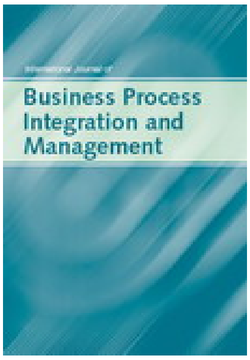

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Obtaining the best practices from internal benchmarking: an analysis of the efficiency of a network of fuel stations

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Abstract: This research developed an internal benchmark among a network of five fuel retailers using data envelopment analysis (DEA). Only three of the five fuel retailers reached the efficiency frontier within the analysed period. We identify which factors are representative of increasing the performance of the units considered inefficient. The research shows that the implementation of an efficiency monitoring standard is an important factor to follow. Identifying best practices can help increase the efficiency of inefficient operations without the need for external comparisons. DEA contributes to efficiency evaluation due to its robustness. One of the contributions of this study is the identification of fuel retail network units that are benchmarks. It sought to identify improvement opportunities to increase the technical efficiency of the units considered inefficient. This study proposes a management model capable of evaluating efficiency over time, as well as defining, prioritising, and monitoring actions that enable performance improvements.

Keywords: fuel retailers; data envelopment analysis; DEA; efficiency; benchmarking.

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1 Introduction

Fuel retailing, as well as other retailers, is a competitive environment. It is up to the manager of each company to define key performance indicators to monitor the business performance (Chan and Chan, 2004). For fuel retailers, there is a need to increase efficiency due to their reduced profitability since the result of fuel stations is directly related to their sales volume. Focusing on market competition, fuel retailers need to identify inefficient and efficient units/variables in their operation so that they may develop improvement actions and replicate best practices. The analysis of efficiency may contribute to this sense, as it enables managers to make decisions to improve the overall performance of operation (Hadi-Vencheh et al., 2014; Martins et al., 2019).

The effects of efficiency analyses on fuel stations have been little studied. It is possible to observe a series of studies referring to the analysis of efficiency of other levels of the oil industry. There are studies focusing on upstream and midstream. Upstream means exploration, drilling, and oil production activities, and midstream means refining activities. For example, Hawdon (2003) conducted a study using DEA to measure the performance level of different countries concerning the use of resources in the oil industry. Another study focuses on comparing efficiency on other levels of the supply chain (Vasconcellos et al., 2006; Thompson et al., 1996; Calôba, 2003). Vasconcellos et al. (2006) seeks to detect, among a group of refineries, the one that operates most efficiently in its inputs and outputs. de Souza et al. (2018a, 2018b) analyses the productive efficiency and the best operational practices in an armament manufacturer.

Such units pointed to best practices and served as a benchmark for targeting inefficient units. Thompson et al. (1996) analyse the performance of the 14 largest oil and gas exploration and production companies. Also, within the scope of the petrochemical industry, Calôba (2003) conducted a study integrating DEA to the theory of preference and the evaluation of blocks to create an investment decision environment for a Regulatory Agency and oil companies.

Publications focusing on downstream are scarce. However, the studies found evidence of the importance of efficiency evaluation for this sector. Downstream is the area of activity of the petroleum industry comprising transportation, distribution, and commercialisation of petroleum products, which is the focus of this study. Asayesh and Raad (2014) evaluated the efficiency levels of 26 fuel stations in two cities located in northern Iran using DEA. Sueyoshi (2000) evaluated the efficiency of fuel retailers and presented three analysis scenarios: an optimistic production, a realistic scenario, and a pessimistic scenario.

The study by Lopes et al. (2015) stands out in comparing efficiency among units of a same network of fuel stations. Lopes et al. (2015) evaluated the performance of fuel outflow processes of a network of eight fuel stations located in the Brazilian regions of Triângulo Mineiro and Alto Paranaíba. Also, they sought to verify the relation between the location of fuel stations and their size, and the influence of these factors on efficiency. Sudarma and Surjandari (2022) compare the performance of three ownership schemes in an Indonesian state-owned oil and gas company's gas stations, utilising two-stage DEA to assess operational and cost efficiency. Also in Indonesia, Windoko el al. (2024) assess the performance disparities among gas stations driven by the escalating transportation vehicle numbers. Their aim is to identify influential factors, evaluate station efficiency, and devise improvement strategies for underperforming stations in the oil and gas industry.

Existing studies contribute to a better understanding of efficiency analysis in the studied segment. However, no research was found evaluating the same variables in a fuel station network and contributing to a results management model for the increase in and continuous evaluation of efficiency in Brazil. Thus, this study has the objective of conducting a longitudinal evaluation of the technical efficiency of units of a fuel retailer network. Besides, it seeks to identify the units that may be used as benchmarks to evaluate opportunities for improvement in inefficient units. Also, this study proposes a results management model capable of evaluating efficiency over time, defining actions, prioritising them, and following them, ensuring their effectiveness.

The contribution of this study is to empirically verify the technical efficiency behaviour of five fuel stations over a given period. We identify the units of the fuel station network that are benchmarks by an internal analysis (Piran et al., 2021, 2023), whereby managers have greater access to information. Also, the analysis of efficiency may guide standardisation actions of existing practices in efficient units for the fuel stations. The analysis of slacks based on data envelopment analysis (DEA) allows focusing improvement actions to increase the efficiency of units and of the fuel station network as a whole. This study may also contribute to guiding process improvement actions based on a quantitative and comparative analysis of efficiency among units. Finally, we present a discussion to find elements justifying the differences in efficiency among the units investigated.

The article is organised into five sections, in addition to this introduction. The following section presents a theoretical overview of DEA. Then, Section 3 describes the methodological procedures that supported the planning and conducting of the study. After, we present and discuss the results in Section 4. Section 5 explains the managerial implications. Finally, the conclusions, work limitations, and suggestions for future studies are outlined in Section 6.

2 Theoretical background

DEA is a technique that allows measuring the efficiency of DMUs with several inputs and outputs (Charnes et al., 1978; Campisi and Costa, 2008; Padhi et al., 2014; Veltri et al., 2016; Kumar and Thakur, 2019; Kumar et al., 2015; Camanho et al., 2023). DEA does not require converting input and output variables into comparable economic values (Asayesh and Raad, 2014; Camanho et al., 2023), which is one of its main advantages.

Decision making units (DMUs) may be defined as a measurement object of efficiency (Piran et al., 2020a). By using multiple inputs and outputs, DMU analysis units produce an efficiency score (Piran et al., 2017; Padhi et al., 2014; de Souza et al., 2018a; Piran et al., 2020b; Pungchompoo and Sopadang, 2015). The efficiency for each DMU is determined by the proportion of sums of weighted inputs and outputs of each DMU, producing a single measurement of productivity (Chen et al., 2008; Goyal and Dutta, 2020).

For each DMU deemed inefficient, a set of references of an efficient DMU is identified by the DEA, which may be used as a benchmark for improvement (Cook et al., 2014). Benchmarking is understood as a continuous and systematic process of evaluating products, services, and work processes in organisations recognised by their best practices aiming an organisational improvement (Vinodh and Aravindraj, 2015; Castro and Frazzon, 2017).

Thus, benchmarking is regarded as a parameter of comparison between the performance of organisations, products, processes, and services (Jain et al., 2008; Anand and Kodali, 2008; Seth et al., 2021; Camanho et al., 2023). Benchmarking may be functional, external, or internal (Jain et al., 2008; Piran et al., 2023). Southard and Parente (2007) pointed out the importance of prioritising internal benchmarking to external benchmarking. One of the main drawbacks of external evaluations is the difficulty of obtaining reliable and easily accessible information. The benchmark performed using DEA allows an analysis of targets (Barbosa et al., 2017; de Souza et al., 2018a; Telles et al., 2020). Targets are levels that variables must achieve to turn inefficient DMUs into efficient DMUs.

3 Research design

To develop this study, we adopted case study as a methodology. Case study makes it possible to conduct a study keeping the characteristics of the object. Specifically, we chose a longitudinal case study. It is suitable for single or incorporate cases for it has the potential to increase the internal validity of results (Barratt et al., 2011). Thus, this study comprised:

1 a definition of the case study
2 DEA model design
3 data collection
4 data analysis
5 discussion and conclusions.

3.1 Context and selection of analysis units

This study was conducted on operational units of a fuel retailer network composed of five retailers. Therefore, the analysis units of this study are the five fuel stations of the network. The fuel stations offer five types of fuels: regular gasoline, premium gasoline, S500 diesel, S10 diesel, and ethanol. These five products represent 95% of the organisation's revenue, which enabled a fuel-focused analysis. Besides, fuel stations offer oil exchange services and lubricant services, as well as convenience stores. The physical structure of fuel stations has a fuelling track, where the gasoline pumps are located, the main building with offices, convenience stores, toilets, boxes for oil and lubricant exchange services, and underground fuel storage tanks.

After the definition of the company and the conceptual structure of the study, we established the design phase of the DEA model used to measure the efficiency of business units. At the DEA project stage, we consulted experts and professionals in the organisation studied. They were the director of the company, managers of the five fuel retailers in the network, and administrative assistants of three operations. The choice for the professionals was based on experience in the company and the function they performed. They could assist data collection and share the knowledge they already had in the segment. The group provided information about the process in data collection, helping to define variables. The professionals of the company are presented in Table 1 according to function, activity of support in the study, and time in the company.

Based on the discussion with the professionals of the company, we verified that the five business units of the network could be susceptible to analysis. Thus, the DEA model contemplated the five business units, which were named station 1, station 2, station 3, station 4, and station 5.

Table 1 Company professionals

Duty	*Support to the project*	*Time in the company*
Director	Support in model definition, data collection and model validation	2 years
Operation Manager 1	Support in model definition and data collection	10 years
Operation Manager 2	Support in model definition and data collection	16 years
Operation Manager 3	Support in model definition and data collection	14 years
Operation Manager 4	Support in model definition and data collection	6 years
Operation Manager 5	Support in model definition and data collection	4 years
Operation Adm. Auxiliary 2	Data collection	10 years
Operation Adm. Auxiliary 3	Data collection	1 year
Operation Adm. Auxiliary 5	Data collection	1.5 years

Source: Authors

For the design of the DEA model, the five main products marketed were taken into account. The analysis includes the following products: regular gasoline, premium gasoline, ethanol, S500 diesel, and S10 diesel. According to experts, this analysis allows assessing the total volume of fuel types without the need to separate them. It would only be necessary to differentiate them if the analysis considered monetary variables as inputs and outputs.

The study is characterised as longitudinal; therefore, it is necessary to determine the period of analysis. Upon conducting a consultation with experts and on databases, we found that data from the last few years were available for collection. Therefore, we chose the years 2014, 2015, and 2016 until May (date of collection). We considered more recent data still capable of enabling tendency analyses for two years and five months, totalling 29 months.

3.2 Project of DEA

We defined DMUs with a longitudinal basis in 2014, 2015, and in five months of 2016. The analysis period is divided into months, thus totalling 145 DMU's.

We used the CRS model since we intend to analyse fuel stations whose amplitudes and proportionalities of variables are similar. Finally, we chose an orientation to output, since it aims to maximise the result of each of fuel station in the context of analysis.

3.2.1 Variables, collection and DEA data analysis

A pre-listing of variables for the DEA model was performed. Later, we discussed and validated them together with experts who supported the development of this study, it was therefore decided that:

a all five types of fuel marketed would be consolidated into a single variable as total volume, both for purchase volume and sales volume, since monetary quantities will not be considered in this analysis

b the variable number of refuelling pumps was changed to number of refuelling nozzles

c the variable total operating time was included in the model.

Table 2 Description and detail of inputs and outputs used in the DEA model

Variable	*Description*	*Name*	*Unit*
Input 1	Total volume (l) of fuel purchased, including five types of fuels: regular gasoline, premium gasoline, S500 diesel, S10 diesel and ethanol	Volume of fuel purchased	Litres (l)
Input 2	Storage capacity (l) of underground fuel tanks	Tank capacity	Litres (l)
Input 3	Covered area (m^2) for customer service, where attendants and vehicles circulate	Track area	m^2
Input 4	Number of nozzles (pieces) available in pumps.	Number of nozzles	Pieces
Input 5	Total time (h) the station was in operation during the period analysed	Operation hours	Hours
Input 6	Time worked (h) during the period analysed considering the number of employees and the operation working hours	Hours worked by attendants	Hours
Input 7	Number of means of payment accepted	Number of means of payment	Units
Output 1	Total volume (l) of fuel sold, including five types of fuels: regular gasoline, premium gasoline, S500 diesel, S10 diesel and ethanol	Volume of fuel sold	Litres (l)

Source: Authors

The data relating to inputs track area; number of means of payment and three number of nozzles did not require any treatment. The other variables required treatment, namely:

1 For the input volume of fuel purchased and for the output volume of fuel sold, the sum of all five types of fuel sold in each of the 29 months in the 5 operations analysed was used.

2 The tank capacity for the different types of fuel were added up.

3 The operating hours of each of the service stations was calculated by multiplying the working days of each month during the analysis period by the operating hours of the service station, considering the number of Sundays. On Sundays, only a few of the analysis units operate and these work a reduced working day.

4 The hours worked by the attendants was calculated by multiplying the working days of each month during the analysis period by the number of hours worked in the shifts, also considering the particularities of Sundays, and finally multiplying by the number of employees working in each of the shifts, for each of the operations.

Table 2 shows the final listing of variables used in the model, as well as their function (input or output) and measurement unit collected.

Data were collected using the same management software as used by the fuel station network and the same spreadsheets as used to control operations.

3.3 Statistical analysis

After we obtained efficiency scores through DEA, Shapiro Wilk and Barlett tests were performed to verify whether data resulting in efficiency obtained by calculations refer to a normal distribution and whether they are homogeneous. We also performed an analysis of variance (ANOVA) to verify whether there are significant differences between the means of standard efficiency groups relative to each fuel station. Tests for the verification of normal distribution and homogeneity are presupposed for using ANOVA. ANOVA is used to test whether there are significant differences between the means of efficiency groups for each station in the analysis context (Piran et al., 2016; de Souza et al., 2018a).

This analysis is important because statistically significant differences between efficiency scores of the fuel station network allow defining improvement goals. The definition of improvement goals is based on the identification of DMUs that translate into best practices. Thus, it is necessary to ensure that the means are significantly different. From this, it is possible to analyse in-depth the specific aspects of efficient and inefficient stations.

4 Results

Table 3 shows the efficiencies of the five fuel retailers for 29 months in chronological order. Also, the average monthly efficiencies and the efficiencies of each analysis unit are presented. The monthly minimum and maximum and each DMU efficiency within the analysed period are also presented. Finally, the mean and standard deviation calculations are presented.

Upon analysing Table 3, it is understood that the better the performance of a given station in a given month, the higher the efficiency score resulting from the calculation performed using the DEA. Thus, it is observed that the best efficiency performance refers to station 1 (Feb/14), station 1 (Oct/15), station 1 (Nov/15), station 2 (Oct/15), station 2 (Dec/15), station 3 (Oct/15) and station 3 (Jan/16).

The DMUs referring to these stations, in those months, obtained an efficiency equal to 1.000. It can be observed that the stations with the best performances are the stations 1, 2 and 3 and that there is a period when these units had their best performances: between October 2015 and January 2016. The worst efficiency performance was obtained by the station 4 in January 2015. After, the worst performances were station 4 (May/14) and station 4 (Nov/15). The 25 worst efficiency performances refer to the stations 4 and 5. It can be observed that the station 1 obtained the maximum efficiency in three months, but, among the minimum efficiencies, the station 2 had the minimum efficiency, that is, in its worst month of analysis, the station 2 obtained an efficiency of 0.862.

It is possible to observe the performance of the three most efficient stations concerning the average among the five stations during all 29 months. Station 1 was above the average for 69.9% of the period (20 months), while the station 3 above the average was 83.7% of the period (24 months). The station that remained above average for more months was station 2: 86.2% of the period (25 months). It can be noticed that stations 1 and 3 presented months of instability to the network from 2014 until May 2015. Station 2 does not show the same behaviour and had two months of poor performance with the others in 2016 (January and February).

Concerning the two stations with low efficiency scores, we sought to perform the same analyses as performed on the group of more efficient stations. Thus, for maximum and minimum efficiencies, the stations 4 and 5 obtained, respectively, 1a) maximum efficiency: 0.977 (Feb/16), and 1b) minimum efficiency: 0.785 (Jan/15); 2a) maximum efficiency, 0.923 (Feb/16), and 2b) minimum efficiency, 0.810 (Sep/14). It is observed that both had their maximum efficiency in February 2016. We also found that the range between the minimum and the maximum efficiency, presented by station 4, is more significant than the range presented by station 5. Thus, station 4 had the highest maximum efficiency score and the lowest minimum efficiency score in the group of the least efficient stations.

The performance of stations 4 and 5 can be compared to the average of the five stations. Station 4 was above the average only for 24.1% of the period (7 months) and station 5 was above the average for 17.2% of the period (5 months). It can be seen that the predominant period in which stations 4 and 5 performed below the average occurred from May 2015, exactly the contrary to the behaviour of the stations 1 and 3. In the months before May 2015, there were fluctuations between months, when they were more or less efficient than the average of the network.

Table 3 Efficiency of analysis units (see online version for colours)

Month/year	*Efficiency of station 1*	*Efficiency of station 2*	*Efficiency of station 3*	*Efficiency of station 4*	*Efficiency of station 5*	*Average monthly efficiency*	*Minimum monthly efficiency*	*Maximum monthly efficiency*	*Month mean*	*Monthly standard deviation*
Jan/14	0.860	0.862	0.887	0.871	0.887	*0.873*	*0.860*	*0.887*	*0.871*	*0.013*
Feb/14	1.000	0.963	0.943	0.891	0.863	*0.932*	*0.863*	*1.000*	*0.943*	*0.055*
Mar/14	0.892	0.932	0.936	0.866	0.920	*0.909*	*0.866*	*0.936*	*0.920*	*0.030*
Apr/14	0.878	0.928	0.897	0.962	0.820	*0.897*	*0.820*	*0.962*	*0.897*	*0.054*
May/14	0.897	0.877	0.923	0.789	0.856	*0.868*	*0.789*	*0.923*	*0.877*	*0.051*
Jun/14	0.880	0.884	0.893	0.898	0.852	*0.881*	*0.852*	*0.898*	*0.884*	*0.018*
Jul/14	0.870	0.933	0.909	0.830	0.923	*0.893*	*0.830*	*0.933*	*0.909*	*0.043*
Aug/14	0.904	0.957	0.913	0.972	0.913	*0.932*	*0.904*	*0.972*	*0.913*	*0.030*
Sep/14	0.879	0.886	0.965	0.853	0.810	*0.878*	*0.810*	*0.965*	*0.879*	*0.057*
Oct/14	0.889	0.909	0.881	0.828	0.841	*0.870*	*0.828*	*0.909*	*0.881*	*0.034*
Nov/14	0.915	0.922	0.963	0.924	0.899	*0.925*	*0.899*	*0.963*	*0.922*	*0.024*
Dec/14	0.894	0.906	0.856	0.903	0.904	*0.893*	*0.856*	*0.906*	*0.903*	*0.021*
Jan/15	0.859	0.874	0.936	0.785	0.834	*0.858*	*0.785*	*0.936*	*0.859*	*0.055*
Feb/15	0.885	0.915	0.885	0.855	0.895	*0.887*	*0.855*	*0.915*	*0.885*	*0.022*
Mar/15	0.885	0.937	0.927	0.919	0.824	*0.898*	*0.824*	*0.937*	*0.919*	*0.046*
Apr/15	0.936	0.928	0.917	0.929	0.903	*0.923*	*0.903*	*0.936*	*0.928*	*0.013*
May/15	0.911	0.926	0.953	0.835	0.891	*0.903*	*0.835*	*0.953*	*0.911*	*0.044*
Jun/15	0.901	0.885	0.909	0.837	0.847	*0.876*	*0.837*	*0.909*	*0.885*	*0.032*
Jul/15	0.951	0.981	0.949	0.944	0.898	*0.945*	*0.898*	*0.981*	*0.949*	*0.030*
Aug/15	0.971	0.971	0.953	0.838	0.872	*0.921*	*0.838*	*0.971*	*0.953*	*0.062*
Sep/15	0.929	0.927	0.925	0.820	0.847	*0.890*	*0.820*	*0.929*	*0.925*	*0.052*
Oct/15	1.000	1.000	1.000	0.908	0.888	*0.959*	*0.888*	*1.000*	*1.000*	*0.056*
Nov/15	1.000	0.979	0.986	0.791	0.893	*0.930*	*0.791*	*1.000*	*0.979*	*0.088*
Dec/15	0.993	1.000	0.991	0.926	0.828	*0.948*	*0.828*	*1.000*	*0.991*	*0.073*
Jan/16	0.964	0.949	1.000	0.918	0.917	*0.949*	*0.917*	*1.000*	*0.949*	*0.035*
Feb/16	0.959	0.910	0.946	0.977	0.923	*0.943*	*0.910*	*0.977*	*0.946*	*0.027*
Mar/16	0.904	0.910	0.929	0.846	0.849	*0.888*	*0.846*	*0.929*	*0.904*	*0.038*
Apr/16	0.936	0.939	0.944	0.906	0.851	*0.915*	*0.851*	*0.944*	*0.936*	*0.039*
May/16	0.928	0.937	0.942	0.832	0.850	*0.898*	*0.832*	*0.942*	*0.928*	*0.052*
Average station efficiency	*0.920*	*0.929*	*0.933*	*0.878*	*0.872*	*0.906*	*0.849*	*0.949*	*0.919*	*0.041*
Minimum station efficiency	*0.859*	*0.862*	*0.856*	*0.785*	*0.810*	*0.858*	*0.785*	*0.887*	*0.859*	*0.013*
Maximum station efficiency	*1.000*	*1.000*	*1.000*	*0.977*	*0.923*	*0.959*	*0.917*	*1.000*	*1.000*	*0.088*
Station mean	*0.904*	*0.928*	*0.936*	*0.871*	*0.872*	*0.898*	*0.846*	*0.942*	*0.919*	*0.039*
Station standard deviation	*0.044*	*0.037*	*0.036*	*0.055*	*0.034*	*0.028*	*0.037*	*0.034*	*0.036*	*0.018*

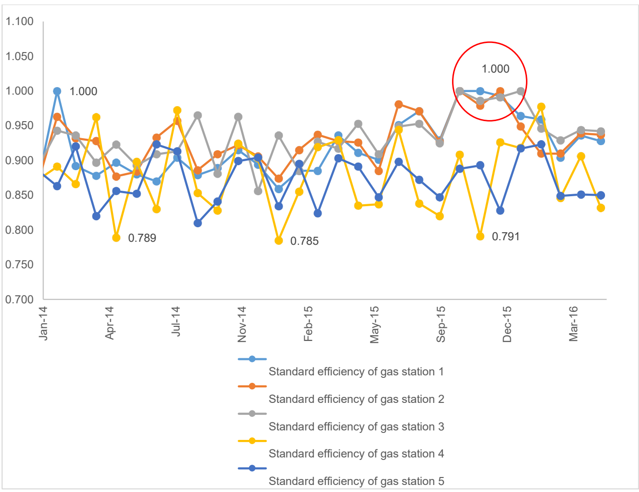
Source: Authors

We also performed a comparison of efficiencies of the stations about their average during the analysis period. We made this comparison with stations with high efficiency scores. Station 3 was the only one with a greater number of months with efficiency above its average concerning efficiency. Station 3 was above its average for 51.7% of the months (15 months).

Station 1 was above its average efficiency for 12 months, which is 41.4% of the analysed period. Station 2 was above its average efficiency for 13 months, representing 44.8% of the analysed period. We observed a concentration of months below the average between January 2014 and June 2015, that is, after the second half of 2015, there was an increase in performance by this station.

We also performed a comparison between the lowest station efficiencies to their average during the analysis period. The stations 4 and 5 presented the same result, being above their average efficiency for 48.3% of the analysed period, which represents 14 months. It can be observed that, in these stations, there is not a period of concentration of months below the average efficiency since the months are recurrent until the last month of the analysis period. Thus, it is understood that these stations did not achieve a significant increase in performance over the period.

Figure 1 Standard efficiency over the period (see online version for colours)



Source: Authors

We attempted to graphically illustrate (Figure 1) the data on the standard efficiency of all five stations for 29 months. The graph allows better visualisation of the course of scores over time. It is possible to observe the period during which the best efficiencies are concentrated. They are circled in red.

It can be seen in Figure 1 that the stations 1, 2, and 3 are those that obtained the best performances over time, while the stations 4 and 5 presented the worst performances. This reinforces the previous analyses. Based on Figure 1, we could verify that there is no DMU, i.e., a given station which is the benchmark in each month. What we observed was a period which contemplates some DMUs that are benchmarks in this study.

4.1 *Analysis of variance*

To perform the ANOVA, the efficiency scores were divided into groups of 29 DMUs referring to the 29 months of analysis of each station. Thus, there are 5 groups:

1 DMUs from 1 to 29, corresponding to station 1

2 DMUs from 30 to 58, corresponding to station 2

3 DMUs from 59 to 87, corresponding to station 3

4 DMUs from 88 to 116, corresponding to station 4

5 DMUs from 117 to 145, corresponding to station 5.

As for the ANOVA statistical test and its assumptions, we found that the Kolmogorov-Smirnov test result for station 1 (sign. = 0.827), station 2 (sign. = 0.584), station 3 (sign. = 0.466), station 4 (sign = 0.604) and station 5 (sign. = 0.773) presented a significance level higher than 0.05. Therefore, it is possible to accept the hypothesis that the data constitute a normal distribution.

Besides, we found that the result obtained for the Bartlett test (sign. = 0.846) is greater than 0.05. Therefore, the hypothesis is accepted according to which data are homogeneous. Thus, the analysis of assumptions allowed performing the ANOVA test. ANOVA test results are presented in Table 4.

By the results of Table 4, it is observed that the value of F is 13.898235 and the p-value is 0.0000000014. It is understood that the higher the F score, the more significant the p-value of the ANOVA test. Thus, it can be stated that the observed difference between the means of station efficiencies is statistically significant. Therefore, it can be stated that it is relevant to analyse the differences between the technical efficiencies of the five fuel retailers.

4.2 *Analysis of slacks*

Initially, the slacks are analysed per fuel retailer station and then per period.

4.2.1 *Slack analysis per station*

We performed a slack analysis per fuel retailer station. Efficient DMUs will be excluded from this analysis because they showed the best practices, and thus are assumed to have used the resources appropriately.

Table 4 ANOVA test among the stations analysed

Source of variation	*SQ*	*df*	*LS*	*F*	*p-value*	*Critical F*
Between groups	0.09754046	4	0.0243851	13,89823528	0.0000000014	2,436317464
Within groups	0.24563666	140	0.0017545	-	-	-
Total	0.34317712	144	-	-	-	-

Source: Authors

In station 1, the targets and slacks are discussed using the DMU13 (Table 5), which corresponds to the efficiency of station 1 in January 2015. The DMU13 was the lowest efficient DMU in station 1 during the analysed period. The total volume of fuel sold was 3,170,284 litres. The DMU does not show any slacks in the volume of fuel purchased. As for the capacity of tanks, there is a slack of 17,705 litres, that is, if the DMU were efficient, it could have sold 3,170,284 litres with 792,295 litres of a storage tank.

Given that tanks are a fixed resource of the station, and that the objective of this study is to maximise the volume of fuel sold, it can be verified that there is enough slack to maximise sales. The variable track area (input2) has a slack of 52 m^2. As for the number of nozzles, 81 nozzles were used, while the target would be 79 nozzles, resulting in slack of 2 nozzles. As for the variables related to hours of operation (input 5) and hours worked by attendants (input 6), both have slacks. The DMU presented a slack of 2,469 hours of operation and a slack of 518 hours worked by attendants.

About the means of payment accepted, 171 were used. The target presented a total of 167 means of payment; therefore, there is a slack of 4 means of payment. The same analyses may be performed for the other DMUs and variables.

We conducted an analysis of total slacks and slack mean resulting from the 26 inefficient DMUs of station 1. The results are shown in Table 6. As for the volume of fuel purchased, there is a total slack of 216,000 litres. This corresponds to the slack presented by the DMU 24. The other DMUs of station 1 did not present any slacks compared to the volume of fuel purchased.

The DMU 24 refers to station 1 in December 2015. According to specialists, this high fuel stock occurred because there was a possibility of fuel shortage in the market and, in that period, station owners chose to work with high stocks so that there would be no loss of sales due to lack of fuel. The mean evidence how great is the slack of each variable in the period.

We also conducted an analysis of total slacks and slack mean resulting from the 26 inefficient DMUs of station 2. Based on Table 7, the station 2 presented a total slack equal to zero for the input 1 (volume of fuel purchased) and for the input 7 (number of means of payment accepted), that is, all DMUs of the station 2 were efficient as for the inputs 1 and 7.

Table 5 Relation of targets and slacks of the lower efficiency DMUs of analysis units

DMU	*Values*	*Input1*	*Input2*	*Input3*	*Input4*	*Input5*	*Input6*	*Input7*	*Output1*
		Volume of fuel purchased	*Tank capacity*	*Track area*	*Number of nozzles*	*Operation Hours*	*Hours worked by attendants*	*Number of means of payment*	*Volume of fuel sold*
DMU 13 (Station 1; Jan/2015)	Current	3,222,000	810,000	2,385	81	19,899	4,356	171	3,170,284
	Target	3,222,000	792,295	2,333	79	17,430	3,838	167	3,690,808
	Slack	-	*17,705*	*52*	*2*	*2,469*	*518*	*4*	-
DMU 30 (Station 2; Jan/2014)	Current	2,475,000	810,000	2,640	72	15,309	3,645	90	2,299,432
	Target	2,475,000	620,956	1.958	58	12,387	2,867	90	2,667,395
	Slack	-	*189,044*	*682*	*14*	*2,922*	*778*	-	-
DMU 70 (Station 3; Dec/2014)	Current	1,773,000	495,000	852	54	12,636	3,645	90	1,650,375
	Target	1,773,000	495,000	852	54	12,177	3,513	90	1,928,776
	Slack	-	-	-	-	*459*	*132*	-	-
DMU 100 (Station 4; Jan/2015)	Current	1,683,000	810,000	2,422	72	14,400	4,356	126	1,514,331
	Target	1,683,000	413,852	1,219	41	9,105	2,005	87	1,927,880
	Slack	-	*396,148*	*1,203*	*31*	*5,295*	*2,351*	*39*	-
DMU 125 (Station 5; Sep/2014)	Current	1,845,000	810,000	3,153	72	13,968	4,248	144	1,711,567
	Target	1,845,000	453,689	1,336	45	9,981	2,198	96	2,113,451
	Slack	-	*356,311*	*1,817*	*27*	*3,987*	*2,050*	*48*	-

Source: Authors

Table 6 Relation of total slacks and slack mean resulting from inefficient DMUs of the station 1

DMU	*Values*	*Input1*	*Input2*	*Input3*	*Input4*	*Input5*	*Input6*	*Input7*
		Volume of fuel purchased	*Tank capacity*	*Track area*	*Number of nozzles*	*Operation hours*	*Hours worked by attendants*	*Number of means of payment*
Total	Slack	216,000	134,563	396	13	26,301	5,983	28
Mean	Slack	8,308	5,176	15	1	1,012	230	1

Source: Authors

Table 7 Relation of total slacks and slack mean resulting from inefficient DMUs of the station 2

DMU	*Values*	*Input1*	*Input2*	*Input3*	*Input4*	*Input5*	*Input6*	*Input7*
		Volume of fuel purchased	*Tank capacity*	*Track area*	*Number of nozzles*	*Operation hours*	*Hours worked by attendants*	*Number of means of payment*
Total	Slack	-	5,699,936	20,571	436	72,402	19,743	-
Mean	Slack	-	211,109	762	16	2,682	731	-

Source: Authors

Table 8 Relation of total slacks and slack means resulting from inefficient DMUs of the station 3

DMU	*Values*	*Input1*	*Input2*	*Input3*	*Input4*	*Input5*	*Input6*	*Input7*
		Volume of fuel purchased	*Tank capacity*	*Track area*	*Number of nozzles*	*Operation hours*	*Hours worked by attendants*	*Number of means of payment*
Total	Slack	160,573	897,201	-	109	22,038	8,268	126
Mean	Slack	5,947	33,230	-	4	816	306	5

Source: Authors

Table 9 Relation of total slacks and slack mean resulting from inefficient DMUs of the station 4

DMU	*Values*	*Input1*	*Input2*	*Input3*	*Input4*	*Input5*	*Input6*	*Input7*
		Volume of fuel purchased	*Tank capacity*	*Track area*	*Number of nozzles*	*Operation hours*	*Hours worked by attendants*	*Number of means of payment*
Total	Slack	-	9,400,963	28,642	683	97,004	55,452	715
Mean	Slack	-	324,171	988	24	3,345	1,912	25

Source: Authors

Table 10 Relation of total slacks and slack mean resulting from inefficient DMUs of the station 5

DMU	*Values*	*Input1*	*Input2*	*Input3*	*Input4*	*Input5*	*Input6*	*Input7*
		Volume of fuel purchased	*Tank capacity*	*Track area*	*Number of nozzles*	*Operation hours*	*Hours worked by attendants*	*Number of means of payment*
Total	Slack	-	10,502,336	53,196	789	122,511	61,822	1,434
Mean	Slack	-	362,150	1,834	27	4,225	2,132	49

Source: Authors

Then, we performed an analysis of total slacks and slack mean resulting from the 27 inefficient DMUs of station 3. The results can be seen in Table 8. We verified that the total slacks for the input1 (volume of fuel purchased) are 160,573 litres, resulting from the sum of the slack of the DMU 81 and the DMU 82. The other DMUs did not present any slacks for this variable. The DMUs 81 and 82 refer to November and December 2015, in which there was a possible fuel shortage that also affected, during this period, the station 1. Therefore, station 3 worked in these two months with high stocks to ensure that it did not lose sales due to a lack of fuel.

However, high stocks harmed efficiency. We also verified that the station 1 does not present slacks in the variable track area (input3): its slacks are zero.

Concerning the analysis of total slacks and slack mean of the station 4, there is an average slack of 1,912 hours worked by attendants, that is, based on the analysed period, 1,912 hours of attendants could have been discarded. The slack means for input2 (324,171 litres of tank capacity), input3 (988 m² of track area) and input4 (24 nozzles) indicate that the structure of the station 3 holds a higher than average demand over the last 29 months.

The analysis of total slacks and a slack mean of station 5 was also performed. Thus, there was a high average with hours of operation and hours worked by attendants. According to experts, such slacks exist because this station has the highest number of operation hours and is also open on Sundays. However, on Sundays, its sales are not so high, therefore such opening hours do not impact its efficiency. In the case of station 1, for example, which also opens on Sundays, the sales are high to the point of not impacting its efficiency. Still according to the experts, such analyses will be relevant to review the study on the capacity of attendants in face of high number of hours worked.

4.2.2 Analysis of slacks among stations (per year)

In this section, we perform an analysis between stations. We performed a subdivision per year, allowing a comparative analysis in three different periods, and consequently allowing an analysis of the behaviour tendency of slacks from the analysed period.

In 2014, the station 5 presented the highest slacks to all variables, except for the variable fuel purchased, in which all the stations had total slacks of zero, that is, no station had any slacks in any DMU during 2014. As for the smallest slacks, regarding the variables tank capacity, number of nozzles and hours worked by attendants, the lowest slacks were presented by the station 1.

Station 3 had the smallest gap concerning the variable track area. However, the variable number of means of payment was high in station 2. We verified that station 5 was the one with the highest slacks in all variables to benchmarking in 2014.

Station 1 presented a minor adjustment, necessary for three variables to reach the target. Station 2 and station 3 did not present slacks in two variables, that is, they were efficient with these variables.

In 2015, the station 5 presented the highest slack to the variables tank capacity, track area, number of nozzles, operating hours, hours worked by attendants, and number of means of payment. However, the highest slack, concerning the variable volume of fuel purchased, refers to station 1. The lowest slacks, regarding the variables tank capacity, number of nozzles and hours worked by attendants, were presented by the station 1. Regarding track area and hours of operation, the lowest slacks referring to these variables were presented by station 3.

Table 11 Relation of total slacks and slack mean resulting from inefficient DMUs during 2014 per station

			Input1	*Input2*	*Input3*	*Input4*	*Input5*	*Input6*	*Input7*
Station	*Total/average*	*Values*	*Volume of fuel purchased*	*Tank capacity*	*Track area*	*Number of nozzles*	*Operation hours*	*Hours worked by attendants*	*Number of means of payment*
1	Total	Slack	-	*44,262*	*130*	*4*	*17,285*	*3,825*	*9*
	Mean	Slack	-	4,024	12	-	1,571	348	1
2	Total	Slack	-	*3,045,968*	*10,993*	*233*	*40,840*	*11,056*	-
	Mean	Slack	-	253,831	916	19	3,403	921	-
3	Total	Slack	-	*572,269*	-	*70*	*16,534*	*5,979*	*80*
	Mean	Slack	-	47,689	-	6	1,378	498	7
4	Total	Slack	-	*4,651,967*	*14,141*	*357*	*56,551*	*26,604*	*442*
	Mean	Slack	-	387,664	1,178	30	4,713	2,217	37
5	Total	Slack	-	*4,985,041*	*23,894*	*391*	*64,815*	*28,686*	*728*
	Mean	Slack	-	415,420	1,991	33	5,401	2,390	61
General	*Total*	*Slack*	-	*13,299,507*	*49,159*	*1,055*	*196,025*	*76,150*	*1,260*
	Mean	*Slack*	-	*2,659,901*	*9,832*	*211*	*39,205*	*15,230*	*252*

Source: Authors

Table 12 Relation of total slacks and slack mean resulting from inefficient DMUs during 2015 per station

			Input1	*Input2*	*Input3*	*Input4*	*Input5*	*Input6*	*Input7*
Station	*Total/average*	*Values*	*Volume of fuel purchased*	*Tank capacity*	*Track area*	*Number of nozzles*	*Operation hours*	*Hours worked by attendants*	*Number of means of payment*
1	Total	Slack	*216,000*	*57,629*	*170*	*6*	*6,589*	*1,534*	*12*
	Mean	Slack	21,600	5,763	17	1	659	153	1
2	Total	Slack	-	*1,805,635*	*6,517*	*138*	*21,285*	*5,869*	-
	Mean	Slack	-	180,563	652	14	2,129	587	-
3	Total	Slack	*160,573*	*267,463*	-	*33*	*5,335*	*2,119*	*38*
	Mean	Slack	14,598	24,315	-	3	485	193	3
4	Total	Slack	-	*3,425,553*	*10,419*	*238*	*30,561*	*20,763*	*219*
	Mean	Slack	-	285,463	868	20	2,547	1,730	18
5	Total	Slack	-	*3,959,262*	*20,874*	*288*	*42,248*	*23,716*	*512*
	Mean	Slack	-	329,939	1,739	24	3,521	1,976	43
General	*Total*	Slack	*376,573*	*9,515,542*	*37,979*	*703*	*106,018*	*54,001*	*780*
	Mean	Slack	*75,315*	*1,903,108*	*7,596*	*141*	*21,204*	*10,800*	*156*

Source: Authors

Table 13 Relation of total slacks and slack mean resulting from inefficient DMUs during 2016 per station

Station	*Total/average*	*Values*	*Input1*	*Input2*	*Input3*	*Input4*	*Input5*	*Input6*	*Input7*
			Volume of fuel purchased	*Tank capacity*	*Track area*	*Number of nozzles*	*Operation hours*	*Hours worked by attendants*	*Number of means of payment*
1	Total	Slack	-	*32,672*	*96*	*3*	*2,427*	*624*	*7*
	Mean	Slack	-	6,534	19	1	485	125	1
2	Total	Slack	-	*848,334*	*3,062*	*65*	*10,276*	*2,818*	-
	Mean	Slack	-	169,667	612	13	2,055	564	-
3	Total	Slack	-	*57,470*	-	*7*	*168*	*170*	*8*
	Mean	Slack	-	14,367	-	2	42	43	2
4	Total	Slack	-	*1,323,443*	*4,082*	*87*	*9,892*	*8,085*	*54*
	Mean	Slack	-	264,689	816	17	1,978	1,617	11
5	Total	Slack	-	*1,558,033*	*8,428*	*111*	*15,449*	*9,420*	*194*
	Mean	Slack	-	311,607	1,686	22	3,090	1,884	39
General	*Total*	*Slack*	-	*3,819,951*	*15,667*	*373*	*38,212*	*21,117*	*263*
	Mean	*Slack*	-	*763,990*	*3,133*	*55*	*7,642*	*4,223*	*53*

Source: Authors

Table 14 Summary of total and mean slacks resulting from inefficient DMUs over time

Year	*Total/average*	*Values*	*Input1*	*Input2*	*Input3*	*Input4*	*Input5*	*Input6*	*Input7*
			Volume of fuel purchased	*Tank capacity*	*Track area*	*Number of nozzles*	*Operation hours*	*Hours worked by attendants*	*Number of means of payment*
2014	Total	Slack	-	*13,299,507*	*49,159*	*1,055*	*196,025*	*76,150*	*1,260*
	Mean	Slack	-	2,659,901	9,832	211	39,205	15,230	252
2015	Total	Slack	*376,573*	*9,515,542*	*37,979*	*703*	*106,018*	*54,001*	*780*
	Mean	Slack	75,315	1,903,108	7,596	141	21,204	10,800	156
2016	Total	Slack	-	*3,819,951*	*15,667*	*273*	*38,212*	*21,117*	*263*
	Mean	Slack	-	763,990	3,133	55	7,642	4,223	53

Source: Authors

Station 2 had the lowest number of means of payment. The stations 2, 4, and 5 did not present any slacks concerning the volume of fuel purchased. It can be verified, therefore, that the highest slacks refer to station 5, but, about the lowest slacks, they are dispersed between the stations 1, 2 and 3. Station 2 presents two variables without slacks, while the ion 3 presents one variable with slacks, and the ion 1 no slacks.

In 2016, the station 5 presented the highest slacks to all variables, except for the variable fuel volume purchased, in which none of the stations had any slacks in the months analysed for the year 2016.

Regarding the lowest slacks, station 3 stood out with the variables track area, hours of operation, and hours worked by attendants. Station 1 had the lowest slacks related to tank capacity and number of nozzles. However, station 2 presented the lowest slack concerning the variable number of means of payment. The stations 2 and 3 had two variables with zero slacks, that is, they were efficient to that variable.

From the analyses, we verified that station 5 presented the highest slacks during the two years and five months analysed. The lowest slacks were distributed between stations 1, 2, and 3. However, we noted that there was a uniform behaviour, for example, the station with the lowest slack in the input X in the year Y is the same station that had the lowest slack in the input X in the year Y+1. Thus, we verified that the station 1 had the lowest slacks, followed by station 3 after station 2.

Table 14 shows a summary of slacks per year over the period analysed and slack mean per year during the period analysed. There was a reduction in slacks over the two years and five months of analysis. The total number of slacks decreased from 2014 to 2015 and from 2015 to 2016. The only exception was the variable volume of fuel purchased, which presented a slack of 376,673 liters. If converted into monetary values, this gap represents US$ 1,412,523.75. This slack is attributed to the fact that, in November and December 2015, two fuel stations in the network worked with high fuel stocks due to the possibility of a fuel shortage in distributors. Given the above, managers have chosen to bear the costs of inventory and not run the risk of losing sales due to lack of fuel.

5 Managerial implications

This study contributed to the discussion regarding the comparison of efficiencies in different fuel stations of a fuel station network. Based on a review of literature, we could verify the scarcity of studies on this topic. We also did not identify a single study addressing the same inputs and outputs to analyse the efficiency of fuel stations. Thus, the list of variables used in the research may serve as a basis for further studies.

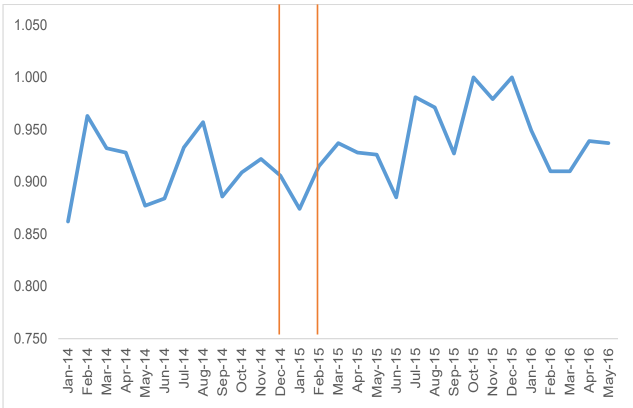
This study also contributed to the organisation on which the study was carried out, since the measurement was a way to analyse the efficiency from resources used in each of the network fuel stations. It was able to provide quantitative and measurable data for the evaluation of results. It is important to highlight that, until this study, no technique such as DEA was used to measure the results of businesses. According to the discussion with the organisation's experts about the results obtained, they reported that the information provided is useful for establishing comparative parameters between stations and parameters that allow observing the evolution of a given fuel station over time.

When confronted with the results, the specialists pointed out some factors and specific relevant events, such as the performance of the station 5, which proved to be the least efficient station. However, according to experts, this station has satisfactory financial results. However, experts pointed out a relevant factor that refers to the city where the station is located. It is the only unit located in a municipality different from the other stations. Still in relation to location and competitor aspects, they vary between both municipalities. Such external variables are not part of the DEA model used in the study. The model focuses on internal factors only, and, according to them, the station 5 had the lowest efficiency. We may conclude that managers could increase the efficiency of this station using the benchmark stations of the network, causing an improvement in financial results by properly using existing resources.

As for station 2, experts reported that in December 2014 a change was made to the management of the station. The transition and stabilisation period of operation occurred between December 2014 and February 2015. By Figure 2, it is possible to observe that, after the change of management, station 2 increased its efficiency. The said period is illustrated by the red lines. In October and December 2015, station 2 was efficient (i.e., efficiency equal to 1.0), and in the other months after the change, it kept its efficiency level above 0.885. It is understood that this finding reinforces the need to analyse the internal factors that impact on efficiency. Also, it reinforces the importance of the manager to drive the organisation towards performance improvement.

As for the increase in performance observed in stations 1, 2, and 3, respondents believe that this increase may be related to several factors. One of the factors highlighted by them refers to improvements made throughout 2015, which are related to different aspects: improvement in convenience stores, maintenance, and painting of the facade, and training of employees. According to them, such improvement actions were carried out in all five fuel stations. However, it was observed that the stations 4 and 5 were not successful after these actions.

Figure 2 Efficiency of station 2 over the period analysed (see online version for colours)



Source: Authors

Experts attribute the low efficiency of the station 4 to the factor location. The access to the station 4 is made by two routes of intense flow, making access to the station difficult. Still related to the location factor, it is possible to emphasise the level of competition in the region where the fuel station 4 is located: it is the central region of the city, where there is intense competition.

Although the model does not present any variable that takes competition into account, it may be negatively impacting sales volume, reducing efficiency. In this sense, it can be observed that the station 4 has a structure with a capacity superior to its sales volume. The experts pointed out that, through the DEA technique, they could perceive that improvement initiatives did not impact as to increase the efficiency of this station. As such, they will have to look for alternatives to increase performance. In the same sense, we also pointed out that they should set parameters to resize resources with slacks based on the results obtained by the DEA technique.

We found that, in addition to location problems, as reported by specialists, station 1 presented slacks about the variable track area throughout the period. Thus, an opportunity for improvement was observed. We proposed to build commercial stores in station 1. The proposal assessed the following points:

1 slack presented by track area

2 location, which would be positive for the stores due to the intense flow of people through the city centre

3 the fact that aggregate services at fuel stations are currently a source of competitive advantage since the public associates the factor convenience with fuel stations.

Therefore, when presenting a structure with aggregate services, one considers that it would positively impact the volume of sales. Therefore, the increase in efficiency would potentially occur through an adjustment to slacks in the variable track area and the increase in the output of the volume of fuel sold.

Another aspect highlighted by specialists refers to station 1 which, before the research, was regarded as a reference for the network. However, there were no measurements that reinforced this statement, nor measurements that replicated the good practices of the unit.

This study allows using benchmarks in the presented model. By using the benchmark, it is possible to seek references in the organisation and outside it. External benchmarks can be used to compare the stations of a network to stations with high performance. In this sense, the research may provide information for the target setting based on benchmarks.

Because of the intention of the network of stations to expand its activities, we identified a contribution of the model to the dimensioning of new units. When designing a new fuel station, managers may use the DEA model to perform analyses indicating the best practices to be replicated for a new unit. In addition, through DEA, it is possible to validate the design of a new fuel station by verifying whether there are slacks in the variables, or whether there are resources that may represent a bottleneck for operations.

In summary, this study contributes to the organisation by reducing costs, using resources, allocating investment, and setting goals. After the contributions of this study and based on the analyses carried out, we highlight the importance of continuously monitoring the behaviour of efficiencies in an organisation. Therefore, a results management model is proposed to integrate the management model currently used by the company. The results management model presented in Figure 3 consists of three steps:

1 collect data and run the DEA model in the software
2 evaluate the results and communicate to employees
3 monitor reports with improvement actions for each position.

Figure 3 Proposed results management model

1		2		3
DATA COLLECTION	⇨	EVALUATE THE RESULTS OF THE MONTH	⇨	MANAGEMENT OF RESULTS
Collect input and output data from all stations		Transfer software results to Excel spreadsheets		Communicate results to experts
Handle data		Evaluate results		Discuss actions, progress of actions, effectiveness of completed actions, and define new actions.
Perform calculations of efficiency scores in the software				Update results management spreadsheets

Source: Authors

In the first stage, data regarding the inputs and outputs of the DEA model of all fuel stations will be collected at the end of each month. Afterward, the collected data is processed. Once processed, the data will be entered into Excel spreadsheets containing the history of the previous months. Then, the efficiency scores are calculated.

The second stage refers to the evaluation of results obtained by the software. In this step, data regarding efficiencies, target data, and resulting slacks are extracted. Then, the data is organised in spreadsheets for analysis.

In the third step, results are communicated to managers and administrative assistants of all units through a standard e-mail containing

1 graph with the behaviour of efficiencies of stations
2 a table showing efficiencies, averages of efficiencies, minimum efficiency, maximum efficiency, etc., contemplating 12 retroactive months
3 12-month retroactive spreadsheet showing the targets and the slacks of each station.

The managers are present with actions in progress, completed actions, their efficiency, and new actions to be carried out. They must update the spreadsheet for the control and consultation of all employees involved in the process. Also, it is suggested to hold periodic meetings to discuss actions and results among the managers of all units.

6 Conclusions

It is understood that the factors influencing the performance of stations may be attributed not only to internal variables, such as management change, but also to external variables, such as location and market behaviour. Thus, it is perceived that evaluating the organisation continuously and in an effective way is essential to optimise the results of the organisation. For this, a results management model was proposed based on a DEA model presented to process experts to verify their viability in routines and to identify possible improvements. The results management model was then validated by experts by proposing a follow-up of results and improvement actions with periodic meetings.

Despite contributions, this study has limitations. Since this is a single case study, empirical generalisation is limited. However, analytical generalisation is possible, meaning that the model developed can be applied in similar contexts. In the DEA model, monetary variables were not considered, such as purchase price and fuel sale price. Such variables were not considered because the organisation did not have the history of these data for the whole analysis period. Thus, the model considers efficiency based only on non-monetary variables.

For future studies, we suggest that competitive factors be considered. We assumed that the most significant competition fuel stations are those located within a radius of 10 km. Thus, we suggest a competition study within a 10 km radius to take this external variable into account in the DEA model. It is important to conduct studies that seek to identify prevalent external factors in the determination of technical efficiency. Besides, we also recommend implementing this method in organisations of other branches, which operate their activities through units, such as networks.

In addition, we suggest future studies on the behaviour of efficiency over time in fuel retailer stations and fuel retailer networks. Another suggestion regards future studies including other variables, such as purchase prices and fuel sales prices, to integrate the operational results and the financial results into the model. Similar cases could utilise two-stage DEA analysis to account for external variables, such as location and competition, that may impact efficiency.

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