The use of data envelopment analysis for international market selection in the presence of multiple dual-role factors

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Abstract: Selection of international market (IM) is a critical decision and needs to be made with considerable attention and deliberation. In some situations however, some criteria have the nature of both cost and profit. Likewise, in data envelopment analysis (DEA) some criteria play both input (cost) and output (profit) roles, simultaneously. In the DEA literature such criteria are called dual-role factors. Hence, the objective of this paper is to develop a new model for international market selection (IMS), using DEA based on ternary variable in the presence of dual-role factors. A case study illustrates the application of the proposed model.

Keywords: international market selection; IMS; data envelopment analysis; DEA; dual-role factor; ternary variable.


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1 Introduction

International business is conducted in an increasingly globalised environment characterised by fewer barriers, growing competition, and greater opportunities for expansion (Papadopoulos and Martin, 2011). For these reasons, today’s business world has compelled a large number of firms to select international markets (IM) (Malhotra et al., 2009). Foreign-market opportunity analysis is the ‘most frequent objective of IM research’ (Sheng and Mullen, 2011). It is common knowledge that the marketplace is no longer restricted to a particular geographic location. Businesses no longer can expect only competition from neighbouring businesses or from businesses within their own region; the marketplace is now global. In the past, it was common to think that only the multinational firms, which employ thousands of employees and has sales revenues in the millions, consider international competition. Soon even the smallest of organisations competes on an international level (Minifie and West, 1998).

Firms enter the international marketplace for various reasons. Firms seek to site their value-added activities at the most profitable points in space (Brouthers et al., 2009). Expansion into the new IMs provides opportunities for survival and growth (Sheng and Mullen, 2011; Yeoh, 2011). Sometimes the entry into the international marketplace results from the need to provide goods at a lower cost by using labours in other countries or through the acquisition of low cost raw materials. For other businesses, international market selection (IMS) may be result of saturation in the home market, where the only possibility of increasing sales is to enter new IMs and find new consumers (Minifie and West, 1998). The other reason for selecting an IM is that it allows the transfer of ownership advantages so efficiently by which overcomes the competitive disadvantage. Internationalisation advantages also focus on minimising transaction costs in different locations. By selecting an IM in which transaction costs are low, firm performance is enhanced (Brouthers et al., 2009). Furthermore, when location advantages can be combined with firm-specific advantages, firms may be able to generate new or stronger competencies that provide an advantage over competitors. These advantages may lead to superior performance outcomes for subsidiaries (Brouthers et al., 2009). Additionally, it can help exporters set long, medium and short term plans for the future and allows them to prioritise enquiries and also it prevents to waste time and money on enquiries from infeasible markets.
The use of data envelopment analysis for international market

Selecting the best IMs can make the enterprise’s product, price and channel strategy more effective, and make good use of its tangible and intangible resources to increase the enterprise’s tangible and intangible assets (Li et al., 2004). The identification of promising IMs is an essential issue in international marketing and international business research, strategy and management (Breton and Martin, 2011). Clearly, IMS is a critical success factor for both small exporters and mature multinational firms (Papadopoulos et al., 2002). Due to the complexity, this critical decision needs to be made with considerable care and deliberation (Douglas and Craig, 2011). Systematic IMS contributes to export success whereas wrong choice can put the firm in an unfavourable strategic position (Papadopoulos et al., 2002; Papadopoulos and Martin, 2011).

The IMS theory suggests that both the pluses and minuses of the IM should be considered for effective decisions. These are commonly expressed as tradeoffs between opportunities vs. risks, costs vs. benefits, or cost vs. control (Malhotra et al., 2009; Papadopoulos et al., 2002). Yet, an IMS model that is flexible, comprehensive, and cost-efficient enough to accommodate the diversity across industries is still rare (Sheng and Mullen, 2011). Therefore, there is a need for a model that considers various criteria for IMS. DEA provides such a capability for decision makers to consider a set of potential IMs as well as a variety of input/output criteria.

DEA is a well known non-parametric technique for measuring relative efficiency based on Farrell original work (Farrell, 1957). It was later popularised by Charnes, Cooper and Rhodes (CCR) in 1978. DEA examines the consumed inputs and produced outputs in terms of homogeneous units. The unit is called decision making unit (DMU) (Parthasarathy and Anbazhagan, 2008). Recent years have seen a great variety of applications of the DEA in hospitals, banks, maintenance crews, and even the evaluation of suppliers and technologies (Shabani et al., 2012; Azadeh et al., 2010; Chiu et al., 2006).

In standard DEA, it is assumed that the input versus output status of each chosen performance measures is known. However, in some settings finding the status of some variables from the perspective of input or output is very difficult. The variables which play both input and output roles are called dual-role factors [for instance see Shabani et al. (2011)]. Likewise, in the evaluation process of IMs, some criteria (for instance: marketing costs, average tariff rate, and sales price) might be dual-role factors. Remembering that the simple definition of efficiency is the ratio of output to input; an output can be defined as anything whose increase will cause an increase in efficiency. Similarly, an input can be defined as anything whose decrease will cause an increase in efficiency. Obviously, marketing costs have a positive momentous affect on the sales volume of a company; therefore, spending more budgets on the marketing costs increases the total income of a company. Therefore, marketing costs can be considered as an output. On the other hand, the nature of marketing cost is ‘cost’; thus, it can be considered as an input. Similarly, as Farzipoor Saen (2011b) addressed, the average tariff rate for destination market can be considered as both an input and an output. The reason is that the increase in the average tariff rate will decrease market attractiveness and consequently, prevents from competitor entry to the destination market, whereas, if the average tariff rate is considered as an input, then any decrease in the average tariff rate will increase market attractiveness. Because the decrease in the average tariff rate will reduce the product price of the company and will increase the sales volume. In the same way, the sales price has the alike nature. If a company increases the sales price, the profit will be increased; but in future, the market attractiveness for other competitors who offer
cheaper product will then be increased. If a company decreases the sales price, the market attractiveness for other competitors will be decreased and the profit will be decreased as well. Therefore, the sales price is considered as a dual-role factor.

The objective of this paper, accordingly, is to develop a new model for IMS, using DEA based on ternary variable in the presence of dual-role factors. To the best of knowledge of authors, there is not any use of DEA technique that deals with IMS problem in the presence of multiple dual-role factors and ternary variable.

This paper proceeds as follows. In Section 2, literature review is presented. Proposed model and case study are discussed in Sections 3 and 4, respectively. Section 5 illustrates concluding remarks, managerial implications, and future research directions.

2 Literature review

2.1 International market selection

To solve the IMS problem, Zhang et al. (2007) proposed a multigroup classification model based on a hybrid fuzzy neural network (NN) model. Their model is combined with fuzzy inference system and back-propagation NN. Li et al. (2004) discussed the feasibility of IMS by using fuzzy theory. In their study the advantages and disadvantages of the fuzzy methods for IMS are considered. Buyukozkan (2004) suggested the use of fuzzy logic based on multi-criteria evaluation as a means of improving the efficiency of decision making for the e-marketplace selection under uncertain conditions. In the suggested approach, both fuzzy analytic hierarchy process (AHP) and fuzzy Delphi methodologies were employed. Taaffe et al. (2008) developed a profit maximising model to address the firm’s integrated market selection, marketing effort, and procurement decisions. Their resulting model is a non-linear integer optimisation problem including specialised solution methods. One of the most widely used areas of data mining for industry is in marketing. Market basket analysis is a marketing method used by many retailers to determine the optimal locations to promote products. Hemalatha (2012) defined market basket analysis as a data mining tool used to extract important information from existing data and enable better decision making throughout an organisation.

Papadopoulos et al. (2002) proposed a new tradeoff model to IMS problem, using two key constructs, demand potential and trade barriers, as well as firm strategy as a contingency construct. In their study each key construct is measured by four variables, resulting in simplicity and low application cost, and strategy is used to develop weights for the variables. Brouthers et al. (2009) developed a model of IMS that enhanced firm-specific advantages and transaction cost considerations to previously explored IMS factors based on Dunning’s eclectic framework. Andersen and Buvik (2002) attempted to establish a research agenda on selecting foreign market. Their study examines the characteristics of the traditional approaches (systematic and non-systematic) of the IMS. The interrelationship between the choice of entry mode and choice of foreign market/customer is emphasised in their study as well. Ojala and Tyrväinen (2008) used a sample of 100 US small- and medium-sized software firms to study foreign market selection decisions. They found that the market size of a specific industry in a target country is the best single indicator for international market entry decisions.
Of the many host country factors, market potential, in particular, is widely considered as one of the most important variables in foreign market evaluation (Ellis, 2008). Swoboda et al. (2009) explored foreign market potential at an industry level by examining how firms choose international sourcing and sales markets.

Sakarya et al. (2007) presented a tool composed of four criteria specific to the preliminary assessment of emerging markets as international expansion opportunities. They pointed out the limitations of IMS models. The needs for a specialised approach as well as improving assessment criteria for emerging markets are shown in their study. Alexander et al. (2007) and Sousa and Lages (2011) considered factors that determine direction of the IMS. Their work shows that language and hence, by implication, culture plays a fundamental role in determining direction of expansion. The important role of psychic distance for service companies in the IMS process is noticed in their work. Malhotra et al. (2009) found out that while cultural and geographic distance factors have a significant, negative impact on the number of cross-border acquisitions, administrative and economic distances have a significant, positive effect. They also discovered that the market potential of target countries significantly moderates the relation between the distance factors and the number of cross-border acquisitions. In addition, their study highlighted several boundary conditions of the impact of distance factors on firms’ internationalisation processes. He and Wei (2011) investigated how a firm’s market orientation resources and capabilities influence the firm’s IMS between culturally close and distant markets by drawing on the resource-based view. They also examined how the matching of market orientation and IMS impacts on its international performance.

To evaluate travel market segments in terms of the expected economic return on each identified segment, Lee et al. (2006) developed an economic value portfolio matrix based on the stay-spend index (SSI) and market share. Koch (2001) had a comprehensive discussion of factors influencing the IMS process. He discussed that IMS process is influenced by a larger number of the external, internal, and mixed environment factors than most previous models have assumed. Furthermore, his study focuses on the evaluation stage of the model and briefly examines the great variety of influences on the IMS process outcomes. Falkenbach (2009b) studied the market selection criteria in international real estate investments and indicated that the most important factors for market selection are safety of property rights and title as well as expected return on property investments. The main purpose of Falkenbach (2009b) is to study the criteria that investors use for selecting the IM. Also, Lima and Alencar (2008), and Falkenbach (2009a) carried out a research which indicates two main rationales for conducting international investments are diversification benefits and possibilities to achieve higher returns for investments.

Sheng and Mullen (2011) proposed a new model for IM opportunity analysis by combining the marketing-based overall market opportunity index (OMOI) with the economic-based gravity model in order to more accurately assess IM potential. Their hybrid model extends previous OMOI models and was applied to industry level analysis. Douglas and Craig (2011) highlighted the importance of considering contextual factors and their impact on consumption behaviour. Their study examines the impact of context at several distinct levels and suggests how this may impact IMS decisions. Minifie and West (1998) developed a model to assist small businesses in determining those IMs that are most favourable to market entry by analysing the IM opportunities. O’Farrell and Wood (1994) focused upon the key strategic decision of the IMS, attempted to contribute for developing of an extended conceptual framework in two key ways:
by arguing that the nature, depth, types and modes of interaction between supplier
and client during the phases of service production will influence the IMS by business
services
by emphasising the need to consider the relationship between the IMS and change in
organisational form by the investing company.

Papadopoulos and Martin (2011) stressed the complexities of IMS as a strategic decision
by international firms and explored the various ways and perspectives to view on IMS.
They found out the complexity characterising this field arises from the fact that it is
closely intertwined with the broader area of internationalisation and a number of other
decisions related to it, such as the ‘go/no-go’ decision and the firm’s choice of mode of
entry. Sousa et al. (2010) focused on managers’ values which significantly influence
strategic decisions and the export performance of the firm. Breton and Martin (2011)
proposed a two-stage model of IMS and segmentation in the process leading to the
identification of promising European target markets. Farzipoor Saen (2011b) proposed an
advanced DEA model in order to select efficient markets. Koxa and Leeuwenb (in press)
proposed a new way for analysing the efficiency of dynamic market selection, based on
the persistence of scale economies. They used the new methodology to investigate the
causes of stagnating productivity growth in EU business services. They also used a DEA
method to construct the productivity frontier by sub-sector and size class, for business
services in 13 EU countries.

2.2 Dual-role factor

In a study of the efficiency of university departments, Beasley (1995, 1990) treated
research funding on both the input and output sides. However, as Cook et al. (2006)
addressed, the model proposed by Beasley (1995, 1990) has two limitations. The first
limitation is that in the absence of constraints (e.g., assurance region or cone ratio) on
the multipliers, each DMU will be 100% efficient. The second limitation is that the dual-role
factor is considered as a discretionary factor. Cook et al. (2006) developed a new model
that does not have the aforementioned limitations. However, their development is
appropriate for a single dual-role factor and does not consider multiple dual-role factors.

According to the model of Cook et al. (2006), Farzipoor Saen (2010a) proposed a
model for selecting third-party reverse logistics (3PL) providers in the presence of the
multiple dual-role factors. Cook and Zhu (2007) proposed a new model for classifying
inputs and outputs in the DEA. However, their model requires too many variables and
constraints to be used. Toloo (2009) presented a revision on model of Cook and Zhu
(2007). The results of his study lead to increases in discrimination power of Cook and
Zhu’s (2007) model. Farzipoor Saen (2010b) proposed a method for selecting the best
suppliers in the presence of weight restrictions and dual-role factors. Hatefi and Jolai
(2010) proposed a new model based on translog output distance function for classifying
inputs and outputs. They evaluated the performance of DMUs by considering flexible
measures. Farzipoor Saen (2011a) introduced a model for selecting 3PL providers in the
presence of both dual-role factors and imprecise data. Again, Farzipoor Saen (2010c)
presented a model for selecting the best technologies in the presence of dual-role factors.
Shabani et al. (2011) introduced an innovative DEA model entitled non-binary
arithmetic operator dual-role (NAOD) under free disposability assumption, for selecting
3 Proposed model

The ternary variable is also called trivalent or three-valued variable. The ternary variable is any of several many-valued logic systems in which there are three truth values indicating true, false and some indeterminate third value. This is contrasted with the more commonly known bivalent variables such as classical sentential or Boolean system\(^1\) which provides only for true or false (Brian, 2001; Rojas, 1984).

Ternary variable is a system \(L\) whose elements are called propositions or statements, valued in the set \(\{0, 1, 2\}\). This set is denoted by \(Z_3\) (Arpasi, 2009). If \(x\) is a proposition, the value of \(x\) can be seen a mapping \(v: L \rightarrow \{0, 1, 2\}\) such that;

\[
v(x) = \begin{cases} 1; & \text{if } x \text{ is true}, \\ 0; & \text{if } x \text{ is perhaps true}, \text{perhaps false}, \\ 2; & \text{if } x \text{ is false} \end{cases}
\]

Based on the work of Rojas (1984) and some basic notions of binary variable and algebra of Boole, there are some elementary properties for ternary variable. These properties are as follows:

- ternary variable is a generalisation of binary variable
- it has not a structure to be a Boolean algebra
- it is based on more than three basic operations
- its tautologies and contradictions are more complicated for finding out.

The generalisation is in the sense that if one proposition \(p\) is true (false) under the rules of binary variable then it is true (false) under the ternary variable. The lack of Boolean structure, in ternary variable, is compensated by powerful tools for inferential analysis (Arpasi, 2009).

The DEA has been widely applied to address various decision analysis problems due to its usefulness in evaluating multi-criterion systems. It is a non-parametric mathematical programming technique that determines an efficient frontier of the most efficient DMUs and calculates the efficiency of each DMU relative to this efficient frontier based on multiple observed inputs and outputs. An efficiency score of a DMU is generally defined as the weighted sum of outputs divided by the weighted sum of inputs, while weights need to be assigned. To avoid the potential difficulty in assigning these weights among various DMUs, a DEA model computes weights that give the highest possible relative efficiency score to a DMU while keeping the efficiency scores of all DMUs less than or equal to one under the same set of weights (Liu et al., 2000).

As it was cited earlier, classical DEA models assume that the input versus output status of each chosen performance measures is known. However, in some settings finding the status of some variables from the perspective of input or output is very difficult. In other words, the role of a specific measure is not known in relation to input or output roles. Hence, these kinds of measures simultaneously have dual role.
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 some particular factors are held by each DMU in the amount \( w_{lj} \) \( (l = 1, \ldots, f) \), and serve as both input and output factors. The proposed model for considering multiple dual-role factors is as follows (Farzipoor Saen, 2010a).

\[
\begin{align*}
\text{max} & \quad \sum_{r=1}^{s} u_r y_{ro} + \sum_{i=1}^{m} t_i x_{io} - \sum_{l=1}^{f} p_l w_{lo}, \\
\text{s.t.} & \quad \sum_{i=1}^{m} v_i x_{io} = 1, \\
& \quad \sum_{r=1}^{s} u_r y_{rj} + \sum_{l=1}^{f} t_l w_{lj} - \sum_{i=1}^{m} p_i x_{ij} - \sum_{l=1}^{f} v_l x_{lj} \leq 0, \quad j = 1, \ldots, n, \\
& \quad u_r, v_i, t_l, p_i \geq 0, \forall r, i, l.
\end{align*}
\]

where \( u_r \) is the weight given to output \( r \) and \( v_i \) is the weight given to input \( i \). \( t_l \) and \( p_l \) are the weights given to dual-role factor \( l \). 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 \( r \). Regarding to the consumption and the production, the role of \( w_{lo} \) \( (l = 1, \ldots, f) \) for DMU \( o \) is unknown.

The basis of Model (1) is Model (2) which is formulated as a fractional programming (Charnes et al., 1978). Likewise, based on Model (2), current study develops an innovative model in which ternary variables are applied to solve the problem of dual-role factors.

\[
\begin{align*}
\text{max} & \quad \sum_{r=1}^{s} u_r y_{ro} / \sum_{i=1}^{m} v_i x_{io}, \\
\text{s.t.} & \quad \sum_{r=1}^{s} u_r y_{rj} / \sum_{i=1}^{m} v_i x_{ij} \leq 1, \quad j = 1, \ldots, n, \\
& \quad u_r, v_i \geq 0, \forall r, i.
\end{align*}
\]

At this point, the new model is developed. Since dual-role factors simultaneously play input and output roles, they have to be inserted into numerator and denominator of both objective function and constraint in Model (2). Therefore, there will be:

\[
\begin{align*}
\text{max} & \quad \sum_{r=1}^{s} u_r y_{ro} + \sum_{l=1}^{f} p_l w_{lo} / \sum_{i=1}^{m} v_i x_{io} + \sum_{l=1}^{f} p_l w_{lo}, \\
\text{s.t.} & \quad \sum_{r=1}^{s} u_r y_{rj} + \sum_{l=1}^{f} p_l w_{lj} / \sum_{i=1}^{m} v_i x_{ij} + \sum_{l=1}^{f} p_l w_{lj} \leq 1, \quad j = 1, \ldots, n.
\end{align*}
\]
In Model (3), both objective function and constraint are included a non-linear dependence between output and input components in connection with dual-role factor (for more details see Cook et al., 2006). To set up a linear dependence and to obviate the problem, the input components of the dual-role factors, with a negative sign, are transferred to the numerators of Model (3). Thus, Model (4) is obtained as below.

\[
\begin{align*}
    & \max \sum_{r=1}^{s} u_{r} y_{ro} + \sum_{i=1}^{f} p_{i} w_{io} - \sum_{i=1}^{f} p_{i} w_{io} \\
    \text{s.t.} & \quad \sum_{r=1}^{s} u_{r} y_{ro} + \sum_{i=1}^{f} p_{i} w_{io} - \sum_{i=1}^{f} p_{i} w_{io} \leq 1, \quad j = 1, \ldots, n, \\
    & \quad u_{r}, v_{i}, p_{i} \geq 0, \forall r, i, l.
\end{align*}
\]

Apparent, after running Model (4), the dual-role factors will be just in equilibrium, i.e., output component \( \sum_{i=1}^{f} p_{i} w_{io} \) will be neutralised by input part \(-\sum_{i=1}^{f} p_{i} w_{io}\).

Accordingly, \( q_{l} (l = 1, \ldots, f) \) is defined as ternary variable. It can be inserted in either input part, or output part of dual-role factor. In model (5), it is put in output part. So, if \( q_{l} \) takes 0, 1, and 2 values then the dual-role plays input, equilibrium, and output role, respectively. Note, if \( q_{l} \) is put in input part, values 0, 1, and 2 respectively represent output, equilibrium, and input role for the dual-role factor.

\[
\begin{align*}
    & \max \sum_{r=1}^{s} u_{r} y_{ro} + \sum_{i=1}^{f} q_{i} p_{i} w_{io} - \sum_{i=1}^{f} p_{i} w_{io} \\
    \text{s.t.} & \quad \sum_{r=1}^{s} u_{r} y_{ro} + \sum_{i=1}^{f} q_{i} p_{i} w_{io} - \sum_{i=1}^{f} p_{i} w_{io} \leq 1, \quad j = 1, \ldots, n, \\
    & \quad q_{l} \in \mathbb{Z}, \quad l = 1, \ldots, f, \\
    & \quad u_{r}, v_{i}, p_{l} \geq 0, \forall r, i, l.
\end{align*}
\]

Using the Charnes-Cooper transformation, the above fractional programming models can be simplified as Model (6).

\[
\begin{align*}
    & \max \sum_{r=1}^{s} u_{r} y_{ro} + \sum_{i=1}^{f} q_{i} p_{i} w_{io} - \sum_{i=1}^{f} p_{i} w_{io} \\
    \text{s.t.} & \quad \sum_{r=1}^{s} v_{i} x_{io} = 1,
\end{align*}
\]
Clearly, Model (6) is non-linear. Now, it is transformed to a linear form by change of variables $q_l p_l = t_l$. For each $l$, constraints (7) and (8) are imposed.

$$0 \leq t_l \leq q_l, \quad l = 1, \ldots, f$$

(7)

$$t_l + (1-q_l) \leq p_l \leq t_l + (1-q_l), \quad l = 1, \ldots, f$$

(8)

Finally, the proposed linear Model (9) is formulated as below.

$$
\begin{align*}
    & \max \sum_{i=1}^s u_i v_{i0} + \sum_{j=1}^f t_j w_{j0} - \sum_{j=1}^f p_j w_{j0}, \\
    \text{s.t.} \\
    & \sum_{j=1}^m v_{j0} = 1, \\
    & \sum_{i=1}^s u_i v_{ij} + \sum_{j=1}^f t_j w_{j0} - \sum_{j=1}^f p_j w_{j0} - \sum_{j=1}^m v_{j0} x_{j} \leq 0, \quad j = 1, \ldots, n, \\
    & 0 \leq u_i \leq q_i, \quad l = 1, \ldots, f, \\
    & \sum_{i=1}^s t_l = q_l, \quad l = 1, \ldots, f, \\
    & t_l + (1-q_l) \leq p_l \leq t_l + (1-q_l), \quad l = 1, \ldots, f, \\
    & q_l \in \mathbb{Z}_+, \quad l = 1, \ldots, f, \\
    & u_i, v_{i0}, p_{l}, t_l \geq 0, \forall r, i, l.
\end{align*}
$$

(9)

**Definition 1.** DMU$_o$ is said to be DEA efficient if the objective function of Model (9) is equal to one, otherwise, it is said to be DEA inefficient.

After running Model (9), one of three potential solutions exists in regard to the sign of $t_l - \hat{p}_l$, where $t_l, \hat{p}_l$ are the optimal values of Model (9); $t_l - \hat{p}_l > 0$, $= 0$, or $< 0$.

a) if $t_l - \hat{p}_l < 0$; then the dual-role factor has input role; therefore, less of this factor is better, and would lead to an increase in efficiency

b) if $t_l - \hat{p}_l > 0$; then the dual-role factor has outputs role; therefore, more of this factor is better, and would lead to an increase in efficiency

c) if $t_l - \hat{p}_l = 0$; then dual-role factors are at equilibrium or optimal level.

### 4 Case study

Iran Docharkh Company (IDC) was founded in 1970 in Tehran, Iran, with the aim of supplying different types of bicycles and motorcycles. The factory of the IDC is spread over 80,000 square metres with a covered area of about 58,000 square metres at Alborz Industrial zone, Qazvin, Iran. The IDC has a deep collaboration with the well-known brands such as Peugeot and Yamaha Motors companies. Nowadays, IDC as one of the
important exporters of bicycles and motorcycles has a capacity of 125,000 motorcycles and 204,000 bicycles per year. Because of high technical capabilities, the IDC has been assigned by the Institute of Standards and Industrial Research of Iran (ISIRI) to delegate the standard and quality certificates to the other related manufacturers.

Table 1 The data set of 30 international markets

<table>
<thead>
<tr>
<th>International market (DMU)</th>
<th>Number of foreign competitors</th>
<th>Number of local manufacturers</th>
<th>Marketing costs (US dollar)</th>
<th>Average tariff rate (%)</th>
<th>Sales price (US dollar)</th>
<th>Estimation of sales volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>4</td>
<td>10,000</td>
<td>40%</td>
<td>425</td>
<td>7,500</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>3</td>
<td>5,600</td>
<td>20%</td>
<td>465</td>
<td>5,500</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>9,800</td>
<td>10%</td>
<td>430</td>
<td>6,500</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>4</td>
<td>7,700</td>
<td>15%</td>
<td>400</td>
<td>11,500</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>7</td>
<td>6,200</td>
<td>13%</td>
<td>450</td>
<td>8,000</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
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Entry into the new IMs is one of the continual goals of the IDC. The department of international marketing of IDC collected data set of 30 potential IMs. The objective is to select the best IMs. Table 1 depicts the data set. Note that the data set has been manipulated because of the data confidentiality. Number of foreign competitors, number of local manufacturers, marketing costs, average tariff rate, sales price, and estimation of
sales volume are six criteria which are defined. Number of foreign competitors and local manufacturers are considered as inputs and estimation of the sales volume is considered as output. Moreover, as discussed before, marketing costs, average tariff rate, and sales price are three dual-role factors.

For IDC to go international, it must decide which foreign market(s) to select. Additionally, since the identification of promising foreign target markets is a critical issue in international marketing, distinguishing efficient and inefficient IMs is a momentous duty. Accordingly, Table 2 shows the results obtained through running the Model (9). The efficiency scores of DMUs 4, 16, 19, 24, and 27 are one. Therefore, these IMs are the best options for which IDC concentrates its international marketing efforts to prevent the resource wastes.

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On the other hand, the DMUs 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 20, 21, 22, 23, 25, 26, 28, 29, and 30 have the efficiency score less than unit so that they all are inefficient and unattractive alternatives.

Furthermore, in Table 2 the role of dual-role factors are determined. For instance consider DMU #18. The efficiency score of this IM is 0.687, and the role of the first dual-role factor, marketing cost, is determined as equilibrium, i.e., $\hat{t}_1 - \hat{p}_1 = 0$. As well, the average tariff rate, the second dual-role factor, plays input role, i.e., $\hat{t}_2 - \hat{p}_2 < 0$. Therefore, less of this factor is better, and would lead to an increase in efficiency. The role of the sales price, the third dual-role factor, is determined as equilibrium.

Using the inefficiency scores, moreover, help managers to better analyse IMs which are not identified as lucrative places. Consider again DMU #18. Corresponding quantities of number of foreign competitors and number of local manufacturers (inputs criteria) are 4, and 6, respectively. Also, the value for average tariff rate, which plays the role of an input, is 11%. Note, since proposed model in this paper is input-oriented, so that it aims to minimise inputs while satisfying at least the given output levels, the values of inputs should be considered. Therefore, if the mentioned quantities reduce by 0.687, this DMU will be an efficient IM. That is to say, inefficiency of DMU #18 originates from excess usage of these input criteria.

To compare the outcomes of the proposed model with Model (1), the results obtained through Model (1) are shown in Table 3. These results are contrasted graphically by Figure 1, as well. The DMUs 2, 3, 4, 5, 7, 8, 12, 16, 17, 18, 19, 20, 21, 22, 24, 26, 27, 28, and 30 are efficient. Consider DMU #28 which is efficient. The role of the first dual-role factor, marketing cost, is determined as input, i.e., $\hat{t}_1 - \hat{p}_1 < 0$. Therefore, less of this factor is better, and would lead to an increase in efficiency. As well, the average tariff
rate, the second dual-role factor, is determined as equilibrium, i.e., $t_2 - \hat{p}_2 = 0$. The role of the sales price, the third dual-role factor, is as output; therefore, more of this factor is better, and would lead to an increase in efficiency.

It is clear that results of Model (1) show more efficient DMUs in comparison with Model (9). It means that Model (9) distinguishes DMUs in a good way in respect of Model (1).

5 Concluding remarks

As Papadopoulos et al. (2002) discussed, IMS is the first and most important step in export strategy and makes it a critical success factor for both smaller exporters and mature multinational firms. Internationalisation advantages focus on minimising transaction costs in different locations. By selecting IMS in which transaction costs are low, firm performance is enhanced.

In this paper a new model is developed for IMS problem. The proposed model is based on the ternary variable and is able to select the most efficient IMS by comparing them with each other in the presence of dual-role factors. This study determines whether in an IMS the factors are behaving predominantly like inputs, hence the IMS would benefit from having less of the factors, like outputs where more of the factors are desirable, or where they are in equilibrium.

The chief contributions of this paper are as follows:

- for the first time proposed model is applied in IMS in the function of a marketing research’s tool
- for the first time the DEA methodology applies ternary variable to compute efficiency of a DMU
- for the first time the problem of dual-role factors is solved by means of ternary variable
- in contrast to earlier IMS’s procedure, the proposed approach is very simple and straightforward
- this study contributes to enhancing knowledge of marketing, selection theories, and operation research by linking these different topics
- an application of the methodology has been performed on a set of data retrieved from an industrial company’s information.

The results of proposed model are interesting in the way that they suggest additional alternative efficient IMS so that a company can consider them due to its sourcing policy. Moreover, the proposed model can be modified in accordance with various deliberations and marketing strategies.

When compared to traditional subjective IMS techniques, the methodology introduced in this paper provides an objective statement of how attractive an IMS is look like on multiple criteria relative to other IMS. This methodology allows the companies to evaluate effectively each IMS relative to the best IMS, through calculation of DEA.
efficiency measures. Such an appraisal may greatly affect a company’s ability to compete in the marketplace.

A complete assessment of the approach presented in this study would require stating the following critical points. First, as an important point, the marketing techniques should be used in a holistic way and complemented by other evaluation approach such as DEA to be more suitable and applicable for IMS decision process. Second, the approach improves the quality of IMS. But by no means it is aimed to fully replace management judgment. Although the framework enables one to systematically incorporate the dual-role factors into the decision process, subjective judgment is still required to select the inputs and outputs. Finally, for a decision-maker who is not familiar with mathematical programming, DEA may appear as a ‘black box’. A user-friendly interface could be helpful for practical application of the proposed approach.

The problem considered in this paper is at initial stage of research and further researches can be done based on the results of this paper.

- In the search for discovering money-making IMs, some variable might be expressed linguistically. For instance, a linguistic variable such as age may have a value such as young or its antonym old. Fuzzy logic is able to process incomplete data and provide approximate solutions to problems other methods find difficult to solve. Accordingly, similar research can be repeated for dealing with fuzzy data in the presence of dual-role factors.

- In any realistic situation there may exist some criteria that involves or contains chance or probability. As a result, it seems that extending the proposed model for taking into account stochastic data is a worthwhile idea.

- Consider a criterion like customer image of company in each IM. In certain circumstances, the information available may permit one to provide a complete rank ordering of the IMs on such a factor. Therefore, the data may be imprecise. As a consequence, developing the proposed model to deal with ordinal and bounded data (imprecise data) seems to be an interesting area of research.

- Since the usage of proposed model makes DMUs free to decide which criteria to emphasise, there may be exist efficient DMUs. Therefore, the proposed model can be developed to rank efficient DMUs.

- In some situation there may exist some criteria that are beyond the control of the management. These factors are called non-discretionary or exogenously fixed factors. Similar research can be repeated for IMS in the presence of non-discretionary factors.

- IMS can be repeated in the presence of both dual-role factors and weight restrictions. In other words, preferences of decision-makers can be incorporated into the proposed model by restricting the feasible region of the inputs and outputs’ weights.

- In this study, the model has been applied to a problem related to IMS. However, the same model could be applied, with minor modifications, to other areas of the decision making.
Acknowledgements

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References


The use of data envelopment analysis for international market


Notes

1 A Boolean system is based on things that can be either true or false, but not both. It links statements with words called operators, such as AND, OR, and NOT. Boolean systems are used to write computer programs, especially internet search programs. The program searches for information using Boolean logic.