Abstract: The application of the analytical methods and techniques of the Operational Research discipline can help in making better decisions, which thus allow decrease of costs, increase of revenue and profit, as well as market share, efficiency, etc. The non-parametric methodology Data Envelopment Analysis (DEA) is considered to be the leading methodology for measuring the relative efficiency of the Decision Making Units (DMUs). The DMUs should be homogeneous, i.e. they should use the same inputs to produce the same outputs. Ever since its beginnings up to today, the application of this methodology has noted a significant growth. It has been used in education, health care, banking, agriculture, the defence sector, energetics, tourism, sports, supply chain, transportation, public policy, etc. The aim of this paper is to provide a literature review of the application of DEA in the Republic of North Macedonia. On the basis of the reviewed papers published in journals and conference proceedings, books, Master’s theses and Doctoral dissertations, it has been confirmed that this methodology is most commonly used in the finance sector.

Keywords: Relative Efficiency, DEA, Literature Review, Republic of North Macedonia.

1. INTRODUCTION

Amazon, American Airlines, BMW, British Airways, British Telecommunications, Citibank, Dell, DHL, Eastman Kodak, EDS, Federal Express, General Motors, Hewlett-Packard, IBM, Motorola, NASA, Peugeot, Procter & Gamble, Samsung Electronics, etc. These organizations belong to various industries, they are with different size, with headquarters in different countries, but something is common for all of them. What is it? They all use the discipline Operational Research (O.R.) to make better decisions. The usual phases of an O.R. study are the following six (Hillier and Lieberman 2010, p. 8): (1) Define the problem of interest and gather relevant data; (2) Formulate a mathematical model to represent the problem; (3) Develop a computer-based procedure for deriving solutions to the problem from the model; (4) Test the model and refine it as needed; (5) Prepare for the ongoing application of the model as prescribed by management; and (6) Implement. These phases are described in detail in Hillier and Lieberman (2010, pp. 8-19). Some of the decision areas where this discipline is applied are (Anderson et al. 2009): assignment, data mining, financial decision-making, forecasting, logistics, marketing, networks, optimization, project planning and management, queuing, simulation, transportation. By using O.R. numerous organizations have increased revenue, profit, efficiency, market share, as well as having decreased costs, improved production, etc.

According to the management guru, Peter F. Drucker: “What gets measured gets improved.” Efficiency is an indicator of success and consists of achieving greater results (outputs) by using a minimum of resources (inputs). If an organization (profit or non-profit) achieved a higher output for a given input level, or the same output using less input, it means that the organization has increased efficiency. To measure the efficiency of entities, there exist two approaches in the relevant literature: the parametric (econometric) approach and the non-parametric (mathematical programming) approach. In this paper the focus is on the non-parametric approach, i.e. on Data Envelopment Analysis (DEA). In the literature of the discipline Operational Research, DEA was introduced by Charnes et al. (1978). DEA can be applied to measure the efficiency of decision-making units (DMUs) that use the same resources (inputs) to produce the same results (outputs). On the basis of the data for the specified inputs and outputs, an efficiency frontier is constructed, details can be found in Cooper et al. (2007). The bibliography of DEA published in 2018 (Emrouznejad and Yang 2018) includes 10300 DEA related articles published in journals since its introduction up to 2016. The focus of this paper is the application of DEA in the Republic of Macedonia. In the literature review there have been considered 14 articles (published in journals, conference proceedings, book, master thesis and PhD dissertation).
This paper is organized as follows: after the Introduction, the non-parametric methodology DEA is explained; then the application of DEA in the Republic of North Macedonia is presented, and the Conclusion is given in the end.

2. APPLICATIONS OF DEA IN THE REPUBLIC OF NORTH MACEDONIA

Table 1 shows a literature review of the applications of data envelopment analysis in the Republic of North Macedonia. In this review there have been included papers found through Google Scholar and personal contacts with researchers, as well as the author(s)/year, application, period, sample, variables, and the model of the covered papers. 14 papers are considered, 7 of which have been published in journals, 3 in conference proceedings, 2 are master's thesis, 1 is a doctoral dissertation, and 1 is a book. The analyzed paper are published in the period 2006-2017. Most of the applications are in the financial sector (7 papers), followed by the defense sector (2), education sector (2), tourism (2), and agriculture (1) (Table1). In terms of the period covered, the shortest is one year, and the longest is nine years. The smallest sample for analysis comprises 8 DMUs, and the largest consists of 47 DMUs. The average number of inputs and outputs is two. The most commonly used are CCR, BCC and window analysis models. Besides these papers, Cvetkoska (2013) uses DEA to measure the performance of the branches of one of the leading banks in the Republic of North Macedonia - Komercijalna Banka AD Skopje, but this paper (doctoral dissertation) is not given in the review because parts of it have been processed and published in Cvetkoska (2017).

Table 1: DEA applications in the Republic of North Macedonia: Literature review

<table>
<thead>
<tr>
<th>Author(s)/year</th>
<th>Application</th>
<th>Period</th>
<th>Sample</th>
<th>Variables</th>
<th>Model</th>
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</thead>
<tbody>
<tr>
<td>Atanasova-Pacemska and Timovski (2014)</td>
<td>Higher education</td>
<td>Generation of students 2007/2008</td>
<td>24 courses of the study program of Informatics at the Faculty of Computer Sciences, “Goce Delchev” University in Stip</td>
<td>Three inputs: expenses for professors and assistants, number of classes held, and expenses for equipment and inventory; Two outputs: index of the level of contribution of each course in skills, competences and knowledge delivery, prescribed with the accreditation elaborate of the study program</td>
<td>Dual DEA CCR model</td>
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<tr>
<td>Cvetkoska (2010)</td>
<td>Banking sector</td>
<td>2005-2008</td>
<td>16 banks</td>
<td>Operating approach: Three inputs: interest expenses, commission and fees expenses, and other expenses; Three outputs: interest income, commission and fees income, and other income; Intermediation approach: Three inputs: tangible and intangible investments, number of employees, and total amount of received deposits; Two outputs: total amount of granted loans, and short-term securities</td>
<td>CCR model (input and output oriented), DEA model for measuring the super-efficiency, and combination of DEA and AHP for weight restrictions</td>
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<td>Cvetkoska (2015)</td>
<td>Banking sector</td>
<td>2009-2011</td>
<td>8 bank-branches of Komercijalna Banka AD Skopje</td>
<td>Two inputs: deposits structure and operational costs (salary and material costs); Two outputs: corporate lending and lending to citizens</td>
<td>Output-oriented DEA window analysis model with VRS assumption</td>
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<tr>
<td>Cvetkoska (2017)</td>
<td>Banking sector</td>
<td>2009-2011</td>
<td>8 bank-branches of Komercijalna Banka AD Skopje</td>
<td>Production approach: two inputs (staff; salaries of employees) and material expenses; Two outputs (total number of F/X transactions and domestic payment operations – total transactions); Intermediation approach: Two inputs (deposits structure and operating costs); Two</td>
<td>DEA window analysis model for the three approaches (production, intermediation and profitability);</td>
</tr>
<tr>
<td>Authors</td>
<td>Sector</td>
<td>Years</td>
<td>Countries</td>
<td>Inputs</td>
<td>Outputs</td>
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<tr>
<td>Cvetkoska and Barisic</td>
<td>Tourism</td>
<td>2004-2013</td>
<td>15 European countries (Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, France, Greece, Italy, Macedonia, Montenegro, Portugal, Serbia, Slovenia, Spain)</td>
<td>Two inputs: visitor exports and domestic travel and tourism spending; Two outputs: travel and tourism total contribution to GDP, and travel and tourism total contribution to employment</td>
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<td>(2014)</td>
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<tr>
<td>Cvetkoska and Barisic</td>
<td>Tourism</td>
<td>2010-2015</td>
<td>11 Balkan countries (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Macedonia, Montenegro, Romania, Serbia, Slovenia, Turkey)</td>
<td>Two inputs: visitor exports and domestic travel and tourism spending; Two outputs: travel and tourism total contribution to GDP, and travel and tourism total contribution to employment</td>
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<td>(2017)</td>
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<td>Cvetkoska and Savic</td>
<td>Banking sector</td>
<td>2009-2011</td>
<td>8 branches of Komercijalna Banka AD Skopje</td>
<td>Two inputs: personnel (number of employees) and material expenses; Two outputs: corporate lending and deposits structure</td>
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<td>(2017)</td>
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<td>Georgieva et al.</td>
<td>Defence sector</td>
<td>2007-2009</td>
<td>36 participating countries in NATO-led mission in Afghanistan, ISAF</td>
<td>Two inputs: total population of each participating country and GDP per capita of the participating countries (in US dollars); One output: number of soldiers (troops) of each participating country per rotation</td>
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</table>
3. CONCLUSION

Data envelopment analysis as a non-parametric methodology for measuring the efficiency of decision-making units notes numerous applications in different areas worldwide. According to the DEA bibliography published in 2018, agriculture, banking, supply chain, transportation and public policy are the areas where DEA is applied the most.

The aim of this paper is to present the application of DEA in the Republic of North Macedonia. There have been analyzed 14 papers (7 published in journals, 3 in conference proceedings, 2 master thesis, 1 is a
doctoral dissertation, and 1 is a book). These papers were published/defended in the period 2006-2017. 2017 is characterized as the year with the most published/defended DEA papers (4) applied in the country.

The analyzed papers reflect the possibility of a wide application of DEA in measuring the efficiency of different areas (finance, defence, tourism, education and agriculture). 54% of the analyzed papers are applied in finance.

In the review there have been included papers that we have found through Google Scholar and through personal contacts with researchers, yet a limitation of this paper is that there may exist more papers with DEA applications in the Republic of North Macedonia that are not covered in the literature review.

The applicability of DEA for measuring the efficiency in various areas of society as well as social phenomena and trends is our next challenge for further research.

REFERENCES


