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APPLICATIONS OF MANAGEMENT SCIENCE VOLUME 19

APPLICATIONS OF MANAGEMENT SCIENCE

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SECTION A
MANAGERIAL APPLICATIONS OF DEA

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INTERCOLLEGIATE ATHLETICS EFFICIENCY: A TWO-STAGE DEA APPROACH

Mauro Falasca and John F. Kros

ABSTRACT

As the pressure to win and generate revenue and as the allegations of out-of-control spending continue to increase, there exists much interest in intercollegiate athletics. While researchers in the past have investigated specific issues related to athletics success, revenue generation, and graduation rates, no previous studies have attempted to evaluate these factors simultaneously. This chapter discusses the development of a data envelopment analysis (DEA) model aimed at measuring how efficient university athletic departments are in terms of the use of resources to achieve athletics success, generate revenue, and promote academic success and on-time graduation. Data from National Collegiate Athletic Association (NCAA) Division I Football Bowl Subdivision (FBS) universities are used to evaluate the relative efficiency of the institutions. The model identifies a series of "best-practice" universities which are used to calculate efficient target resource levels for inefficient institutions. The value of the proposed methodology to decision makers is discussed.

Keywords: Benchmarking; college sports; data envelopment analysis; efficiency analysis; management science; linear programming

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INTRODUCTION

Data collected from over 2,000 higher education institutions in the year 2013 indicated that athletic department expenditures totaled almost US$15 billion (Office of Postsecondary Education of the US Department of Education, 2015). Those expenditures represent a figure larger than the 2013 gross domestic product of countries such as Jamaica and Zimbabwe (International Monetary Fund, 2017). In the case of the Division I Football Bowl Subdivision (FBS), athletic department expenditures ranged from US$10 million to US$150 million, with the average Division I FBS institution spending over US$50 million (Office of Postsecondary Education of the US Department of Education, 2015).

The high economic stakes inherent to big-time intercollegiate athletics fuel an extreme pressure to win that may result in inefficiencies (Clark, 2010; Cullen, Latessa, & Byrne, 1990; Smith, 2000; Upthegrove, Roscigno, & Charles, 1999). Evaluating efficiency in college sports is further complicated by the increased spending that has characterized the so-called athletics "arms race" (Budig, 2007; Hoffer, Humphreys, Lacombe, & Ruseski, 2015; Tsitsos & Nixon, 2012). It is estimated that between 1994 and 2001, capital expenditures related to intercollegiate athletics increased by around 250% (Brake, 2010).

While a small number of quantitative studies have previously investigated issues related to college athletics success, the athletics "arms race" and college graduation rates, no previous studies have attempted to evaluate those different factors at the same time. The purpose of this study is to develop a model that simultaneously incorporates multiple inputs and outputs related to collegiate athletics. More specifically, the model is aimed at evaluating the relative performance of athletic departments responsible for managing resources to achieve athletic success, generate revenue, and promote academic success and on-time graduation.

The rest of the chapter is organized as follows: the study begins with a brief overview of the field of data envelopment analysis (DEA) and DEA sports-related applications, which provide the theoretical background for this study. The authors then discuss the development of the proposed model before transitioning to the methodology section. In the final two sections, results are presented and conclusions are discussed.

DATA ENVELOPMENT ANALYSIS

DEA represents an analytical technique that can be used to measure the relative performance of a group of peer entities which convert inputs into outputs (Cooper, Seiford, & Zhu, 2011). Key advantages of this technique over traditional statistical modeling approaches, such as regression analysis, include the facts that DEA does not require prescribing any functional forms

(Cooper, Seiford, & Tone, 2007), and that DEA can easily accommodate multiple input and multiple output variables (Emrouznejad & Cabanda, 2014).

Since first being introduced by Charnes, Cooper, and Rhodes (1978), DEA has been widely used to analyze the performance of decision makers in many different subject areas. For example, DEA has been one of the most commonly used approaches to measure performance in the healthcare industry (Hollingsworth, 2008), the education sector (Bessent, Bessent, Charnes, Cooper, & Thorogood, 1983), as well as the area of sports.

Sports-related DEA applications have primarily focused on professional sports. At the collegiate level, Fizel and D'itri (1996) used DEA to assess coaching efficiency in college basketball, Fizel and Michael (1999) measured efficiency to assess the impact of managerial firings and hirings in college basketball, while Bartholomew and Collier (2011) used defense metrics to evaluate the defensive efficiency of college basketball teams.

At the professional level, the technique has been widely used to assess the efficiency of players in basketball (Cooper, Ramón, Ruiz, & Sirvent, 2011; Cooper, Ruiz, & Sirvent, 2009), hockey (Leibenstein & Maital, 1992), male and female golf (Fried, Lambrinos, & Tyner, 2004), as well as tennis (Ruiz, Pastor, & Pastor, 2013). DEA has also been used to analyze the relative efficiency of professional teams and coaches in basketball (Moreno & Lozano, 2014) and soccer (Barros, Assaf, & Sai-Earp, 2010; Dawson, Dobson, & Gerrard, 2000; Haas, 2003). Previous DEA research has also examined the efficiency of professional teams over time (Boscá, Liern, Martínez, & Sala, 2009) and analyzed the offensive and defensive efficiency of teams in different professional leagues (Boscá et al., 2009). From a managerial standpoint, DEA models have been developed to analyze the efficiency of salaries in professional sports (Einolf, 2004), to evaluate management and improve operational efficiency (Kang, Lee, & Sihyeong, 2007; Lee, 2009), as well as to assess managerial performance in professional baseball (Lewis, Lock, & Sexton, 2009).

While DEA models have been successfully implemented in a wide variety of sports-related applications, no published studies have, to the best of our knowledge, used this technique to assess efficiency in the context of intercollegiate athletics using multiple financial inputs and multiple outcome variables.

MODEL

The objective of a DEA model is to estimate the efficiency a decision-making unit (DMU) (Charnes et al., 1978). Each DMU generates y outputs from x inputs. The efficiency of a DMU is measured by comparing the sum of its weighted outputs to the sum of its weighted inputs. In the linear program formulation (1) below, the weights λ represent the decision variables, while the different inputs and outputs are used as the model parameters.

$$\max \phi \tag{1}$$

subject to

$$\sum_{j=1}^{n} x_{ij}\lambda_j = x_{i0} \qquad i = 1, 2, \ldots, m$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j = \phi y_{r0} \qquad r = 1, 2, \ldots, s$$

$$\lambda_j \geq 0 \qquad j = 1, 2, \ldots, n$$

Efficiency scores are first calculated for each DMU by solving model formulation (1) once for each DMU. In our context, an efficiency score of 100% would indicate that a school has efficiently used its financial resources. On the other hand, an efficiency score smaller than 100% would suggest that, relative to the institutions included in the analysis, a school has been inefficient in its use of the resources available.

Model formulation (1) can then be used to identify a set of efficient and a set of inefficient institutions. Finally, input and output slacks can be calculated using linear formulation (2).

$$\max \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right) \tag{2}$$

subject to

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = x_{i0} \qquad i = 1, 2, \ldots, m$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = \phi y_{r0} \qquad r = 1, 2, \ldots, s$$

$$\lambda_j \geq 0 \qquad j = 1, 2, \ldots, n$$

In this case, input s_i^- and output s_r^+ slacks are optimized by fixing the optimal ϕ in formulation (2). With respect to the DEA formulations (1) and (2), an output-oriented (O-O) model is employed because the purpose of this study is to analyze how institutions may be able to improve their performance given their current level of inputs.

METHODOLOGY

Data Collection

Data from Division I FBS universities were used to evaluate the relative efficient use of athletic resources. The data were obtained from four sources: the National Association of Collegiate Directors of Athletics (NACDA) Directors' Cup website (NACDA, 2013), the Office of Postsecondary Education (OPE) Equity in Athletics Disclosure Act (EADA) database (Office of Postsecondary Education of the US Department of Education, 2015), the National Collegiate Athletic Association (NCAA) Federal Graduation Rate (FGR) database (NCAA, 2016), and the USA Today athletic director salary database (Upton & Berkowitz, 2013).

Sample Size and Missing Data

A total of 110 Division I FBS universities were analyzed. Fifteen other institutions with missing values were excluded from the study, as recommended by Cooper et al. (2011). These institutions included the Air Force Academy, Boston College, Brigham Young University, Georgia State University, the University of Miami, the Naval Academy, Northwestern University, Rice University, Temple University, Tulane University, the University of Tulsa, the University of Southern California, Southern Methodist University, Stanford University, and the United States Military Academy.

Cluster Analysis and Sample Size Requirements

Division I FBS athletic conferences tend to be relatively heterogeneous in terms of resource levels (Dunn, 2013). From a DEA standpoint, homogenous sets of DMUs must be developed so that valid comparisons can be made (Golany & Roll, 1989). For this reason, Ward's method, a clustering approach that tends to produce groups with fairly similar number of entities, was used to identify meaningful clusters (Hair, Anderson, Tatham, & Black, 1998). The results suggested that the universities included in the sample could be grouped into two meaningful groups. Table 1 displays the two resulting clusters. The first group included the American Athletic Conference, the Power Five conferences, and an "Independent" institution (The University of Notre Dame). The second group included the Mid-Major conferences and the remaining "Independent" institutions.

Table 1. Breakdown of Conferences by Cluster.

Conference	DMUs
Cluster 1	**66**
Atlantic Coast Conference (ACC)	12
American	8
Big 12	10
Big Ten	11
Independent	1
PAC-12	10
Southeastern Conference (SEC)	14
Cluster 2	**44**
Conference USA (CUSA)	11
Independent	2
Mid-American	13
Mountain West	11
Sun Belt	7
Total	**110**

At the same time, it is important to include a large enough number of DMUs in each group in order to develop models that have adequate discriminatory power. In this respect, researchers have proposed different rules of thumb related to the minimum number of observations required by a DEA model. Dyson et al. (2001), for example, suggest including at least twice the number of input and output variables combined. Since our proposed model includes five input variables and three output variables, the minimum required number of 30 observations is satisfied since 44 and 66 institutions were included in each cluster.

Model Inputs

Five input measures are used in the proposed DEA model: operating expenses, recruiting expenses, and the salaries of athletic directors, coaches, and assistant coaches. As previously explained, athletic directors' salaries were obtained from the USA Today athletic director salary database, while the remaining input estimates were retrieved from the OPE Equity in Athletics database.

A summary by conference of the input measures for all institutions included in our study are presented in Table 2.

Table 2. Mean DEA Model Inputs.

Athletic Conference	Operating Expenses (US$)	Recruiting Expenses (US$)	Athletic Director Salary (US$)	Coaches' Salary (US$)	Assistant Coaches' Salary (US$)
Cluster 1					
ACC	9,376,455.42	1,266,514.92	600,829.75	6,765,098.33	6,120,694.58
American	8,836,516.50	864,869.88	552,271.50	5,430,913.13	4,179,665.63
Big 12	10,802,779.90	1,370,494.90	700,978.60	8,514,084.40	5,983,300.40
Big Ten	12,665,118.18	1,671,502.45	712,164.09	8,501,835.00	6,387,767.55
Independent	17,428,290.00	1,984,195.00	1,026,942.00	7,885,007.00	9,051,746.00
PAC-12	10,521,867.00	1,164,198.90	508,415.80	6,999,686.00	5,659,243.70
SEC	11,068,737.21	1,680,231.71	857,971.07	8,658,138.71	6,908,843.29
Cluster 2					
CUSA	4,312,147.45	465,126.18	272,591.55	1,897,575.09	1,975,270.27
Independent	4,506,367.50	409,011.50	214,497.00	1,307,327.50	1,460,213.50
Mid-American	3,622,522.54	444,356.92	228,471.62	1,976,659.85	2,137,618.15
Mountain West	4,947,952.64	613,263.09	307,644.55	2,922,637.55	3,075,485.00
Sun Belt	3,090,002.43	391,230.00	181,251.43	1,655,145.71	1,921,363.14
Mean	**8,070,542.03**	**1,023,214.52**	**505,862.70**	**5,411,862.86**	**4,536,994.63**

Model Outputs

The proposed DEA model includes outputs related to intercollegiate athletics success, collegiate athletics revenues, and academic success.

The model incorporates the number of points recorded by each institution in the 2013 Directors' Cup standings as an estimate of intercollegiate athletics success. The Directors' Cup is a competition aimed at recognizing the most successful collegiate athletic programs in the United States. The competition is organized by the NACDA and is designed to recognize institutions that maintain successful athletics programs in both men's and women's sports. In the Directors' Cup, each educational institution is awarded points in multiple men's and women's sports. Michigan State University, for example, recorded 670.50 points across 10 men's and 10 women's sports in the year 2013.

In terms of collegiate athletics revenues, the DEA model uses revenue data from the OPE EADA database. These estimates include revenues from actual ticket and luxury box sales, contributions from alumni, fund-raising activities, sponsorships, state or other government support, and any other revenues related to intercollegiate athletic activities. For instance, total collegiate athletics revenues at Michigan State University in the year 2013 totaled US$86,586,155.00.

Because one of the main goals of college is graduate with a degree, the model uses FGRs as an estimate of student-athlete academic success. Institutions that offer athletics aid are required by NCAA legislation and the 1990 Student Right-to-Know act to report graduation rates. FGRs are calculated as the percentage of student-athletes who complete a degree from their initial school within six years. The FGR for Michigan State University in the year 2013, for example, was 62%.

Table 3 displays the output measures, summarized by conference, for all institutions included in the analysis.

RESULTS AND DISCUSSION

Efficiency Scores

Efficiency scores were calculated for each school by solving formulation (1) 110 times (i.e., once for each of the schools included in our study). The DEA model results, summarized by athletic conference, are displayed in Table 4.

As previously explained, efficiency scores of 1.0 or 100% indicate that the corresponding institution has efficiently used its financial resources. On the other hand, efficiency scores lower than 1.0 or 100% indicate that, relative to the universities included in the analysis, an institution can be categorized as inefficient.

Table 3. Mean DEA Model Outputs.

Athletic Conference	Directors' Cup Pts.	Total Revenue (US$)	FGR
Cluster 1			
ACC	603.86	74,646,608.83	72.08
American	260.66	57,035,349.88	61.63
Big 12	575.77	92,881,695.30	63.00
Big Ten	748.83	103,155,757.36	72.09
Independent	1,015.50	114,843,522.00	94.00
PAC-12	644.23	77,998,683.80	63.40
SEC	718.18	98,526,536.36	63.64
Cluster 2			
CUSA	75.00	26,705,829.55	58.55
Independent	83.25	21,038,172.00	55.50
Mid-American	119.82	26,401,731.23	70.00
Mountain West	180.00	32,921,371.00	63.45
Sun Belt	93.71	20,733,315.00	57.14
Mean	**418.40**	**62,510,050.17**	**65.12**

Table 4. Summary of DEA Model Results.

Athletic Conference	DMUs	Efficient DMUs	Benchmark DMUs	Mean Efficiency Score (%)
Cluster 1				
ACC	12	8	7	94.36
American	8	6	3	96.98
Big 12	10	5	4	91.33
Big Ten	11	6	5	94.72
Independent	1	0	0	85.76
PAC-12	10	6	5	96.40
SEC	14	5	4	92.68
Cluster 2				
CUSA	11	2	1	86.12
Independent	2	1	1	93.25
Mid-American	13	8	7	96.82
Mountain West	11	4	2	91.83
Sun Belt	7	6	4	97.12
Count (Mean)	**110**	**57**	**43**	**(93.57)**

Our results indicate that, based on their current levels of intercollegiate athletic success, revenue generation, and academic success, 52% (57 out of 110) of the universities were classified as efficient in terms of their use of athletic financial resources (i.e., based on the data, there is no evidence to demonstrate that a peer institution can perform better). The remaining 48% (53 out of 110) of the institutions were classified as inefficient by the DEA model. On the other hand, a total of 43 universities (39% of the total) were identified as benchmark of "best-practice" institutions. These institutions were used to calculate specific input and output inefficiencies.

Input and Output Inefficiencies

From a modeling standpoint, DEA projects inefficient DMUs as a weighted combination of efficient peer institutions. Therefore, the DEA model not only helps identify the set of efficient and inefficient higher education institutions but also provides relevant information regarding what actual changes would need to be made to the input and output levels of inefficient universities in order to achieve efficiency.

In order to increase their efficiency, certain institutions might be required to reduce their operating expenses, whereas other universities might need to reduce their athletic director's salary. Similarly, certain universities might be required to increase their revenues, while others might need to see an increase in the number of Directors' Cup points. Auburn University from Cluster 1, for example, was categorized as inefficient. The model identified Louisiana State University, Mississippi State University, Syracuse University, and the University of Alabama as the corresponding best-practice peer institutions. Table 5 illustrates how target input values and specific input inefficiencies were calculated for Auburn University.

The athletic director salary at Auburn University was regarded as efficient since the current actual salary (US$612,000) was equal to the projected value calculated using the set of benchmark institutions ($0.103 \times$ US$725,000 + 0.241 $\times$ US$182,000 + 0.159 $\times$ US$570,057 + 0.670 $\times$ US$600,500 = US$612,000). However, the level of recruiting expenses was considered inefficient since the actual expenses (US$2,706,621) were larger than the target value ($0.103 \times$ US$1,313,261 + 0.241 $\times$ US$1,042,840 + 0.159 $\times$ US$935,914 + 0.670 $\times$ US$2,193,655 = US$2,006,716), resulting in an excess of US$699,905. Given the current input and output levels included in the data set, reducing recruiting expenses would help increase the efficiency level of Auburn University.

Table 6, on the other hand, illustrates how target output values and specific target output improvements were calculated for Auburn University.

All three current output levels were regarded as inefficient. From a total revenue perspective, for example, the current level (US$120,699,075) was lower

Table 5. Input Projections (Auburn University).

Institution	Estimate	Operating Expenses (US$)	Recruiting Expenses (US$)	Athletic Director Salary (US$)	Coaches' Salary (US$)	Assistant Coaches' Salary (US$)
Auburn University	Actual	13,681,369	2,706,621	612,000	10,382,755	9,988,521
	Projected	13,681,369	2,006,716	612,000	10,382,755	9,276,972
	Difference	0	−699,905	0	0	−711,549
Reference Set	Benchmark λ	Operating Expenses (US$)	Recruiting Expenses (US$)	Athletic Director Salary (US$)	Coaches' Salary (US$)	Assistant Coaches' Salary (US$)
Louisiana State University	0.103	9,982,267	1,313,261	725,000	9,875,761	10,591,725
Mississippi State University	0.241	7,502,741	1,042,840	182,000	5,619,407	4,599,365
Syracuse University	0.159	9,082,505	935,914	570,057	3,872,290	6,368,125
The University of Alabama	0.670	14,015,941	2,193,655	600,500	11,024,497	9,040,529

Table 6. Output Projections (Auburn University).

Institution	Estimate	Directors' Cup Pts.	Total Revenue (US$)	FGR
Auburn University	Actual	636.83	120,699,075	67.00
	Projected	781.86	144,346,194	80.13
	Difference	145.03	23,647,119	13.13
Reference Set	Benchmark λ	Directors' Cup Pts.	Total Revenue (US$)	FGR
Louisiana State University	0.103	847.00	132,828,429	64.00
Mississippi State University	0.241	454.75	59,655,385	69.00
Syracuse University	0.159	555.00	87,647,822	71.00
The University of Alabama	0.670	740.50	152,588,651	68.00

than the target value of US$144 million (0.103 × US$132,828,429 + 0.241 × US$59,655,385 + 0.159 × US$87,647,822 + 0.670 × US$152,588,651 = US$144,346,194), resulting in a difference of over US$24 million. In this case, increasing total athletics revenues would help Auburn University increase its efficiency level. Similar calculations can be performed for the remaining inefficient institutions.

The model results can then be used to identify the amount and type of excess resources used by all inefficient DMUs. Those excess resources represent savings that could be achieved if inefficient DMUs were to perform as efficiently as the benchmark or "best-practice" institutions. Table 7 displays mean efficient target input values for all the institutions included in our study summarized by conference.

Finally, the DEA model can also be used to estimate efficient output levels. Mean target output measures for all the institutions included in our study (summarized by conference) are presented in Table 8.

If the current input and output levels are compared against the efficient target levels across all 110 institutions, potential input savings and output improvements can be estimated. These results (summarized by conference) are presented in Table 9.

The model results presented above suggest that if inefficient institutions were able to perform as efficiently as the "best-practice" DMUs, significant savings could be achieved for four of the five input variables (operating expenses, recruiting expenses, coaches' salary, and assistant coaches' salary). The mean difference in athletic directors' salaries was not found to be significant at the 0.05 level of significance ($p = 0.09$). It should also be noted that this variable had the largest relative variability of all five input variables. In the case of the model outputs, significant improvements could be achieved for all three output variables.

Table 7. Summary of Efficient Target Input Levels.

Athletic Conference	Operating Expenses (US$)	Recruiting Expenses (US$)	Athletic Director Salary (US$)	Coaches' Salary (US$)	Assistant Coaches' Salary (US$)
Cluster 1					
ACC	9,376,455.42	1,266,514.92	600,829.75	6,645,020.97	5,949,982.23
American	8,534,620.54	864,869.88	502,467.02	4,857,112.41	4,179,665.63
Big 12	10,760,916.34	1,300,553.92	681,020.51	8,143,436.83	5,983,300.40
Big Ten	12,599,825.48	1,639,355.79	677,775.72	8,154,889.21	6,387,767.55
Independent	14,269,730.83	1,874,596.22	939,416.36	7,885,007.00	9,051,746.00
PAC-12	10,423,707.55	1,155,384.21	508,415.80	6,943,756.62	5,659,243.70
SEC	10,788,371.37	1,610,324.42	648,647.92	7,967,999.97	6,842,437.16
Cluster 2					
CUSA	4,121,487.49	431,142.45	250,513.31	1,744,539.13	1,975,270.27
Independent	3,665,578.16	384,829.34	214,497.00	1,233,439.51	1,460,213.50
Mid-American	3,382,555.19	428,466.96	220,887.37	1,964,398.17	2,114,647.72
Mountain West	4,850,151.66	586,737.09	305,165.25	2,696,243.84	3,061,997.46
Sun Belt	3,090,002.43	369,510.93	181,251.43	1,649,950.03	1,921,363.14
Mean	**7,892,437.27**	**993,195.92**	**466,198.46**	**5,154,656.28**	**4,505,856.33**

Table 8. Summary of Efficient Target Output Levels.

Athletic Conference	Directors' Cup Pts.	Total Revenue (US$)	FGR
Cluster 1			
ACC	665.31	79,985,355.32	77.09
American	307.06	60,144,989.48	64.03
Big 12	659.34	100,882,263.06	69.61
Big Ten	796.20	109,641,209.98	76.92
Independent	1,184.19	133,920,457.81	109.61
PAC-12	692.52	80,859,206.97	65.69
SEC	780.60	106,340,929.65	73.19
Cluster 2			
CUSA	94.15	31,026,933.32	70.23
Independent	90.19	23,045,303.16	62.04
Mid-American	124.10	27,274,579.55	72.50
Mountain West	211.17	35,948,862.98	75.57
Sun Belt	97.83	21,476,908.76	58.84
Mean	**460.61**	**67,044,344.76**	**71.39**

Table 9. Actual versus Projected Input and Output Levels.

Variable	Actual	Projected	Difference
Input			
Operating expenses (US$)	8,070,542.03	7,892,437.27	−178,104.76**
Recruiting expenses (US$)	1,023,214.52	993,195.92	−30,018.59**
Athletic director salary (US$)	505,862.70	466,198.46	−39,664.24
Coaches' salary (US$)	5,411,862.86	5,154,656.28	−257,206.58**
Assistant coaches' salary (US$)	4,536,994.63	4,505,856.33	−31,138.30*
Output			
Directors' Cup pts.	418.40	460.61	42.21**
Total revenue (US$)	62,510,050.17	67,044,344.76	4,534,294.59**
FGR	65.12	71.39	6.27**

Notes: **Mean difference significant at the 0.01 level.
*Mean difference significant at the 0.05 level.

CONCLUSIONS

The purpose of this study was to develop a model that simultaneously combined multiple financial aspects of athletic department operations with multiple

outcomes related to intercollegiate athletics. To accomplish the stated research objective, the authors developed a DEA model that evaluates the relative performance of athletic departments in charge of managing financial resources to achieve athletic success, generate revenue, and promote academic success and on-time graduation.

The proposed two-stage DEA methodology can help not only calculate efficiency scores for each school, but also estimate specific input and output inefficiencies and identify benchmark or "best-practice" peer institutions. Data from NCAA Division I FBS universities were used to evaluate the relative efficiency of institutions. Overall, the model results indicate that certain institutions are more efficient than others, and that significant input savings and output improvements could be achieved if all institutions managed their current resources as efficiently as the efficient DMUs. The model also identified a series of "best-practice" universities which were used to calculate efficient target levels for inefficient institutions. The value of the proposed methodology to decision makers was discussed. In this respect, the proposed methodology provides decision makers with relevant information regarding what changes would need to be made to the input and output levels in order to become more efficient.

It is important to note that DMU efficiency is only relative to the schools included in a particular data set. If one or more schools were to be added or removed from the data set, a previously efficient institution may be classified as inefficient or, alternatively, an inefficient institution may be classified as efficient. In this respect, institutions should not be compared with other DMUs outside of the corresponding group and/or time frame. Similarly, the efficiency of a DMU is relative to the input and output variables included in the analysis. As a result, an institution identified as efficient in the study may be categorized as inefficient if different input or output variables were included in the analysis. Future research should therefore explore the impact of additional input and output variables on the model results. Notwithstanding the above limitations, the proposed methodology offers a relevant means for evaluating the efficiency or relative performance of decision makers responsible for competing in the business of intercollegiate athletics.

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