Performance Measurement of Gas Station in Indonesia Based on Ownership Status using Two-Stage Data Envelopment Analysis

Priani Nadhira Sudarma and Isti Surjandari
Departement of Industrial Engineering
Faculty of Engineering, Universitas Indonesia
Kampus UI Depok, Indonesia
priani.nadhira@ui.ac.id, isti@ie.ui.ac.id

Abstract

The growth of the gas station business in Indonesia is increasing from year to year. It requires companies in oil and gas industries to improve performance. Oil and gas company state-owned in Indonesia have 3 ownership schemes, namely COCO (Company Owned, Company Operated), CODO (Company Owned, Dealer Operated), and DODO (Dealer Owned, Dealer Operated). This study analyzes differences in the performance of the three schemes. The results can be used as company's strategic planning. Gas station performance measured by the efficiency of each gas station unit, also differences between the three schemes. Two-stage Data Envelopment Analysis (DEA) is used to calculate the efficiency of each gas station. In the first phase of DEA, measuring efficiency in the operational aspects of gas stations with the aim of maximizing sales and transaction numbers. In the second stage of DEA, it measures cost efficiency at gas stations, by minimizing the cost at gas stations. According to the findings of the study, DEA analysis of the two stages is that there is no significant difference, however COCO gas station has highest efficiency, followed by the CODO gas station, and in the last place the DODO gas station with the lowest average efficiency.

Keywords

Two-Stage DEA, Performance Measurement, Efficiency, Oil and Gas, Ownership Status.

1. Introduction

The dynamic development and growth of the industrial world make every element in it to always be adaptive to make changes and sustainable improvements (Keh & Chu, 2003). This is in addition to increasing company profits, as well as maintaining consumer loyalty to ensure the company's existence during increasingly fierce competition. The dynamics of business competition also occur in the fuel oil (BBM) and natural gas industries. The competition in the gas station company requires to take strategic steps to improve performance and infrastructure in the downstream sector (refining, marketing, and trade).

PT. Pertamina is a BUMN (State Owned Enterprise) whose job is to manage oil and gas mining in Indonesia from upstream to downstream. Pertamina has three gas station ownership schemes, the first of which is DODO gas stations (Dealer Owned, Dealer Operated) where the gas station is fully owned by the private sector, including land, assets, and operational activities. The second type of ownership is CODO (Company Owned Dealer Operated) gas stations where the gas stations are owned by Pertamina, but operational activities are carried out by the private sector. Furthermore, the third type of gas station is COCO gas station (Company Owned Company Operated) (Pertamina 2016). Until now, there is no standard measurement for performance of gas stations. Pertamina never knows how the performance of CODO, and DODO gas stations is, so it cannot be certain whether private gas stations are appropriate or not managing gas stations. Due to the importance of maintaining gas station performance, performance measurement is needed for each gas station. This performance can be seen from the efficiency figures of each gas station unit and the gas station ownership scheme. One of the efforts to improve the performance of gas stations is to look at the efficiency value of each gas station based on gas station ownership.

2. Literature Review

There have been several previous studies regarding measuring gas station performance, Galankashi et al (2016) evaluated gas stations in Malaysia using the DOE simulation method by classifying problems into two categories, namely customer aspects and aspects of the number of nozzles and operator filling time. The results obtained from the experimental design show that filling time and arrival time have a significant effect on determining the queue length, while all factors and their interactions have a significant effect on the level of sales. However, this research only analyzes the relationship between variables with one output, namely sales.

Due to the many aspects used in gas station performance measurement, further analysis is needed for knowing the influence of variables in the gas station. In several previous studies, many performance measurements have been carried out by considering each unit and considering the output and input used. In the field of retail business, research has also been carried out by measuring the efficiency of each store. In Surjandari and Margaretha (2009) analyzing the quality of hypermarket services in Indonesia using DEA and pairwise comparison, then Nong (2022), Duman et al. (2017), Keh & Chu (2003), Camanho et al. (2009), Ko et al. (2017), Gafner et al. (2021) and Barros (2005) examined the efficiency of using DEA in the fields of fashion, food and beverage, supermarket, and hypermarket, but no one has yet discussed gas station retail.

Previous research related to group-efficiency DEA has also been studied by Surjandari and Handari (2012), in this study there were two DMU groups, namely RSBI and non-RSBI schools, the results were that non-RSBI schools were more efficient even though the difference with RSBI schools was not significant. Ang et al. (2018) examined the performance of hotels in Taiwan with hotel DMUs and their subsidiaries using the cross-efficiency DEA method with the development of a model based on the average performance of DMUs in a group and based on the Tong Principle, by determining the performance of a group from the efficiency of the weakest unit. The DEA Metafrontier analysis approach and k-medoids cluster analysis were carried out by Yen and Li (2022) by analyzing the performance of airlines on Asian routes and United States (US) routes. Hospital efficiency is calculated by See et al (2021), where the hospital category is divided into specialists and non-specialists, this study uses the Metafrontier-Dynamic Network DEA in calculating hospital sub-groups and the results are non-specialist hospitals that have a higher efficiency value higher than a specialist hospital. In this study, efficiency analysis was carried out on DMU groups based on gas station ownership, namely COCO, CODO, and DODO using two-stage DEA.

In determining the input and output variables used, we refer to previous research in the retail industry. Here are some references in determining DEA input and output variables (Table 1):

Table 1. List of Research on Retail Performance Efficiency

No.	Reference	Methods	Input	Output	Scope
1.	Nong (2022)	Delphi & DEA	Number of employees, Operational Cost, Size Store	Revenue, Total Customers	Fashion Industry
2.	Duman et al. (2017)	DEA	Size Store, Store Manager experience, Store Location, Promotion Cost	Revenue dan Customer Satisfaction	Food Industry
3.	Keh & Chu (2003)	DEA	Number of employees, Salary, *Capital* (Occupancy, Utilities, Maintenance, and Total Cost)	Distribution Service dan Revenue	Company Leve
4.	Camanho et al. (2009)	DEA	Stock, Operational Cost, Salary, Losses, Area, dan Population	Revenue	Supermarket
5.	Ko et al. (2017)	DEA & Tobit	Size Store, Stock, Number of Employees, Rental Costs	Revenue dan Total Customers	Retail in Korea
6.	Gafner et al. (2021)	FAHP-DEA-TOPSIS	Storage Area, Population, Total Cost, Employee Working Hours	Order Quantity, Revenue	Retail Storage
7.	Barros (2005)	DEA	Size Store, Age of Employees, Average Stock	Revenue Per Category	Hypermarket

3. Methods

3.1 Two-Stage DEA

Two-stage DEA has been widely used in previous research, previously Yin et al (2020) conducted a two-stage DEA analysis by looking at operational and marketing aspects of hotels and hotel partners, where the aim is to understand operational and marketing performance in hotel management collaborations with partners. Ramanathan (2016) also takes several aspects in the two stages of DEA, namely financial, operational, environmental, and service aspects. This study uses a two-stage DEA, namely the operational stage and cost efficiency. In this study, the first stage of DEA includes the operational stage by maximizing output in the form of transaction numbers and income, then the second stage includes the cost efficiency stage by minimizing costs at the gas station.

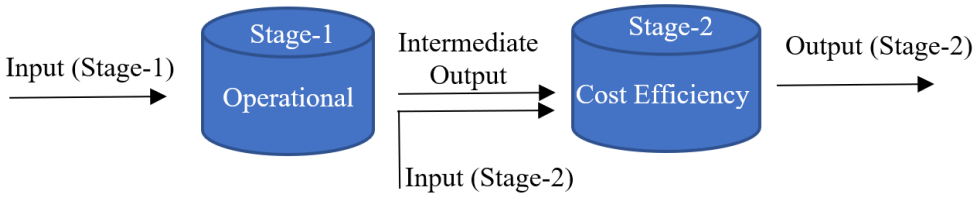

Figure 1. Two-Stage DEA Framework

3.2 Decision Making Unit (DMU) and Input-Output Variable

In this study, the DMU used was a gas station unit in the West Java region. According to Fitzsimmons (2011), the sample size or DMU used has the formula, DMU ≥ 3 (number of inputs + number of outputs). In this study, the number of DMUs used was 30 DMUs or 30 gas stations. With each ownership of 10 gas stations.

In previous research, many have measured retail performance using DEA, but no one has specifically discussed retail gas stations. In this regard, the determination of input and output variables in this study is determined by combining several variables in the references while still considering business processes and company goals. The following input and output variables are used based on previous research (Table 2):

Table 2. Input and Output Variable

Stage	Variable	Variable's Name	Variable Measurement
Operational	Input (Stage-1)	Area	Square meter (m^2)
		Amount of Nozzle	Unit
	Intermediate Input	Revenue	Rupiah
		Amount of Transaction	Amount of Transaction
Cost Efficiency	Input (Stage-2)	Salary	Rupiah
		Utilities	Rupiah
		Losses	Rupiah
	Output	Profit	Rupiah

The next step in this research is select of DEA orientation. In the first stage, operational stage using output orientation, where the input variables are fixed, and the output variables are maximized. Revenue and transaction numbers at this stage are maximized by inputting the area of the gas station and the number of nozzles at the gas station. Furthermore, in stage 2, namely the cost efficiency stage using input orientation, where the input numbers in the form of worker's salaries, utility costs, and losses, are minimized, with the output profit or profit of the company.

4. Results and Discussion

4.1 Results

Data processing in this study used DEAP ver. 2.1 published by the School of Economics University of Queensland. Data processing was carried out twice in stages, the first for DEA stage 1 using an output orientation with 2 input variables and 2 output variables. Furthermore, DEA stage 2 uses an input orientation with 5 inputs and 1 output. Following are the results of data processing in stage 1:

Table 3. DMU's Efficiency Value

DMU	Gas Station-Ownership	Stage-1 Efficiency	Stage-2 Efficiency
DMU 1	COCO	0,67	0,57
DMU 2	COCO	0,72	0,65
DMU 3	COCO	0,72	0,75
DMU 4	COCO	**1,00**	**1,00**
DMU 5	COCO	**1,00**	0,64
DMU 6	COCO	**1.00**	**1,00**
DMU 7	COCO	0,76	**1,00**
DMU 8	COCO	**1,00**	**1,00**
DMU 9	COCO	0,57	**1,00**
DMU 10	COCO	0,95	**1,00**
Average Efficiency (COCO)		**0,84**	**0,86**
DMU 11	CODO	0,74	0,89
DMU 12	CODO	**1,00**	0,65
DMU 13	CODO	**1,00**	**1,00**
DMU 14	CODO	0,98	**1,00**
DMU 15	CODO	0,47	**1,00**
DMU 16	CODO	0,97	0,84
DMU 17	CODO	0,96	0,49
DMU 18	CODO	0,66	**1,00**
DMU 19	CODO	0,49	**1,00**
DMU 20	CODO	0,85	0,98
Average Efficiency (CODO)		**0,81**	**0,88**
DMU 21	DODO	0,76	0,64
DMU 22	DODO	**1,00**	0,71
DMU 23	DODO	0,72	0,59
DMU 24	DODO	0,48	**1,00**
DMU 25	DODO	0,74	0,68
DMU 26	DODO	**1,00**	0,97
DMU 27	DODO	0,40	**1,00**
DMU 28	DODO	0,53	0,75
DMU 29	DODO	0,67	0,90
DMU 30	DODO	0,44	0,83
Average Efficiency (DODO)		**0,68**	**0,81**
Average Efficiency (All)		**0,78**	**0,85**

In the results of DEA processing stages 1 and 2 in Table 3., out of a total of 30 calculated DMU, there were 8 efficient DMU, 4 DMU each from COCO gas stations, 2 DMU from CODO gas stations, and 2 DODO gas stations. In Stage2 there are 13 efficient DMU, including 6 COCO gas stations, 5 CODO gas stations, and 2 DODO gas stations.

4.2 Discussion

Efficiency analysis using two-stage DEA has been carried out using DEAP software version 2.1. In stage 1 (Operational Stage) it is carried out using an output orientation by maximizing sales figures and transaction numbers by inputting the area of gas stations and the number of nozzles at gas stations. Furthermore, in stage 2 (Cost Efficiency Stage) it is carried out using an input orientation by minimizing salary costs, utilities, and losses with an output profit/profit.

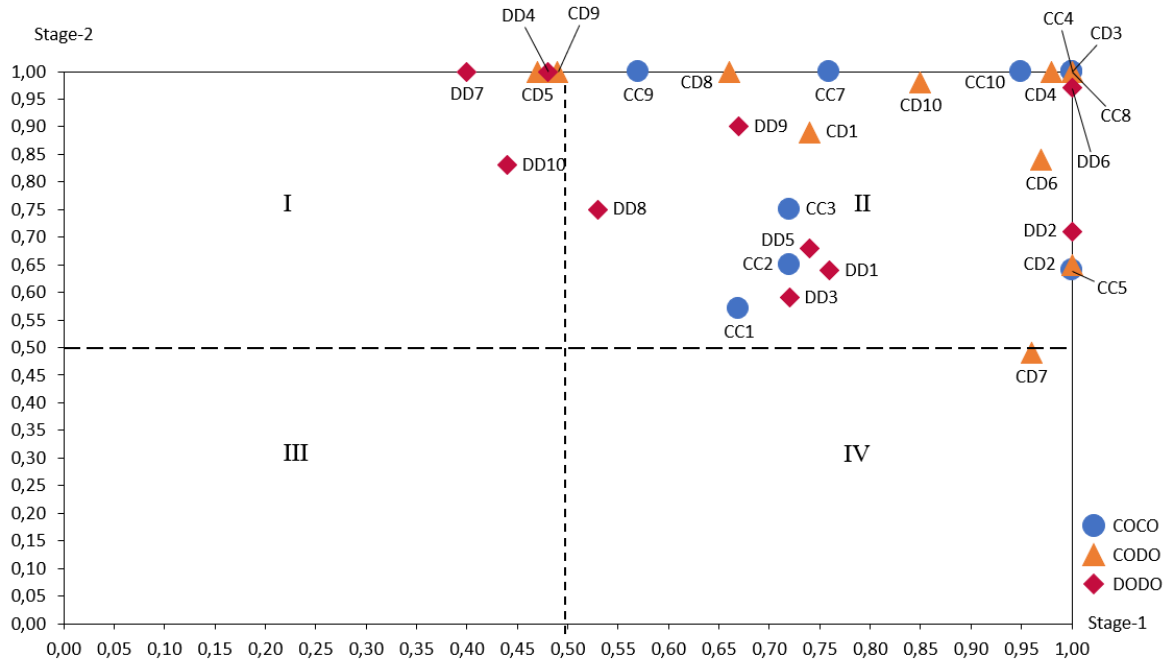

Figure 2. Scatter Plot of Stage 1 and Stage 2 Efficiency Values

The efficiency figures for each stage and type of ownership have been described. In stage 1, all DMU have an average efficiency score of 0.78 and 0.85 in the second stage. When viewed from the two stages, COCO gas stations have the highest average efficiency with efficiency figures of 0.84 and 0.86 at each stage, followed by CODO gas stations with efficiencies of 0.81 and 0.88, and in last place DODO gas stations has efficiency figures of 0.68 and 0.81.

Efficiency analysis is divided into four quadrants, where quadrant I has DMUs with low efficiency values (0.5 below) in stage I and high efficiency (above 0.5). It can be interpreted that the DMU in quadrant I has less efficient operations, but quite good cost efficiency, in this case it means that the DMU is less efficient in maximizing revenue and transaction numbers but is good at minimizing costs at gas stations. In quadrant I there are 4 DMUs, with 2 units of CODO gas stations and 2 units of DODO.

The largest population of DMUs is in quadrant II, where the efficiency values for phase I and phase II are both quite high and several gas stations are 100% efficient. There are 25 DMUs in quadrant II, of which 3 DMUs at COCO gas stations have 100% efficiency in both stages. In quadrant 2 there are 10 COCO gas stations, 7 CODO gas stations, and 7 DODO gas stations. In this quadrant, it can be defined as having units with quite good and very good efficiency at both stages, meaning that gas stations in this quadrant have good revenues with efficient costs. There are no DMUs located in quadrant III, which means that there are no gas stations that have low efficiency in both stages of DEA.

The last one is in quadrant IV, where the DMU in that quadrant has a good efficiency score (above 0.5) at stage 1 and the efficiency score is not good at stage 2, meaning that gas stations can maximize revenue but their performance in minimizing costs is not good. In this quadrant IV there is 1 DMU at the CODO gas station type.

Efficiency performance based on the type of gas station ownership (COCO, CODO, and DODO) in stage 1 (Operational) and stage 2 (Cost Efficiency) can be seen in Figure 3 below:

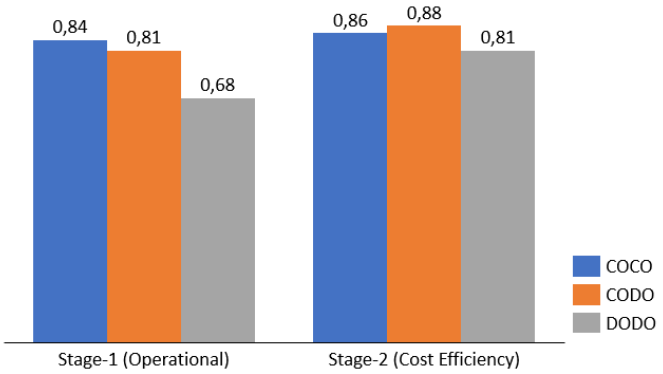

Figure 3. Efficiency Graph by Stage and Ownership

At the operational stage, COCO gas stations have an average efficiency of 0.84, while CODO gas stations have an average efficiency of 0.81, and DODO gas stations are 0.68. At the cost efficiency stage, COCO gas stations have an average efficiency value of 0.86, followed by CODO gas stations with an average efficiency of 0.88, then in last place DODO gas stations have the lowest average efficiency with a value of 0.81. It can be concluded in the graph above that in Stage 1 COCO gas stations are superior, which means that COCO gas stations have the best efficiency in maximizing revenue. In the second stage, CODO gas stations are purple with an efficiency value of 0.88, which means that CODO gas stations have the best performance in cost efficiency.

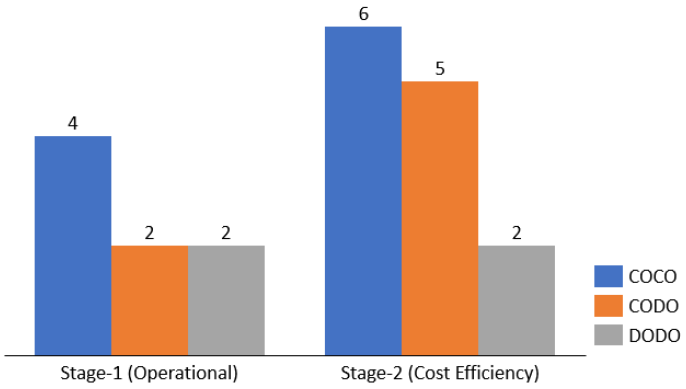

Figure 4. Graph of Efficiency Value 1 based on stage and Ownership

In stage 1 (Figure 4), there are a total of 8 gas stations with an efficiency value of 1, including 4 COCO gas stations, 2 CODO gas stations, and 2 DODO gas stations. In stage 2, there are a total of 13 gas stations with an efficiency value of 1, including 6 COCO gas stations, 5 CODO gas stations, and 2 DODO gas stations. In stage 2 COCO gas stations also excel in the most efficiency values. From Table 2 and Table 3 COCO gas stations excel in operational efficiency performance, and CODO gas stations excel in cost efficiency.

5. Conclusion

The Data Envelopment Analysis method is useful for determining the performance of units within a company, by using the efficiency value of each DMU. Gas station performance is important for the sustainability of the company, especially where the company has various gas station ownership schemes. According to research, COCO (Corporate Owned Corporate Operated) gas stations have the highest efficiency of all aspects analyzed in this study with average efficiency value is 0,84. CODO gas stations (Corporate Owned Dealer Operated) have the highest efficiency value in terms of cost efficiency with efficiency value 0,88. The Last, DODO gas stations (Dealer Owned Dealer Operated) have the lowest efficiency in the two stages of DEA.

References

Ang, Sheng et al., Group cross-efficiency Evaluation in Data Envelopment Analysis: An Application to Taiwan Hotels, *Journal Computers & Industrial Engineering*, no. 125, pp. 190-199, 2018.

Barros, C.P., Efficiency Measurement among Hypermarkets and Supermarkets and the Identification of the Efficiency Drivers: a case study. *International Journal of Retail & Distribution Management*, 2006.

Camanho, A. S. et al., Efficiency Analysis Accounting for Internal and External non-Discretionary Factors.*Journal Computers & Operations Research*, no. 36(5). Pp 1591–16012, 2009.

Duman, G, M. et al., A holistic Approach for Performance Evaluation using Quantitative and Qualitative Data: a Food Industry Case Study, *Journal Expert Systems with Applications*, no. 81, pp 410–422, 2017.

Fitzsimmons & Fitzsimmons, *Service Management, Operations, Strategy, Information Technology*, Seventh Edition, New York, McGraw-Hill, 2011.

Gafner, A. Loske, D. & Klumpp, M., Efficiency measurement of grocery retail warehouses with DEA, *Hamburg International Conference of Logistics (HICL),* pp. 317–348, Hambug, 2021.

Galankashi, et al., Performance evaluation of a petrol station queuing system: A simulation-based design of experiments study, *Journal Advances in Engineering Software*, no. 92, pp. 15-26, 2016.

Keh and Chu., Retail Productivity and Scale Economies at the Firm level: a DEA Approach, The International Journal of Management Science, no. omega 31, pp. 75-82, 2003.

Ko, K. et al., Efficiency Analysis of Retail Chain Stores in Korea, Sustainability, vol. 9, no. 9, pp. 1629, 2017.

Nong, Nhu-Mai Thi., An Application of Delphi and DEA to Performance Efficiency Assessment of Retail Stores in Fashion Industry, The Asian Journal of Shipping and Logistics, no. xx, pp. xx, 2022.

Pertamina, Pedoman Manajemen Business Fungsi Business Fuel & Gas, No, A-001/1100/2016-S0, 2016.

Ramanathan, Ramakrishnan et al., Linking Operations, Marketing and Environmental Capabilities and Diversification to Hotel Performance: A data Envelopment Analysis Approach, *Int. J. Production Economics,* no. 176, pp. 111-122, 2016.

Surjandari, Isti dan Handari., Pengukuran Kinerja SMA Rintisan Sekolah Bertaraf Internasional (RSBI) dan Non RSBI Berbasis ISO 9001 Menggunakan Data Envelopment Analysis, 2012.

Surjandari, Isti dan Margaretha. Analisis Kualitas Pelayanan Hypermarket Antar Cabang di Wilayah DKI Jakarta dan Sekitarnya dengan Metode DEA dan Pairwise Comparison, 2009.

Yen, Barbara T. H. dan Li., Route-based Performance Evaluation for Airlines – A Metafrontier Data Envelopment Analysis Approach, *Transportation Research Part E,* vol. 162, no. 102749, 2022.

Yin, Pengzhen, et al., A DEA-based Two-stage Network Approach for Hotel Performance Analysis: An Internal Cooperation Perspective, *Omega,* Vol. 93, no. 102035, 2020.

Biographies

Priani Nadhira is a master's program student at the Department of Industrial Engineering Faculty of Engineering, Universitas Indonesia, majoring in Quality and Data Engineering. She received her bachelor's degree from Statistics Department, Universitas Padjadjaran in 2017, and in the same year, she started working in oil and gas company state-owned in Indonesia. The research topic for her thesis is measuring performance of gas station using two-stage DEA.

Isti Surjandari is Professor and Head of Statistics and Quality Engineering Laboratory in the Department of Industrial Engineering, Faculty of Engineering, Universitas Indonesia. She received her bachelor's degree in industrial engineering from Universitas Indonesia in 1987 and Ph.D. degree from the Ohio State University in 2002. She also holds master's degree in industrial engineering and Management from Bandung Institute of Technology and master's degree in economics from the Ohio State University. Isti is a Certified Quality Engineer (CQE) form American Society for Quality (ASQ) and Insinyur Profesional Utama (Executive Professional Engineer IPU) from The Institution of Engineers Indonesia (PII). Her research interests are in quality engineering and management, applied statistics and data analysis including data mining.