077	0.044	0.030	0.032	0.026	0.031
I11	0.026	0.068	0.077	0.051	0.028	0.029	0.040
I12	0.041	0.077	0.027	0.027	0.026	0.026	0.036
I13	0.029	0.077	0.040	0.046	0.026	0.034	0.033
GRG	0.522	0.895	0.544	0.515	0.360	0.359	0.570
Ranking	4	1	3	5	6	7	2

According to the grey relational grade, the ranking of countries in term of logistics performance is show in table (7). Therefore, China with a value 0.895 has the best performance following by Russian Federation, Côte d'Ivoire, Brazil, Ghana, Nigeria and Pakistan with the value 0.570, 0.544,0.522, 0.515, 0.360 and 0.359, respectively.

5. Discussion and conclusions

This study aimed to use integrated BSC-entropy in evaluating countries' logistics performance in other to obtained the weights of multicriteria decision analysis problem. GRA is applied as an extension of entropy method for performing prediction analysis and decision making in countries' logistics performance. The upper-middle-income countries, China and Russia, are at the top of our ranking, respectively, while lower-middle-income countries (Nigeria and Pakistan) close the rank. Additionally, the results presented in table (4) shows that GDP per Capita, R&D expenditures, and total revenue are the keys indicator of logistics performance. This study added other indicators to those proposed by the LPI, and the results are roughly in line with those reported by the World Bank Group report. Advanced economies remain the global leaders in trade logistics (Arvis et al., 2018). It reveals high-income countries score, on average, 48% higher than low-income countries when it comes to logistics performance. However, the lowest-ranked countries are generally low-income, isolated, fragile, or facing conflict or unrest. In the lower-middle-income group, large economies such as India and Indonesia and emerging economies such as Vietnam and Côte d'Ivoire stand out as the best performers.

Recent studies have shown a growing demand for logistics development in countries with high per capita income. According to Arvis et al. (2018), the policy actions for improving logistics performance vary according to income level. In low-income countries, progress in logistics performance is generally due to improved infrastructure and customs and other border agencies' reforms. For middle-income countries, the focus is on developing logistics services with an increasing demand for outsourced logistics—Furthermore, the need for environmentally and socially sustainable logistics increases as a country's income level increases. Khan et al. (2017) show that renewable energy sources and per capita income have a statistically significant and positive association with green logistics activities. Foreign investment is attracted by green policies and practices adopted in global logistics operations.

Therefore, Logistics competence and infrastructure promote economic growth and sectoral added value and are essential factors in logistics performance. As global logistics operations increasingly attract foreign investment, logistics operations also strengthen economic activities with greater export opportunities. This study confirms the evidence that R&D investments have a significant and positive effect on the logistics performance of countries (Özsoy, Tunahan & Esen, 2019). However, in general, most countries have pursued logistics-related reforms and investments to build infrastructure, facilitate transport and trade, or develop modern services. Despite these developments, poor logistics standards can hamper economic performance.

BSC-entropy integration offers a valuable way to solve multicriteria decision-making problems. It has also proven to be very useful for comparing discrete alternatives. The study provides a reliable analytical tool and credible academic bases and references for evaluating logistics performance. Moreover, this study had some limitations, which require improvements. This study is limited to only a few countries. In future research, more countries with different income levels, from the lowest to the highest, should be examined, also adding additional indicators. Further research will be directed towards analyzing and applying other analytical tools in the proposed model and then providing a different perspective on the issue developed.

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