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Third Party Service Provider Selection Using TOPSIS based Approach (A Case Study of Ghana Manganese Company)

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ABSTRACT

The business strategy structure of a logistics firm is determined by its well-integrated supply chain. A lot of companies fail to structure their business strategy models as their line of activities permit them to improvise.

Third party service providing has been a strategic planning implementation and enforcement of many organizations to achieve their objective as an organization. In the last few decades, third party service providers have upgraded their ability or capacity to support organizations engaging them in their activities which is or could be performed in-house.

The ultimate aim of this research was to ascertain a service provider for the road haulage activities of GMC, the Ghana Manganese Company as a case study and also to aid in the restructuring of the company's business strategy model using the Technique for Order of Preference by Similarity to Ideal Solution TOPSIS approach. In addition, the shipping and logistics manager of the case company emphasized that the four selection criteria comprising "Cost of delivery", "compatibility", "reputation", and "certification" should be given due consideration as a priority among the other criterion for selection and scrutiny process. As a result, it will be efficient and responsive for the researcher to simulate a best service provider for the road haulage activities of Ghana Manganese Company.

Keywords— Supply Chain, Logistics, Third Party Logistics, Logistics Strategies, Third Party Service Providers, Transportation

I. INTRODUCTION

Globalization in a technical form causes tremendous rise in competitions and this fact leads the companies having to focus on their core activities in order to attain competitive advantage. In today's market conditions, a decision making process has become more complicated due to improvements in options, targets and environmental conditions parallel to technology. According to Aktas and Ulengin, owing to the globalization of sources, manufacturing and production, distribution companies in recent years have been adopting the logistics management view to guide their business operations. Three most important types of logistics value chain-related strategic alliances have attracted the interest of researchers: third party logistics (3PL), retailer-supplier partnerships and distributor integration (Wu et al., 2009; Buyukozkan et al., 2008). Outsourcing provides a certain power that is not available within an organization's internal departments. This power can have many dimensions: economics of sale, process expertise, access to capital, access to expensive technology etc. in the global supply chain systems, industries try to outsource what is not their core business and third party service providers are one of the choices. Selecting the Third Party Service Providers providing the best selection problems is an interesting and important subject of companies with face when trying to select a suitable and long-term Third Party Service company.

There is one operational manganese ore mine in Ghana, Nsuta-Tarkwa, which is located at Tarkwa Banso in the Western Region, utilizing an opencast, strip-mining method. In 2006 the mine produced 1.6m tonnes, of which 52% was exported to Ukraine, 37% to China, and the remainder to Norway. The Ukrainian Private Group has now possessed managerial rights to the Ghana Manganese Corporation (GMC), viewed by some as a move to ensure stability of supply – an intention to revise existing contracts has been announced. The Ghanaian government has continued trying to attract foreign investment, with measure such as tax breaks, off-shore banking etc. but concern has recently been expressed at a government plan to levy a windfall tax. Consmin, through its wholly owned subsidiaries, owns 90% of Ghana Manganese Company Limited (GMC). The remaining 10% is owned by the Government of Ghana. Operations from this mine have a history stretching back to 1916 when the first manganese material was mined from the site.

GMC owns and operates the Nsuta manganese mine in the western region of Ghana. GMC holds a mining concession for manganese over an area of 175 square kilometers in and around Nsuta in the Western Region of

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Ghana, less than 3% of which has been mined to date. GMC ore is one of the highest manganese-to-iron ratio ores in the market (Mn:Fe ~31) and is low in phosphorous, alumina and other heavy metal impurities, making it well-suited for both alloy and manganese metal production.

Nsuta is in very close proximity to Tarkwa, which is a well-established mining center due to the large gold mining activities around it.

The company has a support office situated in Accra where most of the interaction with regulators and executive functions are performed. Furthermore, the company operates and owns its own ship loading facilities in the port of Takoradi. A transshipment (TSV) system is in place, enabling the company to load mini cape-sized vessels up to 110kt. The Headquarter and operations management is located at the mine site along with all other administrative functions. The company has access to all modern forms of communication and is fully connected.

II. METHODOLOGY

2.1 Introduction

This chapter seeks to provide the research methodology around the research conducted. It entails the methods and techniques the researcher used to gather information for the research. The method explains the scope of the study and also defines the sample area and size, methods and techniques for sampling, instruments and challenges faced on the research area.

The ultimate aim in this study research is to determine the very best 3PL provider for Ghana Manganese Company. The model used here is one of the Multi Criteria Decision Making Methods, TOPSIS method for determining the best alternative.

2.2 Multi-Criteria Decision Making Process in Service Provider Selection

Multi-criteria decision making (MCDM) basically refers to the making of choices of the best alternative from among a finite set of decision alternatives or available options in terms of multiple, usually conflicting criteria. According to Hwang, Yoon, 1981; Jahanshahloo, Hosseinzadeh, Lofti, Izadikhah, 2006a], the main steps in multi-criteria decision making are the following:

- Establish system evaluation criteria that relate system capabilities to goals
- Develop alternative systems for attaining the goals (generating alternatives).
- Evaluate alternatives in terms of criteria
- Apply one of the normative multiple criteria analysis methods
- Accept one alternative as “optimal” (preferred)
- If the final solution is not accepted, gather new information and go to the next iteration of multiple criteria optimization.

2.3 Techniques Involved in Multi-Criteria Decision Making Process for Service Provider Selection in the Supply Chain

Multi-criteria Decision Making techniques without doubts are important tools to aid decision maker (s) to choose options in the situation of discrete problems. Ultimately, with the use of the Personal computer, the methods have become easier for the users, so they have found great acceptance in many areas of decision making processes in management. According to Chen Hwang, 1992, among many Multi-Criteria Decision Methods, MAXMIN (Maximization: Minimization decision rule), MAXMAX (Maximization: Maximization decision rule), SAW (Simple Addictive Weighting), AHP (Analytical Hierarchy Process), TOPSIS (Technique for Order Preference by Similarity to the Ideal Solution), SMART (The Simple Multi Attribute Rating Technique), ELECTRE (Elimination and Choice Expressing Reality) are the most frequently used methods. The nature of the recommendations of one of those methods depends on the problem being addressed: choosing, ranking or sorting. The selection of models or techniques can be based also on such evaluation criteria as:

- Internal consistency and logical soundness
- Transparency
- Ease of use
- Data requirements are consistent with the importance of the issue being considered
- Realistic time and manpower resource requirements for the analytical process
- Ability to provide an audit trail
- Software availability, where needed

According to Chen Hwang, 1992, the classification methods can be categorized by the type of information from the decision maker (no information, information on attributes or information on alternatives), data type or by solution aimed at. For instance, in the MAXMIN technique, there is an assumption that the overall performance of an alternative is determined by its weakest attribute. In the MAXMAX technique however, an alternative is selected by its best attribute value. The SAW method simply multiplies the normalized value of the criteria for the alternatives with the importance of the criteria and the alternative with the highest score is selected as the preferred. The TOPSIS selects the alternative closest to the ideal solution and farthest from the negative ideal alternative. This classical method is based on findings on attribute from decision maker, numerical data with the solution targeting evaluation, prioritization and selection where the only subjective inputs are weights.

2.4 The Classical Technique for Order Preference by Similarity to the Ideal Solution (Topsis Method)

This research is based on the classical TOPSIS method which was presented by Hwang and Yoon, (1981) and developed by many authors [Jahanshahloo, Lofti, Izadikhah, 2006a; 2006b; Zavadskas, Turskis, Tamosaitiene, 2008; Hung, Chen, 2009].

According to Hung, Cheng, 2009, the main advantages of this methods are:

- Simple, rational, comprehensible concept
- Intuitive and clear logic that represent the rationale of human choice
- Ease of computation and good computational efficiency
- A scalar value that accounts for both the best and worst alternatives ability to measure the relative performance for each alternative in a simple mathematical form
- Possibility for visualization

The method takes into consideration of intangible criteria besides tangible ones. The characteristics with great importance in the decision making process provides flexibility to the experts. In the classical TOPSIS method, we assume that the ratings of alternatives and weights are represented by numerical data and the problem is solved by a single decision maker. Some of the benefits enjoyed in this method are simplicity, rationality, comprehensibility, good computational efficiency and ability to measure the relative performance for each alternative in a simple mathematical form but complexity arises when there are more than one decision makers because the preferred solution must be agreed on by interest groups who usually have different goals.

III. PRIOR APPROACH

3.1 Procedures Involved in the Topsis Algorithm

The classical TOPSIS algorithm for a single decision maker is systematically described below;

The idea of classical TOPSIS procedure can be expressed in a series of steps following: [Chen, Hwang, 1992; Jahanshahloo, Lofti, Izadikhah, 2006a].

Step 1. Construct the decision matrix and determine the weight of criteria.

Let $x = (x_{ij})$ be a decision matrix and $w = [w_1, w_2, \dots w_n]$ a weight vector, where $x_{ij} \in \mathfrak{R}, w_j \in \mathfrak{R}$ and $w_1 + w_2 \dots w_n = 1$.

Criteria of the functions can be: benefit functions (more is better) or cost functions (less is better).

Step 2. Calculate the normalized decision matrix.

This step transforms various attribute dimensions into non-dimensional attributes which allows comparisons across criteria. Because various criteria are usually measured in various units, the scores in the evaluation matrix X have to be transformed to a normalized scale. The normalization of values can be carried out by one of the several known standardized formulas. Some of the most frequently used methods of calculating the normalized value n_{ij} are the following:

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x^2{}_{ij}}}$$

$$n_{ij} = \frac{x_{ij}}{\max_i x_{ij}}$$

$$n_{ij} = \begin{cases} \dfrac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} & \text{if } C_i \text{ is a benefit criterion} \\ \dfrac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} & \text{if } C_i \text{ is a cost criterion} \end{cases}$$

for $i = 1, \dots, m;\ j = 1, \dots., n.$

Step 3. Calculate the weighted normalized decision matrix.

The weighted normalized value v_{ij} is calculated in the following ways:

$v_{ij} = w_j n_{ij}$ for $i = 1, \dots, m; j = 1, \dots, n.$

where w_j is the weight of the j-th criterion,

$$\sum_{j=1}^{n} w_j = 1$$

Step 4. Determine the positive ideal and negative ideal solutions.

Identify the positive ideal alternative (extreme performance on each criterion) and identify the negative ideal alternative (reverse extreme performance on each criterion). The ideal positive solution is the solution that maximizes the benefit criteria and minimizes the cost criteria whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria.

The positive idea solution A^+ has the form:

$$A^+ = (v^+{}_1, v^+{}_2, v^+{}_n) = \left((\max_i v_{ij} \,|j \in I), (\min_i v_{ij} \,|j \in J) \right),$$

Negative ideal solution A^- has the form:

$$A^- = (v^-{}_1, v^-{}_2, v^-{}_n) = \left(\left(\min_i v_{ij} \,\middle|j \in I\right), \left(\max_i v_{ij} \,\middle|j \in J\right) \right)$$

Where I is associated with benefit criteria and J is associated with the cost criteria,

$i = 1, \dots., m; j = 1, \dots, n.$

Step 5. Calculate the separation measures from the positive ideal solution and the negative ideal solution.

In the TOPSIS method, a number of distance metrics can be applied. The separation of each alternative from the positive ideal solution is given as

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$$d^{+}{}_{i} = \left(\sum_{j=1}^{n}\left(v_{ij} - d^{+}{}_{j}\right)^{p}\right)^{\frac{1}{p}}, i = 1,2,\dots,m.$$

The separation of each alternative from the negative ideal solution is given as

$$d^{-}{}_{i} = \left(\sum_{j=1}^{n}\left(v_{ij} - d^{-}{}_{j}\right)^{p}\right)^{\frac{1}{p}}, i = 1,2,\dots,m.$$

Where $p \geq 1$. For $p = 2$ we have the most used tradition n-dimensional Euclidean metric.

$$d^{+}{}_{i} = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v^{+}{}_{j}\right)^{2}}, i = 1,2,\dots,m,$$

$$d^{-}{}_{i} = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v^{-}{}_{j}\right)^{2}}, i = 1,2,\dots,m,$$

Step 6. Calculate the relative closeness to the positive ideal solution.

The relative closeness of the i −th alternative A_j with respect to A^+ is defined as

$$R_i = \frac{d^{-}{}_{i}}{d^{-}{}_{i} + d^{+}{}_{i}}$$

, where $0 \leq R_i \leq 1, i = 1,2,\dots,m.$

Step 7. Rank the preference order or select the alternative closest to 1.

A set of alternatives now can be ranked by the descending order of the value of R_i.

2.5 Problem Description

In current business environment, the provision of a third party logistics service is convenient, e.g. transportation, production, warehousing, manufacturing, packaging, etc. is extended to a large number of customers in terms of globalization. The company segment selected for this research is an operational manganese ore mining company limited situated in Western Region of Ghana precisely Takoradi. The aim of the present research is to evaluate logistics service providers for hiring their service to transport the manganese ore from the mining site in Tarkwa, Nsuta the ship loading facility in the Port of Takoradi.

A series of face-to-face interviews and discussion sessions were held with the management of the company and the following problem areas were identified for improvement in supply chain of the manganese ore.

- Uncertainty is always involved in the supply of manganese to the ship loading facility and the company is unable to forecast the quantity.
- The case company does not have any well-structured business model of logistics practice.
- Huge expenses in setting up transshipment (TSV) systems at prime locations.

To solve the problems and improve the business performance, Ghana Manganese Company is ready to assign the regular transportation of manganese ore to logistics service providers. The management must have enough or the required knowledge to identify and outline the goals and benefits from outsourcing of logistics service and may be able to convince about the goal and desired achievements to the service provider. Service level desired from the logistics service providers must include both the present and the future service standards of the company. The problem addressed here is to build a sound decision support methodology to evaluation and selection of best logistics service providers. It will aid minimize the supply chain cost including procurement, inventory, etc.

IV. OUR APPROACH

4.1 Application of the Topsis Method for Ghana Manganese Company's Third Party Logistics Service Provider Selection Process

The decision matrix table below indicates the information for the application of the method for the service provider for Ghana Manganese Company.

From the table, the decision matrix is as followed with the weights of the various criterion (Cost of delivery, Compatibility, Reputation, Certification) as 35%, 25%, 25% and 15% respectively. Criteria of the functions can be: benefit functions (more is better) or cost functions (less is better). From the table, the various costs of delivery from the mining site to the transshipment facility were $250, $200, $300, $275, and $225 for Provider A, Provider B, Provider C, Provider D, and Provider E respectively. The beneficial criterion was graded by a 50% level.

Table 3: Decision Matrix With Weights Of Various Criterion

weightage	Non Benf. 0.35	Benf. 0.25	Benf. 0.25	Benf. 0.15
	Cost of delivery	**Compatibility**	**Reputation**	**Certification**
Provider A	250	31	27	40
Provider B	200	31	18	30
Provider C	300	42	31	40
Provider D	275	42	30	50
Provider E	225	31	26	20

Field data (December, 2018)

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4.2: Calculating the normalized matrix

Calculating the normalized decision matrix,

Let $x = (x_{ij})$ be a decision matrix and $w = [w_1, w_2, \dots w_n]$ a weight vector, where $x_{ij} \in \Re, w_j \in \Re$ and $w_1 + w_2 \dots w_n = 1$.

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x^2{}_{ij}}}$$

With the formula above, the figures in the table 3 were generated by:

- **For Cost of Delivery,**

For Provider A,

$$= \frac{250}{((250^2) + (200^2) + (300^2) + (275^2) + (225^2))\text{^}0.5}$$
$$= \frac{250}{(62{,}500 + 40{,}000 + 90{,}000 + 75{,}625 + 50{,}625)\text{^}0.5}$$
$$= \frac{250}{(318{,}750)\text{^}0.5}$$
$$= \frac{250}{564.57949}$$
$$= 0.44$$

For Provider B,

$$= \frac{200}{((250^2) + (200^2) + (300^2) + (275^2) + (225^2))\text{^}0.5}$$
$$= \frac{200}{(62{,}500 + 40{,}000 + 90{,}000 + 75{,}625 + 50{,}625)\text{^}0.5}$$
$$= \frac{200}{(318{,}750)\text{^}0.5}$$
$$= \frac{200}{564.57949}$$
$$= 0.35$$

For Provider C,

$$= \frac{300}{((250^2) + (200^2) + (300^2) + (275^2) + (225^2))\text{^}0.5}$$
$$= \frac{300}{(62{,}500 + 40{,}000 + 90{,}000 + 75{,}625 + 50{,}625)\text{^}0.5}$$
$$= \frac{300}{(318{,}750)\text{^}0.5}$$
$$= \frac{300}{564.57949}$$
$$= 0.53$$

For Provider D,

$$= \frac{275}{((250^2) + (200^2) + (300^2) + (275^2) + (225^2))\text{^}0.5}$$
$$= \frac{275}{(62{,}500 + 40{,}000 + 90{,}000 + 75{,}625 + 50{,}625)\text{^}0.5}$$
$$= \frac{275}{(318{,}750)\text{^}0.5}$$
$$= \frac{275}{564.57949}$$
$$= 0.49$$

For Provider E,

$$= \frac{225}{((250^2) + (200^2) + (300^2) + (275^2) + (225^2))\text{^}0.5}$$
$$= \frac{225}{(62{,}500 + 40{,}000 + 90{,}000 + 75{,}625 + 50{,}625)\text{^}0.5}$$
$$= \frac{225}{(318{,}750)\text{^}0.5}$$
$$= \frac{225}{564.57949}$$
$$= 0.40$$

- **For Compatibility**:

For Provider A,

$$= \frac{31}{((31^2) + (31^2) + (42^2) + (45^2) + (31^2))\text{^}0.5}$$
$$= \frac{31}{(961 + 961 + 1{,}764 + 2{,}025 + 961)\text{^}0.5}$$
$$= \frac{31}{(6{,}672)\text{^}0.5}$$
$$= \frac{31}{81.6823114}$$
$$= 0.38$$

For Provider B,

$$= \frac{31}{((31^2) + (31^2) + (42^2) + (45^2) + (31^2))\text{^}0.5}$$
$$= \frac{31}{(961 + 961 + 1{,}764 + 2{,}025 + 961)\text{^}0.5}$$
$$= \frac{31}{(6{,}672)\text{^}0.5}$$
$$= \frac{31}{81.6823114}$$
$$= 0.38$$

For Provider C,

$$= \frac{42}{((31^2) + (31^2) + (42^2) + (45^2) + (31^2))\text{^}0.5}$$
$$= \frac{42}{(961 + 961 + 1{,}764 + 2{,}025 + 961)\text{^}0.5}$$
$$= \frac{42}{(6{,}672)\text{^}0.5}$$
$$= \frac{42}{81.6823114}$$
$$= 0.51$$

For Provider D,

$$= \frac{45}{((31^2) + (31^2) + (42^2) + (45^2) + (31^2))\text{^}0.5}$$
$$= \frac{45}{(961 + 961 + 1{,}764 + 2{,}025 + 961)\text{^}0.5}$$
$$= \frac{45}{(6{,}672)\text{^}0.5}$$
$$= \frac{45}{81.6823114}$$
$$= 0.55$$

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For Provider E,

$$= \frac{31}{((31^2) + (31^2) + (42^2) + (45^2) + (31^2))\text{^}0.5}$$
$$= \frac{31}{(961 + 961 + 1{,}764 + 2{,}025 + 961)\text{^}0.5}$$
$$= \frac{31}{(6{,}672)\text{^}0.5}$$
$$= \frac{31}{81.6823114}$$
$$= 0.38$$

- **For Reputation,**

For Provider A,

$$= \frac{27}{((27^2) + (18^2) + (31^2) + (30^2) + (26^2))\text{^}0.5}$$
$$= \frac{27}{(729 + 342 + 961 + 900 + 676)\text{^}0.5}$$
$$= \frac{27}{(3{,}608)\text{^}0.5}$$
$$= \frac{27}{60.0666297}$$
$$= 0.45$$

For Provider B,

$$= \frac{18}{((27^2) + (18^2) + (31^2) + (30^2) + (26^2))\text{^}0.5}$$
$$= \frac{18}{(729 + 342 + 961 + 900 + 676)\text{^}0.5}$$
$$= \frac{18}{(3{,}608)\text{^}0.5}$$
$$= \frac{18}{60.0666297}$$
$$= 0.30$$

For Provider C,

$$= \frac{31}{((27^2) + (18^2) + (31^2) + (30^2) + (26^2))\text{^}0.5}$$
$$= \frac{31}{(729 + 342 + 961 + 900 + 676)\text{^}0.5}$$
$$= \frac{31}{(3{,}608)\text{^}0.5}$$
$$= \frac{31}{60.0666297}$$
$$= 0.52$$

For Provider D,

$$= \frac{30}{((27^2) + (18^2) + (31^2) + (30^2) + (26^2))\text{^}0.5}$$
$$= \frac{30}{(729 + 342 + 961 + 900 + 676)\text{^}0.5}$$
$$= \frac{30}{(3{,}608)\text{^}0.5}$$
$$= \frac{30}{60.0666297}$$
$$= 0.50$$

For Provider E,

$$= \frac{26}{((27^2) + (18^2) + (31^2) + (30^2) + (26^2))\text{^}0.5}$$
$$= \frac{26}{(729 + 342 + 961 + 900 + 676)\text{^}0.5}$$
$$= \frac{26}{(3{,}608)\text{^}0.5}$$
$$= \frac{26}{60.0666297}$$
$$= 0.43$$

- **For Certification:**

For Provider A,

$$= \frac{40}{((40^2) + (30^2) + (40^2) + (50^2) + (20^2))\text{^}0.5}$$
$$= \frac{40}{(1{,}600 + 900 + 1{,}600 + 2{,}500 + 400)\text{^}0.5}$$
$$= \frac{40}{(7{,}000)\text{^}0.5}$$
$$= \frac{40}{83.6660027}$$
$$= 0.48$$

For Provider B,

$$= \frac{30}{((40^2) + (30^2) + (40^2) + (50^2) + (20^2))\text{^}0.5}$$
$$= \frac{30}{(1{,}600 + 900 + 1{,}600 + 2{,}500 + 400)\text{^}0.5}$$
$$= \frac{30}{(7{,}000)\text{^}0.5}$$
$$= \frac{30}{83.6660027}$$
$$= 0.36$$

For Provider C,

$$= \frac{40}{((40^2) + (30^2) + (40^2) + (50^2) + (20^2))\text{^}0.5}$$
$$= \frac{40}{(1{,}600 + 900 + 1{,}600 + 2{,}500 + 400)\text{^}0.5}$$
$$= \frac{40}{(7{,}000)\text{^}0.5}$$
$$= \frac{40}{83.6660027}$$
$$= 0.48$$

For Provider D,

$$= \frac{50}{((40^2) + (30^2) + (40^2) + (50^2) + (20^2))\text{^}0.5}$$
$$= \frac{50}{(1{,}600 + 900 + 1{,}600 + 2{,}500 + 400)\text{^}0.5}$$
$$= \frac{50}{(7{,}000)\text{^}0.5}$$
$$= \frac{50}{83.6660027}$$
$$= 0.60$$

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For Provider E,

$$= \frac{20}{((40^2) + (30^2) + (40^2) + (50^2) + (20^2))^{\wedge}0.5}$$

$$= \frac{20}{(1{,}600 + 900 + 1{,}600 + 2{,}500 + 400)^{\wedge}0.5}$$

$$= \frac{20}{(7{,}000)^{\wedge}0.5}$$

$$= \frac{20}{83.6660027}$$

$$= 0.24$$

Table 4: Normalized Decision Matrix

	Cost of delivery	Compatibility	Reputation	Certification
Provider A	0.44	0.38	0.45	0.48
Provider B	0.35	0.38	0.30	0.36
Provider C	0.53	0.51	0.52	0.48
Provider D	0.49	0.55	0.50	0.60
Provider E	0.40	0.38	0.43	0.24

Source: Author, (2019)

4.3: Calculating the Weighted Normalized Decision Matrix

Calculating the weighted normalized decision matrix,

$$v_{ij} = w_j * n_{ij} \text{ for } i = 1, \dots, m; j = 1, \dots, n.$$

where w_j is the weight of the j-th criterion,

$$\sum_{j=1}^{n} w_j = 1$$

- **For Cost of delivery**,

Provider A = 0.44*0.35 = 0.15
Provider B = 0.35*0.35 = 0.12
Provider C = 0.53*0.35 = 0.19
Provider D = 0.49*0.35 = 0.17
Provider E = 0.40*0.35 = 0.14

- **For Compatibility,**

Provider A = 0.38*0.25 = 0.09
Provider B = 0.38*0.25 = 0.09
Provider C = 0.51*0.25 = 0.13
Provider D = 0.55*0.25 = 0.14
Provider E = 0.38*0.25 = 0.09

- **For Reputation,**

Provider A = 0.45*0.25 = 0.11
Provider B = 0.30*0.25 = 0.08
Provider C = 0.52*0.25 = 0.13
Provider D = 0.50*0.25 = 0.13
Provider E = 0.43*0.25 = 0.11

- **For Certification,**

Provider A = 0.48*0.15 = 0.07
Provider B = 0.36*0.15 = 0.05
Provider C = 0.48*0.15 = 0.07
Provider D = 0.60*0.15 = 0.09
Provider E = 0.24*0.15 = 0.04

Table 5: Weighted Normalized Decision Matrix

	Cost of delivery	Compatibility	Reputation	Certification
Provider A	0.15	0.09	0.11	0.07
Provider B	0.12	0.09	0.08	0.05
Provider C	0.19	0.13	0.13	0.07
Provider D	0.17	0.14	0.13	0.09
Provider E	0.14	0.09	0.11	0.04

Source: Author, (2019)

4.4: Calculating the Ideal Best and Ideal Worst

Calculating the Ideal best and Ideal Worst,

TABLE 6: IDEAL BEST

V+	0.12	0.14	0.13	0.09

For ideal best, $A^+ = (v^+{}_1, v^+{}_2, v^+{}_n) = \left((\max_i v_{ij} \,|j \in I), (\min_i v_{ij} \,|j \in J)\right)$

Source: Author, (2019)

TABLE 7: IDEAL WORST

V-	0.19	0.09	0.08	0.04

For ideal worst, $A^- = (v^-{}_1, v^-{}_2, v^-{}_n) = \left((\min_i v_{ij} \,|j \in I), (\max_i v_{ij} \,|j \in J)\right)$

Source: Author, (2019)

4.5: Calculating the Euclidean Distance from the Ideal Solution

Calculating the Euclidean distance from the ideal worst and ideal best,

From ideal best, $\boldsymbol{d^+{}_i = \sqrt{\sum_{j=1}^{n}(v_{ij} - v^+{}_j)^2} \;, i = 1, 2, \dots, m}$,

For Provider A,

$$= ((0.15 - 0.12)^2 + (0.09 - 0.14)^2 + (0.11 - 0.13)^2 + (0.07 - 0.09)^2)^{0.5}$$

$$((0.03)^2 + (-0.05)^2 + (-0.02)^2 + (-0.02)^2)^{0.5}$$

$$= (0.0009 + 0.0025 + 0.0004 + 0.0004)^{0.5}$$

$$= (0.0042)^{0.5}$$

$$= \mathbf{0.06}$$

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For Provider B, $((0.12-0.12)^2+(0.09-0.14)^2+(0.08-0.13)^2+(0.05-0.09)^2)^{0.5}$
$= \mathbf{0.08}$

For Provider C, $((0.19-0.12)^2+(0.13-0.14)^2+(0.13-0.13)^2+(0.07-0.09)^2)^{0.5}$
$= \mathbf{0.07}$

For Provider D, $((0.17-0.12)^2+(0.14-0.14)^2+(0.13-0.13)^2+(0.09-0.09)^2)^{0.5}$
$= \mathbf{0.05}$

For Provider E, $((0.14-0.12)^2+(0.09-0.14)^2+(0.11-0.13)^2+(0.04-0.09)^2)^{0.5}$
$= \mathbf{0.07}$

From ideal worst, $\boldsymbol{d^-{}_i = \sqrt{\sum_{j=1}^{n}\left(v_{ij}-v^-{}_j\right)^2}\ , i = 1,2,\ldots,m,}$

For Provider A,

$= ((0.15-0.19)^2+(0.09-0.09)^2+(0.11-0.08)^2+(0.07-0.04)^2)^{0.5}$
$((-0.04)^2+(0)^2+(0.03)^2+(-0.03)^2)^{0.5}$
$= (0.0016+0+0.0009+0.0009)^{0.5}$
$= (0.0034)^{0.5}$
$= \mathbf{0.06}$

For Provider B, $((0.12-0.19)^2+(0.09-0.09)^2+(0.08-0.08)^2+(0.05-0.04)^2)^{0.5}$
$= \mathbf{0.06}$

For Provider C, $((0.19-0.19)^2+(0.13-0.09)^2+(0.13-0.08)^2+(0.07-0.04)^2)^{0.5}$
$= \mathbf{0.07}$

For Provider D, $((0.17-0.19)^2+(0.14-0.09)^2+(0.13-0.08)^2+(0.09-0.04)^2)^{0.5}$
$= \mathbf{0.09}$

For Provider E, $((0.14-0.19)^2+(0.09-0.09)^2+(0.11-0.08)^2+(0.04-0.04)^2)^{0.5}$
$= \mathbf{0.06}$

4.6: Calculating the Performance Score

Calculating the performance score,

The relative closeness of the i –th alternative A_j with respect to A+ is defined as

$$R_i = \frac{d^-{}_i}{d^-{}_i + d^+{}_i}$$

, where $0 \le R_i \le 1, i = 1,2,\ldots,m.$

For Provider A,

$$R_i = \frac{0.06}{0.06+0.06} = \frac{0.06}{0.12} = \mathbf{0.51}$$

For Provider B,

$$R_i = \frac{0.06}{0.08+0.06} = \frac{0.06}{0.14} = \mathbf{0.45}$$

For Provider C,

$$R_i = \frac{0.07}{0.07+0.07} = \frac{0.07}{0.14} = \mathbf{0.53}$$

For Provider D,

$$R_i = \frac{0.09}{0.05+0.09} = \frac{0.09}{0.14} = \mathbf{0.65}$$

For Provider E,

$$R_i = \frac{0.06}{0.07+0.06} = \frac{0.06}{0.13} = \mathbf{0.44}$$

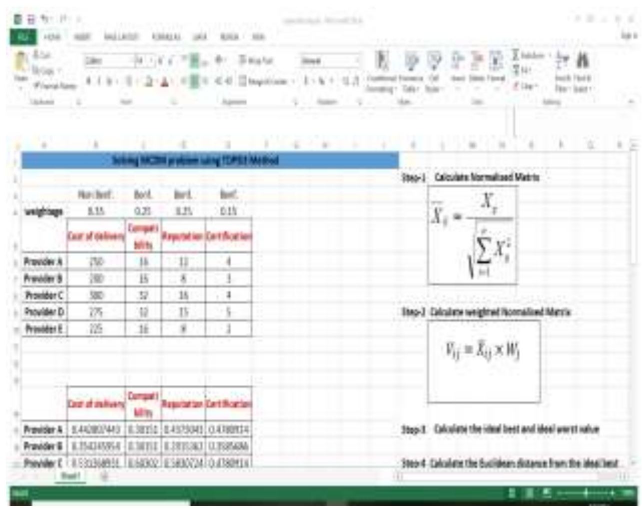

Figure 3: Illustration of the decision matrix with weights of the various criterion on Excel
Source: Author, (2019).

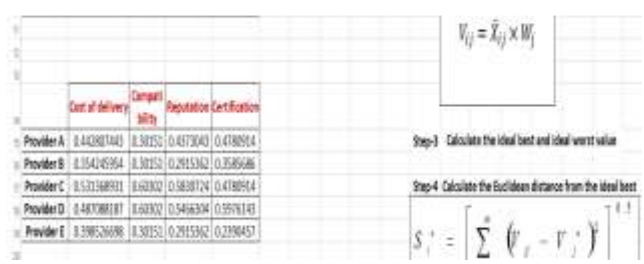

Figure 4: Illustration of the results of the calculated Normalized Matrix on Excel
Source: Author, (2019).

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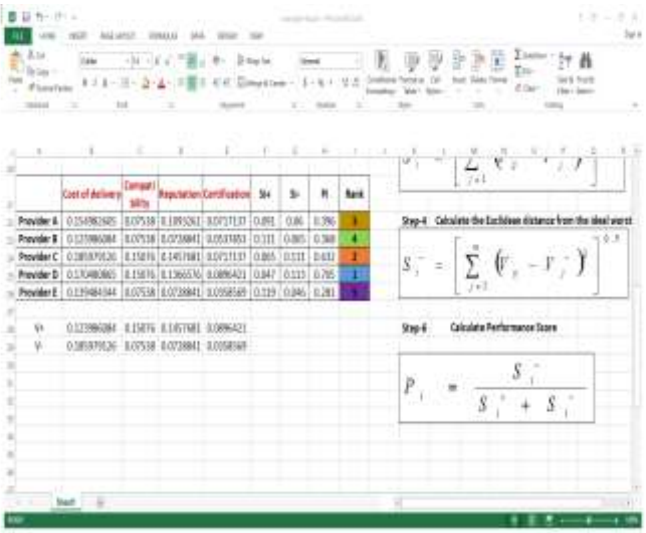

Figure 5: Illustration of the results of the performance score and ranking of the providers from the best to worst. Source: Author, (2019)

4.7: Ranking the Performance Score Results

Ranking the performance score for the various providers, **Provider D** was ranked **1st** with a performance score of **0.65**. **Provider C** was ranked **2nd** with performance score of **0.53**. **Provider A** was ranked **3rd** with a performance score of **0.51**. **Provider B** was ranked **4th** with performance score of **0.45** and **Provider D** was ranked **5th** with performance score of **0.44**. The ranking was based on the performance score which is closer to the integer 1.

V. CONCLUSION

According to the results obtained by the TOPSIS method, **Provider D** is favored over the other providers (**A, B, C,** and **E**) with the highest performance score of **0.705**. This superiority of Provider D with respect to the other 4 providers can be explained by the experience of the company in 3PL sector, financial performance and the fact that it has a very strong infrastructure of information technologies. The most important factor in the provider selection was found to be Cost of delivery with a (35%) weight followed by Compatibility and Reputation with (25%) weight and certification with (15%) weight respectively.

As part of the benefit that may accrue to Ghana Manganese Company when they engage a Third Party Logistics Service Provider for their road haulage services would include:

- The ability to organize a well-structured business model for logistics practices

When a 3PL is engaged, GMC can structure their logistics practices by ultimately naming the provider in their supply chain as their service provider and maintaining the relationship to increase effectiveness and efficiency in the entire supply chain of Ghana Manganese Company

- Cost reduction or much better, the elimination of the huge cost of setting transshipment facilities at prime locations

Initially, Ghana Manganese Company considered setting up transshipment facilities because the logistics practices in its supply chain was not well-structured.

5.4 Recommendations

Based on the findings and the conclusion of this research, the researcher recommends the following to Ghana Manganese Company;

- The decision maker must not be misled by the fact that logistics service at a minimum cost is one of the prerequisites for achievement. This indicates that the Certification criterion must not be overlooked. Since criteria and its importance were determined by the company requirements, another study of a different company may obtain different selection or scrutiny criteria and their importance or priority.
- The company should engage third party logistics service providers in its entire supply chain since most of the logistics activities in its supply chain are not in their core competence.
- The company should access the infrastructures for the third party services very well to enjoy privileges. In this case, the trucks that are used by the service provider so that the supply of the manganese to the ship loading facility can be forecasted and ultimately to enjoy economies of scale as a result.

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