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Performance Evaluation of Student's Racing Teams Based on DEA Model
--Take WUTE Racing Team as an Example

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ABSTRACT
As the scale of FSEC competitions increasing rapidly in recent years, each team is facing with fluctuations. It is necessary to comprehensively evaluate the performance of these students' racing team to improve the performance in the competition. This study uses the DEA model and takes Wuhan University of Technology WUTE team as an example to analyze the overall operating efficiency of the WUTE team from 2014 to 2019. According to the team's management regulations and actual operating conditions over the past few years, we provide some proposed improvement strategies. After implementing these suggestions, 2020 season has witnessed a sharp rise in DEA efficiency. Therefore, other teams can learn from this research about how to improve their performance.

Keywords: *Formula Student Electronic China, Performance Evaluation, DEA model.*

1. RESEARCH BACKGROUND

1.1. Brief Introduction to Formula Student Electronic China

The Formula Student Electronic China (FSEC) is a formula car design and manufacturing event organized by the China Society of Automotive Engineering. The participated teams, which consist of thousands of students with great enthusiasm for racing cars, follow all the rules set by the organizing committee, design and manufacture a motor-driven car in one season, and strive to complete all or part of the competition. The race is divided into static races and dynamic races, which include a total of 8 events and a vehicle inspection to check whether the racing car is qualified before the race. The report of racing car design, manufacturing cost evaluation, and marketing report are divided into static races, while the straight-line acceleration test, the eight-character loop test, the high-speed obstacle avoidance test, the durability test, and the efficiency test are called dynamic races. FSEC is mainly an engineering design competition, and its project is set up to comprehensively evaluate the automotive engineering-related abilities of participating students. The competition started in 2013. The scale of the competition will be from 20 teams in 2013 to 73 teams in 2020, some of which are foreign teams. As the scale of the event continues to increase, the number of participating colleges has increased year by year, and the popularity has continued to increase. The event has become a great car event for college students in China and even the world.

1.2. Research Purpose

In the past 6 FSEC competitions (2014-2019), most of the teams have given stable and strong support from the school, but their results have been fluctuating. This reflects the lack of management and other aspects of the team. However, the previous study did not analyze the DEA model for racing teams. Therefore, the author hopes to use the DEA method, which is commonly used in automobile companies, taking the WUTE team of Wuhan University of Technology as an example, to evaluate its operational performance, and to provide reference opinions for each participating team.

2. RESEARCH METHOD AND DESIGN

2.1. DEA Method Analysis [1]

DEA refers to data envelopment analysis. It is a nonparametric method in operations research and economics for the estimation of production frontiers. It is used to empirically measure productive efficiency of

decision-making units. When evaluating the optimal efficiency value and relative effectiveness of decision-making units, this method could guarantee the objectivity of the results through the principles of operations research and calculation methods that rely on multiple inputs and multiple outputs. It is widely used in enterprises to evaluate the performance of various departments and academic research in other fields.

2.2. The Feasibility of DEA Evaluation Method in this Research Plan

Since the teams' operating performance and efficiency evaluation is based on the complex results of their operating conditions, the evaluation model that needs to be selected has the ability to adapt to multiple inputs outputs. Moreover, the operating efficiency of racing teams needs to be considered from many aspects, which leads to different input and output index units. But the DEA evaluation method does not need to consider the uniformity of dimensions.

2.3. The Working Principle of DEA Model [2]

The DEA model is widely used to evaluate the relative effectiveness of the same departments. It was first proposed in 1978 by the famous operations researchers A.Charnes, W.W.Cooper, and E.Rhodes. This model is very suitable for situations with multiple inputs.

For any decision-making unit, the input-oriented model can be expressed as:

$$s.t.\begin{cases}\min\theta-\varepsilon(e^T S^- + e^T S^+)\\ \sum_{j=1}^{n} X_j\lambda_j + S^- = \theta X_0\\ \sum_{j=1}^{n} Y_j\lambda_j - S^+ = Y_0\\ \lambda_j \geq 0, S^-, S^+ \geq 0\end{cases}$$

Among them, $j=1,2,...,n$ represents the decision-making unit, X,Y represent input and output vectors respectively.

If $\theta=1, S^+=S^-=0$, then in the perspective of DEA, the decision-making unit is valid;

If $\theta=1, S^+\neq 0, \text{or } S^-=0,$ then in the perspective of DEA, the decision-making unit is weakly valid;

If $\theta<1$, then in the perspective of DEA, the decision-making unit is not valid;

2.4. Selection of Variables

As groups that participate in the FSEC competition, having certain scientific research results, the participating teams not only need to use the school's scientific research funds to bear the expenses of the racing, but also require the team members to spend time on materials processing and parts assembly. So, the annual racing cost is selected as an indicator index. Moreover, the average working hours per week during the processing period of the team members are used to measure the input indicators of the system. Considering the output index, the team not only participates in the competition, but also undertakes certain scientific research tasks. Therefore, if we take the WUTE team of Wuhan University of Technology as an example to evaluate its operational performance, then we select the final scores obtained in each competition and the number of innovation projects completed by the school as the output index.

The input indicators are as follows:

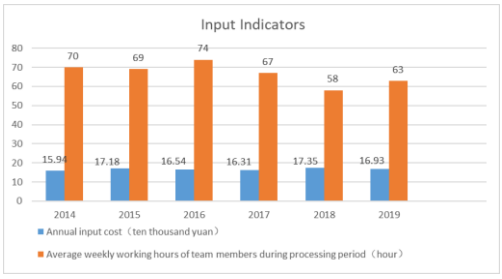

Figure 1 Input Indication

Output index situation:

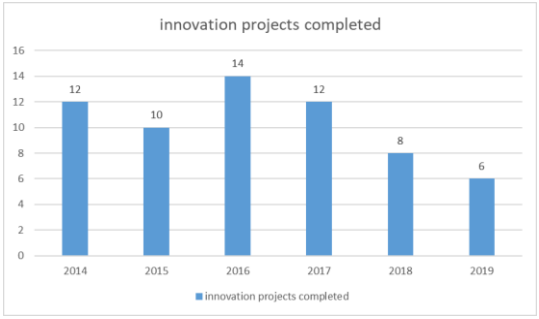

Figure 2 Innovation projects completed

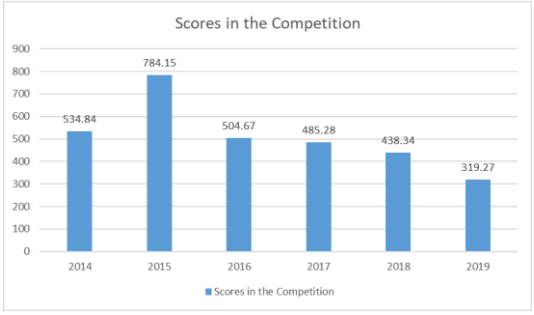

Figure 3 Scores in the Competition

Table 1. Summary

Year/Indicators	Input Index		Output Index	
	Annual Input cost	Average weekly working hour during processing period	Scores in the competition	Innovation projects completed
2014	15.94	70	534.84	12
2015	17.18	69	784.15	10
2016	16.54	74	504.67	14
2017	16.31	67	485.28	12
2018	17.35	58	438.34	8
2019	16.93	63	319.27	6

3. ANALYSIS IN THE PERSPECTIVE OF DEA AND RESULTS DISCUSSION

Import the selected data indicators and output indicators into the DEAP2.1 software to calculate the efficiency value, then we can get the follow results:

Table 2. Results

Year/Indicators	Overall Efficiency	Technical Efficiency	Scale Efficiency	Return to scale
2014	0.971	1	0.971	irs
2015	1	1	1	crs
2016	1	1	1	crs
2017	0.977	1	0.977	irs
2018	0.828	1	0.828	irs
2019	0.566	0.993	0.57	irs

Among them, irs (increasing returns to scale) means that the input ratio is less than the output ratio, indicating that it has not reached the maximum scale and there is insufficient input; crs (creasing returns to scale) means that the input ratio is equal to the output ratio and reaches the optimal scale. So that the investment is sufficient.

1)The ratio of the maximum output to the input during the operation of the racing team is the overall efficiency. When the overall efficiency is equal to 1, the technical efficiency and the scale efficiency are both 1, and the slack variable is 0, indicating that the use of input resources in the operation of the team has reached the maximum value and the effective use of resources has been realized. The results in the table show that both 2015 and 2016 seasons are at the forefront of comprehensive input-output efficiency.

2) It can also be seen from the table that the technical efficiency of the 2014 and 2017 seasons is 1, while the overall efficiency and scale efficiency are both less than 1, indicating that the resource input in this season has not been fully and effectively used, which means there are phenomena such as excessive resource input. It is necessary to reconsider the team rules and player management of the season in combination with the actual situation at that time.

3) The overall efficiency, technical efficiency, and scale efficiency of the past three seasons have all been less than 1, indicating that in addition to resource waste or unreasonable investment, there are also problems in resource allocation and utilization. Reasonable arrangements and divisions should be made for the allocation of team staff and the use of funds. Blindly expanding the scale at this time may not necessarily produce good results for the improvement of performance

4) In terms of trends, the team experienced a period of reduced efficiency from 2017 to 2019 after experiencing high efficiency in the 2015 and 2016 seasons.

4. IMPROVEMENT MEASURES AND EFFECTS

4.1. Improvement Measures

After the performance decline in 2019, the WUTE team of Wuhan University of Technology implemented the following measures to improve the performance decline of the team

1) From the perspective of cost-saving, strict project management of the design cycle, processing cycle and final test cycle is carried out to avoid the delay of one stage from affecting all stages. Also, while the design meets the competition regulations to the design concept, it is considered at the same time. For some cost-saving solutions, we should perform more detailed program simulation. What's more, it is effective for us to find manufacturers with stable operating conditions to prevent delays in the construction period and affect the assembly cycle. For better management, we should check multiple times at the end of the design stage to prevent final flaws. Team members should purchase materials that are carefully managed to prevent loss.

2) From the perspective of reducing the average working hours of the team members during the processing period without delaying the progress, the team should reasonably coordinate the time of team members. Also, the team should strengthen the recording of working hours, sign-in, and carry out fine management to prevent the failure to schedule tasks in time. Each group should strengthen communication to prevent errors in docking.

3) From the perspective of accumulating data, we should strengthen the data collection of the vehicle testing and personnel management of the team. By facilitating the record and analysis of the entire team's operating conditions, we can evaluate our team in a more objective way. In terms of vehicle testing, the team should build a data collection platform to obtain real data on real conditions of racing cars. Moreover, we could compare it with the design situation, then obtain real-time

feedback, accumulating experience for the future. In terms of personnel management, each group should flexibly sign in through forms analyze and manage the time of team employees.

4.2. Results after Implementing Improvement Measures

Table 3. Input for the 2020 season

Year/Indicators	Input Index		Output Index	
	Annual Input cost	Average weekly working hour during processing period	Scores in the competition	Innovation projects completed
2020	17.58	72	651.48	10

The efficiency of the 2020 season calculated by the DEA model is as follows:

Table 4. Results for the 2020 season

Year/Indicators	Overall Efficiency	Technical Efficiency	Scale Efficiency	Return to scale
2020	0.888	0.95	0.935	irs

It can be seen that the overall efficiency, technical efficiency and scale efficiency of this season have been greatly improved compared with the 2019 season, reflecting the effect of the adjustments made.

5. CONCLUSIONS

Judging from the example of the WUTE team of Wuhan University of Technology, each team should do more sophisticated project management on the design cycle, processing cycle and final test cycle, and reasonably allocate team members' tasks and time. Make more detailed predictions and management of all aspects of the project through punching cards, form check-in, etc., and strengthen communication in all aspects, thereby reducing internal management inefficiency, improving the final overall efficiency, and making it more likely to achieve better results.

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