The Impact of the COVID-19 Pandemic on Work Productivity in Project X in Batam Using the Data Envelopment Analysis (DEA) Method

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Abstract

The advancement of Industry 4.0 has significantly impacted the utilization of gas as an energy resource, prompting Qatargas to expand its production capacity through the addition of new platforms at its production site. The construction process of the Qatargas platform is managed by Project X, located at a fabrication facility in Batam, Indonesia, under a contract covering engineering, procurement, construction, and installation (EPCI) that began at the end of 2021. However, the COVID-19 pandemic brought unexpected challenges, resulting in restrictions on work activities that negatively affected construction productivity. This study employs the non-parametric Data Envelopment Analysis (DEA) method to measure the performance trends of Project X through daily progress data from 2022, representing the pandemic conditions, and 2023 as the post-pandemic phase. SWOT and PEST analyses are also applied to formulate strategies to improve project performance. Efficiency measurements are conducted using the DEA approach on three input variables: the number of employees, the amount of welding, and WP (Work Pack) issued, with one output variable, namely the total manhours earned. The study examines six divisions as Decision-Making Units (DMUs) and also utilizes SWOT analysis to identify factors affecting project performance and strategies for enhancing efficiency. The results indicate that the pandemic conditions did not significantly impact the performance of Project X, as the project was able to continue fabrication processes while adhering to health protocols. The project achieved an average efficiency of 0.734 in 2022 and 0.656 in 2023, reflecting a decrease of 0.078. This performance decline was primarily due to lower productivity in the Production Electrical and Structural Quality divisions. Strategies to improve project efficiency include optimizing the number of employees, minimizing rework, and implementing daily monitoring of manhours earned to prevent inaccurate work hour claims.

Keywords: *Construction company, COVID-19, Data Envelopment Analysis (DEA), Efficiency, EPCI project, Performance*

1. Introduction

The COVID-19 pandemic has compelled many countries to implement strict health protocols and regional quarantine measures to curb the spread of the virus.[1] As a result, numerous construction projects have faced significant delays in their schedules and, in some cases, have been suspended. This is primarily due to the enforcement of Large-Scale Social Restrictions (PSBB) that limit activities and mobility, directly impacting the progress of these projects.[2] The success of a company in achieving its goals, particularly in navigating the challenges posed by the COVID-19 pandemic, is closely linked to its ability to select, place, and develop its human resources effectively.[3] This success hinges on having capable, skilled, and educated individuals in key roles. The presence of such skilled personnel plays a crucial role in enabling the company to adapt and thrive in difficult conditions.[4] This situation has a significant impact on the construction sector, leading to obstacles in construction work and potentially slowing down project completion. Construction contracts typically have fixed deadlines, and any delays can adversely affect cash flow, potentially resulting in failure to complete the work. These delays not only disrupt the planned schedule but also pose financial risks, which can jeopardize the overall success of the project.[5]

Qatargas, the world's largest LNG (Liquefied Natural Gas) producer with an annual output of 77 million tons, has been significantly impacted by the geopolitical tension between Russia and Ukraine.[6] This conflict has led to the cessation of gas supplies to European countries, creating substantial opportunities for other gas companies, including Qatargas, to expand their operations. In its efforts to develop, produce, and market hydrocarbons from the largest non-associated gas fields globally, Qatargas is pursuing expansion by adding new platforms to its production fields. This expansion positively affects the oil and gas construction sector by increasing the demand for infrastructure procurement in the industry. [7] Project X is a critical undertaking for PT. Y during the 2022-2023 period, with a contract value of approximately 50 million US dollars and involving over 50% of PT. Y's workforce. Consequently, the efficiency of Project X significantly impacts PT. Y's overall performance during this period. During the fabrication process of facilities for Qatargas, an unexpected situation arose: the outbreak of the coronavirus disease, commonly known as COVID-19. To continue working on Project X for Qatargas, PT. Y implemented several operational policies for fabrication. These policies were designed to ensure the continuity of the fabrication and installation processes while safeguarding employees from the ongoing spread of COVID-19. The measures aimed to protect the workforce and maintain the project's progress despite the challenging circumstances.[8]

Performance can be measured using the Data Envelopment Analysis (DEA) method [9]. Several studies in the construction industry have utilized DEA, such as the research which employed a two-stage DEA with different input and output configurations to assess the impact of the COVID-19 pandemic on the performance of construction companies in Indonesia.[10] DEA was used to evaluate the efficiency of construction firms and compare their performance with similar companies before and during the pandemic.[5] Another study by Rahman examined the performance of power plants in Malaysia from 2015 to 2017.[11] This study combines the Data Envelopment Analysis (DEA) method with the Malmquist Total Factor Productivity (TFP) index to assess changes in technical efficiency and technology, providing a clearer understanding of factors affecting shifts in local productivity.[12] Using installed capacity (MW) as the input and two outputs average thermal efficiency (%) and average equivalent availability factor (%) the study examines ten major power plants. The findings indicate that technological change is crucial for improving TFP performance in fossil fuel power plants in Malaysia. Additionally, a decline in TFP performance is attributed to a lack of technical innovation, while larger power plants tend to have better TFP efficiency.[13]

According to Procel, DEA is a non-parametric method used to measure the relative efficiency of a group of Decision Making Units (DMUs).[14] Measurement is conducted using predetermined input and output variables. DMUs can be companies, government agencies, organizations, or work units within a company or organization. DEA compares the input and output variables of each DMU with those of efficient DMUs as benchmarks to determine the efficiency values. At the final stage, the efficiency rankings of DMUs are established, and it is possible to have more than one efficient DMU due to DEA's nature of seeking efficiency benchmarks. This study will employ the DEA method to measure the performance of Project X owned by QatarGas, which is being executed by construction company PT. Y. The research aims to identify the factors influencing the performance of Project X by analyzing performance trends during and after the COVID-19 pandemic to assess the impact of the pandemic on the project's performance. The performance of Project X will be processed by analyzing the productivity values from the period of 2022 to 2023.

2. Method

The following is a research flowchart that outlines the main stages in a study analyzing the impact of COVID-19 on productivity in a construction project in Batam. This flowchart helps visualize the process of data collection, processing, and analysis to achieve the research objectives.

This research begins with the problem identification phase, which aims to formulate the main issue to be addressed: the impact of the COVID-19 pandemic on productivity in a construction project in Batam. Following this, a literature review is conducted, covering topics such as offshore construction projects, project management, factors affecting productivity, and the application of the Data Envelopment Analysis (DEA) method.[15] The next phase is data collection, which focuses on project X data, such as actual vs. planned schedule comparison, contract details, installation progress, KPI data, and the number of employees involved in the project.

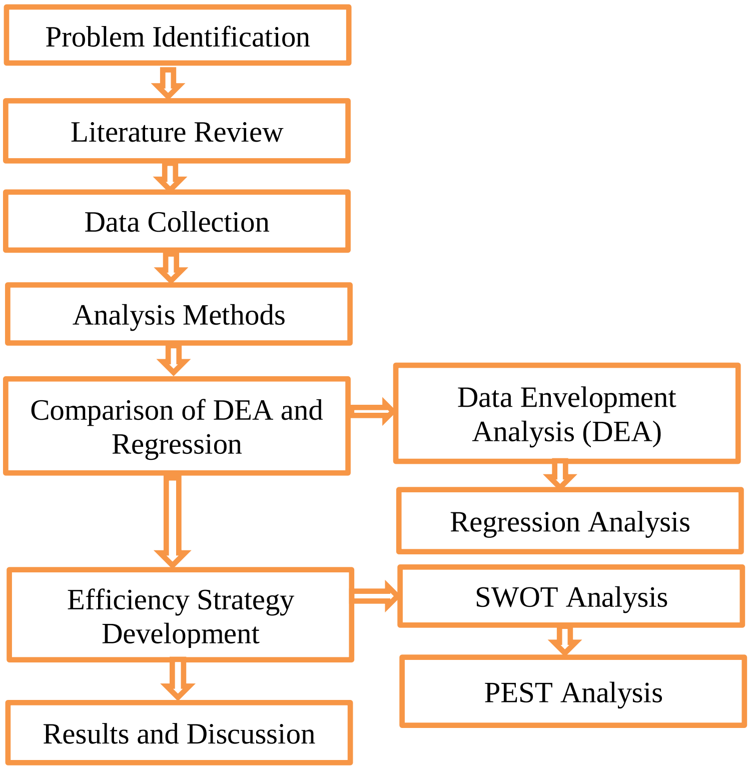

Figure 1. Research Workflow Diagram

To analyze the collected data, two main methods are employed: DEA and regression analysis. DEA is used to measure the relative efficiency of various decision-making units (DMUs), considering the relationship between inputs and outputs during the pandemic period (2022) and post-pandemic period (2023). Regression analysis is used to identify the influence of independent variables (such as the number of employees, number of welding activities, and WP issued) on the output measured, which is manhours earned. The results from both methods are then compared to provide a more comprehensive understanding of the project's performance.

Subsequently, strategies for improving efficiency are developed using SWOT and PEST analyses. The SWOT analysis aims to identify the strengths, weaknesses, opportunities, and threats within project X, based on data obtained from DEA and regression analysis. Meanwhile, the PEST analysis is used to evaluate external factors that may affect project performance, such as government policies, economic conditions, social factors, and technological developments. All of these findings are combined to formulate effective strategies to enhance efficiency and performance in future construction projects.

3. Results and Discussion

3.1. Determining the Decision Making Unit (DMU)

The initial identification to determine efficiency in a project using the Data Envelopment Analysis (DEA) method is to determine the Decision Making Unit (DMU). Efficiency measurement is carried out by comparing the effectiveness of a group of homogeneous Decission Making Units (DMUs). The form of a DMU can be in the form of a company, department, division, or administrative unit with the same goals and objectives and having common inputs and outputs. To obtain a discriminative value, it is recommended that the number of DMUs be greater than the multiplication of inputs and outputs. The discriminative value in a study is important because it ensures that each concept of the models differs from other variables, and it is also used to test the accuracy of the measuring tools.

Table 1. List of Decission Making (DMUs) for Project X

No.	Division Name	Qualification	DMU
1	Production Structural	Fab. Ops.	U01
2	Production Piping	Fab. Ops.	U02
3	Production Electrical	Fab. Ops.	U03
4	Quality Control Structural	QAQC	U04
5	Quality Control Piping	QAQC	U05
6	Quality Control Electrical	QAQC	U06

The total number of departments involved in Project X can be divided into 12 departments, including Production Structural, Production Piping, Production Electrical, Production Painting, Production Mechanical, Quality Control Structural, Quality Control Piping, Quality Control Electrical, Quality Control Painting, Quality Control Mechanical, and Commissioning. In this study, the DMUs selected as research objects are 6 divisions involved in the construction of Project X. These were chosen based on the similarity of functions, inputs, and outputs, thus fulfilling the homogeneity requirement. Additionally, the 6 selected divisions are the most influential in the productivity of Project X. The Decision Making Units (DMUs) for Project X can be seen in Table 1.

3.2. Variable Selection

The selection of input and output variables is based on a literature review that states inputs are the resources used by the DMU, while outputs are the benefits generated from the DMU's operational activities. In this case, the inputs used by the six DMUs include the number of employees, the number of welding operations, and WP issued. Meanwhile, manhours earned represent the total working hours spent by the six DMUs. Based on the available data and performance measurement stages in this study, the selected input and output variables are shown in Table 2.

The number of selected variables will affect the number of DMUs that must be analyzed to ensure more discriminative analysis results. In this study, the available data cover six divisions. The number of variables for analysis includes three input variables and one output variable. The requirement is that the number of DMUs must be greater than the product of the input and output variables.[16] Table 3 shows that the minimum requirement for DEA measurement has been met with the available number of DMUs.

From the calculation, it can be concluded that the selected number of DMUs meets the requirements, as the total exceeds the product of the input and output variables.

Table 2. Variable List for Project X

Variable	Symbol	Definition
Input	x_1	Number of employees
Input	x_2	Number of welding
Input	x_3	WP issued
Output	y_1	Manhours earned

Table 3. Number of DMUs

Stage	Minimum Number of DMUs	Number of DMUs
I	3×1=3	6

3.3. Multicollinearity Test

Based on the multicollinearity test conducted using Microsoft Excel, the correlation values between independent variables and the calculation of the VIF (Variance Inflation Factor) against the tolerance values were obtained. The test was conducted to determine whether the selected input and output variables meet the DEA method's requirements, specifically that they must be inclusive and have positive values. The multicollinearity test was performed on each input and output variable for the period of 2022, representing pandemic conditions, and 2023, representing post-pandemic conditions. The results of the correlation calculation between independent variables are shown in Table 6.

Table 4. Correlation Values Between Independent Variables

Variables	Correlation (r)
X1X2	-0.2969
X1X3	-0.3123
X2X3	0.9050
Y1X1	-0.062
Y1X2	-0.0398
Y1X3	0.0733

Table 5. Tolerance Values for Correlation Between Independent Variables

Tolerance	Value
X1X2	0.9119
X1X3	0.9025
X2X3	0.1810
Y1X1	0.9961
Y1X2	0.9984
Y1X3	0.9946

Table 6. VIF Values for Tolerance

VIF	Value
X1X2	1.0966
X1X3	1.1081
X2X3	5.5259
Y1X1	1.0039
Y1X2	1.0016
Y1X3	1.0054

After obtaining the correlation values between independent variables, the next step is to calculate the Tolerance and VIF values using Equations 4.2 and 4.3. If the Tolerance value is greater than 0.1 and the VIF value is less than 10, it can be concluded that multicollinearity does not occur between variables, indicating that the variables meet the exclusivity requirement. The test results are presented in Tables 5 and 6.

From the multicollinearity test results, it can be seen that the Tolerance values are greater than 0.1 and the VIF values are less than 10. Based on these calculations, it can be concluded that there is no multicollinearity between the input variables X1 (number of employees), X2 (number of welding operations), X3 (WP issued), and the output variable Y1 (manhours earned). Therefore, it can be stated that the input and output variables used fulfill the exclusivity requirement. The second test was conducted to meet the positivity requirement, ensuring that all input and output variables have positive values. Based on the observed data, all input and output variables have positive values.

Table 7. DMU Efficiency Values for 2022 (Pandemic) - 2023 (Post-Pandemic)

DMU	2022 (Pandemic)	2023 (Post-Pandemic)	Mean
U01	1	1	1
U02	0.806	1	0.903
U03	0.717	0.278	0.4975
U04	1	0.244	0.622
U05	0.646	1	0.823
U06	0.233	0.412	0.3225
Mean	0.734	0.656	0.695

Note:
The efficiency value used is scale efficiency, calculated as the ratio of crste/vrste, where crste represents the technical efficiency from CRS DEA, and vrste represents the technical efficiency from VRS DEA.

Table 8. Statistical Data of DMU Efficiency Values

Stage	Statistics	2022	2023
Stage 1	Min	0.233	0.244
	Max	1	1
	Mean	0.734	0.656
	Std Dev	0.285	0.381

3.4. Efficiency Calculation of Decision Making Units (DMU)

The next step is to calculate the efficiency of the six DMUs. The calculation is performed in one stage, based on the total manhours earned. Efficiency measurement is carried out for each year over a two-year period (2022-2023). During these two years, the study focuses on two conditions: pandemic conditions represented by 2022 data and post-pandemic conditions represented by 2023 data. Table 9 shows the relative efficiency results of the DMUs for the 2022 (pandemic) and 2023 (post-pandemic) periods.

3.5. Efficiency Analysis

Through calculations using DEAP version 2.1 software, the relative efficiency values of each DMU have been obtained. The efficiency values are relative, as they apply only within specific DMU groups; differences in the quantity or scale of variables will affect the calculation results. The efficiency scale ranges from 0 to 1, where a value of 1 indicates maximum efficiency, while values below 1 indicate lower efficiency.

The DMU efficiency values for Stage 1 are shown in Table 10. In the efficiency calculations over the two-year period, it can be observed that the DMU consistently maintaining an efficiency value of 1 is DMU U01, namely Production Structural. This indicates that this division has been efficient, while the other five divisions have not. The division with an efficiency value of 1 serves as a benchmark for other divisions in both 2022 and 2023. DMU U01 consistently records a high number of earned man-hours each year, utilizing an adequately efficient number of employees, and this division is also able to maintain weekly progress by keeping the number of welds and WP issued each week.

In addition to showing information about efficient divisions, the results in Table 10 also indicate other divisions that were efficient for only one year. The DMUs approaching efficiency, with average values close to 1, are DMU U02 and U05 from the Production Piping and Quality Control Piping divisions, which were efficient DMUs in 2023. These nearly efficient DMUs served as benchmarks for others due to their good performance, achieving an efficiency value of 1 in 2023; however, they received efficiency values of 0.806 for DMU U02 and 0.646 for DMU U05 in 2022. Other DMUs that need attention are those with average efficiency values below 0.5, such as DMU U03 and U06. In this calculation stage, the inefficiency in project division performance is dominated by excessive workloads and a higher number of employees compared to the output achieved. It can be stated that the number of earned man-hours achieved by this division is low compared to the number of employees, welding activities, and WP issued.

3.6. Comparison of Efficiency During the COVID-19 Pandemic and Post-COVID-19

The calculation of construction company performance efficiency can be analyzed through the manhours earned method. The performance of the construction company on Project X shows a decline in three DMUs, namely U02, U05, and U06, which were affected by the pandemic. However, the overall decline in company performance is not very significant. During the pandemic period analyzed in 2022, the company's average performance was recorded at 0.734, which decreased to 0.656 in 2023. Looking at the average calculation results, the efficiency value of the construction company remains below 0.85, indicating a low level of efficiency. In fact, the efficiency value of Project X in 2022 was better than the average efficiency value in 2023. This is due to the significant variation in the overall efficiency values of the company, where some DMUs show high efficiency, while others have very low efficiency values.

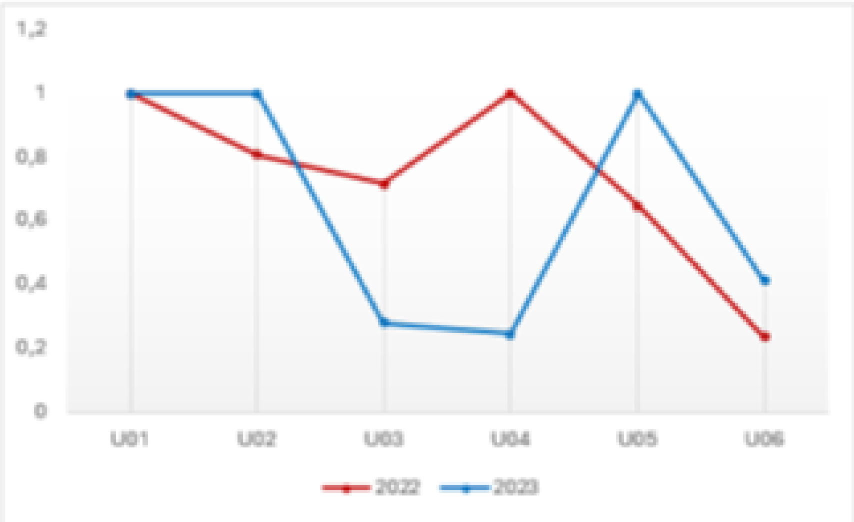

Figure 2. DEA Performance Trend

As shown in the DEA performance trend in Figure 2 there has been a decline in the productivity of tasks in the Electrical Production (U03) and Structural Quality (U04) departments. Several factors have contributed to this decline. Electrical Production (DMU U03), which falls under the E&I (Electrical and Instrument) department, followed a different work strategy. The workers in U03 were generally expected to work simultaneously. After the pandemic, the department tried to catch up on the progress by carrying out work orders (WO) uncontrollably. This was done without considering the capacity or ability of the field team, which had not yet stabilized its performance. This situation led to a significant increase in the backlog of work in 2023. In 2022, E&I requested around 4,000 workpacks in the field, while in 2023, this number increased to approximately 10,000 workpacks, signaling a 2.5-fold increase from the previous year. This, of course, disrupted the efficiency of the project as workers were pushed to do more with limited conditions. The department was unaware that this was an unideal condition, leading to a decrease in the project's performance.

Quality Control (DMU U04) involves work in the structural scope. Structural work is the foundation of the project, so the focus is always on ensuring the success of the structural work. This requires the work to proceed according to the milestones set, unaffected by the pandemic or other obstacles. When the pandemic hit, work in other departments slowed down, but not for structural work. All tasks continued as normally as possible, without disregarding the health ministry’s advisories. This situation caused structural work to have a better performance trend, which led to a gradual reduction of tasks in 2023. Quality Control (QC) not only supervises the work on-site but also handles documentation. Although fieldwork decreased, the number of workers remained the same, as they shifted focus to paperwork, often referred to as dossiers. These dossiers account for 5% of the milestone deliverables to the client, making it essential to maintain performance. This shift led to a reduction in workpacks, but the number of workers stayed constant. According to the DMU calculation, this will appear as a decrease in efficiency, even though it did not impact the overall project.

3.7. Analysis of Slack Values

Slack values represent the potential for improvement that can transform inefficient Decision Making Units (DMUs) into efficient ones. If a slack value of 0 is found in an inefficient DMU, it indicates that the DMU is on the frontier line but not within the efficient area. To improve the performance of inefficient DMUs, benchmarking against efficient DMUs is necessary. There are two terms in slack: **excess**, which refers to input slack, indicating the surplus input that could yield output, and **shortage**, which denotes output slack, representing the deficit in generated output.

Tables 9 and 10 display the slack values for each input and output variable over a two-year period. For example, in 2023, the efficient DMUs are U01, U02, and U05, which have slack values of 0 for the number of employees, number of weldings, WP issued, and manhours earned. There is also an inefficient DMU, U04, with slack values of 0 for both input and output, meaning it is on the frontier but has not yet entered the efficient area. Other DMUs, namely U03 and U06, need to reduce their input values and increase their output according to the slack values to reach the frontier. For instance, DMU U03 needs to reduce the number of employees by 57, decrease the number of weldings by 10,318, and reduce the number of WP issued by 7,275 to align with the frontier. It is important to note that merely reducing input and increasing output according to slack values may not make a DMU efficient. Therefore, benchmarking is essential to determine the optimal input and output levels needed to achieve efficiency.

This table shows the slack values for each Decision Making Unit (DMU) under pandemic conditions. DMU U01 has an efficiency score of 1, indicating it is already efficient with no slack across all input and output variables. This means there is no need for this DMU to reduce input or increase output for greater efficiency. DMU U02, with an efficiency score of 0.806, also shows no slack in input or output variables, suggesting that although it is not efficient, there is no necessity to adjust input or output to achieve efficiency. DMU U03 has an efficiency score of 0.717, with slack in Input 1 (number of employees) at 68 and Input 3 (WP issued) at 1,599. This indicates that to attain efficiency, DMU U03 needs to reduce the number of employees by 68 and WP issued by 1,599. DMU U04 has an efficiency score of 1, meaning it is efficient and has no slack across all variables. DMU U05, with a score of 0.646, also shows no slack in input or output variables, indicating that even though this unit is inefficient, it does not require any adjustments to reach efficiency. DMU U06, with a low efficiency score of 0.233, similarly has no slack, which implies that despite being very inefficient, it has no need for input reductions or output increases to become efficient.

Table 9. Slack Values for 2022 (Pandemic Condition)

DMU	Score	Input 1	Input 2	Input 3	Output 1
U01	1	0	0	0	0
U02	0.806	0	0	0	0
U03	0.717	68	0	1,599	0
U04	1	0	0	0	0
U05	0.646	0	0	0	0
U06	0.233	0	0	0	0

Table 9 displays the slack values for each DMU in the post-pandemic conditions. DMU U01 retains an efficiency score of 1, indicating it remains efficient with no slack across all input and output variables, thus requiring no adjustments. DMU U02 also shows an efficiency score of 1, confirming it is efficient with no slack. However, DMU U03 exhibits a lower efficiency score of 0.278, with slack values for Input 1 (number of employees) at 57, Input 2 (number of weldings) at 10,318, and Input 3 (WP issued) at 7,275. This indicates that DMU U03 must reduce the number of employees by 57, decrease the number of weldings by 10,318, and reduce WP issued by 7,275 to achieve higher efficiency. DMU U04, with an efficiency score of 0.244, shows no slack in any input or output variables, indicating that despite its low efficiency, no adjustments are required. DMU U05, which maintains an efficiency score of 1, demonstrates that it is efficient with no slack across variables. Lastly, DMU U06 has an efficiency score of 0.412, with slack in Input 2 (number of weldings) at 11,087 and Input 3 (WP issued) at 4,918, indicating that to improve efficiency, DMU U06 must reduce the number of weldings by 11,087 and WP issued by 4,918.

Table 10. Slack Values for 2023 (Post-Pandemic Condition)

DMU	Score	Input 1	Input 2	Input 3	Output 1
U01	1	0	0	0	0
U02	1	0	0	0	0
U03	0.278	57	10,318	7,275	0
U04	0.244	0	0	0	0
U05	1	0	0	0	0
U06	0.412	0	11,087	4,918	0

3.8. Regression Analysis

From the obtained data, it can be observed that DMUs have varying levels of resources and outputs. For example, DMU U01 has the highest number of employees and manhours earned, while DMU U06 has the highest number of weldings and WP issued but the lowest manhours earned. Regression analysis was conducted using Microsoft Excel with the aim of determining the coefficients β_1, β_2, and β_3, and assessing their statistical significance.

Table 11. Regression Analysis Data for 2022 (Pandemic Condition)

Coefficients	Standard Error	t Stat	P-value
Intercept	237786.1162	210480.005	1.12973257
Number of Employees	2605.796418	326.4817963	7.98144475
Number of Weldings	-47.37718548	84.94904978	-0.557713
WP Issued	-11.12807373	50.55324554	-0.2201258

From Table 11, the regression statistic value for R Square is 0.981637436, indicating that 98.16% of the variation in manhours earned can be explained by variations in the number of employees, the number of weldings, and WP issued. The p-value for the intercept is 0.375857, showing that this intercept is not statistically significant. The p-value for the number of employees is 0.01533752, indicating that the effect of the number of employees is statistically significant at the 5% significance level. The p-value for the number of weldings is 0.63313469, indicating that the effect of the number of weldings is not statistically significant. The p-value for WP issued is 0.84619952, suggesting that the effect of WP issued is not statistically significant. Therefore, from this regression analysis, it can be concluded that the number of employees is the only variable that has a significant effect on the manhours earned during the pandemic in 2022. The number of weldings and WP issued do not have a significant impact on the earned manhours. This suggests that to improve the earned manhours, the primary focus should be on managing the number of employees.

From Table 12, the regression statistic value for R Square is 0.61373293, indicating that 61% of the variation in manhours earned can be explained by variations in the number of employees, the number of weldings, and WP issued, with the remaining 39% explained by other variations. The p-value for the intercept is 0.534567325, indicating that this intercept is not statistically significant. The p-value for the number of employees is 0.279512505, suggesting that the effect of the number of employees is not statistically significant. The p-value for the number of welding is 0.919463921, indicating that the effect of the number of welding is not statistically significant. The p-value for WP issued is 0.950468076, suggesting that the effect of the issued permits is not statistically significant. Therefore, from this regression analysis, it can be concluded that there are no independent variables that have a significant effect on the manhours earned in the post-pandemic condition of 2023. This is evident from the p-values, all of which are greater than the significance level of 0.05 or 5%. Thus, this regression model cannot be used to draw meaningful conclusions about the relationship between the number of employees, the number of welding, and WP issued with the manhours earned in the post-pandemic condition.

Table 12. Regression Analysis Data for 2023 (Post-Pandemic Condition)

Coefficients	Standard Error	t Stat	P-value
Intercept	446240.8743	600041.96	0.743682782
Number of Employees	3762.88515	2560.978302	1.469315514
Number of Welding	-29.55478903	258.6481442	-0.114266387
WP Issued	21.77667208	310.4973574	0.070134807

3.9. Relationship Between Data Envelopment Analysis (DEA) and Regression Analysis

Data Envelopment Analysis (DEA) and regression analysis play complementary roles in measuring efficiency and identifying factors that influence the performance of Decision Making Units (DMUs).[17] DEA is used to determine the relative efficiency level of DMUs by comparing the inputs used and the outputs generated.[18] In the context of this research, DEA helps identify efficient and inefficient divisions in construction projects using variables such as the number of employees, the number of welding, and WP issued as inputs, and manhours earned as outputs. The results of the DEA indicate relative efficiency values and provide guidance on divisions that can serve as benchmarks for others.

Regression analysis is employed to understand the relationship between the dependent variable (output) and the independent variables (inputs). In this study, multiple linear regression is used to determine the effect of the number of employees, the number of welding, and WP issued on manhours earned. The results of the regression analysis provide information on the significance of each independent variable's impact on the dependent variable. In 2022, the number of employees was found to have a significant effect on manhours earned, while the number of welding and WP issued were not significant. However, in 2023, no independent variables were found to be significant, indicating a change in dynamics following the pandemic.

4. Conclussion

Based on the research results on construction companies during the period from 2022 to 2023 using the Data Envelopment Analysis (DEA) method, several conclusions can be drawn as follows: The average efficiency of Project X during the pandemic in 2022 is 0.734. This indicates that despite the significant challenges faced during the pandemic, such as the implementation of strict health protocols, mobility restrictions, and supply chain disruptions, Project X was still able to maintain a relatively high level of efficiency in project execution. Mitigation measures taken, such as adjusting work schedules and enforcing strict health protocols, helped reduce the negative impact of the pandemic.

In the post-pandemic period of 2023, the average efficiency of Project X decreased to 0.656. The decline in Project X's performance post-pandemic was attributed to demands for work beyond capacity at DMU U03 (Production Electrical) and a shift in work focus without a reduction in the number of employees at DMU U04 (Structural Quality). Strategies for improving efficiency in the future for Project X include optimizing the use of personnel and minimizing re-work. This can be achieved through selective worker selection and results-oriented task distribution, where each stakeholder involved sets job priorities based on urgency levels. Strict control over weekly Key Performance Index (KPI) and issuance of Work Packages (WP) according to priorities is also essential to ensure that focus and productivity remain high. Additionally, daily monitoring of manhours earned should be conducted to avoid claims for work hours that do not align with actual tasks, thereby maintaining optimal project efficiency and productivity.

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