IMPROVING CONSTRUCTION PROJECT SCHEDULING PERFORMANCE AMID COVID-19 PANDEMIC

LU HAW ZHENG

FACULTY OF BUILT ENVIRONMENT
UIVERSITI MALAYA
KUALA LUMPUR
2022

IMPROVING CONSTRUCTION PROJECT SCHEDULING PERFORMANCE AMID COVID-19 PANDEMIC

LU HAW ZHENG

RESEARCH PROJECT SUBMITTED TO THE FACULTY OF BUILT ENVIRONMENT UNIVERSITY OF MALAYA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF PROJECT MANAGEMENT

FACULTY OF BUILT ENVIRONMENT UNIVERSITI MALAYA KUALA LUMPUR

2022

UNIVERSITY OF MALAYA

ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: Lu Haw Zheng

Matric No: S2013030

Name of Degree: Master of Project Management

Title of Project Paper/Research Report/Dissertation/Thesis ("this Work"):

Improving Construction Project Scheduling Performance Amid Covid-19 Pandemic

Rates Field of Study: Project Schedule Management

I do solemnly and sincerely declare that:

(1) I am the sole author/writer of this Work;
(2) This Work is original;
(3) Any use of any work in which copyright exists was done by way of fair dealing and for permitted purposes and any excerpt or extract from, or reference to or reproduction of any copyright work has been disclosed expressly and sufficiently and the title of the Work and its authorship have been acknowledged in this Work;
(4) I do not have any actual knowledge nor do I ought reasonably to know that the making of this work constitutes an infringement of any copyright Work;
(5) I hereby assign all and every right in the copyright to this Work to the University of Malaya ("UM"), who henceforth shall be owner of the copyright in this Work and that any reproduction or use in any form or by any means whatsoever is prohibited without the written consent of UM having been first had and obtained;
(6) I am fully aware that if in the course of making this Work I have infringed any copyright whether intentionally or otherwise, I may be subject to legal action or any other action as may be determined by UM.

Candidate's Signature   Date: 17 June 2022

Subscribed and solemnly declared before,

Witness's Signature   Date: 18 JULY 2022

Name:

Designation:

IMPROVING CONSTRUCTION PROJECT SCHEDULING PERFORMANCE AMID COVID-19 PANDEMIC

ABSTRACT

Construction projects have been one of the pioneer economic activities in Malaysia ever since the economic transformation in the late 1980s. As part of the project management plan, project schedule management is deemed essential for upkeeping construction projects scheduling performance. The research statement is then established, as there is limited empirical research in dealing with constrained resources in complementing the scheduling performance other than the scientific calculation. Nonetheless, the resources-constrained project scheduling techniques are yet to be researched to confront the shortage of resources unpredictably throughout the pandemic. The aim of this research is to study the construction project scheduling performance issues due to resource constraints amid Covid-19 pandemic crisis in Malaysia. Whereas, the aim is supported by 3 research objectives: to identify the constrained resources in construction projects during Covid-19 pandemic, to analyse the implication of the constrained resources to the construction projects, and finally to propose empirical suggestions to reduce construction project scheduling performance issues in dealing with constrained resources amid Covid-19 pandemic. The study is carried out by applying mixed method approach where 5 site managerial staffs located in Klang Valley are chosen to be involved in the interview. This is followed by a qustionaire survey among architectural coordinators, project managers and senior project managers. Then, the data collected from both questionnaire surveys and interviews were analysed via correlational analysis in 2 phases, perceived and accessed analysis. Findings show that onstrained resources, including time, cost and quality constraints has been identified as the apparent contributors to the project scheduling performance amid the Covid-19 pandemic. A set of empirical suggestions in

reducing project scheduling performance issues in dealing constrained resources. It is anticipated that this study will help the project management practitioners to improve their project schedule management practices and effectiveness. Furthermore, this research also has expended the knowledge on the current project scheduling problems amid the pandemic by identifying new variables and updating context issues related to project schedule management.

Keywords: Construction Project, Project Schedule Management, Project Triple Constraint, Scheduling Performance, Covid-19 Pandemic

IMPROVING CONSTRUCTION PROJECT SCHEDULING PERFORMANCE AMID COVID-19 PANDEMIC

ABSTRAK

Projek pembinaan telah menjadi salah satu aktiviti ekonomi perintis di Malaysia sejak transformasi ekonomi pada akhir 1980-an. Pengurusan jadual projek merupakan sebahagian daripada pelan pengurusan projek dipandang penting untuk projek pembinaan untuk membantu mengenal pasti keberkesanan, kecekapan, dan keberkesanan amalan penjadualan projek berbanding dengan jadual projek yang dirancang. Justeru, pernyataan penyelidikan telahpun diasaskan, bahawa terdapat kajian empirikal yang terhad dalam menangani sumber yang terbatas untuk mengimbangkan prestasi penjadualan selain daripada andaian dan ramalan yang menggunakan pengiraan saintifik jadual projek. Namun begitu, teknik penjadualan projek yang dikekang oleh sumber masih belum dikaji untuk menghadapi kekurangan sumber yang tidak dapat diramalkan sepanjang penularan wabak dalam industri pembinaan. Kajian ini dijalankan untuk mengkaji isu-isu berkaitan dengan prestasi penjadualan projek pembinaan yang dikekang oleh sumber sepanjang krisis penularan wabak Covid-19 di Malaysia. Kajian ini disokong oleh 3 objektif kajian: mengenali kekangan sumber dalam projek pembinaan semasa pandemik Covid-19, menganalisis kesan kekangan sumber kepada projek pembinaan, dan mengusulkan cadangan empirikal untuk meminimakan isu berkaitan dengan prestasi penjadualan project pembinaan yang dikekang oleh sumber sepanjang pandemik Covid-19. Kajian ini dijalankan berdasarkan kaedah pencampuran kualitatif dan kuantitatif yang melibatkan 5 kakitangan pengurusan di tapak pembinaan yang terletak di Lembah Klang untuk terlibat di dalam sesi temuduga. Ini diikuti dengan pengumpulan data secara kajian soal selidik yang melibatkan penyelaras seni bina, pengurus projek dan pengurus kanan projek. Data yang diekstrak daripada kajian selidik dan sesi temubual telah dianalisa dalam 2 fasa,

analisis penganggapan dan analisis pengeksesan. Hasil kajian mendapati kekangan sumber, termasuk kekangan masa, kos dan kualiti telahpun dikenalpastikan sebagai penyumbang tampak kepada prestasi penjadualan projek sepanjang wabak Covid-19. Justeru, satu set cadangan empirikal untuk meminimakan isu berkaitan dengan prestasi penjadualan projek yang dikekang oleh sumber dikemukakan. Adalah diharapkan kajian ini dapat membantu pengurusan projek pembinaan untuk menambah baik amalan pengurusan jadual projek dan keberkesanannya. Selain itu, hasil kajian ini juga telah mengembangkan ilmu, dari segi mengenalpastikan pembolehuban baru dan mengemaskini isu konteks yang berkaitan dalam bidang pengurusan jadual projek.

Kata kunci: Projek Pembinaan, Pengurusan Jadual Projek, Kekangan Utama Projek, Prestasi Penjadualan, Pandemik Covid-19

ACKNOWLEDGEMENT

First and upmost, I would like to express my praises to the God, for his showers of blessing throughout the research in order to complete the research study successfully.

Secondly, I would like to take this opportunity to thank my parents, Lu Ah Kong and Yap Yik Lim, as well as my sister, Reina Lu for their moral and financial supports since my pursuance of my Master's Degree. They are my mental supports for staying days and nights in completing the study despite it has been a exhausted journey for me.

In addition, I would like to express my sincere appreciation to research supervisor, Dr. Nur Mardhiyah binti Aziz, for giving her upmost care and opportunities to expedite my research with invaluable guidance throughout the studies. Her teachings and advices were inspired me in better presenting my research outcomes as comprehensive as possible. It was a great privilege and honour to work and study under her guidance. I am grateful and thankful for her efforts of offering her patience and acceptance throughout the discussion for the preparation of this studies.

Lastly, it is much thankful to Universiti Malaya for giving us the opportunities to conduct the empirical studies in the industries with their tremendous legal and literature supports. To conclude the appreciation, we would also like to express my gratitude to all my friends and family for their cheers and supports for encouraging me in contributing the research for the societal benefits.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

GDP   Gross Domestic Product

HR   Human Resources

LAD   Liquidated Ascertained Damage

PERT   Project Evaluation and Review Technique

PMI   Project Management Institute

RCPSP   Resource-Constrained Project Scheduling Problem

RCPSP-FRP   Resource-Constrained Project Scheduling Problem-Flexible Resource Management

WBS   Work Breakdown Structure

WFH   Work/Working From Home

CHAPTER 1.   INTRODUCTION

1.1   Introduction of the Chapter

This chapter will be going to discuss the background of the research proposal and the issues which are going to lead to research initiation and further justify its importance in this research. In addition, it discusses the research aim, objectives, and methodology before determining the scope of the research. Finally, this chapter will present the background of the thesis by presenting the contents in each chapter.

1.2   Research Background

Construction projects have been one of the pioneer economic activities in Malaysia ever since the economic transformation in the late 1980s. The project scheduling practice is the major element in all construction projects to hand over the project deliverables on time, which is stipulated in the building contract to prevent Liquidated Ascertained Damage (LAD) (Chin, Chai, Chong, Md Yusof, & bt Azmi, 2018). Therefore, as part of the project management plan, project schedule management is deemed essential for construction projects to help identifying the effectiveness, efficiency, and efficacy of the project scheduling practices as compared to the planned project schedules. An effective schedule management plan involves a series of process inclusive project activities definition, activities sequencing and duration estimation, resource allocation, risks identification, monitoring and controlling the process throughout the project lifecycle and development of the project schedule (PMI, 2021). Schedule management planning will be going to be executed in the planning phase of the project (Suresh & Sivakumar, 2019).

Therefore, the presence of the project schedule management is mandatory to execute and enhance the project's operational process (Suresh & Sivakumar, 2019). Project

scheduling provides a detailed plan that represents how the project delivers the products, services and results defined in the project scopes. It further serves as a tool for communication, managing stakeholders' expectations, and as a benchmark in measuring scheduling performance (PMI, 2021). An improper project scheduling or lack of determining the lead time for project scope delivery will lead to project delay, which is further bound to project failure (Doloi, Sawhney, Iyer, & Rentala, 2012). Scheduling management plan helps in time management of each activity defined in the project scope throughout the project phase by providing the facilities of monitoring different tasks in a project (Suresh & Sivakumar, 2019). Also, a project schedule should be remained flexible throughout the project lifecycle to respond to the gained knowledge, gained risk identification and value-added activities along the time subjected to changes be made (PMI, 2021).

In addition, project schedule management will directly determine the project scheduling performance by its effectiveness measures. There are several criteria for measuring the project scheduling performance, such as proper allocation of resources, project manager competencies, project priority, inventory of resources, delivery dates and availability of raw materials and labours (Suresh & Sivakumar, 2019). It helps to evaluate the amount of monetary and resources utilization performance according to the duration of the project to justify whether a project will be on track, ahead or behind the planned schedule (Radzuan, Mohd Nawi, & Mohd Nasir, 2016). According to Zerjav (2015), if the project resources, scope, schedule are not well articulated and assigned despite how well the project schedule is planned, there would be more cost implication as additional efforts or cost to keep the schedule on track. It could be worse if the schedule is delayed and additional cost is implied, it would further hinder the project deliverable quality (Suresh & Sivakumar, 2019).

Implementing schedule management in the construction project will give a significant identity of project scheduling criteria as compared to generic project schedule management. As stated earlier, construction project schedule management will be focusing on the generic triple constraint, which is time, cost, and quality, together with the issues of constrained resources in the construction project (Hassan, Adeleke, Hussain, & D.M, 2019b). However, complex construction projects with lengthy project lifecycle will have additional uncertainties and risks in allocating the resources in time precisely, as both of them would be defined throughout the project lifecycle process (Zerjav, 2015). Therefore, the constrained resource issues in the construction project schedule management are the consequence of the unidentified project activities and scopes. The lack of proper planning on the cost, activities duration and deliverable expectation would lead to inaccurate estimation in the schedule or resource allocation planning. Thus, the aforesaid issue will reflect in the project delay or incompletion of the activities, which determines the underperformance of the project scheduling practice (Hassan, Adeleke, & D.M, 2019a).

The Covid-19 pandemic have further affected the project scheduling performance in the construction project in terms logistics, cost, schedule, project communication and coordination (Mishra & Moktan, 2019). Working from home (WFH) has to be a new norm in practicing social distancing to reduce virus spreads (Bao, Li, Xia, Zhu, Li, & Yang, 2020). However, WFH has a negative impact on the worker's productivity for complex projects (Bao et al., 2020). A construction project requires constant communication and validation on site to precisely observe the schedule progress. Moreover, it also requires iterative site coordination and scope validation to ensure the project scopes are performed as planned. This is necessary to avoid unknown and

uncertainty about the ongoing works on site, as all the staffs are working from home (Gamil & Alhagar, 2020).

According to the studies done by Fernandes (2020), the economic impact of the pandemic of 30 countries has 3-6% fall in their gross domestic product (GDP). It will oppose as a critical risk that GDP drives the growth rate of the real estate and construction sectors. As playing a domino effects, the construction sector has to endure the negative consequences of constraining the available resources on the construction activities, logistic, monetary resources, human resources and project duration as planned (Jallow, Renukappa, & Suresh, 2020). A mitigation plan is demanded to minimize the impact on the construction project performance via proper project scheduling practices (Nanthagopan, Williams, & Page, 2016). Contingency project schedule plan has to be carefully planned and analysed iteratively to deal with unpredictable scenario to respond with the context to uphold the project performance (PMI, 2021).

1.3   Problem Statement

Project schedule management is very important for the construction project to manage resource allocation. It ensures the smooth execution of the project activities according to the project duration without cost or schedule overrun (Suresh & Sivakumar, 2019). According to Hassan (2019), project triple constraint, time, cost and quality are the biggest playing roles in determining the efficiencies of schedule management and planning. As such issues persist, it would severely cause project delays or poor deliverables as shown as poor scheduling performance (Aftab, Sarwar, Sarwar, & Amin, 2016). In India, 951 of projects had been surveilled, 309 projects have cost overruns and 474 projects were behind schedule, as one of the worst nations compared to others of

having the high average schedule overrun (Doloi et al., 2012). On the other hand, in the Malaysian construction industry, 50% of project failure was caused by design issues, 40% was caused by construction faults and 10% was due to material issues (Hassan et al., 2019a). Thus, both statistics from India and Malaysia show the consequences of poor scheduling performance which is due to the improper project scheduling method in managing project triple constraints (Pinha & Ahluwalia, 2019). It is deemed important for the Malaysia construction industry as an increment in the number of project failure would drastically affect the national GDP growth of as much as 6% (Hassan et al., 2019a), especially during the pandemic era which is to compensate the economic loss in overall (Gamil & Alhagar, 2020).

Through series of literature reviews of Villafáñez, Poza, López-Paredes, Pajares and Olmo (2019), Habibi, Barzinpour and Sadjadi (2018) and Lima, Tereso and Faria (2019), several issues have been highlighted regarding the project triple constraints scheduling problem. Villafáñez et al. (2019) and Habibi et al. (2018) have proposed the algorithm method in dealing with resource-constrained project scheduling problem (RCPSP) in a heuristic approach. Whereas Lima et al. (2019) has proposed the RCPSP method with Flexible Resource Management (RCPSP-FRM) with a set of models, algorithms and automated methods. However, both RCPSP algorithm methods could only be applied in the planning stage with accurate and complete information. Industrial practitioners have to plan the schedule by assuming and predicting all the data. The scheduling performance is not merely dependant on the prediction, but how well the scheduling practices to be performed practically to minimize or mitigate all the risks that would affect the project performance in the shortest time (Alsakini, Wikström, & Kiiras, 2004).

Therefore, there is limited empirical research in dealing with constrained resources in complementing the scheduling performance other than the scientific calculation of the project schedule with tremendous assumption and prediction merely on the planning stage. It might be working well if all the assumptions are accurate as planned. However, it might not be subjected to unforeseen circumstances. Nonetheless, resources-constrained project scheduling techniques are yet to be researched to confront the shortage of resources unpredictably throughout the pandemic in the construction industry. During the pandemic, several hypothetical scenarios in the construction project to be tested with iterative core schedule management components to prove their workability with constrained resources concerns agilely (Safapour, Kermanshachi, Habibi, & Shane, 2017). Hassan et al. (2019b) have suggested to perform empirical research on the influence of project triple constraints upon scheduling performance of the construction industry, to broaden the resource-constrained scheduling practices via empirical perspective in contributing to the industry practitioners and researchers. Demirkesen Çakır and Ozorhon (2017) have recommended visualizing the relationship between schedule management practices and project management performance, which would indirectly affect the scheduling performance via framework construction with a spotted-on approach, rather than scientific calculation.

Thus, an empirical resource-constrained scheduling practices is necessary to identify the core scheduling practice components in dealing the project triple resource constraints (time, cost and quality), especially during the pandemic. The proposed scheduling framework will act as a catalyst for the industrial practitioners, which would maintain or increase their project scheduling performance despite hard time in the agile approach. The research outcome will lead the researchers as well in complementing the knowledge of dealing with constraint resources rapidly in uncertain conditions in other industries. The research statement as below:-

1. What are the constrained resources in the construction projects during Covid-19 pandemic?

2. How will the constrained resources be giving implication to the construction projects?

3. How will the project scheduling performance issues be reduced in dealing with constrained resources amid Covid-19 pandemic?

1.4   Research Aim

The aim of this research is to study the construction project scheduling performance issues due to resource constraints amid Covid-19 pandemic crisis in Malaysia.

1.5   Research Objectives

This aim is supported by the following objectives: -

1. To identify the constrained resources in construction projects during Covid-19 pandemic.

2. To analyse the implication of the constrained resources to the construction projects.

3. To propose empirical suggestions to reduce construction project scheduling performance issues in dealing with constrained resources amid Covid-19 pandemic.

1.6   Research Methodology

This research is carried out by applying mixed method approach in obtaining both numeric and non-numeric data from the industrial practitioners of construction sectors in Malaysia. As empirical project scheduling performance measures are deemed subjective

and it might not the same as different project managers have different approaches on scheduling the plan in responding to the resources constrained issues amid Covid-19 pandemic. The research will be conducted as correlational case study, which the researcher knows the variables associated with the problem better. All the correlational variables to be examined are extracted from the referred journals, reference books, e-books, online database, so on and so forth. Then, mixed method is then applied inclusive closed-format survey questionaires and semi-structured interviews with open-ended questions with site managerial staffs of the 5 construction projects out of 3 G7-graded high-rise residential main contractor firms to address the research objectives. 5 of the project teams in different construction projects across Klang Valley area will be interviewed to verify the project schedule management elements to be assessed to improve the project scheduling performance.

Resource-constrained related question will then be verified in accordance to scheduling performance amid the pandemic via interview, in helping to know better on how the project team will handle the project during the pandemic in order to minimize the project risks in causing schedule or cost overrun (Chin et al., 2018). The data gathered from the case study from 5 construction projects will be analysed on 2 phases: perceived variables and accessed variables from the literature review as data sources (Barad & Raz, 2000), in order to capture the correlational relationship between project scheduling practices and scheduling performance benchmarks. All the primary data will be examined via correlational analysis to retrieve statistical evaluation of both perceived and accessed variables. Finally, the analysed data will be critically evaluated based on the literature data sources as secondary data to justify the findings of the case study. The empirical suggestion is then derived from the primary research materials complemented by the literature inputs.

1.7   Scope of Research

This research covers project schedule management over its scheduling performance throughout the construction project lifecycle from project initiating, planning, executing, monitoring and controlling, and eventually project closure phase. Only several large size construction firms in Kuala Lumpur and Selangor, Malaysia will be approached which involves high-rise residential, retails and commodities to best demonstrate the background of the research. This study will be narrowed down to a period of time of Covid-19 pandemic to identify its validity, adaptivity and applicability onto the project scheduling practice of construction project in Malaysia. As there is no empirical research on the resource-constrained project scheduling practice rather than demonstrating generic algorithm, this research will focus on the empirical analysis in real life project schedule management practice, rather than theoretical analysis. As stated earlier, the empirical aspects of the studies are focused via pivotal approach, rather than holistic approach on the theoretical issues.

1.8   Research Contribution

This study will contribute to the construction project management practitioners in their future real time practice in order to improve their project schedule management practices and effectiveness. Therefore, this would help in anticipating the potential risks, proposing necessary mitigation plan and increasing the project scheduling performance. In addition, the aforesaid practice would be able to lead the project to towards success in the recent construction project development despite the project is under condition of having constrained resources in hard time. This research will also be giving implication for researchers and academicians in the future studies, which in response to the current project scheduling problems amid the pandemic by expanding pertinent knowledge,

identifying new variables or updating context issues. This would help in radically resolving the aforesaid issues with empirical data gathered in validating with theoretical frameworks related to the project schedule management knowledge area.

1.9 Structure of Thesis

This research will be arranged via chapters based on the research process of this study. It can be summarized as per described below: -

Chapter 1 – Introduction

This chapter introduces the brief background of the research followed by the summary of the contents of the study. It also determines the research statement, aim and objectives in order to shape the research approach and methodology with complementary of literature inputs in the subsequent topics.

Chapter 2 – Literature Review

This chapter will review the literature materials majoring project schedule management, which is going to be synthesized and analysed for further use under research methodology and data analysis. Several key definitions will be identified and critically described in order to define the area of the research. Research problem will then be formulated via information inputs from literature reviews to be further researched in order to resolve the research objectives.

Chapter 3 – Research Methodology

This chapter will describe the research methodology to be applied in this research. A mixed method qualitative approach of multiple case studies will be used in this study as

it is the best method to identify the validity of the empirical study of the research, as it covers the whole area of the data gathering to ensure the empirical data gathered is accurate and consistent. Data analysis strategy will be explained under this chapter to identify the best way of collecting, synthesizing, summarizing, analysing and interpreting the data to ensure the detailed information gathered are credible to be contributed to the industry practitioners.

Chapter 4 – Data Analysis and Results

This chapter will conduct the research results based on the research methodology proposed in the previous section in accordance to the literature inputs, in order to validate the research gaps with the industry practitioners. The findings of the overall research study will be summarized and concluded to be synthesized with gathering, processing, analysing and presenting in order to validate the coherence of the research statement as to the theoretical data from the literature review and further contribute to the research objectives. Then, all the analyses will be critically evaluated and criticised to produce the best conclusion in accordance to the theoretical inputs from the literatures for future uses.

Chapter 5 – Conclusion

This chapter will conclude this research study with explanation from the research findings and analyses in order to fulfil the research objectives. Then, the recommendations made in reference to the research findings are to be discussed for future research or practitioners' interests, as well as limitation of the research.

1.10   Summary

This chapter discusses the outline of this study by determining the issues within the context which lead to the initiation of the research. It comprised the research aim, research objectives and the brief introduction of the research strategy to be executed to conduct the research. The next chapter will be critically reviewed and discussed of the respective literatures which are in accordance to the research methodology and analysis of this research.

CHAPTER 2. LITERATURE REVIEW

2.1   Introduction

This chapter will be exploring the empirical problem which is having the research potential, as it is unique and mandatory as revealed through series of literature reviews. It reveals the definition of the project schedule management with constrained resource in relation to the project scheduling performance amid the pandemic. It helps to indentify the relevance and validity to the construction sector industries in Malaysia. The definition of the project schedule management, project scheduling performance and resource-constrained project will be discussed by synthesizing the theories to further identify the project scheduling practices and performance with constrained-resource concern in accordance to the Project Management Institute (PMI), guide to project management standard (PMI, 2021). Then, the construction project scheduling practices in Malaysia will be explored by interpreting the generic project schedule management and its scheduling performance specifically.

2.2   The Key Definition

The following sub-section will address the key definitions in relevance to the research, especially the definition of schedule, project schedule management and project scheduling performance as found in current literature in respect with the industry landscape. All these definitions have provided a basis and reference in terms of the subject area while looking for the respective sources of references for this research.

2.2.1   Definition of Schedule

Schedule is a plan of procedure in written format. It is used for a proposed objective, mainly comprised of sequence and time plotted for each item, activity and operation to

be completed in certain amount of time (Larson & Gray, 2017). It is also known as a timetable with series of activities synthesized to be done or occurred during a particular time or period. Usually it is written in detail, in classified or tabular form with explanatory information supported to another document (Heldman, 2015).

2.2.2 Definition of Project Schedule Management

Project schedule management is the process included plan schedule management, define activities, sequence activities, estimate activity durations, develop schedule and control schedule processes required to manage the timely completion of the project (PMI, 2021). This planning process group requires a lot of time and effort in order to enhance the overall project components which how they will deliver the product, services or results in the scope definition (Heldman, 2015). It often serves as a tool to communicate the project progress in relation to resources, time and cost allocation with project stakeholders and their expectation, as a basis of project performance indicator (Larson & Gray, 2017). It helps in deciding the duration and cost of the project activities, as well as risk analysis on the project cost, duration and others in order to produce comprehensive charts with simultaneity of varies project components to accomplish the project goals or objectives with proper performance supervision (Chen, Griffis, Chen, & Chang, 2013). The sub-section below will demonstrate the definition for each process under project schedule management.
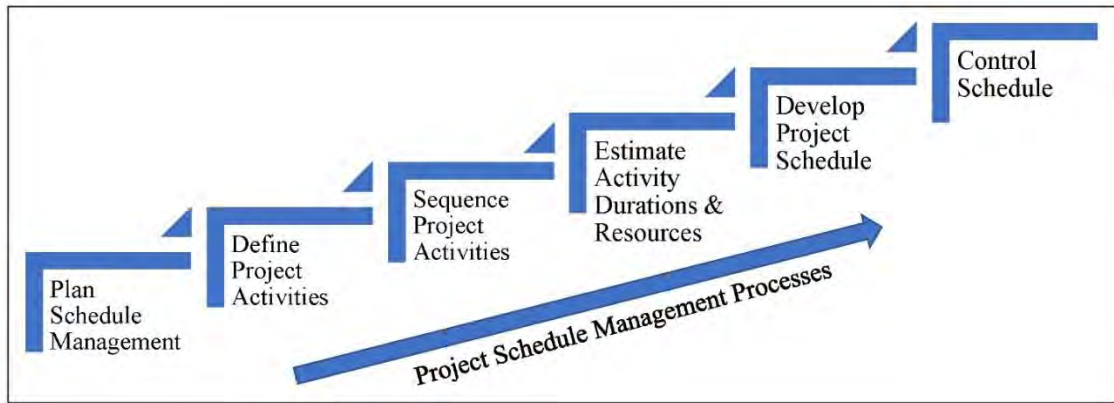
Figure 2.1: Project Schedule Management Processes, PMI (2021)

2.2.2.1 Plan Schedule management

The plan schedule management describes how the schedule will be developed, executed and controlled, as well as incorporating change process in the project components (Heldman, 2015). It serves as a guideline for the project team to direct the project. The input of this process includes the project management plan, project charter, enterprise environmental factors and organizational process assets. The project management plan comprises of Work Breakdown Structure (WBS), which is the key to derive the project schedule on defining the plan schedule management output, developing schedule management plan (PMI, 2021).Several key elements has to take into consideration while forming the schedule management plan such as methodologies of schedule development, accuracy of estimating activity durations and its measuring units, thresholds for the project activities duration and schedule performance measurement.

2.2.2.2 Define Project Activities

Defining project activities will help the project team in identifying and documenting the operation to be performed to produce the project deliverables (PMI, 2021). It decomposes the work packages into the activities to be carried out in the schedule which provide a basis of estimating, scheduling, executing, monitoring and controlling the project work

(Larson & Gray, 2017). Usually, it works together with project scope definition as to clarify the project activities by further breaking down the work package elements of the WBS. All the project activities will be easily identified, assigned, estimated, scheduled and controlled through the usage of WBS which it breaks down the activity processes to the subprojects level by level in comprehensive and detailed manner (Heldman, 2015).

2.2.2.3 Sequence Project Activities

Once the project activities have been defined in details, activity sequencing in logical order manner is deemed important with dependencies exist among the project activities (PMI, 2021). This helps to study the logical relationship amongst the project activities and to be sequenced correctly in order to facilitate the development of the achievable, tangible and reliable project schedule (Heldman, 2015). Several activity sequencing techniques are useful depending on the situation of the project, such as iterative rolling wave planning which helps to constantly define the project activities together with scope, especially for lengthy project possesses unidentified risks and uncertainties. Moreover, it's important to determine dependencies and integration between each project activities in order to create smooth work flows along the schedules, such as activities with predecessor and successor relationships.

2.2.2.4 Estimate Activity Durations and Resources

Apparently, all the projects required resources to be estimated to complete the project in respecting to the predetermined duration. Estimating activity duration helps project team to determine the time taken to complete the said of each project activity to be quantified accordingly (Heldman, 2015). Whereas estimating resources helps the project team to determine how much the resource required to complete the said work packages included

16

people, equipment, supplies, materials and others which is needed by the project to be accomplished. More so, three-point estimating method is generally be used under estimate activity duration and resource process to accurately estimate the duration and resources of the project activities with different approach depending on the scenario (PMI, 2021).

2.2.2.5 Develop Project Schedule

The development of project schedule is the most important part in the planning process group of the project. This is where the schedule is laid with inputs of project activities, estimated activity durations and resources plus their sequencings to determine the start and finish date for each project activities synthesized in the schedule plan (Heldman, 2015). The linked-bar chart diagram to be used in developing the project schedule data in calendar mode, such as Gantt Chart diagram. Through the project schedule, project performance can be observed and several scheduling techniques can be used in responding to the context, such as Critical Path Method (CPM). These scheduling techniques can help the project team to either compress or optimize the schedule performance to achieve intended project objectives.

2.2.2.6 Control Schedule

Once the project schedule has been developed and executed, controlling the schedule process is important to maintain the schedule baseline throughout the project in terms of managing changes of the scopes (PMI, 2021). By constantly monitor and control the schedule, project team will be able to determine the to date actual performance to make sure the project is on track in respecting to the project requirement. Mitigation plan shall

take place via this process should the project team has identified the discrepancies between the project performance with the planned schedule.

2.2.3 Definition of Project Scheduling Performance

Project scheduling performance is defined as a measure of the efficiencies of the project schedule planning of cost versus duration which identifies whether if the project is ahead or behind the planned of the planned schedule in the control schedule process within project schedule management (Heldman, 2015). It can be measured via earned value management and analysis of the project which calculate the deviation of the schedule timeline in accordance to the earned deliverables and cost (PMI, 2021). There are 6 types of analysis will be used in measuring the project scheduling performance, such as earned value analysis, iteration burndown chart, performance review, trend analysis, variance analysis and what-if scenario analysis. Generally, as the earned value below the expected value at that period of time, therefore it will be considered the project as behind the schedule, and further to be labelled as low project scheduling performance. Whereas if the earned value of the project is higher than the planned value in the performance index calculation, therefore the project will be considered as ahead the schedule, known as high project scheduling performance.

Table 2.1: Types of Analysis upon Project Scheduling Performance

Types of Analysis	Description	Source
Earned Value Analysis	To acquire schedule variance (SV) and schedule performance index (SPI) to measure the variation of the schedule versus baseline.	Chen et al. (2013), PMI (2021)
Iteration Burndown Chart	To measure the work in the iteration backlog mode via line chart to forecast the likely trend of work progress towards completion.	PMI (2021)
Performance Review	To survey, compare and analyse the schedule performance versus schedule baseline.	Heldman (2015), PMI (2021)
Trend Analysis	To analyse the work performance over time to justify whether if the project is in lifted up or decline trend.	Larson and Gray (2017)
Variance Analysis	To compare the planned with actual progress of works and determine the float variance for analysing the cause and implication of those variance to be salvaged if required.	Heldman (2015)
What-if Scenario Analysis	To approach various possible scenarios based on the risk assessment outputs to plan for corrective action to align with the plan project schedule.	PMI (2021)

There are many factors which will affect the performance of the project scheduling in the current construction industries, mainly cost and resources allocation over the time ought to be monitored and reviewed (Neves, Borgman, & Heier, 2017). Illustrated in Figure 2.2 are the 5 indicators to analyse the project scheduling performance or known as project success factor as discussed by (Suresh & Sivakumar, 2019).
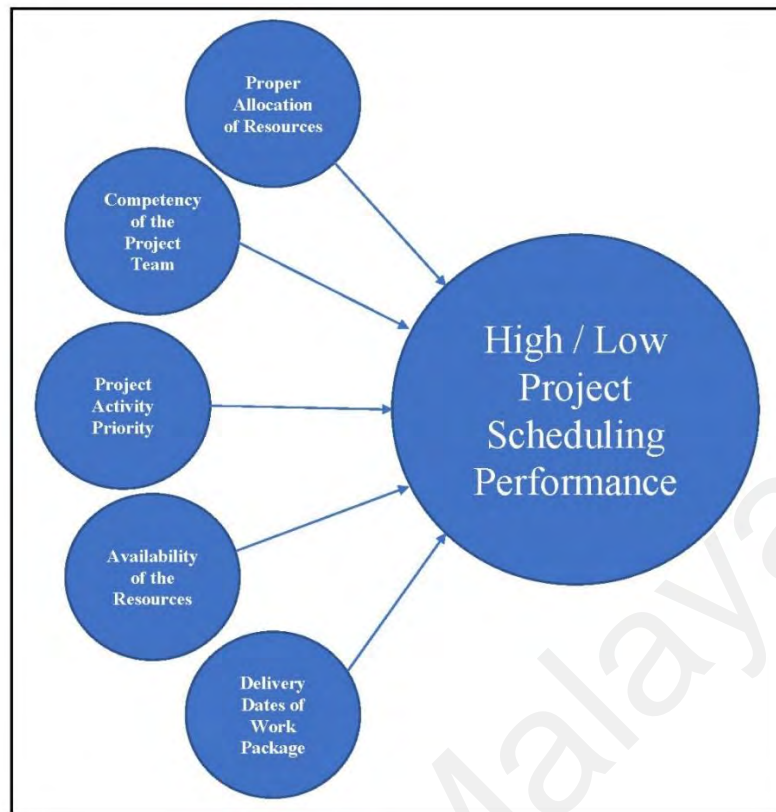
Figure 2.2: Benchmarks of Project Scheduling Performance

Table 2.2: Project Scheduling Performance Benchmarks Description

Benchmarks	Description	Source
Proper Allocation of Resources	The resource or cost allocation is the process of distributing the requisite number of those materials of the work packages inscribed and acknowledged in the project schedule in the planning stage. It is necessary for the project team to measure the resources allocation in order to optimize the usage of the resources in each project activities within the schedule, thus the resources will not go waste. Fix allotment of the resources is not important, somehow some of the activities required lesser resources whereas some of them need the same resources in higher number in later stage of the project.	Bjorvatn and Wald (2018) ,Habibi et al. (2018)

Benchmarks	Description	Source
Competency of the Project Team	Successful development or integration of the project team is mandatory to manage the planned schedule with adequate allocation of the resources to ensure the project works towards success. Scheduling performance might be pulling down if the project team is negatively affected by lack of information sharing and integrating within the project team. Improper project team integration will cause an increase in costs or delay the delivery date of project completion due to lack of planning of resources prior the project execution.	Alsakini et al. (2004), Moura, Carneiro and Diniz (2018)
Project Activity Priority	Project team has to be resilient in prioritizing the project activities in different phases of a project to ensure the activities is able to be executed smoothly and meet the timely completion. Project schedule planning has to be stated in a manner which helps the project team to recognize and access the project activity priorities without jeopardizing the overall schedule plan.	Aftab et al. (2016), Lima et al. (2019)

Benchmarks	Description	Source
Availability of the Resources	Project scheduling planning is very sensitive on the ascertainment of the resources which either owned in the inventories or to be able outsourcing when needed. Scheduling needs to be adaptive in order to respond to the context where the resources required changes in the project work packages depending on the resources availability to ensure smooth execution. If the materials are out of availability or not up to the project standard, then the schedule needs to be prepared accordingly in changing the definition to ensure there are no delays beyond the project activities delivery time.	Chen et al. (2013)
Delivery Dates of Work Package	Project schedule is also depending on the delivery dates of the work packages determined in the schedule as it gives the project team an insight of adhering the deadlines fixed for the completion of the work packages. The project schedule needs to be prepared in advance with comprehensive consideration in order to guarantee the well-time delivery of the work scopes to the project stakeholders. In order to smoothen the project execution phase with delivery date fixed prior project execution, project resources allocation played an important role in reducing the pressure for their demand session throughout the project lifecycle (Suresh & Sivakumar, 2019).	Suresh and Sivakumar (2019)

2.2.4 Accessing Project Scheduling Performance

Project scheduling performance accessment is based on the attainable project deliverables in comparison to the actual resources and cost involved to deliver project scopes throughout the schedule timeline (Castro, Bahli, Barcaui, & Figueiredo, 2020). Projects are often recorded and measured via Gantt Chart with variables of planned timeline, scope commencement and completion in percentage (%), as well as planned and actual durations (PMI, 2021; Suresh & Sivakumar, 2019). This will help the project manager in accessing scheduling performance by reviewing the planned project progress versus actual progress with consideration of the costs and resources involved (Villafáñez et al., 2019). High performance of project scheduling will be resulted in both low schedule and cost variances in earned value analysis as illustrated in Figure 2.2, which has been applying generally in most of the projects. Whereas low project scheduling performance can be observed in high schedule and cost variances, representing either overspending of the project cost, or low project delivery output which would lead to project delays (Alsakini et al., 2004).

$$CV = EV - AC$$
$$SV = EV - PV$$
$$CPI = EV / AC$$
$$SPI = EV / PV$$
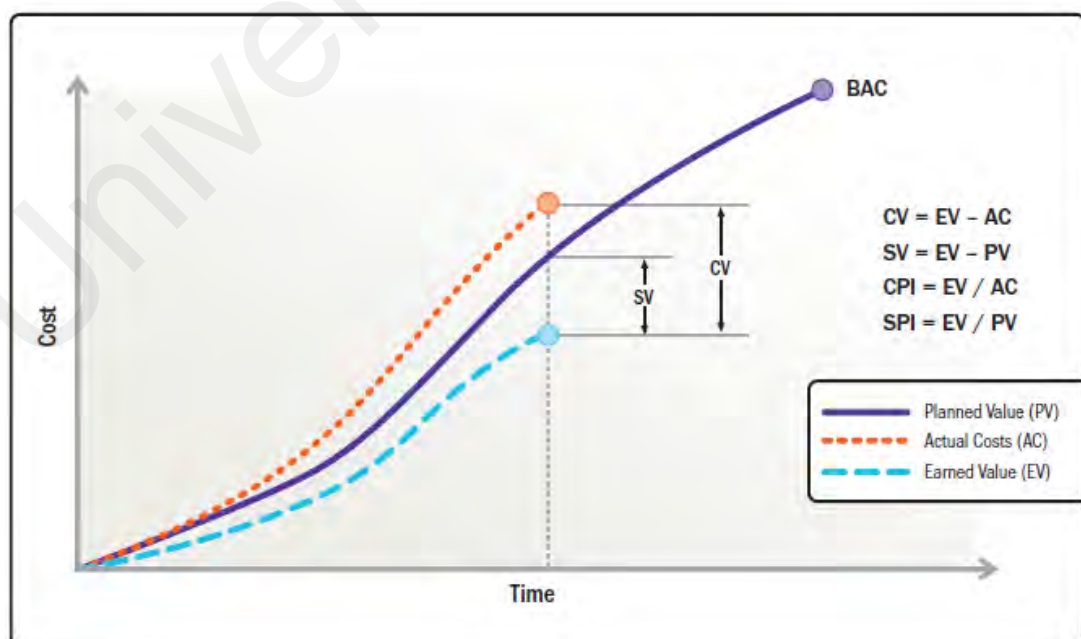
Figure 2.3: Earned Value Analysis Showing Schedule and Cost Variance, PMI (2021)

As for the construction projects, the scheduling performance can often be analysed via the schedule performance analysis with recorded data in the project gantt chart, particularly focusing on the schedule variance (ElZomor, Burke, Parrish, & Gibson, 2018). The recorded earned value in project gantt chart, or known as delivered project scopes will be quantified in percentage, to indicate the overall delivery of the project scopes versus planned deliverables over time (Heldman, 2015). By accessing a total of 2541 construction projects across the world, therefore, Doloi et al. (2012), Hassan et al. (2019a), (Alsakini et al., 2004) and Pinha and Ahluwalia (2019) have concluded that the project scheduling performance can be accessed via schedule variances as tabulated below:-

Table 2.3: Indicator of Project Scheduling Performance Measured by the Schedule Variance in %, Doloi et al. (2012); Hassan et al. (2019a); (Alsakini et al., 2004); Pinha and Ahluwalia (2019)

Schedule Variance	Project Scheduling Performance Indicator	Construction Projects Attempted
5%<	High	343
>5%>10%<	Average	1484
>10%	Low	714

2.2.5   Definition of Resource-constrained Project Scheduling

Resource-constrained project scheduling is referred to the project schedule planning with the consideration of resources level available cannot be exceeded in accordance to the project duration (Larson & Gray, 2017). Resources constraints are often referring to limited availability of the project resources such as people, materials or equipment (Mishra & Moktan, 2019). Human resources are normally classified by the skills and expertise possessed which benefits the projects. If some of the skills are overlapping in the project activities, then it might cause loss of productivity (Ling Florence Yean, Ning,

Chang Yi, & Zhang, 2018). Whereas material or equipment constraints are the project materials which is less in availability and shortages which might cause project delays (Barbalho, Silva, & Toledo, 2017). Materials should be allocated and planned beforehand in order to avoid the hassle demands at the same period of time within the project schedule to ensure the smooth progress of the project activities with adequate resources allocated.

As mentioned earlier, resource-constrained project requires high level of scheduling practices in order to deal with inadequate resources to meet the demands in a peak season which is not possible to source more (Delerue & Sicotte, 2020). In order to resolve or minimize the issues that are ought to cause the project delays, project activities prioritization with reasonable number of resources allocated without exceeding the resources limit in order to minimize the schedule delay. Resource-constrained project scheduling is considered as complex method in planning the schedule as it even consists several project activities with only few resources identified might have several feasible solutions to tackle the schedule planning issues (Pinha & Ahluwalia, 2019). Therefore, the most appropriate approach onto the massive resource-constrained scheduling problem is by applying heuristic approach to resolve the large sophisticated mathematical scheduling issues (Larson & Gray, 2017).

Heuristic approach on the resource-constrained project scheduling is very capable in resolving the discrepancies amongst the project activities with many types of resources possibilities to produce an effective and efficient schedule (Zerjav, 2015). However, it might be a lengthy process to develop several solutions of rules and test them to have the most accurate rules of resources allocation which minimize the delays. Nonetheless, heuristic approach on resource-constrained project scheduling practice is able to help

minimizing the project delay by prioritizing the resources on the critical activities and identifying activities which do not have sufficient resources to work with (Villafáñez et al., 2019). Parallel method works the best with heuristic approach as a process integrating within the initiation phase of the project execution to monitor the resources allocation amongst the project activities (Management, 2012). Figure 2.4 shows the 3 priority rules of parallel method to effectively and efficiently allocate the resource to achieve the best performance of the schedule (Larson & Gray, 2017):-
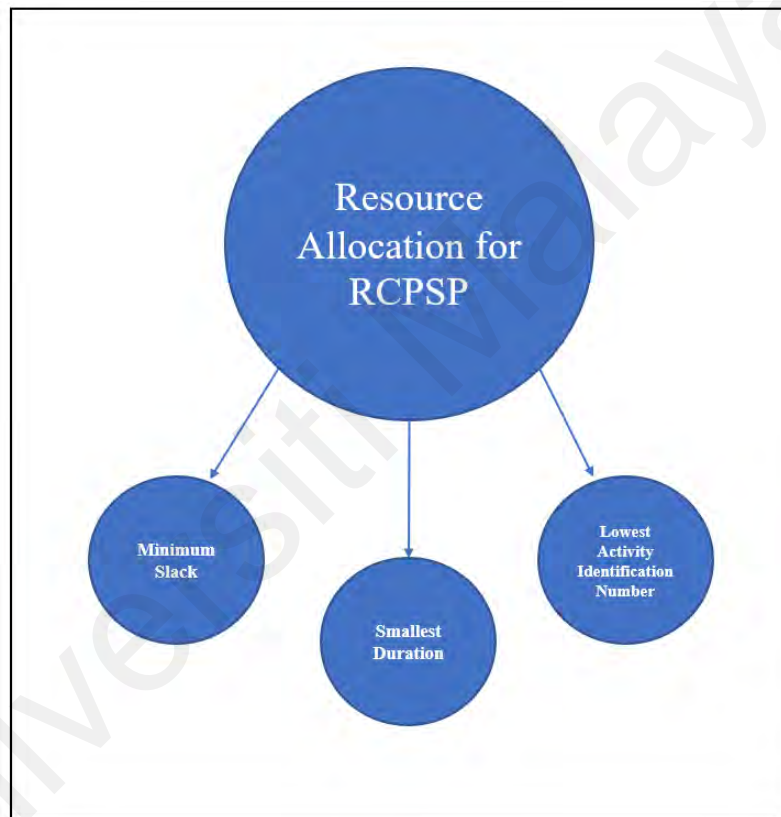
Figure 2.4: Resource Allocation Method for RCPSP

Table 2.4: Resource Allocation Method Description for RCPSP

Types of Method	Description	Source
Minimum Slack	To acquire schedule variance (SV) and schedule performance index (SPI) to measure the variation of the schedule versus baseline.	Larson and Gray (2017), Villafáñez et al. (2019)

Types of Method	Description	Source
Smallest Duration	To measure the work in the iteration backlog mode via line chart to forecast the likely trend of work progress towards completion.	Larson and Gray (2017), Villafáñez et al. (2019)
Lowest Activity Identification Number	To survey, compare and analyse the schedule performance versus schedule baseline.	

2.2.6   Key Definition

Based on all the definitions stated above, the fundamentals of project scheduling practices with constrained resources are generally defined. These serve as a set of techniques or methods for guiding and correcting the project management team in scheduling the projects to achieve better project scheduling performance in terms of cost, resources and time management (Mohammady & Gibson, 2020). This includes the process of identifying project schedule management practice which affect the scheduling performance in respecting to the constrained resources concern. Thus, resources-constrained project scheduling practice must be studied by the construction practitioners in order to be literately handling the scheduling issues in order to avoid the project delay or resources overrun, which would bound to project failure. The main objective of the practice is to generate empirical information in supporting project schedule planning process, with being adaptive to the situation of having constrained resources and smartly mitigate the issues via refined project scheduling techniques.

2.3 Triple Constraints of Construction Project

Project triple constraints, often referred to a construction project with 3 major resource variables:- time, cost and quality (Barbalho et al., 2017) as llustrated in Figure 2.4. These 3 variables, which might affect the project operation and success throughout the project execution. Considering these 3 factors is deemed important in decision making and evaluation for the construction projects to execute the schedule planning effectively. This is because most the failed projects are mostly caused by delay in time, cost overrun and quality discrepancies (Hassan et al., 2019a). Moreover, without a carefully consideration or analysis of the triple constraint in planning the resource allocation, it might cause the project scheduling performance decreased drastically over the time, and eventually bound to failure (Banihashemi, Hosseini, Golizadeh, & Sankaran, 2017).

As the 3 variables work out in a whole, they are all correlated in terms of influencing construction project success (Doloi et al., 2012). The schedule of the project is dependable on the allocated time, the period of the project schedule might be lengthened if the work package of the projects is not properly scheduled and caused delay. The primary concern for the construction project is always be meeting the deadline of the deliverables, as the longer the work progress, the greater the cost incurred to accomplish the deliverables on time (Delerue & Sicotte, 2020). Meanwhile, quality management is one of the crucial practices in construction projects, as it aids to reduce unnecessary cost incurred for cost for non-conformance and control all the project activities (PMI, 2021). Therefore, project triple constraints help to identify the optimal resource required in order to execute the work packages of the construction projects, which would significantly improve the scheduling performance of the project.
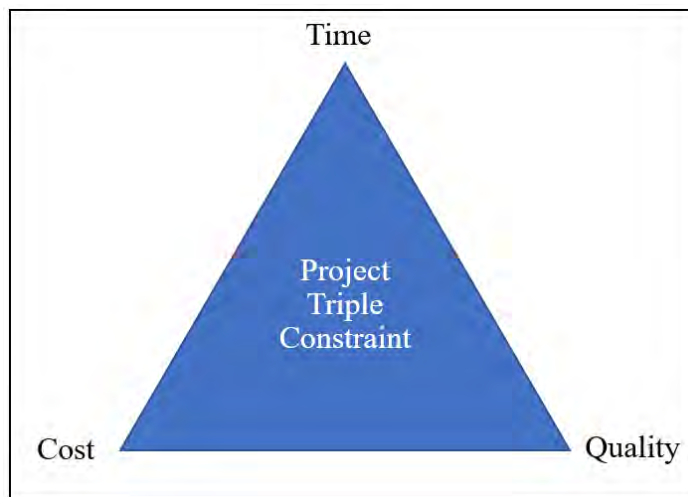
Figure 2.5: Project Triple Constraint, Hassan et al. (2019a)

2.4 Constrained Resources in Construction Project

Construction project in Malaysia has been suffering underperformance of the project scheduling according to the study by Hassan et al. (2019b). Construction project is always concerning about the triple constraints such as time, cost and quality (Barbalho et al., 2017) as they are the main 3 factors which controlling the overall schedule performance for a construction project. Thus, project manager has to comprehensively managing these 3 aspects in managing the construction project which they are determining the success or failure of the project (Suresh & Sivakumar, 2019). However, ineffective construction project schedule management of the construction project may imply negative impacts towards the intended project objectives.

Thus, there are some factors should project managers to take into consideration while planning the schedule for the construction projects. Firstly, work packages of the project should be clearly defined prior developing the working schedule, as it will justify the amount of resources to be allocated and duration to complete the job scopes, and directly affect the overall duration of the project (Pinha & Ahluwalia, 2019). Next, the economical and environmental factors should be taking into account in planning the schedule.

Economic downturn will affect the process of the project capital allocation, such there is insufficient cash flow for the construction companies to run the construction (Ogunde, Olaolu, Afolabi, Owolabi, & Ojelabi, 2017). Normally, construction projects are exposed to the extreme weather in Malaysia. Bad weather could affect the scheduling performance as well. Construction workers are not able to conduct their works under the bad weather such as raining, therefore it will adversely affect the project timeline in the schedule plan (Hassan et al., 2019a). The common constrained resources are summarized in the table as below: -

Table 2.5: Constrained Resources of Construction Project

Types of Constrained Resources	Constraint Variables	Description	Source
Time	Communication	Communication breakdown amongst project members.	Pollack and Matous (2019), Trach and Bushuyev (2020)
	Design Development	Drawings/design solution is not on time delivered.	Dinis, Sanhudo, Martins and Ramos (2020)
	Environmental Factors	Extreme weather condition or soil condition.	Doloi et al. (2012)
	Logistic	Immigration restriction or logistic shortage.	Sriyakul, Umam and Jermsittiparsert (2019)
	Political Factors	Political uncertainty or restrictions.	(Hassan et al., 2019a)

Types of Constrained Resources	Constraint Variables	Description	Source
Time	Site Coordination	Unrealistic schedule planned, poor decision making, lack of commitment.	Demirkesen Çakır and Ozorhon (2017), Doloi et al. (2012)
Cost	Economic Factors	Economic downturn or uncertainties.	Fernandes (2020), Deng, Li and Quigley (2012)
	Material Availability	Construction materials Shortage, which would lead to cost increment due to in surge of demands.	Lima et al. (2019)
	Technical knowledge & Machineries	Machineries, spare parts availability & technical specialists.	Doloi et al. (2012)
Quality	Scope Clarification	Discrepancies of scope requirements for work packages.	Collins, Parrish and Gibson (2017)
	Human Resource	Capability of workers and managerial staffs.	Ling Florence Yean et al. (2018), Aftab et al. (2016)
	Material Storage	Improper or insufficient storage for construction materials lead to damage.	Ogunde et al. (2017), Doloi et al. (2012)

However, there is lack of project schedule management practices and awareness in focusing on the project scheduling performance in Malaysia construction sector. Most of the companies would only be focusing on the profit made from the project but the core solutions of effectively reducing the cost or resource overrun through project scheduling practice. The core factor of affecting the profit gained by the construction companies is the effective project schedule planned as it helps to identify the excess cost should not be spent or wasted throughout the project duration. The additional profit might be made from the saved cost or resources resulted in excellent scheduling performance (Chen et al., 2013). Construction project has always been having compacted working schedule in Malaysia as due to major concern of budget saving. Limited resources schedule usually increase the time slack of the work packages, thus reduce the flexibility of changes in scope or resource allocation to further minimize the project delay (Larson & Gray, 2017). Scheduling difficulties is increased as resource constraints might limit the change flexibility, thus schedule compression occurs in order to facilitate the limited resources upon planned work package in order not to affect the project schedule and delivery time.

2.5   Project Scheduling Practices in Construction Project

Project scheduling has been mandatory practices in construction projects worldwide in order to improve the project success rate (Aftab et al., 2016). It helps project managers in planning the schedule by predefining and optimize scheduling objectives while addressing series of limitation, such as precedence relation of the project activities, resource constraints and temporary restriction according to Villafáñez et al. (2019). Scheduling practices in construction projects has been carried out since 1950s with methods of Program Evaluation and Review Technique (PERT) and modern algorithms calculation (PMI, 2021). However, these methods have to assume all the required resources by activities must be available on their execution, certainly considered as

32

unrealistic and inaccurate (Villafáñez et al., 2019). This is because all the resources within a construction projects are to be shared between several activities as observed (Alsakini et al., 2004). Thus, a series of empirical project scheduling practices to be summarized, which has been practicing to schedule for the construction projects across the world as below: -

Table 2.6: Empirical Project Scheduling Practices in Construction Project

Types of Scheduling Practices	Description	Source
Critical Path Method	To analyse the longest activity path which determines the shortest duration for the project to determine the schedule or resource flexibility.	Larson and Gray (2017), PMI (2021), Heldman (2015), Alsakini et al. (2004), Lima et al. (2019)
Resource Levelling	To adjust the project activity start and finish dates based on the resource availability to balance the demand for resources.	
Resource Smoothing	To adjust the project activities resource requirement depends on the perquisites resource limits.	
Schedule Crashing	To shorten the project schedule duration by adding resources with certain amount of cost increment.	Larson and Gray (2017), PMI (2021), Heldman (2015), Alsakini et al. (2004), Lima et al. (2019)
Schedule Fast Tracking	To compress the project activities to be performed in parallel mode with portions of activities overlapped throughout the schedule with risk possessed.	
Agile Release Planning	To provide iterative analysis of the project activity schedule to determine the resources to be allocated based on the project milestones or goals.	

2.6   Impact of Covid-19 Pandemic over Construction Project Scheduling Performance

Covid-19 pandemic may give the deconstructive impact towards the construction project in Malaysia. As due to travel ban and social distancing, it might further burden the resource allocation to the work packages with the project schedule, for instance the goods and materials are not be able to send to the construction site (Lima et al., 2019). The project schedule would suffer from the tight resource allocation, which is inscribed in the resource-constrained scheduling problem (Zerjav, 2015). Delays in project schedule plan is anticipated as due to lack of resources allocated as the result from the travel ban. The supply chain of the construction sector is thoughtfully affected by the travel restriction. Thus, the project team in current construction projects is yet to figure out the contingency scheduling method in order to deal with the pandemic situation, as to further minimize the project delays away from the intended schedule (Gamil & Alhagar, 2020). The best way to mitigate the situation is by identifying critical viable suppliers, consider legal and financial implications, communicating with the stakeholders in advance, conducting scenario analysis, and eventually create a contingency plan (Jallow et al., 2020). However, it is yet to be verified and implemented in the real scenario yet.

2.7   Summary

This chapter explored the project schedule management area in aiding the exploration of the current issues of the project scheduling practices in Malaysia Construction Project. The definition of the schedule management and its performance indicates gaps between the schedule management practices and scheduling performance of the project with resources constrained concern amid Covid-19 pandemic. Therefore, research gaps have been highlighted pertaining the scheduling issues of construction project to be researched

empirically in order to prove the theoretical approach is parallel with the empirical inputs from the current practitioners.

CHAPTER 3. RESEARCH METHODOLOGY

3.1   Introduction

This chapter will be discussed on the methodology approached used in conducting this research. Research methodology will be designed under a plan of how the research will be conducted with methods to obtain the data in order to address the research objectives.

3.2   Research Design

This research will be carried out on a perceived and assessed variable basis. All the literature materials are prior studied and critically analysed to better understand the root idea of the research. There will be several similar construction project case studies to support the requirement of study, which is to gain the empirical data without relying on single input source. In order to identify whether the study-to-be construction projects are in high or low scheduling performances, several scheduling performance benchmarks are identified via literature readings, synthesis and accessed to be the accessed variables for the research. It is important to have the benchmark indicator variables as this information will clearly justify whether a construction project is planned in manner and therefore reflects in their respective scheduling performance outcome. Despite that, scheduling practices are the fundamental inputs from literature to be the perceived variables in order to measure its effectiveness against the accessed variables.

By assessing both variables via correlational study, researcher will be able to identify which perceived variables, which is project scheduling practices are mostly affecting the scheduling performance on the first round of assessment. Then, the accessed perceived data are to be further investigated via validating the scheduling performance benchmarks to find out their correlational relationship, which will help the researcher to identify which

variables are the key factors of driving the construction project scheduling performance amid the pandemic critically. The accessed variables are then to be carefully validated with secondary data sources, known as literature inputs to further discuss their factors of occurrence and their implication towards the construction projects in current time. Series of empirical suggestion are to be proposed based on the accessed data with real time circumstances with complementary of other researchers input and literature sources.
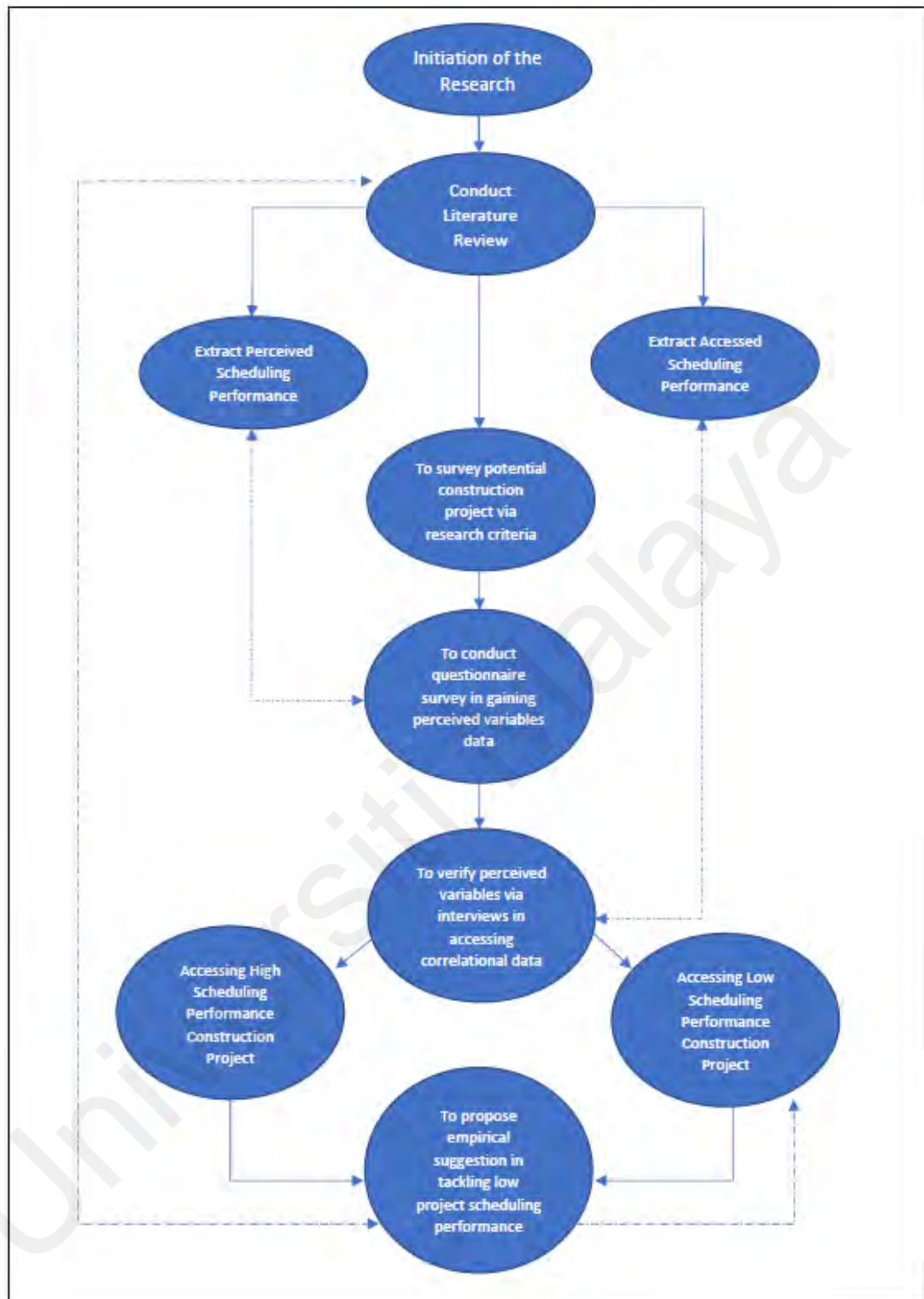
Figure 3.1: Research Design Approach

3.3   Research Approach

This research will be conducted via numeral method of research approaches in order to collect behavioural data of project scheduling practices from the industry practitioners in holistic manner. Correlational case study is carried out in explanatory mode in order to retrieve the perceived and assessed scheduling performance and practice variables with correlational relationship involved (Pinha & Ahluwalia, 2019).   The variables are identified in the literature review will then be testified as the database in the real time practices with the all the respective site managerial personnel in the construction projects.

3.3.1   Mixed-Method Approach

In order to testify the perceived and accessed variables, mixed method approaches is applied in the research study. It will work the best to quantify all the primary data based on the literature inputs from the industrial practitioners (Hassan et al., 2019a). Moreover, it is best as well to collect the primary data which is "in context" and factual, where all the data inputs are deemed to be subjective depends on the cases via ground studies in the indsutry. In this research, scheduling practices might vary across the construction projects as due to uncertain variables and factors over time, thus it would be suitable to retrieve or understand their real time scheduling practices via mixed-method approach. To be specific, correlational case study will be conducted to study the scheduling perceived and accessed variables. The researcher and the project members from the construction sector are jointly involved in the interviews supported by questionnaire survey inputs to deal with the current scheduling problem of the construction project in addressing the research purpose, and to close the gap between researchers and practitioners (Doloi et al., 2012). This seems to be an appropriate approach to apply the findings of this research in a later study. The advantage of the mixed method would suit researcher well as researcher has more available time to conduct the surveys without full time commitment except face-to-

face interview session as compared to action research, which would require higher commitment to conduct several times of workshops with interviewees to gather the information. In addition, the time needed to invest in an action research is not possible within a part-time study for the researcher. However, at this explorative stage, different projects should be examined to get a better understanding of the researched phenomenon.

3.3.2 Closed-Format Question

Closed-format question is whereas a type of questionnaire with pre-structured choice of answers to be selected by the respondents with the perceived variables: empirical project scheduling practices in accordance to the constrained resources of contruction projects.. This would help researcher in retrieving the responses in the shortest period of time, as there would be no lengthy but straight forward inputs from the respondents. However, closed-format question would have limited range of possible answers as respondents would not be able to contribute extra ideas towards the findings. For instance, the project scheduling practices might be falsely identified in dealing with contrained resources as due to rigidity of the literature theories without precedented scenarios of the pandemic. Thus, interview is demanded to further access the perceived variables extracted from the questionnaire for correlational analysis.

3.3.3 Semi-Structured Interview

A semi-structured interview comprised of elements of both open-ended and fixed questions with fixed-choice open responses to the interviewees to answer. Fixed questions such as accessed variables: benchmarking project scheduling performance based on the perceived data extracted from the questionnaire survey to be analysied based on the response accumulated via the interview sessions. The interviews were carried out through

online conference calls via Google Meet, as due to Covid-19 SOP, as well as targeted company's regulation of no visitors are allowed during the pandemic. Researcher will not only be overflooded with unnecessary information but in gaining all the primary empirical data in depth and order manners to further analyse the perceived variables which are contributing to the high or low project scheduling performance in the respective case study.

3.3.4 Literature Material Assessment

The literature reviews which supported the research findings are conducted via online reading database, e-books, journal books and open sources. All the reading materials are carefully selected based on the research background, suitability of the contexts (local and overseas), related research paper topics, knowledge areas, keywords and background of the journals, such as Journal of Project Management is deemed preferred. All the referred journals are extracted from the accredited journal databases such as Scopus, Science Direct, Elsevier, Google Scholar and other academic databases. The purpose of the researching literature materials is to find out what are the readily knowledge areas relating to the scheduling performance and practices. Besides that, it can be served as secondary source of data to validate all the findings from the primary research where to ensure all the acquired data input are relevant to the research knowledge area.

3.4 Data Collection

3.4.1 Unit of Analyses

The study will be focusing on the identification of constrained resources which would be contributing to the construction project scheduling performance. Hence, a total of five (5) high-rise residential construction projects in Klang Valley, which representing pioneer

construction projects in Malaysia was sampled for the study, to ensure the reliability of the research outcome. One (1) representative will be selected from respective construction project organization, a total of five (5) key persons will be involved in the case study. The selected key persons must play an important role in managing the project scheduling-related matters, such as project managers, architectural coordinators and site supervisors, as they would have better insights and commitment in dealing the project constraint throughout the project phase in committing the planned project schedule. The data will be collected via one-to-one interview with each selected representative from all the selected construction project, supported by the survey questionaires.

3.4.2 Selection of Case Study Project

The selection of case study construction projects is evaluated based on the research criteria set by the researcher to best suit the research requirements, such as type, scale and resources involved of the construction projects. In order to have more comparative results, the selection of the case study is preferred to have 10 similar of complex construction projects to have adequate depth of study. With massive development in Klang Valley occurred recently, it would be better to pick the construction projects targeting high-rise residentials. Withthe turnover of each high-rise residential projects were average around 200-400 million, serving as the pioneer in the construction industry within the state.

To best evaluate the scheduling performance of the construction project, complex construction projects are preferred as the enormous scale, resources and project management practices are complex enough to get sufficient input to contribute into the research. According to CIDB (2020), G7 contractor firms are preferred as the project scale with turnover of RM200 million and above, whereas G6 and below are not more

than 10 million turnover, thus it might not be suitable for the study. However, due to the Covid-19 SOP restriction, only five (5) construction companies out of ten (10) agreed to participate in the study. The criteria of case study project selection are summarized as below for the study.

a) Listed as G7-graded construction companies by CIDB;

b) Execellent track record of high-rise residential project delivery;

c) Experienced companies in constructing high-rise residential buildings above 8 years;

d) Construction companies which are having on-going high-rise residential projects during the pandemic;

e) On-going high-rise residential projects within Klang Valley area.

3.4.3 Data Collection

The primary data will be collected based on the research variables extracted via literature review. The perceived data collection will be carried out firstly to gain the perceived variables to identify the correlation materials and access the scheduling performance. Whereas, online interviews will be commenced with selected key person-in-charge of respective high-rise residential projects with a week interval between each project. Semi-structured interviews will be applied to gain information which is not restricted with limited in fix order. Semi-structured interview helps the researcher in gaining the open response from the interviewees while selection of the response is still available in order to be easily controlled the interview session. The consistency of the data collected is assured via this method while open-ended response is expected to be gathered as well to ensure the reliability of the accessed data. Thus, this approach provides enough flexibility to adapt to the interviewee's context and to gain new insights other than theoretical contexts which derived from the conversation and to keep control over the time

management. Hypothetical questions will be applied to visualize the implication of pandemic towards project scheduling performance. Thus, they are able to give responses critically regarding the scheduling practices in the situation.

Moreover, face-to-face interviews provide the advantage of verbal communication. Thus, for this research, interviews were conducted face-to-face which is the preferred interview mode for gaining for valid information and their interests in responding the questions. Other than that, telephone interviews will also be fine to conduct the interviews should the participants are not available for face-to-face interview. However, as remote interviewing offers more flexibility in answering the questions, which the responses might not be accurate It also bears the risk that participants feel less committed, thus the desired information would be hard to gather on line.

Despite that, there are several challenges needed to overcome while in the interview process, such as obtaining trust, awareness of social interaction, getting access, location of the interviews and recording of the interviews (Mohammady & Gibson, 2020). For this research, trust is going to be built through the full transparency at each stage of the interview process for the interviewee about the background of the research and the researcher, why and how the interviewee has been selected, about the usage of the anonymised data, and the right for the participant to withdraw at any time. In addition, before the interview started, some information about the aims of the study, the interview, the position of the interviewee and some information about the interviewee's professional environment are shared among others. This helped the interviewer to obtain trust and to put self in the context throughout the interviews. The place and the time for the interview,

whether the interview might be recorded and what happens to the data was explained and clarified beforehand.

The closed-format questions comprised of 2 sections. Section A comprised of personnel background in the industry, such as experiences of services, or educational background. Followed by the Section B of multiple choice questions of empirical project scheduling practices in addressing RCPSP. After the questionaires are collected, the data will be extracted for accessing the empirical data via online interviews. The online interview consisted of 5 open-ended questions of project scheduling performance benchmarks with the perceived inputs from questionnaire surveys. Selected key persons representing each of their respective construction project are summarized in Table 3.1:-

Table 3.1: Summary of Interviewees Information from 5 Construction Projects

Projects	Representative Position in the Organization	Work Experience in their Respective Field	Educational Background
Project A	Architectural Coordinator	4 Years	Architecture
Project B	Project Manager	4 Years	Civil Engineering
Project C	Assistant Project Manager	6 Years	Civil Engineering
Project D	Senior Project Manager	12 Years	Civil Engineering
Project E	Project Manager	2 Years	Architecture

Each session will be held of about an hour to interact with the interviewees in accumulating the empirical data for each construction project. In order to validate the reliability of the accessed variables, literature reviews, project progress reports, financial statements and other relevant documents are reviewed with the limited given consent by the respective PICs. As the perceived and accessed data were accumulated through the literature reviews, the collection of both perceived and accessed data took around four (4) months to complete.

3.4.4 Case Study Protocol

Correlational case study is vital to increase the feasilibity and validity of the case study and as the baseline for the researcher to carry out the research study. Chen et al. (2013); Liu, van Nederveen and Hertogh (2017) highlighted 4 key elements of case study protocol as below:-

a)   Case study Introduction and Protocol Purposes

The framework of the study to be set up comprising the inputs from the literature review in Chapter 2, and current issues that shall be verified involving the questions and its implication for the case study.

b)   Methods of Data Collection

i.   Selection of case study location, key personnel to get in touch, and access to the companies;

ii.   Prepared methodology of data collection such as expected result, issues to be covered, and items to be observed throughout the data collection.

c)   Framework of the Case Study Report

The case study report is suggested to have the correlational access to the issues arise in each contruction project, the reviewed scheduling performance to date, recommendation of the practices, and references to the relevant documents.

d)   Questions of the Case Study

The questionaires described the details of each projects, the goals, objectives and resource-constrained issues. The questions shall be constructed based on these protocols, as well as 2 research objectives to be addressed, including identification of constrained resources and its implication towards construction project scheduling performance. The overall questions shall be starting from definition and design stages, followed by preface, collection and data analysis, and lastly conclude the research.

3.4.5   Data Analysis

From the mixed method studies by Zeerjav (2015), the information surveyed will be considered as perceived data to be accessed via correlational study via the interviews with all the key PICs of the construction projects in defining the factors affecting the scheduling performance. This might be helpful to quantify the empirical findings through the interview in hybrid way. Content analysis is an intuitive and open approach to analysing data, e.g. text, which might start by imposing external structures, based on ideas or concepts derived from the research questions or from the data themselves (Zerjav, 2015). All the variable data are to be accessed and analysed via correlational grouping, ranking and identification, to accurately highlight the key variations of the data to attribute the correlational studies and determine the project scheduling performance.

3.5   Summary

This chapter explored how the research to be conducted in sequential manner. In order to successfully conduct the research, several case study protocols have to be highlighted beforehand. The procedure of data collection shall be carefully executed to ensure the data obtained are reliable for the analysis and favourable results.

CHAPTER 4. DATA ANALYSIS AND DISCUSSION

4.1   Introduction

This chapter will be presenting the analyses of the data through questionnaire surveys and online interviews with each key person-in-charge of five (5) similar high-rise residential projects. All of the selected interviewees were responsive and completed the participation in the study. However, due to the company disclose policies, all the data collected will be presented anonymously with the references to as Project A, Project B, Project C, Project D and Project E. After the synthesis of the collected data, the result is generated through the correlational studies of empirical scheduling performance in accordance to the associated constraint resources during the pandemic, as well as scheduling performance benchmarking. This will help in generating empirical solution in reducing constraint resources project scheduling problem arise amid the pandemic with implication addressed.

4.2   Background of The Case Study

The data collection conducted in 2 stages: the questionnaire survey conducted firstly to obtain perceived variables via the supporting references from the literature review, then followed by the online interviews to obtain accessed variables to identify the scheduling performance of each project. Each session required the basic information from the interviewees such as project background, status of the project related to the schedules, and the issues arise amid the pandemic.

4.2.1   Project A

A senior architectural coordinator with 4 years of working experience was interviewed for the Project A with the educational background of Bachelor of Science in Architecture. The project is a high-rise housing development started in July 2018 with total of 447

residential units within the land of 1.4 acres. The project was awarded with the contract value of RM 238,500,000.00. The project was currently in the architectural trade stage while the interview was conducted, which is 6 month before the project handover as stipulated in the contract. The architectural trades including wall painting works, doors and windows installation and sanitary ware installation are carried out duing the pandemic.

The project was accessed as high project scheduling performance, as the resources allocated such as funding reports, materials delivered to site, allocation of human labours are in positive figures shown in the project progress reports. This was due to the managerial team of the construction site with competent and experienced management practices brought ahead the project schedule from the planned milestone. The impacts of the Covid-19 pandemic were minimized, as the critical path of the project required heavily allocated resources were completed just before the national lockdown in March 2020. Thus, even though the project was dragged slightly due to suspension of work during the lockdown period, the project was still on track with the progressed scope of architectural trades delivered creating the buffer for the project schedule towards the delivery date. Table 4.1 shows the results of questionare survey, as well as interview outcomes consisted of perceived variables of scheduling practices applied in the project.

Table 4.1: Perceived Variable Generated in Project A

Empirical Project Scheduling Practices	Constrained Resources Associated with the Scheduling Practices	Project A
Critical Path Method	Time	√
Resource Levelling	Cost	√
Resource Smoothing	Quality	√
Schedule Crashing	Time	None
Schedule Fast Tracking	Quality	√
Agile Release Planning	Cost	√

4.2.2 Project B

Project B is managed by an experienced project manager with the educational background of Civil Engineering. This project is a high-rise residential tower launched in March 2019 with total of 220 luxury residential units within the land of 2.25 acres. The project was awarded with the contract value of RM 304,000,000.00. The project was currently in the structural erection stage up to facility floor. Despite the project was commenced succefully, the project in in low project scheduling performance due to adverse delays occurred during the pandemic lockdown with short of human labours. This was due to isolation of workers with the outbreaks in the worker dormitory in the site. The project managerial team has proposed to salvage the project from the delays through sourcing additional human labours from another construction site, to alleviate the suffers from the slow construction progress. Table 4.2 shows the project scheduling practices applied in the project salvagement from the delays of total 89 days, despite the EOT was granted.

Table 4.2: Perceived Variable Generated in Project B

Empirical Project Scheduling Practices	Constrained Resources Associated with the Scheduling Practices	Project B
Critical Path Method	Time	None
Resource Levelling	Cost	√
Resource Smoothing	Quality	None
Schedule Crashing	Time	√
Schedule Fast Tracking	Quality	None
Agile Release Planning	Cost	None

4.2.3 Project C

Meanwhile, Project C is taken care by an assistant project manager with the educational background of Bachelor of Civil Engineering. This project is a joint-ventured high-rise residential project launched in January 2019 with total of 537 government housing scheme units, known as the largest government housing development in Kuala Lumpur. The project was launched with the contract value of RM 233,000,000.00 with the subsidies from the government. The project was currently in the structural erection stage up to level 13. The project was accessed in average project scheduling performance, as the management of the construction site was unstable due to short of site supervising staffs, including site engineers, technical coordinators and machinery operators. In addition, the shortfall of material supplies, such as rebar reinforcement due to inport restriction and cost increment, significantly delayed the civil structure erection and thus, the project was in sluggish progress until the loosen Covd-19 SOP in May 2020. Table 4.3 illustrates the project scheduling practices adopted in Project C.

Table 4.3: Perceived Variable Generated in Project C

Empirical Project Scheduling Practices	Constrained Resources Associated with the Scheduling Practices	Project C
Critical Path Method	Time	√
Resource Levelling	Cost	√
Resource Smoothing	Quality	None
Schedule Crashing	Time	None
Schedule Fast Tracking	Quality	None
Agile Release Planning	Cost	√

4.2.4 Project D

Project D is managed by a senior project manager with the educational background of Civil Engineering. This project is a joint-ventured high-rise residential project launched in August 2019 with total of 277 residential units in the land size of 0.97 acre. The project was launched with the contract value of RM 254,380,000.00 to the construction company. The project was currently in the structural erection stage up to level 21. The project was accessed in high project scheduling performance, as all the site workers were carefully managed with strict construction site SOP in dealing the pandemic outbreaks. However, the site was hindered with limited land use around workable site area, which burdened the logistics of material transportation to upper floors via tower crane, as well as storage for the raw materials. Thus, the senior project manager has proposed the system formwork for structural erection, to save up the construction time of average of 25% than conventional timber formwork erection due to minimal new timber plywoods required to be acquired on site, therefore the logistic of the site was eased. Table 4.4 illustrates the project scheduling practices adopted in Project D.

Table 4.4: Perceived Variable Generated in Project C

Empirical Project Scheduling Practices	Constrained Resources Associated with the Scheduling Practices	Project D
Critical Path Method	Time	√
Resource Levelling	Cost	√
Resource Smoothing	Quality	√
Schedule Crashing	Time	None
Schedule Fast Tracking	Quality	√
Agile Release Planning	Cost	√

4.2.5   Project E

Project E is managed by a project manager with the educational background of Architectural Studies. This project is a high-rise residential project launched in December 2020 with total of 366 residential units in the land size of 1.5 acre as mixed development with 98 retails. The project was launched with the contract value of RM 453,380,000.00 after the contract negotiation and revision, a total cost saving of RM 14,000,000.00 with façade finish material substitution. The project was currently in architectural trades while the infrastructure works are ongoing concurrently. The project was accessed in low project scheduling performance with the project schedule in aligned as planned. During the pandemic, the project has jeopardized from the pandemic outbreaks, with instability of the building material supplies to the site, as well as human labours. Adversely, the project was delayed of 134 days after the EOT granted. The project manager intended to accelerate the project progress via sourcing the additional human workforce and raw materials into the project with additional cost implied as agreed in the board meeting with the developer. Table 4.5 illustrates the project scheduling practices adopted in Project E.

Table 4.5: Perceived Variable Generated in Project E

Empirical Project Scheduling Practices	Constrained Resources Associated with the Scheduling Practices	Project E
Critical Path Method	Time	None
Resource Levelling	Cost	None
Resource Smoothing	Quality	None
Schedule Crashing	Time	√
Schedule Fast Tracking	Quality	√
Agile Release Planning	Cost	None

4.2.6 Summary of Selected Project Case Study

The summary of the accessed project case studies are tabulated in Table 4.6.

Table 4.6: Summary of Selected Project Case Studies

Type of Development	Project A	Project B	Project C	Project D	Project E
	High-Rise	High-Rise	High-Rise	High-Rise	High-Rise
No. of Units	447	220	537	277	366
Contract Sum (RM)	238,500,000.00	304,000,000.00	233,000,000.00	254,380,000.00	453,380,000.00
Original Completion Date	February-2022	March-2022	March-2022	August-2022	Dec-2023
Actual Completion Date	February-2022	July-2022	May-2022	September-2022	April-2024
Delays	-9 days	-122 days	-58 days	-25 days	-134 Days
Delays in %	-1.2%	-13.3%	-6.2%	-3%	-14.5%
Scheduling Performance	High	Low	Average	High	Low

4.3   Perceived Variable Analysis

Table 4.7 presented the summary tabulation of perceived contribution for the 6 empirical project scheduling practices adopted in 5 construction projects with the classification of the constrainted resources associated in the application. The classification of the responses were also applied to assigned ranks, in accending order (the highest rank is 1), to the perceived contribution of the practices. This is to identify the most feasible scheduling practices based on the perceived factors derived from the project information and its progress. It is observed that Resource Levelling was perceived as the practices likely to contribute the most to high project scheduling performance rate. While Resource Smoothing and Schedule Crashing were at the bottom of the rank.

It is observed that resource levelling was the best practice in scheduling the construction projects amid the uncertainty circumstances of the pandemic. It aided the project manager in adjusting the project activity commence and delivery milestones based on the resource availability to balance the construction material supplies (Alsakini et al., 2004). While both resource smoothing and schedule crashing seemed ineffective in scheduling the project with the limitation of readily resources, as they have the weakest correlation with other empirical practices. This supports the statements of Larson and Gray (2017), that adjusting the resource required based on the availability, nor crashing the schedule with additional resources will not guarantee the projects to be delivered on time. The project delivrable quality would also has be compromised.

Meanwhile, Critical Path Method, Schedule Fast Tracking and Agile Release Planning are seemed to be moderately effective in scheduling the resource-constrained projects.

Table 4.7: Perceived Contribution of Empirical Project Scheduling Practices in Dealing Constrainted Resources amid the Pandemic

Types of Empirical Project Scheduling Practices		Constrained Resources Associated with the Scheduling Practices	Project A	Project B	Project C	Project D	Project E	Rank (by Perceived Contribution)
P1	Critical Path Method	Time	√	None	√	√	None	2
P2	Resource Levelling	Cost	√	√	√	√	None	1
P3	Resource Smoothing	Quality	√	None	None	√	None	3
P4	Schedule Crashing	Time	None	√	None	None	√	3
P5	Schedule Fast Tracking	Quality	√	None	None	√	√	2
P6	Agile Release Planning	Cost	√	None	√	√	None	2

4.4   Accessed Variable Analysis

Next, the data extracted from the perceived variable studies will be complementing into the accessed variable analysis. It enabled the benchmarking of the scheduling performance by validating the scheduling practices in responding to the constrained resources via interviews. Table 4.8 illustrated the summary tabulation of accessed contribution in benchmarking the project scheduling performance for 5 construction projects with the classification of the constrainted resources associated in the application. The classification of the responses were also applied to assigned ranks, in accending order (the highest rank is 1), to the accessed contribution of the practices.

This is to validate the effectiveness of empirical project scheduling practices in upkeeping the scheduling performance with addressing the constrained resources during the pandemic. The project activity priority has the highest rank in determining the high project scheduling performance. While resource availability seemed to be less correlated with the scheduling performance benchmarking, the availability of construction materials do not affect the scheduling performance, rather it could be mitigated via better scheduling practices (Lima et al., 2019).

It is observed that project activity priority setting is the most feasible approach in utilizing the limited resources while maintain the balance between the project completion period and the smoothness of the scope execution (Aftab et al., 2016). While Lima et al. (2019) argued that scheduling a project based on the availability of resources will not favour the project scheduling performance, as the work scope of the projects should be versatile and subjected to change in responding to the context of material shortage, thus it resulted to be the least correlation in the analysis.

Table 4.8: Accessed Contribution of Benchmarking Project Scheduling Performance in Dealing Constrainted Resourcess amid the Pandemic

Benchmarks of Project Scheduling Performance		Constrained Resources Associated with the Scheduling Practices	Project A	Project B	Project C	Project D	Project E	Rank (by Accessed Contribution)
A1	Proper Allocation of Resources	Cost	√	√	None	√	None	2
A2	Competency of the Project Team	Quality	√	None	√	√	None	2
A3	Project Activity Priority	Quality	√	√	√	√	None	1
A4	Availability of the Resources	Cost	√	None	None	None	None	3
A5	Delivery Dates of Work Package	Time	√	None	None	√	None	2

4.5 Implication of Constraint Resources for Construction Project Scheduling Performance Amid Covid-19 Pandemic

Through the series of perceived and accessed variable analysis, the results are concluded as the implication of the resources contraints for project scheduling performance amid the pandemic. With the similar constraint resources occurred in the construction projects, it leads the project into tough situation, where the balancing between the material supplies and project delivery timeline should be in optimum condition. It depends on the competency of the managerial staffs, such as project manager in making diligent decision for the upmost interest for their projects (Safapour et al., 2017).

Through the summary tabulation of the correlational analysis of both perceived and accessed data, the study highlighted the time constraint is the highest correlated in driving the project scheduling performance. Despite it might not be identified based on the perception of the project managerial personnel in the aforesaid projects, it is somehow proven that the time constraint, such as logistic shortage or communication breakdown were actually affect the scheduling performance of the construction projects. Communication breakdown due to the isolation and less communication promoted via the social distancing initiative as part of Covid-19 SOP will discourage the allocation of resources on site without closely supervision (Pollack & Matous, 2019). Whilst Nanthagopan et al. (2016) supported the results with their research outcome of immigration restriction or logistic shortage identified in the supply chain industries.

In the other hand, cost and quality constraints are shared less coherence to the variable testified as indicated in the Table 4.9. Hence, it is proven that cost and quality constraints could be resolved in dealing with pandemic circumstances while maintaining the

scheduling performance through interative review of the schedule planning implementation (Mishra & Moktan, 2019). It was overestimate accessed to be considered as insignificant affection to the project performance, thus they were to apply in isolation. These results testified that the mere consideration of quality and cost constraints are not likely to cause a significant results in manipulating the project scheduling performance amid the pandemic.

Despite the cost and quality constraints in lesser coherence showing low impacts contributed to the project scheduling performance, the industry players have recommended that these constraints should not be overlooked. This is due to all 3 constraints are interdependent and shall be giving domino effects should one of the constraints is not carefully managed (Lima et al., 2019). For instance, the incapability of the site managerial staffs without adequate experiences has jeopardized the distribution of works to site workers due to social restriction without attending for physical supervision as observed in both Project B & E.

Table 4.9: Accessed Contribution of Benchmarking Empirical Project Scheduling Practices in Dealing Constrained Resources Amid the Pandemic

Types of Empirical Project Scheduling Practices		Constrained Resources Associated with the Scheduling Practices	Correlated Variables	Rank (by Perceived Contribution)	Mean Rank (by Accessed Contribution)	Median Rank (by Outcome Variable)	Rank (by Significantly Correlated Outcome Variable)
P1	Critical Path Method	Time	A5	2	2	2	3
P2	Resource Levelling	Cost	A1, A4	1	2.5	1.75	4
P3	Resource Smoothing	Quality	A2, A3	3	1.5	2.25	2
P4	Schedule Crashing	Time	A5	3	2	2.5	1
P5	Schedule Fast Tracking	Quality	A2, A3	2	1.5	1.75	4
P6	Agile Release Planning	Cost	A1, A4	2	2.5	2.25	2

4.6 Recommendation

4.6.1 Empirical Suggestions in Reducing Construction Project Scheduling Issues in Dealing with Constrained Resources

The study has drawn a summary where reducing the construction project scheduling issues are the upmost efforts in upkeeping scheduling performance. Generally, the construction projects are often struggled with the triple constraints including time, cost and quality. Covid-19 pandemic has brought up aforesaid struggles to a head, as the pandemic restriction has intensified further the project scheduling issues. Thus, the empirical suggestions are then proposed, taking the consideration of insightful inputs from both industry players, and literatural supports. The empirical suggestions have summarized in the Table 4.10 according to the project triple constraints as below:-

Table 4.10: Summary of Empirical Suggestions to Reduce Project Scheduling Performance Issues in dealing Constrained Resources in Construction Projects

Constrained Resources in Construction Project		Empirical Suggestion to Reduce Project Scheduling Performance Issues in dealing Constrained Resources
Time Constraint	Communication Breakdown	Resource Utilization Strategy in dealing RCPSP
	Unprecedented Environmental Factors	
	Logistic Restriction and Shortage	
Cost Constraint	Material Unavailability	Versatile Scheduling Performance Review Framework
	Depleting Economic Factors	
Quality Constraint	Labour Incapability	HR Training and Supports

4.6.2 Resource Utilization Strategy in dealing RCPSP

In order to utilize the time-constrained resources, predominantly in communication and logistic breakdown amid the pandemic, resource allocation method addressing RCPSP shall be implemented in the construction projects to upkeep the scheduling performance and therefore lead to project success (Bjorvatn & Wald, 2018). Forcasting the possible occurrence of likely trends iteratively shall be the appropriate approach in dealing with the sudden surge of the constraint issues on site via Smallest Duration Method (Larson & Gray, 2017). It would aid the project team to identify, reduce or eliminate possible cause of resource constraints, which would contributing to the delay of the project (Zwißler & Hermann, 2012). Despite schedule crashing method in salvaging the project scheduling performance to back on track, it involves ernormous amount of resources which would attribute to cost of non-conformance (Barad & Raz, 2000). After all, schedule crashing would be the inevitable approach to upkeep the project back to the track after the constrained resources havoc.

4.6.3 Versatile Scheduling Performance Review Framework

While considering the implementation of empirical scheduling practice be the short-term solution, versatile scheduling performance review shall not be neglected as the long-term endeavours in responding to cost constraints (Pinha & Ahluwalia, 2019). Iterative review and monitoring of planned resources (materials) distribution throughout the project lifecycle enable the project teams in forecasting the possible risks and challenges, which would affect the limited viable resources allocation in the shortest time possible. For instance, the project team would have dealt the pandemic outbreaks better by slowing down secondary project scope which is resource-consuming unnessesary, to maintain the scheduling performance, thus the project will not bound to failure over the period (Aftab et al., 2016).

64

4.6.4 Human Resource Training and Supports

Human Resource training and supports are mandatory for construction projects and all organization to increase the project scheduling performance and achieve project success. Specialist intervention such as appointing project management experts in construction industry will lead to positive value added to the project outcome. The continuous improvement comprising training and practical internship provided for the project managerial staffs. An expert project managerial team will help managing a good project, however, the competencies of the project team members are paramount to ensure the success implementation of the scheduling practices (Dirani, Abadi, Alizadeh, Barhate, Garza, Gunasekara, Ibrahim, & Majzun, 2020). A clear measurable objective and organizational goals associated with good project scheduling practices is demanded to ensure project success. In order to have full participation as in achieving high project scheduling performance, the project managerial staffs as well as all the site workers as project participants, should be aware with their respective roles by disseminating equal responsibilities via trainings, in maintaining the good working culture, which would contribute to lesser dispute and discrepancies occurred during the project execution (Dirani et al., 2020). Moreover, other relevant departments such as risk, legal and contractual department are strongly suggested to have training associated with project schedule management. This helps in ensuring all the project participants are aware on how project scheduling practices would operate better with the intergration of other field of good practices.

4.7 Summary

An overview of the identification of constrained resources in 5 construction projects during Covid-19 pandemic is presented here, followed with the correlational analysis concerning the implication of the constrained resources to the construction projects.

Empirical suggestions are then presented based on the key constrained resources with the inputs from both literatural studies and industry practitioners. In the following chapter, the gist of the findings found in each of the objectives will be briefly presented for the fulfilment of the research objectives. A discussion on the contribution to knowledge will be presented supported by a discussion on the limitation of the research, and suggestion for the future research.

CHAPTER 5. CONCLUSION

5.1   Introduction

This chapter summarizes the overall research outcome for the study, which all the data are synthesized, analyzed and presented to conclude the research study. The implication, limitation and suggestion are highlighted for researchers, academicians, or industry players for future endeavours are also discussed.

5.2   Conclusion

This research was undertaken based on the landscape of project schedule management that revealed problems existed unprecedentedly in this research area. A set of robust and remedial solution is demanded in salvaging the sluggish construction projects scheduling performance amid the Covid-19 pandemic, in the effort of upkeeping the industry contribution to GDP and ultimately national economic growth. Mixed method qualitative approach of multiple case study has been applied as the research methodology for this research where at the beginning stage, the selected construction projects were accessed with identification of the constrained resources via correlational analysis. In addition, the implication of constrained resources contributed to each construction project scheduling performance amid Covid-19 pandemic was critically discussed. Then, a set of empirical suggestions in reducing project scheduling performance issues in dealing constrained resources is presented. It would be able to complementing into the best practices of increasing project scheduling performance and eventually striving to project success.

5.3   Fulfilment of the Research Objectives

The overall aim of the research was expected to be addressed through a number of objectives as stated below. The following sections reflected on how they have been achieved.

5.3.1 To Identify the Constrained Resources in Construction Projects during Covid-19 Pandemic

Project triple constraints, including time, cost and quality constraints has been the most contributing factors to project scheduling performance. These has been proven through the correlational analysis via multiple case studies between perceived and accessed variables of empirical project scheduling practice and its benchmarks under Chapter 4.2 to 4.4, after synthesization of primary data gathered through surveys and interviews. The variables were critically evaluated through a series of literatural studies and to be categorized under 3 different constraints. Furthermore, it has drawn to sum up that the time constraint, specifically on logistic shortage or communication breakdown variables was identified as the primary constrained resources in the construction projects amid the Covid-19 pandemic, followed by the secondary constrained resources of cost and quality constraints.

5.3.2 To Analyse the Implication of the Constrained Resources to the Construction Projects

The process of analysing the implication of constrained resources started with the correlational analysis between perceived and accessed variables to find their inter-coherence relationships of the empirical project scheduling practice variables in dealing constrained resources amid Covid-19 pandemic. Time constraint as the primary constributing factor to the scheduling performance, including its variables were discussed on how it would give its implication to the construction project scheduling performance during the pandemic era. Schedule crashing has been identified as the most applied scheduling practice in dealing with the constrained resources, to sustain the project scope delivery timeline while several challenges have been highlighted under Chapter 4.5.

Moreover, cost and quality constraints were also discussed, as they are interdependent in influencing the scheduling performance of the construction projects.

5.3.3 To Propose Empirical Suggestions to Reduce Construction Project Scheduling Performance Issues in Dealing with Constrained Resources amid Covid-19 Pandemic

The establishment of the empirical suggestions was then presented under Chapter 4.6 for reducing the project scheduling performance issues of the construction projects in dealing with the constrained resources, including time, cost and quality constraints. 3 empirical suggestions were then proposed specifically for each constrained resources, to tackle the construction project scheduling performance issues highlighted earlier as summarized in Table 4.10. The empirical suggestions including Resource Utilization Strategy in dealing RCPSP, Versatile Scheduling Performance Review Framework and HR Training and Support, which are suggested based on the literatural studies, as well as empirical inputs gathered from the industry players during the data collection.

5.4 Limitation of the Research Study

The major limitation of conducting this research are the sample sizes which were only five (5) case studies to be accessed. Due to time and company policy constraints, the samples size is very limited and not viable, as they were only 5 out of 10 selected construction companies agreed for the participation. Therefore, it cannot be representing the whole industries of project scheduling practices. This study is mainly spotted on improving project scheduling performance with constrained resources amid the pandemic. As a result, the approach is seemed less persuasive, as there is no precedent studies regarding the project scheduling performance amid the pandemic. Furthermore, there are many guidelines and standards for project scheduling management such as PRINCE2, P2M, PMBOK and so on. The definition of project schedule management might be differ from one publication to another, thus this

could be the hinderence for the researcher in accessing the theoretical framework of the scheduling practices.

5.5   Suggestion for Future Research

The future study is suggested to have an expansion of the sampling size to ensure the reliability of the findings are representative for both local and global construction industry, as well as serving as precedental research for the construction industry amid the pandemic. Moreover, the study could be improved by comparing other code of practices related to scheduling management with empirical application. This could provide insider viewpoints to the future researcher to identify the best practice in improving the scheduling performance which would not merely be limited to the construction industry.

REFERENCES

Aftab, J., Sarwar, H., Sarwar, H., & Amin, S. (2016). Influence of Project Management Performance Indicators on Project Success in Construction Industry of Punjab, Pakistan. *International Research Journal of Management Sciences (ISSN: 2147-964X)*, *4*, 511-520.

Alsakini, W., Wikström, K., & Kiiras, J. (2004). Proactive schedule management of industrial turnkey projects in developing countries. *International Journal of Project Management*, *22*(1), 75-85. https://doi.org/https://doi.org/10.1016/S0263-7863(03)00006-1

Banihashemi, S., Hosseini, M. R., Golizadeh, H., & Sankaran, S. (2017). Critical success factors (CSFs) for integration of sustainability into construction project management practices in developing countries. *International Journal of Project Management*. https://doi.org/10.1016/j.ijproman.2017.01.014

Bao, L., Li, T., Xia, X., Zhu, K., Li, H., & Yang, X. (2020). *How does Working from Home Affect Developer Productivity? -- A Case Study of Baidu During COVID-19 Pandemic*.

Barad, M., & Raz, T. (2000). Contribution of quality management tools and practices to project management performance. *International Journal of Quality & Reliability Management*, *17*, 571-583. https://doi.org/10.1108/02656710010298607

Barbalho, S., Silva, G., & Toledo, J. (2017). The impact analysis of functions of Project Management Office on perfor-mance of triple constraint of new-product development projects. *Direccion y Organizacion*, *61*, 19-31.

Bjorvatn, T., & Wald, A. (2018). Project complexity and team-level absorptive capacity as drivers of project management performance. *International Journal of Project Management*, *36*(6), 876-888. https://doi.org/https://doi.org/10.1016/j.ijproman.2018.05.003

Castro, M. S., Bahli, B., Barcaui, A., & Figueiredo, R. (2020). Does one project success measure fit all? An empirical investigation of Brazilian projects. *International Journal of Managing Projects in Business*.

Chen, S.-M., Griffis, F. H., Chen, P.-H., & Chang, L.-M. (2013). A framework for an automated and integrated project scheduling and management system. *Automation in Construction*, *35*, 89-110. https://doi.org/https://doi.org/10.1016/j.autcon.2013.04.002

Chin, L., Chai, C., Chong, H., Md Yusof, A., & bt Azmi, N. (2018, 2018//). The Potential Cost Implications and Benefits from Building Information Modeling

(BIM) in Malaysian Construction Industry. *Proceedings of the 21st International Symposium on Advancement of Construction Management and Real Estate*, Singapore.

CIDB. (2020). *ISO 14001 IMPLEMENTATION TO G7 CONTRACTORS WITH ANNUAL TURNOVER RM200 MILLION AND ABOVE*. https://www.cidb.gov.my/sites/default/files/2020-12/8.CIDB-Tech.-Pub.-No.186Impact-Study-on-Implementation-ISO-14001.pdf

Collins, W., Parrish, K., & Gibson, G. E. (2017). Development of a Project Scope Definition and Assessment Tool for Small Industrial Construction Projects. *Journal of Management in Engineering*, *33*(4), 04017015. https://doi.org/doi:10.1061/(ASCE)ME.1943-5479.0000514

Delerue, H., & Sicotte, H. (2020). Resource interdependence and project termination: An analysis in the biopharmaceutical industry. *International Journal of Project Management*, *38*(5), 256-266. https://doi.org/https://doi.org/10.1016/j.ijproman.2020.06.001

Demirkesen Çakır, S., & Ozorhon, B. (2017). Impact of Integration Management on Construction Project Management Performance. *International Journal of Project Management*, *35*, 1639-1654. https://doi.org/10.1016/j.ijproman.2017.09.008

Deng, Y., Li, Z., & Quigley, J. M. (2012). Economic returns to energy-efficient investments in the housing market: Evidence from Singapore. *Regional Science and Urban Economics*, *42*(3), 506-515. https://doi.org/10.1016/j.regsciurbeco.2011.04.004

Dinis, F. M., Sanhudo, L., Martins, J. P., & Ramos, N. M. M. (2020). Improving project communication in the architecture, engineering and construction industry: Coupling virtual reality and laser scanning. *Journal of Building Engineering*, *30*, 101287. https://doi.org/https://doi.org/10.1016/j.jobe.2020.101287

Dirani, K. M., Abadi, M., Alizadeh, A., Barhate, B., Garza, R. C., Gunasekara, N., Ibrahim, G., & Majzun, Z. (2020). Leadership competencies and the essential role of human resource development in times of crisis: a response to Covid-19 pandemic. *Human Resource Development International*, *23*(4), 380-394.

Doloi, H., Sawhney, A., Iyer, K. C., & Rentala, S. (2012). Analysing factors affecting delays in Indian construction projects. *International Journal of Project Management*, *30*(4), 479-489. https://doi.org/https://doi.org/10.1016/j.ijproman.2011.10.004

ElZomor, M., Burke, R., Parrish, K., & Gibson, G. E. (2018). Front-End Planning for Large and Small Infrastructure Projects: Comparison of Project Definition Rating Index Tools. *Journal of Management in Engineering*, *34*(4), 04018022. https://doi.org/doi:10.1061/(ASCE)ME.1943-5479.0000611

Fernandes, N. (2020). Economic Effects of Coronavirus Outbreak (COVID-19) on the World Economy. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3557504

Gamil, Y., & Alhagar, A. (2020). The Impact of Pandemic Crisis on the Survival of Construction Industry: A Case of COVID-19. *Mediterranean Journal of Social Sciences*, *11*(4), 122. https://doi.org/10.36941/mjss-2020-0047

Habibi, F., Barzinpour, F., & Sadjadi, S. (2018). Resource-constrained project scheduling problem: review of past and recent developments. *Journal of Project Management*, *3*, 55-88. https://doi.org/10.5267/j.jpm.2018.1.005

Hassan, A., Adeleke, A. Q., & D.M, T. (2019a). THE Effects of Project Triple Constraint on Malaysia Building Projects.

Hassan, A., Adeleke, A. Q., Hussain, S., & D.M, T. (2019b). Partial Least Square Structural Equation Modeling: An Approach to the Influence of Project Triple Constraint on Building Projects among Malaysian Construction Industries.

Heldman, K. (2015). *PMP: Project Management Professional Exam Study Guide: Updated for the 2015 Exam*. Wiley. https://books.google.com.my/books?id=Pwv9CgAAQBAJ

Jallow, H., Renukappa, S., & Suresh, S. (2020). The impact of Covid-19 outbreak on United Kingdom infrastructure sector. https://doi.org/10.1108/sasbe-05-2020-0068

Larson, E. W., & Gray, C. F. (2017). *Project Management: The Managerial Process*. McGraw-Hill Higher Education. https://books.google.com.my/books?id=dsbMwQEACAAJ

Lima, R., Tereso, A., & Faria, J. (2019). Project management under uncertainty: resource flexibility visualization in the schedule. *Procedia Computer Science*, *164*, 381-388. https://doi.org/https://doi.org/10.1016/j.procs.2019.12.197

Ling Florence Yean, Y., Ning, Y., Chang Yi, H., & Zhang, Z. (2018). Human resource management practices to improve project managers' job satisfaction. *Engineering, Construction and Architectural Management*, *25*(5), 654-669. https://doi.org/10.1108/ECAM-02-2017-0030

Liu, Y., van Nederveen, S., & Hertogh, M. (2017). Understanding effects of BIM on collaborative design and construction: An empirical study in China. *International Journal of Project Management*, *35*(4), 686-698. https://doi.org/https://doi.org/10.1016/j.ijproman.2016.06.007

Management, A. f. P. (2012). *APM Body of Knowledge*. Association for Project Management. https://books.google.com.my/books?id=NybkMwEACAAJ

Mishra, A., & Moktan, K. (2019). IDENTIFICATION OF CONSTRAINTS IN PROJECT SCHEDULE MANAGEMENT. *International Journal of Research - GRANTHAALAYAH*, 18-35. https://doi.org/10.5281/zenodo.2580485

Mohammady, S., & Gibson, G. E. (2020). A Forensic Evaluation of Projects in Afghanistan Using the Project Definition Rating Index (PDRI). In *Construction Research Congress 2020* (pp. 181-190). https://doi.org/doi:10.1061/9780784482889.020

Moura, R. L. d., Carneiro, T. C. J., & Diniz, B. D. (2018). Influence of the project manager's personal characteristics on project performance. *Gestão & Produção*, *25*, 751-763. http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0104-530X2018000400751&nrm=iso

Nanthagopan, Y., Williams, N., & Page, S. (2016). Understanding the nature of Project Management capacity in Sri Lankan non-governmental organisations (NGOs): A Resource Based Perspective. *International Journal of Project Management*, *34*, 1608–1624. https://doi.org/10.1016/j.ijproman.2016.09.003

Neves, F., Borgman, H., & Heier, H. (2017). *Success Lies in the Eye of the Beholder: A Quantitative Analysis of the Mismatch Between Perceived and Real IT Project Management Performance*. https://doi.org/10.24251/HICSS.2017.624

Ogunde, A. O., Olaolu, O., Afolabi, A., Owolabi, J., & Ojelabi, R. (2017). CHALLENGES CONFRONTING CONSTRUCTION PROJECT MANAGEMENT SYSTEM FOR SUSTAINABLE CONSTRUCTION IN DEVELOPING COUNTRIES: PROFESSIONALS PERSPECTIVES (A CASE STUDY OF NIGERIA) [challenges, confronting, construction, project management, Nigeria.]. *2017*, *8*(1). http://spaj.ukm.my/jsb/index.php/jbp/article/view/207

Pinha, D. C., & Ahluwalia, R. S. (2019). Flexible resource management and its effect on project cost and duration. *Journal of Industrial Engineering International*, *15*(1), 119-133. https://doi.org/10.1007/s40092-018-0277-3

PMI, P. M. I. (2021). *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)–Seventh Edition*. Project Management Institute.

Pollack, J., & Matous, P. (2019). Testing the impact of targeted team building on project team communication using social network analysis. *International Journal of Project Management*, *37*(3), 473-484. https://doi.org/https://doi.org/10.1016/j.ijproman.2019.02.005

Radzuan, K., Mohd Nawi, M. N., & Mohd Nasir, N. (2016). *Relationship between time management in construction industry and project management performance Relationship between Time Management in Construction Industry and Project Management Performance* (Vol. 1761). https://doi.org/10.1063/1.4960919

Safapour, E., Kermanshachi, S., Habibi, M., & Shane, J. (2017). *Resource-Based Exploratory Analysis of Project Complexity Impact on Phase-Based Cost Performance Behavior*. https://doi.org/10.1061/9780784481271.043

Sriyakul, T., Umam, R., & Jermsittiparsert, K. (2019). Total Quality Management and Logistic Performance: Moderating Role of Reserve Supply Chain in Pharmaceutical Industry of Indonesia. *5*, 228-248.

Suresh, D., & Sivakumar, A. (2019). Impact of Schedule Management Plan on Project Management Effectiveness.

Trach, R., & Bushuyev, S. (2020). Analysis communication network of construction project participants. *Przegląd Naukowy Inżynieria i Kształtowanie Środowiska*, *29*(3), 388-396. https://doi.org/10.22630/pniks.2020.29.3.33

Villafáñez, F., Poza, D., López-Paredes, A., Pajares, J., & Olmo, R. d. (2019). A generic heuristic for multi-project scheduling problems with global and local resource constraints (RCMPSP). *Soft Computing*, *23*(10), 3465-3479. https://doi.org/10.1007/s00500-017-3003-y

Zerjav, V. (2015). Design boundary dynamics in infrastructure projects: Issues of resource allocation, path dependency and problem-solving. *International Journal of Project Management*, *33*(8), 1768-1779. https://doi.org/https://doi.org/10.1016/j.ijproman.2015.09.009

Zwißler, F., & Hermann, M. (2012). Supply chain risk management in the electronics industry. *Risk Management for the Future–Theory and Cases*, 467-496.