THE PERFORMANCE INDICES FOR SHIPPING ALLIANCE

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Abstract: This article presents a performance index to the evaluation of shipping alliance competitiveness. The estimation program and solved by our performance index. Based on the output/input table for shipping alliances are derived, the input/output can be aggregated into the performance index for shipping alliance, by which each shipping alliance can classify his own competitiveness. The performance index can be further integrated into an overall performance indices, by which shipping alliances can classify their competitiveness ranking.

Key Words: The performance index, shipping alliance, competitiveness ranking

1. INTRODUCTION

Decision Making Units (DMUs) are units of organizations such as banks, universities, and hospitals, which typically perform the same function. A DMU usually uses a set of inputs to secure a set of outputs. Our propose is to develop a new decision making units methodology from modeling unstructured programs in the economic, social, and management sciences. When we think, we identify objects or ideas and also relations among them. The weight factor is obviously important, weights that reflect the relations of various inputs and outputs are usually needed in order to obtain such kind of single measure. In real world situations, there exist peer groups of DMUs, such as governments, enterprises, industries, etc., which use various resource (inputs) to generate various results (outputs). For example, harbors may use two labor inputs, operators and engineers, and capital inputs such as offices and areas to produce research and efficiency. We may want to know the overall performance of DMUs by their outputs consumed and inputs generated. It is desirable that we are able to combine various outputs and inputs into one measure, such as the ratio of aggregated outputs to aggregated inputs (output/input), so that we can evaluate and rank the performance of DMUs to agree with “single measure”.

There are some possible ways to determine the weight. We could use Delphi method, Analytical Hierarchical Process method, etc., to specify the weights. Of course, any DMUs size less than 5-8 could be used. We could also user optimization or multivariate statistical
techniques to find the weight. The mathematical programming approach knows, as Data Envelopment Analysis (DEA) is one popular optimization method used for measure the relative efficiency of DMUs. The discussion in DEA provides a very brief introduction to modern efficiency measurement. DEA proposed that the efficiency of firms consists of two components: one is technical efficiency the other is allocating efficiency; these two measures are then combined to provide a measure of total economic efficiency. One main advantage of DEA is that it allows several inputs and several outputs to be considered at the same time.

Principal component analysis (PCA) is also a popular ranking method in multidimensional analysis; it is data reduction skill used to identify a small set of variables that account for a large portion of the total variance in the original variables (Bolch and Huang, 1974). DEA has compared with regression. For example, Banker et al applied DEA and translog method approach with the same hospital data (Banker, Conrad and Strauss, 1986). DEA is also compared with PCA. Zhu (1998) applied DEA and PCA approach with the same Chinese cities. MDS has more advantage than PCA and DEA. First, MDS is based on distance between points whereas the PCA is based on the angles between vectors; it is easier to interpret distances between points than angles between vectors. Secondary, PCA has a strict assumption those linear relationships between the variables, when data reduction, it will lose some original information. The MDS approach dose not contains this strict assumption (Susan et al., 1981; Daniel, 1978), and it can use data for a hundred percentages.

In order to conduct MDS process, we first define some new measures by each input and each outputs. That is, we define individual output to input ratios for each DMUs. The MDS for newly defined measure are then determined. Finally, a single measure is obtained by weight the MDS in terms of the information on one-dimensional coordinates. The coordinate is a rough score, we trans it to a single measure; we called it the performance index. MDS is applied to real world data set for measure the economic performance of global alliance in shipping industry.

The remained of the article is structured as follows. Section 2 presents the MDS method. Section 3, we applied the method to global alliance in shipping industry. Finally, the conclusions are made in section 4.

2 A MDS APPROACH TOWARD THE PERFORMANCE INDICES
In this section, we introduce some fundamental concepts that are necessary for proper understanding of the Multidimensional Scale Method and performance indices. MDS include
DEA’s strength that is in simultaneously considering multiple inputs and multiple inputs without any need for a priori assignment of weight. But MDS does not include PCA’s weakness that reduce data will lose some original information. When employing the Takane, Young, and de Leeuw (1978) and Young, Takane, and Lewyckyj (1977) methodology, MDS is an iterative program, each iteration consists two subjects, one that tries to estimate the best possible order-preserving transformation of the raw data and the other of which estimates stimulus coordinates and weights. Following Schiffman, Reynolds, and Young (1981), We get the following well know Young (1978) ALSCAL model (step1-step6). We will also apply steps “eight” to compute performance indices $d$, in this section (Chou and Lee, 2004).

**Step1**: Estimate an additive constant $C_k$, which is added to the observed proximity measures, for illustration, $o_{ijk}$. Thus,

$$o_{ijk}^* = o_{ijk} + c_k$$

such that for all triples the triangular inequality holds:

$$o_{ijk}^* + o_{jlk}^* \geq o_{ilk}^*$$

and $o_{ijk}^* \geq 0$

where

- $o_{ijk}^*$ is the adjusted proximity between stimulus $i$ and stimulus $j$ for subject $k$
- $o_{jlk}^*$ is the adjusted proximity between stimulus $j$ and stimulus $l$ for subject $k$
- $o_{ilk}^*$ is the adjusted proximity between stimulus $i$ and stimulus $l$ for subject $k$

This step is necessary to make the $B_k^*$ matrix, described below, positive semidefinite.

**Step2**: Compute a scalar product matrix $B_k^{**}$ for each subject $k$ by double centering $O_k^*$, the $B_k^{**}$ matrix $b_{ijk}^{**}$ is computed as follows:

$$b_{ijk}^{**} = -\frac{1}{2}(o_{ijk}^* - o_{i,k}^* - o_{j,k}^* + o_{k}^*)$$

where
The row means for the adjusted proximities for subject $k$ are $o_{i,k}^*$, the column means for the adjusted proximities for subject $k$ are $o_{j,k}^*$, and the grand mean for subject $k$ is $o_{.,k}^*$.

**Step 3:** Normalized so that they have the same variance, the normalized matrix $B_k^*$ is found for each subject. The elements of the matrix are

$$b_{ij,k}^* = \frac{b_{ij,k}^{**}}{\sqrt{\left(\sum_i \sum_j (b_{ij,k}^{**})^2 / (n(n-1))\right)}}$$

where $n$ is the number of stimuli, $n(n-1)$ is the number of off-diagonal elements in the $B_k^{**}$ matrix. The denominator is both the root mean square and the standard deviation of the unnormalized scalar products matrix $B_k^{**}$.

**Step 4:** Computed an average $B_k^*$ matrix over the subjects. The matrixes are

$$b_{ij,k}^* = \frac{\sum b_{ij,k}^*}{m}$$

where $m$ is the number of subjects.

**Step 5:** Computed an initial stimulus configuration. The initial stimulus configuration is computed as follows:

$$B_1^* = XX'$$

where $X$ is an $n \times 1$ matrix of $n$ stimulus points on one-dimensions, the $X$ matrix is the initial configuration.

**Step 6:** Computed initial weight configuration matrices $W_k$. The initial weight matrices $W_k$ are $1 \times 1$ matrices, such that $B_k^* = YW_kY'$, where $Y = XT$ and $TT' = I$, and where $T$ is an
orthogonal rotation of the configuration $X$ to a new orientation $Y$. (If not optimal solutions then go back step1.)

**Step7:** Used ALSCA process to reproduce the one-dimensional coordinates $Y = (y_i)$. 

**Step8:** One-dimensional coordinates in step 7 are used to compute performance index of $DMU_j$. The performance indices are 

$$d_j = \frac{e^{y_j-y_i}}{\sum_i e^{y_j-y_i}}$$

where $y_j$ is the index of $DMU_j$ (ith decision-making unit.)

The first set of Aggregated Performance index is computed from the coordinates and exp-weights found in the one-dimensional coordinate. Subsequently, new Aggregated performance indices are computed from new coordinates found in the iteration process. To the last, we use monotonic transformation to ranking decision-making units.

### 3 AN EMPIRICAL EXAMPLE WITH GLOBAL ALLIANCE IN SHIPPING INDUSTRY

In order to demonstrate the usefulness of the technique developed herein, we apply it to a data set from the global alliance in shipping industry (Shipping Digest, 1999-2000). Table 1 provides five shipping alliance and two operation zones in 1999. Two inputs and two outputs were chosen to characterize the technology of these shipping alliance. Note that these input and output measure are of particular important to the activities of shipping alliance under study.

Output1 (Y1): Total shipping alliance output value of the Pacific Ocean (TEUs) where TEU is the 20-foot equivalent container units,

Output2 (Y2): Total shipping alliance output value of the Far East and Europe (TEUs) where TEU is the 20-foot equivalent container units,

Input1 (X1): The shipping alliance operating route of the Pacific Ocean route,

Input2 (X2): The shipping alliance handling ship number of the Pacific Ocean route,
Input3 (X3): The shipping alliance operating route of the Far East and Europe route,
Input4 (X4): The shipping alliance handling ship number of the Far East and Europe route.

Table 1 1999, shipping alliance and two operation zones

<table>
<thead>
<tr>
<th>Alliance (DMU)</th>
<th>Output1</th>
<th>Input1</th>
<th>Input2</th>
<th>Output2</th>
<th>Input3</th>
<th>Input4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand alliance (1)</td>
<td>971,620</td>
<td>5</td>
<td>32</td>
<td>1394,640</td>
<td>6</td>
<td>48</td>
</tr>
<tr>
<td>New world alliance (2)</td>
<td>1716,364</td>
<td>9</td>
<td>53</td>
<td>839,280</td>
<td>4</td>
<td>32</td>
</tr>
<tr>
<td>United alliance (3)</td>
<td>1237,704</td>
<td>7</td>
<td>37</td>
<td>951,288</td>
<td>5</td>
<td>31</td>
</tr>
<tr>
<td>K line/YML Cosco (4)</td>
<td>1133,808</td>
<td>7</td>
<td>39</td>
<td>585,780</td>
<td>3</td>
<td>23</td>
</tr>
<tr>
<td>Maersk/Sea-Land (5)</td>
<td>827,112</td>
<td>5</td>
<td>32</td>
<td>933,920</td>
<td>4</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 2 The value of Output / Input of five shipping alliance

<table>
<thead>
<tr>
<th>Output/input ratios</th>
<th>Grand alliance (1)</th>
<th>New world alliance (2)</th>
<th>United alliance (3)</th>
<th>K line/YML Cosco (4)</th>
<th>Maersk/Sea-Land (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>194,324</td>
<td>190,707</td>
<td>176,815</td>
<td>161,972.5714</td>
<td>165,422</td>
</tr>
<tr>
<td>C2</td>
<td>30,363.125</td>
<td>32,384</td>
<td>33,451.5</td>
<td>29,072</td>
<td>25,847</td>
</tr>
<tr>
<td>C3</td>
<td>232,440</td>
<td>209,820</td>
<td>190,258</td>
<td>195,260</td>
<td>233,480</td>
</tr>
<tr>
<td>C4</td>
<td>29,055</td>
<td>26,228</td>
<td>30,686.7</td>
<td>25,468.69565</td>
<td>40,605</td>
</tr>
</tbody>
</table>

Table 2 gives the value of Output / Input of five shipping alliance, we define the following four output/input ratios as follow:

\[
C_1 = \frac{Y_1}{X_1}, \quad C_2 = \frac{Y_2}{X_2}, \quad C_3 = \frac{Y_3}{X_3}, \quad C_4 = \frac{Y_4}{X_4}
\]

Table 3 MDS rankings of five shipping alliances

<table>
<thead>
<tr>
<th>Alliance</th>
<th>Rank</th>
<th>MDS scores</th>
<th>Aggregated Performance indices</th>
<th>DMU no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand alliance</td>
<td>1</td>
<td>1.2202</td>
<td>0.432795</td>
<td>1</td>
</tr>
<tr>
<td>Maersk/SeaLand</td>
<td>2</td>
<td>1.0414</td>
<td>0.361935</td>
<td>5</td>
</tr>
<tr>
<td>New world alliance</td>
<td>3</td>
<td>-0.0605</td>
<td>0.120249</td>
<td>2</td>
</tr>
<tr>
<td>United alliance</td>
<td>4</td>
<td>-1.0811</td>
<td>0.043335</td>
<td>3</td>
</tr>
<tr>
<td>K line/YML Cosco</td>
<td>5</td>
<td>-1.1199</td>
<td>0.041686</td>
<td>4</td>
</tr>
</tbody>
</table>
Table 3 gives MDS scores of five shipping alliance and two operation zones in 1999, columns 1 and 2 indicate alliance names and DMU numbers, columns 3, 4, and 5 indicate MDS score, aggregated performance indices, and DMU numbers. This analysis determines the efficiency with each shipping alliance produces a set of outputs from a set of inputs. The categories of inputs and outputs for each process are shown in Table 1. For each process, the shipping alliance has been ranked according to their aggregated indices and thus there are up to five ranking for each of the shipping alliance. The result of this individual process analysis are then aggregated using the methodology described herein to create an institutional aggregated process efficiency score. The aggregated performance indices are used to analyze the role of process efficiency in describing performance of shipping alliances.

According to Table 3, Grand alliance is the most performance alliance with other alliances. Base on this article, we find two strengths for Grand alliance. First is the service frequency, Grand alliance will aim to have at least week service. In doing so, Grand alliance make a trade-off between frequency and vessel-size on the line. Until January 2005, Grand Alliance selects loops on the East Asia Europe route and there are five operator loops and 40 vessels. Average vessel size now amounts to more than 6,000 TEU (post-panamax class). Smaller vessel class capacities allow more frequent services and as such meet shipper’s demand for lesser transit times, while large vessel class will allow operators to benefit from economies of vessel-size.

4 CONCLUSION

Strategy and policy in shipping alliance is determined by a wide range of things not least of which is the input/output context for the shipping management. In the article, we have presented a MDS for shipping alliance. With our method, the output/input table is constructed. Namely, they are the performance indices from the output/input are derived. With the performance indices, shipping alliance can identify their strength and weakness under the performance measures taken into consideration. Shipping alliance can identify their competitive positions by the output/input by aggregating the performance indices.

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