Journal of the Serbian Society for Computational Mechanics / Vol. 18 / No. 1, 2024 / pp 1-15 / original paper
(10.24874/jsscm.2024.18.01.01)

PROJECT RISKS DURING THE COVID-19 PANDEMIC AND THEIR EFFECTS ON DELAYS AND COST OVERRUNS

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Abstract

The COVID-19 pandemic has significantly impacted project implementation costs and caused delays across numerous industries. Various analysis found in the literature show that the predominant cause of project delays and higher costs have been people, material, and equipment movement restrictions, supply chain disruptions, and social distancing policies. The COVID-19 pandemic has seriously disrupted international supply chains in a variety of sectors. Many variables, including travel restrictions, labor shortages, lockdown procedures, and a spike in demand for medical supplies and equipment, were the main causes of the interruptions. To confirm this assumption, a comprehensive study was conducted to understand whether these factors affected project delays and cost overruns. A multiple regression analysis was conducted to analyze the significance and the volume of the effects of specific factors on project delays and rising project costs. Contrary to the previous understanding, we found that only a few factors or project risks associated with the COVID-19 pandemic have an effect. The findings show that only those risk factors related to material supply and epidemic prevention methods that the company was requested to implement inside the company had the influence on the delays in project implementation, while other risk factors had no major effects on a project schedule. Additionally, it has been found that only risks associated with rising costs of material supply affected the rising costs of projects during the COVID-19 pandemic, while other project risk factors had no influence. These findings can be valuable for developing risk mitigation strategies that will enable a smooth implementation of projects during similar events and long-term disruptions.

Keywords: Project risks, COVID-19 pandemic, project delays, project costs.

1. Introduction

Although the global COVID-19 pandemic is slowly waning, the impact it has left on various aspects of business is still visible. A special impact is visible through delays in the implementation of projects and a significant increase in the costs of project deliveries. This situation not only has effects on individual project organizations and customers, but it also has a visible spill-over effect on the global economy as a whole. Therefore, it is important to recognize the risks related to project delays and the increase in project delivery costs.

The COVID-19 epidemic, natural disasters, and political unrest are just a few recent reasons that have caused huge disruptions in the global economy. Project delays and higher costs have resulted from these interruptions, which have had a significant impact on supply chains. The hazards connected to project delays and cost increases are looked at in the context of long-term disruptions in this study. Lockdowns, social distance policies, and other limitations have caused numerous projects to experience major delays and cost overruns. Project managers were requested to proactively identify and evaluate the risks related to COVID-19 and its consequences on their projects. This knowledge can be beneficial in identifying project management strategies in similar situations during long-term disruption. The evaluation of project risks becomes crucial in this situation because it enables project managers to foresee and reduce potential delays and cost overruns. This covers not just the hazards associated with the pandemic itself but also its unintended consequences, such as supply chain disruptions, shifts in stakeholder priorities, and challenges in accessing necessary resources.

This study focuses on different risks that occurred due to the COVID-19 pandemic, and that may happen again, with particular attention on how they might affect project costs and schedules. Project managers may ensure that their projects continue to go forward in the face of the pandemic's hurdles by adopting a proactive approach to risk management. Thus, it is necessary to identify the risks affecting delays and rising costs for projects during the COVID-19 pandemic. The aim of this study is the assessment of different risks associated with the COVID-19 pandemic and their effects on costs and deals of projects. The findings of the study can represent a valuable lesson for future challenging situations in which project managers can find themselves and enable them to react adequately to certain types of project risks in a period of long-term disruption.

2. Literature review

Globally, organizations and industries have been significantly impacted by the COVID-19 pandemic's effects on supply chains. The COVID-19 pandemic has had a significant impact on the global economy, with many industries facing disruptions and delays. In particular, the construction industry has been affected by supply chain disruptions, project delays, and increased costs. To understand the extent and nature of these risks, it is important to review the literature on the subject. This literature review examines the risks associated with project delays and cost increases during the COVID-19 pandemic but also makes an overview of the risks associated with other types of long-term disruptions. In a study by Ghandour (2020), the main objective was to determine how the COVID-19 pandemic might affect project delivery in the United Arab Emirates, with a particular emphasis on the construction sector.

The literature abounds with works related to the disruption of supply chains and the ways companies should manage it. The effects of dynamics on disruption orientations, resilience, and financial success are examined by Yu et al. (2019, 2021). Although learning is implied in definitions of supply chain resilience, little is known about the precise changes that organizations may make to their daily operations to foster resilience. In their studies, Scholten et al. (2019) suggested specific learning mechanisms to foster the resilience of supply chains. The study by Polyviou et al. (2020) aims to investigate the tools or skills that help medium-sized businesses be resilient, specifically to prevent and recover from supply chain interruptions. The effectiveness of the most well-known practices to improve resilience (flexibility, agility, redundancy, and collaboration) in reducing each type of supply chain disruption (demand, supply, process, control, and environmental disruptions) is examined through a systematic review of the literature by Shekarian et al. (2021). A theoretical model was created to investigate the moderating impacts of the various supply chain disruptions on performance outcomes, drawing on the organizational information process theory (2021).

A very important topic discussed in the literature is related to project delays. The diverse reasons for project delays from the perspectives of the owner and the contractor have only been partially studied. The goal of Banobi et al. (2019) was to identify the reasons for delays and determine how to reduce them to improve the success of the project. The results should help companies build more effective risk management procedures, enhancing their profitability, project results, and client satisfaction (2020). Aljamee et al. (2020) examined construction projects in the Iraqi petroleum sector, which have had considerable issues during the past ten years. Yamin et al. (2017) developed a framework for the success of international development projects in the Maldives. They found it is crucial to look at aspects that have a big impact on the project timetable. Tran et al. (2020) explored the use of time management on a specific transportation construction project in a developing nation, which is about the six-line urban railway project in Ho Chi Minh City, Vietnam. Purba et al. (2020) recommended that key stakeholders should use the FIDIC contract to further research its contents, to help minimize the risk of project delays, particularly during construction. The impact of the COVID-19 pandemic delays on Malaysia's oil and gas projects was studied by Abdelrassoul et al. (2021). Erlita et al. (2021) reported a study on the building of an Indonesian food plant by looking into the main reasons for time overruns from the viewpoint of a consultant. Other significant works related to project delays are given by Abebe et al. (2021).

Hasan et al. (2019) examined the strength of the link and the nature of how material supply chain risk affects project performance. Kissi et al. (2021) explored how innovation plays a moderating influence on the relationship between supply chain disruptions and the organizational performance of infrastructure projects. Butt (2022) investigated how COVID-19 had disrupted supply chains, as well as the steps taken to mitigate these disruptions. Three buying organizations, four distribution centers, and four supplying firms located in four different countries participated in semi-structured interviews for this study (Pakistan, Sri Lanka, China, and India).

While controlling disruption risks in supply chains, Ivanov et al. (2020) analyzed the circumstances underlying the design and deployment of the digital twins. They also focused on different factors important for the effectiveness of supply chains during long-term disruption. These scholars found that micro, small, and medium-sized businesses are the primary COVID-19 outbreak victims. Shafi et al. (2020) sought to evaluate how the COVID-19 outbreak has affected these companies and offer policy recommendations to assist micro, small, and medium companies in minimizing economic losses and weathering the crisis. The impact of an epidemic outbreak on global supply chains is modeled (2021) taking into account the rate of pandemic spread, the length of production, distribution, and market disruption, as well as a fall in demand.

Majumdar et al. (2020) goal was to comprehend the causes of the absence of social sustainability in the apparel supply chain working in South Asian nations and to make recommendations for the proper course of action. As a result, pandemics require researchers to re-examine the theoretical frameworks that provide an understanding of supply chain phenomena to aid supply chain managers in better preparing for the next pandemic and promoting transience (i.e., the ability to simultaneously restore some processes and change – often radically – others). By taking into account how the key tenets of well-known and emerging theories might expose difficulties and potential solutions, Craighead et al. (2020) provided an agenda for supply chain management research on pandemics to aid scholars and managers in achieving these goals.

Khan et al. (2022) investigated the effects of disruptions in the food supply chain on cases of undernutrition in particular Asian nations. Hassan (2021) sought to draw attention to the damage that COVID-19 had done to the key horticulture crops in Jammu and Kashmir, India, which are the main source of revenue for the Union Territory. The antecedents and effects of supply chain risk management competencies were assessed by Yang et al. (2021).

In addition to the studies already mentioned, several other studies have examined how the COVID-19 pandemic has affected project delivery in various sectors and nations. The majority of these studies have concluded that the pandemic has had a significant influence on project delivery, and they have advised the implementation of good risk management and contingency planning procedures to lessen the impact of pandemics on project delivery. However, there is a lack of systematic analyses that investigate how specific risks associated with the COVID-19 pandemic can affect project delays. This is very important to understand since not all risks are of equal importance while dealing with project delays. To investigate this issue, the first hypothesis is proposed: H_1: *There is a significant multiple linear regression relationship between the delays in project delivery and the combination of project risks associated with the COVID-19 pandemic, indicating that changes in the values of project risks are associated with systematic changes in project delays.*

Apart from delays of projects, challenges with rising project costs are also elaborated on in the literature. The economic and environmental concerns for a dual-channel green supply chain, when the market demand is interrupted, are examined by Rahmani et al. (2019). Employing the constructal law of physics, Handfield et al. (2020) sought to direct future research on the impacts of global supply chain management. Sinha et al. (2020) evaluated the variations between the business scenarios before and following the COVID-19 pandemic. Chakraborty et al. (2020) emphasized the impending COVID-19 influence on the supply chain, focusing on root-cause analysis and statistical data on textile product consumption both locally and globally. Barakat et al. (2020) add to both the resilience theory and the expanded resources-based view. The factors surrounding the design and execution of the digital twins when managing disruption risks in supply chains and how they affect project costs are also explored by Ivanov et al. (2020), taking into account the rate of pandemic spread, the length of production, distribution, and market disruption, as well as a fall in demand. The main focus of Majumdar (2021) is to examine in more detail the steps taken by the Indian hotel business to recover revenues, conserve resources, and achieve higher operational and financial efficiencies while dealing with the COVID-19 issue.

The COVID-19 epidemic has caused many businesses to incur additional costs. This is a result of rising shipping and transportation expenses as well as rising prices for components and raw materials. Costs have escalated as a result of many businesses having to spend more on safety precautions to safeguard their workers from the virus (2020). To understand how different risks associated with the COVID-19 pandemic affect project costs, the second hypothesis is suggested: H_2: *There is a significant multiple linear regression relationship between the cost of projects and the combination of project risks associated with the COVID-19 pandemic, indicating that changes in the values of project risks are associated with systematic changes in project costs.*

3. Methodology

To assess the hypotheses and understand the research problem, a comprehensive study was conducted. A survey questionnaire was sent to the project organizations that were asked to answer specific questions related to our research problems. The questions were given in the form of statements that the respondents could answer using the Likert scale. The questionnaire was sent to different companies using the SurveySparrow online survey software. A total of 125 respondents participated in the survey in the period January-March 2022. The structure of the sample includes project organizations from different parts of the globe, mainly from Europe (75%), the Middle East (17%), Asia (8%), America North and South (8%), and Africa (1%). The intention was to have a diversity of respondents from different parts of the world and respondents with different structures of suppliers. In the sample, 18% of respondents cooperate mainly with suppliers from local markets, 14% cooperate with suppliers from national regional markets, 15% with suppliers from national markets, 24% with suppliers from international regional markets, and 36% from global markets.

After the collection of data, the analysis was conducted using multiple regression technique. To test these two hypotheses, we established a model of multiple linear regression:

$$Y = b_0 + b_1X_1 + b2X_2 + b_3X_3 + b4X_4 + b_5X_5 + b_6X_6$$

The values for independent variables are taken from the survey based on the following survey statements:

- Project Delays: How long did the interruption caused by particular risks during the COVID-19 pandemic last? for H_1 with a total of 7 levels for responses: (1) No interruption, (2) Up to 1 week, (3) between 1 and 4 weeks, (4) 1-3 months, (5) 3-6 months, (6) 6-12 months (7) interruption is still present.
- Project Costs: These risks that occurred during the COVID-19 pandemic affected the rising of our Project Business COSTS for H_2 with a total of 7 levels for responses: Absolutely disagree (1) Mostly disagree (2) Somewhat disagree (3) Neither agree nor disagree (4) Somewhat agree (5) Mostly agree (6) Absolutely agree (7).

Dependent variable Y represents delays of projects for H_1 and rising costs for H_2. The values for these variables are taken from the survey respondents on the following statements:

- Due to interruption caused by COVID-19, our company projects were delayed (on average) for H_1 with a total of 7 levels for responses: (1) No interruption, (2) Up to 1 week, (3) between 1 and 4 weeks, (4) 1-3 months, (5) 3-6 months, (6) 6-12 months (7) interruption is still present.
- Due to interruption caused by COVID-19, our company project costs were increased for H_2 with a total of 7 levels for responses: Absolutely disagree (1) Mostly disagree (2) Somewhat disagree (3) Neither agree nor disagree (4) Somewhat agree (5) Mostly agree (6) Absolutely agree (7).

Independent variables represent different risks associated with the COVID-19 pandemic. In our model, these independent variables were analyzed:

- X_1 – Dstaff (when Y = delays), Cstaff (when Y = costs): staff accessibility to the site and shortage of workers, technicians, and operators
- X_2 – Dmat (when Y = delays), Cmat (when Y = costs): material supply
- X_3 - Deq, (when Y = delays), Ceq (when Y = costs): machine supply and delivery
- X_4 - dmet, (when y = delays), cmet (when Y = costs): epidemic prevention methods that the company was requested to implement inside the company
- X_5 - Dpan, (when Y = delays), Cpan (when Y = costs): panic of residents
- X_6 – Dext, (when Y = delays), Cext (when Y = costs): administrative epidemic control policy outside of company

The questions related to different risks associated with COVID-19 are based on the framework proposed by Wang et al. (2020) who suggested 6 categories of risks that can affect project schedule and costs, namely risks related to people, materials, machines, methods, and environmental factors in the context of disruption of supply chains during Covid-19 pandemic.

After applying the enter method of multiple linear regression, we found multicollinearity issues that were checked against the value of tolerance ≤0.10, VIF > 10, and Condition Index ≥15. This trashed VIF is used by the suggestion provided in Gwelo (2019). This was solved by applying the stepwise method of multiple linear regression using Z-scores of standardized coefficients.

4. Findings

In this part, the results of the assessments of different risks are identified. The findings are presented within two separate sub-sections related to the effects of project delays and rising costs.

5. Assessment of risks affecting project delays

The results show $R^2= 0.377$ revealing that 38 % of the variability observed in delays of project executions is explained by the regression model that includes 6 different project risks associated with the COVID-19 pandemic.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.614[a]	.377	.307	1.612
a. Predictors: (Constant), Dext, Deq, Dmet, Dpan, Dstaff, Dmat				

Table 1. Model summary for assessment of risks affecting project delays

Based on ANOVA results $F(6,54) = 5.437$, $p = .000$, we can confirm that independent variables representing 6 project risks associated with the COVID-19 pandemic predict the changes in delays of project delivery during the COVID-19 pandemic.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	84.787	6	14.131	5.437	.000[b]
	Residual	140.361	54	2.599		
	Total	225.148	60			
a. Dependent Variable: Delays						
b. Predictors: (Constant), Dext, Deq, Dmet, Dpan, Dstaff, Dmat						

Table 2. ANOVA: assessment of risks affecting project delays

However, prior to making any conclusions, we should examine the effect of individual project risks on delays. As per the findings using the enter method of multiple linear regression, all coefficients are at the level p≥0.05 showing that all of them are not statistically significant predictors which is a contradictory result.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.024	.527		1.942	.057		
Dstaff	.244	.160	.261	1.529	.132	.395	2.532
Dmat	.359	.235	.374	1.526	.133	.192	5.212
Deq	-.001	.240	-.001	-.006	.995	.188	5.320
Dmet	.172	.150	.195	1.153	.254	.402	2.489
Dpan	.061	.154	.068	.394	.695	.382	2.621
Dext	-.146	.168	-.151	-.872	.387	.384	2.602
a. Dependent Variable: Delays							

Table 3. Coefficients for assessment of risks affecting project delays

The previous result indicates the issue of multicollinearity that can be associated with a high correlation between independent variables. If we take a value of tolerance ≤0.10 and VIF >10 as the cut-off value for checking multicollinearity, we find there is no multicollinearity issue present in the model based on these two tests. Although the significance levels shown in Table 3 are more than 0.05 for all variables, the overall model (Table 2) is highly significant at the level of 0.01. Thus, it is obvious there is an issue of multicollinearity that was checked in the next step using collinearity diagnostics. The results of collinearity diagnostics are shared in Table 4.

Dim	Eigen.	Con. Index	Variance Proportions						
			Cons.	Dstaff	Dmat	Deq	Dmet	Dpan	Dext
1	6.204	1.000	.00	.00	.00	.00	.00	.00	.00
2	.366	4.118	.00	.00	.04	.04	.04	.05	.02
3	.149	6.455	.53	.02	.01	.03	.02	.20	.03
4	.113	7.418	.45	.22	.01	.00	.00	.20	.12
5	.089	8.366	.00	.01	.00	.00	.71	.18	.24
6	.057	10.445	.01	.71	.08	.01	.16	.10	.41
7	.023	16.282	.00	.04	.87	.91	.08	.26	.18
a. Dependent Variable: Delays									

Table 4. Collinearity diagnostics for assessment of risks affecting project delays

With Condition Index ≥ 15 to check multicollinearity, we found CI=16.282 for dimension 7 suspecting the presence of multicollinearity. Based on collinearity diagnosis, we found for dimension 7 a collinearity issue between two variables Dmat (vp=0.87) and Deq (vp=0.91).

6. Stepwise regression with Z-scores

This issue of multicollinearity is solved by using standardized Z scores and applying stepwise linear regression. Based on this approach, we obtain two statistically significant models. The first model shows R2= 0.264 revealing that 26 % of the variability observed in delays of project executions is explained by the regression model that includes Dmat variable. The second model shows R2=0.347 indicating that 35 % of the variability observed in delays of project executions is explained by the regression model that includes two variables: Dmat and Dmet.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.514[a]	.264	.252	1.676
2	.589[b]	.347	.325	1.592
a. Predictors: (Constant), Zscore(Dmat)				
b. Predictors: (Constant), Zscore(Dmat), Zscore(Dmet)				

Table 5. Model summary for assessment of risks affecting project delays with z scores

Having in mind the R2 of the second model that is higher than in the first model, we will focus on it. Based on ANOVA results F(2,58) = 15.416, p=.000, we can confirm that Dmat and Dmet predict the changes in delays of project delivery during the COVID-19 pandemic in a statistically significant way. We can confirm the H_1 hypothesis for these two variables. Thus, deals in material supply and delays caused by epidemic prevention methods that companies were requested to implement inside the company have statistically significant effects on delays in the delivery of projects during the COVID-19 pandemic.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	59.473	1	59.473	21.180	.000[b]
	Residual	165.675	59	2.808		
	Total	225.148	60			
2	Regression	78.145	2	39.073	15.416	.000[c]
	Residual	147.002	58	2.535		
	Total	225.148	60			
a. Dependent Variable: Delays						
b. Predictors: (Constant), Zscore(Dmat)						
c. Predictors: (Constant), Zscore(Dmat), Zscore(Dmet)						

Table 6. ANOVA: assessment of risks affecting project delays with z scores

Both variables, Dmat and Dmet, are statistically significant ($p \leq 0.05$). Based on the findings, we can provide a linear regression result:

$$Y = 3.572 + 0.833*Dmat + 0.588*Dmet$$

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.561	.215		16.593	.000		
	Zscore(Dmat)	1.000	.217	.514	4.602	.000	1.000	1.000
2	(Constant)	3.572	.204		17.516	.000		
	Zscore(Dmat)	.833	.215	.428	3.871	.000	.919	1.088
	Zscore(Dmet)	.588	.217	.300	2.714	.009	.919	1.088
a. Dependent Variable: Delays								

Table 7. Coefficients for assessment of risks affecting project delays with z scores

7. Assessment of risks affecting costs of projects

The results show R^2= 0.314 revealing that 31 % of the variability observed in rising project costs during the COVID-19 pandemic is explained by the regression model that includes 6 different project risks associated with the COVID-19 pandemic.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.560[a]	.314	.220	1.660
a. Predictors: (Constant), CEext, CEmat, CEstaff, CEpan, CEmet, CEeq				

Table 8. Model summary for assessment of risks affecting project costs

ANOVA shows the result F(6,44) = 3.357, p = .008, we can confirm that independent variables representing 6 project risks associated with the COVID-19 pandemic predict the changes in project costs during the COVID-19 pandemic.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	55.485	6	9.248	3.357	.008[b]
	Residual	121.220	44	2.755		
	Total	176.706	50			
a. Dependent Variable: Costs						
b. Predictors: (Constant), CEext, CEmat, CEstaff, CEpan, CEmet, CEeq						

Table 9. ANOVA: assessment of risks affecting project costs

Even in this case, we found no significant effect of any independent variable on the project costs (p≥0.05) during COVID-19 pandemic. Again, it can be a problem of multicollinearity that should be checked.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	2.780	.672		4.138	.000		
CEstaff	-.023	.168	-.023	-.139	.890	.552	1.811
CEmat	.574	.379	.640	1.513	.138	.087	11.489
CEeq	-.086	.355	-.094	-.241	.811	.103	9.698
CEmet	.133	.274	.127	.484	.631	.227	4.397
CEpan	-.243	.227	-.237	-1.073	.289	.320	3.128
CEext	.021	.278	.021	.075	.940	.207	4.839
a. Dependent Variable: Costs							

Table 10. Coefficients for assessment of risks affecting project costs

Table 10 shows a significance level of more than 0.05 for all variables. However, the overall model (Table 9) is highly significant at the level of 0.01. Again, it is obvious there is an issue of multicollinearity that was checked in the next step using collinearity diagnostics. The results of collinearity diagnostics are shared in Table 11.

With the cut-off value of tolerance ≤0.10 and VIF >10 for checking multicollinearity, we found there is a multicollinearity issue present for the variable *CEmat*.

Dim	Eigen	Con. Index	Variance Proportions						
			Cons.	CEstaff	CEmat	CEeq	CEmet	CEpan	CEext
1	6.509	1.000	.00	.00	.00	.00	.00	.00	.00
2	.218	5.467	.00	.01	.02	.03	.01	.08	.02
3	.115	7.512	.66	.09	.01	.01	.01	.05	.01
4	.084	8.802	.31	.81	.00	.01	.00	.00	.00
5	.039	12.948	.01	.01	.01	.00	.29	.80	.14
6	.026	15.920	.00	.01	.02	.08	.53	.05	.60
7	.009	26.656	.02	.08	.94	.87	.16	.03	.22
a. Dependent Variable: Costs									

Table 11. Collinearity diagnostics for assessment of risks affecting project costs

With Condition Index ≥ 15 to check multicollinearity, we found CI=15.920 for dimension 6 suspecting the presence of multicollinearity between *CEmet* (vp=0.53) and *CEext* (vp=0.60). We also found CI=26.656 for dimension 7 suspecting a serious multicollinearity issue between *CEmat* (vp=0.94) and *CEeq* (vp=0.87).

8. Stepwise regression with Z-scores

Even in this situation, the multicollinearity was solved using the Z score of standardized coefficients and by applying stepwise linear regression. Based on this approach we get one model that is statistically significant with $R^2 = 0.287$ indicating that 29% of the variability observed in rising project costs during the COVID-19 pandemic is explained by the regression model that includes only one project risk associated with the COVID-19 pandemic which is CEmat.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.536[a]	.287	.273	1.603
a. Predictors: (Constant), Zscore(CEmat)				

Table 12. Model summary for assessment of risks affecting project costs with z scores

ANOVA analysis shows F(1,49) =19.760, p=0.000 indicating that the model which includes only the CEmat variable is statistically significant and that CEmat predicts the changes in costs of projects during the COVID-19 pandemic. Thus, we can confirm the H_2 hypothesis and state that the rising costs of material supply significantly affected the rising costs of projects during the COVID-19 pandemic.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	50.781	1	50.781	19.760	.000[b]
	Residual	125.925	49	2.570		
	Total	176.706	50			
a. Dependent Variable: Costs						
b. Predictors: (Constant), Zscore(CEmat)						

Table 13. ANOVA: assessment of risks affecting project costs with z scores

Based on the findings, we can identify the statistically significant model of linear regression as follows:

$$Y = 4.573 + 0.976CEmat$$

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	4.573	.226		20.265	.000		
	Zscore (CEmat)	.976	.220	.536	4.445	.000	1.000	1.000
a. Dependent Variable: Costs								

Table 14. Coefficients for assessment of risks affecting project costs with z scores

9. Discussion

We have to agree with the review Adekoya et al. (2020) gave that even a controlled outbreak of COVID-19 can significantly influence the world's economy in both the short-term and long-term. Especially, project delivery has been significantly impacted by the COVID-19 pandemic, which has resulted in delays and disruptions to projects in a variety of industries. Project delivery has been impacted by the pandemic in several ways, including supply chain disruptions, decreased labor availability, modifications to the project's scope, and heightened health and safety precautions. These difficulties have caused project timeframes to be prolonged, costs to rise, and project quality to decline.

Project delays and cost overruns have been significantly impacted by the COVID-19 epidemic across numerous industries. The epidemic has significantly delayed and increased the cost of projects by disrupting supply chains, decreasing worker productivity, and raising health and safety costs. This is also confirmed by numerous scholars including Hasan et al. (2019), Kissi et al. (2021), and Hassan (2021). Some very good points are suggested by Sinha et al. (2020) who suggest going beyond the usual supply chain strategy. Their idea to introduce the System Dynamics model is fully justifiable since it deploys continuous simulation that focuses on hypothetical connections between various activities and procedures. In doing so, new technology proposed by Ethirajan and Kandasamy (2020) can help project managers get real-time information on labor and material shortages. We should also agree with Kissi et al. (2021) who stressed the importance of the moderation role of innovation in supply chain management.

Throughout the pandemic, supply chain interruptions have been a significant problem for many projects. Border closures and travel restrictions have delayed the delivery of supplies and equipment, which has delayed projects and raised expenses. In addition, price surges brought on by increased demand for some commodities, such as personal protective equipment, have driven up project prices even further. The cost of supplying safety equipment, screening employees for the COVID-19 pandemic, and putting additional cleaning and disinfection procedures in place have all increased as a result of the pandemic. Cost overruns have occurred as a result of these charges being added to the project's overall costs. In this regard, Majumdar (2021) provided some proposals focused on the postponement of capital expenditure and an increasing shift to localizing supply chains. Some forms of hybrid payment proposed by Mashud et al. (2021) can also work to address similar disruption considering inflation, cash discount, price-sensitive demand, and preservation technology investment for non-instantaneous deteriorating products.

There are many other risks associated with the COVID-19 pandemic. Project delays and cost overruns have also been caused by the decrease in worker productivity brought on by lockdowns and social isolation policies. Due to social distance regulations, several construction sites have had to cut back on the number of employees present, which has slowed down job progress. Also, employees who have tested positive for COVID-19 or who have come into touch with infected people have had to isolate themselves, which has decreased productivity and pushed back project completion dates. In response to these challenges, a decision model that optimizes workforce allocation for projects to achieve sustainable workforce management and making a trade-off between pandemic prevention and work resumption proposed by Wang et al. (2021) can be considered. Furthermore, to address challenges related to delays and cost overruns of projects during the period of disruptions, Faten et al. (2020) focus on some factors that should be taken into consideration such as design changes, poor management on the site, delay in progress payment by owner and fluctuation in material price.

In addition, delays brought on by the pandemic may result in legal issues between suppliers, contractors, and project owners. For instance, suppliers who are unable to provide materials on time may face claims for damages, and contractors who fail to reach project deadlines may be subject to liquidated damages. Project managers need to think about amending their project contracts to contain clauses that cover the pandemic's potential effects. These could include terms allowing for delays or extensions due to unanticipated events, such as a pandemic, and dispute resolution procedures that make it easier to effectively resolve legal problems. Having in mind special circumstances, it is a fully justifiable call to local governments raised by Wang et al. (2021) to make substantial contributions to solving the difficulties related to disruptions in project deliveries.

This latest pandemic has provided project managers with useful lessons learned. Project managers should think about establishing risk management procedures that take into consideration the potential hazards and repercussions of the pandemic to lessen the impact of the pandemic on project delays and cost overruns. This can entail creating backup plans for supply chain interruptions, fostering greater collaboration and communication with suppliers and contractors, and utilizing technology to boost productivity and efficiency. Thus, Alogla et al. (2021) observations about the necessity for flexibility in supply chain design as a critical capability are fully justifiable.

This study enabled further elaboration on the theoretical framework given by Wang et al. (2020), providing more in-depth insights into how different risks associated with the Covid-19 pandemic affected project schedules and project costs. This also provides practical implications for companies active in project management with valuable insights into which risks should be priorities in similar pandemic situations that may occur in the future. Many project organizations did not include these risks in project contingency plans. Based on this study, project organizations can do their assessments of the importance of specific risks related to a pandemic and include them in future risk management plans for their projects.

The limitations of this study reflect the sample size. Although it did not affect the generalization of the conclusions, this reduced the possibility of a deeper analysis of the specificity of certain subgroups of project companies from different sectors that could feel different effects of the risks associated with the COVID-19 pandemic on project delays and the cost of projects. Furthermore, we found the models in both cases statistically significant while none of the variables were found significant, indicating the issue of multicollinearity that was also checked with collinearity diagnosis. This problem has been solved by Stepwise regression with Z-scores. This can be avoided with a bigger sample and/or by including new variables.

10. Conclusions

The project management industry has been significantly impacted by the COVID-19 pandemic, particularly in terms of delays and cost overruns. In the literature, we can find many different risks associated with the pandemic stated as the reasons for these challenges in project delivery. Some scholars argue that COVID-19 pandemic severely hampered supply chains, which has caused delays and raised prices for supplies of raw materials and machinery. Furthermore, it has been stated that social distancing policies and lockdowns reduced employee availability and impacted their productivity. Finally, as a result of growing health and safety concerns, more precautions are required to safeguard employees and stop the virus from spreading.

The focus of this study is to reveal which risk factors had a real influential effect on project delays and cost overruns. It is interesting to note that not all risk factors had a substantial impact on the project's cost rise and project delays. The results demonstrate that although other risk factors had no significant implications on a project timeline, only risk factors linked to material supply and epidemic prevention methods that the business was requested to undertake internally affected project delays. Furthermore, it was discovered that, during the COVID-19 pandemic, only risks related to growing material supply costs had an impact on project costs; other project risk factors had no influence.

These results can be useful for creating risk mitigation plans that will make it possible for projects to be successfully implemented under comparable occurrences and protracted disruptions. Dealing with less important things in project risk management can reduce the effectiveness of risk strategies. Thus, this study provides an answer in which direction the project risk management strategy should be directed to achieve the best results. This study is not only a reflection on the problems in time and cost management of projects during the COVID-19 pandemic. It also provides guidelines for measures to be taken in similar circumstances that may occur in the future, not only during a pandemic but also during the long-term disruption of supply chains.

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