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RESEARCH ARTICLE

# UNDERSTANDING THE IMPACTS OF LOCKDOWN AND WORK DISRUPTION: A DEMATEL BASED MODEL

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**ABSTRACT -** Almost every construction activity has been affected by the impact of COVID-19. Many construction workers were laid off during the Movement Control Order (MCO) due to lockdowns and the closure of all construction sites. In light of these circumstances, this study aims to investigate the impacts of lockdowns and work disruptions due to COVID-19, as well as explore potential strategies to overcome these impacts. Literature review efforts identified a range of potential impacts. Following a process of synthesis, six key impacts were identified for further analysis. The Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique was used to examine the causal relationships between the impacts based on the pairwise rankings of 15 construction professionals in the construction industry. The findings suggest that a shortage of skilled labor (A), insufficient supplies and material delays (E), and project deceleration (D) emerged as the most critical impacts. The study proposes several strategies to mitigate these critical impacts, aiming to assist key stakeholders in both the government and construction sectors in developing effective interventions to address the consequences of lockdown and work disruption during a severe pandemic.

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## INTRODUCTION

The construction industry plays a pivotal role in fostering economic growth and enhancing societal well-being (Khan et al., 2014). These factors are paramount to a nation's prosperity. Additionally, the construction sector significantly contributes to job creation within the national economy. Unfortunately, the Malaysian construction industry experienced substantial economic losses exceeding RM42 billion since the implementation of the Movement Control Order (MCO) on March 18, 2020 (BERNAMA, 2021). This highlights that the COVID-19 pandemic has not only impacted public health but also inflicted significant damage on the economy (Esa et al., 2020).

The COVID-19 pandemic has demonstrably impacted the construction industry in several key ways. A significant number of construction workers have tested positive for the virus (Alsharef et al., 2021). Movement control orders (MCOs), while essential for curbing viral transmission, have had a cascading effect on the industry. Contractors and employers face numerous challenges, including shortages of construction materials and increased resource costs, leading to project delays and even outright cancellations (Majumder & Biswas, 2021; Pamidimukkala & Kermanshachi, 2021). Management has struggled to adapt and navigate these COVID-19 challenges, resulting in project cancellations, delays, or modifications, with new initiatives placed on hold (Pamidimukkala & Kermanshachi, 2021). It would be beneficial to cite additional sources here that document the specific challenges faced by the Malaysian construction industry during the pandemic to strengthen the argument.

While MCOs and disruptions are the most evident negative consequences, these were unavoidable public health measures. These restrictions, however, triggered a chain reaction of downstream effects, operational adjustments, and the need for compliance with social distancing standards mandated by the Prevention and Control of Infectious Diseases Act of 1988 and the Police Act of 1967. Construction workers have had to adapt to stricter personal protective equipment (PPE) protocols, enhanced sanitation regulations, and, whenever possible, utilize technology for remote work tasks (Pamidimukkala et al., 2021). However, existing research has yet to fully explore the interconnectedness of these lockdown and disruption impacts. This study aims to address this critical gap by investigating the interrelationships between the impacts of lockdown and disruptions using the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method. Additionally, the study proposes strategies for intervening and mitigating these negative consequences.

## RESEARCH OBJECTIVES

This study aims to examine the interrelationships between the impacts of lockdowns and disruptions in construction projects due to COVID-19.

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## LITERATURE REVIEW

### Inadequate Skilled Workers (IS)

The COVID-19 pandemic has significantly hindered the timely completion of construction projects in Malaysia. This challenge coincides with a pre-existing issue in the industry - a scarcity of skilled labour to meet industry demands (insert citation here). This lack of skilled workers, both domestically and internationally, has been a longstanding problem. Furthermore, data suggests that construction workers were disproportionately impacted by the pandemic, with a higher number of positive cases compared to other sectors like transportation, healthcare, and manufacturing (Allan-Blitz, 2020). This, coupled with job losses among skilled construction personnel (Rodzi, 2020), has exacerbated the existing labour shortage.

The implementation of Movement Control Orders (MCOs) further limited the number of workers permitted on construction sites during lockdowns. This manpower shortage has cascading consequences. Project timelines may be significantly extended due to delays in completing structures. In extreme cases, projects might even be entirely scrapped. Additionally, the quality of construction could be compromised due to a lack of skilled labour. Finally, the competency of remaining employees, potentially lacking the necessary skills, could negatively impact project outcomes, leading to increased costs associated with correcting poor workmanship or potential third-party damages caused by worker negligence.

### Payment Issues (PI)

Movement control orders (MCOs) have had a significant negative impact on the Malaysian construction industry's financial health. Lockdowns not only halted construction activities but also severely disrupted cash flow (Zamani et al., 2021; Brown et al., 2020). Work disruptions demonstrably weaken workplace operations and adversely affect project timelines (Brown et al., 2020).

The inability to complete work due to lockdowns inevitably leads to delayed payments throughout the construction chain. Contractors may incur additional costs associated with liquidated damages for project delays (Alsharef et al., 2021). This financial strain can often lead to a domino effect, with main contractors struggling to pay subcontractors, suppliers, and even their employees on time (Pamidimukkala & Kermanshachi, 2021). Construction workers, already facing the health risks associated with the pandemic, may also face the additional stress of potential termination due to project delays or infection (Alsharef et al., 2021).

### Psychological Stress (PS)

The COVID-19 pandemic, characterized by unpredictability, inescapability, and significant challenges in management, has had a demonstrably negative impact on worker well-being (Hansen, 2020). The pandemic's effects have heightened anxiety and fear among construction workers (citation needed). Lockdowns and work disruptions have necessitated the implementation of social distancing protocols, which, while crucial for curbing viral transmission, can lead to increased social isolation (Brown et al., 2020). This isolation, particularly for migrant workers who may already face social disconnection, can exacerbate psychological distress and worsen mental health issues (ibid). Studies suggest a correlation between social isolation and increased anxiety and depression (insert citation here). Consequently, compared to those who are not separated from their support networks or continue working outside of quarantine restrictions, construction workers forced to work remotely or isolate may be at a higher risk of developing mental health problems.

### Project Delay (PD)

Lockdowns and associated work disruptions have had a significant ripple effect on the construction industry, leading to project suspensions and labour shortages, which ultimately contribute to project delays (Esa et al., 2020). Even after the conditional lifting of lockdowns, the continued need for social distancing measures at workplaces has demonstrably impacted project progress and worker productivity (Esa et al., 2020). Research suggests that labour shortages alone can lead to the postponement of multi-billion-dollar mega-projects (Rabe & O'Sullivan, 2022) and project duration increases ranging from 30% to 90% (Araya, 2021).

### Supply Chain Issues (SC)

Lockdowns and work disruptions have had a significant negative impact on the construction industry's supplier selection and overall supply chain management systems. The COVID-19 pandemic has demonstrably disrupted global supply chain networks (Fernandes, 2020), imposing limitations on transportation and movement of materials, particularly within restricted zones (Raj et al., 2022). As a consequence, construction projects often face difficulties in procuring construction materials promptly, leading to delays in construction activities (Choi, 2021). These delays can disrupt client decision-making and hinder the timely delivery of procured shipments from external sources needed to meet local demand (Alsharef et al., 2021). Furthermore, logistical challenges include extended quarantine periods for shipping vehicles entering ports, further slowing down operations and increasing lead times (Raj et al., 2022).

**Diminution in Productivity and Efficiency (DP)**

Labour productivity issues have long plagued the construction industry (Natawidjana and Nurasiyah, 2020), and they continue to suffer as a result of social distancing recommendations (Alsharef et al., 2021). Productivity and efficiency on the construction site are the cornerstone of project success (Almamlook et al., 2020). However, repercussions of lockdowns such as self-quarantine and social distancing, strictly reduce productivity and efficiency at work. Lockdowns and work disruptions also cause myriads of adverse health impacts (Kitagawa et al., 2021), and distract the senior management from their productivity in dealing with the pandemic (Bloom et al., 2020). Lack of labour supervision during lockdowns is seen as the main underpinning factor influencing labour productivity and efficiency (Quezon et al., 2021).

## Research Methodology

To explore the interconnectedness of impacts arising from lockdowns and work disruptions, this study employs the Decision-Making Trial Evaluation Laboratory (DEMATEL) method. DEMATEL utilizes directed graphs (digraphs) to depict cause-and-effect relationships within a system, offering valuable insights into the complex network of influences among various factors (Lee et al., 2022; Zhu et al., 2020). While DEMATEL excels at visualizing these relationships, it's important to acknowledge the potential for subjectivity in expert judgments and its limitations in statistical rigour. However, for this study, DEMATEL serves as a valuable first step to identify key relationships, which can then be further investigated using more statistically robust methods if necessary. The DEMATEL method is carried out through six (6) steps as follows (Lee et al., 2023):

### Step 1: Derive Average Matrix Z based on Respondents' Opinion

In this study, the respondents are construction professionals with expertise in this research subject. Each respondent was asked to provide feedback on the degree of direct impact between two factors using integer ratings based on a pair-wise comparison. The integer score ranging from 0 to 4 represents 4 = Very High Impact, 3 = High Impact, 2 = Moderate Impact, 1 = Low Impact, and 0 = No impact.

The degree to which respondents believe factor I influences factor j is denoted by x_ij. A non-negative n x n matrix is created as X^k = [x_ij^k ], where k is the number of respondents that participated in the assessment procedure using 1 ≤ k ≤ m. X^1, X^2, X^3,…..X^m are matrices derived from m respondents. The average matrix Z = [Zij] will be constructed after counting all of the opinions from m respondents using the formula (1) shown below:

$$Z_{ij} = \frac{1}{m}\sum_{k=1}^{m} x_{ij}^{k}$$

Average matrix Z is also known as initial direct-influenced matrix Z. The first direct-influenced matrix Z aims to highlight the initial direct impacts that each criterion has as well as benefits from other criteria.

### Step 2: Calculate Normalized initial direct-relation matrix D

Normalized initial direct-relation matrix D will be calculated using the formula below (Wang et al., 2012):

$$D = \lambda * Z, \tag{2}$$

or

$$\left[d_{ij}\right]_{n \times n} = \lambda \left[z_{ij}\right]_{n \times n} \tag{3}$$

where,

$$\lambda = Min\left[\frac{1}{\max_{1\le i\le n} \Sigma_{j=1}^{n}[z_{ij}]}\ ,\ \ \frac{1}{\max_{1\le j\le n} \Sigma_{i=1}^{n}[z_{ij}]}\right] \tag{4}$$

Based on the principles of Markov chain theory, the matrix D is raised to various powers denoted as D^m. These powers, such as D2, D3, …, D^∞ ensure the attainment of a convergent solution for matrix inversion, as follows:

$$\lim_{m\to\infty} D^{m} = [0]_{n \times n} \tag{5}$$

### Step 3: Formulate total relation matrix T

Total relation matrix T in the DEMATEL approach, was derived from normalised matrix D, where I is an identity matrix.

$$T = D\,(I - D)^{-1} \tag{6}$$

### Step 4: Calculate the sum of the columns & rows of matrix T

The row and column sums in the total-influence matrix T are determined using the equations represented by vectors r and c, respectively. Symbol r denoted the sum of the rows, and symbol c represented the sum of the columns.

$$r = [r_i]_{n \times 1} = \left(\sum_{j=1}^{n} t_{ij}\right)_{n\times 1} \tag{7}$$

$$c = [c_j]'_{1\times n} = \left(\sum_{j=1}^{n} t_{ij}\right)'_{1\times n} \quad (8)$$

Let $r_i$ be the sum of the $i^{th}$ row in matrix T. The $r_i$ value represented the entire value of impacts provided in both direct and indirect methods by which component $i$ influenced other factors. Then, $cj$ equals the sum of the $j^{th}$ column in matrix T. The $cj$ value represented the entire value of impacts obtained in both direct and indirect ways from all other variables influencing factor $j$.

While $j = i$, the value of $(r_i + c_j)$ reflected the total impacts both delivered and received by factor $i$ indicating how important factor $i$ is in the overall system. The value of $(r_i - c_j)$ represents the net contribution of cause $i$ to the system. If $(r_i - c_j)$ is negative, factors $i$ will be a net receiver whereas if $(r_i - c_j)$ is positive, factor $i$ will be a net cause.

**Step 5: Define a threshold value (α)**

To create the directed graph, it is compulsory to set a threshold value to assist the decision-maker in identifying significant and insignificant impacts in matrix T. As the directed graph shows the overall of the criteria in the matrix T, it will only illustrate impacts that exceed the threshold value. The following formula can be used to calculate the threshold value:

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}[t_{ij}]}{N}$$

where N denotes the total number of criteria in matrix T.

**Step 6: Construct a relationship diagram**

The relationship diagram will be obtained by mapping the data set $(r_i + c_j, r_i - c_j)$, where $(r_i + c_j)$ represents the horizontal axis (x-axis) and $(r_i - c_j)$ represents the vertical axis (y-axis) (Lee et al., 2023). The complex causal relationships can be made through this visible structural model (Wang et al., 2012).

## RESULTS AND DISCUSSION

Six major impacts of lockdown and work disruption were identified. The DEMATEL method was employed to examine the interrelationship between these impacts.

**Demographic of Respondents**

Table 1 below depicts the demographic profile of the construction professionals. A purposive sampling technique was employed to approach 15 construction professionals. The respondents have an experience in construction with at least 3 to 15 years. Sixty-seven (67%) percent of the professionals were female, and the rest were male. 7% of them were below 25 years old, sixty percent (60%) were in the range of 25-30 years old, twenty percent (20%) were in the range of 31-39 years old, while another 13% were in the range of 40-45 years old. Most of the respondents were consultants (47%), followed by developers (33%), and contractor (20%). The Construction Industry Development Board (CIDB) grade reported for contractors includes G3 (13%), G4 (7%), G6 (7%), and G7 (33%). Majority of the respondents are Quantity Surveyors (33%), civil engineers (27%), site supervisors (20%), project managers (13%), and mechanical engineers (7%).

Table 1. Demographic of respondents

| Characteristics | Frequency | Percentage (%) |
|---|---|---|
| Gender | | |
| Female | 10 | 67 |
| Male | 5 | 33 |
| Age | | |
| Below 25 | 1 | 7 |
| 25-30 | 9 | 60 |
| 31-39 | 3 | 20 |
| 40-45 | 2 | 13 |
| Education Level | | |
| Diploma | 1 | 7 |
| Bachelor's Degree | 12 | 80 |
| Master's Degree | 2 | 13 |

Table 1. (cont.)

| Characteristics | Frequency | Percentage (%) |
|---|---|---|
| Working Experience (years) | | |
| 3-5 years | 4 | 27 |
| 6-10 years | 9 | 60 |
| 11-15 years | 2 | 13 |
| The firm's service | | |
| Developer | 5 | 33 |
| Consultant | 7 | 47 |
| Contractor | 3 | 20 |
| CIDB grade | | |
| G3 | 2 | 13 |
| G4 | 1 | 7 |
| G6 | 1 | 7 |
| G7 | 5 | 33 |
| Role | | |
| Project Manager | 2 | 13 |
| Site Supervisor | 3 | 20 |
| Civil Engineer | 4 | 27 |
| Mechanical Engineer | 1 | 7 |
| Quantity Surveyor | 5 | 33 |
| Total | 15 | 100% |

**Application of DEMATEL Method to the Six (6) Impacts of Lockdown and Work Disruption**

**Step 1: Derive Average Matrix Z based on Respondents' Opinion**

The feedback participated by 15 respondents was further translated into a computed Average Matrix Z where each cell represents the average score given by respondents for relationships between two impacts. Those values in Table 2 indicate the strength between the two impacts, higher values represent stronger relationships.

Table 2. Average Matrix Z

| | A | B | C | D | E | F | SUM |
|---|---|---|---|---|---|---|---|
| A | 0 | 1.666667 | 2.8 | 3.266667 | 2.133333 | 3.333333 | 13.2 |
| B | 1.533333 | 0 | 1.6 | 2.6 | 2.866667 | 3.533333 | 12.13333 |
| C | 1.466667 | 1.733333 | 0 | 3.266667 | 1.733333 | 3.066667 | 11.26667 |
| D | 3.333333 | 3.533333 | 2.866667 | 0.266667 | 3.466667 | 3.4 | 16.86667 |
| E | 2.466667 | 3.333333 | 2 | 3.6 | 0 | 3.466667 | 14.86667 |
| F | 3 | 3.266667 | 2.933333 | 3.4 | 3.266667 | 0 | 15.86667 |
| SUM | 11.8 | 13.53333 | 12.2 | 16.4 | 13.46667 | 16.8 | |

**Step 2: Calculate Normalized initial direct-relation matrix D**

This computation breaks down the interrelationships between the important elements by representing the normalized strength of the direct relationships between each pair of impacts in Table 3. A value closer to 1 indicates a stronger direct relationship between the two impacts, while a value closer to 0 indicates a weaker direct relationship. In short, table 3 provides insights into the relative strengths of the direct relationships between each pair of impacts.

Table 3. Normalized initial direct-relation matrix D

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| A | 0 | 0.098814 | 0.166008 | 0.193676 | 0.126482 | 0.197628 |
| B | 0.090909 | 0 | 0.094862 | 0.15415 | 0.16996 | 0.209486 |
| C | 0.086957 | 0.102767 | 0 | 0.193676 | 0.102767 | 0.181818 |
| D | 0.197628 | 0.209486 | 0.16996 | 0.01581 | 0.205534 | 0.201581 |
| E | 0.146245 | 0.197628 | 0.118577 | 0.213439 | 0 | 0.205534 |
| F | 0.177866 | 0.193676 | 0.173913 | 0.201581 | 0.193676 | 0 |

**Step 3: Formulate total relation matrix T**

Formulated data in Table 4 showcase the total strength of the relationships between each pair of impacts, including both direct and indirect relationships. These values provide insights into the overall influence of each impact on other impacts within the system, accounting for both direct interactions and secondary effects through intermediate impacts. Overall, it allows a comprehensive understanding of the complex relationships between impacts in the system.

Table 4. Total relation matrix T

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| A | 1.635286 | 0.805847 | 0.787468 | 0.986619 | 0.821753 | 1.00295 |
| B | 0.680686 | 1.674334 | 0.68905 | 0.904848 | 0.813409 | 0.960138 |
| C | 0.640193 | 0.723894 | 1.565311 | 0.885424 | 0.719038 | 0.88904 |
| D | 0.938621 | 1.046986 | 0.928591 | 2.017029 | 1.037825 | 1.193565 |
| E | 0.831682 | 0.961698 | 0.818365 | 1.089282 | 1.790083 | 1.102121 |
| F | 0.884316 | 0.990815 | 0.891428 | 1.122282 | 0.984651 | 1.973016 |

**Step 4: Calculate the sum of the columns & rows of matrix T**

This calculation is made to determine the overall influence of each impact within the system. It considers direct, indirect, ingoing and outgoing relationships. Finally, the net influence of each impact within the system was evaluated on whether it carries positive or negative values.

Table 5. The sum of the columns & rows of matrix T

| | Sum R | Sum C | R + C | R - C |
|---|---|---|---|---|
| A | 5.039923 | 4.610784 | 9.650707 | 0.429138 |
| B | 4.722465 | 5.203575 | 9.92604 | -0.48111 |
| C | 4.422901 | 4.680213 | 9.103114 | -0.25731 |
| D | 6.162616 | 6.005484 | 12.1681 | 0.157132 |
| E | 5.59323 | 5.166759 | 10.75999 | 0.426471 |
| F | 5.846508 | 6.120829 | 11.96734 | -0.27432 |

**Step 5: Define a threshold value (α)**

Significant and insignificant relationships between impacts are distinguished through threshold value that identifies only meaningful and impactful relationships. For this specific analysis, the threshold value is determined to be 0.8830. Any value greater than the threshold value is considered significant. Conversely, any values below the threshold value are considered insignificant instead. The threshold value plays a crucial role in filtering out less important relationships and pinpointing the most significant influences on construction project delays. By establishing a threshold value, the analysis can focus on identifying and prioritizing the most influential relationships between impacts. It would enable facilitated targeted interventions and formulate strategies in addressing key challenges.

**Step 6: Construct a relationship diagram**

The visual presentation demonstrates the complex relationships between impacts and how it highlights the strength and direction of relationships.

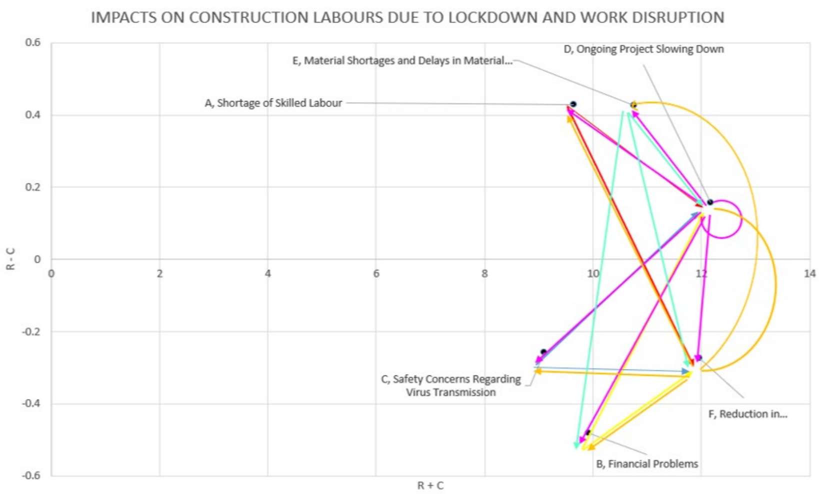


Figure 1. Relationship diagram between impacts of lockdown and work disruption

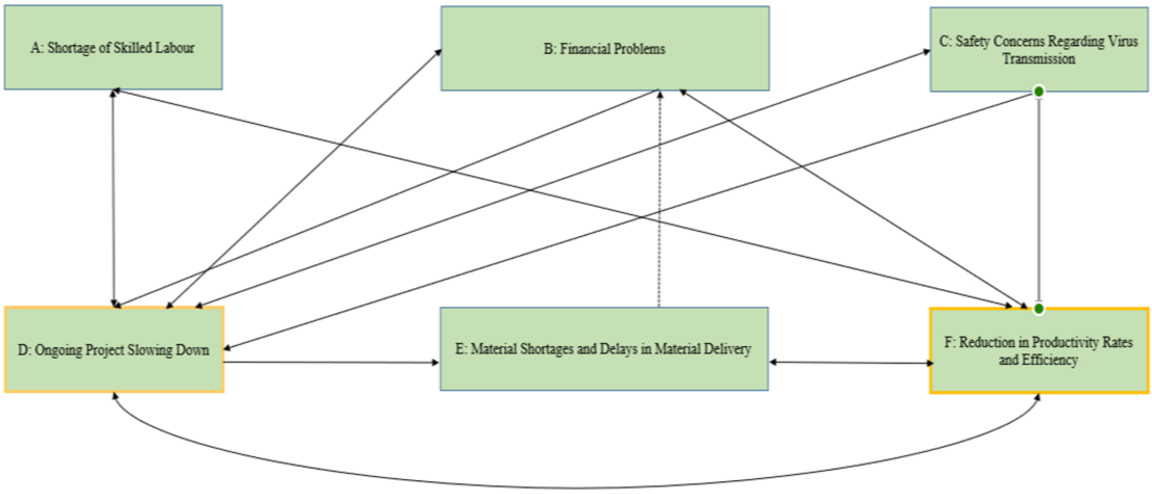


Figure 2. Impact relation diagram between impacts of lockdown and work disruption

**Prominence Vector (R + C)**

This column shows the calculated value of R + C for each impact in Table 6. The R + C value represents the sum of the influence of an impact on other impacts (Sum R) and the influence received by that impact from other impacts (Sum C). It reflects the overall prominence or importance of each impact within the system. Additionally, it is ranked from highest to lowest based on the R + C values.

Interpretation drawn from Table 6 on the highest significance is the R+C value of 12.16810015 (D = Project Delay). Then, it is followed in second by 11.96733702 (F = Diminution in Productivity and Efficiency) and the rest are progressively decreasing. This suggests that project delays and decreased productivity are major concerns arising from lockdowns and work disruptions.

Table 6. Calculated value of R + C (Impacts)

| Rank | Factor | R + C |
|---|---|---|
| 1 | D | 12.16810015 |
| 2 | F | 11.96733702 |
| 3 | E | 10.75998912 |
| 4 | B | 9.92603977 |
| 5 | A | 9.650707162 |
| 6 | C | 9.103113579 |

**Relative Vector of Causal Group (R - C)**

This particular ranking of data in Table 7 reflects the net influence or relative importance of each impact within the system. The highest relative influence is an R - C value of 0.426470531 (A = Inadequate Skilled Workers) which represents the most significant net influence within the system. Afterwards, followed by 0.426470531 (E = Supply Chain Issues) and 0.157132134 (D = Project Delay) which show the relative influence of different impacts within the system. Also, the dynamics of causal relationships suggest that addressing issues related to a skilled labour shortage and supply chain disruptions may have significant positive impacts on mitigating other disruptions caused by lockdowns.

Table 7. Calculated value of R - C causal groups

| Rank | Factor | R - C |
|---|---|---|
| 1 | A | 0.429138236 |
| 2 | E | 0.426470531 |
| 3 | D | 0.157132134 |

**Relative vector of effect group (R - C)**

Table 8 shows the net influence or relative importance of each impact calculated on the R – C values. The highest relative influence exhibits negative values within the effect group of impacts is an R - C value of -0.481109273 (B = Payment Issues) followed in second by F = Diminution in Productivity and Efficiency with the value of approximately -0.274320047, indicating that they are more affected by other impacts compared to their influence on others. This underscores the importance of addressing these factors to prevent cascading effects on other aspects of construction projects.

Table 8. Calculated value of R + C effects group

| Rank | Factor | R - C |
|---|---|---|
| 1 | B | -0.481109273 |
| 3 | F | -0.274320047 |
| 2 | C | -0.257311581 |

**Inner Dependency Matrix**

Table 9 shows interdependencies between different impacts which reveals causal relationships between impacts. The absence of values in corresponding cells is an indication of no significant direct dependencies. All and all, table 9 demonstrates how changes in one impact may affect others. D = Project Delay shows dependencies with the rest of the impacts which implies that project delays are influenced by factors such as inadequate skilled workers, payment issues, psychological stress, and diminished productivity and efficiency. Understanding these causal relationships is crucial for devising effective strategies to mitigate the negative impacts of lockdowns.

Table 9. Calculated value inner dependency matrix

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| A | - | - | - | 0.986619 | - | 1.00295 |
| B | - | - | - | 0.904848 | - | 0.960138 |
| C | - | - | - | 0.885424 | - | 0.88904 |
| D | 0.938621 | 1.046986 | 0.928591 | 1.017029 | 1.037825 | 1.193565 |
| E | - | 0.961698 | - | 1.089282 | - | 1.102121 |
| F | 0.884316 | 0.990815 | 0.891428 | 1.122282 | 0.984651 | 0.973016 |

In conclusion, DEMATEL analysis provides valuable insights into the complex interrelationships between different impacts of lockdown and work disruptions in construction projects. It helps in identifying critical areas for intervention, understanding causal relationships, and prioritizing strategies to mitigate the negative effects effectively. By addressing the identified critical impacts and understanding their interdependencies, stakeholders can develop more targeted and comprehensive approaches to manage the challenges posed by lockdowns and work disruptions.

## COMPLEX INTERRELATIONSHIPS

**Inadequate Skilled Workers (IS)**

The correlation between Inadequate Skilled Workers (IS) and Payment Issues (PI) is positive, indicating that a lack of qualified workers might render it more difficult to meet payment obligations potentially as a consequence of delays in project completion or problems with quality. Furthermore, the positive correlation shown between IS and Psychological Stress (PS) suggests that an absence of qualified personnel may cause existing workers under more pressure and increase their overall workload, which might end up resulting in burnout or lower productivity.

Then, the positive relationship between IS and Project Delay (PD) indicates that the inability to accomplish tasks effectively or on time may lead to delays in project deadlines due to a lack of competent workers and another positive relationship with Supply Chain Issues (SC) could very well suggest shortages in skilled labour disrupts supply chain, as key construction activities may be delayed or halted due to a lack of skilled workers.

**Payment Issues (PI)**

Payment Issues (PI) and IS share a positive link, indicating that when there is an inadequate supply of skilled labour, payment issues may occur as a result of performance concerns or contractual conflicts. Similarly, as financial instability may have an impact on workers' lives and job security, there is a positive correlation between PI and Psychological Stress (PS), suggesting that payment-related concerns may raise stress levels among construction workers.

Moreover, since there is a positive correlation between project delay (PD) and payment integrity (PI), contractors might prioritize projects with better conditions for payment or attempt to secure additional compensation for late payments, which may lead to delays in project completion. Another positive relationship involving Supply Chain Issues (SC) suggests that supply chain disruption could cause payments delayed to suppliers or subcontractors, leading to material shortages or work stoppages.

**Psychological Stress (PS)**

Given the possibility of higher workloads or pressure to make up for labour shortages, construction workers may experience psychological stress, as evidenced by the positive link found between IS and Psychological Stress (PS). In a similar vein, the positive correlation shown between PS and PI raises the possibility that payment delays and other financial uncertainty may exacerbate psychological stress among construction workers, affecting their emotional health and sense of fulfilment in their jobs. Besides, the positive correlation shown between PS and Project Delay (PD) suggests that construction workers may experience psychological stress as a result of project delays, as they may get dissatisfied or lose motivation due to schedule setbacks. This may also occur as supply chain interruptions ensue which causes difficulties or uncertainty in obtaining the goods or resources.

**Project Delay (PD)**

Project Delay (PD) and IS have a positive association, which emphasizes how recruiting poorly trained individuals can cause delays in project completion because of activities taking longer to complete due to deficiencies in skills. Comparably, the positive correlation between PD and PI raises the possibility that payment disputes or delays may exacerbate project delays by causing work stoppages or other disturbances to project progress. In addition, the strong correlation between PD and PS suggests that construction workers' psychological health may be impacted by project delays, since they may experience stress or demoralization due to schedule setbacks. Also, Project delays can arise from supply chain disruptions, as evidenced by the positive correlation found between project delays and supply chain issues (SC).

**Supply Chain Issues (SC)**

The strong correlation shown between Supply Chain Issues (SC) and IS implies that supply chain disruptions may make the skilled labour shortage worse by affecting construction timelines and personnel availability due to delays or shortages in supplies or resources. In similar circumstances, another positive correlation shown between SC and PI suggests that problems with the supply chain might lead to payment disputes or delays by impeding contractors' capacity to pay for their work due to resource or material shortages. Other than that, the positive correlation between SC and PD emphasizes how supply chain disruptions can cause project delays since they might affect construction operations and progress due to delays or shortages in supplies or resources.

## FINDINGS

This study provides a comprehensive analysis of the impacts of lockdowns and work disruptions on construction projects, particularly in the context of the COVID-19 pandemic. Through a combination of literature review and DEMATEL analysis, several key findings have emerged. Firstly, the study identifies critical impacts such as project delays and diminution in productivity and efficiency, highlighting the significant challenges faced by construction projects during periods of lockdown and disruption. These impacts not only affect project timelines but also have cascading effects on project outcomes, stakeholder relationships, and overall industry resilience.

Secondly, the analysis reveals the complex interrelationships among different impacts, emphasizing the interconnected nature of the construction project ecosystem. Factors such as inadequate skilled workers, supply chain disruptions, and psychological stress are shown to be closely intertwined, influencing and being influenced by each other. Understanding these interdependencies is crucial for devising effective strategies to address the root causes of disruptions and enhance project resilience.

Thirdly, the study identifies strategic intervention points where targeted actions can yield maximum impact. By addressing issues related to skilled labour shortage, supply chain disruptions, and payment delays, stakeholders can mitigate the adverse effects of lockdowns and work disruptions, improve project performance, and enhance industry competitiveness.

## DEEPER INTERPRETATIONS OF FINDINGS

The findings highlight project delays (PD) and decreased productivity which are potentially linked to psychological stress (PS) as prominent concerns due to the cascading effects of inadequate skilled workers (IS). The lack of skilled labour (IS) triggers a cascade of negative consequences, ultimately impacting project timelines. Firstly, a shortage of skilled workers can lead to project delays (PD) due to tasks being completed at a slower pace or with compromised quality. Secondly, the pressure to compensate for the skilled labour gap can increase workloads and psychological stress (PS) among existing workers. This stress can then manifest as decreased productivity, further contributing to project delays.

## PRACTICAL IMPLICATIONS

In response to the challenges identified in this study, construction companies and policymakers can adopt several strategies to mitigate the negative impacts of skilled labour shortages. Construction companies can prioritize workforce development initiatives by investing in upskilling programs for existing employees or establishing partnerships with vocational training institutions to create a pipeline of skilled labour. Proactive workforce planning through anticipating future skill needs and preemptive recruitment or training can further address potential shortages.

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future skill needs and preemptive recruitment or training can further address potential shortages. Policymakers can play a crucial role by investing in vocational training programs and apprenticeship opportunities to address existing skill gaps and prepare the workforce for future industry demands. Immigration policies that attract skilled foreign workers while ensuring opportunities for local workforce development can also be considered. Furthermore, policymakers can contribute by investing in infrastructure projects that create training and upskilling opportunities within the construction sector.

Finally, reviewing and streamlining permitting processes can minimize administrative delays and allow construction projects to progress more efficiently. By implementing a combination of these strategies, stakeholders can work collaboratively to address skilled labour shortages, improve project delivery timelines, and ensure a healthy and productive construction workforce.

## CONCLUSION

In conclusion, the study has provided valuable insights into the multifaceted impacts of COVID-19 and lockdowns on the construction industry. Through the use of the DEMATEL method, we have identified the complex interrelationships between various factors such as inadequate skilled workers, payment issues, psychological stress, project delays, and supply chain disruptions. These findings underscore the need for a holistic and integrated approach to address the challenges faced by the construction sector during times of crisis.

However, it is important to acknowledge the limitations of the study, including the small sample size, methodological constraints, and potential biases in the data collected. Despite these limitations, the study offers a starting point for further research and exploration into the long-term implications of the pandemic on the construction industry. Moving forward, policymakers, industry stakeholders, and researchers must collaborate to develop effective strategies to mitigate the negative impacts of COVID-19 and ensure the resilience and sustainability of the construction sector. This may involve implementing supportive policies, enhancing workforce training programs, fostering innovation, and promoting international collaboration. By addressing these challenges and building upon the insights gained from this study, we can strive towards a more resilient and adaptive construction industry in the face of future crises.

## LIMITATIONS OF STUDY

The study on the impacts of COVID-19 and lockdowns on the construction industry has shed light on several important insights, but it is not without its limitations. Firstly, the sample size of 15 construction professionals may not fully represent the diverse perspectives within the industry, and the study's focus on Malaysia may limit its applicability to other regions. Additionally, while the DEMATEL method offers a structured approach, it relies on subjective judgments that could introduce bias. Furthermore, the study primarily focused on immediate impacts, potentially overlooking longer-term trends. Incorporating perspectives from a broader range of stakeholders, such as construction workers and government agencies, could provide a more comprehensive understanding. The absence of comparative analysis with pre-pandemic data or alternative scenarios also limits the study's depth.

Response bias is another concern, as participants may provide socially desirable answers. Finally, while the study proposes intervention strategies, there is limited discussion on their feasibility and effectiveness. Despite these limitations, the study serves as a valuable starting point for understanding the challenges faced by the construction industry during the pandemic. Addressing these limitations and conducting further research could lead to a more nuanced understanding of the impacts and help develop effective mitigation strategies.

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## CONFLICT OF INTEREST

The author(s), as noted, certify that they have NO competing financial interests or personal relationships that could have influenced the work reported in this paper.

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