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Ranking of the suitability of investment for online sales in different fields of clothing in Shiraz City using the Data Envelopment Analysis method

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Abstract
One of the common concerns of investors is determining the suitable field for investment. Due to the attractiveness of online sales in various fields such as clothing, newcomers and even existing companies tend usually to sell online. In this research, the rank of the suitability of an investment for online sales in different fields of clothing in Shiraz City was determined using the data envelopment analysis method. In the beginning, we form an expert team. Also, we recognized ten fields of clothing as investment alternatives for online sales (DMUs). Then, we defined suitable inputs and outputs by reviewing the literature and obtaining the opinions of expert team members. Also, we determine an epsilon-based input-oriented BCC model as a suitable DEA model for DMU ranking. Then, we obtained the input and output values from the expert team members and considered the average values as the inputs and outputs of the DEA models. Formulating and solving epsilon-based input-oriented BCC models showed that three DMUs were inefficient, and the other seven DMUs were efficient. Therefore, the rank of these three DMUs was determined. Next, to determine the rank of the other seven DMUs, we formed and solved the Andersen-Peterson epsilon-based input-oriented BCC models. The results of solving the DEA models showed that the fields of "Designing, producing, and selling of wedding dresses", "Designing, producing, and selling suits and formal dresses", and "Designing, producing, or selling local clothing" have the first to third ranks, respectively.

Keywords: Ranking, investment appropriateness, online sales, data envelopment analysis, Andersen-Peterson model.

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1. Introduction

Clothing has been one of the basic needs of humans, and it is natural for humans to feel the need to buy clothes. One of the concerns of people who want to enter this industry is the right choice for proper investment in this field. The present research aims to rank the suitability of investment for online sales of different fields of clothing in Shiraz by using data envelopment analysis.

Concerning clothing fields, it is natural to say that newcomers and even existing companies in this field feel the need to enter the discussion of online sales. But, due to the vastness of the Internet and its diversity and service range, online sales are different from the discussion of physical sales. So, even an active organization in clothing fields that intends to enter online sales should pay attention to the efficiency of each field. The present research aims to rank the appropriateness of the investment for online sales in different fields of clothing in Shiraz City using the data envelopment analysis method. In this regard, DMUs are the ten fields mentioned above.

The results of this research may be beneficial for people who want to establish a clothing sales company on the Internet and for active companies in this field.

2. Literature Review

Barthes (1990) gives a brief history of semiology and identifies economics as a reason for the luxuriant prose of the fashion magazine [1]. Serrano-Cinca et al. (2005) have measured efficiency and ranking in dot com internet companies using DEA. After ranking the companies, they applied a multivariate analysis method to show the strengths and weaknesses of the companies. They also proved that a meaningful relationship exists between the type of e-commerce and the way to gain efficiency [2]. Ho et al. (2011) proposed a DEA-based multiple valuation approach for valuing internet companies [3]. Pour Pourghafar Maghferaty et al. (2013) evaluated the R&D units of manufacturing companies in Gilan province by using DEA and AHP methods. After that, they determined the efficiency of DMUs and ranked them by input-oriented BCC model. Then, they evaluated the rank of efficient DMUs by Andersen-Petersen [4]. Lawrence et al. (2013) analyzed the efficiency of operating units in electronic shopping stores by DEA. They used two different models [5]. Bay and Wincasa (2015) determined the efficiency of Swiss shopping centers using DEA and identified efficient and inefficient DMUs. In this research, he used an integration CCR and BCC model [6]. Qiuping (2016) investigated customer satisfaction in e-commerce using the DEA method. The results showed that service features and website quality are the main factors that affect customer satisfaction [7]. Salari Boron and Zandieh (2016) conducted the efficiency of online stores using the DEA (CCR model). Inefficient DMUs and their benchmarks are identified in the mentioned research [8]. Liu and Chen (2016) have researched the marketing efficiency of WeChat Mall Enterprises using DEA [9]. Zandieh and Salari Boron (2021) measured the efficiency of Internet shops using a multi-stage DEA model [10]. Lins et al. (2022) investigated public tendering in government procurement. Using DEA, they provided a method to measure the performance and rank the proposals [11]. Krejnus et al. (2023) investigated the use of DEA to measure the efficiency of Electronic Public Administration [12]. Wang et al. (2023) proposed an enhanced dynamic network DEA for sustainable

development efficiency assessment in the Internet and logistic sectors [13].

3. Methodology

3.1. Research Design

As Shown in Figure 1, "forming an expert team", "identifying and finalizing DMUs, inputs and outputs", "data gathering and defining appropriate DEA models", and "determining the efficiency of DMUs and their ranking" are the steps of current research.

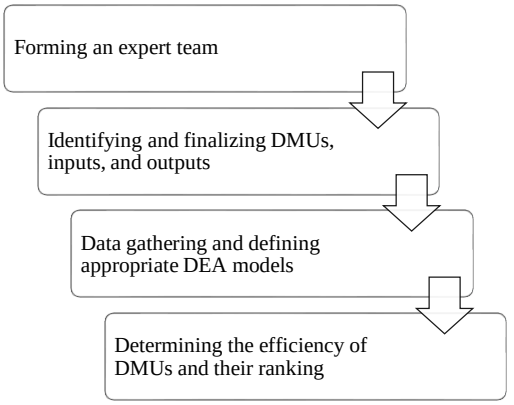

Figure 1. Methodology Diagram

3.2. Forming an expert team

At this stage, the expert team forms by using the Snowball method.

3.3. Identifying and finalizing DMUs, inputs, and outputs

A preliminary list of inputs and outputs is created by reviewing the literature. Then, recognized inputs and outputs are finalized by getting the opinions of the expert team members.

3.4. Data gathering and defining appropriate DEA models

At this stage, the value of the inputs and outputs of each DMU should determine. For this purpose, first, the expert's opinions considering the values of inputs and outputs should obtained. Then, the average values are the values of inputs and outputs.

Then, for ranking DMUs, recognizing the appropriate DEA model is necessary. There are three types of DEA models. In the input-oriented DEA models, the DMUs reach the efficient frontier by reducing input without increasing output values. In the output-oriented DEA models, the DMUs reach the efficient frontier by increasing output without decreasing input values. In input-output-oriented DEA models, efficient DMUs drive the efficient frontier by reducing input and increasing output values. So, for determining suitable DEA models, defining the type of return to scale (such as fixed or variable) and the nature of the model (such as input-oriented or output-oriented) are necessary.

For example, first, model (1) can be used for ε determination in an epsilon-based BCC input-oriented DEA model: [14]

$$Max\ w = \varepsilon \qquad (1)$$

$$s.t \sum_{i=1}^{m} v_i x_{ij} \leq 1\ ,\ j = 1 \dots n,$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - u_o \leq 0\ ,\ j = 1 \dots n,$$

$$v_i \geq \varepsilon, i = 1 \dots m,$$

$$u_r \geq \varepsilon, r = 1 \dots s,$$

$$u_o\ sign\ free.$$

After that, ε^* can applied as a lower bound for v_i and u_r variables in the model (2) [14].

$$Max\ z_o = \sum_{r=1}^{s} u_r y_{ro} - u_o \qquad (2)$$

$$s.t \sum_{i=1}^{m} v_i x_{io} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - u_o \leq 0\ ,\ j = 1 \dots n,$$

$v_i \geq \varepsilon^*, i = 1 \dots m,$

$u_r \geq \varepsilon^*, r = 1 \dots s,$

$u_o \quad sign\ free.$

In the optimal solution of model 2, DMU_o is inefficient if its efficiency score is less than one ($z_o < 1$). The rank of inefficient DMUs can determined by forming and solving models (1) and (2). However, the rank of efficient DMUs cannot determined through forming and solving models (1) and (2).

In 1993, Anderson and Peterson presented a model for ranking efficient DMUs of the DEA model. In this model, by removing the DMU under investigation from the production possibility set (PPS), the efficiency value of the model (super-efficiency) is calculated. It may be greater than one. The super-efficiency values are applied to determine the rank of DMUs [15].

For example, after forming and solving models (1) and (2), the rank of efficient DMUs was determined by creating and solving related Anderson-Peterson models (models (3) and (4)). In this regard, model (3) can used for ε determination in an Anderson-Peterson epsilon-based BCC input-oriented DEA model:

$$Max\ w = \varepsilon \qquad (3)$$

$s.t \sum_{i=1}^{m} v_i x_{ij} \leq 1\ ,\ j = 1 \dots n,\ \ j \neq o,$

$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - u_o \leq 0\ ,\ \ j = 1 \dots n,\ ,\ \ j \neq o,$

$v_i \geq \varepsilon, i = 1 \dots m,$

$u_r \geq \varepsilon, r = 1 \dots s,$

$u_o \quad sign\ free.$

After that, ε^* can applied as a lower bound for v_i and u_r variables in model (3) as seen in model (4).

$$Max\ z_o = \sum_{r=1}^{s} u_r y_{ro} - u_o \qquad (4)$$

$s.t$

$$\sum_{i=1}^{m} v_i x_{io} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - u_o \leq 0\ ,\ \ j = 1 \dots n,\ j \neq o,$$

$v_i \geq \varepsilon^*, i = 1 \dots m,$

$u_r \geq \varepsilon^*, r = 1 \dots s,$

$u_o \quad sign\ free.$

3.5. Determining the efficiency of DMUs and their ranking

The code of the appropriate DEA models (such as models 1 and 2) should be prepared and run using suitable software (such as GAMS) to determine the efficiency of DMUs. If only one DMU is efficient, the ranking of all DMUs will determined according to the results. Otherwise, other DEA models (such as models 3 and 4) should be used to determine the ranking of efficient units.

4. Results

4.1. Expert team

The expert team includes seven experienced people working in the field of clothing. These people include experienced people with the position of chief executive officer (CEO) or sales manager (SM). Table 1 shows the specifications of the expert team members.

Table 1. Expert team specifications

Exp. No.	Age	Gender	Education level	Work Experience (years)	Resp.
1	25	Female	M.Sc.	10-15	CEO
2	26	Man	M.Sc.	5-10	CEO
3	27	Female	M.Sc.	5-10	CEO
4	41	Female	M.Sc.	15-20	CEO
5	26	Female	M.Sc.	0-5	CEO
6	35	Man	M.Sc.	10-15	CEO
7	19	Female	B.D.	0-5	SM

4.2. DMUs, inputs, and outputs

According to [1] and experts' opinions, ten DMUs are considered (Table 2).

Table 2. DMUs

DMU	Clothing field
1	Designing and producing women's underwear
2	Designing and producing men's underwear
3	Producing ordinary clothes
4	Producing children's clothes
5	Designing, producing, and selling of wedding dresses
6	Producing maternity clothes
7	Designing, producing, or selling local clothing
8	Designing, producing, and selling suits and formal dresses
9	Designing, producing, and selling formal dresses
10	Designing, producing, and selling sportswear

Also, by reviewing the previous research ([3, 5, 9, 10]) and obtaining experts' opinions, we determined six inputs and five outputs (Tables 3 and 4).

Table 3. Inputs

	Name	Description	Ref.
1	Inventory cost	Costs spent on maintaining and taking care of inventory (for example, monthly or yearly)	[5]
2	Processing fee	Costs incurred for the sale of products (for example, per product)	[3,5]
3	Distribution costs	Expended costs to distribute the product so that the product reaches the customers	[5,10]
4	The purchase price of goods	The amount paid to buy goods from wholesalers or manufacturers	Expert Team
5	Capital sleep	Products not sold in the desired season	[3, 5, 10]
6	Advertising cost	Costs incurred to introduce the business	Expert Team

Table 4. Outputs

	Name	Description	Ref.
1	Sales volume	Sales amount (for example, per day, month or year)	[5, 9]
2	Incomes	Revenues from the sale of the company's products	[3, 10]
3	Recommended times	The best times to sell goods (for example, hours, days and months)	Expert Team
4	Sales price	The price of product	[9]
5	Variety of goods	The types of clothes which provide	[9]
6	Advertising cost	The spent cost for advertising	Expert Team

4.3. The value of the inputs, the outputs, and determining the appropriate DEA model

At this stage, the values of inputs and outputs are determined according to experts' opinions. Since reducing inputs and increasing outputs were desirable, the expert team members asked to use numbers 1 to 9 to show the importance of inputs and numbers 1 to 9 to show the importance of outputs, respectively. Then, according to Tables 5 and 6, the average values of the numbers were considered as the values of inputs and outputs.

Table 5. The value of inputs

DMU	I1	I2	I3	I4	I5	I6
1	7.29	5.29	7.86	5.57	7.86	3.29
2	8.14	4.43	8.71	5.86	6.14	2.14
3	6.71	5.29	5.29	5.29	6.14	3.57
4	5.00	3.86	5.57	3.57	4.14	2.43
5	1.86	2.43	1.29	2.43	1.57	1.29
6	7.29	4.43	5.86	5.57	1.86	1.86
7	2.14	2.14	2.14	4.14	1.86	1.00
8	6.71	5.29	3.86	4.43	5.86	3.57

9	7.86	6.14	7.00	5.86	8.14	4.71
10	7.00	5.29	7.29	5.00	4.71	3.29

Table 6. The value of outputs

DMU	O1	O2	O3	O4	O5
1	7.86	7.57	8.71	6.14	9.00
2	6.14	6.14	8.43	6.14	4.71
3	7.86	7.29	9.00	7.00	8.43
4	4.71	6.43	8.71	6.43	7.00
5	1.86	7.29	6.71	7.57	5.86
6	3.29	5.29	7.57	5.86	3.57
7	1.57	3.57	4.43	6.43	6.43
8	7.00	7.86	9.00	7.86	7.29
9	8.71	9.00	9.00	7.29	9.00
10	5.29	5.57	7.57	6.14	7.00

Also, we determine an epsilon-based input-oriented BCC model (models 1 and 2) as a suitable DEA model for DMU ranking.

4.4. The efficiency of DMUs and their ranking

During formulating and solving models 1 and 2 (with GAMS software), the efficiency of DMUs was calculated (Table 7). As seen in Table 7, DMU02, DMU06, and DMU10 are inefficient, and the other seven DMUs are efficient. Hence, the ranks of these DMUs are 9, 8, and 10, respectively. It is considerable that $\varepsilon^* = 0.025183$ through solving model 1.

The epsilon-based Anderson-Peterson input-oriented BCC model (models 3 and 4) was suitable to rank efficient DMUs (1, 3-5, 7-9). So, the rank of these DMUs was determined by forming and solving models 3 and 4 with GAMS software (Table 8). It is considerable that ε^* was 0.025183 through solving model 3, too.

Table 7. The results of solving models 1 and 2

DMU	z^* (Model 2)	Rank
1	1	1-7
2	0.68	9
3	1	1-7
4	1	1-7
5	1	1-7
6	0.77	8
7	1	1-7
8	1	1-7
9	1	1-7
10	0.65	10

Table 8. The results of solving models 3 and 4

DMU	z^* (Model 4)	Rank
1	0.9983	6
3	1.0901	4
4	1.0898	5
5	2.9520	1
7	1.2699	3
8	1.3506	2
9	0.0087	7

Considering Tables 7 and 8, the final rank of DMUs is recognized (Table 9).

Table 9. Rank of DMUs

Rank	DMU	Clothing field
1	5	Designing, producing, and selling of wedding dresses
2	8	Designing, producing, and selling suits and formal dresses
3	7	Designing, producing, or selling local clothing
4	3	Producing ordinary clothes
5	4	Producing children's clothes
6	1	Designing and producing women's underwear
7	9	Designing, producing, and selling formal dresses
8	6	Producing maternity clothes
9	2	Designing and producing men's underwear
10	10	Designing, producing, and selling sportswear

5. Conclusion

In this research, the rank of the suitability of an investment for online sales in different fields of clothing in Shiraz City was determined using the data envelopment analysis method. At first, an expert team was formed (Table 1). Then, by reviewing the literature and obtaining the experts' opinions, ten fields of clothing were identified as investment alternatives

for online sales (Table 2). Then, by reviewing the literature and obtaining the views of expert team members, suitable inputs and outputs were recognized (Tables 3 and 4). Also, according to the conditions of the problem, the epsilon-based input-oriented BCC models (models 1 and 2) were recognized as suitable DEA models to determine the efficiency of the DMUs. Then, the input and output values were determined considering the opinions of expert team members, and the average values were considered as the inputs and outputs of the DEA model (Tables 5 and 6). Formulating and solving epsilon-based input-oriented BCC models (models 1 and 2) showed that in ten investigated clothing fields, three of them were inefficient, and the rest were efficient. Therefore, the 8th to 10th rank of DMUs was recognized (Table 7). Then, the rank of efficient DMUs was recognized by forming and solving models 3 and 4 (Table 8). So, the final ranks of DMUs were obtained (Table 9).

Someone may expect that "Designing and producing women's underwear" (with rank 6), "Designing and producing men's underwear" (with rank 9), and "Producing ordinary clothes" (with rank 4) would be among the highest ranks (Table 9). Because of some reasons (like the amount of profit in volume goods or the presence of a large number of competitors), the result of the research was not like this. Unlike this, the results showed that "Designing, producing, and selling wedding dresses" and "Designing, producing, and selling formal dresses" were ranked 1 and 2. However, seeing clothes in these two fields is required before buying them. Since these two fields are among the highest-rank fields in clothing, and according to experts, creating a web page only for advertising and referring people in person is also very useful. Therefore, placing these two fields in the 1st and 2nd ranks is justified.

Conducting similar research for topics other than clothing fields and using other DEA models can be proposed as future research.

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