APPLICATION OF TOPSIS TO PRIORITIZE WELDING AND FABRICATION OPERATIONS IN NIGERIA

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Abstract

Most researchers have paid a lot of attention to weld integrity, quality and process optimization but no attention has been paid towards the future and sustainability of the fabrication industries in Nigeria. The Nigerian fabrication industries is poorly developed as most of the heavy metal construction are outsourced to offshore companies which amounts to millions of dollars yearly ,which has a great effect on the employability of locally trained welders. This study was carried out with the aim of predicting the future of welding operations in Nigeria. To achieve this aim, secondary data was collected from the archive of RAYBEN fabrications, the data captures types of welding operations such as barge maintenance, oil tanker fabrication, boat maintenance and pipeline fabrication. A thirteen year data was collected and analyzed using the techniques for order preference by similarity to ideal solution (TOPSIS).The data collected from the archives of RAYBEN was normalized by using the expert weighted evaluation method which converts the data into values between 0 and 1 the normalized data was separated into the positive and negative ideal solution whose values were used to generate values for the relative closeness to the ideal solution. From the results it is clear that revenue and salary 7 has the highest value of the relative closeness to the ideal solution which corresponds to 63 numbers of barge maintenance, 49 oil tankers fabrication and 54 pipeline fabrication.

Introduction

Cary and Helzer (2005) mentioned that welding has gained a lot of attention globally since it is one of the means used for assembling materials in the most effective and cost-effective way. Current skills behind welding have hugely created prospects to add more value to welded structures and products. Typical examples are the cars, air-crafts, vessels, trains, space shuttles, offshore platforms, to name but a few. As these structures are predominated by metals, the quest for the use of metals in manufacturing innovative products by utilizing welding as the main joining process is highly necessary. In recent times, the interest in welding activities in emerging economies in Nigeria is on the increase. This interest is as a result of the increasing need to outsource welding manufacturing jobs to developing economies since welding manufacturing jobs in developed economies are becoming more expensive but cheaper in emerging economies, and also the need to increase welding purchasing generally. Ericsson, (2012) observed that massive investments have currently taking place and growth in investments in the next ten years in emerging economies especially in Africa is highly feasible. The Nigerian fabrication industries is poorly developed as most of the heavy metal construction are outsourced to offshore companies ,which amounts into millions of dollars yearly ,research study on the future of welding and fabrication and its economic impact has not been examined in Nigeria following this interest and the technological shift in metal production. Nevertheless, very few research studies articles have been published about welding activities and practices in Nigeria.

Adu, (2012)mentioned that most research studies tend to focus on general practices , and health and safety issues in welding rather than quality, productivity and economy issues. Mathers (2013) reported that welding economy covers everything about welding operation being it quality issues, productivity issues, training issues, health and safety issues, environmental issues, and customer satisfaction. Performing welding in economical way therefore requires that all these issues are clarified and properly dealt with. The economy of welding however falls short if any of the above mentioned issues is not attended to in the most appropriate way.

Research Design

Research design can be described as a major procedure to be followed in carrying out research. Scientifically conducted research works are mostly structured in such a way that there is an integrated framework for the control of data collection and analysis. Accordingly, the Case Study method involving the use of secondary data to evaluate the future of the welding industry. The relevant welding production data and time series data were collected, analyzed and appropriate forecast was made.

Population of the Study

Population here describes all the items of subjects that possess characteristics of the phenomenon under study. The population of interest is RAYBEN welding and fabrication yard a sample size of the population was considered in respect to welding revenue ,salary , quantity of barge repairs ,tanker fabrication and pipeline construction.

Sources of Data

The type of data required for research may be nominal, ordinal or interval data. The source of data to be collected and used determines to a large extent the reliability and accuracy of the data collected. The data used in this study is obtained from a secondary source.

TOPSIS MODEL

The TOPSIS method referred to as (TECHNIQUES FOR ORDER PREFERENCE BY SIMILARITY TO IDEAL SOLUTION) used for optimizing data is broken down into steps as presented herein-under

Steps-1

Construct the normalized decision matrix

- to transform the various attribute dimensions into **non-**dimensional attributes, which allows comparison across the attributes

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{1}$$

Steps-2

Construct the weighted normalized decision matrix

$$V = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1j} & \cdots & v_{1n} \\ \vdots & \vdots & & \vdots & & \vdots \\ v_{i1} & v_{i2} & & v_{ij} & & v_{in} \\ \vdots & \vdots & & \vdots & & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mj} & \cdots & v_{mn} \end{bmatrix} = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \cdots & w_j r_{ij} & \cdots & w_n r_{1n} \\ \vdots & \vdots & & \vdots & & \vdots \\ w_1 r_{i1} & w_2 r_{i2} & & w_j r_{ij} & & w_n r_{in} \\ \vdots & \vdots & & \vdots & & \vdots \\ w_1 r_{m1} & w_2 r_{m2} & \cdots & w_j r_{mj} & \cdots & w_n r_{mn} \end{bmatrix} \tag{2}$$

Weight Allocation

Ozturk and Batuk **(2011) said that t**he derivation of weights is a central step in eliciting the decision-maker's preferences. A weight can be defined as a value assigned to an evaluation criterion that indicates its importance relative to other criteria under consideration. As the value of the weight increases, the criterion's importance in the overall utility also increases. The weights are usually normalized to sum to 1. In the case of *n* criteria, a set of weights is defined as follows

$$W_{ij} = \left(W_1, W_2, ---, W_{j---}, W_n\right), \quad \sum W_{ij} = 1 \qquad (3)$$

The simplest method to assess the importance of weights is to arrange them in rank order. Every criterion under consideration is ranked in the order of the decision-maker's preference. Once the ranking is established for a set of criteria, several procedures are available to generate numerical weights from rank order information .

In the rating method, the decision-maker estimates weights based on a predetermined scale; for example, a scale of 0 to 100 can be used (Malczewski, 1999).

Rating weights are calculated according to Eq. (3.3) (Ananda and Herath 2006).

$$W_{ij} = \frac{W}{\sum_{j-0}^{i=0} W} \qquad (4)$$

Wu **and** *Olson (2006)* **said that i**n decision analysis, these weights would reflect relative criterion importance (as long as scale differences are eliminated through standardization). Here, they are interested in the relative value of each attribute in explaining the outcome of each case. These *m* weights *wi* will be between 0 and 1 and will have a sum of 1.

Steps-3

Determine ideal and negative-ideal solutions

$$\left.\begin{aligned} A^{+} &= \{(\max_{i} v_{ij} \mid j \in J), (\min_{i} v_{ij} \mid j \in J') \mid i = 1,2,\ldots m\} \\ &= \{v_1^{+}, v_2^{+}, \ldots, v_j^{+}, \ldots, v_n^{+}\} \\ A^{-} &= \{(\min_{i} v_{ij} \mid j \in J), (\max_{i} v_{ij} \mid j \in J') \mid i = 1,2,\ldots m\} \\ &= \{v_1^{-}, v_2^{-}, \ldots, v_j^{-}, \ldots, v_n^{-}\} \\ \text{where } J &= \left\{ j = 1,2,\ldots,n \mid j \text{ associated with benefit criteria} \right\} \\ J' &= \left\{ j = 1,2,\ldots,n \mid j \text{ associated with cost criteria} \right\} \end{aligned}\right\} \qquad (5)$$

Steps-4

Calculate the separation measure

–ideal separation

$$s_i^{+} = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^{+} \right)^2} \qquad i = 1,2,\ldots,m \qquad (6)$$

– negative-ideal separation

$$S_i^- = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^-\right)^2} \qquad i = 1, 2, ..., m \tag{7}$$

Steps-5

Calculate the relative closeness to the ideal solution

$$\left.\begin{aligned} C_i^* &= \frac{S_i^-}{\left(S_i^+ + S_i^-\right)}, 0\angle C_i^+ \angle 1; i = 1, 2, ..., m \\ C_i^* &= 1, if\ A_i = A^+ \\ C_i^* &= 0, if\ A_i = A^- \end{aligned}\right\} \tag{8}$$

Steps-6

Rank the preference order

- A set of alternatives can now be preference ranked according to the descending order of c_i^*

Jahanshahloo et al (2006) said that to rank the preference order. Ranking of alternatives using this index, alternatives can be ranked in decreasing order. They said further that the basic principle of the TOPSIS method is that the chosen alternative should have the "shortest distance" from the positive ideal solution and the "farthest distance" from the negative ideal solution.

Results and discussion

Table 1: Welding and fabrication data from RAYBEN Nigeria

Year	Pipe line fabrication	Oil tanker fabrication	Barge maintenance and repair	Revenue million(USD)	Salary (USD)
2005	62	33	34	10.2	1000
2006	15	27	42	12.3	1300
2007	52	18	47	19	1500
2008	18	13	34	22.08	2000
2009	33	22	18	13.5	2100
2010	27	19	56	18	1900
2011	54	49	63	37	2200
2012	19	27	57	21	1800
2013	21	27	53	23	2000
2014	26	26	13	17	1800
2015	32	22	44	25	1900
2016	37	18	27	17	1800
2017	24	19	33	18	2000
Expert score Weight, w_{ij}				4 0.3076923	5 0.3846154

Table 2: Weighted Normalization Process

	Revenue	Salary
1	0.3076923 x 0.137 = 0.04228	0.3846154 x 0.1522 = 0.0585
2	0.3076923 x0.1657 = 0.05098	0.3846154 x 0.1979 = 0.0761
3	0.3076923 x 0.2560 = 0.0787	0.3846154 x 0.2284 = 0.0878
4	0.3076923 x 0.297 = 0.0913	0.3846154 x 0.3045 = 0.1171
5	0.3076923 x 0.1818 = 0.0559	0.3846154 x 0.3197 = 0.1229
6	0.3076923 x 0.2425 = 0.0746	0.3846154 x 0.2893 = 0.1112
7	0.3076923 x 0.4985 = 0.1533	0.3846154 x 0.3349= 0.1288
8	0.3076923 x 0.2829 = 0.0870	0.3846154 x 0.2740 = 0.1053
9	0.3076923 x 0.3098 = 0.0953	0.3846154 x 0.3045 = 0.1171
10	0.3076923 x 0.2290 = 0.0704	0.3846154 x 0.2740 = 0.1053
11	0.3076923 x 0.336 = 0.1033	0.3846154 x 0.2893 = 0.11126
12	0.3076923 x 0.229 = 0.0704	0.3846154 x 0.2740 = 0.105
13	0.3076923 x 0.2425 = 0.0746	0.3846154 x 0.3045 = 0.117
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From Table 2, the positive ideal solution (PIS) denoted by A^+ comprises of the highest values of revenue and salary, which are as follows:

$V^+_j = A^+ = [0.1533, 0.1288]$

Also, from Table 5 the negative ideal solution (NIS) denoted as A^- which is the lowest values of revenue and salary respectively

$V^-_j = A^- = [0.04228, 0.0585]$

Table 3 shows the separation from the positive and negative ideal solution

Table 3: Separation from the Positive and Negative Ideal Solution

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year	$S_j^+ = \left[\sum\left(V_i^+ - V_{ij}\right)^2\right]^{\frac{1}{2}}$	$S_j^- = \left[\sum\left(V_i^- - V_{ij}\right)^2\right]^{\frac{1}{2}}$
1	$\begin{bmatrix}(0.1533-0.04228)^2\\+(0.1288-0.0585)^2\end{bmatrix}^{\frac{1}{2}}=0.131$	$\begin{bmatrix}(0.04228-0.04228)^2\\+(0.0585-0.0585)^2\end{bmatrix}^{\frac{1}{2}}=0$
2	$\begin{bmatrix}(0.1533-0.05098)^2\\+(0.1288-0.0761)^2\end{bmatrix}^{\frac{1}{2}}=0.115$	$\begin{bmatrix}(0.04228-0.05098)^2\\+(0.0585-0.0761)^2\end{bmatrix}^{\frac{1}{2}}=0.103$
3	$\begin{bmatrix}(0.1533-0.0787)^2\\+(0.1288-0.0878)^2\end{bmatrix}^{\frac{1}{2}}=0.085$	$\begin{bmatrix}(0.04228-0.0787)^2\\+(0.0585-0.0878)^2\end{bmatrix}^{\frac{1}{2}}=0.0466$
4	$\begin{bmatrix}(0.1533-0.0913)^2\\+(0.1288-0.1171)^2\end{bmatrix}^{\frac{1}{2}}=0.063$	$\begin{bmatrix}(0.04228-0.0913)^2\\+(0.0585-0.1171)^2\end{bmatrix}^{\frac{1}{2}}=0.076$
5	$\begin{bmatrix}(0.1533-0.0559)^2\\+(0.1288-0.1229)^2\end{bmatrix}^{\frac{1}{2}}=0.097$	$\begin{bmatrix}(0.04228-0.0559)^2\\+(0.0585-0.1229)^2\end{bmatrix}^{\frac{1}{2}}=0.065$
6	$\begin{bmatrix}(0.1533-0.0746)^2\\+(0.1288-0.1112)^2\end{bmatrix}^{\frac{1}{2}}=0.080$	$\begin{bmatrix}(0.04228-0.0746)^2\\+(0.0585-0.1112)^2\end{bmatrix}^{\frac{1}{2}}=0.061$
7	$\begin{bmatrix}(0.1533-0.1533)^2\\+(0.1288-0.1288)^2\end{bmatrix}^{\frac{1}{2}}=0$	$\begin{bmatrix}(0.04228-0.1533)^2\\+(0.0585-0.1288)^2\end{bmatrix}^{\frac{1}{2}}=0.131$
8	$\begin{bmatrix}(0.1533-0.0870)^2\\+(0.1288-0.1053)^2\end{bmatrix}^{\frac{1}{2}}=0.070$	$\begin{bmatrix}(0.04228-0.0870)^2\\+(0.0585-0.1053)^2\end{bmatrix}^{\frac{1}{2}}=0.064$
9	$\begin{bmatrix}(0.1533-0.0953)^2\\+(0.1288-0.1171)^2\end{bmatrix}^{\frac{1}{2}}=0.059$	$\begin{bmatrix}(0.04228-0.0953)^2\\+(0.0585-0.1171)^2\end{bmatrix}^{\frac{1}{2}}=0.0789$
10	$\begin{bmatrix}(0.1533-0.0704)^2\\+(0.1288-0.1053)^2\end{bmatrix}^{\frac{1}{2}}=0.0861$	$\begin{bmatrix}(0.04228-0.0704)^2\\+(0.0585-0.1053)^2\end{bmatrix}^{\frac{1}{2}}=0.054$
11	$\begin{bmatrix}(0.1533-0.1033)^2\\+(0.1288-0.11126)^2\end{bmatrix}^{\frac{1}{2}}=0.052$	$\begin{bmatrix}(0.04228-0.1033)^2\\+(0.0585-0.11126)^2\end{bmatrix}^{\frac{1}{2}}=0.080$
12	$\begin{bmatrix}(0.1533-0.0704)^2\\+(0.1288-0.105)^2\end{bmatrix}^{\frac{1}{2}}=0.086$	$\begin{bmatrix}(0.04228-0.0704)^2\\+(0.0585-0.105)^2\end{bmatrix}^{\frac{1}{2}}=0.054$
13	$\begin{bmatrix}(0.1533-0.0746)^2\\+(0.1288-0.117)^2\end{bmatrix}^{\frac{1}{2}}=0.079$	$\begin{bmatrix}(0.04228-0.0746)^2\\+(0.0585-0.117)^2\end{bmatrix}^{\frac{1}{2}}=0.066$

Table 4: Relative Closeness to the Ideal Solution

Year	$C_i^+ = \frac{S_j^-}{(S_j^+ + S_j^-)}$	Rank
1	$\frac{0}{0.131+0} = 0$	13
2	$\frac{0.103}{0.115+0.103} = 0.472$	6
3	$\frac{0.0466}{0.085+0.0466} = 0.354$	12
4	$\frac{0.076}{0.063+0.076} = 0.546$	4
5	$\frac{0.065}{0.097+0.065} = 0.401$	9
6	$\frac{0.061}{0.08+0.061} = 0.432$	8
7	$\frac{0.131}{0+0.131} = 1$	1
8	$\frac{0.064}{0.07+0.064} = 0.477$	5
9	$\frac{0.078}{0.059+0.078} = 0.569$	3
10	$\frac{0.054}{0.0861+0.054} = 0.385$	11
11	$\frac{0.080}{0.052+0.080} = 0.606$	2
12	$\frac{0.054}{0.086+0.054} = 0.386$	10
13	$\frac{0.066}{0.079+0.066} = 0.45$	7

Conclusion

In this study, the future of RAYBEN Fabrication Company, its economic and productivity components have been examined. This company is known for pipeline fabrication, Barge maintenance and oil and gas tankers fabrication. The TOPSIS model was used to select the most lucrative and favorable welding fabrication jobs in the metal construction industry. A thirteen year data comprising salary and revenue for the company was collected, normalized and expert weight computation was of done, thereafter a positive and negative ideal solution was determined. the result showed that solution for year seven was closest to the ideal solution and was selected as the best The study has successfully applied the TOPSIS model to examine the future opportunities available in the fabrication industries which has not been established .This study has shown that Barge maintenance jobs are the key revenue generators, as they rake in huge revenue for the company as well as welders salary and also shows that the future of welding and fabrication seems to be very lucrative both for fabrication investors and welding professionals as the demand for heavy metal fabrication will be on high demand.

Reference

Adu .E (2011) "Research Survey of Current Welding Practices in Selected Metal Welding Industries in Ghana," Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Cary .H.B and Helzer S.C (2005) "Modern Welding Technology, Pearson Education, Inc.: New Jersey, USA,

Ericsson .M (2012) "Trends in the Mining and Metal Industry," International Council on Mining and Metals, London, UK,

Mathers . G "Welding Cost," Job Knowledge 96, 30 July 2013.

Ozturk D. and Batuk, F. (2011) Technique for order preference by similarity to ideal solution (TOPSIS) for spatial decision problems.

Malczewski J (1999) *GIS and Multicriteria Decision Analysis*. Wiley, New York.

Ananda J, Herath G (2006) "Analysis of forest policy using multi-attribute value theory in *using multi-criteria decision analysis in natural resource management*, Eds.

G. Herath and T. Prato, Ashgate Publishing Ltd., Hampshire, pp. 11-40.

Wu D. Olson D. (2006) A TOPSIS data mining demonstration and application to credit scoring. Intl Journal of Data Warehouse and Mining 2(3), 1-10, July-September (2006)

Jahanshahloo GR, Hosseinzadeh LF, Izadikhah M (2006) Extension of the TOPSIS method for decision-making problems with fuzzy data. Applied Maths and Computing 181: 1544–1551