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Impact of COVID-19 on Construction Project Performance in the US

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Coronavirus disease (COVID-19), which was declared as a global health emergency by World Health Organization (WHO) had a profound impact on the construction industry. The disruptions created due to the shutdown of construction projects, manufacturing facilities, and major international transportation hubs because of the pandemic impacted the construction industry which is still unfolding. The goal of this study was to investigate the effect of COVID-19 on construction project performance using metrics previously established by the Construction Industry Institute (CII). Data was collected through surveys from construction professionals in the US across various sectors of the industry provided valuable insights about the immediate impact of COVID-19 on project performance. Project performance was measured in terms of the CII's five metrics: cost, schedule, rework, changes, and safety. Out of them, cost, schedule, and changes were significantly impacted due to the pandemic. The survey responses also revealed the measures adopted by companies to abate the effects of COVID-19 on project performance and the steps taken to enhance project performance during this period.

Key Words: COVID-19, Project performance, Cost, Schedule, Changes, Rework, Safety

Introduction

World Health Organization (WHO) identified the Coronavirus disease (COVID-19) as a global health emergency on January 30, 2020. It forced everyone to make changes to their ways of life and impacted the global economy. Filho, Brandli, Salvia, Rayman, and Platje (2020) reported that the impact of COVID-19 on the global economy will unfold gradually and is estimated to be more challenging than the financial crisis of 2007–2009. Many trends in architecture and urban design that we see today were derived from measures taken before COVID -19 to ensure the health, hygiene, and comfort of urban residents (Megahed & Ghoneim, 2020).

The rapid spread of COVID-19 cases engendered many countries to declare complete national lockdowns. Lockdown was a cautionary measure against the swift spreading virus. This decision restricted the movement of people and resulted in partial or complete shutdown of many businesses

across many sectors. The construction industry in the US was affected by statewide lockdown orders issued by different states. During this time, most construction projects and developments were postponed. The construction industry is an industry where workers are typically on-site daily to either perform construction activities or to ensure work is carried out in accordance with the plans and specifications. The extensive lockdown caused by COVID-19 disrupted the construction processes and thereby impacted project performance. Measurement of project performance is defined as a process of assessing performance relative to a defined goal (Ali & Rahmat, 2010). To ensure construction project performance satisfaction, projects are managed with the aim of meeting the required standards predetermined and expected by all stakeholders (Gyadu-Asiedu 2014). Project performance is achieved in any given project when the aim and goals of different parties involved in the project are met. Financial and non-financial metrics can be used to measure performance of construction projects.

The goal of this study was to investigate the effect of COVID-19 on construction project performance. Existing literature investigating the effect of COVID-19 has mostly utilized exploratory strategies to gather the perceptions of industry professionals (Filho et. al, 2020, Alsharif et. al, 2021, Pamidimukkala & Kermanshachi, 2021). This study, on the other hand, used a structured survey with established metrics of project performance to measure the effect of COVID-19 on construction projects. Metrics used in this study to measure performance were developed and vetted by the Construction Industry Institute (CII). The specific metrics used were cost, schedule, rework, changes, and safety. Study participants recruited from various sectors within the US construction industry were surveyed to understand the impact of COVID-19 on the construction projects' performances based on the five metrics. The respondents identified cost, schedule, and changes as the three metrics out of the five that were significantly impacted during COVID-19. While the construction companies implemented new safety protocols to ensure safety of the workers from COVID, occupational safety as a performance metric was not affected during this period. To cope with the disruptions caused due to the pandemic, respondents reported practicing more off-site construction to make it easier to abide by safety guidelines and enhance quality and productivity.

Literature Review

According to Associated General Contractors of America (2021), the construction industry is comprised of over 680,000 employers with over 7 million employees and produces nearly \$1.3 trillion worth of structures each year. Historically, changes from the original contract's time and cost are considered cardinal performance measurement metric (Konchar & Sanvido, 1998). Measuring construction project performance is an integral part of project management/project controls process. Gransberg and Buitrago (2002) explained that the metrics focused on changes from the original contract's time and cost are well known, however they suffer from lack of clarification regarding project success. They are generally represented as either a positive or negative percentage of original contract requirements, but they do not indicate the reason for the change from original, nor do they assign responsibility for that change.

Measurement metrics can be beneficial to companies; performance measurement over time assist managers to identify explanatory reasons for good/poor performances. Also, measurement metric is useful to track the implications of certain managerial and technological implementations. With a standard and acceptable performance metrics, companies can compare their policies and procedures with peers/competitors to improve their own efficiency and become more competitive. Despite the importance attached to measuring project performance in the construction industry, several researchers and experts have identified shortcomings attached to the different approaches to

performance measurement and doubt whether the primary purpose of the measurement would be eventually achieved if implemented. Some researchers believe performance should be measured at the company level, while others believe performance should be measured at the project level. Traditional benchmarking models were developed for the manufacturing industry and are difficult to adapt to the construction industry due to the nature of industry participants, projects, and methods of execution. (Lee, Thomas, & Tucker, 2005).

Gyadu-Asiedu (2014) pointed out different problems associated with existing performance assessment philosophies, concepts, and paradigms. He identified problems with success/failure definition, problems with the performance assessment procedure, and problems with the use of lagging measures. Various studies have provided strong evidence indicating a causal linkage between the application of performance measurement and business excellence. To enhance productivity and quality in the construction industry, an acceptable way of measuring performance must be implemented. To resolve the controversies surrounding project performance, the Rethinking Construction report (Egan, 1998) suggested rethinking: capital cost, construction time, predictability, defects, accident, productivity and turnover, and profit as a set of suitable performance measurement metrics. Additionally, institutes such as the Department of Environment, Transport, and Regions (DETR) and the Construction Industry Institute (CII) have developed metric to measure performance suitable for their own assessments. The DETR suggested cost, quality, time, client satisfaction, change order, business performance, and health and safety, while CII proposed cost, schedule, rework, change order, and safety (Kpi Group, 2000).

Performance Metrics

The CII benchmarking and metrics (BM&M) was created in 1995 with four main goals: (1) to establish a common set of metric definitions in the construction industry, (2) to provide performance norms to the industry, (3) to quantify the use and value of best practices, and (4) to help focus CII research and implementation efforts (Costa, Formoso, Kagioglou, Alarcón, & Caldas, 2006). The performance metrics regarding cost, schedule, safety, changes, and rework in the construction industry have been studied since 2001 by researchers in academia and industry. Previous research carried out on performance measurement has shown that performance measurements can be done in terms of financial and non-financial measures, or the combination of both. This study focused on the impact of COVID-19 on project performance at the project level using the CII metrics, which are designed to measure at the project level. These metrics have been vetted and established as robust metrics to measure project performance over the years.

COVID 19 and Project Performance

The construction industry professionals have experienced various degrees of impacts due to the COVID-19 depending on the local and state responses to the pandemic. The construction industry members will need to address both short-term and long-term challenges posed by COVID-19.

According to Occupational Safety and Health Administration (2020), the COVID-19 exposure risk levels associated to various construction tasks vary. Low exposure risk tasks are associated with tasks where employees remain six feet apart with little contact with the public, visitors, or customers. Construction tasks associated with medium exposure risks are tasks that require workers to be within six feet with customers, visitors or public. Entering an indoor site occupied by someone suspected of having or known to have COVID-19 is regarded as high exposure risk level. It is worthy to note that, offsite construction is especially beneficial in the fight against COVID-19 due to its capability for

rapid delivery of projects, decentralized working system, and reduced dependencies between project activities (Gbadamosi, Oyedele, Olawale, & Abioye, 2020).

The impact of the COVID-19 on the US construction industry created immediate effects. Faced with cancelled projects, supply chain disruption, and uncertainties due to pandemic, approximately 40% of U.S. construction firms reported layoffs by the end of April 2020 (Engineering.com, 2021). Three suggested actions for post COVID-19 era success from industry experts are:

- Fortify supply chains; recognize vulnerabilities and find options to counter them before being faced with a shortage.
- Readjust business priorities; capital and resources may need to be deployed elsewhere.
- Consider preassembly options; a controlled environment provides numerous benefits.

Research Method

This study adopted a survey method to collect data from construction professionals comprising of construction managers, cost estimators, project managers, superintendents, and project engineers in the United States. For this study, construction managers and project managers were listed as two distinct roles. Construction managers are those contracted by the project owner and represents their interest (CMAA, 2020) while project managers are employees of the general contractor assigned to a project (PM.com, 2020). They were selected based on their roles and involvement in construction operations and day-to-day activities on the job site. According to the U.S. Bureau of Labor Statistics (2021), the U.S. construction industry consist of 476,700 construction managers, 214,200 cost estimators, 288,451 project managers, 209,346 superintendent and 211,595 project engineers. Convenience sampling was implemented to identify possible participants by job title from the researchers' U.S. LinkedIn network. The industry professionals were then recruited using the LinkedIn email and direct message features. Regional or state location was not a consideration for this study due to the national impact of COVID-19 on the construction industry.

An online questionnaire was created and sent to participants who were assured of confidentiality and anonymity in their feedback. Given the metrics for this study were established and vetted by CII and the questions about actions taken aligned with previous industry research (Engineering.com, 2021), the questionnaire used for this study was not independently vetted. The questionnaire included four sections with different types of questions: one with demographic questions, one with Likert scale questions, and two with 'yes' or 'no' questions. The first section consisted of three demographic questions about the participants role in the industry; number of years in the industry; and sectors of projects. In section two, questions were designed using the CII metrics (cost, schedule, safety, rework, and changes) and asked participants to identify the impact of COVID-19 on the company's projects being constructed during the pandemic. A Likert scale of 1-5 was used with 5 being 'most significant impact'; 4 being 'fairly significant impact'; 3 being 'significant impact'; 2 being 'slightly significant impact'; and 1 being 'no impact'. The following CII definitions were provided for each metric:

- Cost - Expense incurred by a contractor for labor, material, and equipment
- Schedule - Project schedule outlines project milestones and activities involved in construction sequentially.
- Rework - Act of redoing or correcting work that was not carried out effectively the first time and prevalent on construction job sites.
- Safety - State of being safe, freedom from the occurrence/risk of injury, danger, or loss.
- Change - Refers to work deleted or added to from the original scope of work of a contract, which changes the original contract amount and/or completion date.

Section three was designed to collect data about the different construction methods and processes that the company may have implemented to keep workers safe and healthy to abate the effects of COVID-19 on project performance. Participants were provided with the list shown in Table 3 and were asked to answer ‘yes’ or ‘no’ if the new measure was implemented. In section four participants were asked to respond ‘yes’ or ‘no’ to the 10 questions shown in Table 4 about project performance monitoring strategies and on-site changes made due to COVID-19.

A total of 209 surveys were sent and 94 responses recorded, indicating an initial response rate of 45%. The process of cleaning the data was implemented to detect and correct any errors in the database. The data from this study was cleaned to identify and delete any incomplete data within the dataset, as a result the responses from nine participants were identified as incomplete and thus deleted reducing the response rate to 41%. The remaining data was then organized and analyzed using descriptive statistics.

Findings

Table 1 shows the background information of the participants. Among the respondents, a little more than one third were project managers, and the remaining were project engineers, cost estimators, superintendents, and construction managers. More than half of the respondents had between five to 10 years of industry experience (Table 1). The respondents had experience of working in various sectors of the construction industry such as multifamily residential, institutional, commercial, etc. Almost one third of them had experience of working in the commercial sector, and the others worked in the multifamily residential, institutional, infrastructure, and healthcare (see Table 1).

Table 1

Background information of the participants

	Categories	N (%)
Participants' Titles	Project Manager	30 (35)
	Project Engineers	18 (21)
	Cost Estimators	17 (20)
	Superintendent	15 (18)
	Construction Managers	5 (6)
Participants' number of years in the industry	5-10 years	45 (53)
	Less than 5 years	24 (28)
	Over 10 years	16 (19)
Participants' company sectors	Commercial	27 (32)
	Commercial & Multifamily residential	16 (18)
	Multifamily residential	15 (18)
	Infrastructure and Heavy construction	11 (13)
	Healthcare	9 (11)
	Institutional	7 (8)

This study included five of the construction sectors in the United States but combined the sectors into one group to reflect the design of items in Table 3 and Table 4. Six sectors were available to select from with one being a combination of Commercial and Multi-family Residential as shown in Table 1. Measures adopted to abate for the impact on project performance, and measures adopted to enhance project performance were designed by industry experts as post COVID-19 strategies for all sectors to practice in the evaluation of project performance.

Followed by the background information, the survey requested the participants to select the CII performance metrics (cost, rework, schedule, changes, safety) based on how those were impacted on the company's projects being constructed during the pandemic. The CII metrics were implemented because they were designed to measure performance at project level not company level and performance was measured at the project level for this study. Project level metrics provide an effective way to evaluate project process and guides project objectives with the aim of tracking performance and enhances improvement when needed (Sham, 2013). Table 2 shows the impact of the pandemic on each performance metric according to the participants in the study. Thirty of the 85 participants (35%) selected cost as the metric most significantly impacted by COVID-19. Whereas on the other end of the scale, 28 participants (33%) selected safety as the metric for which there was no significant impact because of COVID-19. It is worth mentioning here that safety as performance metric specifically refers to occupational accidents and incidents on projects. Based on Table 1, if the levels of impact are categorized into two groups: more significant (combining 'most significant', 'fairly significant', and 'significant') and less significant (combining 'slightly significant' and 'not significant'), then "change of project scope" appears to be the metric most significantly affected (62% respondents). The other significantly affected metrics were schedule (54%) followed by cost (53%). Safety remained the least impacted metric (39%).

Table 2

Impact on performance metrics due to COVID (five-point Likert scale)

Performance Metrics	Level of Impact				
	Most Significant N (%)	Fairly Significant N (%)	Significant N (%)	Slightly Significant N (%)	Not Significant N (%)
Cost	30 (35%)	10(12%)	13(15%)	19(22%)	13(15%)
Rework	21(25%)	11(13%)	15(18%)	23(27%)	15(18%)
Schedule	16(19%)	27(32%)	11(13%)	16(19%)	15(18%)
Changes	13(15%)	15(18%)	34(40%)	9(11%)	14(16%)
Safety	5(6%)	22(26%)	12(14%)	18(21%)	28(33%)
Total (%)	85 (100%)	85 (100%)	85 (100%)	85 (100%)	85 (100%)

Table 3 presents the responses to the dichotomous questions asked about the measures implemented to abate the effects of COVID on project performances. The measures had been recommended by industry experts and represent seven actions for project success in the future (Engineering.com, 2021). Practicing more off-site construction to achieve a controlled environment to make it easier to abide by safety guidelines, quality enhancement and to increase productivity is the most effective measure to reduce impact of COVID-19 on project performance. The fortification of supply chain process through the identification of vulnerabilities and finding options to counter them before being faced with a shortage was identified as the least applicable measure needed to subside COVID-19's impact on project performance.

Table 3

Measures taken by companies to abate the effects of COVID-19 on project performance

Adopted measures	Yes N (%)	No N (%)
Practicing more off-site construction to achieve a controlled environment to make it easier to abide by safety guidelines, quality enhancement and to increase productivity.	74 (87%)	11 (13%)
Incorporation of new safety protocols.	69 (81%)	16(19%)
Investing in employees and the company culture by providing and training employees on new tools and technologies.	63 (75%)	22 (25%)
Preparing allocation of resources across projects with the ability to quickly identify and respond by incorporating technologies with real-time transparency.	62 (73%)	23 (27%)
Fortification of the supply chain process through the identification of vulnerabilities and finding options to counter them before being faced with a shortage.	60 (70%)	25 (30%)

Due to page limitations, only the top six measures implemented by participants to enhance project performance are shown in Table 4. The questions were designed to collect project level data from the company with the expectation that participants may not have the responsibility to initiate or perform the measures but would have knowledge as to whether the measures were taken by the company. According to survey analysis, making changes to jobsite rules in response to COVID 19 guidance is the highest rated measure to ensure performance is attainable. The complete list of questions and results are available upon request.

Table 4

Measures taken by companies to enhance project performance during COVID-19 disruptions

Adopted measures	Yes N (%)	No N (%)
Did you make changes to jobsite rules in response to COVID 19 guidance?	75 (88%)	10 (12%)
Do you have to revisit contract terms around delays, unforeseen circumstances, excusable conditions, time extension, and liquidated damages?	71 (84%)	14 (16%)
Do you perform scheduled or time impact analysis, which include the examination of the status of material procurement to identify potential delays in the schedule?	70 (82%)	15 (18%)

Do you understand the resourcing trend on a real-time basis to be able to forecast changes to productivity compared to the plan?	61 (72%)	24 (28%)
Did you assess the cost impact of the reduced workforce, enhanced cleaning, and other modification germane to COVID 19 guidance?	60 (71%)	25 (29%)
Did you review insurance policies to understand whether the impact caused by pandemic (COVID-19) on construction programs is covered?	60 (71%)	25 (29%)

Conclusions

Data collected from participants in this study provided valuable insight about the immediate impact of COVID-19 on project performance related to cost, rework, schedule, changes, and safety. The study also revealed the measures adopted by companies to abate the effects of COVID-19 on project performance and the measures adopted to enhance project performance due the disruption caused by the pandemic. As might be expected, all participants reported COVID-19 had a significant or greater impact on cost, rework, schedule, and changes. The shutdown of construction projects, manufacturing facilities, and major international transportation hubs during the early months of the pandemic in 2020 slowed or stopped projects across the country. Once the lockdown was lifted and projects restarted many were operating with a reduced workforce due to CDC guidelines and the high infection rate among workers. The disruption impacted the workforce and supply chain, which had a direct impact on project performance. Seventy percent (70%) of participants reported that measures were adopted to fortify the supply chain process through the identification of vulnerabilities and options to counter them before being faced with a shortage. However, the adoption of measures to enhance project performance was less with 63% of participants completing a proactive analysis of efficiency impacts due to labor shortages and 65% completed a risk analysis on disruptions to the supply chain. Due to the inherent nature of the construction industry's reliance on a project-based supply chain the impact of COVID-19 on project performance was significant.

In contrast to cost, rework, schedule, and changes, only 46% of participants reported COVID-19 had a significant or greater impact on project performance. Keeping in mind that project performance is measured across the duration of a project, 87% adopted measures to practice more off-site construction to make it easier to abide by safety guidelines and 81% incorporated new safety protocols. Also, 88% of participants made changes to jobsite rules in response to CDC guidelines.

While the study revealed findings from companies working across a variety of construction sectors, it was limited in two areas. First, it was limited to US construction companies and did not consider the impact of COVID-19 on project performance in other countries. Also, all the survey questions were closed ended and did not provide participants with the opportunity to elaborate on their responses. Future research that includes international companies could provide useful comparisons and insights related to project performance metrics. However, this study revealed the immediate impact of COVID-19 on US project performance and provided insight into steps taken to abate the impact and enhance project performance. It appears that the measures adopted related to safety on the project may have reduced the impact of COVID-19 on that metric. Whereas the cost, rework, schedule, and changes metrics can be linked to the workforce and supply chain shortages. Lessons learned from the impact of COVID-19 on the workforce and supply chain could change how the industry manages both in the future.

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