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ENHANCING EDUCATIONAL EFFICIENCY THROUGH DATA ENVELOPMENT ANALYSIS A CASE STUDY OF THE UNIVERSITY CENTRE OF MAGHNIA-ALGERIA

This article assess the educational efficiency of the Maghnia University Centre in both input and output dimensions using Data Envelopment Analysis (DEA). This method enables the identification of necessary adjustments for the two decision-making units that were found to be inefficient in order to achieve comprehensive efficiency, as indicated by the study's results.

Keywords: data envelopment analysis; educational efficiency; the COVID-19 pandemic; decision-making units.

Education is of great importance for individuals and nations. Hence, individuals who acquire higher education are well-positioned to start or guarantee well-paying jobs in the market. The level of education also plays a crucial role in determining an individual's lifetime return. Additionally, educational institutions that provide opportunities for students to interact with people from diverse backgrounds contribute to the development of appreciation, understanding, and crucial life skills like time management. Moreover, higher education is often associated with higher salaries and increased employment opportunities based on an individual's education level. At the national level, the correlation between eco-

nomics and education is becoming increasingly evident as people's productivity enhances. Furthermore, highly educated individuals are less likely to engage in criminal activities, whereas uneducated individuals are usually unemployed and may resort to crimes because of poverty. Furthermore, individuals with higher education levels are informed about climate change, and this knowledge can be used to improve sustainability-related policies and procedures in organizations and society as a whole. Lastly, inadequate education is often viewed as the underlying reason of poverty within a population. In conclusion, many factors make higher education essential overall and investing every dollar in this field is important. Therefore, it is crucial that sources for education are used efficiently.

Efficiency means doing more with less, and generally, there are numerous methods to calculate and evaluate the efficiency of universities, the traditional approach to efficiency is based on ratio analysis (Output-Input). However, for a homogenous group of units, Data Envelopment Analysis is predominantly an interesting method for measuring efficiency. The background and literature review demonstrated that most studies began by calculating efficiency for various universities and making comparisons between them.

Through this study, we start by calculating efficiency and making comparisons between the institutes of the same University Centre. This paper aims to fill this gap by focusing on the efficiency of the University Centre of Maghnia during the COVID-19 pandemic using Data Envelopment Analysis, which led the director of this University Centre to change his strategy in the near future.

EDUCATIONAL EFFICIENCY

Which refers to getting more with fewer resources, is what efficiency is all (Evenstad, 2017). This includes maximizing outputs, such as the quantities of services provided, while minimizing inputs, such as the financial resources needed to produce services.

This concept was developed by an Italian economist and sociologist called Vilfredo Pareto, he used his mathematics in economic analysis and in his Manual of Political Economy for more specifically. Moreover, Pareto believes that an allocation is efficient when an action makes some individual better off and not worse off (Martorana, 2007).

Throughout time, the literature of efficiency in the education field has expanded where we can find a lot of studies in this sector such as technical, economic, internal and external efficiency. However, many economists see the educational system as efficient when we get outputs of educational production with a low level of resources (Johnes, Portela, Thanassoulis, 2017). But educational efficiency is generally based on two goals, achievement of quantity and quality of the educational system output intended for economic and social development is the objective external efficiency (Alharbi, 2015), and internal efficiency based on the comparison between learning and economic cost as an input (Lockheed, Hanushek, Policy, 1994).

DEA FOR EFFICIENCY STUDY

Historically, DEA returned to Farrell's work (Farrell 1957) but 20 years later, Charnes et. al. used the term DEA and contributed Farrell's ideas (IÇöz, Sönmez, 2015). Then, the DEA becomes a program Based on a linear mathematical technique (Fotova Čiković, Martinčević, Lozić, 2022) for the efficiency percentage of decision-making collection. In addition, we use it to calculate the efficiency ratio for bank branches and universities for example (Thanassoulis, Kortelainen, Allen, 2012). Since its discovery in 1978, DEA has become the first non-parametric methodology used in many essential domains, such as agriculture, banking, supply chain, transportation, and public policy (Fotova Čiković, Martinčević, Lozić, 2022). Mathematically, this linear programming procedure is used for frontier analysis of inputs and outputs, and efficiency, by definition, is the ratio of output to input. When comparing with other relevant units, DEA assigns a result of 1 to a decision-making unit and less than one to (relatively) inefficient units. DEA assigns an efficiency score (Rosenmayer, 2014).

DEA models vary according to efficient border assumptions called returns to scale assumptions and input or output orientation selection. The first DEA model, called the CCR model, is named after the founders of the model: Charnes, Cooper, and Rhodes. Under the assumption of constant returns to scale, this model is used to calculate relative total activities based on Decision Making Units (DMUs) operating at an optimal scale (Ergulen, Ünal, Harmankaya, 2021).

The second DEA model, called the BCC model, was invented by Banker, Charnes, and Cooper and is based on variable returns to scale (VRS), where the returns are not proportionate to increases in efforts. The BCC model takes size infractions into account (rather than ignoring it) and calculates the real technical efficiency. The lack of homogeneity for BCC is not a problem, as the best-suited DMUs or different firms and organizations operating in the same businesses are taken into consideration (Khan, Pai, Kachwala, 2020). After defining the chosen model, the next step is choosing the orientation, which depends on the purpose of the analysis. We choose input orientation if we take reducing input as the essential way to adjust the efficiency of an inefficient unit. We should choose an output-oriented model when we take increasing output as the essential way to improve efficiency (Lai, Shi, Zhou, 2020).

As a Previous studies, the first one by M. Mojahedian et al. titled "A review on inputs and outputs in determining the efficiency of universities of medical sciences by the data envelopment analysis method". The main goal of this research paper was to use the number of academic staff, budget and costs, number of students, number of non-academic staff, spaces, equipment, and student's entrance scores as inputs. Additionally, the outputs considered were the number of graduates, publications, incomes, number of students, and student's scores. All of these factors were used to determine efficiency. This study proves that DEA is an essential method for determining the efficiency of universities. Analyzing efficiency through DEA allows policymakers to develop policies and define guidelines to improve performance. Furthermore, the study suggests

using inputs and outputs to evaluate medical universities. This study shows that a large number of individuals are seeking to measure and compare the efficiency of universities in order to improve efficiency, reduce costs, and manage resources (Mojahedian, Mohammadi, Abdollahi et al., 2020).

The second one by Sophia XiaoxiaDuan "An application of data envelopment analysis and strategic group analysis to Australian universities":

The **purpose of this article** is to understand how teaching and research contribute to the efficiency of universities. Furthermore, it adopts a new approach to evaluate the efficiency of universities in terms of their operations, teaching, and research efficiency. The researcher applies data envelopment analysis to assess the efficiency of 36 Australian universities between 2011-2015 and compared the high levels of efficiency (Duan, 2019).

The third one for Ergulen et al. "Data envelopment analysis and efficiency analysis of higher education institutions: example of selcuk university By using DEA". In this study, the researchers try to determine the efficiency of just one university, Selcuk University, using DEA. They consider various inputs (number of academic staff, number of administrative staff, number of students) and outputs (total expense, number of graduates, academic grade point average). The decision-making units in this study are the twenty faculties of the university. The researchers use Selcuk University's 2018 Administration Annual Report and 2018 Academic Incentive Score data. They use both the CCR and BCC models. The study shows that there are 10 faculties working with perfect efficiency (Ergulen, Ünal, Harmankaya, 2021).

The fourth one by: Halkos et al. "A DEA approach for measuring university departments' efficiency":

Through this paper, the authors use data envelopment analysis to calculate two models, the constant returns to scale (CRS) and variable returns to scale (VRS), to determine the efficiency levels of 16 departments of a public university. The study provides an example of how current advancements in statistical inference and efficiency analysis can be used to assess institutional performance concerns. The findings show that there has been ineffective resource allocation and/or application of departmental policy formulation (Halkos, Tzeremes, Kourtzidis, 2010).

About study period, The COVID-19 pandemic has had a significant impact on education globally. With schools closed and social distancing measures in place, many students are unable to attend classes. As a result, the education sector has been forced to adapt and find new ways of providing education to students. During the COVID-19 pandemic, learning and teaching environments started to change on a dramatic scale for all stakeholders (e.g., students, teachers, educational leaders, educationalists, etc.) due to the restriction strategies adopted and imposed by national governments in many parts of the world. The pandemic forced educators to quickly adopt and familiarize themselves with remote teaching technology, resulting in new forms of learning that may enhance accessibility, inclusivity, and flexibility.

Consequently, the Ministry of Higher Education and Scientific Research in Algeria during the COVID-19 pandemic forced all universities to take urgent measures, but it also caused an explosion in the online education system, which emerged as a necessary response to the health crisis. As a benefit, using information technologies in education provides effective learning-teaching environments from almost day one, and in many cases, are still in place at this time. Under this context, the University Center of Maghnia took swift methods towards digital transformation in education and started to actively encourage the application of distance learning, and teaching.

Generally, through this research paper, we will study the result of this strategy change in the number of alumni students for the 2021-2022 academic year.

APPLICATION TO THE UNIVERSITY CENTRE OF MAGHNIA

The proposed model in this work is based on the BCC DEA model. This model calculates the maximum weighted output-to-input ratio. The relative efficiency study was completed for decision-making entities such as institutes of higher education and the University Centre of Maghnia. DEA is a handy technique for determining DMU efficiency. The DEA model chosen is determined on the research topic and the features of the DMUs under consideration. Researchers should be aware of DEA's assumptions and limitations and use it in conjunction with other methodologies to gain a more complete knowledge of DMU efficiency.

In terms of educational efficiency during the Covid-19 period, our main source of data is the University Centre of Maghnia (Table 1). For more details we have taken Students registered, and teachers for each level as Input variables to be used, Concerning education achievement or the output of the system is mea-

Table 1. **Variables sources for educational efficiency in University Center of Maghnia**

Institute	Level	Students registered	Teachers	Alumni students
Economics Institute	Licence	625	39	567
	Master	417	19	410
Institute of Law	Licence	765	25	570
	Master	338	19	221
Institute of Arabic Languages and Literature	Licence	443	17	375
	Master	302	16	282
Institute of Technology	Licence	151	33	103
	Master	68	17	65

Source: University Center of Maghnia administration.

sured by alumni students, we can observe that the evaluation of efficiency in high educational systems is more complicated by the fact that students not only learn at university's classrooms but also in their homes, library and through using internet sources... Therefore, the appropriate output for efficiency considerations is that portion of student growth or development that can be reasonably attributed to specific educational experiences. in other words, with these variables we can construct just a view about quantitative efficiency not on qualitative efficiency and the hours timing at the university refer to first source of student's knowledge, at the latest, as we see perhaps the economics institute and institute of law have the biggest numbers but efficiency is based on the fractional relationship and does not take these differences into account.

EMPIRICAL RESULTS AND SUGGESTIONS
THE EFFICIENCY VALUE OF (VRS) MODEL

In the Frontier Analysis (DEA) program, the BCC (VRS) model of DEA was analyzed using an inputs and output-focused method, score value was assigned to each decision-making units (DMUs), with the highest score being 1.00 and the lowest score being 0. (DMUs) that reached the highest score were considered effective, while those scoring below this value were deemed ineffective. Improvement rates were proposed for those with ineffective scores.

DETERMINATION OF SCORE
RATES FOR THE BCC MODEL

On one hand, In the input orientation, efficiency is based on reducing input to get the same output and for more efficiency the result of data envelopment analysis show that the average overall efficiency is 0.944 (Table 2) and six DMUs exhibit the best performance with value of 1 and do not require any improvement in the inputs, and with the others DMUs we should make some changes to be more perfect and efficiency these adjustments are determined by comparing them with the closest unit on the efficiency curve, as like 4 and the 7 DMUs. two DMUs exhibit lower efficiency: law master level with technical efficiency 0,66 and licence technology level with technical efficiency 0.7.

On the other hand, output efficiency orientation is based on concept of maximizing output while keeping the same input, from this perspective, the average overall efficiency is 0.700 and it is acceptable. But we observe a similarly lower level of efficiency in the output orientation for DMUs number 4 and 7 specifically master law and Licence of technology.

With DEA program, we have the opportunity to make positive changes on unless decision making unit's efficiency. To achieve 100% of efficiency in input orientation we should be reducing 52 Students registered and 3 teachers to get the efficiency for master of law through, this can be achieved through a comparison with peers 8 and 6 (Table 3).

By reducing the number of Students registered in Institute of Technology license level to 106 and teaching only by 17 teachers we can make it efficient, this can be achieved by comparing with peers 2 and 8 (Table 4).

On the other hand, the projected value for the output orientation of efficiency will be 332 alumni students if we maintain the same inputs, this result

Table 2. **DEA results for education efficiency in the University Center of Maghnia**

Institutes	Level	Firm — DMU	Input orientated	Output orientated
Economics Institute	Licence	1	1.000	1.000
	Master	2	1.000	1.000
Institute of Law	Licence	3	1.000	1.000
	Master	4	0.846	0.666
Institute of Arabic Languages and Literature	Licence	5	1.000	1.000
	Master	6	1.000	1.000
Institute of Technology	Licence	7	0.705	0.700
	Master	8	1.000	1.000
		Mean	0.944	0.921

Source: DEA program outputs.

Table 3. **Results for firm: 4**

Variables	Original value	Projected value
Output 1	221.000	267.031
Input 1	338.000	285.859
Input 2	19.000	16.069
PEERS	Firm 4	Firm 8 Firm 6

Source: DEA Program Outputs.

Table 4. **Results for firm: 7**

Variables	Original value	Projected value
Output 1	103.000	103.000
Input 1	151.000	106.441
Input 2	33.000	17.220
PEERS	Firm: 7	Firm: 2 Firm: 8

Source: DEA Program Outputs.

Table 5. **Results for firm: 4**

Variables	Original value	Projected value
Output 1	221.000	331.905
Input 1	338.000	338.000
Input 2	19.000	18.547
PEERS	Firm: 4	Firm: 2 Firm: 8

Source: DEA Program Outputs.

Table 6. **Results for firm: 7**

Variables	Original value	Projected value
Output 1	103.000	147.049
Input 1	151.000	151.000
Input 2	33.000	17.476
PEERS	Firm: 7	Firm: 2 Firm: 8

Source: DEA Program Outputs.

should only be considered accurate when we comparing it to peers number 2 and 8 at last, for licensed technology we can up to 147 alumni students just with the same number of Students registered in this level and few teachers, only 17 teachers are needed 100% efficiency (Tables 5, 6).

CONCLUSION

Overall, education becomes great power and today the university has become an industry of production knowledge and students with qualifications to lead themselves in life. With limited knowledge, all students take the path between the levels of the university as an input of the educational system, but after a long time, they will become an output or alumni. Therefore, educational efficiency starts from the relation between output/input to avoid educational loss. As you know, educational efficiency is a complex concept, but with this concept, we can ensure that all students have the opportunity to succeed, which is the real objective of this study.

To sum up, this study is divided into two parts. The first part includes the introduction, literature review, and the study's tools, where we proved that we can use the same quantitative tool to obtain different results. The second part of this paper is a quantitative study based on applied DEA to calculate efficiency in the University Center of Maghnia through comparing the levels of each institute in The University Center of Maghnia (bachelor's-master's). The inputs of the study were registered students and teachers, and the output was alumni. We chose the period of study as the time during the COVID-19 pandemic, and this study is based on the applied BBC model. This model is based on various returns to scale in the two orientations: input orientation and output orientation. The highest score was 1.00, and anything lower than that indicated an inefficient DMUS, which required some changes. This study identified two inefficient decision-making units: the Master's level in Law and the Bachelor's level in Technology Sciences. These units scored only 84% and 70%, respectively, on input orientation, where the average efficiency was 94%. Any changes in these units should be compared with the performance of 2, 6, and 8 peers.

Similarly, both units received low marks on output orientation, with an average efficiency of 92%. For this category, comparisons should be made with 2 and 8 peer units.

To be efficient, we may need to make some changes between the inputs and outputs, but the deeper changes will be in the educational system, such as:
- create new curricula for all subjects;
- Raising the efficiency of all university staff through training;
- revision learning environment;
- creation of new course materials;
- update of exams and evaluation system;
- linking of education outputs with market of employment.

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ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ ОСВІТИ ЗА ДОПОМОГОЮ АНАЛІЗУ ОХОПЛЕННЯ ДАНИХ НА ПРИКЛАДІ УНІВЕРСИТЕТСЬКОГО ЦЕНТРУ МАГНІЇ (АЛЖИР)

Ефективність — це фундаментальна концепція, яка передбачає досягнення більшого з меншими ресурсами. У галузі освіти ефективність означає використання менших або навіть обмежених ресурсів для отримання бажаних результатів навчання. Проте вимірювання ефективності освіти є складним завданням, яке потребує використання відповідних методів. Одним з таких методів є аналіз охоплення даних (Data Envelopment Analysis — DEA) — непараметричний метод, який широко застосовують у різних галузях, зокрема в освіті, охороні здоров'я і банківській справі. Ця система базується на дослідницьких операціях, здатних надати користувачам варіанти стратегії досягнення оптимальної ефективності.

Метою даної статті є використання DEA для розрахунку ефективності Університетського центру Магнії у період пандемії COVID-19 шляхом порівняння різних інститутів цього центру. Використання DEA в цьому дослідженні дасть особам, які ухвалюють рішення, можливість виробити ефективну стратегію і уникнути непотрібних витрат.

Результати дослідження свідчать, що два осередки ухвалення рішень (Decision-Making Unit — DMU), а саме магістратура з права і бакалаврат з технологічних наук, не працюють з повною ефективністю. З використанням аналізу даних визначено необхідні зміни для досягнення повної ефективності. Для порівняння використано такі DMU: магістратури з економіки, арабських мов і літератур, магістратура з технології. Показано, що середня ефективність у орієнтації на вхід становила 94 %, тоді як у орієнтації на вихід — 92 %, при цьому було прийнято, що ефекти масштабу є різними. Ці висновки вказують на можливість підвищення ефективності роботи Університетського центру Магнії.

Ключові слова: *метод аналізу охоплення даних; ефективність освіти; пандемія COVID-19; осередки ухвалення рішень.*