Investigation and Prioritization of Delay Factors in Industrial Projects: A Best-Worst Method

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Abstract

This study develops a procedure to prioritize delay factors of industrial projects. The concept of delay factors, and other related concerns have been examined in previous studies on construction projects. However, the delay factors of industrial projects are less examined. Furthermore, this problem is poorly linked with novel Multiple-Criteria Decision Making (MCDM) models such as Best-Worst Method (BWM). In this regard, to fill the gap of previous literature, two linked phases have been addressed to obtain different objectives of this research. The initial phase of this study investigates different delay factors of industrial projects. To do so, a literature review is conducted to develop numerous factors which cause delays in industrial projects. Next, the second phase of this research applies a BWM to investigate and prioritize these factors. According to the obtained results, contractors, consultants, climate, customers, shortages of raw materials, financial issues and poor manpower are the most important delay factors of industrial projects, respectively. Finally, a conclusion and some future research directions are provided in the final section of this research.

Keywords
Industrial Projects, MCDM, Delay Factors, and BWM.

1. Introduction

The final output of an idea is directly related to a proper decision making (Hashemzahi et al., 2020). In this regard, it is critical to investigate different aspects of a decision considering their short, medium- and long-term effects (Hemmati et al., 2018:2019). As an important instance, there are many decisions which are necessary to complete industrial projects. In other words, many issues should be seen to complete an industrial project before the due time. More specifically, on-time completion of industrial projects is directly affected by numerous factors which cause delays and prevent managers to finish the task before the due date (Sweis et al., 2018). In this regard, it is necessary to recognize and prioritize them. There are many quantitative and qualitative Multiple-Criteria Decision Making (MCDM) tools to be applied in this problem (Tavassolirizi et al., 2020).

With the progress of industrial revolutions, there are many industrial projects which should be completed. In other words, industrial projects play an important role in progressing the economic condition of countries, especially in developing countries. Furthermore, different industrial projects need numerous obligations such as technical issues, quality considerations, safety, manpower, and many others. However, among these different necessities, on time

completion of industrial projects is necessary as delays might impose numerous expenses. In other words, late completion of industrial projects will force managers to spend more costs with regard to manpower, energy, materials and other issues of projects. Additionally, as industrial projects should be completed according to though contracts, the delays could not be easily compensated and impose extra costs of penalty to project managers. Therefore, delay factors of project are important and should be more investigated (Khesal et al., 2018). According to recent studies on delay factors of projects, it is necessary for project managers to find the main reasons of delays and remove them as much as possible. In other words, prevention has been highlighted as an appropriate tool to decrease the delays of projects. More specifically, different operational and non-operational reasons of delays should be seen in industrial projects. Additionally, comparable with other MCDM problems, a decision maker should apply numerous criteria in the decision-making process as sole concentration on financial criteria is not enough (Khorramrouz and Galankashi, 2019). In this regard, a proper prioritization of projects delay must focus on three concurrent issues of applied criteria, proper MCDM tools and suitable investigation of obtained outputs.

Although different causes of delays in construction projects has been adequately examined in previous literature (Assaf and Al-Hejji, 2006), it is less investigated in industrial projects. Also, the problem is not adequately linked with MCDM tools. As it is clear, there are many criteria to prioritize different causes of delays in industrial projects and the problem should be addressed using MCDM tools. Also, many managers, practitioners, and decision makers prefer new MCDM tools as they need less comparison tables (Khorramrouz et al., 2019; Rezaei et al., 2020; Galankashi et al., 2021). In other words, new MCDM approaches such as BWM needs less pairwise comparison matrices and provide more reliable results compared with older approach such as AHP (Rezaei, 2015). Therefore, these approaches are highly recommended in recent literature as they are more flexible to be applied by decision makers and provide more consistent outputs.

However, investigating the previous literature on delay factors of industrial projects, using an appropriate data collection approach, prioritizing those using MCDM techniques, and investigating the obtained results are the main challenges of project managers. There are numerous factors causing delays in industrial project. However, they are not adequately examined in previous studies, especially in developing countries. In this regard, by neglecting the availability of these delay factors and how they affect the completion of industrial project, many project managers still focus on cost related issues and ignore other important aspects which delays the completion of projects. Therefore, it is valuable to investigate and understand which delay factors are more important to be addressed in project management process. Nevertheless, proposing a step by step procedure to prioritize different delay factors of projects is important as:

1. The methodology is applicable in real industrial projects
2. The outputs are applicable in other projects such as healthcare and construction

This research is limited to delay factors of industrial projects. In other words, the scope of this research is related to different delay factors which cause delay in industrial projects. To be more specific, a step by step procedure is suggested to develop and prioritize different delay factors of industrial projects. Though, although the scope of this research is limited to delay factors of industrial projects, the methodology, results, and criteria are applicable to be used by project managers, researchers and practitioners of construction and healthcare projects. This study contributes to develop and prioritize the major delay factors of industrial projects using MCDM techniques. Thus, this study develops an integrated approach to prioritize different delay factors of industrial projects. As a summary of different steps requited to achieve the objectives of this study, this research analyzes previous studies on project management, finalize different delays of industrial projects, and finally apply BWM for prioritization. The remainder of this study is arranged as follows. Next section investigates the previous literature. Following, numerous phases to attain the research objectives are investigated in Section 3. Then, The data collection process is provided in section 4. Finally, the results, discussions and future research directions are provided in Sections 5 and 6, respectively.

2. Literature Review

Numerous concepts, definitions and similar studies comprising project, project management, delay factors, and an investigation of previous literature are provided in this section. Lastly, a summary and identification of research gaps are provided at the end of this section.

2.1 Industrial Projects

Industrial projects are called differently according to the scope, limitations, required time and many other issues. According to previous literature, industrial projects are mainly concerned with actions which are necessary to complete an industry related activity. In this regard, many activities including but not limited to constructing an industrial plant, scheduling a job shop, new product development, recycling and manufacturing sites are considered as industrial projects. In this regard, although there are different activities under the name of industrial project, the majority of these projects are directly or indirectly related to manufacturing sector of economy (Galankashi and Helmi, 2016). Therefore, the main output of an industrial project might be the final delivery of products to final customers in desired time, quality, quantity, location and price (Bidoki et al., 2021). In addition, these projects aim to maintain or achieve the desired goals of different industries by providing the technical requirement of manufacturing processes such as plants, machines, manpower, processes and many other related issues. There are numerous issues linked with these projects. Though, financial, non-financial, operational and non-operational issues are the most important issues of these projects (Galankashi and Rafiei, 2021). Therefore, similar to other projects, according to previous studies, project delays might be related to suppliers, contractors, man power, raw materials and customers. However, similar to other projects, the weight or ranking of delay factors are not the same and might vary according to different issues of industrial projects.

2.2 Project Management

Based on previous literature, a big portion of previous literature on project delay factors have been completed in developed countries. In this regard, as the problem is less investigated in developing countries, it is necessary to focus on different aspects of projects, delay factors and their prioritization to enrich the problem. According to previous literature, industrial projects compromises numerous steps to convert manufacturing ideas in practice. In other words, these projects aim to improve the quality, price and other outputs of manufacturing ideas. However, as there are many objectives to seek, industrial projects need a comprehensive project management to coordinate numerous aspects such as cost, time, manpower, technology and other issues. In other words, concurrent consideration of all these issues need a lot of time, cost and coordination. In addition to these issues, the necessities of projects might be both qualitative and quantitative. In this regard, a project manager should handle all these issues concurrently. Therefore, the potential causes of project delay should be recognized and prioritized for the aim of better planning.

2.3 Project Delay Factors

As discussed in previous sections, there are different project delay factors. In other words, according to previous literature, there are different factors causing delays in completing industrial projects. However, similar to other areas, there might be a bunch of factors with similar function. In this regard, a literature survey is applied to find the major causes of project delay as tabulated in Table 1.

Table 1. Major causes of project delay

Criteria	Sample Reference
Consultants	Alzara et al., (2016)
Customers	Cosa et al., (2021)
Shortages of raw materials	Wanjari and Dobariya (2016)
Poor manpower	Al-Emad et al., (2017)
Climate	Naylor et al., (2007)
Financial issues	Agyekum-Mensah and Knight (2017)
Contractors	Akomah and Jackson (2016)

2.4 Identification of research gap

According to the highlights of previous studies presented in this section, a step by step methodology to prioritize delay factors of industrial projects is not properly examined, especially in developing countries. In addition, as there are different causes of project delays, it is critical to develop and prioritize the specific causes of delays in industrial projects. Finally, as managers, decision makers and practitioners prefer to make their pairwise judgments using fewer tables, it is recommended to apply recent MCDM tools such as BWM to address the problem. Hence, to address the gap of previous literature, this research develops a step by step procedure to develop different causes of delay in industrial projects and prioritize them using BWM.

3. Research Methodology

This section discusses the applied research methodology to achieve different objectives of this study. As depicted in Figure 1, this study has been completed in two linked phases as follows. The initial phase of this research applies a literature review to investigate previous studies on the topic. In other words, the first phase of this research applies previous studies to develop the major causes of delay in industrial projects. To do so, numerous keywords including project delay, project delay factors, project delay contributors, delay of project, industrial projects delay, and delay causes of projects have been applied to find related studies. Therefore, in summary, the initial phase of this research reviews previous studies on the topic to finalize potential causes of delay in industrial projects. Following, the second phase of this study finalizes the ranking of these delay factors. In other words, this phase investigates the potential delay factors to be considered as the main cause of delay in industrial projects. To do so, a BWM is applied as an applicable and recent decision-making tool to prioritize different causes of delay in industrial projects. To do so, according to Rezaei (2015), there are different steps required to complete the BWM. Firstly, it is necessary to formulate the problem. In other words, similar to other MCDM techniques, the goal, alternatives and criteria should be determined. Next, potential alternatives should be assessed with regard to the criteria. Next, the importance of all criteria should be determined. Following, once the proper data are collected, it is necessary to run the model to achieve the outputs. Finally, similar to other MCDM techniques such as AHP (Ziaei et al., 2013; Galankashi et al., 2016), it is necessary to check the validity and reliability of the obtained results. According to Rezaei (2015), it is necessary to do a consistency test to validate the BWM outputs. Different phases of this research are depicted in Figure 1. In addition, different steps of BWM are depicted in Figure 2 (Duleba et al., 2021).

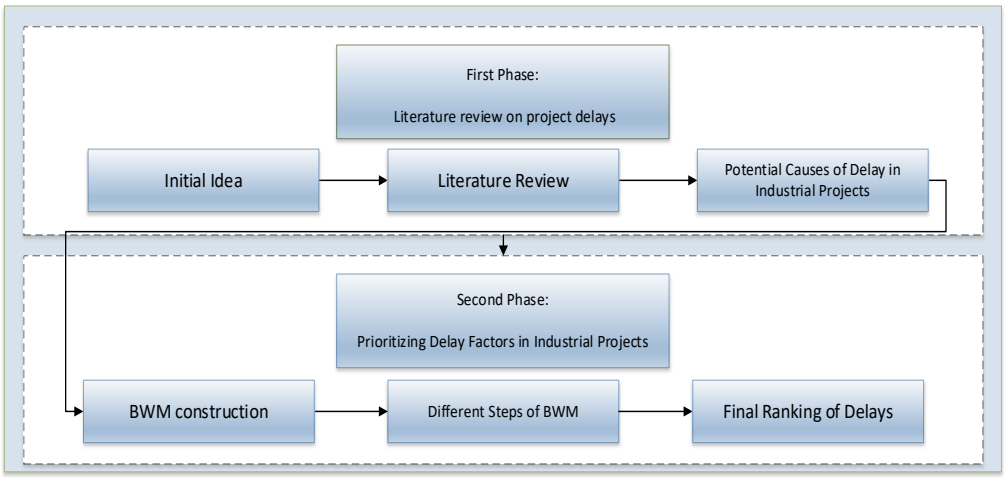

Figure 1. Research Steps

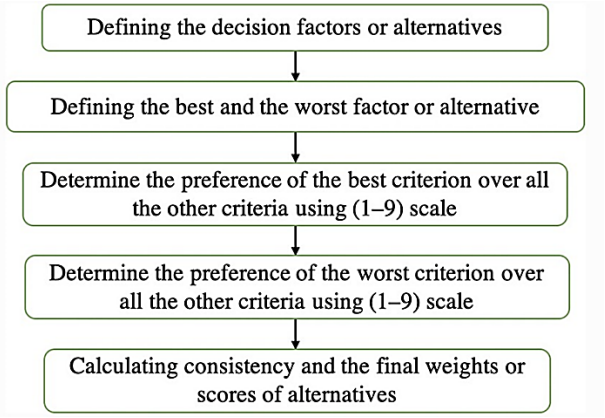

Figure 2. BWM Steps (Duleba et al., 2021)

4. Data Collection

In this study, a literature survey was applied to indentify the specific delay factors of industrial projects. Next, the BWM questionnaire was designed to use experts' opinions to complete different steps of this method. Finally, the results of this process are provided in section 5.

5. Results

This section presents the obtained results of this research. As discussed in research methodology section, two phases are required to address the objectives of this research. Hence, to ease the tracking process of results, this section has been arranged according to different phases of research methodology. However, there were some issues linked with data collection process. Initially, it was essential to develop the specific delay factors of industrial projects. To do so, a literature survey was applied to develop these factors. Next, the BWM questionnaire was designed according to different steps required to complete this approach. Finally, as the comments of experts have been applied to prioritize the delay factors of industrial projects, the obtained results are completely reliable. According to research methodology section, the first phase of this research analyzes the previous literature to find the main delay factors of industrial projects. As a reminder, the main output of this phase is tabulated in Table 1. According to this table, consultants, customers, shortages of raw materials, poor manpower, climate, financial issues and contractors are considered as potential causes of delay in industrial projects. Following, a BWM is applied to prioritize these delay factors as follows. As discussed, the first step of BWM should formulate the problem. Therefore, according to discussed research methodology, the addressed problem aims to prioritize different delay factors of industrial projects. Next, it is essential to determine some criteria to be ranked. In this regard, the delay factors tabulated in Table 1 are investigated to determine their final weight. However, according to BWM, it is necessary to set the best and worst criteria. To do so, the customers and poor manpower have been set as the best and worst criteria, respectively. Saaty's 1-9 scale for AHP (Saaty, 1996) is applied for the aim of comparison as tabulated in Table 2. Table 3 presents the comparison of best criteria with others. Similarly, Table 4 presents the comparison of other criteria with the worst one. Lastly, the final weights of delay factors are tabulated in Table 5 and depicted in Figure 3. According to the obtained results, contractors, consultants, climate, customers, shortages of raw materials, financial issues and poor manpower are the most important delay factors of industrial projects, respectively.

Table 2. Saaty's 1-9 scale

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one over another
5	Strong importance	Experience and judgment strongly favor one over another
7	Very strong importance	Activity is strongly favored and its dominance is demonstrated in practice
9	Absolute importance	Importance of one over another affirmed or the highest possible order
2,4,6,8	Intermediate values	Used to represent compromise between the priorities listed above

Table 3. Comparison of the best criteria with others (best-to-others preference)

Best-to-others	Contractors	Consultants	Customers	Climate	Poor Manpower	Shortages of Raw Materials	Financial Issues
Customers	1	3	4	2	6	5	8

Table 4. Comparison of other criteria with the worst (others-to-worst preference)

Poor Manpower	**Others-to-worst preference**
Contractors	2
Consultants	5
Customers	7
Climate	6
Poor Manpower	1
Shortages of Raw Materials	8
Financial Issues	4

Table 5. Final weights and inconsistency ratio to delay factors

Delay Factor	Contractors	Consultants	Customers	Climate	Poor Manpower	Shortages of Raw Materials	Financial Issues
Weight	0.2799	0.1615	0.1211	0.0377	0.2423	0.0969	0.0606
Inconsistency: 0.20							

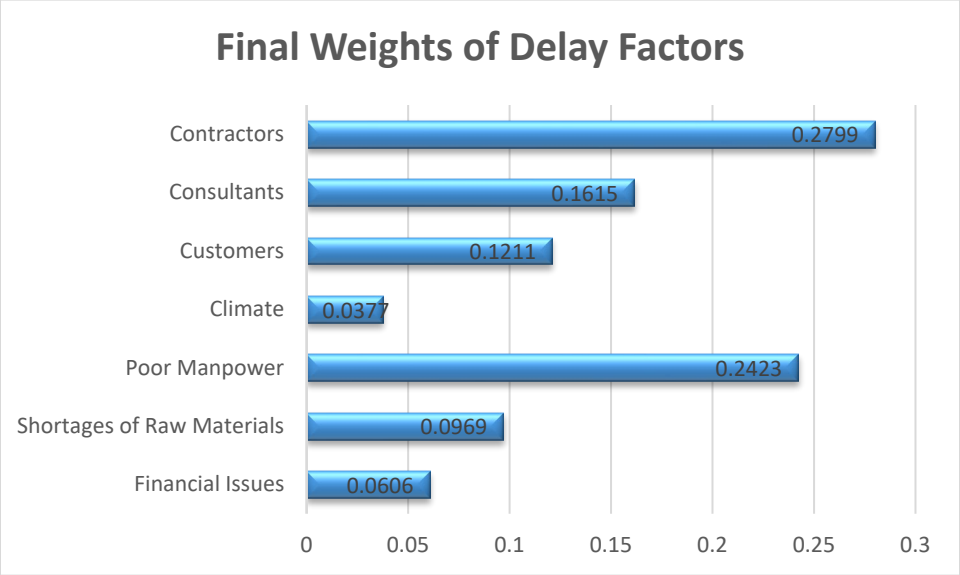

Figure 3. Final weight of delay factors

6. Conclusion

This research proposed a step by step methodology to rank different delay factors of industrial projects. As discussed, potential delay factors of projects, and their related tools and techniques have been vastly investigated in previous literature on construction industry. However, it was necessary to focus on different delay factors of industrial projects as they are less examined in recent literature. Additionally, the problem is not properly and adequately linked with recent MCDM techniques such as BWM. Therefore, with regard to these motivations, this research was completed in two linked phases as follows. The first phase of this study investigated numerous delay factors of industrial projects. To do so, a literature survey was completed to develop different delay factors of industrial projects. Following, a BWM was applied to investigate and prioritize different delay factors of industrial projects. The obtained results showed that contractors, consultants, climate, customers, shortages of raw materials, financial issues and poor manpower are the most important delay factors of industrial projects, respectively. As a direction for future research,

other MCDM and fuzzy MCDM techniques can be applied in a similar research. In addition, the methodology of this research can be repeated in construction or healthcare projects.

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