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Factor Analysis and Principal Component of Project Delays Durign the Covid-19 Pandemic Due to Supply Chain Disruptions: Lesson Learned

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ABSTRACT
Each crisis provides food for thought concerning project management, and lessons can be drawn for the future regarding risk mitigation. In that milieu, there has been a lot of scientific discussion about the effects of the COVID-19 pandemic on project implementation. That discussion pointed to numerous factors that led to delays in the execution of projects. Thus, this study aims to identify the main factors that caused project delays during the pandemic. For this purpose, we used factor analysis, more precisely principal component analysis, to determine the main culprits that caused project delays. Factor analysis pointed to two primary causes of project delays during the pandemic, namely Epidemic-Related Disruptions and Supply chain disruptions. These findings indicate two basic groups of factors enabling a much more focused approach to project management should similar crises occur in the future.

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1. Introduction

The onset of the COVID-19 pandemic in early 2020 and the lightning speed at which it spread across the globe caught off guard individuals and businesses alike. Draconian social distancing measures, including lockdowns, were imposed almost immediately to slow the transmission of the virus which disrupted, inter alia, project workflows. Thus, the pandemic negatively impacted not only people's health but also nearly every aspect of human life, including the project management sector. Completing projects on time encountered unforeseen challenges, as supply chains were disrupted, and workforces were unable to work due to illness and quarantine or social distancing regulations.

Ergo, scholars, with the benefit of hindsight, have initiated an academic discussion to provide decision-makers input on managing crises of that magnitude. Many factors are critical to the sustainability of supply chains to ensure continuity in project supply deliveries. For instance, Puska et al. (2021) suggested using fuzzy methods in the decision-making process of selecting sustainable suppliers by applying several economic, social, and environmental criteria. Additionally, Ivanov (2022) introduced a viable supplier framework focusing on the ability of a supply chain to continue operating in a volatile environment during long-term disruptions.

Considering previous discussions in which supply chain disruptions were identified as a primary reason for project delays, this study has focused on the main components causing delays in project deliveries. In this context, this study investigates the supply disruption risks that caused significant delays in project delivery during the COVID-19 pandemic with the aim of identifying what triggered those delays. In this way, valuable lessons would be identified, facilitating effective project management in similar future crises. Understanding the intricate interplay of these supply chain exigencies is essential for project managers, decision-makers, and stakeholders who seek to enhance their preparedness for future disruptions. Moreover, this study underscores the importance of effectively assessing and addressing the risks associated with supply disruptions during times of crisis while offering a deeper understanding of the critical factors that impact project delays and consolidating the lessons learned concerning project management in similar crises.

2. Literature review

The last decade has been focused on the concept of sustainable development. Even the choice of suppliers is seen through the prism of sustainability. Puska et al (2020) argue about the importance of establishing three-dimensional supply chains, including supplier partnerships, customer relationships, and level and quality of information sharing, representing supply chain practices, flexibility, agility, and innovation as the main characteristics of supply chain performance. Puska et al. (2018) and Puska et al. (2021) contributed to creating a framework for the selection of sustainable suppliers using interval fuzzy logic in group decision-making.

However, the COVID-19 pandemic has caused significant disruptions to global and local supply chains, leading to economic slowdown and social issues (Pujawan & Bah, 2022; Sarkis, 2020; Ozdemir et al., 2022; Xu et al., 2020). Pujawan & Bah (2022) provided a significant contribution to reviewing the existing literature on supply chain disruptions during the pandemic and highlighted the importance of safety, digitalization, localization, and redefining efficiency. According to them, mitigation strategies such as redundancy and flexibility are still relevant, but there is a stronger emphasis on digitalization and supply-based localization. With this perspective, it has been revealed that existing strategies were not enough.

Shahed et al. (2021) reminded us that every organization in a supply chain experiences disruptions from manmade and natural disasters. They put focus on the inventory model to manage supply chain disruption risks. However, it is questionable whether this is enough. Sarkis (2020) emphasized the need for research on sustainability and resilience. While short-term environmental gains have been observed, the long-term effects are uncertain. The authors highlight the importance of environmental sustainability practices for organizations in managing future crises.

Ozdemir et al. (2022) argued that the COVID-19 pandemic has posed significant challenges to supply chains. Their study examines the effectiveness of existing solutions in promoting supply chain resilience. The findings indicate that pandemic-related disruptions have impacted resilience-building activities. Innovation is highlighted as a crucial factor for resilience, followed by robustness, empowerment, and risk management.

Moosavi et al. (2022) suggested solutions for building resilience into supply chains, such as regionalization and investment in digital technologies. The study concludes by emphasizing the complexity and interconnectedness of supply chain disruptions during the pandemic and the need for further research in this area.

Xu et al. (2020) showed that the COVID-19 pandemic has resulted in unprecedented disruptions to the mechanics of most GSCs such as pharmaceuticals, food, electronics, automotive industry, etc. Unlike previous major disruptions, COVID-19 has adversely affected GSCs throughout all their stages with major turbulences in manufacturing, processing, transport, and logistics, as well as significant shifts in demand. The analysis pinpointed that enhancing supply chain resilience is the main key driver to reducing vulnerability in disruptive times.

Magableh (2021) examined the impact of the COVID-19 pandemic on the supply chain, including disruptions, challenges, and trends. The study is novel as it identifies and categorizes essential factors in a comprehensive framework. Per this scholar, the impact is expected to affect businesses indefinitely; and supply chains are unlikely to resume their pre-COVID-19 status. Chowdhury et al. (2021) identified four recurring themes: the pandemic's impacts, resilience strategies, the role of technology, and supply chain sustainability. Paul et al. (2021) highlighted issues of raw material scarcity, production and transportation disruptions, and social distancing.

Since many projects were fixed, this posed a challenge for project organizations since they were not able to meet deadlines during the COVID-19 pandemic. Alfadil et al. (2022) discussed the legal aspects of project implementation. They highlighted that the force majeure clause has been associated with wars and natural disasters, while environmental risks have been connected to safety issues, pollution, and waste management. However, the COVID-19 pandemic created a unique situation that did not happen for decades, affecting individuals, societies, and countries. Al-Mhdawi et al. (2022) also highlighted that the COVID-19 pandemic had contractual implications, but also implications on financial markets, supply chains, safety, and risk management. Factors such as safety management measures, interpretation of contract language, building materials prices, risk management practices, construction materials, construction labor, and construction subcontractors have been greatly impacted.

Khalfan & Ismail (2020) discussed labor scarcity, supply chain disruption, decreased productivity, increased project financing rejection rate, and reduced foreign investment being the main challenges. Their study also highlights the increased unemployment rate and the need for active labor policies. Sutterby et al. (2023) investigated the impact of the pandemic on a large Australian construction company's daily operations and emphasized the importance of effective construction supply chain management in minimizing negative effects. The study finds that processes and maintaining relationships with stakeholders are key factors during the pandemic.

Majumder & Biswas (2021) especially highlighted safety concerns due to the COVID-19 pandemic, requiring employers to implement safety measures to protect workers, thus leading to delays. The pandemic has caused delays in construction projects and increased concerns about health and safety. It is crucial to assess the risks and implement safety measures for workers during and after the pandemic.

Alsharef et al. (2021), in their study on the U.S. construction industry, found effects of the COVID-19 pandemic such as delays, material shortages, reduced productivity, cash flow challenges, project suspensions, price escalations, and potential conflicts. However, they found new opportunities such as fast-track medical facility construction and recruitment of skilled workers, with risk management measures including safety protocols and government relief programs being widely adopted. The findings of this study will be useful for governmental agencies seeking to address the adverse effects on the construction industry.

Ogunnusi et al. (2020) argued that there are positive and negative impacts of the COVID-19 pandemic on the construction industry. The pandemic has highlighted the importance of investing in communication infrastructure and fostering local capacity in the construction industry. Furthermore, Ogunnusi et al. (2021) highlighted specifically positive and negative impacts on the construction industry, including cost reduction, remote working, and improved productivity, but also low business turnover, delays in payment, and job losses, highlighting

the need for improved health and safety measures and strategies for future-proofing the industry. One major negative impact was the increase in mental health issues due to the unexpected change in the working environment.

Sami et al. (2022) analysed the effects of Covid 19 pandemic on the construction industry in the United Arab Emirates. They highlighted the main effects such as schedule delays, disrupted cashflows, and various challenges. The main problems that they identified were delays due to international travel restrictions, lockdowns, and other preventive measures. This has resulted in financial losses, restricted resources, and invalidated contracts. For them, efforts by the government and construction industry, such as economic support programs and digitization, have proven effective in mitigating the adverse effects of the pandemic. The industry has also embraced digital tools and methods to manage projects during the pandemic.

Alajmani et al. (2023) discussed about the top five factors of delays in the United Arab Emirates including awarding projects to the lowest bidder, delay in progress payment, change orders by the owner, poor subcontractor performance, and inadequate planning and scheduling by the contractor. The paper also emphasizes the shift in perceptions of construction professionals due to the pandemic. The study fills a gap in the literature by providing insights from construction professionals on the impact of COVID-19 on delays in the UAE construction industry.

Gatenholm & Halldórsson (2023) examined how organizations have responded to disruptions in their product-based service supply chains during the COVID-19 pandemic, identifying various strategies ranging from restoration to radical change. The findings suggest that these disruptions can be categorized as external supply-side, demand-side, or interactional, and a conceptual framework combining resilience and transformation is proposed to create new service opportunities. The study provides insights into the first-response abilities and coping mechanisms of manufacturing firms during the pandemic, highlighting the importance of fostering transilience in supply chains.

Alhammadi (2022) evaluated factors affecting Riyadh's construction sector in light of the COVID-19 pandemic. The factors include managerial, economic, social, cultural, and environmental factors. The findings highlight the abandonment of talent and expertise, conflict in bidding prices, social and cultural factors, and the process of requesting raw materials as the top factors affecting the management of Riyadh's construction sector during the pandemic.

Alenezi (2020) did an extensive literature review on delays in construction projects, particularly during the COVID-19 pandemic in Kuwait. The study found that critical delays in construction projects were mainly due to COVID-19, and proper planning and communication can help reduce delays. The survey identified 17 factors of delay, which were ranked based on their importance level. Many factors cause delays in the construction project, some falling within the owner's liability and some within the contractor's liability. The COVID-19 pandemic has also highlighted additional management issues, such as the need for social distancing and increased welfare facilities for workers.

Gumusburun & Çivici (2023) provided a framework for analyzing and prioritizing weaknesses to minimize the adverse impact of the pandemic. The study found that increased costs and supply chain disruptions, as well as challenges with payment and cash flows, were the most influential factors. The research suggests that contractors, architects, and civil engineers should analyze their weaknesses and prioritize effectively to minimize the adverse effects of the pandemic.

Want et al. (2020) were very specific in identifying risks related to project delays during the COVID-19 pandemic. The specific risks related to COVID-19 in tunnel construction projects include worker availability, site accessibility, shortage of construction materials, and inadequate epidemic prevention materials. According to them, social panic and epidemic prevention requirements are key issues that need to be addressed before construction work can resume. shortage of workers, materials, machines, and site accessibility greatly hindered the schedule of the tunnel construction projects at the early outbreak of the COVID-19 epidemic in China.

3. Methodology

To understand the complex problem of the effects of supply chain disruption during Covid 19 pandemic

on project delays, this study utilized factor analysis or more precisely principal component analysis. Principal component analysis was used to identify the latent dimensions that influence the variation in the level of importance of different supply chain disruption risks associated with project delays.

The research design involves the use of a survey questionnaire. A seven-level Likert scale was used to address the respondents' perceptions of project delays. The questionnaire was distributed using Survey Sparrow online survey software. A total of 125 respondents around the globe who are engaged in project business took part in the survey over three months from January to March 2022.

This study analyzed the risks associated with the Covid-19 pandemic proposed by Wang et al. (2020). These risks are used as the variables in this study, namely:

- Dstaff: disruption of staff access to the site and shortage of workers, technicians, and operators:
- Dmat: material supply disruption
- Deq: machine supply and delivery disruption
- Dmet: disruption due to epidemic prevention methods that the company was requested to implement inside the company:
- Dpan: disruption due to panic of residents:
- Dext: Disruption due to administrative epidemic control policy outside the company:

To understand the opinion about the effects of supply chain disruption risks on project delays, the survey respondents should answer the following question for each of the 6 identified risks: How long did the interruption caused by particular risks during the COVID-19 pandemic last? The Likert scale for measuring project delays included the following response options: (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.

The principal factor component analysis was conducted in this study. This analysis started with calculating the correlation matrix of the standardized variables to provide information about the relationships between variables. Correlations between variables should be statistically significant at the level of $p \leq 0.05$ to be considered that the data are suitable for factorial analysis. On the other hand, the correlation coefficients should not cross the threshold value of 0.09 which would suggest the existence of multicollinearity. High correlations between variables suggest multicollinearity, meaning that the variables are measuring similar aspects of the construct. In such cases, selecting one representative variable from the correlated group can help reduce dimensionality.

The Kaiser-Meyer-Olkin (KMO) test was applied to determine the extent to which the variables are related to each other. It helps to assess the adequacy of the data for factor analysis. The KMO measure ranges from 0 to 1, with values closer to 1 indicating a higher degree of intercorrelation among variables. If the f KMO value is above 0.8, this indicates a high degree of common variance, and the data is suitable for factor analysis. However, if KMO values between 0.6 and 0.8, even in this case factor analysis may be performed with caution since there is moderate intercorrelation among variables. However, if KMO values are below 0.6, in this case, factor analysis is not suitable. Furthermore, Bartlett's Test is an additional test to assess whether the variables in the dataset are uncorrelated and unsuitable for factor analysis. If the p-value is significant ($p < 0.05$), this indicates that the correlation matrix significantly deviates from an identity matrix. In this case, the data is suitable for factor analysis.

The next step in principal factor component analysis is to calculate commonalities for each variable. They determine the proportion of the total variance in each variable that can be explained by the factorial analysis. The calculation of commonalities helps in understanding the importance of each variable in the analysis. Higher communalities with a value closer to 1 suggest that the variable contributes more to the overall structure captured by the principal components. Communalities with values below 0.3 are not acceptable.

Furthermore, the total variance explained assists in determining how much of the variability in the original data is captured by the PCA-derived reduced-dimensional representation. The total variance explained enables the identification of the number of principal components to retain in the analysis. The cumulative variance explained by each component identifies the

point at which adding additional components does not contribute significantly to the overall variance explained. This is usually from 80% or 90% of the cumulative percentage which indicates that the extracted principal components are capturing a large portion of the variability in the original data. With the information that is provided by eigenvalues, it is possible to identify components that capture important patterns and structures in the data, indicating their significance in the reduced-dimensional representation. Eigenvalues measure the amount of variance explained by each component. Those eigenvalues greater than 1 indicate significant components. Additionally, the total variance is visually presented with scree plots. This step enables the extraction of factors from the original data.

After factors are extracted, they are rotated to be presented in a more interpretable factor structure. The Varimax rotation method reorients the factors to improve interpretability. Extracted factors are presented in the component matrix which serves to identify the factor loadings of each variable on the extracted factors. Factor loading shows the strength and direction of the relationship between each variable and the underlying factors. Variables with high factor loadings that are closer to 1 or -1 on a particular factor are considered to be strongly associated with that factor. In general, factor loadings above 0.4 are considered to have a reasonable level of association.

Once the principal components are identified, the final step is to explore how these components relate to each other. The component correlation matrix shows the correlations between the principal components, which provides insights into their underlying relationships. The correlation ranges from +1 to - 1. A correlation close to 1 between two components indicates that they are strongly related and capture similar information. This indicates that these components may represent the same underlying factor. A correlation close to -1 between two components indicates that they capture opposite or contrasting information. These components may represent different aspects of the dataset. A correlation coefficient close to 0 indicates a weak relationship between the components. This suggests that the components are relatively independent and capture distinct patterns of the data.

4. Research findings

This section provides the results conducted with the study. This analysis starts with the interpretation of the findings from the correlation matrix. Although there is noticeable a difference in correlation coefficients between variables, the correlation between all coefficients is statistically significant. This can be confirmed by having an insight into the p-value for each correlation which is in all cases at the level $p \leq 0.05$. Furthermore, there are no values of correlation crossing the threshold of 0.09 which would indicate the problem of multicollinearity. This is proof that these data can be used further in principal factor component analysis.

Table 1

Correlation matrix

		Dstaff	Dmat	Deq	Dmet	Dpan	Dext
Correlation	*Dstaff*	1.000	.441	.422	.633	.532	.694
	Dmat	.441	1.000	.880	.285	.228	.302
	Deq	.422	.880	1.000	.264	.314	.237
	Dmet	.633	.285	.264	1.000	.698	.612
	Dpan	.532	.228	.314	.698	1.000	.635
	Dext	.694	.302	.237	.612	.635	1.000
Sig. (1-tailed)	*Dstaff*		.000	.000	.000	.000	.000
	Dmat	.000		.000	.013	.039	.009
	Deq	.000	.000		.020	.007	.033
	Dmet	.000	.013	.020		.000	.000
	Dpan	.000	.039	.007	.000		.000
	Dext	.000	.009	.033	.000	.000	

Notes. Authors' calculation.

The second proof that the data are suitable for facto analysis comes from KMO and Bartlett's Test. Kaiser-Meyer-Olkin Measure of Sampling Adequacy value is 0.669, close to 0.7, which indicates a moderate intercorrelation among variables, thus we can proceed with factorial analysis with caution. Bartlett's Test of Sphericity supports this statement since $p \leq 0.05$. With the confirmation from these two tests, it can be confirmed that factorial analysis can be performed.

Table 2

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.669
Bartlett's Test of Sphericity	Approx. Chi-Square	226.967
	df	15
	Sig.	.000

Notes. Authors' calculation.

After confirmation of suitability data for factorial analysis, the next move is to assess how variables are represented by components. This is done with the assistance of Communalities. As per the findings, variables have an extraction value above 0.3 which can be considered as an acceptable proportion of variance that can be explained by the principal components. Variables Dmat (0.938) and Deq (0.932) are well represented by the components, indicating a strong relationship between these variables and the underlying dimensions captured by the components. The lowest value of communalities has Dstaff (0.718) indicating a moderate relationship with the components.

Table 3

Communalities

	Initial	Extraction
Dstaff	1.000	.718
Dmat	1.000	.938
Deq	1.000	.932
Dmet	1.000	.758
Dpan	1.000	.722
Dext	1.000	.749

Notes. Authors' calculation.

In our analysis, we have 6 components due to 6 variables used in this research. Based on the total variance explained, two principal components have significant eigenvalues values above 1, namely component 1 with a factor loading of 3.412 with 55.86% of variance coming from this component, while the second component factor loading equals 1.405 and explains 23.42% of the variance. Thus, these two components explain 80.28% of the total variance. Other components have no significant eigenvalues values and will not be further elaborated.

Table 4

Total Variance Explained

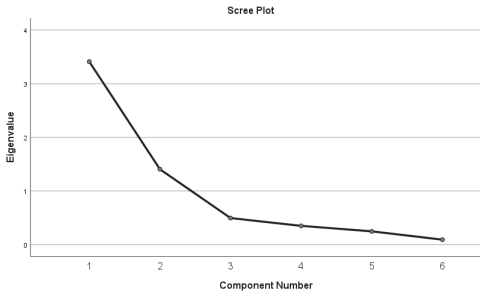
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.412	56.860	56.860	3.412	56.860	56.860
2	1.405	23.421	80.282	1.405	23.421	80.282
3	.495	8.246	88.528			
4	.349	5.822	94.349			
5	.247	4.113	98.462			
6	.092	1.538	100.000			

Notes. Authors' calculation.

The scree plot visualizes the value of eigenvalues for six different components. From the graph is visible that only 2 components have the values above 1. Thus, the data can be grouped into 2 groups.

Figure 1

Scree Plot



Notes. Authors' calculation.

The variables Dmet, Dext, Dpan, and DStaff loaded strongly on Component 1, with loadings of 0.862, 0.856, 0.843, and 0.770 respectively. The high loadings suggest that these variables are strongly associated with this component, indicating their strong influence in explaining the variance within the dataset. The variables Dmat and Deq are not highly associated with component 1. This component can be interpreted as representing a factor related to Epidemic-Related Disruptions, or Human Related factors.

When it comes to the loading factors for component 2, there is a slightly different situation. The variables Dmat and Deq loaded strongly on Component 2, with loadings of 0.953 and 0.951 respectively. Thus, only these two variables are strongly associated with component 2. In this case, component 2 can be interpreted as a factor related to Supply Chain Disruptions, or Non-human related factors.

Table 5

Rotated Component Matrix

	Component	
	1	2
Dstaff	.770	.355
Dmat	.174	.953
Deq	.169	.951
Dmet	.862	.122
Dpan	.843	.109
Dext	.856	.129

Notes. Authors' calculation.

By looking at Component Score Coefficient Matrix, we found a weak correlation of Component 1 with the variables Dext, Dmet, Dpan, and Dstaff based on correlation coefficients 0.329, 0.333, 0.327, and 0.251 respectively. The variables Deq, and Dmat show almost no correlation. With Component 2 the variables Dmat and Deq, with correlation coefficients of 0.531 and 0.532 respectively, show a moderate positive correlation.

Table 6

Component Score Coefficient Matrix

	Component	
	1	2
Dstaff	.251	.064
Dmat	-.108	.531
Deq	-.110	.530
Dmet	.333	-.091
Dpan	.327	-.095
Dext	.329	-.086

Notes. Authors' calculation.

Based on Component Score Covariance Matrix, we found covariance value between Component 1 and Component 2 equals 0.000. This result indicates that there is no linear relationship between the scores of these two components. Thus, the changes in one component's score provide no information about the changes in the other component's score. This lack of correlation suggests that these components capture different and independent aspects of the data. This result emphasizes the unique contribution of each component to the interpretation of the dataset's underlying structure.

Table 7

Component Score Covariance Matrix

Component	1	2
1	1.000	.000
2	.000	1.000

Notes. Authors' calculation.

5. Discussion and conclusions

The Covid 19 pandemic greatly affected project management over a period of two years, especially at the beginning of 2020. The special effect of this pandemic was reflected in project delays. Bearing in mind that certain companies contracted the delivery of projects in accordance with fixed contracts, as indicated by Alfadil et al. (2022) and Al-Mhdawi et al. (2022), this particularly affected them as they could not fulfil their obligations on time. During the pandemic, there was a lot of discussion about the factors affecting the delivery of projects, as well as the measures that needed to be taken. Sometimes there was no systematic approach, and the measures were very dispersed.

For this study, the identified risks causing project delays given by Wang et al. (2020) were the basic points. They identified man, material, machine, method, environment as main risks in project management causing delays during Covid 19 pandemic. However, this and similar studies recognized many different risks and factors that lead to delays, and it is difficult to manage these risks in a systematic way. Thus, this study enables a structural categorization of main components of risks that affected delays of projects during the pandemic. This can serve as a lesson learned for more systematic categorization of projects risks if and when similar situations and crisis occurs.

By analyzing the factors influencing project delays during the pandemic, we came to the discovery of two specific components: Epidemic-Related Disruptions and Supply Chain Disruptions. Epidemic-Related Disruptions refer to factors such as disruption of staff access to the site and shortage of workers, technicians, and operators, disruption due to epidemic prevention methods that the company was requested to implement inside the company, disruption due to panic of residents, and Disruption due to administrative epidemic control policy outside the company. This type of factor was somehow beyond the influence of the project companies and it was difficult to manage. Especially because at the centre of this component is a human who was directly affected by the pandemic through the possibility of infection. As per our findings, these types of factors were more influential in terms of project delays.

On the other hand, we can distinguish another component: Supply Chain Disruptions. Factors within this component refer to material supply disruption and machine supply and delivery disruption. This type of factor affecting the supply of project organizations was already known to project companies that were able to apply already known mitigation strategies. By dividing the factors into more specific groups, human related and non-human related, we are able to focus our mitigation project management strategies in future similar situations. In this way, it is possible to avoid an overly broad approach in managing pandemic-related risks. Therefore, this research can serve as lessons learned about project management during the pandemic. As we move forward, these insights will contribute to the development of more robust project management practices and the successful execution of projects in an ever-changing world.

Having in mind the findings, it is obvious that companies which quickly adapted to the new situation as suggested by Pujawan & Bah (2022), have able to respond to changes in supply chains. Especially good tactics was the one suggested by Panwar & De Marchi (2022) in which automation and digitalization play a key role in these transitions. Their role is irreplaceable in cases where the human factor is the main cause of delays. Thus, we need to acknowledge arguments given by Ogunnusi et al. (2020) that the COVID-19 pandemic has had both positive and negative driving innovation and the use of technology in project management. The pandemic has highlighted the importance of investing in communication infrastructure. Thus, lessons learned about how to deal with health and safety technologies proposed by Yand et al. (2021), such as QR code systems and AI-powered tools, and other technologies can be very effective in case that similar crisis occurs.

Keeping in mind the ideas from Selakovic et al. (2023) about the importance of small and medium enterprises (SMEs) which are carriers of the economic development of local, and regional, this requires the full attention of decision-makers in the period of similar disruptions.

At the end of the day, it can be concluded that mitigation plans should not be left only to new project

companies, but that such plans should also exist at the level of governments, which could act quickly if the situation with the pandemic happens again.

5.1. Theoretical implications

There are numerous studies that have studied the impact of the COVID-19 pandemic on the implementation of projects and the disruption of supply chains. Those studies indicated numerous factors and risks that had a negative effect on project management during this period. The theoretical contribution of this study is that, by adopting the appropriate method of factor analysis, the systematization and grouping of various factors with an impact on project management was carried out. In this way, we obtained a systematized group of factors with effects on project delays during the period of disruption caused by the COVID-19 pandemic.

5.2. Policy and managerial implications

The response of official government policies around the world to the COVID-19 pandemic, as well as the response of businesses to the disruption of value chains that affected project delays, were very different and sometimes not so expedient. This study analyzed the lessons learned from the mentioned period and gave an answer about the most important factors that should be taken into account in similar situations that may happen in the future. Bearing in mind the analysis of the importance of the factors, in future similar situations it is possible to respond more easily to the problems of project delays by focusing on the factors that have a significant impact on project management.

5.3. Limitations and suggestions for future research

This study is focused on the lessons learned from the period of the COVID-19 pandemic. Whether a similar situation will repeat itself in the future remains unknown. Therefore, the application of the results from this study can be applied to similar situations in the future. Furthermore, the number of participants in the study is limited, and by including a larger number of participants in the analysis, an even more detailed analysis can be obtained. This limitation was tried to be replaced by the inclusion of business organizations around the world in order to get as wide an insight into the research problem as possible.

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References

Alajmani, H., Ahmed, S., & El-Sayegh, S. M. (2023). Factors causing delays in the UAE construction industry amid the Covid-19 pandemic. *Journal of Financial Management of Property and Construction.* https://doi.org/10.1108/JFMPC-02-2023-0006.

Alenezi, T. A. N. (2020). Covid-19 causes of delays on construction projects in Kuwait. *International Journal of Engineering Research and General Science, 8*(4), 6-9. https://www.ijergs.org/.

Alfadil, M. O., Kassem, M. A., Ali, K. N., & Alaghbari, W. (2022). Construction industry from perspective of force majeure and environmental risk compared to the CoViD-19 outbreak: a systematic literature review. *Sustainability, 14*(3), 1135. https://doi.org/10.3390/su14031135.

Alhammadi, S. A. (2022). Factors affecting the management of Riyadh's construction sector in the light of COVID-19. *Heliyon, 8*(11). https://doi.org/10.1016/j.heliyon.2022.e11899.

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), 05021015. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000991.

Alsharef, A., Banerjee, S., Uddin, S. J., Albert, A., & Jaselskis, E. (2021). Early impacts of the COVID-19 pandemic on the United States construction industry. *International journal of environmental research and public health, 18*(4), 1559. https://doi.org/10.3390/ijerph18041559.

Chowdhury, P., Paul, S. K., Kaisar, S., & Moktadir, M. A. (2021). COVID-19 pandemic related supply chain studies: A systematic review. *Transportation Research Part E: Logistics and Transportation Review, 148,* 102271. https://doi.org/10.1016/j.tre.2021.102271.

Gatenholm, G., & Halldórsson, Á. (2023). Responding to discontinuities in product-based service supply chains in the COVID-19 pandemic: Towards transilience. *European Management Journal, 41*(3), 425-436. https://doi.org/10.1016/j.emj.2022.02.007.

Gumusburun Ayalp, G., & Çivici, T. (2023). Factors affecting the performance of construction industry during the COVID-19 pandemic: a case study in Turkey. *Engineering, Construction and Architectural Management, 30*(8), 3160-3202. https://doi.org/10.1108/ECAM-10-2021-0890.

Ivanov, D. (2022). Viable supply chain model: integrating agility, resilience and sustainability perspectives—lessons from and thinking beyond the COVID-19 pandemic. *Annals of operations research, 319*(1), 1411-1431. https://doi.org/10.1007/s10479-020-03640-6.

Magableh, G. M. (2021). Supply chains and the COVID-19 pandemic: A comprehensive framework. *European Management Review, 18*(3), 363-382. https://doi.org/10.1111/emre.12449.

Majumder, S., & Biswas, D. (2021). COVID-19 Impacts Construction Industry: Now, then and Future. In: Santosh, K., Joshi, A. (eds) *COVID-19: Prediction, Decision-Making, and its Impacts. Lecture Notes on Data Engineering and Communications Technologies,* vol 60. Springer, Singapore. https://doi.org/10.1007/978-981-15-9682-7_13.

Moosavi, J., Fathollahi-Fard, A. M., & Dulebenets, M. A. (2022). Supply chain disruption during the COVID-19 pandemic: Recognizing potential disruption management strategies. *International Journal of Disaster Risk Reduction, 75,* 102983. https://doi.org/10.1016/j.ijdrr.2022.102983.

Ogunnusi, M., Hamma-Adama, M., Salman, H., & Kouider, T. (2020). COVID-19 pandemic: the effects and prospects in the construction industry. *International Journal of Real Estate Studies, 14* (Special Issue 2). https://intrest.utm.my/index.php/intrest/article/view/71.

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.

Ozdemir, D., Sharma, M., Dhir, A., & Daim, T. (2022). Supply chain resilience during the COVID-19 pandemic. *Technology in Society, 68,*101847. https://doi.org/10.1016/j.techsoc.2021.101847.

Panwar, R., Pinkse, J., & De Marchi, V. (2022). The future of global supply chains in a post-COVID-19 world. *California Management Review, 64*(2), 5-23. https://doi.org/10.1177/00081256211073355.

Paul, S. K., Chowdhury, P., Moktadir, M. A., & Lau, K. H. (2021). Supply chain recovery challenges in the wake of COVID-19 pandemic. *Journal of Business Research, 136,* 316-329. https://doi.org/10.1016/j.jbusres.2021.07.056.

Pujawan, I. N., & Bah, A. U. (2022). Supply chains under COVID-19 disruptions: litera ture review and research agenda. *Supply Chain Forum: An International Journal, 23*(1), 81-95. https://doi.org/10.1080/16258312.2021.1932568.

Puška, A., Kozarević, S., & Okičić, J. (2020). Investigating and analyzing the supply chain practices and performance in agro-food industry. *International Journal of Management Science and Engineering Management, 15*(1), 9-16. https://doi.org/10.1080/17509653.2019.1582367.

Puška, A., Nedeljković, M., Hashemkhani Zolfani, S., & Pamučar, D. (2021). Application of interval fuzzy logic in selecting a sustainable supplier on the example of agri cultural production. *Symmetry, 13*(5), 774. https://doi.org/10.3390/sym13050774.

Puška, A., Stević, Ž., & Stojanović, I. (2021). Selection of sustainable suppliers using the fuzzy MARCOS method. *Current Chinese Science, 1* (2), 218-229. https://doi.org/10.2174/2210298101999201109214028.

Rani, H. A., Farouk, A. M., Anandh, K. S., Almutairi, S., & Rahman, R. A. (2022). Impact of COVID-19 on construction projects: the case of India. *Buildings, 12*(6), 762. https://doi.org/10.3390/buildings12060762.

Sami Ur Rehman, M., Shafiq, M. T., & Afzal, M. (2022). Impact of COVID-19 on project performance in the UAE construction industry. *Journal of Engineering, Design and Technology, 20*(1), 245-266. https://doi.org/10.1108/JEDT-12-2020-0481.

Sarkis, J. (2020). Supply chain sustainability: learning from the COVID-19 pandemic. *International Journal of Operations & Production Management, 41*(1), 63-73. https://doi.org/10.1108/IJOPM-08-2020-0568.

Shahed, K. S., Azeem, A., Ali, S. M., & Moktadir, M. A. (2021). A supply chain disruption risk mitigation model to manage COVID-19 pandemic risk. *Environmental Science and Pollution Research,* 1-16. https://doi.org/10.1007/s11356-021-14617-3.

Selaković, M., Ljepava, N., Tarabasz, A., & Stojanović, I. (2023). E-Business as Catalyst for Global Transformation of SMEs: A Middle East Perspective. *TEM Journal, 12*(3), 1838-1844. https://10.18421/TEM123-67.

Sutterby, P., Wang, X., Li, H. X., & Ji, Y. (2023). The impact of COVID-19 on construction supply chain management: an Australian case study. *Engineering, Construction and Architectural Management.* https://doi.org/10.1108/ecam-10-2021-0942.

Wang, Z., Liu, Z., & Liu, J. (2020). Risk identification and responses of tunnel construction management during the COVID-19 pandemic. *Advances in Civil Engineering*, 1-10. https://doi.org/10.1155/2020/6620539.

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.

Yang, Y., Chan, A. P., Shan, M., Gao, R., Bao, F., Lyu, S., Zhang, Q., & Guan, J. (2021). Opportunities and challenges for construction health and safety technologies under the COVID-19 pandemic in Chinese construction projects. *International Journal of Environmental Research and Public Health,* 18(24), 13038. https://doi.org/10.3390/ijerph182413038.

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Факторска анализа и главна компонента кашњења пројеката током пандемије Covid-19 због поремећаја у ланцу снабдијевања: научене лекције

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Кључне ријечи:
поремећај у снабдијевању пројекта, кашњења пројеката, COVID-19, поремећаји повезани са епидемијом, поремећаји у ланцу снабдијевања

САЖЕТАК

Свака криза пружа материјал за размишљање у вези са управљањем пројектима и из ње се могу извући лекције за будућност у погледу ублажавања ризика. У том контексту, било је много научних расправа о ефектима пандемије COVID-19 на реализацију пројеката. Те расправе су указале на бројне факторе који су довели до кашњења у реализацији пројеката. Стога, ова студија има за циљ да идентификује главне факторе који су изазвали кашњења пројеката током пандемије. У ту сврху, користили смо факторску анализу, прецизније анализу главних компоненти, како бисмо одредили главне узрочнике кашњења пројеката. Факторска анализа је указала на два примарна узрока кашњења пројеката током пандемије, а то су поремећаји повезани са епидемијом и поремећаји у ланцу снабдијевања. Ови налази указују на двије основне групе фактора које омогућавају много фокусиранији приступ управљању пројектима у случају сличних криза у будућности.