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An Innovative Approach for International Market Selection

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Abstract. This paper proposes a data envelopment analysis (DEA) model for international market selection. A numerical example demonstrates the application of the proposed model.

Keywords: International Market selection, Data envelopment analysis, Dual-role factors, Weight restrictions.

1. Introduction

One of the uses of data envelopment analysis (DEA) can be market selection. DEA was developed by Charnes, Cooper, and Rhodes [1] (Charnes, Cooper, Rhodes (CCR) model) to serve as a mechanism to evaluate the relative efficiencies of a set of similar decision making units (DMUs).

In some situations there is a strong argument for permitting certain factors to simultaneously play the role of both inputs and outputs. In the market selection context, average tariff rate for destination market can be considered as both an input and an output. If the average tariff rate is considered as an output, then the increase in the average tariff rate will increase the efficiency of the market. The reason is that the increase in the average tariff rate will decrease market attractiveness and consequently, prevent from competitor entry to the destination market. Likewise, if the average tariff rate is considered as an input, then any decrease in the average tariff rate will increase efficiency. Because the decrease in the average tariff rate will reduce the product price of the company and will increase sales volume. So, depending on how one looks at it, either increasing or decreasing the average tariff rate can increase efficiency.

As well, in many real world applications (especially market selection problems), it is essential to take into account the existence of ordinal (qualitative) factors when rendering a decision on the performance of a DMU. Motivated by those points, the objective of this paper is to propose a model to provide managers with a more effective and efficient model for selecting international markets in the presence of dual-role factors, weight restrictions, and imprecise data.

2. Proposed model

Consider a situation where members j of a set of n DMUs are to be evaluated in terms of s outputs $Y_j = (y_{rj})_{r=1}^{s}$ and m inputs $X_j = (x_{ij})_{i=1}^{m}$. In addition, assume that a particular factor is held by each DMU in the amount w_j, and serves as both an input and output factor. μ_r is the weight given to output r and v_i is the weight given to input i. DMU$_o$ is the DMU under consideration. DMU$_o$ consumes x_{io} ($i=1, \ldots, m$), the amount of input i, to produce y_{ro} ($r=1, \ldots, s$), the amount of output r. Assume that some factors are held by each DMU in the amount w_{fj} ($f=1,\ldots,F$), and serve as both an input and output factors. θ_o^U stands for the best possible relative efficiency achieved by DMU$_o$ when all the DMUs are in the state of best production activity, while θ_o^L stands for the lower bound of the best possible relative efficiency of DMU$_o$. They constitute a possible best relative efficiency interval $[\theta_o^L, \theta_o^U]$. In order to judge whether a DMU is DEA efficient or not, the following definition is given.

Definition 1. A DMU, DMU_o, is said to be DEA efficient if its best possible upper bound efficiency $\theta_o^{U*} = 1$; otherwise, it is said to be DEA inefficient if $\theta_o^{U*} < 1$.

At this point, the new model which simultaneously deals with dual-role factors, weight restrictions, and imprecise data is presented.

$$
\begin{aligned}
& Max \quad \theta_o^U = \sum_{r=1}^{s} \mu_r y_{ro}^U + \sum_{f=1}^{F} \gamma_f w_{fo}^U - \sum_{f=1}^{F} \beta_f w_{fo}^U \\
& s.t. \\
& \sum_{i=1}^{m} v_i x_{io}^L = 1 \\
& \sum_{r=1}^{s} \mu_r y_{rj}^U + \sum_{f=1}^{F} \gamma_f w_{fj}^U - \sum_{f=1}^{F} \beta_f w_{fj}^U - \sum_{i=1}^{m} v_i x_{ij}^L \le 0, \\
& \quad j = 1, \cdots, n \qquad\qquad\qquad (1) \\
& c_i \left(\sum_{i=1}^{m} x_{io}^L v_i \right) - x_{io}^L v_i \le 0, \\
& x_{io}^L v_i - d_i \left(\sum_{i=1}^{m} x_{io}^L v_i \right) \le 0, \\
& \mu_r, v_i, \gamma_f, \beta_f \ge 0 \qquad \forall r, i
\end{aligned}
$$

$$
\begin{aligned}
& Max \quad \theta_o^L = \sum_{r=1}^{s} \mu_r y_{ro}^L + \sum_{f=1}^{F} \gamma_f w_{fo}^L - \sum_{f=1}^{F} \beta_f w_{fo}^L \\
& s.t. \\
& \sum_{i=1}^{m} v_i x_{io}^U = 1 \\
& \sum_{r=1}^{s} \mu_r y_{rj}^U + \sum_{f=1}^{F} \gamma_f w_{fj}^U - \sum_{f=1}^{F} \beta_f w_{fj}^U - \sum_{i=1}^{m} v_i x_{ij}^L \le 0, \\
& \quad j = 1, \cdots, n \qquad\qquad\qquad (2) \\
& c_i \left(\sum_{i=1}^{m} x_{io}^U v_i \right) - x_{io}^U v_i \le 0, \\
& x_{io}^U v_i - d_i \left(\sum_{i=1}^{m} x_{io}^U v_i \right) \le 0, \\
& \mu_r, v_i, \gamma_f, \beta_f \ge 0 \qquad \forall r, i
\end{aligned}
$$

where c_i and d_i is user-specified parameters to reflect value judgments the manager wishes to incorporate in the assessment. Therefore, one unified approach that deals with weight restrictions, dual-role factors, and imprecise data in a direct manner have been introduced. To transform ordinal preference information into interval data the approach proposed by Wang, Greatbanks, and Yang [2] is applied.

Now, one of three possibilities exists in regard to the sign of $\hat{\gamma}_f - \hat{\beta}_f$, where $\hat{\gamma}_f, \hat{\beta}_f$ are the optimal values from model (1); $\hat{\gamma}_f - \hat{\beta}_f > 0, = 0, \text{ or } < 0$. It is useful therefore to examine the three cases in regard to this sign, which will allow us to make important interpretations pertaining to the sign of the variables $\hat{\gamma}_f - \hat{\beta}_f$.

Case 1: $\hat{\gamma}_f - \hat{\beta}_f < 0$. In this case, one can say that the dual-role factors are "behaving like inputs", hence more of these factors are worse, and would lead to a decrease in efficiency.

Case 2: $\hat{\gamma}_f - \hat{\beta}_f > 0$. In this case, one can say that the dual-role factors are "behaving like outputs", hence more of these factors are better, and would lead to an increase in efficiency.

Case 3: $\hat{\gamma}_f - \hat{\beta}_f = 0$. In this case, one can say that the dual-role factors are at equilibrium or optimal level.

3. Numerical example

For illustration purposes, the problem of international market (country) selection is introduced. Table 1 depicts the market's attributes.

Table 1. Related attributes for 18 countries

Country (DMU)	Input	Dual-role factor	Outputs	
	Number of competitors x_{1j}	Average tariff rate w_{1j}	Customer image of company* y_{1j}	Sales volume (1000 KG) y_{2j}
1	5	10%	5	[10, 50]
2	10	25%	10	[25, 40]
3	12	30%	3	[8, 18]
4	8	5%	6	[12, 50]
5	4	12%	4	[14, 50]
6	2	90%	2	[2, 60]
7	13	20%	8	[13, 70]
8	9	18%	11	[50, 60]
9	6	45%	9	[30, 60]
10	10	50%	7	[40, 50]
11	12	60%	16	[10, 55]
12	6	8%	14	[40, 70]
13	9	12%	15	[10, 35]
14	7	14%	13	[60, 90]
15	14	13%	12	[40, 80]
16	10	70%	17	[20, 45]
17	11	25%	1	[15, 65]
18	13	65%	18	[12, 35]

* Ranking such that 18 ≡ highest rank,…, 1 ≡ lowest rank ($y_{1,18} > y_{1,16} \ldots > y_{1,17}$)

According to the decision of manager, the importance of number of competitors, as expressed by the weight v_1, must be as follows:

$$0.5 \le \frac{v_1 x_{1o}}{\sum_{i=1}^{m} v_i x_{io}} \le 3$$

Table 2 reports the results of efficiency assessments and their inputs/outputs behavior for the 18 countries obtained by using model (1).

Table 2. Efficiency scores and input/output behavior

Country (DMU)	Efficiency score (θ_o^{U*})	$\hat{\gamma}_1$	$\hat{\beta}_1$	$\hat{\gamma}_1 - \hat{\beta}_1$
1	.76	0	.6612	-.6612
2	.39	.0523	0	.0523
3	.16	.04358	0	.04358

4	1	0	65	-65
5	.94	0	.826	-.826
6	1	1.111	0	1.111
7	.4	0	.254	-.254
8	.51	0	.294	-.294
9	.61	0	.4413	-.4413
10	.3	.0523	0	.0523
11	.65	.04358	0	.04358
12	1	0	0	0
13	.75	.05811	0	.05811
14	1	0	.3782	-.3782
15	.44	0	.18912	-.18912
16	.87	.0523	0	.0523
17	.42	0	.301	-.301
18	.75	.0402	0	.0402

Based on the definition 1, countries 4, 6, 12, and 14 have the possibility to be DEA efficient. Therefore, decision maker can choose one or more of these efficient countries. The countries 1, 4, 5, 7, 8, 9, 14, 15, and 17 are those that average tariff rate is behaving like an input. The countries 2, 3, 6, 10, 11, 13, 16, and 18 are those that average tariff rate is behaving like an output, where more of such factor would improve the efficiencies of related countries. The country 12 is the DMU that average tariff rate is in equilibrium.

4. Concluding remarks

Effective market selection is a strategic decision that affects export performance. Errors can be costly and may also dampen the firm's export enthusiasm. Papadopoulos, Chen, and Thomas [3] discuss that exporters who select targets from the total set of available countries realize more rapid export growth than those who consider only a few (or no) alternatives. The need for a systematic market selection approach is understood by the complexity of current markets and the growing importance of global strategic positioning.

In this paper, a DEA based model that allows identifying the best markets is presented. The problem considered in this study is at initial stage of investigation and much further researches can be done based on the results of this paper. Some of them are as follows:

- Similar research can be repeated for dealing with fuzzy data in the conditions that dual-role factor and weight restrictions exist.
- This study used the proposed model for international market selection. It seems that more fields (e.g. technology selection, personnel selection, etc) can be applied.
- Determining returns to scale in the presence of weights restrictions, dual-role factors and imprecise data is an interesting topic for future researches.
- Determining the status of multiple dual-role factors in the presence of multiple optimal solutions is another attractive subject for future studies.

5. References

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