Strategic Mitigation of Cost & Time Overruns Due to COVID-19 on SCOR-Based Processes in Construction Supply Chain Management

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School of Civil and Environmental Engineering (SCEE)

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DEDICATION

I dedicate this thesis to my loving family, whose unwavering support and encouragement have been the cornerstone of my academic journey. To my parents, who sacrificed so much to provide me with the best education possible, I am eternally grateful for your endless love and belief in my abilities. Your guidance and wise counsel have shaped me into the person I am today. I also extend my heartfelt appreciation to my dedicated supervisor, Dr. Khurram Iqbal Ahmed Khan, whose expertise, guidance, and patience have been invaluable throughout this research endeavor. Their unwavering support and constructive feedback have pushed me to reach new heights and expand my intellectual horizons. Additionally, I would like to express my gratitude to my friends Usman, Maria, Yasir, Saad, Filzah, Sana, Jaleel, Noman, Rushaan, Hassan, Athar, Arsalan, Talha, Abdullah, Shehzad, Hannan and peers, who have provided unwavering support, stimulating discussions, and countless moments of laughter during this academic journey.

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ABSTRACT

An unparalleled level of difficulty and threat has been posed to construction industry and its supply chain by the COVID-19 pandemic. Overall, the pandemic has caused major disruptions to the construction supply chain, leading to delays and increased costs. The aim of this study is to provide an insight into strategic mitigation of cost and time overruns due to COVID-19 on SCOR-based processes in construction supply chain management. A multiphase research methodology was adopted by the researchers, starting with the literature review and questionnaire survey with 66 construction professionals to shortlist factors affecting construction supply chain due to COVID-19. Semi-structured interview consisting of pre and post strategic implementation impact on cost and time in terms of Likert scale and open-ended question against each factor was developed, asking for the mitigation measures and strategies that the construction companies has implemented to minimize the impact of identified factors. Results show that the pandemic has caused a total of 13 impacts to the construction organizations which were further grouped under five SCOR processes namely plan, source, make, deliver and return. Factors that severely impacted the construction supply chain are shortage of material, operations shutdown/production shutdown, labor shortages, disrupted transportation, border restrictions/closure of ports, disruption in logistic services and product/material price increase. The findings of the study show a considerable level of mitigation by the proposed strategies which is also reflected by the quantitative data. This provides useful insight for construction professional to adopt proactive measures to manage the existing projects in the light of continued pandemic or to minimize such impacts in case of any upcoming unseen pandemic. In essence, the authors' contribution lies in establishing a basis for investigating how the COVID-19 pandemic has affected projects and the supply chain in the construction industry, thus expanding the existing body of knowledge.

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CHAPTER 1: INTRODUCTION

1.1. Background Study

Construction industry is a significant contributor to the gross domestic product (GDP) of many countries, accounting for a substantial portion of economic activity worldwide (Crosthwaite, 2000). Impact of this sector on global economic development is exceptional, with the construction industry comprising approximately 13% of the global GDP. Additionally, it is the biggest employer in maximum countries, providing employment for around 7% of the combined global workforce. Recent data shows that worldwide construction spending in 2018 amounted to nearly $10 trillion and is projected to reach $14 trillion by 2025, according to a survey. (McKinsey & Company, 2017) but now due to the outbreak the projected spending will obviously see a decline. Construction as it seems is not just a simple process of building rather it's a much more complex task consisting of interconnected activities that require an efficient supply chain, a delay in the availability of any required material would ultimately delay the whole project. There is a widely accepted understanding that supply chain disruptions can cause significant harm to businesses, and it is generally believed that responding swiftly to such disruptions can help mitigate their negative impact (Bode & Macdonald, 2017).

The COVID-19 virus was first discovered in China in December 2019 in the city of Wuhan and has since spread globally, greatly impacting the world economy. The World Health Organization (WHO) declared it a pandemic, but a permanent solution has yet to be found (L.P.D.S, 2020). After the COVID-19 outbreak was declared a pandemic, numerous countries enforced a complete national lockdown due to a significant increase in COVID-19 cases. This resulted in limitations on people's movements and the complete closure of several businesses across various sectors. The construction industry, which is a major contributor to economic growth, was also shut down entirely. As a result, all construction projects and developments have been postponed until further notice (D. Y. Gamil & Alhagar, 2020). Supply chain is a series of interlinked activities that involves planning, coordinating, and managing the flow of materials, parts, and finished goods from suppliers to customers. The construction industry worldwide has been greatly affected by the COVID-19 pandemic, underscoring the significance of effectively responding, adjusting, and implementing crisis management strategies to navigate through unpredictable circumstances. In the initial stages of the pandemic, acute restrictions and lockdowns created urgent situations for construction

supply chains that required immediate attention. Nevertheless, numerous companies have now transitioned into a "recovery mode" and are actively strategizing for the long term. As organizations endeavor to enhance their operations and bolster business resilience, the importance of supply chain resilience and risk management has become increasingly evident, surpassing previous levels of recognition. (Mattias Hedwall, 2020). The supply chains (SC) have faced unparalleled challenges due to the COVID-19 pandemic (Ivanov, 2021). The construction materials shortage due to the pandemic had a significant impact on construction industry. It's crucial to take into account the impact caused by the crisis, both at its initial stages and final stages, in order to effectively prepare for any potential future disruptions and gain valuable insights for future contingency planning. (D. Y. Gamil & Alhagar, 2020).

SCOR, which stands for the Supply Chain Operations Reference model, is a tool created by Supply Chain Council. It serves as a management tool for addressing, enhancing, and communicating decisions related to supply chain management. The model describes the necessary business processes to meet customer demands, and it also provides an overview of the processes involved throughout the entire supply chain. SCOR serves as a basis for improving these processes. The framework of SCOR is based on five key areas of the supply chain:

- Plan
- Source
- Make
- Deliver
- Return

The plan process entails efficiently allocating resources to create plans that align with the demands of a supply chain and its diverse activities, encompassing sourcing, production, delivery, and returns. The sourcing process primarily revolves around effectively managing the procurement, delivery, receipt, and transfer of raw materials, subassemblies, products, and services. The make function encompasses the processes that convert products into their final state, while the deliver function involves the management of finished goods and services, which includes order management, transportation management, and distribution management. Lastly, the return process encompasses post-delivery customer support and

processes associated with product returns or receiving returned items. Each of these components is crucial, serving as both an essential intra-organizational function and a critical inter-organizational process (Lemghari et al., 2018). The SCOR model is a tool for mapping material flows and measuring supply chain performance. The SCOR framework was chosen because of its standardized metrics and processes, for measuring supply chain performance and mapping material flows. It is a useful tool for identifying supply chain components, measuring performance, and improving operations. Its well-defined processes and metrics make it a popular choice for organizations to optimize their supply chain operations (Thunberg & Persson, 2014).

1.2. Previous Studies

Supply chain performance has become a crucial concern in diverse industries within today's highly competitive business landscape. The measurement of supply chain performance is widely acknowledged as a fundamental aspect of effective supply chain management. (Balfaqih et al., 2016). The construction industry worldwide has been greatly affected by the COVID-19 pandemic, underscoring the significance of effectively responding, adjusting, and implementing crisis management strategies to navigate through unpredictable circumstances. In the initial stages of the pandemic, acute restrictions and lockdowns created urgent situations for construction supply chains that required immediate attention. Nevertheless, numerous companies have now transitioned into a "recovery mode" and are actively strategizing for the long haul. As organizations endeavor to enhance their operations and bolster business resilience, the importance of supply chain resilience and risk management has become increasingly evident, surpassing previous levels of recognition (Mattias Hedwall, 2020). To prevent potential legal disputes, contractors should assess the impact of COVID-19 on their projects in terms of time and costs and draft appropriate contracts that consider these issues in the future (Sierra, 2022). In various construction industries around the world, time and cost overruns are a critical issue (Apolot et al., 2011). Studies show that many construction projects face issues such as cost overrun and time overrun (Shi et al., 2001). Such issues are some of the most common and challenging problems faced by construction projects globally, causing negative impacts on project success and conflicts among project parties (Abd El-Razek et al., 2008). The construction industry faces significant challenges related to cost and time overruns, which are prevalent issues across various construction projects around the globe (Y. Gamil et al., 2019). Cost and time overruns have emerged as a significant challenge for construction projects worldwide. They result in wastage and missed opportunities for all involved parties, causing significant

negative impacts on project success (Haslinda et al., 2018).

Many construction projects exceed time and budget (Seddeeq et al., 2019). Effective stakeholder management is a critical factor in delivering successful construction projects. However, the capacity to accomplish effective stakeholder management in the construction industry relies on comprehending the interdependencies between critical success factors (CSFs) for stakeholder management and their correlation with project success (PS) (Molwus et al., 2017). Supply chain management encompasses a wide range of activities, functions, components, and role-players (D. du Toit, 2014). A study has suggested that one of the six key steps in the stakeholder engagement process is to measure performance. The outcome of the study reflects that to achieve sustainability-related goals, it is crucial to understand the diverse sustainability agendas of stakeholders and emphasize measuring their performance by using key performance indicators in any stakeholder engagement process (Bal et al., 2013). In order to determine the effectiveness and efficiency of a supply chain (SC), it is essential to utilize performance measures and metrics. The success of a business or SC is reliant on the accuracy of its performance measurement, highlighting the importance of an effective performance measurement system in SCs to ensure that the correct aspects are measured at the appropriate time (Jagan Mohan Reddy et al., 2019). All activities in SCM involve many stakeholders (Asrol et al., 2021). According to a study, the construction sector's key stakeholders, including designers, architects, contractors, engineers, builders, building material suppliers, and the construction firms need to prepare strategically to thrive in the face of disruptions such as the COVID-19 pandemic (Osuizugbo, 2020). With the pandemic affecting the construction industry, identifying underlying issues caused by COVID-19 is crucial to reducing its impact. Hence, it is crucial to prioritize assessing the impact of COVID-19 and formulating strategies to mitigate the challenges it poses within the building construction industry. The study gathered data by conducting individual interviews with 20 contractor companies involved in building construction projects (Zamani et al., 2021). This study presents the results of collected data including interviews with construction project stakeholders so the proposed strategy will use the similar approach. However, no study has been found that assesses the performance of supply chain management in the context of SCOR in construction industry during the situation of COVID-19. Moreover, with the upcoming waves of COVID-19 and other pandemics, there is a need to assess and present strategic mitigation to minimize the losses in construction supply chain management in future.

1.3. Research Gap

Because the topic is new or uncommon, this research discovered a lack of academic studies that were specifically centered onto the major impacts of COVID-19 in context of cost and time overruns on individual SCOR based levels of supply chain and that help mitigate such impacts in next wave of COVID-19, or in any other global pandemic situation. Therefore, the research is pertinent and timely, as it delivers the primary scoping review on how COVID-19 has affected SCOR-based processes in construction supply chain management in terms of cost overruns & time overruns. In situations of crisis, where there is a lot of uncertainty and the possibility of negative consequences, it is important to develop new strategies to ensure survival. The time of crisis can endanger an organization's future and require immediate and effective measures to address the challenges posed by the new environment (Fonseca & Azevedo, 2020). To measure the efficiency and efficacy of a supply chain (SC), it is important to utilize performance measures and metrics. Additionally, effective performance measurement is a crucial factor for the success of any SC or business. Therefore, an effective performance measurement is required to measure the right thing at right time (Jagan Mohan Reddy et al., 2019) especially in the context of supply chain and COVID-19. The global construction industry has experienced substantial repercussions due to the COVID-19 pandemic, underscoring the significance of promptly responding, adapting, and establishing crisis management mechanisms to navigate through periods of uncertainty. In the initial stages of the pandemic, acute restrictions and lockdowns created urgent situations for construction supply chains that required immediate attention. Nevertheless, numerous companies have now transitioned into a "recovery mode" and are actively planning for the long term. As organizations endeavor to strengthen their operations and enhance business resilience, the importance of supply chain resilience and risk management has become more evident than ever before (Mattias Hedwall, 2020). The construction industry is currently implementing various strategies to mitigate the impact of the COVID-19 pandemic on its operations and workers. However, it is crucial to identify the most effective strategies for addressing the pandemic's effects in the short term while also developing response and recovery plans for the long term. As the construction industry grapples with the impact of the pandemic, government agencies are considering revising their policies to provide assistance to construction organizations (Raoufi & Fayek, 2021). The Supply Chain Operations Reference (SCOR) model, developed by the Supply Chain Council, is a valuable tool used for addressing, improving, and communicating decisions related to supply chain management. This model outlines the necessary business processes to

meet customer demands and offers an overview of the processes involved across the entire supply chain. SCOR serves as a foundation for enhancing these processes. The framework of SCOR is built upon five key areas of the supply chain: plan, source, make, deliver, and return. Each of these components is considered vital both as an intra-organizational function and a critical inter-organizational process (Lemghari et al., 2018). The SCOR model serves as a valuable tool for mapping material flows and assessing the performance of supply chains. Its selection is based on the utilization of standardized processes and metrics, which enable the measurement of supply chain performance and the mapping of material flows in a consistent and comprehensive manner (Thunberg & Persson, 2014). The COVID-19 pandemic has highlighted the weaknesses and inefficiencies of the construction industry and it presents an opportunity for the sector to become more productive, resilient, and better prepared for future crises. Therefore, there is a need for studies to identify the specific challenges and issues faced by construction industry in different regions, explore opportunities, and identify appropriate mitigation measures. However, there is a lack of discussion on what mitigation measures and strategies must be implemented based on lessons learned from these challenges. Some experts suggest that it is essential to reassess the current supply chain and develop appropriate strategies to enhance preparedness and mitigate future supply chain disruptions (Choi et al., 2021). It is important to consider that COVID-19 is not the first, and it won't be the last pandemic we will face (Fonseca & Azevedo, 2020). The current response to the COVID-19 pandemic is insufficient, and there are still many challenges and risks that need to be addressed (Butt, 2021). This study will mainly focus on the macro-processes of SCOR i.e., plan, source, make, deliver and return for performance measurement.

1.4. Problem Statement

With the impacts on management processes in construction supply chain due to pandemic outbreak of COVID-19, current literature shows a major gap of study for assessment of construction supply chain management in the context of SCOR model. Moreover, the construction managers lack any strategy to deal with the impacts of COVID 19 on construction supply chain. No study has been found to consider various stakeholders' perspective of business and supply chain impacts. Not only such impacts on supply chain are needed to be assessed but there is a need to provide mitigation strategies to deal with such situations.

This study addresses the following question under consideration:

What are the major COVID-19 pandemic's impacts on construction supply chain management processes and what could be the solutions to such problems in current and upcoming unseen pandemics?

In this context, the question of assessment of CSCM processes after the outbreak of COVID-19 are targeted to be addressed in the current research. Moreover, author will try to find out the impacts and reasons of changes occurred in management processes of construction supply chain. SCOR processes will be used to assess and define the degree of impacts of COVID-19 on various levels of CSCM.

1.5. Research Objectives

- To identify major impacts focused on cost and time overruns during COVID- 19 on Construction Supply Chain Management.
- To analyze the identified impacts in relation to SCOR-based impact fields in post COVID-19 construction supply chain processes.
- To develop a mitigating strategy to minimize such impacts in future pandemic situations.

1.6. Significance of Study

The exacerbation of the crisis posed by the COVID-19 pandemic due to the impacts on the supply chain serves as a strong motivation for conducting this research. Our goal is to assist companies in enhancing their preparedness for the future, enabling them to navigate potential challenges more effectively. This research is also important because it is the first to analyze the impacts on SCOR-based processes in CSCM. It is also the first research to link the impacts of the pandemic to SCOR model and construction supply chain management. This research aims to support the key stakeholders in the construction supply chain by highlighting the primary areas affected within the SCOR model. Furthermore, it was deduced, as stated by (Johnson et al., 2020), that a significant issue lies in our failure to learn from previous pandemics. Consequently, we have not effectively consolidated our understanding of the impacts and the preventive measures that can be implemented (Roque et al., 2021).

The advantages of this study for the construction industry will be that it will identify reasons that cause cost and time overrun in Supply Chain SCOR processes due to COVID-19. As stated by (Bastas & Liyanage, 2018), implementing continuous improvement methods and concepts across the links of a supply chain can enhance its performance. Thus, tracking the performance of supply chains through performance measures has become a critical aspect of the management process. This study will result in the development of mitigating strategy to minimize such impacts in future pandemic situations.

1.7. Thesis Organization

1.7.1. Chapter 1

The introduction chapter includes background study, previous studies, research gap, problem statement, research objectives, and significance of study.

1.7.2. Chapter 2

This chapter includes literature review comprising of introduction of construction industry and COVID-19. Impacts of pandemic on construction industry, supply chain and Pakistan. It also consists of the factors affecting construction supply chain due to COVID-19.

1.7.3. Chapter 3

This chapter includes methodology of study. It also includes the development of the questionnaire survey, respondents' population, data analysis and finalization of issues and challenges.

1.7.4. Chapter 4

This chapter comprises of data collection and analysis followed by results and discussion of the findings.

1.7.5. Chapter 5

This chapter concludes the findings of the study followed by future recommendations and limitations of the study.

CHAPTER 2: LITERATURE REVIEW

2.1. Construction Industry and COVID-19

The construction industry plays a substantial role in contributing to the gross domestic product (GDP) of many countries, accounting for a substantial portion of economic activity worldwide (Crosthwaite, 2000). The impact of this sector on global economic development is exceptional, with the construction industry comprising approximately 13% of the global GDP. Additionally, it is the largest employment creator in most of the countries, providing employment for around 7% of the global workforce. Recent data shows that worldwide construction spending in 2018 amounted to nearly $10 trillion and is projected to reach $14 trillion by 2025, according to a survey. (McKinsey & Company, 2017) but now due to the outbreak the projected spending will obviously see a decline. Construction as it seems is not just a simple process of building rather it's a much more complex task consisting of interconnected activities that require an efficient supply chain, a delay in the availability of any required material would ultimately delay the whole project. There is a widely accepted understanding that supply chain disruptions can cause significant harm to businesses, and it is generally believed that responding swiftly to such disruptions can help mitigate their negative impact (Bode & Macdonald, 2017). The construction sector encompasses a diverse range of activities that include the construction, maintenance, renovation, and demolition of buildings, as well as works executed in civil engineering projects such as roads and utility systems. This industry encompasses various segments, such as architecture and design, fabrication of equipment and materials, transportation, and energy and waste management (Demissew, 2020). The construction industry has the potential to significantly contribute to revenue production and poverty reduction. This is due to its labor-intensive nature and close ties with other economic sectors, which creates significant job generation opportunities. However, while the construction sector can provide employment for a large number of people, these jobs are not always secure and working conditions can vary widely across the world (King et al., 2021).

COVID-19 is an acronym derived from "Coronavirus Disease 2019," denoting the specific illness caused by the SARS-CoV-2 virus (Severe Acute Respiratory Syndrome Coronavirus 2). (Roque et al., 2021). The outbreak, which originated in Wuhan, China, in December 2019, has escalated into a massive global threat to human health. On 11th March 2020, the World Health Organization (WHO) declared this outbreak as a pandemic. The virus transmits by droplets emitted during coughs and exhales, these droplets may spread on

nearby surfaces and infect nearby individuals (Wang et al., 2020). Individuals are at high risk, such as those that have medical conditions including high blood pressure, heart and lung diseases, diabetes and cancer are susceptible to developing serious diseases because of the virus. However, anyone, regardless of age or health status, can get COVID-19 and suffer severe illnesses and even death (WHO, 2021). As of February 2023, more than 757 million people got infected from COVID-19 resulting in more than 6.8 million people fatalities worldwide (World Health Organization Dashboard, 2023). In past global supply chains have faced other disease outbreaks and epidemics such as Middle East Respiratory Syndrome (MERS), Zika virus and Ebola in the past. However, they are currently experiencing the impact of another catastrophic and rapidly spreading pandemic known as COVID-19 (Chigozie Victor Ndukwe, Jinyun Liu, 2021). COVID-19 is not the first pandemic in history and will not be the last one humanity will ever experience (Fonseca & Azevedo, 2020).

2.2. Impact of COVID 19 on Construction Industry

The global COVID-19 pandemic has had a profound impact on the construction industry, underscoring the criticality of promptly responding, adapting, and implementing crisis management mechanisms to navigate through periods of uncertainty. In the initial stages of the pandemic, acute restrictions and lockdowns created urgent situations for construction supply chains that required immediate attention. However, numerous companies have transitioned into a "recovery mode" and are now directing their efforts towards long-term planning. As organizations work to reinforce their operations and enhance business resilience, the importance of supply chain resilience and risk management has become increasingly evident, surpassing previous levels of recognition (Mattias Hedwall, 2020). The COVID-19 pandemic has posed danger to supply chains (SC) on an unexampled scale (Ivanov, 2021). The shortage of construction materials due to the pandemic had a significant impact on the construction industry. Therefore, it is crucial to take into account the impacts of the crisis at both its onset and conclusion. This approach allows for adequate preparation to mitigate potential future disruptions and enables the acquisition of valuable lessons for future planning purposes (D. Y. Gamil & Alhagar, 2020). Contractors face the ongoing challenge of managing project costs and cash flow, with access to cash being a major concern during the COVID-19 pandemic. COVID-19 has disrupted project schedules in many areas and increased the total cost and time of construction projects, with time being the main driver of cost. The implementation of new health and safety procedures, coupled with supply chain delays and disruptions in subcontractor work, has necessitated additional investments and caused delays in construction projects. Consequently, these factors have led

to an average reduction of 20% in on-site productivity. COVID-19 has also heightened the risk of insolvency and cash flow reduction for both general contractors and subcontractors. These stakeholders may face challenges in receiving timely payments, further exacerbating their financial stability and liquidity. The global supply chain has been severely disrupted, making it difficult to obtain key construction materials and materials necessary for hygiene and safety requirements. This has caused delays and price increased due to limited product availability and disrupted logistics (Sierra, 2022). To mitigate the spread of the virus, many construction organizations implemented travel bans and temporarily suspended operations at construction sites and offices. This proactive approach aimed to prioritize the health and safety of employees and stakeholders during the pandemic. However, this has resulted in significant disruptions to project delivery, and the impact of job losses is expected to be felt in the short, medium, and long term. The pandemic has also had potential impacts on the South African CI, including loss of revenue, economic decline, and business interruption (Aigbavboa et al., 2022). The pandemic has disrupted the stability of the construction sector in unexpected ways, with long-term effects that will be felt for decades to come. The sector has experienced supply chain disruptions, funding delays, legal issues, and increased expenses due to the need for jobsite sanitization, higher material prices, and lack of public transportation. The absence of foreign expertise and insolvencies of contractors have further complicated matters, leading to the suspension or slowing down of several projects. COVID-19 has also increased the risk of insolvencies in the construction sector, as project funding has been interrupted and expenses have continued to rise. Contractors are facing higher expenses for issues such as frequent sanitization of offices and construction sites, disrupted supply chains, higher material prices, and reduced labor productivity due to mental stresses and working in multiple shifts (Ayat et al., 2022). The COVID-19 outbreak has had a significant impact on construction markets globally, causing disruptions in supply chains, restrictions on the workforce, and changes in legislation. The pandemic has particularly affected building material prices, safety management measures, construction labor, contract interpretation, risk management practices, construction materials, and construction subcontractors (Al-Mhdawi et al., 2022).

The COVID-19 pandemic has had a significant impact on the construction industry, with a notable percentage of engineering offices experiencing varying degrees of impact. Among the respondents, 37% reported a high impact, while 15% reported a severe impact. In contrast, 33% indicated a moderate impact, with approximately 13% and less than 2% reporting minor or insignificant impacts, respectively.

The challenges faced by construction firms in the current scenario are multi-fold. The most prevalent challenges reported include pandemic-related project delays (70%), financial difficulties affecting all parties involved (67%), reduced investor willingness to initiate new projects (63%), the need to sustain employee salaries (55%), decreased work efficiency (43%), employee absence due to sickness or travel restrictions (40%), implementing new work modes (38%), transitioning to online platforms (33%), supply and material shortages (35%), and restricted site access (32%). Additionally, communication with the government and a general slowdown in work were identified as other notable challenges (Khalfan & Ismail, 2020). The most influential pandemic factors were determined to be reduced workforce, increased costs, price escalations due to material shortages, supply chain disruptions, payment and cash flow challenges (Gumusburun Ayalp & Çivici, 2022). The occurrence and spread of the new crown pneumonia epidemic has seriously affected the normal operation of all walks of life, and brought huge challenges to the production, operation and management of building materials enterprises (Alliance, 2020). COVID-19 has had significant repercussions on the construction industry, resulting in various notable effects. These include financial implications, project suspensions, time and cost overruns, labor impacts, and job losses. Moreover, the industry has faced additional challenges due to the shortage of construction materials, which has severely impacted the timely completion of projects (D. Y. Gamil & Alhagar, 2020).

Due to the contagious nature of COVID-19, temporary halts in construction work have been implemented to prioritize the safety and health of workers in the industry. Unfortunately, these measures have resulted in significant losses for the construction industry and subsequently impacted the global economy. The pandemic has also disrupted transportation systems, leading to supply chain issues and material shortages. Financial struggles have led many construction companies to lay off workers. Overall, the construction industry has been hit hard by the pandemic and is facing many challenges (Biswas et al., 2021). The findings of a study by (Zamani et al., 2021) show that COVID-19 is causing financial and operational problems. Moreover it has also caused problems such as shortage of skilled workers, delivery delays, operation suspension, price escalation and unavailability of raw materials. The industry is also experiencing limited production, disrupted logistics, delays in procuring goods and services, inventory shortages and increased lead times due to the COVID-19 outbreak (Butt, 2022).

2.3. Impact of COVID 19 in Pakistan

The COVID-19 pandemic, recognized as the third outbreak of the coronavirus, has impacted over 209 countries worldwide, including Pakistan and neighboring countries like China, where the outbreak was first experienced. The initial confirmed case of COVID-19 in Pakistan was officially reported on February 26, 2020, in Karachi, located in the Sindh province. Subsequently, on the same day, another case was confirmed in Islamabad. Given Pakistan's geographical location and the escalating number of positive COVID-19 cases, there is an imperative need for comprehensive action, planning, and management. In response, the Ministry of National Health Services, Regulation & Coordination Pakistan unveiled the "National Action Plan for Preparedness & Response to Coronavirus Disease (COVID-19) Pakistan" on February 12, 2020. This plan aims to curb the transmission of the virus and enhance emergency preparedness at both the national and community levels, ensuring a timely, efficient, and effective response to potential COVID-19-related situations (Waris et al., 2020). As an immediate response to the COVID-19 pandemic, the Government of Pakistan introduced a fiscal stimulus package of PKR 1.2 trillion. Notably, a portion of this package, specifically PKR 100 billion, has been allocated for the construction sector (UNDP). According to the Pakistan Economic Survey, the construction industry makes a contribution of 2.53% to the country's Gross Domestic Product (GDP). Additionally, this sector provides employment to 7.61% of the Pakistani labor force.

The construction sector in Pakistan makes a substantial contribution to the country's economic progress by facilitating job creation and generating income. Its activities have a ripple effect on other industries, fostering economic growth and prosperity in the nation (Ofori, 2012). In Pakistan approximately 7% of the labor force and supports 42 related industries (PACRA, 2021). Pakistan IJMPB's economic survey conducted in 2019-2020 revealed that the construction industry has contributed around PKR 316 billion, or between 2.3% and 2.85% of Pakistan's GDP, over the past five fiscal years. This suggests that it is critical for the industry to survive the ongoing pandemic in order to avoid potential financial crises. Additionally, the construction industry can play a vital role in helping to restore society during these challenging times. Therefore, it is important to explore innovative approaches to managing construction projects during the pandemic. The sector has been challenged by disruptions in supply chains, funding delays, legal issues, additional expenses (such as frequent jobsite sanitation, higher material costs, and lack of public transport), contractor insolvencies, and a lack of foreign expertise. Consequently, many projects have

been suspended, temporarily stopped, or slowed down. Furthermore, the construction sector's reliance on foreign funding, expertise, and imported materials and equipment may be another factor contributing to its poor resilience during the pandemic (Ayat et al., 2022).

The COVID-19 pandemic has had a major impact on both the global and Pakistani economy, with businesses experiencing a range of issues such as decreased demand, disrupted supply chains, cancelled export orders, raw material shortages, and transportation disruptions. These problems are causing labor shortages, slower production, and transportation restrictions, which will have far-reaching implications for businesses and the national economy. According to the United Nations Conference on Trade and Development (UNCTAD), Pakistan is likely to be the country hardest hit by the global COVID-19 pandemic (Shafi et al., 2020).

2.4. Impact of COVID 19 on Supply Chain

The COVID-19 pandemic has brought to the forefront the fragility of global supply chains and revealed their susceptibility and limited resilience. The outbreak presented a problem that affected both the supply and demand sides, making it increasingly difficult to mount effective responses. Initially, there was a shock on the supply side, followed by containment policies that further intensified the challenges on the demand side. The foremost priority of governments during the COVID-19 pandemic was to address the health issues stemming from the virus. This was accomplished through the implementation of social distancing measures, increasing the capacity of hospitals, and procuring essential medical supplies, tests and equipment. By prioritizing these actions, governments aimed to safeguard public health and mitigate the impact of the pandemic on healthcare systems. However, finding qualified and reliable suppliers to replace missing deliveries in long global supply chains has proven difficult. As the distance and number of players in the supply chain increase, so does the likelihood of disruption. A valuable lesson derived from this crisis is the importance of developing robust, resilient, and intelligent supply chains. This entails incorporating elements such as decentralized capacity, multi-sourcing, small batch production, and digitization. These factors play a critical role in constructing supply chains that can effectively navigate future challenges and disruptions, ensuring continuity of operations and adaptability to changing circumstances (Roque et al., 2021). A large number of Indian firms have been severely impacted by disruptions in transportation and logistics services due to various factors such as restricted circulation, closure of ports, and slow customs clearances,

which have led to delays and cancellations of cargo. As a result, the production and transportation of goods have been adversely affected, and there have been delays and rerouting of shipments to final consumers. Border restrictions have also led to a temporary halt in transportation activities and human mobility, leading to immense pressure on shipping and road freights and creating severe obstacles for international trade. The transportation disruptions have significantly interrupted the flow of goods and affected the complete supply chain, resulting in operational shutdowns, loss of sales, late deliveries, and reputational damage. The high costs of transport freight have also impacted the supply chain, thereby affecting its efficiency and performance. Transportation is a vital logistical driver that has a direct impact on the responsiveness and effectiveness of supply chains (Sudan & Taggar, 2021).

Impact of the COVID-19 outbreak on construction industry is expected to result in severe negative effects on the overall business, with most respondents reporting interruptions in the materials supply. The study suggests that the long-term consequences of the pandemic for the construction sector may include a significant loss of jobs, the possibility of large construction firms going bankrupt, disruptions to business and labor, delays in infrastructure project delivery, potential site closures, and increased legal disputes related to construction delays, such as claims related to contractual scheduling, mediations, arbitrations, and litigation (Aigbavboa et al., 2022). Shortage of material, liquidity issues (reduction of cash), high market uncertainty, delays caused by lockdown, slowdown of activities were the problems faced by organizations (Ayat et al., 2022).

The survey participants expressed concerns about the potential shortage of raw materials and inventory due to COVID-19 pandemic. They reported that factories and production facilities are operating at a limited capacity, logistics partners are facing a shortage of truck drivers, and production plants at the regional level have been closed for several months. The pandemic has also affected logistics operations, resulting in a lack of workforce and a significant shortage of truck drivers and freight capacity (Butt, 2021). Difficulties in working from home and job losses, low business turnover, delays in construction payment and output, materials and supplies shortages, were some of the negative impacts highlighted by (Ogunnusi et al., 2021) in his study. The COVID-19 pandemic has created additional challenges that may cause further delays in construction projects. The challenges encompass a range of factors, such as financial constraints, the necessity to adapt work schedules, concerns regarding material delivery, contractor capabilities, resource accessibility, and the

imperative for efficient project management to effectively navigate the crisis. (Khalfan & Ismail, 2020).

The China-Australia construction supply chain encountered several crystallized risks, including workforce reductions, delays in operations, rising shipping costs, disruptions in production, and unfavorable movements in foreign exchange rates. (Chigozie Victor Ndukwe, Jinyun Liu, 2021). A study has underscored the challenges faced by supply chains during the pandemic, which encompassed a range of issues such as diminished production and supply, logistical disruptions, scarcity of raw materials, constraints on import-export activities, inventory disturbances, complications on the production/assembly line, workforce shortages, restricted movement of goods and individuals, halted production, sourcing difficulties, logistical challenges, and delivery delays. (Golwelkar, 2020). Amidst the epidemic, a large number of enterprises experienced a state of stagnant production and uncertain prospects for future development. The widespread transmission of the epidemic led to a decline in market orders, challenges in resuming operations, restrictions on transportation and logistics, inadequate workforce, overwhelming fixed costs, disruptions in both upstream and downstream supply chains, and the potential for increased credit and debt risks. These factors collectively posed a significant shock to companies. (Alliance, 2020).

Transportation sector upon which the global supply chain activities are dependent, has remained partially shut down with the implementation of the lockdown. COVID-19 has impacted the supply chain sector which led to disruption in sourcing of raw material, difficulty in distribution, shortage of labor, plant shutdown, inventory shortage, increased inflation and reduced volume of goods distributed across the value chain (pwc, 2020). The COVID-19 pandemic has caused significant disruptions to economies worldwide, with national lockdowns and closed borders exacerbating the strains on global supply chains. This has exposed the vulnerability of modern supply chains to disruptions and highlighted the need for building resilient supply chains. Lockdown policies have particularly impacted the movement of people and business operations, insufficient raw materials, border closure, workforce shortage, delivery delay and increased transportation costs (Zhu et al., 2020). The global spread of the coronavirus initially resulted in several impacts, including the disruption of production of raw materials and spare parts, setbacks in logistics leading to unsatisfied market demand, an increased risk of bankruptcy for small and medium-sized enterprises (SMEs), and an enlargement of demand fluctuations (Cai & Luo, 2020).

The COVID-19 pandemic has had a significant negative impact on several industries

globally, causing disruptions in the availability and supply of raw materials, intermediate goods, and finished products. In contrast to previous disruptions, the pandemic has adversely affected global supply chains (GSCs) at all stages, including manufacturing, processing, transport, and logistics, leading to significant fluctuations in demand. The COVID-19 pandemic has caused travel restrictions and border closures, resulting in significant disruptions, delays, cancellations, and obstacles in international logistics across maritime, air, and land routes (Xu et al., 2020).

A study revealed that a majority of businesses that participated in the research were significantly impacted by the COVID-19 pandemic, facing a range of challenges including financial difficulties, supply chain disruptions, reduced demand, and decreased sales and profits. Enterprises have reported a multitude of challenges arising from the COVID-19 pandemic, including a decline in demand, disruptions in supply chains, the cancellation of export orders, shortages of raw materials and disruptions in transportation. These issues have posed significant obstacles for businesses, requiring them to adapt and find alternative solutions to mitigate the impact on their operations (Shafi et al., 2020).

The COVID-19 pandemic has resulted in the closure of major production centers, leading to severe supply chain disruptions across all manufacturing sectors (Sudan & Taggar, 2021). The construction sector in Pakistan, which heavily relies on foreign funding, expertise, and imported construction materials and machinery, may have contributed to its poor resilience during the pandemic (Ayat et al., 2022). Limited research exists on how firms are effectively mitigating the impact of COVID-19 on supply chain disruptions. This study emphasizes the potential consequences of the pandemic on supply chains and underscores the need for additional research to formulate policies and practices that effectively manage these disruptions. The precise extent of COVID-19's impact on supply chain management remains uncertain and requires further investigation and analysis (Butt, 2021)

The COVID-19 outbreak is expected to have significant and widespread impacts on various sectors, including the labor market, financial sector, economic sector, and logistics sector, among others. (Al-Mansour & Al-Ajmi, 2020).

Table 1 Impacts of COVID-19

Sr. No.	Impacts of COVID-19	Selected References
1	Material Shortage	(Agyekum et al., 2022; Aigbavboa et al., 2022; Biswas et al., 2021; Butt, 2021; Gumusburun Ayalp & Çivici, 2022; Shafi et al., 2020)
2	Operations & Production Shutdown	(Agyekum et al., 2022; Gumusburun Ayalp & Çivici;Aigbavboa et al., 2022; Biswas et al., 2021; Butt, 2021;, 2022; Shafi et al., 2020)
3	Disruption in Transportation	(Agyekum et al., 2022; Aigbavboa et al., 2022; Biswas et al., 2021; Gumusburun Ayalp & Çivici, 2022; Raj et al., 2022; Shafi et al., 2020)
4	Shortages of Labor	(Agyekum et al., 2022; Biswas et al., 2021; Butt, 2021, 2022; Raj et al., 2022; Remko, 2020; Shafi et al., 2020)
5	Logistic Services Disruption	(Agyekum et al., 2022; Biswas et al., 2021; Butt, 2021, 2022; Gumusburun Ayalp & Çivici, 2022; Raj et al., 2022; Remko, 2020)
6	Financial Issues/ Failure in Financing Inventories	(Agyekum et al., 2022; Gumusburun Ayalp & Çivici, 2022; Raj et al., 2022; Remko, 2020; Shafi et al., 2020)
7	Border Closure / Port Restrictions	(Agyekum et al., 2022; Butt, 2021,

		2022; Raj et al., 2022; Remko, 2020)
8	Shortage of Inventory	(Aigbavboa et al., 2022; Biswas et al., 2021; Butt, 2022; Remko, 2020; Shafi et al., 2020)
9	Delays in Delivery	(Aigbavboa et al., 2022; Biswas et al., 2021; Butt, 2022; Raj et al., 2022; Remko, 2020)
10	Decreased Demand	(Raj et al., 2022; Rapaccini et al., 2020; Shafi et al., 2020)
11	Material/ Product Price Increase	(Agyekum et al., 2022; Aigbavboa et al., 2022; Butt, 2022; Gumusburun Ayalp & Çivici, 2022; Remko, 2020)
12	Declining Profits/ Less Revenues	(Agyekum et al., 2022; Aigbavboa et al., 2022; Shafi et al., 2020)
13	Decreasing Productivity/ Work Rate	(Agyekum et al., 2022; Aigbavboa et al., 2022; Biswas et al., 2021; Gumusburun Ayalp & Çivici, 2022)
14	Increased Demand	(Butt, 2021, 2022; Fonseca & Azevedo, 2020; Raj et al., 2022; Remko, 2020)
15	Lower Inventory Levels	(Butt, 2021, 2022; Fonseca & Azevedo, 2020; Remko, 2020)
16	Disruption in Supplies Sourcing	(Aigbavboa et al., 2022; Butt, 2022; Remko, 2020)

17	Supplier Selection Issues	(Butt, 2021; Fonseca & Azevedo, 2020; Roque et al., 2021)
18	Increased Transportation Cost	(Butt, 2021; Chigozie Victor Ndukwe, Jinyun Liu, 2021; Remko, 2020; Roque et al., 2021)
19	Delays in Payment	(Agyekum et al., 2022; Ayat et al., 2022; Gumusburun Ayalp & Çivici, 2022)
20	Poor Communication	(Aigbavboa et al., 2022; Ayat et al., 2022; Butt, 2021; Sierra, 2022)
21	Increased Procurement Costs	(Agyekum et al., 2022; Fonseca & Azevedo, 2020)
22	Decrease in Supply	(Cai & Luo, 2020; D. Y. Gamil & Alhagar, 2020; Raj et al., 2022)
23	Improper Distribution Strategy/ Issues in Distribution	(Butt, 2022; Remko, 2020; Roque et al., 2021)
24	Unavailability of Storage Space	(Chigozie Victor Ndukwe, Jinyun Liu, 2021; Raj et al., 2022; Remko, 2020)
25	Bankruptcy & Liquidity of Firms	(Aigbavboa et al., 2022; Ayat et al., 2022; Cai & Luo, 2020)
26	Poor Quality	(Raj et al., 2022)
27	Less Utilization Rates	(Fonseca & Azevedo, 2020; Rapaccini et al., 2020; Roque et al., 2021)

28	Assembling Problems	(Golwelkar, 2020)
29	Increased Supply	(Butt, 2021)
30	Lack of Suitable Planning	(Agyekum et al., 2022; Remko, 2020; Shafi et al., 2020)

2.5. SCOR Model

The Supply Chain Operations Reference (SCOR) model, developed by the Supply Chain Council, is a valuable tool used for addressing, improving, and communicating decisions related to supply chain management. This model outlines the necessary business processes to meet customer demands and offers an overview of the processes involved across the entire supply chain. SCOR serves as a foundation for enhancing these processes. The framework of SCOR is built upon five key areas of the supply chain: plan, source, make, deliver, and return. Each of these components is considered vital both as an intra-organizational function and a critical inter-organizational process (Lemghari et al., 2018). The SCOR model serves as a valuable tool for mapping material flows and assessing the performance of supply chains. Its selection is based on the utilization of standardized processes and metrics, which enable the measurement of supply chain performance and the mapping of material flows in a consistent and comprehensive manner (Thunberg & Persson, 2014). Based on the validated SCOR model, the research identified the most affected parts of the supply chain, as well as those that have been commonly highlighted in previous studies. The final objective of the study was to identify potential actions that could help mitigate the impact of COVID-19 or similar pandemics. These actions were identified both from the literature and the company under investigation (Roque et al., 2021).

2.6. Factors Affecting Construction Supply Chain Due to COVID 19

The COVID-19 pandemic has had a negative impact on the construction supply chain, which is crucial to delivering construction projects. The supply chain has been affected by delays in customs and safety standards, particularly with cross-border delivery of construction materials (Ogunnusi et al., 2021). During the initial phases of the COVID-19 pandemic, builders in Australia encountered delays in receiving their orders for building materials. This

was primarily caused by the shutdown of manufacturing plants in China. Manufacturers reported delays in delivery due to production stoppages or shipping delays. As a result, pre-order times were extended by approximately half to one month to accommodate the disruption in production. Additionally, shipping times were increased by at least 14 days because of quarantine measures imposed by the Australian Border Force on vessels sailing directly from China. However, it is worth noting that shipping costs experienced a slight decline due to reduced demand during that period. During the COVID pandemic from March to September 2020, a study was conducted to classify the offshoring risks that emerged in the China-Australia construction supply chain (SC) and to measure their effect on SC performance. Risks arising from the pandemic included the closure of manufacturing facilities, transportation limitations in China, shipping delays, customs quarantine, and shutdowns in Australia when the virus spread (Chigozie Victor Ndukwe, Jinyun Liu, 2021). Construction projects have been significantly impacted by COVID-19, leading to delays and disruptions as supply chains have been severely affected. As a result, many construction activities have been temporarily stopped and are expected to resume at a later time (Gumusburun Ayalp & Çivici, 2022).

CHAPTER 3: RESEARCH METHODOLOGY

A comprehensive methodology including four phases is adopted to achieve the objectives of the study. The step wise hierarchy of each phase is shown in following figure:

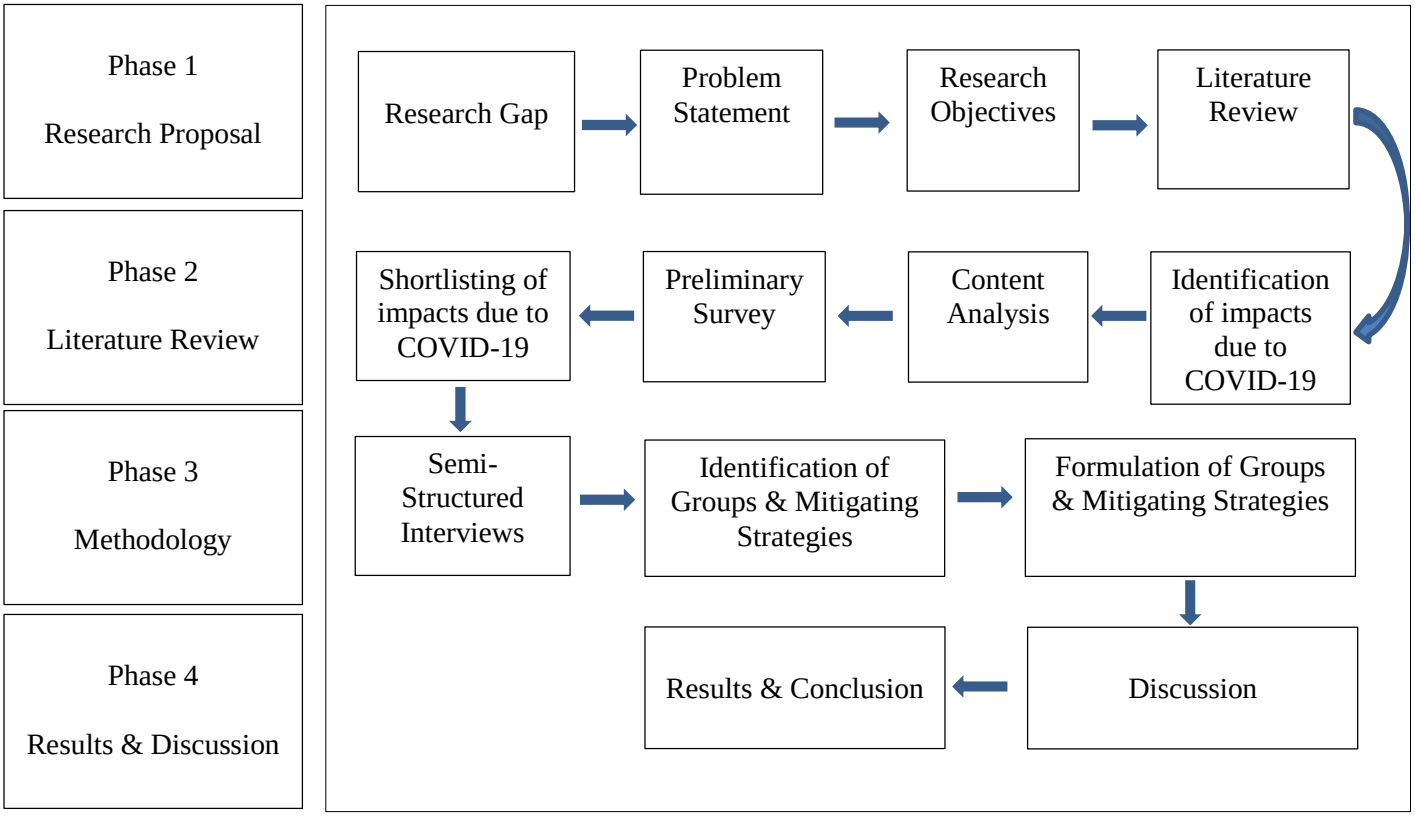

Figure 1 Research Methodology

3.1. Questionnaire Survey

The authors conducted a comprehensive literature review using various databases, including Google Scholar and Scopus, to identify the significant impacts of the COVID-19 pandemic on the construction industry, supply chain, and construction supply chain. The authors utilized specific keywords such as SARS-CoV-2, coronaviruses, COVID-19, novel coronavirus, pandemic virus, construction, COVID-19 impact, pandemic impact on construction industry, COVID-19 impact on construction supply chain, COVID-19 and construction cost, COVID-19 and construction time, and COVID-19 impact assessment to search for relevant published work. (Al-Mhdawi et al., 2022).

Questions included in the questionnaire were based on a review of literature on COVID-19, including published papers. The questions were initially drafted and later refined with the input of construction professionals within the academic institution. This was necessary since there is limited literature on this research area due to its novelty. The questionnaire was organized into sections, and a cover letter was included to provide respondents with an overview of the research, encourage their voluntary participation, and assure them of their anonymity. In the second part the demographic information of the respondents was collected. The first section assessed the response of construction professionals on the identified factors that has impacted the cost of the supply chain processes due to the COVID-19 outbreak in the construction industry. The second section assessed the response of construction professionals on the identified factors that has impacted the time of the supply chain processes due to the COVID-19 outbreak in the construction industry. In both of these sections, the respondents were presented with the identified factors and were asked to rate their magnitude of impact according to their experience and scholarly opinion, using a five-point Likert scale with five being Very Severe, four being Severe, three being Moderate, two being Mild and one being None. The researchers chose to distribute the questionnaire through the use of Google Forms, an online platform that allows for convenient distribution and response collection. This method was chosen because it allowed for a wide distribution of the questionnaire over a large geographical area with ease (Chan et al., 2017).

The survey underwent a verification process by two engineering professionals who specialized in survey methodology. The feedback provided by the reviewers was incorporated into the survey, which was then distributed to construction and supply chain professionals. This process ensured that the survey content was both scientifically and professionally valid.

3.2. Respondents Population

A total of 70 responses were gathered out of which 66 responses are selected after cross checking between section 1 and section 2 of questionnaire. The number of respondents exceeded by the minimum threshold of 30 responses, data to be considered and sufficient for statistical analysis (Zina, 2017). The profile of respondents, experience of respondents and designation is shown in following table.

Table 2 Experience of Respondents

Sr. No.	Experience (years) in Construction Management	Total
1	3 - 5 years	46
2	6 - 10 years	15
3	11 - 15 years	4
4	16 - 20 years	1
5	Above 20 years	0

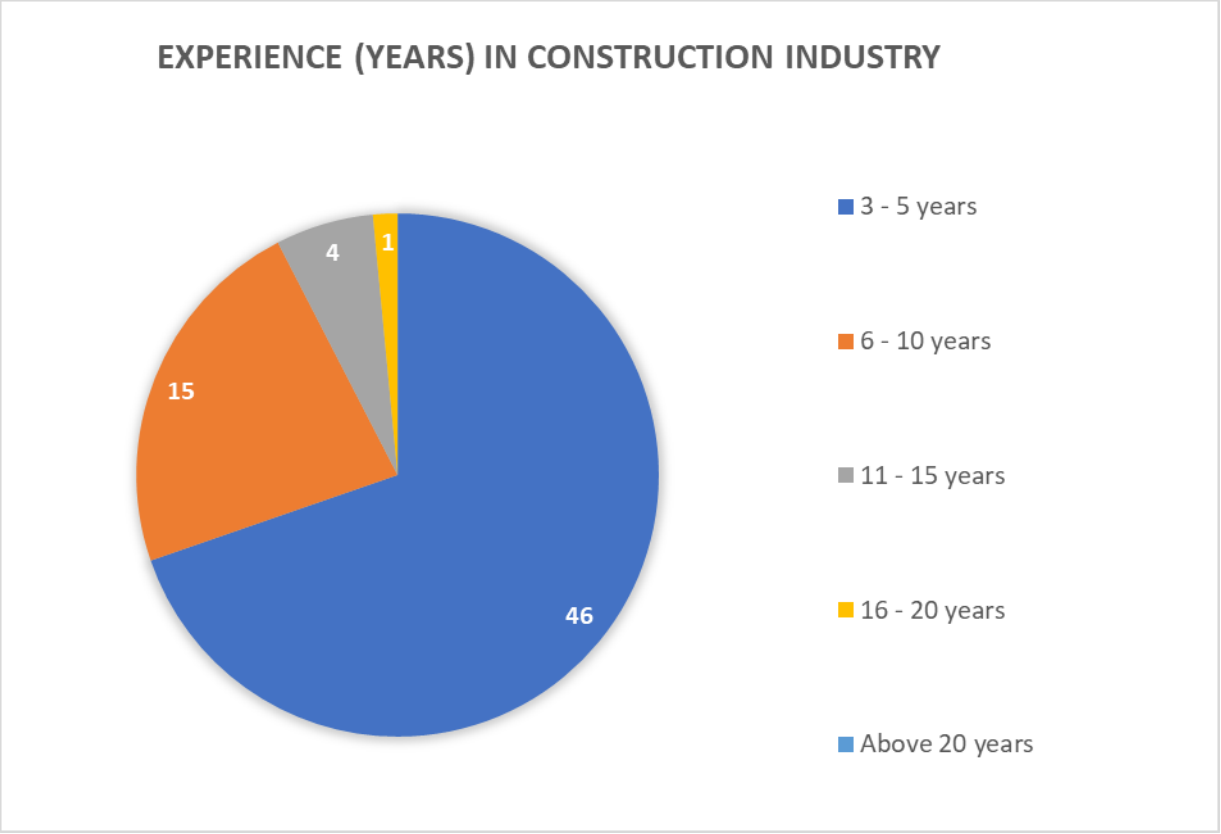

Figure 2 Experience of Respondents

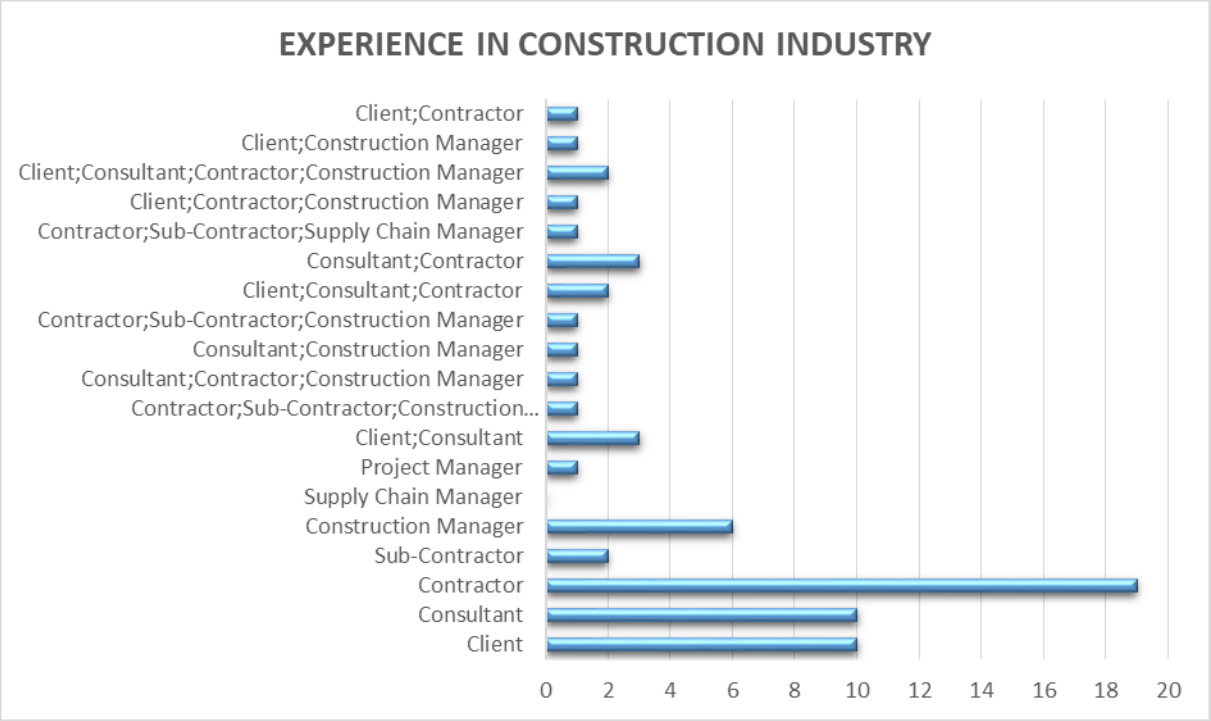

Table 3 Profile of Construction Organization of Respondents

Sr.no.	Experience in Construction industry as:	Total no.
1	Client	10
2	Consultant	10
3	Contractor	19
4	Sub-Contractor	2
5	Construction Manager	6
6	Supply Chain Manager	0
7	Project Manager	1
8	Client, Consultant	3
9	Contractor, Sub-Contractor, Construction Manager, Supply Chain Manager	1
10	Consultant, Contractor; Construction Manager	1
11	Consultant, Construction Manager	1
12	Contractor, Sub-Contractor, Construction Manager	1
13	Client, Consultant, Contractor	2
14	Consultant, Contractor	3
15	Contractor, Sub-Contractor, Supply Chain Manager	1
16	Client, Contractor, Construction Manager	1
17	Client, Consultant, Contractor, Construction Manager	2
18	Client, Construction Manager	1
19	Client, Contractor	1

Figure 3 Experience in Construction Industry

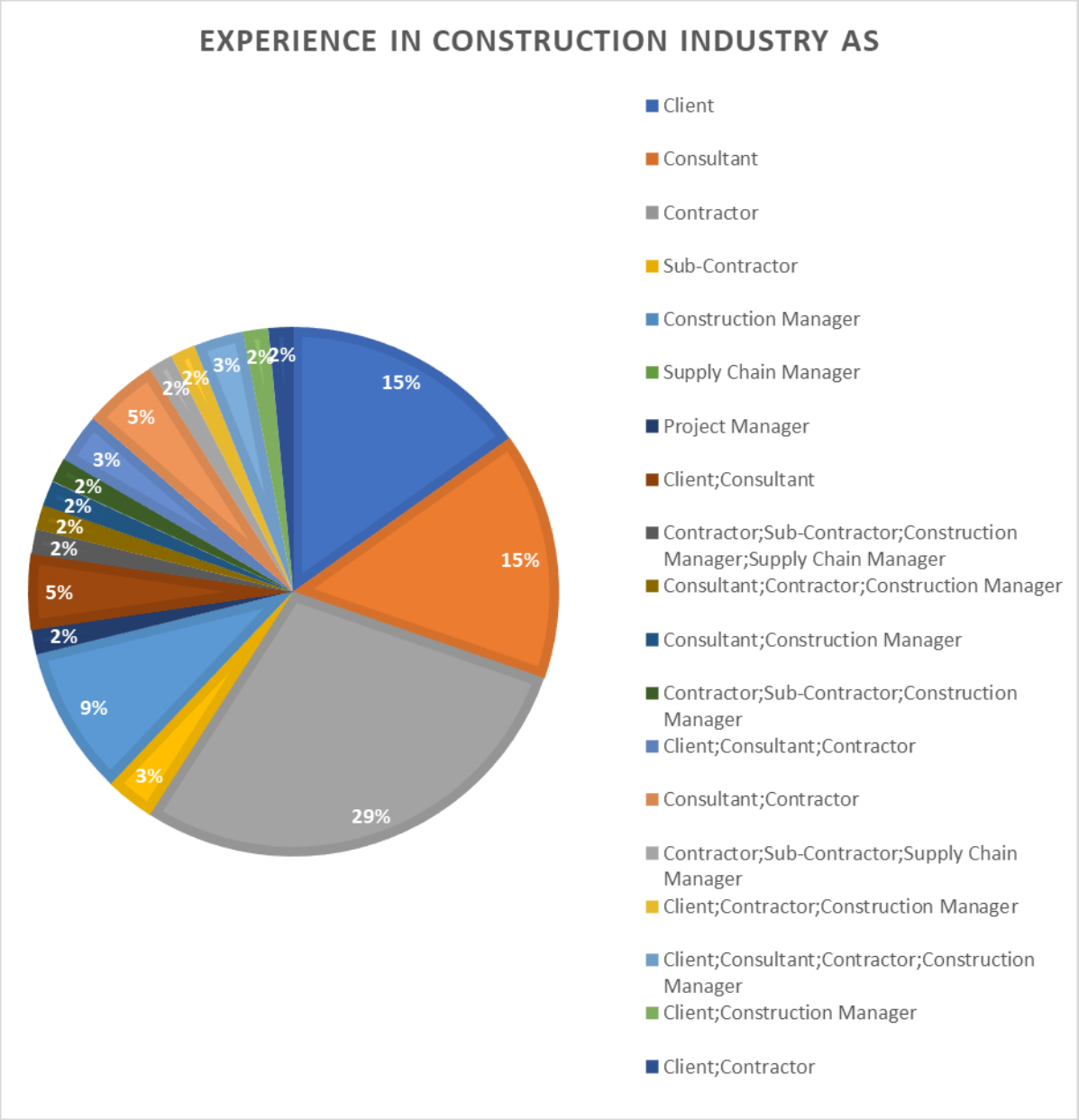

Figure 4 Experience in Construction Industry AS

3.3. Data Analysis

Using one-way ANOVA multiple weighting ratios (20/80, 30/70, 40/60, 50/50, 60/40, 70/30, and 80/20) of literature and field experts were statistically examined. The p-value of 1 indicate that there is no statistically significant difference between any two decision weight combinations in both of the sections.

Table 4 Anova analysis of Section 1 of Questionnaire

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3.47E-18	6	5.78E-19	4.64E-15	1	2.143453
Within Groups	0.025306	203	0.000125			
Total	0.025306	209				

Table 5 Anova analysis of Section 2 of Questionnaire

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.04E-17	6	1.73E-18	1.41E-14	1	2.143453
Within Groups	0.024891	203	0.000123			
Total	0.024891	209				

Cronbach's Alpha Test is used to verify the reliability of results that were based on Likert Scale (Cronbach, 1951). The data analysis was performed using the Statistical Package for Social Scientists (SPSS) version 29. To assess the validity of provided data, the Cronbach's alpha coefficient was utilized. The Cronbach's alpha coefficient ranges from 0 to 1, with a value closer to 1 indicating higher levels of internal consistency within the data. (Hemanta et al., 2012). The value of Cronbach's alpha for verification of factors in the first section of the questionnaire is 0.945579201 as shown in table and the value of Cronbach's alpha for verification of factors in the second section of the questionnaire is 0.943433651 as shown in table. This indicates that the value is higher than acceptable lower limit threshold of 0.70 so research questionnaire is highly reliable and accurate (Creswell & Creswell, 2018).

The Relative Importance Index (RII) is a numerical technique used to assess the relative significance of multiple factors. It is commonly employed for ranking purposes and shortlisting factors based on their importance. The RII provides a quantitative measure that helps prioritize and evaluate factors in various decision-making processes (Govindaraj et al., 2018; Hossen et al., 2015). The RII (Relative Importance Index) is calculated using the following equation for determining the score of 30 factors. A higher RII value indicates a greater importance of the factor.

$$RII = \Sigma W / (A*N)$$

Where, W = Weight assigned to each factor by the respondent, A = Maximum weight, i.e., 5 (For this case), N = Total number of respondents

Table 6 Cronbach's Alpha Test of Section One of Questionnaire

Source of Variation	SS	df	MS	F	P-Value	F critical
Rows	987.39	65	15.19	18.37	2.7E-155	1.31
Columns	210.49	29	7.25	8.78	3.47E-35	1.47
Error	1558.30	1885	0.82			
Total	2756.19	1979				

Table 7 Cronbach's Alpha Test of Section Two of Questionnaire

Source of Variation	SS	df	MS	F	P-Value	F critical
Rows	852.21	65	13.11	17.67	1.5E-149	1.31
Columns	156.07	29	5.38	7.25	1.25E-27	1.47
Error	1397.99	1885	0.74			
Total	2406.28	1979				

Table 8 RII and Mean of Section 1 of Questionnaire

Sr. No.	Factors	RII	Mean
1	Material Shortage	0.71	3.59
2	Operations & Production Shutdown	0.72	3.62
3	Disruption in Transportation	0.69	3.45
4	Shortages of Labor	0.65	3.25
5	Logistic Services Disruption	0.67	3.37
6	Financial Issues/ Failure in Financing Inventories	0.65	3.28
7	Border Closure / Port Restrictions	0.77	3.84
8	Shortage of Inventory	0.72	3.60
9	Delivery Delays	0.71	3.57
10	Decreased Demand	0.56	2.81
11	Material/ Product Price Increase	0.76	3.80
12	Declining Profits/ Less Revenues	0.67	3.39
13	Decreasing Productivity/ Work Rate	0.68	3.43
14	Increased Demand	0.62	3.12
15	Lower Inventory Levels	0.67	3.37
16	Disruption in Supplies Sourcing	0.70	3.53
17	Supplier Selection Issues	0.63	3.15
18	Increased Transportation Cost	0.74	3.71
19	Delays in Payment	0.67	3.34
20	Poor Communication	0.57	2.89
21	Increased Procurement Costs	0.74	3.74
22	Decrease in Supply	0.68	3.43
23	Improper Distribution Strategy/ Issues in Distribution	0.66	3.30
24	Unavailability of Storage Space	0.55	2.77
25	Bankruptcy & Liquidity of Firms	0.62	3.13
26	Poor Quality	0.56	2.83
27	Less Utilization Rates	0.57	2.86
28	Assembling Problems	0.58	2.92
29	Increased Supply	0.53	2.66
30	Lack of Suitable Planning	0.60	3.045

Table 9 RII and Mean of Section 2 of Questionnaire

Sr. No.	Factors	RII	Mean
1	Material Shortage	0.76	3.80
2	Operations & Production Shutdown	0.78	3.93
3	Disruption in Transportation	0.76	3.83
4	Shortages of Labor	0.71	3.59
5	Logistic Services Disruption	0.73	3.65
6	Financial Issues/ Failure in Financing Inventories	0.67	3.36
7	Border Closure / Port Restrictions	0.77	3.87
8	Shortage of Inventory	0.70	3.53
9	Delays in Delivery	0.77	3.87
10	Decreased Demand	0.60	3.04
11	Material/ Product Price Increase	0.67	3.35
12	Declining Profits/ Less Revenues	0.65	3.27
13	Decreasing Productivity/ Work Rate	0.69	3.47
14	Increased Demand	0.62	3.13
15	Lower Inventory Levels	0.66	3.30
16	Disruption in Supplies Sourcing	0.70	3.50
17	Supplier Selection Issues	0.66	3.33
18	Increased Transportation Cost	0.67	3.36
19	Delays in Payment	0.72	3.60
20	Poor Communication	0.63	3.15
21	Increased Procurement Costs	0.67	3.38
22	Decrease in Supply	0.64	3.24
23	Improper Distribution Strategy/ Issues in Distribution	0.66	3.33
24	Unavailability of Storage Space	0.60	3.00
25	Bankruptcy & Liquidity of Firms	0.59	2.98
26	Poor Quality	0.62	3.12
27	Less Utilization Rates	0.62	3.13
28	Assembling Problems	0.65	3.26
29	Increased Supply	0.58	2.92
30	Lack of Suitable Planning	0.66	3.33

3.4. Finalization of Issues and Challenges

To strengthen the study while still considering literature, 60% of the professionals' input and 40% of literature were used (60R/40L distribution). This approach was similar to a previous study conducted by (Jahan et al., 2022). The selection of the final factors for inclusion in the study followed simple majority principle. Factors that collectively accounted for up to 50% of the cumulative impact were chosen for inclusion.

Table 10 List of Finalized Factors and their Ranking

Sr. No.	Factors	Normalized Score	Cumulative Score
1	Material Shortage	0.048	0.048
2	Operations & Production Shutdown	0.047	0.096
3	Shortages of Labor	0.043	0.139
4	Disruption in Transportation	0.042	0.182
5	Border Closure / Port Restrictions	0.042	0.224
6	Logistic Services Disruption	0.041	0.265
7	Product/Material Price Increase	0.040	0.306
8	Financial Issues/ Failure in Financing Inventories	0.040	0.346
9	Shortage of Inventory	0.040	0.387
10	Delays in Delivery	0.039	0.426
11	Declining Profits/ Less Revenues	0.036	0.462
12	Decreasing Productivity/ Work Rate	0.035	0.498
13	Disruption in Supplies Sourcing	0.034	0.533

Table 11 List of Finalized Factors and their Ranking

Sr. No.	Factors	Normalized Score	Cumulative Score
1	Operations & Production Shutdown	0.049	0.049
2	Material Shortage	0.049	0.098
3	Shortages of Labor	0.045	0.143
4	Disruption in Transportation	0.044	0.187
5	Logistic Services Disruption	0.042	0.229
6	Border Closure / Port Restrictions	0.041	0.271
7	Delays in Delivery	0.040	0.312
8	Financial Issues/ Failure in Financing Inventories	0.040	0.352
9	Shortage of Inventory	0.039	0.391
10	Product/Material Price Increase	0.036	0.428
11	Decreasing Productivity/ Work Rate	0.035	0.463
12	Declining Profits/ Less Revenues	0.034	0.497
13	Disruption in Supplies Sourcing	0.033	0.531

3.5. Development of Survey Instrument

Based on the identified factors, a semi-structured interview form was developed and the questions related to all the factors were added. Similarly questions regarding the categorization under SCOR processes were also a part of the interview. Questions added in the semi-structured interview are shown in the table below:

Table 12 Development of Survey Instrument

Sr. No.	Factors	Questions	Questions (SCOR Categorization)
1	Material Shortage	*Did you face shortage of material and what mitigation measures and strategies did you adopted to reduce or minimize its impact?*	*How would you categorize this factor in terms of the SCOR Processes?*
2	Operations & Production Shutdown	*Did your company faced operations shutdown & production shutdown and what mitigation measures and strategies did you adopted to reduce or minimize its impact?*	*How would you categorize this factor in terms of the SCOR Processes?*
3	Shortages of Labor	*Have you experienced a shortage of labor, if so what mitigation measures and strategies did you adopted to reduce or minimize its impact?*	*How would you categorize this factor in terms of the SCOR Processes?*
4	Disruption in Transportation	*Did you encounter any disruptions in transportation that affected your supply chain and what mitigation measures and strategies did you adopted to reduce or minimize its impact?*	*How would you categorize this factor in terms of the SCOR Processes?*
5	Border Closure / Port Restrictions	*Were there any border closure or port restrictions that hindered your international operations, and what actions did you take to mitigate the impact?*	*How would you categorize this factor in terms of the SCOR Processes?*
6	Logistic Services Disruption	*Did you experience any disruptions in your logistics services, if yes than what mitigation measures and strategies did you adopted to reduce or minimize its impact?*	*How would you categorize this factor in terms of the SCOR Processes?*
7	Product/Material Price Increase	*How did you manage any challenges posed by rising product or material costs, and what measures did you take to mitigate their impact?*	*How would you categorize this factor in terms of the SCOR Processes?*
8	Financial Issues/ Failure in Financing Inventories	*Have you encountered any financial issues or difficulties in financing your*	*How would you categorize this*

Sr. No.	Factors	Questions	Questions (SCOR Categorization)
		inventories, and what steps did you take to overcome these challenges?	*factor in terms of the SCOR Processes?*
9	Shortage of Inventory	*Did you face inventory shortage and what mitigation measures and strategies did you adopted to reduce or minimize its impact?*	*How would you categorize this factor in terms of the SCOR Processes?*
10	Delays in Delivery	*Have you faced any delays in delivery, and if yes, what actions did you take to minimize these delays and ensure timely shipments?*	*How would you categorize this factor in terms of the SCOR Processes?*
11	Declining Profits/ Less Revenues	*Have you experienced a decline in revenues or profits, and if so, what steps did you take to improve the situation and enhance financial performance?*	*How would you categorize this factor in terms of the SCOR Processes?*
12	Decreasing Productivity/ Work Rate	*Did you observe a decrease in work rate or productivity, and if yes, how did you address this issue to maintain efficiency?*	*How would you categorize this factor in terms of the SCOR Processes?*
13	Disruption in Supplies Sourcing	*Did you face disruption in sourcing of supplies and what mitigation measures and strategies did you adopted to reduce or minimize its impact?*	*How would you categorize this factor in terms of the SCOR Processes?*

CHAPTER 4: RESULTS AND DISCUSSION

4.1. Data Collection and Analysis

This study employed a convergent parallel design under the umbrella of mix method design, which combines qualitative and quantitative methods in the research process. In a convergent parallel design, the researcher simultaneously carries out both quantitative and qualitative elements within the same phase of the research process. Equal emphasis is placed on both methods, and the researcher analyzes the two components independently. Finally, the results from both methods are interpreted together, allowing for a comprehensive understanding of the research topic (Creswell & Pablo-Clark, 2011). Hence, the researcher conducted both types of analysis simultaneously, treating them equally and interpreting the results together. The aim was to corroborate and validate the findings by comparing the quantitative statistical results and qualitative data. The quantitative data obtained from Likert-scale questions were analyzed using SPSS software, while for the qualitative data obtained through interviews, a content analysis technique was used, involving reading, categorizing, linking data, and establishing meaningful connections with the SCOR processes. In the qualitative stage, the semi-structured interview form was used. The interview form is composed of thirteen main questions and few other questions related to the categorization of the identified factors under SCOR processes. The convergent-parallel approach involves the collection of different but complementary data on the same phenomena, allowing for a comprehensive understanding of the research problem. The data was collected and analyzed concurrently, following a pragmatic research approach.

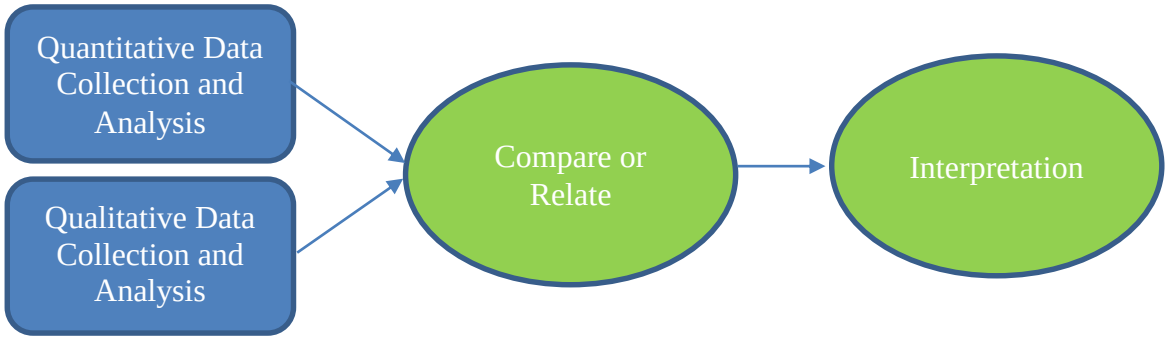

Figure 5 Mixed Method Design

4.1.1. Likert Scale

Questions based on the Likert Scale were presented to the participants. Before and after implementation of mitigating strategies, impact in terms of cost and time was collected as a result of this technique of data collection and the data was analyzed accordingly.

4.1.2. Semi Structured Interviews

The interviews were conducted in a semi-structured format, allowing the interviewees the freedom to express themselves and provide additional information as they deemed necessary. The participants were contacted via email, WhatsApp, phone call and interview dates were confirmed as per their availability. Each meeting lasted for about 30 minutes to an hour. Initially, a brief introduction was given to participants and asked for their consent to use all the relevant information in the research. The participants were asked to respond according to their experience related to projects during COVID-19. The interviews were recorded with the consent of the participants. For analysis of the qualitative results of this study content analysis was conducted on Microsoft Excel, the results of which are presented in the Findings and Discussion section. The details of the industry experts selected for this phase of the study along with their designation, years of experience, project name and project location are presented in table:

Table 13 Demographics of participants of Semi-structured interview

Sr. No	Designation	Experience in Years	Project Name	Project Location
1	Deputy Director Infrastructure	9	A) Tube Wells, Disposal Stations Etc.	Multan
2	Planning Engineer	5	B) Penta Square Mall	Lahore
3	Procurement Officer	5	C) Pre-Fabricated Sheds	Lahore
4	Project Manager	22	D) CPEC-Pitaro-Sehwan Road Project (20 km)	Jamshoro
5	Assistant Engineer	10	E) Nishter 2 Hospital	Multan

Sr. No	Designation	Experience in Years	Project Name	Project Location
6	Project Engineer	4	F) Royal Orchard Residential Apartments	Multan
7	Project Manager	9	G) Beaconhouse School Building, etc	Rawalpindi
8	Assistant Manager Procurement	5	H) Taj Residencia, Asian Trading Services	Islamabad
9	Construction Manager	11	I) Gulberg Greens Infrastructure Work	Islamabad
10	Project Engineer	11	J) Eighteen (Elite Reverie)	Islamabad
11	Project Engineer	6	K) Elan Tower, Move-N-Pick Hotel	Islamabad
12	Project Engineer	5	L) Construction of PCC, Sewerage System & Water Supply	Lahore
13	Material Engineer	23	M) Construction of 32 km Bahrain-Kalam Road	Swat
14	Procurement Officer	7	N) 7 Km Road Project, 16 School Buildings	Abbottabad
15	Director Design	12	O) University, Hospital, College	Jhelum
16	Project Engineer	5	P) Eighteen (Elite Reverie)	Islamabad
17	Project Engineer	5	Q) Move-N-Pick Hotel	Islamabad
18	Deputy Construction Manager	16	R) Elan Square Apartments (4B+G+15)	Islamabad

Sr. No	Designation	Experience in Years	Project Name	Project Location
19	Deputy Project Manager	7	S) Move-N-Pick Hotel	Islamabad
20	Director Procurement	20	T) Citi Housing Infrastructure Works	Gujranwala
21	Project Engineer	15	U) Construction of Civil Engineering Department, KFUEIT	Rahim Yar Khan
22	Deputy General Manager	20	V) ADB Projects	Faisalabad

4.1.3. Demographics of Projects

For selecting the projects for study, the researchers focused on projects that were willing to participate in the study and their accessibility was easy. The various types of projects were selected that were a part of both government and private sector resulting in total 22 number of projects. The relevant details of the projects are mentioned in the table below:

Table 14 Demographics of Projects

Sr. No.	Project	Type	Sector	Location
1	A	Client	Government	Multan
2	B	Contractor	Private	Lahore
3	C	Client/Contractor	Private	Lahore
4	D	Contractor	Government	Jamshoro
5	E	Client	Government	Multan
6	F	Contractor	Private	Multan
7	G	Contractor	Private	Rawalpindi
8	H	Client	Private	Islamabad
9	I	Consultant	Private	Islamabad

Sr. No.	Project	Type	Sector	Location
10	J	Consultant	Private	Islamabad
11	K	Contractor/Consultant	Private	Islamabad
12	L	Contractor	Government	Lahore
13	M	Contractor	Government	Swat
14	N	Contractor	Government	Abbottabad
15	O	Client	Government	Jhelum
16	P	Client/Contractor	Private	Islamabad
17	Q	Contractor	Private	Islamabad
18	R	Contractor/Consultant	Private	Islamabad
19	S	Client/Contractor	Private	Islamabad
20	T	Client/Contractor	Private	Gujranwala
21	U	Contractor	Government	Rahim Yar Khan
22	V	Consultant	Government	Faisalabad

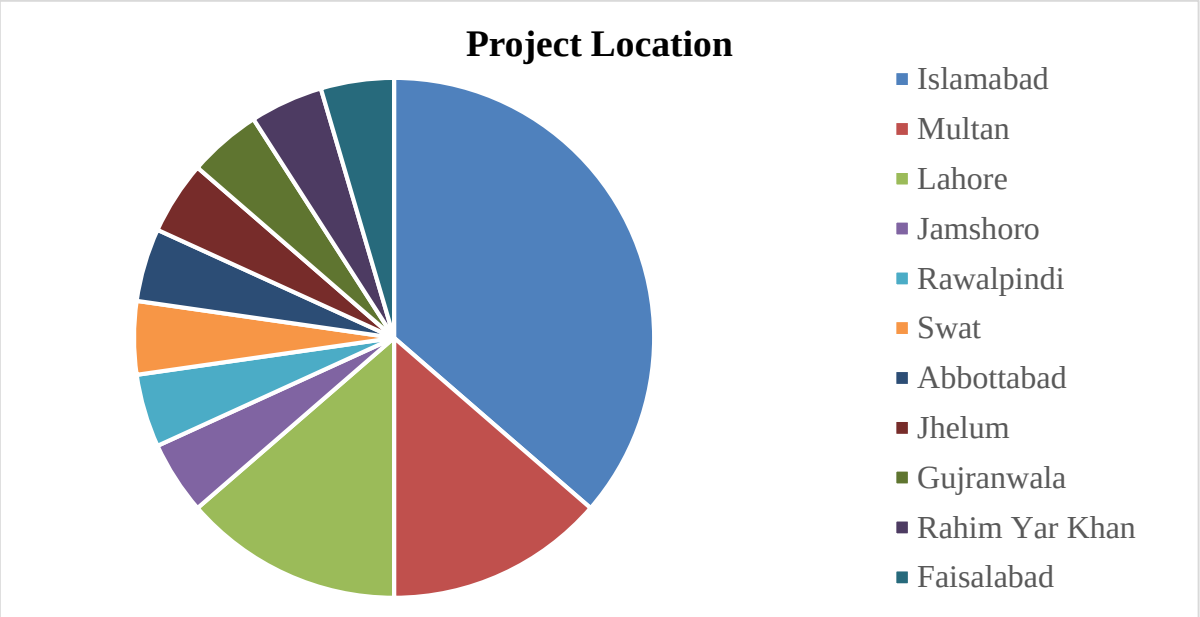

Figure 6 Project Location

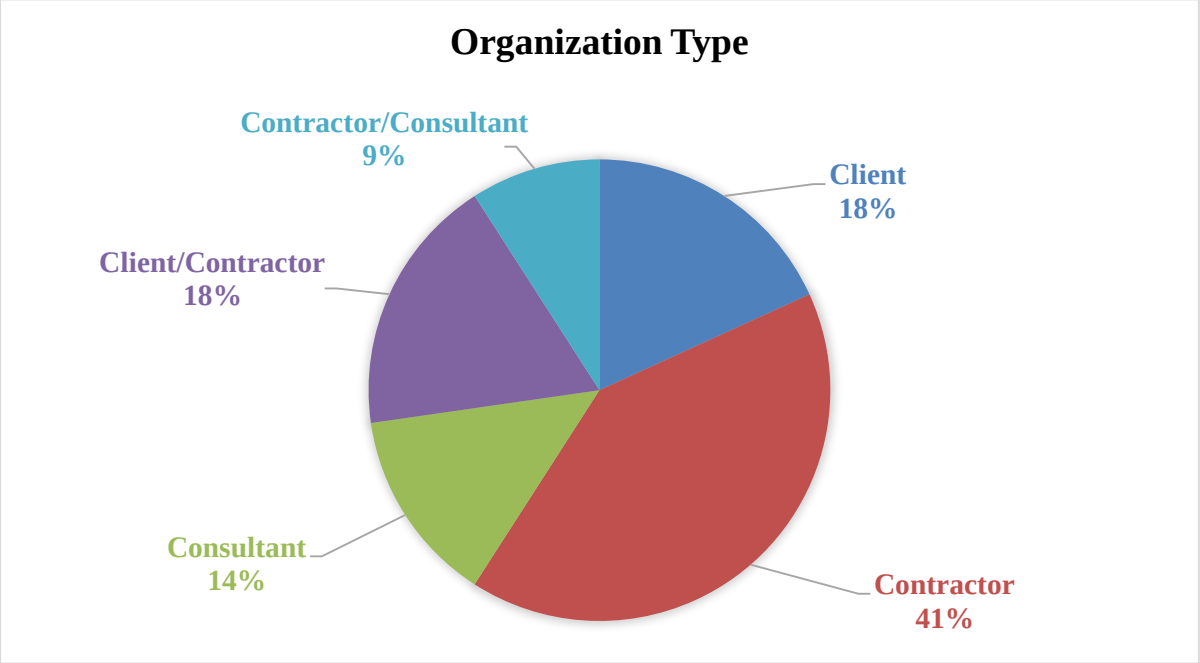

Figure 7 Organization Type

4.1.4. Demographics of Respondents

Considering the fact that the impact of the COVID-19 on construction industry was a much more complicated issue, therefore it was necessary that the semi-structured interviews be conducted with experts. 22 construction professionals having key positions and hands-on experience in the management and operations of construction activities during COVID-19 were interviewed. Consequently, respondents were selected based on their diverse experience and construction knowledge. The sample size of the study included members from supply chain teams, procurement teams, top management, coordination teams, execution staff, and planning teams. Respondents' background information such as experience and position are mentioned in the table below:

Table 15 Demographics of Respondents

Sr. No.	Designation	Project	Experience
1	Deputy Director Infrastructure	A	9
2	Planning Engineer	B	5
3	Procurement Officer	C	5
4	Project Manager	D	22
5	Assistant Engineer	E	10
6	Project Engineer	F	4
7	Project Manager	G	9
8	Assistant Manager Procurement	H	5
9	Construction Manager	I	11
10	Project Engineer	J	11

Sr. No.	Designation	Project	Experience
11	Project Engineer	K	6
12	Project Engineer	L	5
13	Material Engineer	M	23
14	Procurement Officer	N	7
15	Director Design	O	12
16	Project Engineer	P	5
17	Project Engineer	Q	5
18	Deputy Construction Manager	R	16
19	Deputy Project Manager	S	7
20	Director Procurement	T	20
21	Project Engineer	U	15
22	Deputy General Manager	V	20

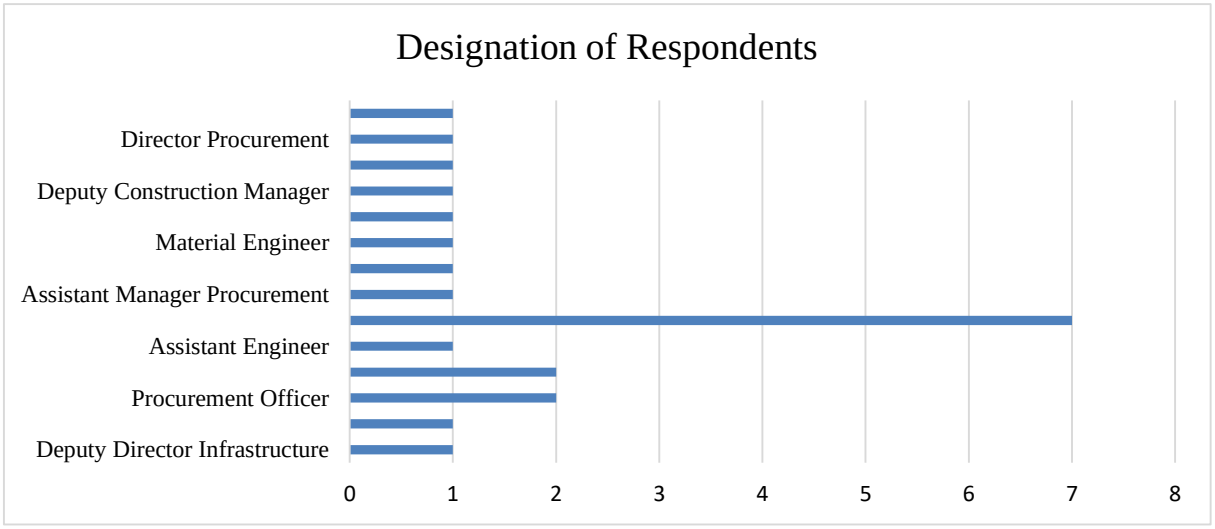

Figure 8 Designation of Respondents

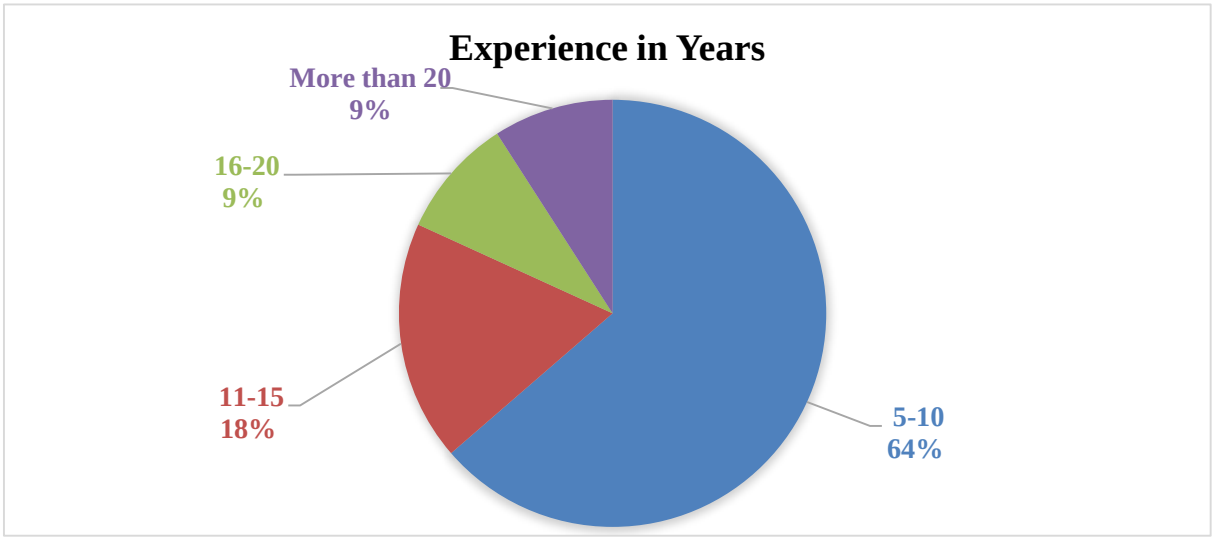

Figure 9 Experience in Years

4.2. Identification of SCOR groups

During the interviews, the participants were questioned regarding the factors that had been identified, with particular emphasis on their insights into how these factors could be categorized into the various processes of the Supply Chain Operations Reference (SCOR) model. Drawing upon their invaluable experience and extensive knowledge, a majority of the participants concurred on a shared consensus regarding the grouping of these factors. This harmonious viewpoint emerged as the prevailing perspective, reflecting the participants' collective expertise and aligning with the best practices observed within the industry.

Table 16 Identified SCOR groups

SCOR PROCESS	Impact	Discussion
Plan	Financial Issues/ Failure in Financing Inventories	The association between " Financial Issues/ Failure in Financing Inventories" and the plan process aligns with the nature of this process, which involves activities such as demand forecasting, resource allocation, and financial planning. The participants likely recognized that securing adequate funding for inventories is vital for effective supply chain planning, as it directly affects the availability and timely procurement of materials and resources.
	Declining Profits/ Less Revenues	The plan process in the SCOR framework involves activities such as demand forecasting, resource allocation, and financial planning. By placing "Declining Profits/ Less Revenues" in this stage, participants acknowledged that financial factors played a crucial role in the planning of construction projects during the pandemic. The decline in revenues and profits directly affected the ability of construction companies to allocate resources effectively and plan for future operations.
	Shortage of Inventory	By placing "Shortage of Inventory" in the plan process, the participants acknowledged the criticality of inventory availability in the construction industry during the COVID-19 pandemic. This placement emphasizes the need for construction companies to develop robust strategies for inventory management, including risk assessment and contingency planning, to ensure continuity of operations during SC disruptions.
Source	Disruption in Supplies Sourcing	The participants' tendency to associate disruptions in sourcing with the source process aligns with the underlying principles of effective supply chain management. Sourcing is a pivotal stage where

SCOR PROCESS	Impact	Discussion
		organizations establish relationships with suppliers, negotiate contracts, and ensure the availability of necessary inputs. Any disruptions in this stage, such as delays in material deliveries or difficulties in finding alternative suppliers, can significantly impact the overall supply chain performance.
	Product/Material Price Increase	The placement of "Product/Material Price Increase" under the source process suggests that participants perceive this factor as primarily related to the sourcing or procurement stage of the supply chain. The source process in the SCOR framework involves activities such as supplier selection, negotiation, contracting, and purchasing. Placing price increases under this process indicates that participants recognize the impact of rising product/material costs on the procurement aspect of the supply chain. The participants' tendency to associate price increases with the source process aligns with the common challenges faced in supply chain management.
Make	Shortages of Labor	The adequacy on the smooth functioning of the construction and production participants' placement of labor shortages under the make process suggests that they recognize the significant impact of workforce availability and activities and ensure operational efficiency within the supply chain.
	Operations & Production Shutdown	The placement of "Operations & Production Shutdown" under the make process suggests that the participants perceive this factor as directly impacting the manufacturing or production stage of the supply chain. This finding aligns with the make process, which encompasses activities related to manufacturing, assembly, and production. It indicates that the participants recognize that operations or production shutdowns can significantly disrupt the smooth flow of goods through the supply chain.
	Decreasing Productivity/ Work Rate	The Make process involves transforming raw materials into finished products or structures. It encompasses activities such as fabrication, assembly, and quality control. The participants' placement of "Decreasing Productivity/ Work Rate" in the Make process indicates their recognition that issues affecting the pace or efficiency of work directly impact the construction phase.
	Material Shortage	The placement of "Material Shortage" in the make process of the SCOR framework in the construction

SCOR PROCESS	Impact	Discussion
		industry during COVID-19 reflects the challenges faced by participants in procuring materials necessary for construction projects. The disruptions in global supply chains, increased demand for certain materials, and the need for alternative sourcing strategies all contributed to the shortage. Construction companies had to adapt and implement various strategies to mitigate the impact and ensure project continuity.
Deliver	Logistic Services Disruption	The placement of "Logistic Services Disruption" in the deliver process also suggests that participants recognize the interdependence between logistics and stakeholders' satisfaction. Timely delivery of construction materials and supplies is crucial for meeting project deadlines and ensuring client satisfaction. Understanding and addressing logistic service disruptions within the deliver process can help construction companies enhance their overall project performance and maintain positive relationships with clients.
	Delays in Delivery	The placement of "Delays in Delivery" in the deliver process underscores the importance of effective logistics and transportation management in construction supply chains. It suggests that participants perceive delays in the delivery of construction materials as a significant challenge that occurred during COVID-19 in the execution phase of a project. Construction projects often involve complex logistics networks, multiple suppliers, and various transportation modes, making the delivery process vulnerable to potential bottlenecks and delays.
	Border Closure / Port Restrictions	The placement of " Border Closure / Port Restrictions " in the deliver process suggests that participants perceive this issue as relevant to the final stages of supply chain management. The deliver process involves activities such as order management, transportation, and customer service, indicating that participants associate border restrictions and port closures with the fulfillment and delivery of goods and construction material to customers.
	Disruption in Transportation	Participants placed "Disruption in Transportation" in the deliver process of the SCOR (Supply Chain Operations Reference) framework. Transportation disruptions caused by lockdowns, travel bans, and reduced capacity significantly impacted the timely delivery of materials and equipment to construction sites. The placement of "Disrupted Transportation" under the make process

SCOR PROCESS	Impact	Discussion
		suggests that the participants perceive this factor as directly impacting the final stage of the construction supply chain.
Return	Logistic Services Disruption	In the return process of the SCOR framework, organizations typically focus on reverse logistics, which involves managing the flow of goods from customers back to the company. This can include handling returns, repairs, or recycling materials. The placement of "Logistic Services Disruption" in this process suggests that participants identified difficulties in coordinating the reverse flow of materials and products during the pandemic due to logistical constraints.

4.3. Results and Discussion

The results and discussion of the semi-structured interviews are given in the upcoming sections.

4.3.1. Material Shortage

Q: Did you face shortage of material and what mitigation measures and strategies did you adopted to reduce or minimize its impact?

86% of the projects faced shortage of material. Most of the participants admitted that they had to face this issue. One of the participants in the discussion raised a crucial point regarding the scarcity of imported material. Recognizing the need to find a viable solution, the team decided to shift their focus towards locally available alternatives. These substitutes were carefully evaluated to ensure they matched the exact specifications outlined in the client's provided specification sheet. By embracing this strategic shift, the team aimed to maintain the project's integrity and meet the client's expectations without compromising on quality. This proactive approach not only showcased the team's adaptability but also emphasized their commitment to delivering a successful outcome while leveraging the resources readily accessible in the local market.

During the interview, one participant emphasized the scarcity of elevator components and other related parts, which hindered their procurement. This shortage extended beyond elevators, affecting the availability of even common items like steel for RCC pipes and manhole covers. Unfortunately, these materials were not locally accessible, forcing the

project to source them from other cities. This procurement challenge highlighted the dependence on external suppliers and the need for effective logistics management. The participant's remark shed light on the broader issue of limited regional availability.

While mentioning some of the mitigating measures that the company took, a participant elaborated on their approach to dealing with the unavailability of a specific brand. In such instances, they decided to explore alternative options from other approved brands. Dura Pipes had to be used but they also faced shortages, prompting the company to adapt further by shifting towards Beta and Popular Pipes. These choices showcased the company's flexibility and willingness to embrace local sourcing as a solution. By diversifying their supplier base, the company not only demonstrated their ability to adapt to unforeseen circumstances but also supported local businesses, fostering stronger ties within the community. This approach not only helped mitigate the impact of shortages but also allowed the company to continue its operations smoothly while maintaining its commitment to delivering quality products to its customers.

Another participant having experienced this issue emphasized the significant impact of material unavailability on overhead costs, explaining that when materials are lacking, work inevitably grinds to a halt. This interruption not only leads to wasted time but also incurs additional expenses. Idle machinery and manpower contribute to the accumulation of overhead costs, as resources remain unutilized. The unavailability of materials creates a ripple effect, causing delays and inefficiencies throughout the project, ultimately increasing overhead expenses. Addressing this issue becomes imperative for organizations to streamline operations, minimize idle resources, and optimize cost-effectiveness. By ensuring a steady supply of materials, businesses can mitigate the burden of overhead costs and maintain a smooth workflow.

During the shortage of materials, construction firms implemented a range of mitigation strategies to address the issue. Firstly, they moved towards alternate vendors/suppliers, seeking reliable sources outside their usual supply chain. Additionally, they focused on local vendors/suppliers, reducing dependency on distant sources and ensuring a more stable supply. To further safeguard against material scarcity, construction firms proactively identified alternate materials in advance and transitioned towards their use. They also prioritized locally available materials, maximizing accessibility and reducing reliance on imported resources. To enhance supply chain resilience, construction firms diversified their supplier/vendor base, engaging with multiple sources to mitigate the impact of disruptions.

They also adopted a strategy of building inventory buffers instead of relying solely on just-in-time practices, ensuring an adequate supply during shortages. Bulk ordering was another approach, allowing them to secure materials in larger quantities and reduce the frequency of orders.

To adapt to the changing circumstances, construction firms revised their base plans, incorporating alternative materials and adjusting specifications. They also initiated contract renegotiations to address material availability issues and explore mutually beneficial solutions. Proper preplanning, comprehensive planning, and effective management played a crucial role in anticipating and mitigating potential shortages. Early decision making and smart allocation of resources helped construction firms stay ahead of the material scarcity challenge. They prioritized critical activities and adjusted schedules accordingly to optimize resource utilization. Building strong relationships with suppliers fostered better communication and collaboration, facilitating a more coordinated response to material shortages. In some cases, construction firms borrowed materials from sister plants within their organization, optimizing internal resources to meet project requirements. They also established direct contacts with upstream suppliers, forging closer relationships to secure supplies and reduce the bullwhip effect, minimizing fluctuations in material availability. Improving processes for planning and forecast sharing between construction firms and their suppliers' enhanced visibility and coordination, enabling better anticipation of material needs. Additionally, prioritizing critical materials ensured that essential components were secured promptly.

Overall, construction firms implemented a comprehensive range of strategies to address material shortages, combining proactive measures such as diversification, inventory management, and alternate sourcing with effective planning, communication, and collaboration.

Due to these strategies, construction firms were able to reduce cost overruns by 30% and time overruns by 46% hence proving these strategies and measures to be effective.

4.3.2. Operations and Production Shutdown

Q: Did your company faced operations shutdown and production shutdown and what mitigation measures and strategies did you adopted to reduce or minimize its impact?

59% of the projects faced operations shutdown/ production shutdown. A participant stated

that during the entire duration of the pandemic, they experienced an extensive one-month period of strict lockdown that compelled us to cease our operations entirely. However, once the lockdown measures were lifted, we diligently adhered to strict Standard Operating Procedures (SOPs) to ensure the prevention of any COVID-19 cases within our premises. Our commitment was twofold: not only did we aim to protect the health and well-being of our workforce, but we also sought to avoid any potential government intervention that could result in the sealing of our premises and subsequent operational disruptions. By prioritizing safety protocols and vigilantly maintaining them, they strived to maintain uninterrupted operations in the face of these challenging circumstances.

Another participant said that there was an initial lockdown of one month, implemented to curb the spread of the virus. As the situation gradually improved, we adopted a phased approach to ease restrictions. We initiated a system where we started calling people on alternative days, allowing for limited social interaction while ensuring safety. This measured approach aimed to balance the need for human connection with the ongoing health concerns. However, as conditions stabilized further, we transitioned back to operating at full capacity while strictly adhering to the Standard Operating Procedures (SOPs). These guidelines played a crucial role in safeguarding the well-being of all participants and mitigating any potential risks associated with the virus while ensuring smooth operations.

During an operations or production shutdown, construction firms implemented a range of mitigation strategies to minimize the impact and ensure smooth operations. Proper planning was prioritized, with projects, work, and activities organized based on criticality and urgency. To accommodate the shutdown period, multiple shifts or staggered shifts were implemented, ensuring continuous work progress. Adhering to standard operating procedures (SOPs) and government guidelines helped maintain safety and compliance during operations. Firms explored the use of alternate materials or changed material options to mitigate supply chain disruptions. Manpower and working hours were increased to compensate for lost progress during the shutdown. Higher administration was actively involved in decision-making to ensure smooth working and overcome challenges. Tasks such as design, estimation, and scheduling were carried out through work-from-home arrangements, utilizing digital solutions. Early procurement of materials and building up inventories helped mitigate potential shortages. Design changes were implemented, considering alternate materials, while digitized solutions improved efficiency. When the plants reopened, production was increased to make up for the lost time. Effective communication with clients

and relevant stakeholders ensured they were well informed about the progress and any adjustments made to meet project timelines.

Due to these strategies, construction firms were able to reduce cost overruns by 37% and time overruns by 38% hence proving these strategies and measures to be effective.

4.3.3. Shortages of Labor

Q: Have you experienced a shortage of labor, if so what mitigation measures and strategies did you adopted to reduce or minimize its impact?

59% of the projects faced labor shortages. According to a participant's statement, this shortage primarily resulted from travel restrictions and the attitudes of the construction workforce. Different provincial governments imposed intercity travel restrictions intermittently, even after the main lockdown was lifted. Additionally, many construction workers held the perception that the coronavirus was only prevalent in urban areas and not in rural villages. As a result, workers residing in villages were deterred from returning to project sites.

Another participant highlighted that as a result of the lockdowns and transportation restrictions, construction workers who had traveled back to their hometowns or villages were unable to return to work. The sudden halt in transportation services, coupled with the fear of contracting the virus, created a significant obstacle for laborers to resume their construction activities.

To address labor shortages, construction firms implemented a range of mitigation strategies. Skilled and unskilled labor were retained on-site, ensuring a consistent workforce. Cross-training programs were implemented to enhance employee versatility and fill skill gaps. Closed and isolated sites were established to minimize exposure to external factors and maintain a controlled work environment. Strict safety measures were enforced to protect workers' well-being. Effective workforce management policies were put in place to optimize labor allocation and productivity. Accommodation and other facilities were provided on-site to isolate workers from external environment to mitigate the risk of COVID 19. In case of a company facing labor shortages and running multiple projects nearby, labor from the nearest site was relocated to the affected site. Local labor was hired to reduce travel distances and increase availability. Work hours were adjusted, offering flexible working hour arrangements. Proper staffing levels were ensured to prevent overburdening of workers.

Payments to labor were made through online modes, and privately arranged vehicles were arranged at the company's expense to transport workers to the site. More reliable and predictable shift schedules were established to improve planning and minimize disruptions. Engagement, communication, and connection were emphasized to foster a safer and more rewarding work culture, which included incentives for overtime work. By implementing these strategies, construction firms aimed to mitigate labor shortages and maintain productivity in a challenging labor market.

These strategies effectively led to a 28% reduction in cost overruns and a 42% reduction in time overruns, demonstrating their efficacy.

4.4.4. Disruption in Transportation

Q: Did you encounter any disruptions in transportation that affected your supply chain and what mitigation measures and strategies did you adopted to reduce or minimize its impact?

73% of the projects faced disrupted transportation. A participant expressed that, this issue was very severe because COVID restrictions caused halting of interstate and inter province transportation at multiple times during COVID. Very less material could be moved locally such as cement, sand and Margalla crush whereas the material that has to me procured and moved from other cities or internationally was on complete halt and could not be moved.

While mentioning some of the mitigating measures that the company took, a participant stated that the transportation to the employees and for material delivery was provided through a licensed company, ensuring the utmost safety. The drivers of this company were not only fully vaccinated but also followed strict standard operating procedures (SOPs), enabling them to smoothly pass through checkpoints without any delays. This efficient arrangement saved precious time for the drivers and ensured uninterrupted transportation, contributing to the overall productivity and seamless operation of the company. By prioritizing health protocols and implementing effective transportation strategies, the company successfully safeguarded its workforce and maintained a smooth flow of operations in terms of material delivery, even in challenging times.

To mitigate the challenges posed by disrupted transportation, construction firms implemented a range of strategies. Firstly, they provided company-provided vehicles to facilitate the movement of labor and materials. Additionally, they allowed their staff to work from home for the works that could be done remotely, reducing the number of individuals

requiring transportation. Licensed transportation companies with vaccinated drivers were hired for employee and material delivery, ensuring a safe and reliable transportation network. Route optimization techniques were employed, utilizing alternate routes to avoid congested or disrupted areas.

Alternative transportation modes were identified and utilized to diversify the transportation options available. The firms focused on local sourcing to minimize dependence on transportation from distant locations, thereby reducing the impact of disrupted supply chains. Contingency planning was implemented to address potential disruptions, including increased trip frequencies within the allowed period of movement and obtaining necessary permissions and support from local government authorities. To ensure fuel availability in the event of fuel supply disruptions, the construction firms had already stored sufficient quantities of petrol and diesel. Leveraging existing transport networks, vehicles used in other material delivery businesses in different cities were engaged and requested to bring required materials on their return trips. The construction firms prioritized clearing and opening routes to maintain access to construction sites. They also arranged for alternate or backup transport options to mitigate the impact of any unexpected transportation disruptions. By implementing these comprehensive mitigation strategies, the construction firms were able to navigate the challenges posed by disrupted transportation effectively and ensure the smooth flow of labor and materials to their construction sites.

By implementing these strategies, construction firms successfully achieved a 32% decrease in cost overruns and a 43% decrease in time overruns, validating the effectiveness of these measures.

4.4.5. Border Closure / Port Restrictions

Q: Were there any border closure or port restrictions that hindered your international operations, and what actions did you take to mitigate the impact?

50% of the projects faced face border restrictions/closure of ports. During the interview, a participant raised concerns about the installation of imported lifts for the ongoing project. According to their statement, these lifts encountered an unforeseen setback when they got stuck at the port, causing delays in their timely delivery. It was only after the ports finally opened that the lifts could be successfully transported and delivered to the project site. This disrupted the project's timeline.

As per the remarks of a participant, mostly finishing items on a project are imported and due to closed borders those items could not be sourced and they had to face delay for up to 6 months so what they did was that they sourced most of the items/material/product locally that were of same specifications as of imported ones.

A participant stated that the sandwich panels could not be imported because some of the consignment got stuck on port and secondly its manufacturing plant got shut down. The local vendors were not able to provide the customized sandwich panels according to the length, width and color scheme so 2 month delay was observed while importing the same from Turkey. EOT was claimed.

While sharing his experience a participant expressed that elevators and some other related components were imported from Spain but got stuck on port. Similarly for their other road project asphalt plant was to be imported but also could not be imported on time.

It was brought to my attention by a participant that LCs of embedded items that were not locally prepared, were done through bank. Due to the border restrictions their payments got stuck because once LC is generated the payment can't be returned. Marble was to be imported from Italy, similarly biomedical equipment for hospital also got stuck on port and could not be moved. Pakistani government when allowed the consignments to be received on the ports the governments of other countries such as England and China were not letting the shipments and consignments through due to their strict COVID-19 policies.

Another participant stated that their project required some essential imported products such as fire hydrant of Al-Haitham Company, gate valves and valves but they could not be imported due to strict COVID-19 restrictions.

During the interview, a participant highlighted that one of our special finishing items such as lighting fixtures had to be imported from Spain and Italy but their import process got suspended due to border restrictions.

A participant stated that shipments comprising of German MEP supplies, insulation materials from HIRA Industries and elevators from KONE Corporation got stuck at the Dubai port. He further added that dry wall, its assemblies and machinery had to face the same fate.

To mitigate the impact of border restrictions or closure of ports, construction firms have

implemented several strategies. First, they have diversified their suppliers to reduce dependence on a single source. This ensures a steady supply of materials even if one supplier is affected by restrictions. Second, they have shifted towards local vendors and suppliers, prioritizing locally available materials and sourcing. This reduces reliance on imported goods and minimizes the disruption caused by border closures. Additionally, construction firms have explored alternative brands if specific imported products were not available, allowing them to find suitable substitutes. Building good relationships with nearby companies has also proven beneficial as they can obtain materials from nearby working companies, ensuring a continuous supply. Another strategy employed is borrowing materials from alternate plants, enabling firms to fulfill their requirements despite disruptions in transportation. Stockpiling materials in bulk quantities has become crucial, allowing firms to maintain a sufficient inventory to sustain operations during periods of restricted supply. In case of delay beyond control, EOT was claimed. Finally, conducting need-based analysis helps identify urgent requirements, enabling firms to prioritize procurement and manage resources effectively. By implementing these mitigation strategies, construction firms can navigate the challenges posed by border restrictions and port closures efficiently.

Cost overruns were reduced by 35% and time overruns by 36% as a direct result of employing these strategies, establishing their effectiveness conclusively.

4.4.6. Logistic Services Disruption

Q: Did you experience any disruptions in your logistics services, if yes than what mitigation measures and strategies did you adopted to reduce or minimize its impact?

59% of the projects faced disruption in logistic services. A participant stated that they faced this issue because logistics are production and transportation dependent, since there was a disruption in the earlier mentioned factors so ultimately disruption in the logistics services was also observed.

Another participant mentioned that the disruption in logistic services during the COVID-19 pandemic was primarily caused by a combination of factors. Firstly, the implementation of lockdown measures and transportation restrictions by government significantly impacted the movement of goods and personnel. These restrictions aimed to curb the spread of the virus but resulted in the closure of borders, suspension of flights, and reduced availability of transportation options. As a result, the logistical infrastructure and supply chains faced unprecedented challenges. Freight transportation, including shipping, air cargo, and trucking,

encountered difficulties in maintaining regular schedules and routes. Additionally, the measures taken to prevent the spread of the virus and ensure the safety of workers within logistics facilities further disrupted services. Social distancing requirements, reduced workforce capacity, and increased sanitation protocols led to operational inefficiencies and slowed down the overall logistics process. Moreover, outbreaks of COVID-19 among logistics workers and drivers resulted in quarantine measures and workforce shortages, further exacerbating the disruption. Adding further they said that the global nature of the pandemic impacted logistics on an international scale. As countries implemented varying measures and lockdowns at different times, coordination and synchronization of logistics operations became increasingly complex. The lack of uniformity in regulations and procedures across borders further impeded the smooth functioning of global supply chains.

The following strategies were implemented by construction firms to mitigate disruptions in logistic services. Proper preplanning, planning, and management ensured that potential challenges were anticipated and addressed in advance. Early decision making allowed for timely actions to be taken, minimizing the impact of disruptions. Following standard operating procedures (SOPs) and government guidelines ensured compliance and a structured approach to operations. Obtaining permission letters and government approvals for logistics operations further ensured legal compliance and smooth functioning. Prioritizing work helped in focusing efforts on critical tasks. Enhanced and effective communication through letters, emails, and platforms like WhatsApp facilitated coordination with stakeholders, enabling smooth operations. Advance ordering of materials ensured availability and reduced the risk of shortages. Arranging prerequisites for logistics, such as storage spaces and company-provided vehicles, enhanced operational efficiency. In the face of disruptions, construction firms also adopted various strategies such as relocating storage spaces, adopting alternate routes, and reorganizing transportation to maintain uninterrupted supply chains. Identifying alternative transportation options and increasing the number of trips within the allowed period of movement helped overcome logistical challenges. Engaging transport used by other material delivery businesses in different cities and requesting them to bring required materials on their return trips further optimized logistics. Emphasizing local sourcing reduced dependence on transportation from distant places, minimizing potential disruptions. Lastly, increasing transparency and communication with suppliers helped anticipate and identify any potential disruptions, enabling proactive measures to be taken. Overall, these strategies collectively contributed to mitigating the impact of disruptions in logistic services for construction firms.

The utilization of these strategies yielded a significant 37% decline in cost overruns and an impressive 32% decrease in time overruns, solidifying their effectiveness beyond doubt.

4.4.7. Product/Material Price Increase

Q: How did you manage any challenges posed by rising product or material costs, and what measures did you take to mitigate their impact?

73% of the projects faced product/material price increase. According to a participant's statement there was a drastic reduction of imported supply as a result of which the prices of locally available product/material got higher.

Another participant told that the prices of the HDP Pipes doubled.

As shared by a participant due to inflation in COVID times the prices of some materials and products got higher by 200-300%. Especially the prices of imported material got higher due to dollar conversion rate. Other than this a surge was also observed in the prices of the local material.

A participant stated that they definitely faced this issue as one of their work that cost 30 Million initially, went up to 50 Million. Some of the items to be used on the project were imported such as aluminum, copper wires and Philips electric accessories, the prices of which surged.

To mitigate the challenges posed by product/material price increases, construction firms have implemented a range of strategies. Firstly, they engage in bulk ordering to leverage their purchasing power and negotiate better prices with vendors. By establishing strong supplier relationships, firms can benefit from preferential treatment and favorable pricing arrangements. Additionally, including clauses in contracts that stipulate non-adjustable prices or fixed-price contracts provide stability and protect against sudden price fluctuations. In cases where price adjustments are necessary, firms engage in proactive renegotiation of contracts to ensure fair and sustainable pricing. Another effective measure is maintaining complete inventories in stock beforehand, reducing the reliance on volatile market prices. Furthermore, by sourcing locally in instances where imported inventories are unavailable, firms can access materials at lower prices. Early bookings and advance payments for materials not only secure supply but may also provide cost advantages. In case of delay beyond control, EOT was taken as a last resort. Diversifying the supplier base allows firms to compare prices and obtain competitive rates. By agreeing on neutral terms between clients

and contractors, both parties can navigate price increases together. Firms also benefit from beneficial government policies that form part of the construction industry's project management package. Lastly, collaboration with stakeholders fosters a shared understanding of the challenges and encourages joint problem-solving. Together, these strategies enable construction firms to mitigate the impact of product/material price increases and maintain project viability.

The application of these strategies resulted in a remarkable 34% decrease in cost overruns and a notable 30% reduction in time overruns, unequivocally proving their efficacy and success.

4.4.8. Financial Issues/ Failure in Financing Inventories

Q: Have you encountered any financial issues or difficulties in financing your inventories, and what steps did you take to overcome these challenges?

73% of the projects faced failure to finance inventories/ financial issues. A participant stated that due to the problems posed by COVID and lockdown the work became slow or halted due to which they were not able to generate invoices and IPCs on time, this caused them financial issues.

These mitigation strategies were implemented by construction firms to address the challenges related to failure to finance inventories and financial issues. Firstly, the companies retained skilled labor while laying off underperforming employees or placing them on long leave, ensuring that the workforce remained efficient and productive. They also developed strong supplier/vendor relationships, paying a certain percentage of inventories upfront and settling the remaining amount after project completion or when the government cleared the bills. Additionally, the firms temporarily halted employee salaries to manage cash flow effectively.

To reduce costs, the construction companies transitioned from imported items to locally manufactured alternatives that were more cost-effective. They also hired additional labor to expedite project completion and generate sufficient revenue. Negotiations with suppliers were conducted to secure favorable terms and conditions. Moreover, the firms sought assistance from clients by obtaining advance payments, providing them with the necessary funds to continue operations. Loans from banks and in few cases funds obtained from parent companies were utilized to address financial gaps. Efficient financial management and cash

flow management practices were implemented to ensure the company's financial stability. This included working under finance clauses and maintaining contemporary records for inventories, allowing for better tracking and control. These strategies collectively enabled construction firms to navigate financial challenges, sustain operations, and mitigate the risks associated with failure to finance inventories.

These strategies were instrumental in slashing cost overruns by 34% and time overruns by 30%, leaving no room for doubt about their effectiveness.

4.4.9. Shortage of Inventory

Q: Did you face inventory shortage and what mitigation measures and strategies did you adopted to reduce or minimize its impact?

68% of the projects faced inventory shortage. As per the remarks of a participant due to the production stoppage of supplies in the local market they had to face this issue because things were got getting manufactured locally while the material/product already in the inventory was slowly getting consumed.

A participant working on the finishing of a 5 star hotel stated that whenever you are working on a premium 5 star hotel, it includes a lot of premium material that has to be imported. Since other countries were facing very strict lockdown so they had to face inventory shortage for some specific materials. To tackle such issue domestic market was explored but minimal results could be achieved because there are no big players in the domestic market that could compete on such a high level in terms of product quality.

To mitigate inventory shortages in the construction industry, some firms have implemented various strategies. Firstly, they have transitioned from just-in-time inventory management to maintaining inventory buffers. This ensures that they have a sufficient stock of materials to meet their needs, even if there are unexpected disruptions or delays in the supply chain. Additionally, they have started exploring alternate brands and locally available materials to reduce reliance on specific suppliers and increase sourcing options. To secure materials in advance, these firms have adopted a practice of booking materials with advance payments. This helps them secure the required materials and minimizes the risk of shortages caused by sudden spikes in demand or supply chain disruptions. Furthermore, effective inventory management techniques are employed, such as prioritizing materials based on their criticality and planning for future demands through requirement and need analysis. By preplanning and

identifying critical materials, firms ensure that inventory levels do not plummet and that the necessary materials are always available. To replenish depleted inventories, construction companies actively search the market for potential suppliers. They establish good relationships with other firms working on similar projects and obtain short inventories from them if needed. By diversifying their supplier base, construction firms reduce the reliance on a single supplier, minimizing the risk of inventory shortages due to supplier-related issues. To enhance supply chain visibility and coordination, construction firms have implemented supply chain management software. These software solutions enable better tracking and management of inventory levels, supplier performance, and overall supply chain operations. This helps in making informed decisions and timely adjustments to avoid inventory shortages. Effective planning and collaboration across the supply chain are also emphasized to ensure smooth material flow and timely deliveries.

In summary, these mitigation strategies, including transitioning to inventory buffers, exploring alternate brands and local materials, booking materials in advance, implementing inventory management techniques, market search for restocking, diversifying supplier base, utilizing supply chain management software, and emphasizing effective planning and collaboration, collectively contribute to minimizing inventory shortages in the construction industry.

A 37% reduction in cost overruns and a 38% reduction in time overruns were achieved due to the successful implementation of these strategies, establishing their efficacy beyond question.

4.4.10. Delays in Delivery

Q: Have you faced any delays in delivery, and if yes, what actions did you take to minimize these delays and ensure timely shipments?

68% of the projects faced delivery delays. A participant stated that due to port congestion and shutdown of the supplier manufacturing facilities they had to face delivery delays. He further added that they had to face delivery delays for MEP fittings of BOSCH Company and air conditioning units of DAIKIN Company.

Another participant having faced the same issue expressed that the COVID-19 pandemic has had a profound impact on the construction industry in Pakistan and the impact on our project was no different as we also had to face delivery delays across our project. One of the primary

factors contributing to these delays was the nationwide lockdown and transportation restrictions imposed by the government to curb the spread of the virus. These restrictions resulted in disruptions in the supply chain, making it challenging to obtain the necessary construction materials and equipment on time. With the closure of manufacturing facilities and limited transportation options, the availability of construction materials became severely constrained. Additionally, transportation bottlenecks and the reduced capacity of logistics networks further compounded the issue, making it difficult to transport materials from one location to another.

In order to mitigate potential delivery delays, construction firms implemented several strategies. Firstly, they hired licensed transportation companies with vaccinated drivers to ensure safe and reliable material delivery. They followed standard operating procedures (SOPs) to maintain efficiency and consistency in their logistics operations. Additionally, they obtained permission letters from the local government to carry out their logistics activities. The companies provided their own vehicles to ensure prompt and reliable transportation. To tackle potential material shortages in case of delivery delays, some firms adopted a proactive approach. They purchased materials upfront and in bulk, ensuring that even in the case of shortages, they had sufficient inventory to prevent delays. They also established contingency plans, including identifying alternate vendors and suppliers to address any potential issues. Prior risk assessments were conducted to identify potential bottlenecks or delays in deliveries, allowing the firms to take preemptive measures. To enhance their delivery capabilities, construction firms increased the number of company vehicles available for transportation. By having a larger fleet, they were better prepared to handle multiple deliveries simultaneously and minimize delays. Standby suppliers were also identified, allowing for quick and efficient procurement if primary suppliers encountered difficulties. Effective planning and collaboration played a crucial role in mitigating delivery delays. The firms employed robust planning strategies, carefully scheduling orders and ensuring they were dispatched according to the planned timeline. Cleared and shorter routes were selected for deliveries to optimize efficiency and reduce travel time.

Furthermore, construction firms aimed to speed up their production and construction activities to reduce dependency on external deliveries. By accelerating their internal processes, they could compensate for any potential delays in material shipments. Lastly, effective human resources management was emphasized. The firms ensured that they had a capable and competent workforce in place, capable of executing tasks efficiently and

resolving any challenges that arose during the delivery process. By implementing these comprehensive strategies, construction firms successfully mitigated the risk of delivery delays, maintaining productivity and meeting project timelines.

With these strategies in place, construction firms managed to curtail cost overruns by 33% and time overruns by 38%, effectively demonstrating the merit of these measures.

4.4.11. Declining Profits/ Less Revenues

Q: Have you experienced a decline in revenues or profits, and if so, what steps did you take to improve the situation and enhance financial performance?

50% of the projects faced fewer revenues/ decline in profits. A participant stated that they were not able to generate invoices and IPCs on time while incurring overhead costs, this caused them lesser revenues and a decline in company's profits.

Another participant shared that he thinks otherwise because government introduced amnesty scheme through which 7% withholding tax was exempted. This tax was returned back by FBR on the submitted IPCs.

During the interview, a participant highlighted that the COVID-19 pandemic had a detrimental impact on the Pakistani construction industry, leading to a significant decline in profits and the companies such as ours were able to generate fewer revenues. Several factors contributed to this challenging situation. Firstly, the nationwide lockdown imposed to curb the spread of the virus resulted in the suspension or slowdown of construction activities. Construction site were temporarily closed, and workers were unable to continue their tasks. This pause in operations caused the delays in project timelines, resulting in cost overruns and decreased productivity. As a result, project faced budget constraints because they were not able to generate IPCs and bills on time and they experienced a decline in revenues. The increased prices of materials, coupled with logistical challenges, significantly hampered construction activities, leading to reduced revenues.

For small sized construction firms he further added that the uncertainty surrounding the pandemic and its duration created a sense of caution among potential investors and homebuyers. Many individuals and companies postponed or canceled construction projects due to financial insecurities and a lack of confidence in the market. This reluctance to invest or proceed with construction contracts directly contributed to the decline in profits for construction companies.

In response to the challenge of fewer revenues and declining profits, construction firms implemented several mitigation strategies. Firstly, skilled and experienced labor was retained, while underperforming labor was placed on unpaid leaves, ensuring that the workforce remained efficient and productive while cutting costs as well. To mitigate costs, price cuts were made by approving alternate brands with lower prices, reducing expenses without compromising quality. Additionally, resources were increased to meet project schedules, and the rate of work was escalated to expedite completion. More man-hours were allocated to ensure timely delivery, and a focused approach on single projects at a time was adopted, allowing for concentrated efforts and better efficiency.

Furthermore, construction firms actively pursued securing new projects to increase revenue streams and offset declining profits. They also encouraged their teams to work more efficiently, fostering a culture of productivity and optimization. Financial support was obtained from the parent company, providing additional funds to sustain operations during challenging times. Negotiating favorable payment terms with clients helped manage cash flow effectively. Cost-cutting measures were implemented, including halting staff salaries temporarily, as a short-term measure to minimize expenses. The firms were mindful of maintaining a breakeven point, ensuring that the project's internal rate of return (IRR) and external rate of return (ERR) values were satisfactory despite declining profits. Lastly, they sought an extension of time (EOT) for project completion, allowing for additional time to address challenges and improve performance.

Overall, these mitigation strategies enabled construction firms to navigate the challenges of reduced revenues and declining profits. By focusing on cost optimization, resource allocation, efficient work practices, and financial management, they aimed to sustain operations, secure new opportunities, and maintain a favorable financial outlook in the face of adversity.

These strategies have proven their effectiveness by reducing cost overruns by 38% and time overruns by 25%, leaving no doubt about their positive impact.

4.4.12. Decreasing Productivity/ Work Rate

Q: Did you observe a decrease in work rate or productivity, and if yes, how did you address this issue to maintain efficiency?

91% of the projects faced decrease in work rate/ productivity. A participant expressed that

due to the limited working time frame, staggered working shifts as part of the SOPs the productivity got compromised. They also mentioned that the officials and staff in a construction work is highly interlinked with each other, people and different departmental teams rely on each other for smoothly carrying out construction activities, if some members are absent due to sickness or the fear of getting COVID than all others will get effected in terms of poor productivity. They had faced such scenarios.

As per the remarks of a participant the company officials were not able to visit site frequently due to safety measures. He further explained that in normal routine whole teams visited the site including Project Director, Director Procurement, Construction Manager, Engineer and Architect and a lot of the issues got resolved on the site by these combined visits but due to COVID restrictions that number of officials travelling together or being together at a site was not possible. This severely impacted the productivity negatively. Secondly another factor that contributed to the less productivity was the fear of getting COVID, due to this fear absenteeism in the top management and employees was observed at occasions.

In response to the decrease in work rate/productivity during the COVID-19 pandemic, construction firms implemented several mitigation strategies. Firstly, they adopted a work-from-home policy to ensure the safety of employees while maintaining business continuity. Additionally, the provision of personal protective equipment (PPEs) such as masks and gloves was made mandatory to safeguard the health of on-site workers. To minimize the risk of virus transmission, interlinked staff were grouped and alternated in attendance, enabling social distancing measures. Safety professionals and managers conducted regular training sessions and awareness campaigns to educate employees about COVID-19 safety protocols, boosting morale and ensuring adherence to guidelines. Walkthrough disinfecting spray gates were installed at entry points to sanitize individuals and equipment upon entering the site. To accommodate a reduced workforce and increase productivity, construction firms implemented multiple shifts, including night shifts, and ensured proper supervision to maintain efficiency. More man-hours were allocated to meet project schedules, and workforce rescheduling was done across multiple projects to optimize resources. Skilled labor was retained, while minimizing outside contact to mitigate the risk of exposure. Improved communication methods, such as online platforms, were utilized to enhance collaboration and ensure smooth coordination among teams. Schedule adjustments and activity prioritization were implemented to optimize time and resources effectively.

Ultimately, these comprehensive mitigation strategies aimed to prioritize employee safety, adhere to COVID-19 protocols, optimize workforce utilization, and enhance communication and coordination, all of which collectively contributed to boosting work rate and productivity in the construction industry during challenging times.

Construction firms were able to achieve a significant 34% reduction in cost overruns and a substantial 44% decrease in time overruns through the implementation of these strategies, validating their effectiveness unequivocally.

4.4.13. Disruption in Supplies Sourcing

Q: Did you face disruption in sourcing of supplies and what mitigation measures and strategies did you adopted to reduce or minimize its impact?

59% of the projects faced disruption in sourcing of supplies. A participant while sharing his experience mentioned that during the pandemic, they faced significant disruption in the sourcing of the supplies. The challenges experienced in obtaining necessary materials and resources affected our construction project. The disruptions were a result of various factors related to the pandemic and its associated restrictions. These factors impacted the movement of goods, including delays in shipments and scarcity of raw materials. The shortage of skilled labor and the implementation of health and safety protocols also played a role in hindering the sourcing process. Additionally, financial constraints faced by both construction company and suppliers further complicated the situation. As a result, our construction project experienced delays, increased costs, and a general disruption in the availability of essential supplies. Efforts were made to adapt by exploring alternative sourcing options and focusing on domestic manufacturing and they were able to reduce the impact somehow.

To mitigate disruptions in sourcing supplies, construction firms implemented several strategies. They maintained complete inventories in stock beforehand, ensuring a buffer to rely on in case of missing imported inventories or a focus on the domestic market. They established good relationships with nearby companies, allowing them to obtain materials from nearby working sources. Moreover, they diversified their supplier base and maintained standby suppliers, reducing dependence on a single source. Pre-planning for potential disruptions and conducting market research for supplies helped in identifying risks and managing them through proper planning. The firms prioritized vendors and suppliers nearest to their construction sites, enabling faster and more efficient sourcing. They also engaged in direct sourcing from companies rather than relying solely on the market. By fostering good

supplier relationships, they established reliable and consistent supply chains. The construction firms benefitted from favorable government policies as part of the PM Package for the construction industry, which supported their operations. They prioritized critical materials, ensuring their availability, and closely monitored and ensured the working plan of suppliers. Furthermore, they actively sought new sources of procurement to diversify their options and reduce dependency on a single supplier, thus enhancing their resilience in the face of disruptions. Overall, these comprehensive mitigation strategies helped construction firms navigate sourcing challenges effectively.

Construction firms were able to achieve a significant 30% reduction in cost overruns and a substantial 31% decrease in time overruns through the implementation of these strategies, validating their effectiveness unequivocally.

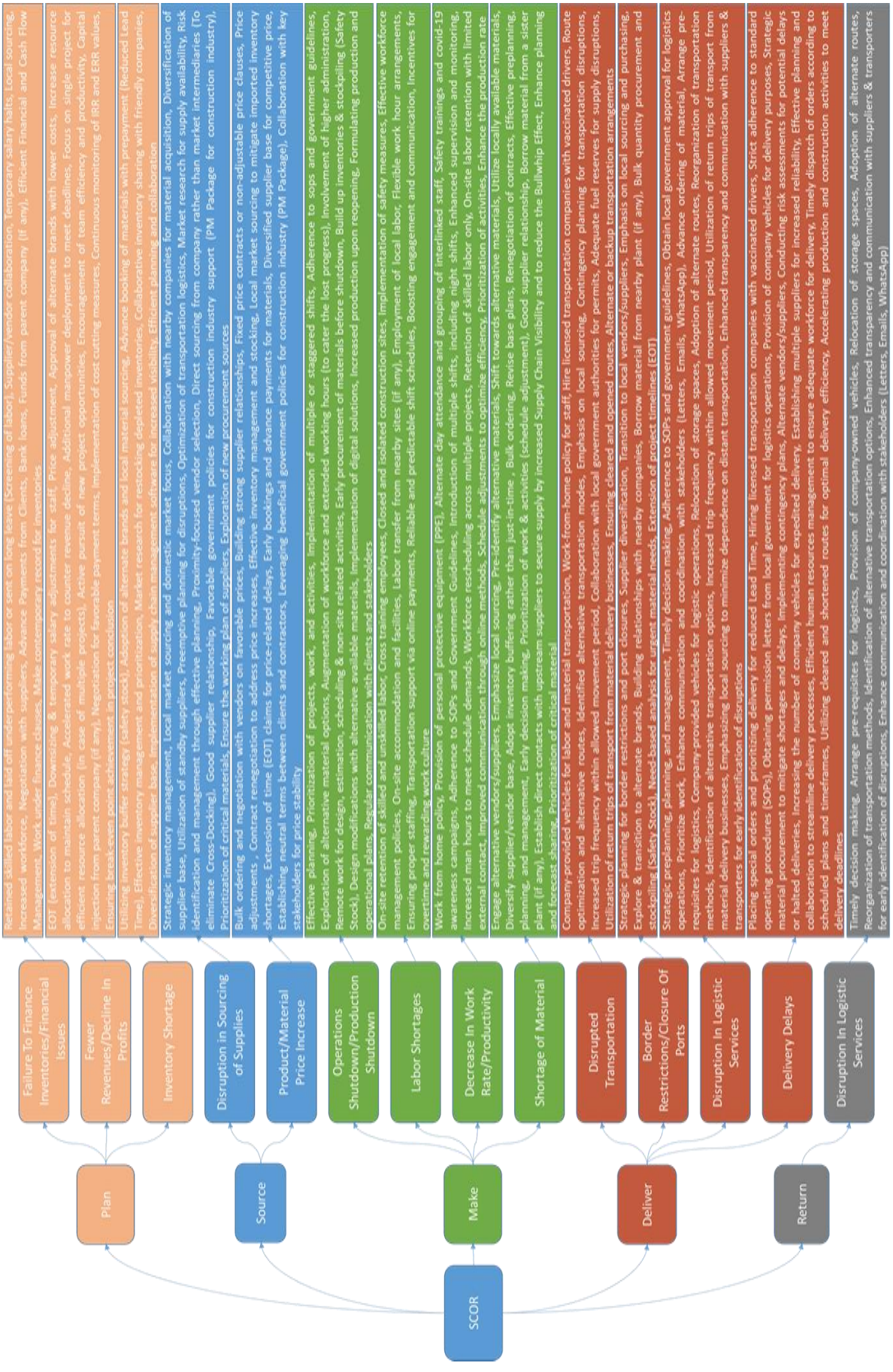

Figure 10 COVID-19 Mitigation Strategies

Table 17 Overall Effect of Mitigation Strategies on Cost

Factors	Mean Before	Mean After	Difference	Percentage Difference
Material Shortage	3.227	2.273	0.955	30
Operations & Production Shutdown	3.227	2.045	1.182	37
Shortages of Labor	2.727	1.955	0.773	28
Disruption in Transportation	3.273	2.227	1.045	32
Border Closure / Port Restrictions	3.727	2.409	1.318	35
Logistic Services Disruption	3.545	2.273	1.273	36
Product/Material Price Increase	3.682	2.318	1.364	37
Financial Issues/ Failure in Financing Inventories	3.318	2.182	1.136	34
Shortage of Inventory	3.227	2.045	1.182	37
Delays in Delivery	3.045	2.045	1.000	33
Declining Profits/ Less Revenues	3.364	2.091	1.273	38
Decreasing Productivity/ Work Rate	3.636	2.409	1.227	34
Disruption in Supplies Sourcing	3.182	2.227	0.955	30

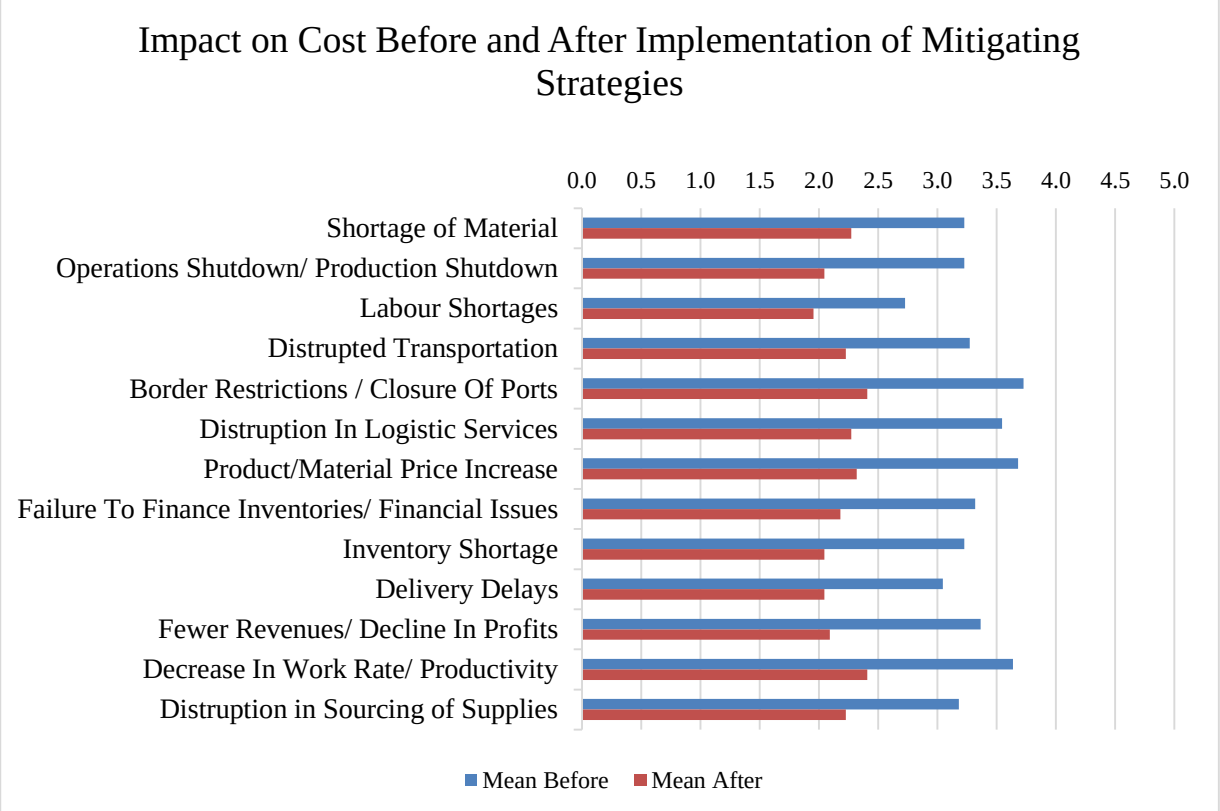

Figure 11 Impact on Cost Before and After Implementation of Mitigating Strategies

Table 18 Overall Effect of Mitigation Strategies on Time

Factors	Mean Before	Mean After	Difference	Percentage Difference
Material Shortage	3.955	2.136	1.818	46
Operations & Production Shutdown	3.455	2.136	1.318	38
Shortages of Labor	3.045	1.773	1.273	42
Disruption in Transportation	3.636	2.091	1.545	43
Border Closure / Port Restrictions	3.818	2.455	1.364	36
Logistic Services Disruption	3.864	2.182	1.682	44
Product/Material Price Increase	3.091	2.091	1.000	32
Financial Issues/ Failure in Financing Inventories	2.864	2.000	0.864	30
Shortage of Inventory	3.364	2.091	1.273	38
Delays in Delivery	3.682	2.273	1.409	38
Declining Profits/ Less Revenues	2.727	2.045	0.682	25
Decreasing Productivity/ Work Rate	3.909	2.182	1.727	44
Disruption in Supplies Sourcing	3.545	2.455	1.091	31

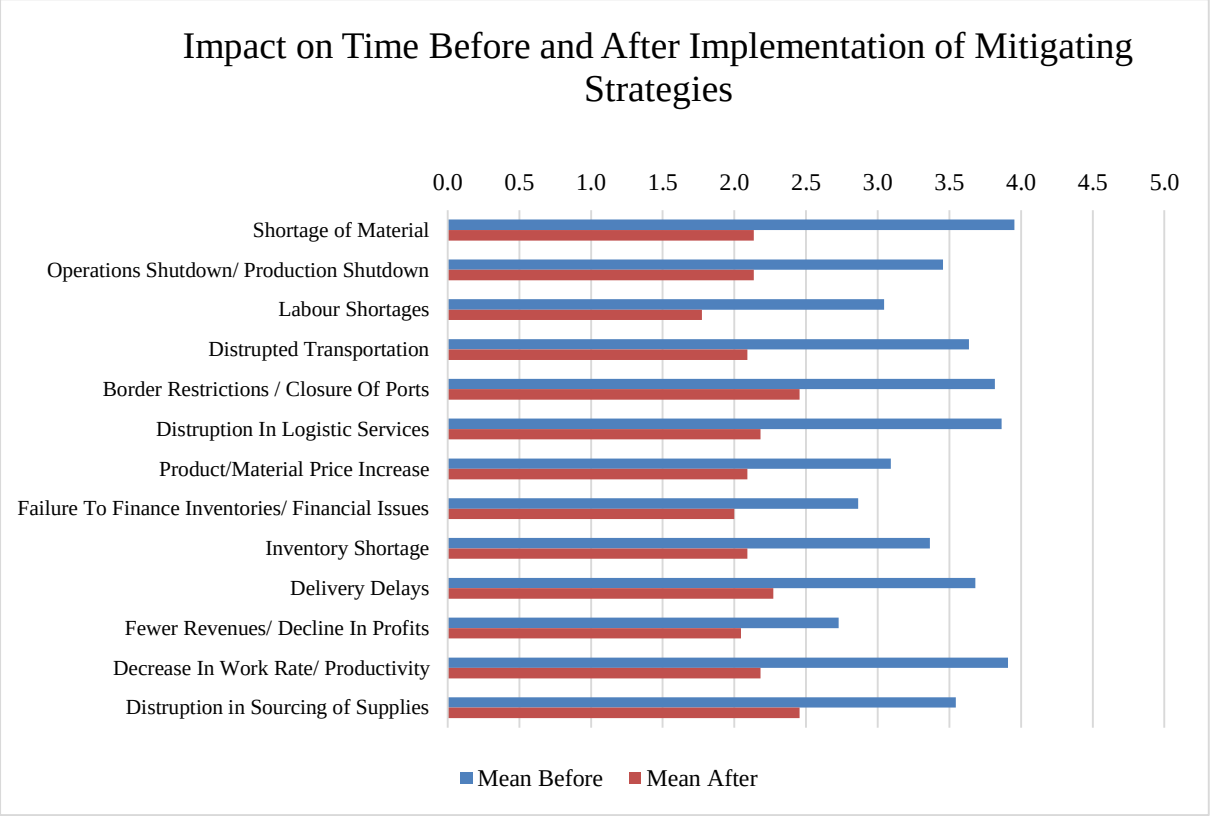

Figure 12 Impact on Time Before and After Implementation of Mitigating Strategies

Table 19 Mitigating Strategies & Measures for Plan Process of SCOR

SCOR Process	Impact	Project	Mitigating Strategy/Measure	Project Affected
Plan	Financial Issues/ Failure in Financing Inventories	C,D,F, H,I,J,K, L,N,P, Q,R,S, T,U,V	Retained skilled labor and laid off underperforming labor or sent on long leave (Screening of labor)	73%
			Supplier/vendor collaboration	
			Temporary salary halts	
			Local sourcing	
			Increased workforce	
			Negotiation with suppliers	
			Advance payments from clients	
			Bank loans	
			Funds from parent company (If any)	
			Efficient financial and cash flow management	
			Work under finance clauses	
			Make contemporary record for inventories	
	Declining Profits/ Less Revenues	C,E,F,J, K,L,N, Q,S,U, V	EOT (Extension of Time)	50%
			Downsizing & Temporary Salary Adjustments for Staff	
			Price adjustment	
			Approval of alternate brands with lower costs	
			Increase resource allocation to maintain schedule	
			Accelerated work rate to counter revenue decline	
			Additional manpower deployment to meet deadlines	
			Focus on single project for efficient resource allocation (in case of multiple projects)	
			Active pursuit of new project opportunities	
			Encouragement of team efficiency and productivity	
			Capital injection from parent company (if any)	
			Negotiation for favorable payment terms	
			Implementation of cost cutting measures	
			Continuous monitoring of IRR and ERR values	
			Ensuring break-even point achievement in project conclusion	

SCOR Process	Impact	Project	Mitigating Strategy/Measure	Project Affected
	Shortage of Inventory	C,E,F, G,H,I,J K,L,M, N,P,Q, C,V	Utilizing inventory buffer strategy (safety stock)	68%
			Adoption of alternate brands and local material sourcing	
			Advance booking of materials with prepayment (Reduced Lead Time)	
			Effective inventory management and prioritization	
			Market research for restocking depleted inventories	
			Collaborative inventory sharing with friendly companies	
			Diversification of supplier base	
			Implementation of supply chain management software for increased visibility	
			Efficient planning and collaboration	

Table 20 Mitigating Strategies & Measures for Source Process of SCOR

SCOR Process	Impact	Project	Mitigating Strategy/Measure	Project Affected
Source	Disruption in Supplies Sourcing	C,D,H,I ,J,K,M, N,O,Q, S,T,V	Strategic inventory management	59%
			Local market sourcing and domestic market focus	
			Collaboration with nearby companies for material acquisition	
			Diversification of supplier base	
			Utilization of standby suppliers	
			Preemptive planning for disruptions	
			Optimization of transportation logistics	
			Market research for supply availability	
			Risk identification and management through effective planning	
			Proximity-focused vendor selection	
			Direct sourcing from company rather than market intermediaries (To eliminate Cross-Docking)	
			Good supplier relationship	
			Favorable government policies for construction industry support (PM	

SCOR Process	Impact	Project	Mitigating Strategy/Measure	Project Affected
			Package for construction industry)	
			Prioritization of critical materials	
			Ensure the working plan of suppliers	
			Exploration of new procurement sources	
	Product/Material Price Increase	A,B,C, D,E,F, G,I,J,K, L,N,Q, R,S,V	Bulk ordering and negotiation with vendors on favorable prices	73%
			Building strong supplier relationships	
			Fixed price contracts or non-adjustable price clauses	
			Price adjustments	
			Contract renegotiation to address price increases	
			Effective inventory management and stocking	
			Local market sourcing to mitigate imported inventory shortages	
			Extension of time (EOT) claims for price-related delays	
			Early bookings and advance payments for materials	
			Diversified supplier base for competitive price	
			Establishing neutral terms between clients and contractors	
			Leveraging beneficial government policies for construction industry (PM Package)	
			Collaboration with key stakeholders for price stability	

Table 21 Mitigating Strategies & Measures for Make Process of SCOR

SCOR Process	Impact	Project	Mitigating Strategy/Measure	Project Affected
Make	Operations & Production Shutdown	A,B,C, D,H,I,J, K,P,Q, R,S,V	Effective planning	59%
			Prioritization of projects, work, and activities	
			Implementation of multiple or staggered shifts	
			Adherence to sops and government guidelines	
			Exploration of alternative material options	
			Augmentation of workforce and extended working hours (to cater	

SCOR Process	Impact	Project	Mitigating Strategy/Measure	Project Affected
			the lost progress)	
			Involvement of higher administration	
			Remote work for design, estimation, scheduling & non-site related activities	
			Early procurement of materials before shutdown	
			Build up inventories & stockpiling (Safety Stock)	
			Design modifications with alternative available materials	
			Implementation of digital solutions	
			Increased production upon reopening	
			Formulating production and operational plans	
			Regular communication with clients and stakeholders	
	Shortages of Labor	B,C,D, H,I,K, N,O,P, R,S,T, V	On-site retention of skilled and unskilled labor	59%
			Cross training employees	
			Closed and isolated construction sites	
			Implementation of safety measures	
			Effective workforce management policies	
			On-site accommodation and facilities	
			Labor transfer from nearby sites (if any)	
			Employment of local labor	
			Flexible work hour arrangements	
			Ensuring proper staffing	
			Transportation support via online payments	
			Reliable and predictable shift schedules	
			Boosting engagement and communication	
			Incentives for overtime and rewarding work culture	
	Decreasing Productivity/ Work Rate	A,B,C, D,E,G, H,I,J,K, L,M,N, O,Q,R,	Work from home policy	91%
			Provision of personal protective equipment (PPE)	
			Alternate day attendance and grouping of interlinked staff	
			Safety trainings and covid-19	

SCOR Process	Impact	Project	Mitigating Strategy/Measure	Project Affected
		S,T,U, V	awareness campaigns	
			Adherence to SOPs and Government Guidelines	
			Introduction of multiple shifts, including night shifts	
			Enhanced supervision and monitoring	
			Increased man hours to meet schedule demands	
			Workforce rescheduling across multiple projects	
			Retention of skilled labor only	
			On-site labor retention with limited external contact	
			Improved communication through online methods	
			Schedule adjustments to optimize efficiency	
			Prioritization of activities	
			Enhance the production rate	
	Material Shortage	A,B,C, D,E,F, G,H,I,J, K,L,M, N,P,Q, S,U,V	Engage alternative vendors/suppliers	86%
			Emphasize local sourcing	
			Pre-identify alternative materials	
			Shift towards alternative materials	
			Utilize locally available materials	
			Diversify supplier/vendor base	
			Adopt inventory buffering rather than just-in-time	
			Bulk ordering	
			Revise base plans	
			Renegotiation of contracts	
			Effective preplanning, planning, and management	
			Early decision making	
			Prioritization of work & activities (schedule adjustment)	
			Good supplier relationship	
			Borrow material from a sister plant (if any)	
			Establish direct contacts with upstream suppliers to secure supply by increased Supply Chain Visibility and to reduce the Bullwhip Effect	
			Enhance planning and forecast sharing	
			Prioritization of critical material	

Table 22 Mitigating Strategies & Measures for Deliver Process of SCOR

SCOR Process	Impact	Project	Mitigating Strategy/Measure	Project Affected
Deliver	Disruption in Transportation	C,E,H,I,J,K,L,M,N,O,Q,R,S,T,U,V	Company-provided vehicles for labor and material transportation	73%
			Work-from-home policy for staff	
			Hire licensed transportation companies with vaccinated drivers	
			Route optimization and alternative routes	
			Identified alternative transportation modes	
			Emphasis on local sourcing	
			Contingency planning for transportation disruptions	
			Increased trip frequency within allowed movement period	
			Collaboration with local government authorities for permits	
			Adequate fuel reserves for supply disruptions	
			Utilization of return trips of transport from material delivery businesses	
			Ensuring cleared and opened routes	
			Alternate or backup transportation arrangements	
	Border Closure / Port Restrictions	C,D,E,F,I,J,L,Q,S,U,V	Strategic planning for border restrictions and port closures	50%
			Supplier diversification	
			Transition to local vendors/suppliers	
			Emphasis on local sourcing and purchasing	
			Explore & transition to alternate brands	
			Building relationships with nearby companies	
			Borrow material from nearby plant (if any)	
			Bulk quantity procurement and stockpiling (Safety Stock)	
			Need-based analysis for urgent material needs	
			Extension of project timelines (EOT)	
	Logistic Services Disruption	E,H,I,J,	Strategic preplanning, planning, and management	59%

SCOR Process	Impact	Project	Mitigating Strategy/Measure	Project Affected
		K,M,N, O,P,R, S,T,V	Timely decision making	
			Adherence to SOPs and government guidelines	
			Obtain local government approval for logistics operations	
			Prioritize work	
			Enhance communication and coordination with stakeholders (Letters, Emails, WhatsApp)	
			Advance ordering of material	
			Arrange pre-requisites for logistics	
			Company-provided Vehicles for Logistic Operations	
			Relocation of storage spaces	
			Adoption of alternate routes	
			Reorganization of transportation methods	
			Identification of alternative transportation options	
			Increased trip frequency within allowed movement period	
			Utilization of return trips of transport from material delivery businesses	
			Emphasizing local sourcing to minimize dependence on distant transportation	
			Enhanced transparency and communication with suppliers & transporters for early identification of disruptions	
	Delays in Delivery	A,B,E, F,G,H,I ,J,K,M, N,O,P, S,V	Placing special orders and prioritizing delivery for reduced Lead Time	68%
			Hiring licensed transportation companies with vaccinated drivers	
			Strict adherence to standard operating procedures (SOPs)	
			Obtaining permission letters from local government for logistics operations	
			Provision of company vehicles for delivery purposes	
			Strategic material procurement to mitigate shortages and delays	
			Implementing contingency plans	
			Alternate vendors/suppliers	
			Conducting risk assessments for	

SCOR Process	Impact	Project	Mitigating Strategy/Measure	Project Affected
			Potential delays or halted deliveries	
			Increasing the number of company vehicles for expedited delivery	
			Establishing multiple suppliers for increased reliability	
			Effective planning and collaboration to streamline delivery processes	
			Efficient human resources management to ensure adequate workforce for delivery	
			Timely dispatch of orders according to scheduled plans and timeframes	
			Utilizing cleared and shortened routes for optimal delivery efficiency	
			Accelerating production and construction activities to meet delivery deadlines	

Table 23 Mitigating Strategies & Measures for Return Process of SCOR

SCOR Process	Impact	Project	Mitigating Strategy/Measure	Project Affected
Return	Disruption in Logistic Services (Reverse Logistics)	E,H,I,J, K,M,N, O,P,R, S,T,V	Timely decision making	59%
			Arrange pre-requisites for logistics	
			Provision of company-owned vehicles	
			Relocation of storage spaces	
			Adoption of alternate routes	
			Reorganization of transportation methods	
			Identification of alternative transportation options	
			Enhanced transparency and communication with suppliers & transporters for early identification of disruptions	
			Enhance communication and coordination with stakeholders (Letters, Emails, WhatsApp)	

The following table represents a comprehensive overview of the SCOR processes and their corresponding impacts within construction organizations. It highlights the potential challenges or issues that arose in each process. For each impact, the table provides a set of top mitigation strategies or measures that can be implemented to address and minimize the negative effects. These strategies encompass various aspects of supply chain management. By understanding the potential impacts and implementing appropriate mitigation strategies, organizations can enhance their resilience and efficiency in managing supply chain challenges. Top mitigation strategies adopted by construction firms to minimize and mitigate the impacts posed by COVID-19 are presented against each factor, also these mitigation strategies were found out to be common within multiple or most of the firms.

Table 24 Top Mitigation Strategies/Measures

SCOR Process	Impact	Top Mitigation Strategies/Measures
Plan	Financial Issues/ Failure in Financing Inventories	Retained skilled labor and laid off underperforming labor or sent on long leave (Screening of labor)
		Supplier/Vendor collaboration
		Temporary salary halts
	Declining Profits/ Less Revenues	Downsizing & temporary salary adjustments for staff
		EOT (Extension of Time)
		Price adjustment
	Shortage of Inventory	Effective inventory management and prioritization
		Efficient planning and collaboration
		Adoption of alternate brands and local material sourcing
		Utilizing inventory buffer strategy (Safety Stock)
		Advance booking of materials with prepayment (Reduced lead time)
Source	Disruption in Supplies Sourcing	Local market sourcing and domestic market focus
		Diversification of supplier base
		Preemptive planning for disruptions
		Market research for supply availability
		Risk identification and management through effective planning
	Product/Material Price Increase	Bulk ordering and negotiation with vendors on favorable prices
		Building strong supplier relationships
		Contract renegotiation to address price increases
		Local market sourcing to mitigate imported inventory shortages
		Fixed price contracts or non-adjustable price clauses
		Price adjustments
		Effective inventory management and stocking
		Early bookings and advance payments for materials
		Diversified supplier base for competitive price
Make	Operations & Production Shutdown	Adherence to SOPs and government guidelines
		Implementation of multiple or staggered shifts
		Effective planning
		Prioritization of projects, work, and activities

		Augmentation of workforce and extended working hours (To cater the lost progress)
		Design modifications with alternative available materials
	Shortages of Labor	On-site retention of skilled and unskilled labor
		Cross training employees
		Incentives for overtime and rewarding work culture
		Effective workforce management policies
		On-site accommodation and facilities
	Decreasing Productivity/ Work Rate	Provision of personal protective equipment (PPEs)
		Safety trainings and COVID-19 awareness campaigns
		Adherence to SOPs and government guidelines
		Work from home policy
		Introduction of multiple shifts, including night shifts
		Increased man hours to meet schedule demands
		Retention of skilled labor only
	Material Shortage	Diversify supplier/vendor base
		Emphasize local sourcing
		Adopt inventory buffering rather than just-in-time
		Engage alternative vendors/suppliers
		Shift towards alternative materials
		Utilize locally available materials
		Prioritization of work & activities (Schedule Adjustment)
Deliver	Disruption in Transportation	Company-provided vehicles for labor and material transportation
		Route optimization and alternative routes
		Identified alternative transportation modes
		Contingency planning for transportation disruptions
		Collaboration with local government authorities for permits
	Border Closure / Port Restrictions	Emphasis on local sourcing and purchasing
		Transition to local vendors/suppliers
		Bulk quantity procurement and stockpiling (Safety Stock)
		Extension of project timelines (EOT)
	Logistic Services Disruption	Company-provided vehicles for logistic operations
		Enhanced transparency and communication with suppliers & transporters for early identification of disruptions
		Strategic preplanning, planning, and management
		Obtain local government approval for logistics operations
		Advance ordering of material
	Delays in Delivery	Placing special orders and prioritizing delivery for reduced lead time
		Provision of company vehicles for delivery purposes
		Alternate vendors/suppliers
		Establishing multiple suppliers for increased reliability
		Obtaining permission letters from local government for logistics operations
		Utilizing cleared and shortened routes for optimal delivery efficiency
Return	Disruption in Logistic Services	Company-provided vehicles for logistic operations
		Enhanced transparency and communication with suppliers & transporters for early identification of disruptions

Figure 13 COVID-19 Impacts Mitigation Framework

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

This research captured the impact of COVID-19 on construction supply chain management. First, the authors conducted extensive literature review followed by questionnaire survey with 66 construction professionals that resulted in a comprehensive and validated list of impacts caused by COVID-19. In the next step, 22 semi-structured interviews were conducted with construction professionals having experience in the Pakistani construction industry to collect the data for finding out the impact of the identified factors on their construction projects in terms or cost and time and what measures/strategies did they adopt to mitigate such impacts. Also the participants were asked that how would they distribute these factors under SCOR processes namely Plan, Source, Make, Deliver and Return. From this the author was able to identify the processes or groups under which these factors fall. Based on the adopted research methodology, the authors identified a total of 13 construction factors that impacted construction industry and construction supply chain grouped under five SCOR processes, including Plan, Source, Make, Deliver and Return. The factors that highly impacted the construction were shortage of material, operations shutdown and production shutdown, labor shortages and disrupted transportation while the factors that least impacted were disruption in sourcing of supplies, decrease in work rate/ productivity, fewer revenues/ decline in profits and delivery delays. Ultimately, the authors contribute to the body of knowledge by providing the foundation for finding out the impact of COVID-19 pandemic on their construction projects and construction supply chain. The findings of the study reflects the impact of COVID-19 on various construction operations along with the adopted strategies to mitigate its impact. This provides useful insight for construction professional to adopt proactive measures to minimize and mitigate such impacts in case of any upcoming unseen pandemic.

5.2. Future Recommendations

Researchers can explore the differential impact of the pandemic on various sectors within the construction industry, both in developing and developed countries. Specifically, focusing on understanding how the pandemic affected different project types, such as residential, commercial, infrastructure, and public works projects. The future research may analyze the variations in challenges faced by each sector and their corresponding performance outcomes to identify sector-specific strategies for future pandemic crisis management and resilience.

Additionally, a deeper analysis of the SCOR model can be conducted in terms of its metrics separately to identify specific mitigation strategies for each aspect. Such research would contribute to a more comprehensive understanding of the diverse impacts of the pandemic on construction supply chains and facilitate the development of targeted strategies to mitigate such impacts in different contexts. Also using the same methodology impact of COVID-19 can also be explored on other industries of the world.

5.3. Limitations

The research outcomes and results are limited to literature review of 30 research papers and 22 semi-structured interviews seeking opinions from construction professionals employed in Pakistan's construction industry. The author didn't get access to the project documents to obtain the exact figures related to time and costs and validate the findings of the study. The study has not applied any statistical analyses of correlation, causality and regressions is also one of the limitations.

References

Abd El-Razek, E.-R. M. E., A., B. H., & M., M. A. (2008). Causes of delay in building construction projects in egypt. *Journal of Construction Engineering and Management*, *134*(11), 831–841.

Agyekum, K., Kukah, A. S., & Amudjie, J. (2022). The impact of COVID-19 on the construction industry in Ghana: the case of some selected firms. *Journal of Engineering, Design and Technology*, *20*(1), 222–244. https://doi.org/10.1108/JEDT-11-2020-0476

Aigbavboa, C. O., Aghimien, D. O., Thwala, W. D., & Ngozwana, M. N. (2022). Unprepared industry meet pandemic: COVID-19 and the South Africa construction industry. *Journal of Engineering, Design and Technology*, *20*(1), 183–200. https://doi.org/10.1108/JEDT-02-2021-0079

Al-Mansour, J. F., & Al-Ajmi, S. A. (2020). Coronavirus 'COVID-19'-Supply chain disruption and implications for strategy, economy, and management. *Journal of Asian Finance, Economics and Business*, *7*(9), 659–672. https://doi.org/10.13106/JAFEB.2020.VOL7.NO9.659

Al-Mhdawi, M. K. S., Brito, M. P., Abdul Nabi, M., El-adaway, I. H., & Onggo, B. S. (2022). Capturing the Impact of COVID-19 on Construction Projects in Developing Countries: A Case Study of Iraq. *Journal of Management in Engineering*, *38*(1). https://doi.org/10.1061/(asce)me.1943-5479.0000991

Alliance, P. (2020). *Investigation and analysis report on the impact of the new coronavirus epidemic on the production and operation of building materials enterprises*.

Apolot, R., Alinaitwe, H., & Tindiwensi, D. (2011). An Investigation into the Causes of Delay and Cost Overrun in Uganda's Public Sector Construction Projects. *Journal of Construction in Developing Countries*, *18*(2), 33–47. http://mak.ac.ug/documents/Makfiles/aet2011/Apolot.pdf

Asrol, M., Marimin, Machfud, Yani, M., & Taira, E. (2021). Risk management for improving supply chain performance of sugarcane agroindustry. *Industrial Engineering and Management Systems*, *20*(1), 9–26. https://doi.org/10.7232/iems.2021.20.1.9

Ayat, M., Ullah, A., & Kang, C. W. (2022). Impact of the Coronavirus disease 2019 and the post-pandemic construction sector (Pakistan). *International Journal of Managing Projects in Business*, *15*(4), 659–675. https://doi.org/10.1108/IJMPB-11-2020-0349

Bal, M., Bryde, D., Fearon, D., & Ochieng, E. (2013). Stakeholder Engagement: Achieving Sustainability in the Construction Sector. *Sustainability (Switzerland)*, *5*(2), 695–710. https://doi.org/10.3390/su5020695

Balfaqih, H., Nopiah, Z. M., Saibani, N., & Al-Nory, M. T. (2016). Review of supply chain performance measurement systems: 1998–2015. *Computers in Industry*, *82*, 135–150. https://doi.org/10.1016/j.compind.2016.07.002

Bastas, A., & Liyanage, K. (2018). ISO 9001 and supply chain integration principles based sustainable development: A Delphi study. *Sustainability (Switzerland)*, *10*(12). https://doi.org/10.3390/su10124569

Biswas, A., Ghosh, A., Kar, A., Mondal, T., Ghosh, B., & Bardhan, P. K. (2021). The impact of COVID-19 in the construction sector and its remedial measures. *Journal of Physics: Conference Series*, *1797*(1). https://doi.org/10.1088/1742-6596/1797/1/012054

Bode, C., & Macdonald, J. R. (2017). Stages of Supply Chain Disruption Response: Direct, Constraining, and Mediating Factors for Impact Mitigation. *Decision Sciences*, *48*(5), 836–874. https://doi.org/10.1111/deci.12245

Butt, A. S. (2021). Strategies to mitigate the impact of COVID-19 on supply chain disruptions: a multiple case analysis of buyers and distributors. *International Journal of*

Logistics Management, December 2019. https://doi.org/10.1108/IJLM-11-2020-0455
Butt, A. S. (2022). Understanding the implications of pandemic outbreaks on supply chains: an exploratory study of the effects caused by the COVID-19 across four South Asian countries and steps taken by firms to address the disruptions. *International Journal of Physical Distribution and Logistics Management*, *52*(4), 370–392. https://doi.org/10.1108/IJPDLM-08-2020-0281
Cai, M., & Luo, J. (2020). Influence of COVID-19 on Manufacturing Industry and Corresponding Countermeasures from Supply Chain Perspective. *Journal of Shanghai Jiaotong University (Science)*, *25*(4), 409–416. https://doi.org/10.1007/s12204-020-2206-z
Chan, A. P. C., Darko, A., & Ameyaw, E. E. (2017). Strategies for promoting green building technologies adoption in the construction industry-An international study. *Sustainability (Switzerland)*, *9*(6). https://doi.org/10.3390/su9060969
Chigozie Victor Ndukwe, Jinyun Liu, and T. K. C. (2021). Impact of COVID-19 on the China-Australia Construction Supply Chain. In *Proceedings of the 18th International Symposium on Advancement of Construction Management and Real Estate*. https://doi.org/10.1007/978-3-662-46994-1
Choi, T. Y., Narayanan, S., Novak, D., Olhager, J., Sheu, J. B., & Wiengarten, F. (2021). Managing extended supply chains. *Journal of Business Logistics*, *42*(2), 200–206. https://doi.org/10.1111/jbl.12276
Creswell, J. W., & Creswell. (2018). Research design: qualitative, quantitative, and mixed methods approaches. *WIREs Water*, *2*(1), 31–36.
Crosthwaite, D. (2000). The global construction market: A cross-sectional analysis. *Construction Management and Economics*, *18*(5), 619–627. https://doi.org/10.1080/014461900407428
D. du Toit, P. J. V. (2014). SUPPLY CHAIN MANAGEMENT: A FRAMEWORK OF UNDERSTANDING. *South African Journal of Industrial Engineering*, *148*(November 2014), 148–162.
Demissew, A. (2020). Assessment on Impact of Covid-19 on Ethiopian Construction Industry. *Ijesc*, *10*(7), 26889–26894.
Fonseca, L. M., & Azevedo, A. L. (2020). COVID-19: Outcomes for Global Supply Chains. *Management and Marketing*, *15*(1), 424–438. https://doi.org/10.2478/mmcks-2020-0025
Gamil, D. Y., & Alhagar, A. (2020). The Impact of Pandemic Crisis on the Survival of Construction Industry : A Case of COVID-19 Dr . Yaser Gamil Abdulsalam Alhagar. *Mediterranean Journal of Social Sciences*, *11*(4), 122–128.
Gamil, Y., Abd Rahman, I., & Nagapan, S. (2019). Investigating the effect of poor communication in terms of cost and time overruns in the construction industry. *International Journal of Construction Supply Chain Management*, *9*(2), 94–106. https://doi.org/10.14424/ijcscm902019-94-106
Golwelkar, T. (2020). Using Data Analytics to Determine the Disruptions in Supply Chain Due to the Covid-19 Pandemic: A Literature Review. *International Journal for Research in Applied Science and Engineering Technology*, *7*(5), 1199–1209. https://doi.org/10.22214/ijraset.2020.5191
Gumusburun Ayalp, G., & Çivici, T. (2022). Factors affecting the performance of construction industry during the COVID-19 pandemic: a case study in Turkey. *Engineering, Construction and Architectural Management*. https://doi.org/10.1108/ECAM-10-2021-0890
Haslinda, A. N., Xian, T. W., Norfarahayu, K., Hanafi, R. M., & Fikri, H. M. (2018). Investigation on the Factors Influencing Construction Time and Cost Overrun for High-Rise Building Projects in Penang. *Journal of Physics: Conference Series*, *995*(1).

https://doi.org/10.1088/1742-6596/995/1/012043
Hemanta, D., Sawhney, A., Iyer, K. C., & Rentala, S. (2012). Analysing factors affecting delays in Indian construction projects. *International Journal of Project Management*, *30*(4), 479–489. https://doi.org/10.1016/j.ijproman.2011.10.004
Ivanov, D. (2021). Supply Chain Viability and the COVID-19 pandemic: a conceptual and formal generalisation of four major adaptation strategies. *International Journal of Production Research*, *59*(12), 3535–3552. https://doi.org/10.1080/00207543.2021.1890852
Jagan Mohan Reddy, K., Neelakanteswara Rao, A., & Krishnanand, L. (2019). A review on supply chain performance measurement systems. *Procedia Manufacturing*, *30*, 40–47. https://doi.org/10.1016/j.promfg.2019.02.007
Jahan, S., Khan, K. I. A., Thaheem, M. J., Ullah, F., Alqurashi, M., & Alsulami, B. T. (2022). Modeling Profitability-Influencing Risk Factors for Construction Projects: A System Dynamics Approach. *Buildings*, *12*(6). https://doi.org/10.3390/buildings12060701
Johnson, H. C., Gossner, C. M., Colzani, E., Kinsman, J., Alexakis, L., Beauté, J., Würz, A., Tsolova, S., Bundle, N., & Ekdahl, K. (2020). Potential scenarios for the progression of a COVID-19 epidemic in the European Union and the European Economic Area, March 2020. *Eurosurveillance*, *25*(9). https://doi.org/10.2807/1560-7917.ES.2020.25.9.2000202
Khalfan, M., & Ismail, M. (2020). Engineering Projects and Crisis Management: : A Descriptive Study on the Impact of COVID-19 on Engineering Projects in Bahrain. *2020 2nd International Sustainability and Resilience Conference: Technology and Innovation in Building Designs*. https://doi.org/10.1109/IEEECONF51154.2020.9319948
King, S. S., Rahman, R. A., Fauzi, M. A., & Haron, A. T. (2021). Critical analysis of pandemic impact on AEC organizations: the COVID-19 case. *Journal of Engineering, Design and Technology*, *20*(1), 358–383. https://doi.org/10.1108/JEDT-04-2021-0225
L.P.D.S, P. (2020). Effect of COVID -19 and Strategic Response: A Review on Sri Lankan Construction Industry. *International Journal of Economics and Management Studies*, *7*(6), 73–77. https://doi.org/10.14445/23939125/ijems-v7i6p110
Lemghari, R., Okar, C., & Sarsri, D. (2018). Supply chain performance measurement: A case study about applicability of scor® model in automotive industry firm. *MATEC Web of Conferences*, *200*(April 2016). https://doi.org/10.1051/matecconf/201820000016
Mattias Hedwall. (2020). The ongoing impact of COVID-19 on global supply chains. *Thomson Reuters*. https://insight.thomsonreuters.com.au/business/resources/resource/impact-of-covid-19-on-global-supply-chains-infographic
McKinsey & Company. (2017). Reinventing Construction: A Route To Higher Productivity. *McKinsey Global Insititute*, *February*. http://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/reinventing-construction-through-a-productivity-revolution%0Awww.revalue.dk
Molwus, J. J., Erdogan, B., & Ogunlana, S. (2017). Using structural equation modelling (SEM) to understand the relationships among critical success factors (CSFs) for stakeholder management in construction. *Engineering, Construction and Architectural Management*, *24*(3), 426–450. https://doi.org/10.1108/ECAM-10-2015-0161
Ofori, G. (2012). New perspectives on construction in developing countries. *New Perspectives on Construction in Developing Countries*, 1–388. https://doi.org/10.4324/9780203847343
Ogunnusi, M., Omotayo, T., Hamma-Adama, M., Awuzie, B. O., & Egbelakin, T. (2021). Lessons learned from the impact of COVID-19 on the global construction industry.

Journal of Engineering, Design and Technology, *20*(1), 299–320. https://doi.org/10.1108/JEDT-05-2021-0286

Osuizugbo, I. C. (2020). Disruptions and Responses within Nigeria Construction Industry amid COVID-19 Threat. *Covenant Journal of Research in the Built Environment*, *8*(2), 37–48.

PACRA. (2021). Construction Sector. *Construction Microeconomics*, 169–187. https://doi.org/10.1002/9781119831938.ch10

pwc. (2020). Impact of COVID-19 on the supply chain industry. *PricewaterhouseCoopers (Pwc)*, 1–16. http://www.pwc.com/ng/covid-19

Raj, A., Mukherjee, A. A., de Sousa Jabbour, A. B. L., & Srivastava, S. K. (2022). Supply chain management during and post-COVID-19 pandemic: Mitigation strategies and practical lessons learned. *Journal of Business Research*, *142*(January), 1125–1139. https://doi.org/10.1016/j.jbusres.2022.01.037

Raoufi, M., & Fayek, A. R. (2021). Identifying Actions to Control and Mitigate the Effects of the COVID-19 Pandemic on Construction Organizations: Preliminary Findings. *Public Works Management and Policy*, *26*(1), 47–55. https://doi.org/10.1177/1087724X20969164

Rapaccini, M., Saccani, N., Kowalkowski, C., Paiola, M., & Adrodegari, F. (2020). Navigating disruptive crises through service-led growth: The impact of COVID-19 on Italian manufacturing firms. *Industrial Marketing Management*, *88*(May), 225–237. https://doi.org/10.1016/j.indmarman.2020.05.017

Remko, van H. (2020). Research opportunities for a more resilient post-COVID-19 supply chain – closing the gap between research findings and industry practice. *International Journal of Operations and Production Management*, *40*(4), 341–355. https://doi.org/10.1108/IJOPM-03-2020-0165

Roque, L. C., Da Silva, R. M., Gauer, G. F., Reis, G. G., & Frederico, G. F. (2021). The impact of COVID-19 on international supply chains looking through the SCOR model. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, *May*, 2413–2424.

Seddeeq, A. Bin, Assaf, S., Abdallah, A., & Hassanain, M. A. (2019). Time and cost overrun in the Saudi Arabian oil and gas construction industry. *Buildings*, *9*(2), 1–17. https://doi.org/10.3390/buildings9020041

Shafi, M., Liu, J., & Ren, W. (2020). Impact of COVID-19 pandemic on micro, small, and medium-sized Enterprises operating in Pakistan. *Research in Globalization*, *2*. https://doi.org/10.1016/j.resglo.2020.100018

Shi, J. J., Cheung, S. O., & Arditi, D. (2001). Construction Delay Computation Method. *Journal of Construction Engineering and Management*, *127*(1), 60–65. https://doi.org/10.1061/(asce)0733-9364(2001)127:1(60)

Sierra, F. (2022). COVID-19: main challenges during construction stage. *Engineering, Construction and Architectural Management*, *29*(4), 1817–1834. https://doi.org/10.1108/ECAM-09-2020-0719

Sudan, T., & Taggar, R. (2021). Recovering Supply Chain Disruptions in Post-COVID-19 Pandemic Through Transport Intelligence and Logistics Systems: India's Experiences and Policy Options. *Frontiers in Future Transportation*, *2*(May). https://doi.org/10.3389/ffutr.2021.660116

Thunberg, M., & Persson, F. (2014). Using the SCOR models performance measurements to improve construction logistics. *Production Planning and Control*, *25*(13–14), 1065–1078. https://doi.org/10.1080/09537287.2013.808836

Waris, A., Atta, U. K., Ali, M., Asmat, A., & Baset, A. (2020). COVID-19 outbreak: current scenario of Pakistan. *New Microbes and New Infections*, *35*(20), 100681. https://doi.org/10.1016/j.nmni.2020.100681

Xu, Z., Elomri, A., Kerbache, L., & El Omri, A. (2020). Impacts of COVID-19 on Global Supply Chains: Facts and Perspectives. *IEEE Engineering Management Review*, *48*(3), 153–166. https://doi.org/10.1109/EMR.2020.3018420

Zamani, S. H., Rahman, R. A., Fauzi, M. A., & Yusof, L. M. (2021). Effect of COVID-19 on building construction projects: Impact and response mechanisms. *IOP Conference Series: Earth and Environmental Science*, *682*(1). https://doi.org/10.1088/1755-1315/682/1/012049

Zhu, G., Chou, M. C., & Tsai, C. W. (2020). Lessons Learned from the COVID-19 pandemic exposing the shortcomings of current supply chain operations: A long-term prescriptive offering. *Sustainability (Switzerland)*, *12*(14), 1–19. https://doi.org/10.3390/su12145858

Zina, L. (2017). The Essential Guide to doing your research. *Doing Your Research Project*, 241.