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Measurement Efficiency of Entrepreneurial Universities by Using Mathematical Programming (DEA) Approach

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Abstract

Entrepreneurship orientation (EO) approach provides universities with a plan and roadmap for getting over rising uncertainty and complexity. Inspiring universities to embrace transformation and innovation, risk taking and proactive policy for planning and executing development strategies for success in the dynamic competitive environment arise from entrepreneurship orientation spirit. To reach this status, the key factors of success in entrepreneurship should be taken into consideration and assessed in universities. Structural and entrepreneurial policies as key non-financial factors are two concepts that have received considerable attention over the past years. Measuring efficiency of universities by the mentioned factors and using mathematical programming like Data Envelopment Analysis (DEA) method is the aim of this study. Hence, this paper applied DEA method for measuring efficiency of 16 faculties and institutes in Ferdowsi University of Mashhad (FUM) in Iran. Descriptive-survey methodology was used and data were collected through questionnaire survey. The faculties and institutes were ranked based on structural policies and EO through DEA. Finally, the DEA method recommended the development roadmaps template for the 11 faculties and institutes which were inefficient.

Keywords: Entrepreneurial orientation; data envelopment analysis; efficiency; entrepreneurial university; organizational structure

1.0 INTRODUCTION

Earlier scholars have focused on EO in universities and various definitions of entrepreneurial university shows the importance of this subject [1]. As argued by Etzkowitz, current universities are increasingly shifting from their traditional principal role as educational suppliers to a more complex and multifaceted "entrepreneurial" university style that encompasses the additional function of the commercialization of knowledge and effective contribution to the growth of private organizations in the localized economy [2-4].

Guerrero and Urbano provided a systematic approach to highlight the concept of a modern entrepreneurial university [5]. Based on their definition, an entrepreneurial university is defined as a dynamical system which comprises special inputs (e.g. structure, rules and regulation, etc.) and outputs (e.g. entrepreneur human resources, effective researches in line with the market needs, Innovations and inventions as well as entrepreneurial centers) and goals to mobilize all of its abilities, capabilities as well as resources for accomplishing its visions. Nelles and Vorley presented an emergent structure for learning entrepreneurial universities, benefit from entrepreneurial architecture [6]. The mentioned authors classified the components of an entrepreneurial university in five: structures, systems, strategies, leadership, and culture.

Based on aforesaid, organizational structure is as an input that helps organizations to optimize the use of their resources to achieve their goals and strategies [7]. Further, the university's organization and governance structure is confronted by a transformation that requires flexibility, efficiency and effectiveness [8-9]. As a result of considering the importance of structure in universities, this study focused on structure and EO aspects of universities to measure efficiency. This study concerned to investigate two perennial questions in process of efficiency measurement in universities, the type of used criterion and the applied method.

2.0 MATERIALS AND METHODS

Generally, there are two methods to measure efficiency: parametric and nonparametric. Data Envelopment Analysis (DEA) is one of the nonparametric approaches. To calculate efficiency using DEA, weighted average of outputs over inputs is

used. Any possible weight can be given to maximize efficiency frontier of a unit provided that if the weight used in a unit is also considered in calculating efficiency of another unit, the efficiency will be ≤ 1 [10]. There are a lot of advantages for employing DEA mentioned compared to the parametric methods [10-12]. According to the above mentioned authors, DEA is useful method in analyzing productions frontier which have several inputs and outputs. Since knowledge on the weight of input and output and their evaluation are not required in DEA, this approach is more capable than other methods [13]. The ability to provide guidance on how to enhance the efficiency of inefficient units as well as the ability to measure the efficiency with respect to the efficiency frontier, which measures the best efficiency that can be achieved in practical terms, is another advantage of DEA [10]. Therefore, this tool presents excellent model for the comparison of efficiency among different faculties and institutes in universities as decision making units (DMUs). This study applied BCC and input-oriented DEA method to measure relative efficiency of 16 faculties and institutes in Ferdowsi University of Mashhad (FUM) in Iran.

2.1 Identification of Criteria of the Study

According to Guerrero and Urbano, structural policies are taken into account as one of the special input for modern entrepreneurial universities which plays a significant role to achieve entrepreneurial behaviour in universities and EO as an achievement (or output) for modern entrepreneurial universities [5]. Therefore, the Robbin's three dimensions of structure (such as: formalization, centralization and complexity) were considered as three inputs and degree of EO in non-academic staff was regarded as output for DEA [14]. In this research, descriptive-survey methodology was used and the data were collected through a questionnaire survey in FUM. Based on annually published report of the Ministry of Higher Education of Iran in 2012, FUM is one of the top ten public universities which were ranked according to: entrepreneurial research activities, education activities, international position, facilities, economic activities, social activities and etc. The two part-questionnaire was applied to measure structural and entrepreneurial orientation which indicates position of structure policies and degree of EO (including: entrepreneurial human resources, effective researches in line with the market needs as well as innovations and inventions and etc.). The target population of the study was non-academic staff of 16 faculties and institutes. The questionnaires were distributed among 350 respondents. Stratified sampling was employed to determine the number of respondents. 286 responses were obtained, yielding a suitable rate of return (81.7%). The interval data were obtained through calculating the mean of each respondent's response to the items of each construct and then the average of total participant's response to any construct of structure and EO were calculated according to the number of each DMU's sample (or respondents).

Besides, since this study plans to focus on changes in structural policies and structural reforms, it comes to view that concentrating on the three mentioned components of structure (formalization, centralization and complexity). Hence, to achieve this status, the study's results through DEA (from the viewpoint of structure policies) can be a roadmap for inefficient universities. Due to these reasons, input-oriented approach in BCC method which is showed in Equation 1 was employed. Regarding the objective function, it is clear that this model is nonlinear and non-convex.

$$\textbf{Min } y_0 = \theta - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$$

Subject to:

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{r0}$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta x_{i0}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0, s_r^+ \geq 0, s_i^- \geq 0$$

➢ **Where:**

1: $s_i^-, s_r^+ = slacks$

2: λ is a nonnegative vector in R^n.

3: (i=1, 2… m), (j=1, 2… n), (r=1, 2… s)

θ free in sign

$y_r = amount\ of\ output for\ r$

$x_i = amount\ of\ input\ i$

Equation 1 Input-oriented and BCC model

3.0 RESULT AND DISCUSSION

The Equation 1 was calculated through Coelli's [15] DEAP software version 2.1. As illustrated in the Table 1, the efficiency score of some DMUs (such as: 9, 11, 14, 15 and 16) equals 1 [15]. Therefore, the DMUs are considered efficient faculties and institutes, and the rest of them are inefficient. Table 1 illustrates return to scale in each DMU. All DMUs except the first DMU and efficient DMUs are increasing return to scale. According to Cooper *et al.* slack movement (in both input and output) in the Table shows the amount of each inefficient DMU's movement toward being efficient [10]. For example, DMU1 is an inefficient unit and according to its slacks in Table 1, DMU1 should move toward efficient through new inputs and new outputs.

Table 1 Input-orientated DEA results

DMUs	TE CRS	TE VRS	SE	Return to scale	Input Slack			Output Slack	Peers
					Input 1	Input 2	Input 3		
1	0.867	0.868	0.998	Drs	0	0	1.280	0	9, 11, 4
2	0.480	0.766	0.627	Irs	0	0	0	21.618	15,16, 4
3	0.588	0.768	0.766	Irs	0.085	0	0	12.969	15, 4
4	0.717	1	0.730	Irs	0	0	2.151	16.15	4
5	0.713	0.833	0.856	Irs	3.905	0	0	0	15, 4, 14
6	0.722	0.877	0.823	Irs	0	0	0.146	0	16, 14, 4
7	0.723	0.765	0.946	Irs	2.000	0.118	0	1.250	15
8	0.453	0.801	0.565	Irs	3.914	0	0	19.008	15, 4
9	1	1	1	-	0	0	0	0	9
10	0.763	0.956	0.798	Irs	7.011	0	0	0.135	15, 4
11	1	1	1	-	0	0	0	0	11
12	0.791	0.867	0.913	Irs	6.333	3.533	0	3.750	15
13	0.809	0.929	0.871	Irs	14.071	8.857	0	7.000	15
14	1	1	1	-	0	0	0	0	14
15	1	1	1	-	0	0	0	0	15
16	1	1	1	-	0	0	0	0	16
Mean	0.789	0.902	0.868		2.333	0.782	0.089	4.108	

Note: TE: Technical efficiency; SE: Scale efficiency; Input1: Centralization; Input2: Formalization; Input3: Complexity; Output: Entrepreneurial Orientation; Drs: Decreasing return to scale; Irs: Increasing return to scale

As a result, by considering the above equation, new input1= 31.936, new input2= 20.958, new input3= 24.668 and new output does not change. In this regard, it could be concluded that DMU's 1 will be efficient if all three components of structure, centralization, formalization and complexity, decrease the degree of three mentioned components to 31.936, 20.958 and 24.668, respectively. It means that the DMU1 should take structural policies which are predisposing factors for decreasing centralization, formalization and complexity in structure of DMU1. The efficiencies of the other DMUs will be improved through taking new inputs and outputs like the aforementioned method for DMU1. Another point that should be discussed is the mean of DMUs' scale efficiency (is equal to 0.868). This number indicates relatively satisfactory rate of efficiency. However, the structure needs to be modified to achieve high rate of intensity in entrepreneurship orientation. To achieve this status, the DMUs which are efficient should be peer for inefficient DMUs. The results, as shown in Table 1 by using DEAP software, indicates that each inefficient DMU should take account some DMUs as peers DMUs. For example, DMU9, DMU11 and DMU14 are as peers for DMU1 since DMU1 is not efficient. A quick glance at Table 1 reveals that DMU's 9, 11, 14, 15 and 16 have scale efficiency values of 1.0 and that their peers are themselves. This is as one would expect and suppose for the efficient points that explain and define the frontier. In this study, DEA determines the amount of employing inputs policies in DMUs to achieve high level of productivity and efficiency. Based on the DEA results, complexity or formalization or centralization or some/all of them along with output should be changed. It can be concluded that DEA is as a roadmap for enhancing efficiency. Furthermore, DEA calculated how to change inefficient units for improvement.

4.0 CONCLUSION

Measuring efficiency is a main concern of universities' managers. DEA is a linear programming technique which simplifies the method necessary to determine operating relative (scale) inefficiency of a cluster of DMUs. This technique is an innovative approach to scale in efficiency measurement using existing multiple inputs and outputs. Besides, DEA determines slack/surplus and target values. This study was conducted to determine relative efficiencies, slack/surplus values of 16 faculties and institutes. The slacks/surpluses for each DMU indicated the measures which should be taken into account in the future. As this study applied input-oriented DEA method, slacks in inputs (structure policies) should be considered and adjusted for improvement of the entrepreneurial orientation. This measure leads to improve efficiency [16, 17]. Practically, the present study shows the direction to identify the inefficient faculties and institutes and provide them with instructions on how to improve structural policies as inputs and EO as output in parallel.

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