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Designing a Model for Evaluation and Classification of Startup Accelerators Using Data Envelopment Analysis Method

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Abstract

The aim of this paper is to measure the performance of American accelerators by using data envelopment analysis approach. Inputs include number of mentors, number of startups, the amount of funding in each startup, the total number of startups, and the accelerator stocks per startup. Outputs include exit count, total withdrawal, and Total Funding Raised. The final results and comparisons with the Seed Accelerator Ranking Project (SARP), as the only evaluation of the performance of accelerators in the world, reveal many differences that often result from the SARP ranking, taking into account only the accelerator output, however we used the DEA method to measure the efficiency of the output-to-input ratio as the evaluation criterion.

Keywords: Accelerator, Startup, Performance Evaluation, Data Envelopment Analysis

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1. Introduction

Due to the expansion of technology and the development of entrepreneurial culture, the growth of startups has had a significant impact on the economy worldwide. According to the counseling survey on England and Wales data from 1871, Deloitte suggests that technology has produced far more jobs than destroyed them (Deloitte, 2015). In addition, new businesses account for virtually the entire net creation of new jobs and 20% of gross jobs in the United States (Haltiwanger et al., 2013). According to other statistics, newly emerged companies have created two-thirds of the job creation, which means about 4 new jobs per company per year (Kauffman, 2009). Generally, companies less than a year of age have, on average, created 1.5 million jobs a year over the past three decades (Kauffman, 2014). Even during the economic crisis between years 2006 and 2009, new firms under the age of 5 and having less than 20 employees, were a net positive net income source of employment growth (8.6 percent); while larger enterprises were destroying more jobs than to create (Fort et al., 2013). The big contribution from the involvement of workforce in the emerging and small businesses is worth considering, however, annually around 450,000 companies and new businesses, in the United States, fail and disappear (Forbes, 2017). Statistics show that, despite a lot of attention to startups, their success rate is not promising (Hudson, 2012). Regarding the above statistics, supporting small startup companies has been a serious consideration by policy makers and private sectors over the past decades. That is why the centers of growth and support for startups have long been created, since 1959. Since establishment of the first business growth center in New York in 1980, it reached 12, and in 1995 it increased to 600 (Wiggins & Gibson, 2003). Nevertheless, the rapid development of growth centers failed to provide the opportunity for new businesses to grow in their prime stages, especially after the collapse of the stock market bubble in the early 21st century. As a result, the weakness of the supportive model of growth centers became more apparent (Dilts and Hackett, 2004). According to some researchers, there are currently more than 3,000 startup accelerators around the world (Hochberg, 2016). Nevertheless, despite their rapid growth and extraordinary ability to nature growth-oriented start-ups, accelerators have been closely monitored by academics (Clayton, Feldman, & Lowe, 2018; Hathaway,2016). Early accelerator programs such as Y Combinator, 500 Start-Ups, and RocketSpace generally adopt a private equity lending pattern (Kim & Wagman, 2014). In the suburbs of the United Kingdom, such as the Northeast, Northern Ireland, Scotland and Wales, about a third of accelerators need public funding (bone et al, 2017). There is a similar case in Finland, where the general budget supports the VIGO accelerator program supported by TEKES (Business Finland, 2018). These examples of public financial investment are evidence that it is important to strengthen indigenous entrepreneurial ecosystems (Bliemel et al., 2019; Hochberg, 2016). Often one of the main reasons for creating accelerated program segments for the public sector is to attract transnational entrepreneurs (henceforth TEs) from other countries to overcome the lack of local entrepreneurial capacity. In fact, it is a major target for government budget accelerators, such as the Chilean Startup Accelerator Program, which employs approximately 80% of its startups from abroad (Gonzalez-Uribe & Leatherbee, 2017). Because accelerators accept applicants from all over the world, they act as an important intermediary or "brokerage mechanism" between promising entrepreneurs / investing in remote locations and local investors (Shane, 2016). Although accelerators are increasingly recognized as an important institutional player, there is currently no clear definition of this organizational model. This may be surprising given the pervasive heterogeneity displayed in accelerators (Hochberg, 2016). Accelerators, on the other hand, are home-centered investments through seed budgets, coaching and peer-based coaching (Pauwels et al., 2016). One of the main differences between an incubator and an accelerator is their different target market and diverse selection criteria (Hochberg, 2016). In this context, the Entrepreneurship Ecosystem sought to create a new framework for replacing growth centers, as the first American accelerator named Y Combinator, founded in 2005. Subsequently, many acceleration centers were created in the United States and elsewhere. In some reports, nearly 700 organizations in the United States were identified as accelerators / growth centers, of which less than one-third of them could have specific requirements and conditions for an accelerator (Hathaway, 2016). An accelerated program, as Miller and Bound (2011) defined in their fundamental article, include five main attributes that differentiate them from other types of funding and growth centers:

1) The free registration process is highly competitive

2) Funding in part of the stock

3) Emphasize and focus on startup teams instead of individuals

4) Comprehensive but short-term mentoring courses

5) Pay attention to startups instead of companies

Although today many accelerators have been established around the world, and their number is increasing day by day, only a small number of them have all the five features mentioned above. Therefore, it is necessary to make an appropriate regional and global assessment for performance of accelerators. In spite of our pursuit of statistical centers related to entrepreneurship such as the Vice President of Science and Technology, there are currently no detailed statistics on the performance of Iranian accelerators to assess them. The main reason is that due to the recent development of these accelerators, the outputs of most of them have not been fruitful and have not entered the market yet. So, we focused on the world's top accelerators. The first accelerator classification in 2014 was called "Startup Accelerator Ranking Project", which focuses on assessing the performance of American accelerators and is repeated every year. The project classifies US accelerators into five categories of platinum plus, platinum, gold, silver and bronze. The classification is based on considerations such as valuation, exit rates, Total Funding Raised, startup success rates, founder consent and alumni network (SeedRanking.com). Although this ranking project is an invaluable attempt to prioritize accelerators, it should be noted that in reality the performance of a system should not be limited to examining and evaluating outputs, but the inputs to outputs. This is required as one of the most important evaluation indicators.

Data Coal Analysis is a suitable method for this type of evaluation, so that this method determines the performance of each unit by comparing output and input values in a comprehensive way. In this paper, we combine an analysis of data coverage to prioritize the accelerator in the United States. The results of this research can be effective in many different ways in the entrepreneurial ecosystem. The first advantage of this performance appraisal is that American accelerators, as the world's first and most advanced accelerators, have always been featured in brochures and articles of entrepreneurship as examples of the new type of support model for startups, so their performance review can be a good critique. The second advantage of this performance assessment is that it can identify and introduce the best accelerators with respect to input and output indicators as a suitable model for all accelerators worldwide. Another advantage of this ranking is for entrepreneurs and startups in order to choose the best acceleration program based on scientific and real analysis, and not only based on available accelerator advertisements.

2. Assessment of Accelerators

In this study, we will use the efficiency criterion to evaluate the accelerators. The efficiency of a unit cannot be measured merely by considering the outputs of a unit, but it is absolutely essential to consider the inputs of a unit to measure performance. Therefore, the efficiency is the ratio of outputs to the inputs of that unit (Rezaeian, 2015). According to this definition, in order to evaluate the efficiency of an accelerator, it is necessary to determine its inputs and outputs, and to calculate the ratio of these two to the efficiency of the accelerators. In the measurement of accelerator performance in the US Startup Accelerator Ranking Project (SeedRanking.com), only accelerator outputs are taken into account. This method cannot be a good measure for measuring performance. In this study, in addition to the outputs, we also consider accelerator inputs. Further inputs and outputs of an accelerator are described.

2.1 Accelerator inputs

The inputs of an accelerator are the resources required to perform an accelerator activity in order to achieve its purpose. These resources, according to various definitions, include the following:

- Number of mentors:

The mentor is the one who, with the necessary support, will enable the startup teams to achieve the skill and performance they need in their startup challenges and stages. Mentors are also trying to create a clear and consistent perspective for members of the group.

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- Number of Startup Funding:

This item, as its name implies, includes the total number of startups funded and sponsored by an accelerator from the beginning.

- Amount of Funding per Startup:

Each accelerator pays a sum of money in cash and in several steps to support the startup team. This amount is determined by factors such as accelerator funds, funding policies, and market average.

- Total Funding:

It is all the investments that an accelerator has made in various startups.

- Startup accelerator stocks:

The agreement we have between the accelerator and the Startup team, in which the Starter allocates a percentage of its shares to the accelerator in exchange for the accelerator support costs and services (Jean and Audet, 2012).

2.2 Accelerator outputs

- Number of Exit:

The risky investment process is divided into three stages before investing, after investment and exit phase (De Clercq, et al. 2006). Therefore, exit is part of the entrepreneurial business process, which is very important for business owners and stakeholders in the ecosystem of the economy (De Tienne, 2010; Wennberg et al., 2010). Exit means that the funder or the shareholder, by examining the conditions, continues to withdraw from the business in order to continue his entrepreneurial activity and assigns his or her share to non-equity. In other words, the funder, in the stage of the business life cycle, sells its share and turns it into cash (Gladstone & Gladstone, 2004). Therefore, the accelerator output means that the accelerator, as its primary funder, has left its stock from the startup to fund in another startup.

- Total Exits:

The sum of the successful exits of accelerator during a particular period. The total withdrawal includes all cash inflows from the accelerator generated by the sale of its share in the various startups.

- Total Funding Raised:

Injecting or attracting liquidity to some startups is called an increase in funding with goals such as scaling up, profitability, support, or survival of the startup (Jahankhani and Parsaian, 2015).

3. Evaluation method

In this research, Data Envelopment Analysis (DEA), a linear Programming approach, has been used to evaluate American accelerators. DEA is an information-driven approach used to evaluate the performance of a number of similar units known as decision-maker units (DMUs), which converts a set of input data into a set of output data (Cook and Zhu, 2014). Since 1978, when DEA was introduced for the first time in the modern world, researchers have identified it as a convenient and easy way to model a functional performance evaluation in different areas. DEA is widely used in many countries and in various fields to evaluate the performance of systems and units with diverse functions such as banks, cities, schools, businesses, and even the performance of countries and regions (Cooper, et al. 2011). Not only is DEA itself a way to evaluate performance, but also creates a new look at different entities that are evaluated by previous approaches. For this reason, the use of DEA in studies on the evaluation of the effectiveness of previous and future activities has also been carried out in the units which are to be tested (Zhu, 2014). In DEA, units are divided into two types: efficient and inefficient. This method introduces how to assess the evaluated units that are inefficiently detected and is a suitable method for researchers with multi-data and multi-output units. Two general types of orientation in the development of data envelopment include direct attention to data in the input-axis method and direct attention to output in the output-driven method (Nooreha et al., 2000).

In this regard, Charles Cooper and Rhodes (1978) describe the efficiency as follows:

1) In the case of a data-driven model, a unit will not work if it reduces each of the data without adding other data or reducing each of the outputs.
2) When the output model is axial, one unit does not work if the increase of each output is possible without reducing an output or increasing an input.

Once a decision unit is effective, none of the above will happen. In this case, the performance is equal to one and less than one efficiency indicates that the linear combination of other units can produce less than the same amount of output with a smaller number of inputs which means this unit is not as efficient as the definition.

Types of methods for data envelopment analysis are respectively the CCR model with assumption of return on a constant scale, and BCC with assumption of return to variable scale (Banker et al., 1984). Both model is briefly explained below:

3.1 CCR Model

In 1978, Charnes, Cooper and Rhodes presented a fundamental paper for the CCR model. In this way, the researcher can compare the inputs and outputs which are observed. In the end, we need to recognize the balanced inputs and outputs. Then the function of each unit is measured as follows:

$$
\begin{aligned}
&\min \theta \\
&st: \sum_{j=1}^{n} \lambda_j x_j \le \theta_{x0} \\
&\sum_{j=1}^{n} \lambda_j y_j \ge y_0 \\
&y_j \ge 0 \\
&j = 1, \ldots\ldots, n
\end{aligned}
$$

3.2 BCC Model

If the returns to the scale change, the CCR method does not have performance measurement functionality. Therefore, Banker, Charnes and Cooper introduced the BCC method in 1984 to address this issue, in which the return to scale is possible, and is shown as follows:

$$
\begin{aligned}
&\min \theta \\
&st: \sum_{j=1}^{n} \lambda_j x_j \le \theta_x \\
&\sum_{j=1}^{n} \lambda_j y_j \ge y \\
&\sum_{j=1}^{n} \lambda_j = 1 \\
&y_j \ge 0 \\
&j = 1, \ldots\ldots, n
\end{aligned}
$$

4. Case Study

In this section, the performance of units is evaluated, using the models introduced in the previous section. In this study, we examined 59 accelerators of the most advanced American accelerators, and we calculated the efficiency of these centers with 2 approaches to data envelopment analysis. These 59 accelerators are selected through the analytical network (seed-db.com). This analytical network examines the status of accelerators in the world and provides their performance in the index and outputs mentioned in the previous sections of the paper. As we focus on American accelerators, we extracted top-notch information from seed-db.com. Information on some of the indicators was not available on this website, such as the number of mentors or percentage of stocks that accelerators receive in exchange for donations. Therefore, we tried to extract this information from the official website of the accelerators. In the case of accelerators, we could not extract information about, or accelerators that were not focused solely on the United States, we removed them from our list. We also received some additional information on these accelerators from the Crunchbase.com website. For example, some American accelerators have been removed from our list despite being listed on the selected project list because their activities are not focused solely on the United States and are also accelerating in other parts of the world. These accelerators include Techstar, HAX, Healthbox, Plug and Play, and Zero to 510. A comprehensive ranking of global accelerators will be explored in a different article. Table-1 shows the performance of each accelerator based on each of the two models. As a result, for each accelerator, we will have two performance values per accelerator.

Table ١: American Accelerator Performance

Accelerator	Efficiency	
	First model	Second model
DMU01	1	1
DMU02	1	0.3408
DMU03	1	1
DMU04	1	0.5625
DMU05	0.4853	0.2746
DMU06	1	0.233
DMU07	1	0.613
DMU08	1	0.092
DMU09	0.7897	0.5225
DMU10	1	0.1902
DMU11	1	1
DMU12	0.6699	0.2202
DMU13	0.2824	0.0521
DMU14	1	0.3765
DMU15	0.606	0.2511
DMU16	0.5905	0.0335
DMU17	0.913	0.7056
DMU18	0.4147	0.2407
DMU19	0.324	0.0971
DMU20	0.2432	0.1102

DMU21	1	0.5109
DMU22	0.5336	0.2854
DMU23	0.9242	0.549
DMU24	0.6706	0.274
DMU25	0.8724	0.4524
DMU26	0.344	0.2078
DMU27	0.719	0.2556
DMU28	0.7874	0.0459
DMU29	1	0.3596
DMU30	1	0.2644
DMU31	0.594	0.1402
DMU32	0.5654	0
DMU33	0.1006	0.0245
DMU34	0.3729	0
DMU35	0.8342	0.4692
DMU36	0.1663	0
DMU37	0.5587	0.1943
DMU38	0.9981	0.3596
DMU39	0.4703	0
DMU40	0.1161	0
DMU41	0.6102	0.454
DMU42	0.1806	0
DMU43	0.4254	0.0936
DMU44	0.0631	0
DMU45	0.2362	0.1602
DMU46	0.3599	0.1602
DMU47	0.064	0
DMU48	0.0661	0
DMU49	0.0435	0
DMU50	0.2078	0.081
DMU51	0.4325	0.2165
DMU52	0.0285	0
DMU53	0.787	0.1119
DMU54	0.4383	0.0416
DMU55	0.0328	0
DMU56	0.408	0.0665
DMU57	0.1454	0

DMU58	0.4873	0.2137
DMU59	0.2001	0.0794

From each of the two models, an efficiency number is obtained in evaluating the performance of each of the accelerators. The first model seeks to find the most efficient one for each accelerator. The second model seeks to increase the efficiency of all acceleration centers. But the third model identifies accelerators that are least efficient, and try to increase their performance. Based on the performance values of the obtained performance, it is possible to determine the rank and position of each accelerator. Naturally, due to the differences noted in the approach of each of the evaluation models, which led to differences in performance values, there could be differences in the ranking of these accelerators. Table-2 shows the rank of each accelerator for each model.

Table ۲: American Accelerator rankings

Accelerator	Ranking	
	Frirst model	Second model
DMU01	1	1
DMU02	1	14
DMU03	1	1
DMU04	1	4
DMU05	21	16
DMU06	1	22
DMU07	1	3
DMU08	1	35
DMU09	7	6
DMU10	1	28
DMU11	1	1
DMU12	12	23
DMU13	32	39
DMU14	1	11
DMU15	14	20
DMU16	16	42
DMU17	4	2
DMU18	26	21
DMU19	31	33
DMU20	33	32
DMU21	1	7
DMU22	19	15
DMU23	3	5

DMU24	11	17
DMU25	5	10
DMU26	30	26
DMU27	10	19
DMU28	8	40
DMU29	1	12
DMU30	1	18
DMU31	15	30
DMU32	17	44
DMU33	41	43
DMU34	28	45
DMU35	6	8
DMU36	38	46
DMU37	18	27
DMU38	2	13
DMU39	22	47
DMU40	40	48
DMU41	13	9
DMU42	37	49
DMU43	25	34
DMU44	44	50
DMU45	34	29
DMU46	29	29
DMU47	43	51
DMU48	42	52
DMU49	45	53
DMU50	35	36
DMU51	24	24
DMU52	47	54
DMU53	9	31
DMU54	23	41
DMU55	46	55
DMU56	27	38
DMU57	39	56
DMU58	20	25
DMU59	36	37

Table 3: Performance and Final Ranking of American Accelerators

Accelerator	Arithmetic mean	
	Efficiency	**Ranking**
DMU01	1.0000	1
DMU02	0.7163	8
DMU03	0.9533	3
DMU04	0.8542	4
DMU05	0.4118	24
DMU06	0.6028	12
DMU07	0.7352	7
DMU08	0.4537	21
DMU09	0.6534	11
DMU10	0.4572	20
DMU11	0.9673	2
DMU12	0.4478	22
DMU13	0.1872	40
DMU14	0.6684	10
DMU15	0.4060	25
DMU16	0.2306	34
DMU17	0.7432	6
DMU18	0.2897	30
DMU19	0.2224	35
DMU20	0.1666	44
DMU21	0.7566	5
DMU22	0.3926	26
DMU23	0.5713	13
DMU24	0.4233	23
DMU25	0.6761	9
DMU26	0.2219	36
DMU27	0.5015	18
DMU28	0.3060	28
DMU29	0.5644	14
DMU30	0.5041	16
DMU31	0.2778	31
DMU32	0.1885	39

DMU33	0.0601	50
DMU34	0.1243	46
DMU35	0.5064	15
DMU36	0.0554	51
DMU37	0.3050	29
DMU38	0.5018	17
DMU39	0.1568	45
DMU40	0.0387	53
DMU41	0.4768	19
DMU42	0.0602	49
DMU43	0.1956	38
DMU44	0.0210	56
DMU45	0.1704	43
DMU46	0.2093	37
DMU47	0.0213	55
DMU48	0.0220	54
DMU49	0.0145	57
DMU50	0.1072	47
DMU51	0.2494	33
DMU52	0.0108	59
DMU53	0.3231	27
DMU54	0.1734	42
DMU55	0.0109	58
DMU56	0.1855	41
DMU57	0.0485	52
DMU58	0.2619	32
DMU59	0.1045	48

Up to now, the performance and rating of each of the accelerators are derived separately from each of the models. Each of these accelerators has two performance levels and two ratings that are sometimes identical and sometimes differentiated in all two ways. But the most fundamental question in this section is, "What should each of these accelerators be attributed to, both performance and rank?" In order to answer this question, we need to say that for each accelerator, these two values of efficiency must be combined in such a way that, based on the combined efficiency, we achieve a single ranking. One of the methods that can effectively integrate performance values, is the average arithmetic mean of the performance of the two models. Table-3 shows the exclusive performance of each accelerator and based on these performance values, the rank of each accelerator is obtained. Table-3 is the final output of this study, which represents the final rating of the examined accelerators. By comparing the output of this ranking with a well-known ranking that evaluates them without considering the inputs of accelerators, thought-provoking results are obtained. Table-4 also shows the output of the 2018 Seed Accelerator Ranking Project (SARP), which ranked American accelerators since 2014, every year.

: Table ٤ Output of the 2018 Seed Accelerator Ranking Project (SARP)، (Source: Seedrankings.com)

Ranking	Accelerator
Platinum Plus	AngelPad, Y Combinator, StartX
Platinum	Amplify LA, MuckerLab, Techstars, U. Chicago
Gold	500 Startups, gener8tor, HAX, IndieBio, MassChallenge, SkyDeck, Alchemist, Dreamit
Silver	Brandery, Capital Innovators, REach, Zero to 510, Healthbox, Accelerprise, AlphaLab, Health Wildcatters, Lighthouse Labs, Tech Wildcatters, TMCx

Among the accelerators in Table-4, the Techstar, HAX, Healthbox, Plug and Play, and Zero to 510 accelerators were omitted from our analysis due to trans regional activity and lack of focus on the United States. However, we consider them in a separate article. StartX, U.Chicago, IndieBio, MassChallenge, R / GA, SkyDeck, REach, FoodX accelerated our analyzes because of their incomplete information on the analytical network (seed-db.com). Finally, 59 top American accelerators were tested. There are a lot of differences between the SARP ranking and our ranking, and there are a number of them due to the high number of ranked accelerators. The AngelPad, Y Combinator accelerators, which are ranked Platinum Plus in the SARP ranking project, ranked 1 and 2 in Table-4. We also ranked them above 1 and 3 Which represents a high performance of these accelerators. But surprisingly, the Upland Labs, Portland Incubator Experiment (PIE), which was not assigned to Table-4, won our third and sixth rankings in our rating. Also, Brandery, Dreamit, which ranked Silver in the Silver Rank, ranked 4th and 5th in our evaluation. The reason for this can be found in the ratio of successful outcomes and increasing capital to the number of small startups and handicrafts that somehow represent a functioning. Platinum Accelerators ranked top notch in the 4th rank in our ranking, and ranked 12, 21, and 24, which again showed that, although the outputs of these accelerators are high, but the output is low in the input. Particularly, some accelerators such as the Upwest Labs, the Portland Incubator Experiment (PIE) are ranked very high in our ranking, while the above-mentioned accelerators in the SARP ranking have not been considered. We also observed that Platinum, which was ranked the highest in the SARP ranking, ranked below the rankings of this article. Other differences can also be found by comparing the rating of this article and the SARP ranking. By examining tables-3 and 4 as well as comparing rankings, inputs and outputs, many differences can be observed. These differences indicate that although the SARP ranking is the world's first and most comprehensive accelerator rating and it annually ranks US accelerators, but due to the criteria for output and lack of attention to inputs, the system can have errors in specifying the best accelerators. In our future research, the method described in this article can be used to measure the performance of Iranian accelerators and also accelerators in the world, which would be a good method for the new incubator style of startups.

5. Conclusion

In today's world, markets are changing rapidly, on the one hand, based on ideas and innovations, and on the other hand, many people around the world have realized their dreams of ownership and business startups. These dreams are not only the most important factor of economic development, but also require special attention. However, if an entrepreneurial dream cannot be organized well, it can lead to failure and cause a high financial cost to the entrepreneur and his life. Entrepreneurship ecosystem has experienced different growth and incubation models for novice businesses so far, and now the starter accelerator model is being tested. This new style of incubation, if not well-evaluated, can turn into a ground for failure. In this paper, we evaluated the performance of the top American accelerators, based on data envelopment analysis models. For each accelerator, we considered two performance values and two rankings. In order to achieve the efficiency and the unique rank, the arithmetic of performance values was used and the efficiency and final rank of each were calculated as a single number. The results of the comparison showed that there are many differences between the SARP ranking, the world's first and the most comprehensive ranking of accelerators, and the ranking provided in this article. In particular, the reason for this discrepancy can be seen not only in the criteria but also in the method of evaluation. The SARP project ranks accelerators solely on the basis of their output, and any accelerator with more output has a higher rating. However, for a comprehensive evaluation of a unit, its efficiency, i.e. the output-to-input ratio, should be used for ranking. Therefore, this study once again showed that simply considering the output cannot be a good way to evaluate the performance of a unit, because a small unit with a small amount of output and input, perhaps is higher than a large unit with a very large amounts of input and output. This also applies to accelerators and can be used as a suggestion to evaluate the performance of Iranian accelerators as well as to modify the SARP evaluation process. In future articles, in addition to expanding the scope of unit performance evaluation to global and Iranian accelerators, we will use other developed methods of data envelopment analysis, including data envelopment analysis based on hierarchical analysis. It can also be considered as a future direction of research in this field in terms of all kinds of uncertainties in input and output data.

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