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# Impacts of COVID-19 on the Middle East construction industry

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## ABSTRACT

The impacts of COVID-19 pandemic on construction project management are not documented and not well understood, which leaves project stakeholders with no guiding information to respond to such threats and no lessons learned to speed up the recovery of the industry in the wake of the pandemic. Although researchers have studied the impacts of pandemics in other industries in various settings, there is little-to-no research specific to the construction industry and especially in the Middle East region. To address this knowledge gap, 202 construction professionals in the Middle East region were surveyed using a questionnaire survey to provide their perceptions of COVID-19 pandemic impact on project finance, construction materials and equipment, labor, contracts, and rental properties. Statistical analysis of the collected data reveals that labor and contracts are the principal classes impacted due to the complex procedures of hiring labor from East Asia, the tightening of health and safety precautionary measures on construction sites, and the expected contract revisions to Force Majeure, Change, and Claim clauses to address pandemic issues. The respondents indicated that many tasks can be safely accomplished by remote work. They also indicated that pandemic-related slowdown can be detrimental to the construction industry; governments need to inject stimulus funding to help keep construction activity momentum; and prolonged COVID-19 pandemic impact would be harsher than oil price collapse. As such, this study contributes to the body of knowledge in construction management by studying the impacts of COVID-19 pandemic and providing construction industry stakeholders with lessons learned and recommendations to response strategies that can alleviate pandemic risks.

**Keywords:** Construction; Infectious diseases; Pandemic, Occupational health; COVID-19.

## INTRODUCTION

Health and safety in the workplace are vital to the timely and efficient execution of projects in the construction industry. The lack of data that documents the impacts of pandemics on the construction industry has considerable repercussions that can be detrimental to project planning and management, as well as workplace productivity (Van Wormer et al. 2017). The current understanding of COVID-19 impacts on the construction industry is very limited and not well documented, and it mainly relies on the informally shared particular experiences of project partners. However, the information available from such limited experiences cannot be as accurate as the collective perception and sentiment that the construction industry community shares about COVID-19. The absence of substantial COVID-

19 data also results in poor understanding of the pandemic impacts, which leaves project stakeholders with no corroborated guidance on how to respond to the threats and no lessons learned to speed up the recovery in the wake of the pandemic. Thus, the currently available data is not sufficient to meet the needs of the construction industry stakeholders and cannot provide substantial understanding for sound project management and decision-making. Although researchers have studied the impacts of pandemics in other industries in various settings (Hendrickson and Rilett 2020; Baqaee and Farhi 2020; Debg et al. 2020; Oerther and Watson 2020; Parr et al. 2020; Paul and Chowdhury 2020; Miyani et al. 2020), there is little-to-no research specific to the construction industry and especially in the Middle East.

Several distinctive characteristics are specific to construction projects and particularly in the Middle East region. First, the economy of Middle East countries is principally oil-dependent (Jarkas et al. 2014), and oil prices collapsed amid the COVID-19 pandemic mainly due to the global disruption of the airline industry that suffered around $880 billion in losses (Yassien et al. 2020). Thus, more powerful and multifaceted response measures are needed in these countries, and it remains a big challenge to address these two problems simultaneously. Second, in other industries, the products and services are typically standardized and produced in highly automated environments, with long-term shared-benefit relationships among business partners (Ballard and Howell 1989; Everett and Slocum 1994; Sherafat et al. 2020). In the construction industry, projects are typically unique, labor intensive, and constructed in a highly fragmented environment with adversarial relationships between the project partners (Tatum 1986; Howard et al. 1989). Thus, COVID-19 impacts on the construction industry are likely to be dissimilar, harsher, and more disputed. Additionally, the labor-intensive nature of the construction industry makes it more vulnerable to the return waves of COVID-19 infections. Because of these problems, there is a crucial need for understanding the impacts of COVID-19 in the Middle East, amid the oil drop crisis, based on collected data from the industry stakeholders.

The objective of this study is to collect and analyze data from construction industry stakeholders in the Middle East countries that can be used to document, investigate, and understand the perceived impacts of COVID-19, on project finance, construction materials and equipment, labor, and contracts. In addition, stakeholders' perceptions of the best response strategies to mitigate the impacts on current and future projects are documented and analyzed. The interpretation of the results and the limitations of the research are then discussed to help future research.

## LITERATURE REVIEW

Although the literature on pandemics in the construction industry, and specifically COVID-19, is limited, it can be grouped into three main groups: (1) COVID-19 pandemic traits, (2) the characteristics of the Middle East construction industry, and (3) the probable impacts of pandemics on construction. In late December 2019, Chinese health authorities reported an outbreak of pneumonia of unknown origin in Wuhan, Hubei Province (Ciotti et al. 2019). The investigations led to the isolation of a novel coronavirus, SARS-CoV-2, previously named 2019-nCov, and commonly known as COVID-19 (Zhu et al. 2020). Since the beginning of the pandemic in late December 2019, COVID-19 has now spread to all continents, and as of June 22, 2021, the World Health Organization reported around 180 million confirmed cases and more than 3 million deaths globally. The effects of this pandemic are catastrophic and impacted all economic sectors around the world (Jallow et al. 2020). For months, many businesses were shut down due to the pandemic, including construction businesses and projects, and many health precautions were applied to reduce the pandemic effects on daily life. Like other economic sectors around the globe, the construction industry in the Middle East suffered from COVID-19 due to its spread globally and especially its spread in the Middle East countries such as UAE, Kuwait, Qatar, Saudi Arabia, and Oman (Al Amri and Marey 2020).

The construction industry in the Middle East has special characteristics such as its dependence on foreign workers and imported construction materials. Countries of the region also depend mainly on oil exports to finance governmental projects, and accordingly, the construction industry in the region is very sensitive to oil price changes

(Tvedt 2002; OE 2015; Nusair 2016; El-Katiri 2016). Since, the construction sector significantly contributes to the local economies, any drop in oil prices for such oil-depending countries becomes very problematic (Soliman et al. 2020). For example, the construction industry sector forms around 6% of the non-oil sector GDP in Kuwait with billions of dollars annually spent on the construction of public buildings and civil infrastructure systems, including housing projects, highways, power plants, educational facilities, and healthcare facilities (KSB 2020; Khalafallah and Shalaby 2019). Likewise, the construction sector accounts for around 8% of the GDP of Dubai, UAE (Johnson and Babu 2020), and 10% of the GDP of Qatar (Al-Nuaimi 2019). Additionally, the construction industry in many of the Middle East countries is influenced by national development plans due to the size of public sector projects compared to the private sector. For example, Kuwait's national development plan (Vision 2035) plays a key role in stimulating interest in the country's construction industry, as a recent report showed that 66% of projects under construction were oil, gas, and infrastructure projects, while just 34% were urban building projects (PT 2019). However, financial support for such plans is dependent on oil revenues, which fluctuate and are currently under pressure due to the collapse of oil prices with the economic slowdown created by the COVID-19 pandemic.

COVID-19 pandemic has probable impacts on the construction industry that stem from the closure of borders, the global economic slowdown, and the application of quarantines and other precautionary measures. Many construction projects in the region were delayed by lockdowns, and subsequently some were suspended, and the others rescheduled. For example, it was reported that 45% of companies in Kuwait have suspended their operations or shut down their business due to COVID-19 (PRN 2020). It was also reported that 39% of architecture, engineering, and construction companies suspended their operations, and 31% had a drop in revenue by more than 80% while still operating. It was also found that only 46% can cover fixed costs for about two months (PRN 2020). COVID-19 problems did affect not only the construction industry, but also the entire economies of these countries, mainly due to the significant contribution of the construction sector to the local economies.

COVID-19 pandemic can affect the construction industry on many levels including the availability of construction materials and equipment, construction labor issues, contracting, and the effects on rental property. The pandemic can impact the procurement of construction materials and their availability in many of the Middle East countries, as most of the construction materials are imported from abroad (Anwar and Tuqan 2006). Due to shutdown of construction materials plants abroad and transportation delays, materials supply chains will be certainly impacted for the coming years. These delays can significantly increase the costs of transportation and customs and influence the lead time required to procure construction materials (Koushki and Kartam, 2004).

The pandemic can also have significant effects on the construction labor workforce and its supply chain (Bonadio et al. 2020; Echeverría-Estrada 2020). Most of the labor workforce working in the region is from abroad, especially from East Asia (Jarkas and Radosavljevic 2013; Al-Bayati et al. 2017). The pandemic forced many laborers to return to their home countries, and accordingly, the availability of construction workers is doubted in the short term (Karim et al. 2020; Fox et al. 2020). Additionally, many local governments in the Middle East countries are currently planning to reduce the dependence on foreign workers in the upcoming years due to the significant budget cuts related to COVID-19 economic recession and other issues, while encouraging locals to enter construction industry (Al-Youbi et al. 2020; Alahmad et al. 2020; De Bel-Air 2019; Malik and Nagesh 2020; OA 2020; Stone 2020). While many middle and top management staff members can work from home, almost all construction workers must work on site. In addition, COVID-19 can have significant impacts related to enforcing safety and minimizing hazards on construction sites, as many safety regulations will change to address the current issues (Paull 2020; Alcorn 2020). Further regulations will be added, including social distancing, wearing face masks, shields, and gloves, and utilizing personal hygiene products (CSU 2020; Black 2020; Ezeokoli 2020). Handwashing and sanitizing stations would also be common through construction sites and additional cost items to project budgets (CSU 2020; Black 2020; Ezeokoli 2020).

It should be noted that pandemics, such as COVID-19, are not defined as a probable source of delay and claims in most of the contracting forms used in the Middle East. For example, Force Majeure clauses in many contracts lack reference to pandemics and legally define the causes to include acts of God, wars, and labor strikes. Over the next few months, many problems and claims can arise due to such clauses and the lack of reference to pandemics as probable causes of Force Majeure. Clearly, the definition of such clause and other clauses related to pandemics should be investigated by research.

# RESEARCH METHODOLOGY

An exploratory study was conducted and targeted a large population of construction professionals using a questionnaire survey that had been revised through interviews with leaders from the construction industry to understand the perception of the construction industry of COVID-19 impacts. Since there is little-to-no research on COVID-19, the research study assumptions, given the Middle East focus, are as follows: (1) the construction industry is dependent on foreign workers, (2) most construction materials are imported, and (3) the construction industry is sensitive to oil revenues and largely dependent on national development plans. The goal of the study is to compare the perceptions of a large sample of construction professionals, working under COVID-19 conditions, in order to identify the possible impact profile facing the construction industry and the best response measures to address these impacts. It should be noted that the research team tried to obtain time and cost overrun data from several construction companies in the Middle East but was not able to acquire it. This is mainly because such data is not readily available by many Middle Eastern companies, and if available, it is often considered confidential. The questionnaire survey design, sampling technique, and the demographics of the respondents are discussed in the next subsections.

## Questionnaire Survey Design

Given the little existing research on the impacts of the pandemic on the construction industry, a preliminary questionnaire survey was designed, synthesizing a list of potential impacts from webinars on the subject, including the series of webinars organized by the Center for Building, Infrastructure and Public Space (CBIPS) and the Center for Construction Research and Training (CPWR), which featured the experience of many construction professionals with the pandemic repercussions (CBIPS 2020; CPWR 2020). The preliminary questionnaire survey was then discussed with 6 leaders from the construction industry and academia. The 6 leaders possess an extensive experience to evaluate the questionnaire quality and objective, as they included five academic professors working in four Middle East countries (Kuwait, Qatar, Saudi Arabia, and Egypt), and one senior project manager with 30 years of experience. A revised questionnaire was then designed based on their feedback and comments, which pointed out that the survey should target several classes of impact such as project finance, construction materials, equipment, labor, contracts, and the rental property market. In the revised questionnaire, most of the questions are designed to be closed-ended questions, with the exception of one open-ended question that was designed to ask the respondents about the lessons learned from COVID-19 pandemic and recommendations to respond to its impacts.

The questionnaire survey consists of five sections. The first section is designed to record the participant general information, including affiliation, sector, years of experience, and the level of managerial experience of the participant. The second section consisted of twenty-two questions to project COVID-19 impacts on: i) project finance, ii) construction materials and equipment, iii) labor, iv) contracts, and v) rental property. The participant is asked to rate the impacts on a 10-point scale. In sections three and four, the participant is asked to rate the possible measures to respond to COVID-19 threats in both future and ongoing projects. The last section of the survey is the open-ended question that asks the participant to identify the lessons learned and any additional recommendations to respond to the threats of COVID-19.

To reduce bias and subjectivity in questions and responses, several approaches are taken. First, the questionnaire survey is designed and reviewed by multiple individuals for clarity. Question phrasing is developed by the second author and then reviewed and revised by the first and third authors to reduce potential researcher's bias in designing the survey questions. The questions are also designed to be short and clear to avoid reading confusion and provide precise straightforward questioning. Second, a common interval scale is used for collecting responses. The survey instrument uses the 10-point Likert scale, which is an interval scale that is easy to understand as it is similar to other scales used in daily life. A wide interval scale is deemed more effective than a Yes/No or limited multiple-choice questions, which can introduce response bias (Harzing et al. 2009). Third, participants are provided with scale rating interpretation (e.g., 1: Low Impact, 10: High Impact, etc.). This helps minimize misinterpretation of the interval scale ratings. Fourth, the survey was distributed over a large number of construction professionals to minimize the likelihood of obtaining biased results and ensure that a representative sample is collected. Lastly, perception is compared among stakeholders using Spearman's Rank Correlation to investigate if bias exists in the responses of demographic groups (e.g., contractors vs. clients, public sector vs. private sectors, etc.).

## Sample Size and Data Cleaning

The questionnaire survey was distributed to more than 654 construction professionals working in various public- and private-sector construction organizations in Kuwait, Qatar, Saudi Arabia, and Egypt. The questionnaire targeted engineers working mainly on building projects for medium-size and large-size companies through the traditional Design-Bid-Build (DBB) system (i.e., projects with cost exceeding $1 Million), which is the most common project delivery system used in the Middle East. Companies are officially size-classified based on financial capacity, experience, number of full time employees, and amount of owned equipment. The targeted engineers were contacted either through their organizations or through personal communications. Out of the 654 distributed questionnaires, 202 responses were received (31% response rate), representing 80 companies with 1–4 responses received per company. It should be noted that the targeted engineers were asked to share the questionnaire within their organizations, and accordingly, for some organizations, more than one response was received. The intention of the research team was to collect responses from as many construction professionals (individuals) as possible and not from companies. The reason for that is to depict the opinion of the construction community, not construction organizations. Considering one response from each company would limit the responses received to 80 responses instead of 202, which might or might not alter the results of the statistical analyses, depending on which responses are discarded. The exact impact is difficult to determine, since it involves discarding responses from some companies, and there is no straightforward method to determine which results to discard. However, fourteen responses were excluded from the analysis as they were incomplete responses, and the rest of the responses were statistically analyzed using SPSS to compute the descriptive statistics of the participant responses.

## Participant Demographics

The participants represented a variety of construction industry domains, including building construction, highways projects, and public utilities; however, most respondents represented the building construction domain. Table 1 illustrates the breakdown of the participants by their demographics. As shown in the table, around 25% represented clients/owners, 18% represented consultants, and 47% of the participants represented contractors, while nearly 10% of the participants represented other construction stakeholders, including vendors, suppliers, and financial institutions (see Fig. 1). Nearly 64% of the participants were working for the private sector, and about 36% of the participants were from public/governmental agencies, as shown in Fig. 2. The respondents represented the various levels of management experience, with 24% representing top management, 51% representing middle management, and 25% representing field-level management, as shown in Fig. 3. Most of the respondents had substantial years of construction experience, with 75% enjoying more than 10 years of experience, as shown in Table 1 and Fig. 4.

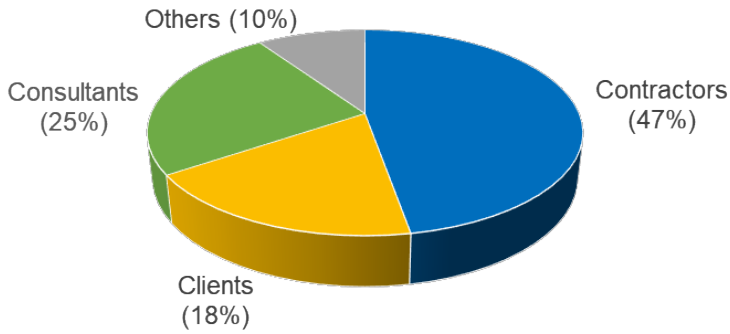


**Figure 1.** Participant Demographics: Employer.

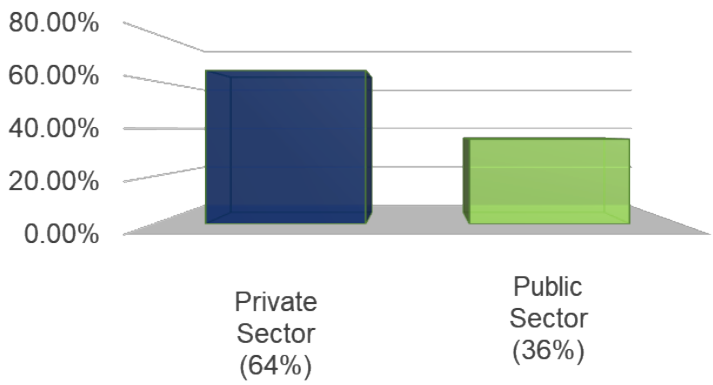


**Fig. 2.** Participant Demographics: Sector.

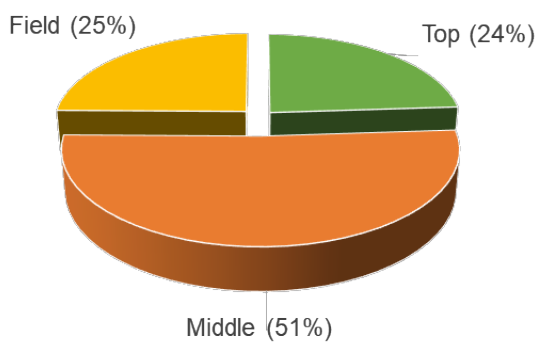


**Figure 3.** Participant Demographics: Management level.

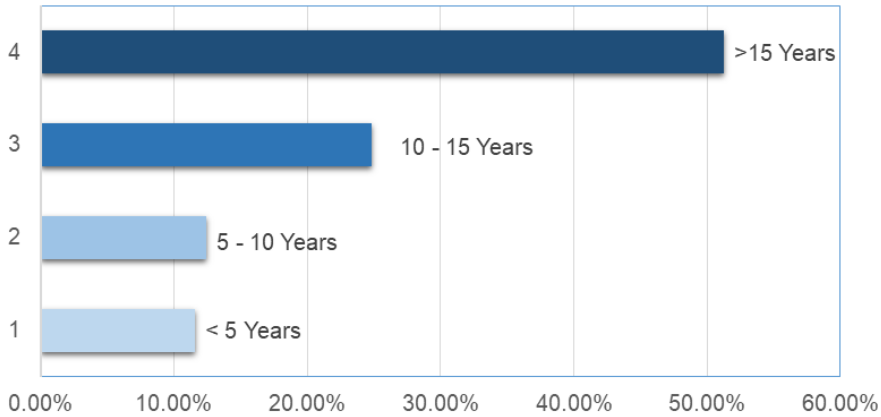


**Figure 4**. Participant Demographics: Years of experience.

**Table 1.** Participant Demographics.

| Category | Distribution | Percentage |
|---|---|---|
| **Employer** | Contractor | 47.20% |
| | Client | 18.40% |
| | Consultant | 24.80% |
| | Others | 9.60% |
| **Sector** | Private | 64.46% |
| | Public | 35.54% |
| **Level of management** | Top Mgmt. | 23.97% |
| | Middle Mgmt. | 51.24% |
| | Field-level | 24.79% |
| **Years of experience** | Less than 5 years | 11.57% |
| | From 5-10 years | 12.40% |
| | From 10-15 years | 24.79% |
| | More than 15 years | 51.24% |
| **Country** | Kuwait | n.a.* |
| | Egypt | n.a.* |
| | Qatar | n.a.* |
| | Saudi Arabia | n.a.* |

*not available due to anonymity of responses

# RESULTS AND ANALYSIS

The collected data is analyzed using descriptive statistical analysis and ordinal logistic regression in order to evaluate the participant perception of COVID-19 impacts on the construction industry, as well as the best response strategies to mitigate these impacts on current and future projects. The following sections discuss the results and analysis in detail.

## Projected Impacts of COVID-19

The questionnaire included twenty-two questions that were designed to assess COVID-19's impact on the construction industry. The mean response rating of each question was calculated using a weighted mean rating, as shown in Eq. 1 and Table 2.

$$WMR = \frac{\sum_{i=1}^{i=10} r_i * n_i}{N} \quad (1)$$

Where,
WMR =Weighted Mean Rating,
$r_i$ = rating, ranges from 1 to 10,
$n_i$ = surveyed number for each rating, and
$N$ = the total number of respondents.

**Table 2.** COVID-19 Impacts on the Construction Industry.

| Class | Impact | Mean (Max 10) | SD | MAD | Kurt | Class Mean |
|---|---|---|---|---|---|---|
| Project Finance | I1. Slowdown in launching new government projects | 7.58 | 3.46 | 1.91 | 0.73 | 7.05 |
| | I2. Redirection of governmental financing to infrastructure projects (especially health care projects) | 6.86 | 2.41 | 1.86 | -0.09 | |
| | I3. Change in governmental plans (e.g. 2035) | 6.91 | 2.60 | 2.14 | -0.24 | |
| | I4. Slowdown in launching new private-sector projects | 7.19 | 2.82 | 2.13 | 0.13 | |
| | I5. Tightened bank arrangements for project financing | 6.21 | 1.91 | 2.15 | -0.53 | |
| | I6. Pandemic impact is harsher than oil price drop | 7.53 | 3.01 | 2.01 | 0.32 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Materials and Equipment | I7. Increase in construction materials & equipment costs | 6.78 | 2.04 | 2.23 | -0.44 | 7.30 |
| | I8. Increase in customs and shipping cost | 6.99 | 2.41 | 2.10 | -0.45 | |
| | I9. Increase in construction materials unavailability | 7.08 | 2.70 | 2.18 | -0.40 | |
| | I10. Increase in usage of local items | 7.33 | 2.63 | 1.93 | 0.29 | |
| | I11. Delays in importing construction materials | 8.31 | 4.35 | 1.48 | 2.79 | |
| Labor | I12. Increase in unavailability of construction labor | 7.63 | 3.44 | 1.93 | 0.73 | 7.76 |
| | I13. More procedures for labor supply chain and visa regulations | 8.32 | 4.67 | 1.56 | 2.12 | |
| | I14. Increase in cost of construction labor | 7.35 | 2.90 | 2.09 | -0.16 | |
| | I15. Increase in labor insurance costs | 7.33 | 3.15 | 1.88 | 0.14 | |
| | I16. Tightened health and safety regulations on sites | 8.17 | 4.28 | 1.59 | 1.58 | |
| Contracts | I17. Revision of Force Majeure clauses in construction contracts | 7.55 | 3.12 | 2.02 | -0.22 | 7.57 |
| | I18. Revision of Change & Claims clauses in contract forms | 7.59 | 3.15 | 1.89 | 0.02 | |
| Rental Property | I19. Stricter health requirements to rental property | 6.34 | 1.86 | 2.03 | -0.64 | 6.02 |
| | I20. Increased demand for rental property | 5.15 | 1.68 | 2.04 | -0.69 | |
| | I21. Change of renting laws and policies | 7.07 | 2.30 | 1.90 | -0.15 | |
| | I22. Increased banking investment in real-estate projects | 5.53 | 1.05 | 2.36 | -1.03 | |

These 22 questions addressed 5 main classes of impact in the construction industry, project finance, construction materials and equipment, construction labor, contracts, and rental property, as shown in Table 2. The following section discusses these impact classes in detail.

## Impact on Project Finance

As per the statistical analysis of the collected data, the respondents indicated that one of the most important impacts of COVID-19 is the slowdown of launching new government projects, which was rated at 7.58 on a 10-point scale, as shown in Table 2. The respondents also indicated that the effect of COVID-19 on the construction industry would be harsher than the current oil price drop, rating this impact at 7.53. Although this might seem a little strange

for oil-producing economies, it could be explicable considering oil price drop as a side effect of COVID-19 pandemic, which resulted in a recession to the global economy and reduction in international travel and transportation demand. In addition, as shown in Table 2, the respondents indicated that COVID-19 would also result in slowdown to the private-sector projects, rating this impact at 7.19. Other relatively less significant impacts included changes in governmental strategic plans (WMR = 6.91), redirection of financing to infrastructure projects and healthcare facilities (WMR = 6.86), and tightened bank arrangements for project financing (WMR = 6.21), as shown in Table 2.

## Impact on Construction Materials and Equipment

In terms of the impact on construction materials and equipment, the respondents indicated that the most significant impact would be the delays in construction material imports, which were rated at 8.31, as shown in Table 2. This would also lead to an increased demand for and usage of local materials (rated at 7.33) and consequently construction material shortages and unavailability (7.08). The respondents also indicated that COVID-19 could lead to increased shipping costs and customs due to changes in the materials supply chain, transportation slowdown, and heightened governmental requirements. In addition, COVID-19 could also lead to an increase in construction materials and equipment costs due to the aforementioned reasons (6.78), as shown in Table 2. All in all, the pandemic is expected to lead to difficulties in construction material procurement locally and from abroad.

## Impact on Labor

As per the statistical analysis of the collected data, the respondents indicated that the most significant COVID-19 impact on construction labor will be the implementation of more complex procedures for hiring labor and issuing work visas (WMR = 8.32). This is mainly due to the region's construction industry dependence on laborers from East Asia, the region in which COVID-19 pandemic emerged. In addition, the pandemic exposed many of the malpractices in the local construction industry, especially the inhumane conditions under which construction labor works and the unhygienic labor housing, as well as work permit corruptions. These findings indicate the need for change in visa issuance regulations and labor supply chain management. In addition to these impacts, the respondents indicated that COVID-19 will result in tightening safety and security on construction sites, rating this impact at 8.17. To a lesser extent, the respondents anticipate that COVID-19 will increase construction labor unavailability (WMR = 7.63), labor cost (WMR = 7.35), and labor insurance rates (WMR = 7.33).

## Impact on Contracts

In terms of COVID-19 impact on contracts, the respondents indicated that COVID-19 will result in revising the Force Majeure clause in contracts (WMR = 7.55). The current clause of the general contact conditions defines the sources of Force Majeure as acts of God, wars, invasions, revolutions, civic unrest, uprisings, and labor strikes, without a clear reference to pandemics. In addition, the respondents also anticipated the impacts of COVID-19 to include revisions to other contract clauses such as the Change and Claims clauses (WMR = 7.59).

## Impact on Rental Property

The respondents were asked whether there would be impacts on the market of rental property, and they indicated that there would be anticipated changes to rent laws and policies due to COVID-19, rating this impact at 7.07. They also indicated that COVID-19 is most likely to trigger stricter health requirements for renting existing property (WMR

= 6.34). As shown in Table 2, the respondents did not indicate that there would be significant impacts on the demand for rental property (WMR = 5.15) or bank investment in the real-estate industry (WMR = 5.53).

## Overall Class Impact

In terms of overall class analysis, Table 2 summarizes the mean scores of the five classes of impact. As shown in the table, the most significant impacted class is the labor class, with an overall WMR of 7.76, followed by contracts (WMR = 7.57), and materials and equipment (WMR = 7.30). To a lesser extent, COVID-19 will impact project finance (WMR = 7.05) and rental property (WMR = 6.02). This could be due to the natural influence of human factors on the labor class as compared to non-human elements in the other classes. It should also be noted that the sentiment against Asian labor, during the pandemic time, could have played a role in these ratings.

## Influence of Project Nature on COVID-19 Impacts

It is also worth noting that other factors can influence COVID-19 impacts on projects, such as the project sector type, level of management, experience, and project delivery method. To evaluate the influence of such factors on COVID-19 impacts, descriptive statistical analysis is performed to compare the mean values of the impacts for the public and private sectors; and ordinal logistic regression has been used to study the explanatory variables that can be predictors of the impact such as the level of management, years of experience, employer type, and sector of employment. Public and private sector projects are generally different in their sizes, bidding and awarding methods, and their delivery methods. For example, public projects tend to be bigger in size and budget and are typically delivered using traditional DBB delivery systems, as compared to private projects, which are typically small-sized and delivered using alternative delivery methods. Table 3 summarizes the comparative analysis of these two types of projects that are different in nature. As shown in the table, for the majority of the impacts, the differences between the mean ratings for public and private sectors did not appear to be significant. For example, the two sectors had similar ratings for the top-ranked impact that the pandemic will change the procedures for labor supply chain in construction projects with mean ratings of 8.46 and 8.15 for the private and public sectors, respectively. However, there were some differences for a few impacts. The public sector had a slightly higher rating that the pandemic impact is harsher than oil price drop, which may indicate that public sector projects were impacted more than private sector projects. Contrarily, the private sector had a slightly higher rating for the revision of change and claims clauses in contract forms, which can be explained based on the rigidity and difficulty of changing public sector contract forms. Levene's Test has been used to check for the equality of variances between the public and private sector ratings. As shown in Table 3, the p-value is 0.423 ($p > 0.05$), which indicates that the null hypothesis should be accepted and that the variances are not significantly different. Accordingly, since the p-value for the t-test is 0.698 ($p > 0.05$), as shown in Table 3, the null hypothesis should be accepted, and the means are not significantly different. In terms of ranking the impacts, while the private sector participants considered tightening health and safety regulations on site to be the second ranked impact, public sector participants ranked the harsher pandemic impact second compared to oil price drop. These differences indicate that the aforementioned factors could have influence on COVID-19 impacts, at least from the point of view of public and private sector participants.

**Table 3.** Influence of Project Nature on COVID 19 Impact: Mean Comparison between Private and Public Projects.

| | **Impact** | **Private** | **Public** | **Prv. Class** | **Pbl. Class** |
|---|---|---|---|---|---|
| **Class** | | | | | |
| Project Finance | I1 | 7.57 | 7.53 | 6.96 | 7.13 |
| | I2 | 6.75 | 6.95 | | |
| | I3 | 6.85 | 6.86 | | |
| | I4 | 7.40 | 6.78 | | |
| | I5 | 6.00 | 6.60 | | |
| | I6 | 7.20 | 8.10 | | |
| Materials and Equipment | I7 | 6.73 | 6.80 | 7.19 | 6.94 |
| | I8 | 7.19 | 6.55 | | |
| | I9 | 7.36 | 6.60 | | |
| | I10 | 7.24 | 7.54 | | |
| | I11 | 7.45 | 7.20 | | |
| Labor | I12 | 7.52 | 7.90 | 7.86 | 7.61 |
| | I13 | 8.46 | 8.15 | | |
| | I14 | 7.59 | 6.85 | | |
| | I15 | 7.36 | 7.29 | | |
| | I16 | 8.36 | 7.85 | | |
| Contracts | I17 | 7.77 | 7.20 | 7.84 | 7.11 |
| | I18 | 7.92 | 7.02 | | |
| Rental Property | I19 | 6.32 | 6.44 | 5.96 | 6.19 |
| | I20 | 5.00 | 5.50 | | |
| | I21 | 7.19 | 6.80 | | |
| | I22 | 5.30 | 6.05 | | |

**Independent Samples Test**

| | Levene's Test for Equality of Variances | | t-test for Equality of Means | | |
|---|---|---|---|---|---|
| | F | Sig. | t | df | Sig. (2-tailed) |
| Equal Var. Assumed | .655 | .423 | -.390 | 42 | .698 |
| Equal Var. not Assumed | | | -.390 | 39.260 | .698 |

## Ordinal Logistic Regression

To study the explanatory variables that can be predictors of COVID-19 impacts, an ordinal logistic regression model was fitted to the impact data. Ordinal logistic regression is a type of regression analysis used for dependent variables of ordinal scale, such as in the applications where human evaluation is of a major role. Such regression models are very suitable for the analysis of scale ratings because questionnaire surveys are generally conducted by

using ordinal verbal scales of measurement (Eboli and Mazzulla 2008). COVID-19 impact data represent a set of dependent ordinal variables with values that exist on an ordered scale, where only the relative ordering between different values is significant. As such, an ordinal regression is suitable and has been conducted using IBM SPSS Statistics 26.

In the analysis of ordinal regression, the independent explanatory variables are the level of management, years of experience, employer type, and sector of employment, which are categorical variables; and the dependent variables are the project finance impact, materials and equipment impact, labor impact, contract impact, and rental property impact, which are ordinal variables. These five dependent variables are the mean values of the respondent scores for each impact class. For example, project finance impact is the mean value of the first six questions, which represent the project finance impact class. Accordingly, five models have been developed to evaluate the independent variables as predictors of the five impact classes.

Table 4 illustrates and summarizes the results of the five models. As indicated in the table, the observed significance levels ranged between 0.004 and 0.989. However, most of the values were greater than 0.05, which indicates that there is no significant difference between the independent variable values as compared to the referential value. Exceptions to that were found in the labor impact model, where the "Employer" type had observed significance levels of less than 0.05, which indicates that the employer type is significantly related to the probability of getting specific labor impact scores. In addition, for the contract impact model, the "Employer" type had observed significance levels of less than 0.05, indicating that the employer type is significantly related to the probability of getting specific contract impact scores. As seen from the model fit information in Table 5, all the significant values are greater than 0.05, ranging between 0.143 and 0.793. Accordingly, the null hypothesis is not rejected, and there is no significant difference between the baseline model (without any independent variables) and the final model (with all possible independent variables), which indicates that the predictors (level of management, years of experience, employer type, and sector of employment) have no significant influence on the models. Additionally, the goodness-of-fit significance of the five models had values ranging from 0.052 to 0.117 ($p>0.05$), which means that the null hypothesis should be accepted and that the observed data fits the model quite well. Moreover, the Pseudo-$R^2$ (Nagelkerke) values, shown in Table 5, indicate that the proportion of the variance explained by the independent variables (level of management, years of experience, employer type, and sector of employment) on the dependent variables (the five classes of COVID-19 impact) in the models is low.

## Response Measures for Future Projects

In the third section of the questionnaire survey, the participant was asked to rate the response measures that can be taken to mitigate COVID-19 impacts on future construction projects. The participant was provided with a list of predefined response measures that were prepared in consultation with the interviewed experts during the preliminary stage of the questionnaire survey design. The participant was given the opportunity to add to the predefined list in the fifth section of the questionnaire survey. The predefined response measures were as follows: (1) increase government spending on public-private partnership projects; (2) attract foreign direct investment to the local construction industry; (3) increase government spending on healthcare projects; (4) reduce government spending on public building projects; (5) revise strategic plans to address the impacts of COVID-19; (6) direct major government funding to infrastructure projects; (7) support the development of local construction materials plants; (8) strengthen labor supply chain by streamlining work permit processing; (9) implement visa reforms to facilitate foreign labor recruitment; (10) include pandemics as applicable sources of Force Majeure in contract forms; (11) limit labor crowding on construction sites and encourage social distancing; and (12) enact new regulations for worker safety through work time change and enforcing the use of special personal protective equipment.

**Table 4.** Ordinal Logistic Regression Models.

| Predictor Variables | Model | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Finance Impact | | Matr. & Equip. Impact | | Labor Impact | | Contract Impact | | Rental Prop. Impact | |
| | Est. | Sig.[b] | Est. | Sig.[b] | Est. | Sig.[b] | Est. | Sig.[b] | Est. | Sig.[b] |
| **Level of Management** | | | | | | | | | | |
| Field / Technical | -0.008 | 0.989 | 0.828 | 0.131 | -0.627 | 0.251 | -0.906 | 0.109 | 0.397 | 0.470 |
| Middle Management | -0.327 | 0.439 | 0.205 | 0.628 | -0.759 | 0.076 | -0.786 | 0.072 | 0.636 | 0.136 |
| Top Management | 0[a] | – | 0[a] | – | 0[a] | – | 0[a] | – | 0[a] | – |
| **Years of Experience** | | | | | | | | | | |
| From 10-15 Years | -0.158 | 0.712 | 0.288 | 0.502 | 0.303 | 0.479 | 0.635 | 0.147 | -0.027 | 0.951 |
| From 5-10 Years | -0.336 | 0.530 | -0.451 | 0.400 | 0.735 | 0.172 | 1.310 | 0.022 | 0.533 | 0.330 |
| Less than 5 Years | -0.409 | 0.512 | 0.559 | 0.376 | 0.154 | 0.806 | 0.620 | 0.335 | 0.175 | 0.781 |
| More than 15 Years | 0[a] | – | 0[a] | – | 0[a] | – | 0[a] | – | 0[a] | – |
| **Sector** | | | | | | | | | | |
| Private | -0.351 | 0.344 | 0.309 | 0.405 | 0.382 | 0.304 | 0.862 | 0.024 | -0.102 | 0.785 |
| Public | 0[a] | – | 0[a] | – | 0[a] | – | 0[a] | – | 0[a] | – |
| **Employer** | | | | | | | | | | |
| Client | -0.511 | 0.439 | -1.123 | 0.102 | -2.018 | 0.004 | -1.396 | 0.049 | -1.027 | 0.134 |
| Contractor | 0.602 | 0.322 | -0.228 | 0.713 | -1.475 | 0.020 | -1.290 | 0.047 | -0.535 | 0.390 |
| Designer | 0.138 | 0.827 | -0.282 | 0.661 | -1.553 | 0.018 | -1.242 | 0.064 | -0.574 | 0.377 |
| Others | 0[a] | – | 0[a] | – | 0[a] | – | 0[a] | – | 0[a] | – |

a: This factor is set to zero as it is the referential factor
b: Significant at $p < 0.05$

**Table 5.** Parameters of the Ordinal Logistic Regression Models.

| PARAMETER | MODEL | | | | |
|---|---|---|---|---|---|
| | FINANCIAL IMPACT | MATERIALS IMPACT | LABOR IMPACT | CONTRACT IMPACT | REAL-ESTATE IMPACT |
| **MODEL FIT INFORMATION** | | | | | |
| -2 LOG LIKELIHOOD | 660.143 | 602.63 | 581.495 | 424.571 | 606.67 |
| CHI-SQUARE | 6.757 | 11.341 | 12.643 | 14.705 | 6.293 |
| SIG.[A] | 0.748 | 0.332 | 0.244 | 0.143 | 0.793 |
| **GOODNESS OF FIT** | | | | | |
| DEVIANCE CHI-SQUARE | 555.395 | 492.23 | 478.37 | 335.884 | 506.57 |
| SIG.[B] | 1 | 1 | 1 | 1 | 1 |
| **PSEUDO-$R^2$** | | | | | |
| NAGELKERKE | 0.054 | 0.09 | 0.1 | 0.117 | 0.052 |

a: Significant at $p < 0.05$

b: Significant at $p > 0.05$

Table 6 summarizes the participant responses and ranks COVID-19 response measures for future projects. As shown in the table, the top-rated response measures are as follows: (1) enacting new regulations for worker safety through work time change and enforcing the use of special protective equipment, (2) revising strategic plans to address the impacts of COVID-19, (3) increasing government spending on healthcare projects, (4) limiting labor crowding on construction sites and encouraging social distancing, and (5) including pandemics as applicable sources of Force Majeure in contract forms.

**Table 6.** Ranking of Response Measures for Future Projects by Participant Demographics.

| Response | Global Rank | Employer Type | | | Management Level | | | Years of Experience | | | | Employer Sector | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Client | Contractor | Consultant | Field | Middle | Top | <15 | 5-10 | 10-15 | >15 | Private | Public |
| R1 | 10 | 7 | 11 | 7 | 6 | 10 | 9 | 7 | 10 | 9 | 10 | 11 | 7 |
| R2 | 12 | 12 | 12 | 12 | 11 | 12 | 12 | 11 | 12 | 7 | 12 | 12 | 11 |
| R3 | 3 | 4 | 4 | 5 | 7 | 2 | 3 | 5 | 1 | 3 | 4 | 5 | 2 |
| R4 | 11 | 10 | 9 | 9 | 9 | 9 | 11 | 12 | 11 | 6 | 11 | 10 | 12 |
| R5 | 2 | 3 | 2 | 2 | 2 | 7 | 5 | 1 | 8 | 2 | 2 | 3 | 4 |
| R6 | 7 | 9 | 8 | 6 | 10 | 6 | 8 | 10 | 9 | 5 | 6 | 8 | 6 |
| R7 | 6 | 5 | 6 | 4 | 8 | 8 | 7 | 4 | 3 | 8 | 5 | 6 | 3 |
| R8 | 9 | 8 | 10 | 11 | 1 | 5 | 6 | 6 | 7 | 12 | 7 | 9 | 8 |
| R9 | 8 | 11 | 7 | 10 | 12 | 11 | 10 | 8 | 4 | 10 | 8 | 7 | 10 |
| R10 | 5 | 6 | 5 | 3 | 5 | 4 | 2 | 9 | 5 | 11 | 9 | 1 | 9 |
| R11 | 4 | 2 | 1 | 8 | 4 | 3 | 4 | 3 | 2 | 4 | 3 | 4 | 5 |
| R12 | 1 | 1 | 3 | 1 | 3 | 1 | 1 | 2 | 6 | 1 | 1 | 2 | 1 |

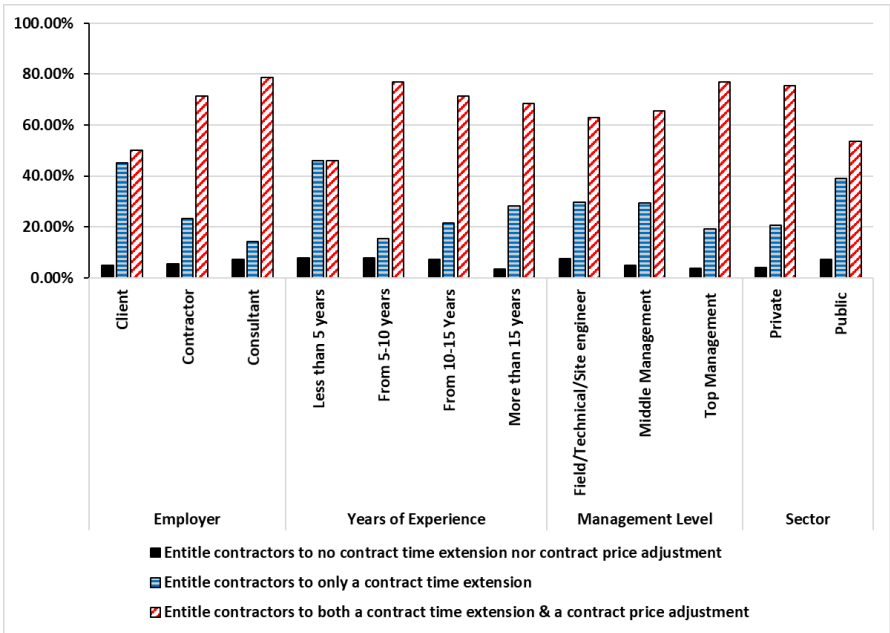


**Figure 5.** Recommended response measures for ongoing construction projects by participant demographics.

## Response Measures for Ongoing Projects

In the fourth section of the questionnaire survey, the participants were asked to rate the response measures that can be taken to mitigate COVID-19 impacts on ongoing construction projects. The participants were asked to select from three main measures: (1) entitling contractors to both an extension of contract time and an adjustment of the contract price, (2) entitling contractors to only an extension of contract time, and (3) entitling contractors to no extension of contract time nor adjustment of the contract price. Figure 5 summarizes participant responses by employer, years of experience, management level, and sector. As shown in the figure, in the view of most participants, contractors should be entitled to both an extension of contract time and an adjustment of the contract price. Around 68% of the respondents selected that response measure, while 27% indicated that contractors should be entitled to only an extension of contract time, and 5% indicated that contractors should not be entitled to any time or price compensation. The figure clearly shows a consensus among the respondents, except the group with less than 5 years of experience, which was divided between measures no. 1 and 2. This contrast seems to be due to the lack of experience in contractual issues. Additionally, as shown in the figure, for the respondent groups working in the public sector and representing clients/owners, slightly more respondents indicated that contractors should be entitled to both a contract time extension and contract price adjustment, as compared to the respondents who indicated that contractors should be compensated for just the contract time.

## Lessons Learned and Additional Recommendations

The fifth section of the questionnaire survey is an open-ended question that was designed to allow the participant to share the lessons learned from COVID-19 pandemic and recommend other response measures not listed in sections 4 and 5. Twenty-two participants responded to the open-ended question. Among the identified lessons learned by the respondents is the fact that many tasks can be accomplished remotely from home or by a hybrid mix of onsite and remote work. Respondents also indicated that they learned that site work can be completed safely, without spreading

the disease, through the strict maintenance of protective measures and social distancing. In addition, some respondents indicated that the reduction of labor crowding to about 30–35% from the typical levels and/or the reduction of working hours helped to reduce the disease transmission.

Several additional recommendations were also listed by the respondents to minimize the negative impacts of COVID-19. The respondents indicated that the governments need to protect the construction industry and its closely related businesses by injecting stimulus funding that can help maintain the current momentum of construction activity and prevent slowdown that can hurt the industry and subsequently the economy. The respondents also recommended accelerating the reopening of businesses and warned that long-term shutdowns could have serious effects on the construction industry and the economy. In addition, recommendations were also made for the support of local consultants, engineers, vendors, and contractors and the reduction of dependence on foreign providers of such services in order to minimize serious industry disruptions. Moreover, the respondents recommended improving the conditions of recruiting foreign construction labor, including providing them with adequate humane housing and protecting them from abusive practices such as labor slavery, fraudulent recruitment, and sponsorship trading. Furthermore, respondents recommended that claims related to COVID-19 pandemic should be studied on a case-by-case basis for time and cost compensation, rather than taking a one-size-fits-all approach.

# DISCUSSION

The responses received represent a good sample size (202), and they indicate that labor would be the most impacted class by COVID-19 pandemic (see Table 2), which may stem from the human factor associations with this class and the fact that construction workers are sensitive to changes of work environment conditions (Hsu et al. 2008). In addition, most of construction site work is team-based, and any infection of a team member would disrupt the work of the entire team and expose the rest of the team members to infection. Many research studies also indicate that such work environment changes can also affect worker's productivity (Taiwo 2010). Thus, reducing the transmission of the disease and infection spread may have direct and indirect effects on construction site work. This can be accomplished, by enacting regulations to ensure workers safety through work time change, sterilizing the workplace, and enforcing the use of special protective equipment such as face masks, face shields, and gloves, as indicated by the respondents. Social distancing and limiting labor crowding may also be effective measures, as indicated by the survey results. The effectiveness of these regulations and measures can be studied by managerial frameworks and engineering models for temporal variations in productivity, and historical daily work reports combined with performance indexes (Ghodrati et al. 2018; Le et al. 2020).

On a larger scale, the negative impacts of the pandemic on the entire construction industry and the economy may be reduced by changes to the government strategic plans and injecting investments into infrastructure projects to stimulate the slowing construction and economic activities, especially those projects that would be under significant demand such as temporary healthcare facilities, quarantines, and rapid testing facilities. The results also indicate a need for revising contract forms to account for disruptions caused by pandemics. If such forms remain without updating, the adversarial relationships among the project partners would get worse, and legal disputes would rise significantly.

## Analyzing Subjectivity and Bias

It should be noted that subjectivity can seep to survey results, and accordingly, it is important to conduct statistical analyses to evaluate whether such issues exist in the results or not. Subjectivity in the results of each question has been analyzed using three measures, the standard deviation (SD) of the rating distribution, the mean absolute deviation (MAD) around the median, and the standard kurtosis (Kurt) value (Kang et al. 2019; Hou and

Wentzell 2011; Jones 1969), as shown in Table 2. The SDs of the rating distributions ranged between 1.05 and 4.67, which is considered relatively low compared to the mean values. This indicates that the coefficients of variation are relatively small (<1) and that the ratings are close to the mean value. Likewise, the MAD analysis illustrates that the average deviation of the ratings around the median varied from 1.48 to 2.36, which are considered low values compared to the median values and therefore suggest that the subjectivity of the results is relatively low. Finally, the kurtosis values were less than 3, ranging between -1.03 and 2.79, as shown in Table 2, which indicates that there are fewer and less outliers and extreme values as compared to normal distributions (Kurt = 3), suggesting low subjectivity in the results.

Bias can also seep into the results for a number of reasons, including sampling errors and sample representation. These issues have mainly been addressed by collecting data from a large group of construction professionals representing various construction stakeholders. Nevertheless, it is important to evaluate and measure the bias in responses received. Rank correlation can be used as an indicator to evaluate the bias as it measures the degree of similarity of ranking among different rankers. Using Spearman's Rank Correlation, a comparative statistical analysis is conducted to investigate if similarity exists in the responses among the different demographic groups of respondents, such as contractors vs. clients and public vs. private sector, and how well the responses are correlated with regard to ranking the measures that can be taken to overcome COVID-19 impacts.

Table 7 shows Spearman's rank correlation coefficients for the employer groups (contractors, clients, and consultants). As shown in the table, the coefficients ranged between 0.74 and 0.78, indicating a relatively high correlation and agreement in the ranking among the employer groups. Likewise, Spearman's rank correlation coefficients for the participant groups based on their management levels ranged between 0.7 and 0.91, as shown in Table 8. The highest rank correlation was between the top and middle management levels (0.90755), which may stem from their significant experience compared to the field-level management. Table 9 summarizes Spearman's rank correlation coefficients for participant groups based on the years of experience. As shown in the table, there is relatively high rank correlations among the groups, except for the group with less than 5 years of experience, which again can stem from the lack of experience. With regard to the participant groups by sector (public and private), Table 10 illustrates a moderate correlation depicted by a Spearman's rank correlation coefficient of 0.61, which can stem from the possible differences between the two sectors in terms of their vision and strategic objectives.

**Table 7.** Spearman's Rank Correlation Coefficients for Employers.

| | Client | Contractor | Consultant/Designer |
|---|---|---|---|
| Client | 1.00000 | 0.78154 | 0.74339 |
| Contractor | | 1.00000 | 0.77605 |
| Consultant/ Designer | | | 1.00000 |

**Table 8.** Spearman's Rank Correlation Coefficients for Management Levels.

| | Field | Middle | Top |
|---|---|---|---|
| Field | 1.00000 | 0.70154 | 0.79099 |
| Middle | | 1.00000 | 0.90755 |
| Top | | | 1.00000 |

**Table 9.** Spearman's Rank Correlation Coefficients for Years of Experience.

| | < 5 years | 5-10 years | 10-15 years | > 15 years |
|---|---|---|---|---|
| < 5 years | 1.00000 | 0.74265 | 0.53944 | 0.86326 |
| 5-10 years | | 1.00000 | 0.21326 | 0.77502 |
| 10-15 years | | | 1.00000 | 0.70696 |
| > 15 years | | | | 1.00000 |

**Table 10.** Spearman's Rank Correlation Coefficients for Sectors.

| | Private | Public |
|---|---|---|
| Private | 1.00000 | 0.61275 |
| Public | | 1.00000 |

# CONCLUSION

COVID-19 has spread all over the world and has affected most economic sectors. The construction industry is no exception and has been affected in many aspects, including project shutdowns, project rescheduling, site labor reduction, and switch to remote working. This study is one of the earliest studies to shed light on some of the impacts of COVID-19 on the construction industry and how to respond to it. In the study, a questionnaire survey was distributed to construction professionals, and 202 responses were collected. The data analysis revealed that most respondents anticipate that there will be significant impacts on the construction industry due to COVID-19. The analysis measured the impacts of COVID-19 on project finance, construction materials and equipment, labor, contracts, and rental property. The response measures recommended by the participants to overcome COVID-19 impacts included the following:

- Enforcing regulations for worker safety by the time of reopening.
- Wearing personal preventative equipment to protect from the virus such as masks, face shields, and gloves.
- Injecting stimulus funding to maintain the momentum of construction activity, and increasing spending on health care projects.
- Changing governmental development plans to reflect the impacts of COVID-19.
- Adding pandemics as one of the Force Majeure sources in the current contract forms.

In addition, the majority of respondents (68%) stated that COVID-19 should give the contractor a right to apply for time extension and cost compensation, while 27% indicated that COVID-19 impacts should allow for time extension only. The respondents also recommended accelerating reopening the economy and projects, with precautions, to avoid long recessions and to save the construction industry.

The study results should prove useful to project management in engineering and construction as guidelines in identifying the major impacts that can hinder project progress during pandemics and their relative significance, which can aid project stakeholders to identify response strategies and project managers to prioritize responses according to

impact relative significance. In addition, the results can prove useful to other countries with similar construction industry conditions, including some countries in South America and East Asia such as Venezuela, Azerbaijan, Kazakhstan, and Iran. The economy of these countries, like the economy of most countries in the Middle East, is principally oil-reliant (Bayramov and Abbas 2017; WEF 2021), and they depend mainly on oil exports to finance construction projects in the public sector, that is, the largest sector of their construction industries, which makes them also very sensitive to oil price collapses during pandemics (Duarte et al. 2006; Gause 2015). Moreover, the results can also be beneficial to occupational safety and health researchers and government officials as they provide the guidance needed to stimulate the construction industry recovery in the wake of pandemics.

## DATA AVAILABILITY STATEMENT

All data, models, and code generated or used during the study appear in the submitted article.

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