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THE IMPACT OF DIGITISATION, DIGITALISATION AND DIGITAL TRANSFORMATION ON PROJECT MANAGEMENT PRACTICES IN THE CONSTRUCTION INDUSTRY IN SINGAPORE

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Submission Date: 13 Sept 2021

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This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Simon Wong

Signed (candidate)

13 Sept 2021

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Abstract

The **Introduction** chapter is elucidated with proper research aims, objectives and research questions to frame this research paper in a structured and coherent manner. Extracting appropriate research result here, in this chapter, research background and problem statement has been explicated with proper justification. Research significance and contribution has also been justified with proper evidence. This introduction chapter has outlined the research components and factors to help in developing the theme for the next chapter.

In the **Literature Review** chapter, the published literature has been discussed and evaluated. The positive impact of the inclusion of digitalisation in the construction industry of Singapore has been discussed here. The challenges that are faced by the project managers in order to implement the technology know-hows in the processes of construction have also been discussed. The theories that are relevant to this topic are also being discussed and a conceptual framework has been provided.

In the **Methodology** chapter, the methods of conducting the research have been discussed in greater details. The data sources have been evaluated properly. Facts determination has been made on each of the sources and types that were used throughout the study. A proper strategic approach has been discussed on the accumulated facts to work out the end results of this discussion. Along with the facts, a structured way of scheduling every task has been made for determining the dependency on every task. In this situation the ethical approaches that were considered in this study has been determined.

The **Data Analysis** section has mainly been guided by the appointment of the thematic analysis tool. Commencing with the interview transcripts, this part has developed a set of themes to showcase the findings of primary qualitative data as mentioned via the interview transcript. Along with face-to-face discussion, a total of four themes have been developed to outline the findings of the secondary qualitative data. Some of the objectives of the entire analysis were to mention the value of digital transformation as well as the challenges being experienced by construction project managers in the adoption of digital tools.

In the **Discussion, Conclusion and Recommendation** chapter, overall discussion of the findings and conclusion are stated. In this chapter, extents to which objectives have been met are discussed with the mentioning of specific relevant sections. Along with that, useful recommendations and limitations of this research have been provided as well. Future prospect of this research has been stated here for a better understanding. The objectives are linked with the discussed part in this section. The overall discussion of the data is covered in this section. The data selection procedures are also included in this topic, so as to have a better insight towards the data approach.

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Abbreviations

BIM= Building Information Modelling

AI= Artificial Intelligence

ICT= Information & Communication Technology

IT= Information Technology

AR= Augmented Reality

VR= Virtual Reality

Chapter 1: Introduction

1.1 Introduction

Digitisation, digitalisation and digital transformation are considered as an integral part of the construction industry of the Fourth Industrial Revolution. The construction industry generally contributes to the socio-economic growth of any country. In Singapore, construction project management works' working structure is gradually changing as it faces formidable challenges, which is a result of increased technological demand. This research report has evaluated all the necessities of digitisation and digital transformations in the construction project management of Singapore. In addition, this research project has been developed as a research platform based on the impact of technology in project management practices in this country. A thorough analysis for this research topic has been conducted through a proper literature discussion, research method and research discussion before finally reaching a conclusive answer.

1.2 Research Background

It can be seen that construction projects and managing them requires a massive amount of effort within the construction industry. In Singapore, construction companies are engaging themselves relentlessly and putting their best efforts to brace themselves for technological interventions respectively (Daniotti *et al.* 2020). The main issue faced by this industry is meeting that benchmark level of technological demand of the construction industry. The implication of digitisation in construction project management is the main issue to be discussed here. As opined by Li, Greenwood, and Kassem, (2019), in 2016, **“digital management office”**, **“building information modelling or BIM”**, **“augmented reality or AR”**, **“virtual reality or VR”**, and **“drone technology”** are the common buzzwords with regards to digitalisation in Singapore's construction industry. This situation also indicates that IT solutions are the most desirable component for developing a robust and efficient construction industry of this country.

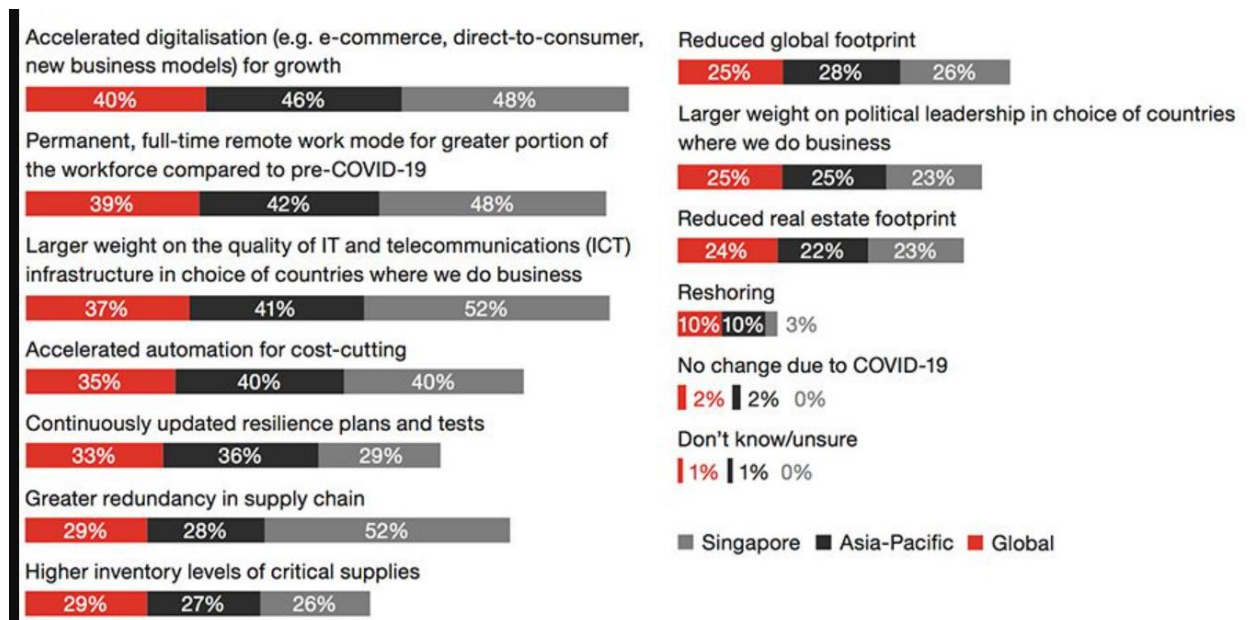


Figure 1.2.1: Construction Challenges Due to Digitisation

(Source: SULEMAN, 2019)

Apart from that, there are no other industries which need that much of technological involvement like the construction industry (Daniotti, Gianinetto, and Della Torre, 2020). From the several business reports, articles and news on Singapore, there were many highlights on how this country is currently transforming its construction projects at a rapid pace. According to a recent study, SULEMAN, (2019), in a Singapore industrial conference, the CEO of “**Building and Construction Authority (BCA)**” has stated that they have made a “*steady progress*” in their construction projects, which have a set target to meet, that is to develop a sustained environment for this industry (Lu, Wu, Chang, and Li, 2017). For such a reason, this research report has accumulated relevant data in a coherent manner on this research topic to demonstrate the significance of the impact of digitisation, digitalisation and digital transformation on construction project management in Singapore.

1.3 Research Aim and Objective

This research report is aimed at understanding the value of “*the implication of digitisation, digitalisation and digital transformations in the construction industry of Singapore*”. In other words, the aim is to indicate the difference between before and after the implementation of digital

technology in construction project management works so as to identify the proper impact and application of digital transformation.

In terms of meeting this research aim, some significant research objectives are also developed here:

- ***“To recognise the value of digitalisation in the construction projects of Singapore.”***
- ***“To understand the transformation in construction project management after implementing the digitalisation process.”***
- ***“To examine the growth and development of construction works after adopting digital transformation strategies.”***
- ***“To recognise the positive changes that came about as a result of digitalisation in construction project management in Singapore.”***
- ***“To find out any challenges faced by the construction project managers, or any project issues faced by them while adopting digitalisation, digitisations or any digital transformation initiatives in their construction management work process.”***

These objectives would give a better understanding of the technological demands in Singapore for construction project management and help to identify the difference between before and after technology adoption. In addition, these are essential facts for the purpose of objectifying the demands of technology for modern construction projects with the ultimate aim of achieving a sustainable building environment across the country. Singapore has taken some progressive steps, which have been established by these objectives.

1.4 Research Questions

Research questions are significant and need to align with research aim and objectives, for the purpose of extracting appropriate research results. Mainly research questions are required for the purpose of shaping the developed objectives so as to align with the research discussion in a more logical and transparent manner. Hence, in this case, research questions are developed in a clear and concise manner so that meaningful research results can be obtained, which are as follows: -

- ***“What is the impact of digitisation, digitalisation, and digital transformations in construction project management of Singapore?”***

- *"What are the recognised values of digitisations in the construction projects of Singapore?"*
- *"What are the challenges faced by the construction project managers while adopting digitisations and digitalisation for their construction project works in Singapore?"*
- *"Are there any positive changes in construction project management for implementing digital transformations?"*
- *"How much growth and developments have been accomplished in the construction industry of Singapore for digitalisation?"*
- *"What types of changes and transformations that have happened in construction project management of Singapore for digitisations?"*

1.5 Problem Statement

Among Asian countries, Singapore ranks as 48th in terms of size, and is considered a developed country, which has a vibrant and efficient construction industry. Nonetheless, it is experiencing growing trade conflicts as a result of global economic upheavals. Often, volatile financial markets and diminishing GDP growth rates have reduced some scopes and opportunities of the Singapore construction market respectively (Lu, Wu, Chang, and Li, 2017). Hence, digital transformation can help to increase a company's productivity and market growth through the application of viable processes and strategy adoptions. However, impacts can yield both negative and positive results for construction project management.

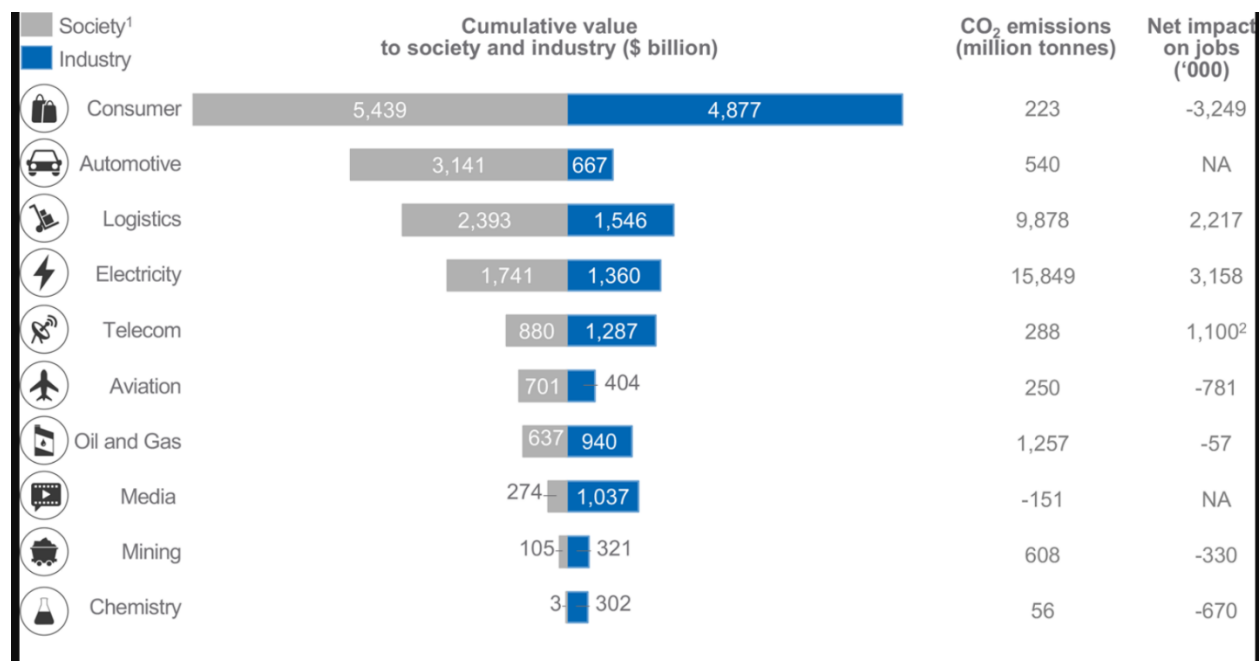


Figure 1.5.1: Cumulative Value for Digital Transformation in the Construction Industry

(Source: Bosch-Sijtsema and Gluch, 2019)

As opined by Banihashemi *et al.* (2017), in a construction cost survey report conducted by “Arcadis Singapore” it stated that, *“according to the international construction cost report for 2019, which gives important insights for the construction market across the world, Singapore is ranked as the fourth most expensive city among Asian cities.”* It was also mentioned in the report that Singapore project managers should be wary of project costs and budgets in order to maintain their project quality and to be concerned about their budget overflow which would impact the company’s productivity.

With regards to the positive impact of these digitalisation, digitisations and digital transformations, Singapore has accomplished many of its targets in increasing its project scopes and opportunities (Ferronato and Torretta, 2019). For example, for any construction projects to commence in Singapore, permission need to be obtained from the “**Urban Redevelopment Authority (URA)**” and the application process is simplified through the use of an integrated platform system. Secondly, power supply is an integral part of the construction projects (Li, Greenwood and Kassem, 2019). In this respect, Singapore possesses an edge via its robust power supply infrastructure system.

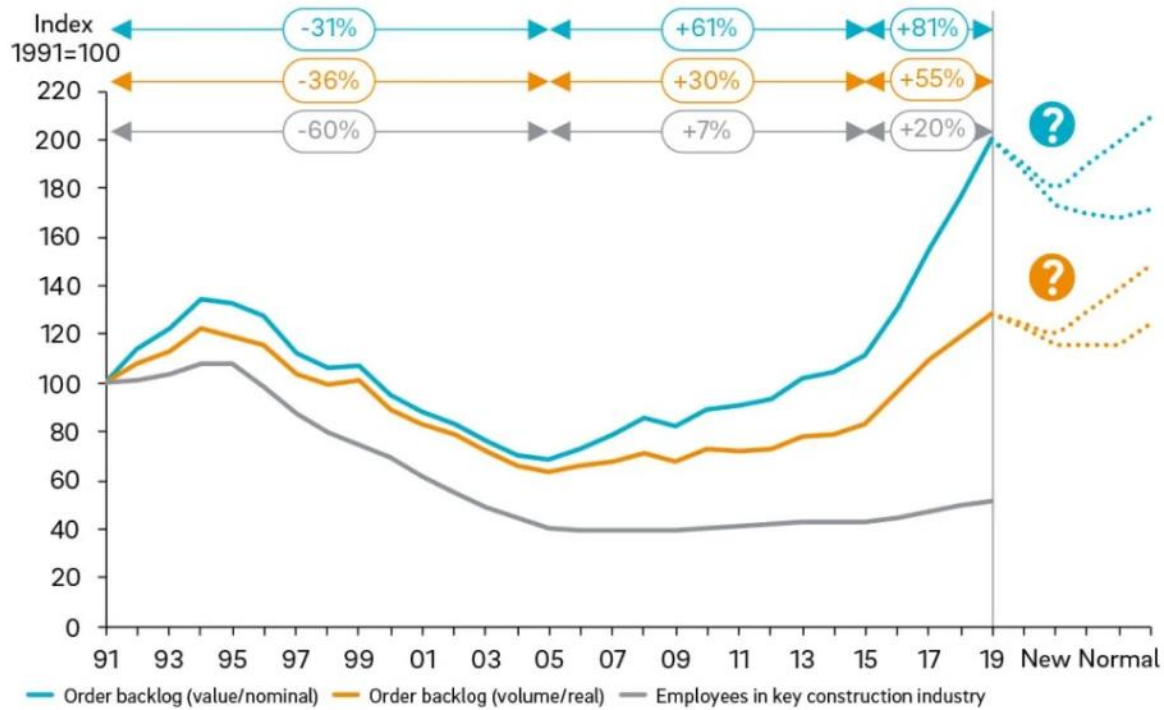


Figure 1.5.2: Construction Project Value in Singapore Due to Digitalisation

(Source: LAU *et al.* 2019)

Aside from these encouraging facts, Singapore’s construction industry is still facing various facets of challenges in the aspect of digital transformations and digitalisation.

“Poor standardisations”- As opined by Bosch-Sijtsema and Gluch, (2019); poor vision and mission to establish a successful project work schedule and timeline constraints are the main challenges to the construction project industry in these modern days. **“Standardise system”** is still under development, in which data management, project data analysis and the digital transformation process are challenging issues in Singapore due to poor company vision and mission (Daniotti, Gianinetto and Della Torre, 2020).

“Poor technical resistance”- Singapore has implemented relevant technologies and progressive working strategies for their industrial works. However, the challenging part is synchronization (Sarhan *et al.* 2017). In many cases, project site location tracking and geographical location tracking for supply chain systems due to poor network creates tremendous obstacles throughout the various phases of work.

“Return On Investments”- Outcome from the project estimation through financial software management implication is a challenge in this country (LAU *et al.* 2019). Calculating ROI over a period of time through software creates challenges that affect investment in the project.

These challenges have emerged due to digital transformation and digitalisation. Thus, even though Singapore is a developed country, the human resources aspect is not fully developed yet in the sense that there is an acute shortage of skilled professionals in this industry (Yin *et al.* 2018). It is a fact that many companies in Singapore face human resources challenges such as manpower recruitment issues, for which, skilled and knowledgeable workers are not available for handling the technical aspects of the project.

1.6 Rationale

“Operational and Legal Issues” – Example as in the use of **“Building Information Modelling”**, which generally include hardware, software and the interior collaborative workflow development process for BIM. Its usage requires skilled and knowledgeable users to handle such technology, of which this is a major challenge faced by a company’s Human Resources Department. The second challenge is to provide training for construction project management professionals (Prušková, Dědič, and Kaiser, 2019). Apart from operational issues, there are regulatory issues such as legal compliance that are being faced by construction companies regarding the collection of market information (SULEMAN, 2019). Developed technological systems have caused some barriers which sometimes resulted in companies being unable to collect their required information. Apart from that, based on the study of Toh, Goh, and Guo, B.H., (2017), new **“innovation and revolution policies”** have also created restrictions to construct any advanced building projects. Somehow achieving environmental sustainability is the most important issue that project managers are facing now.

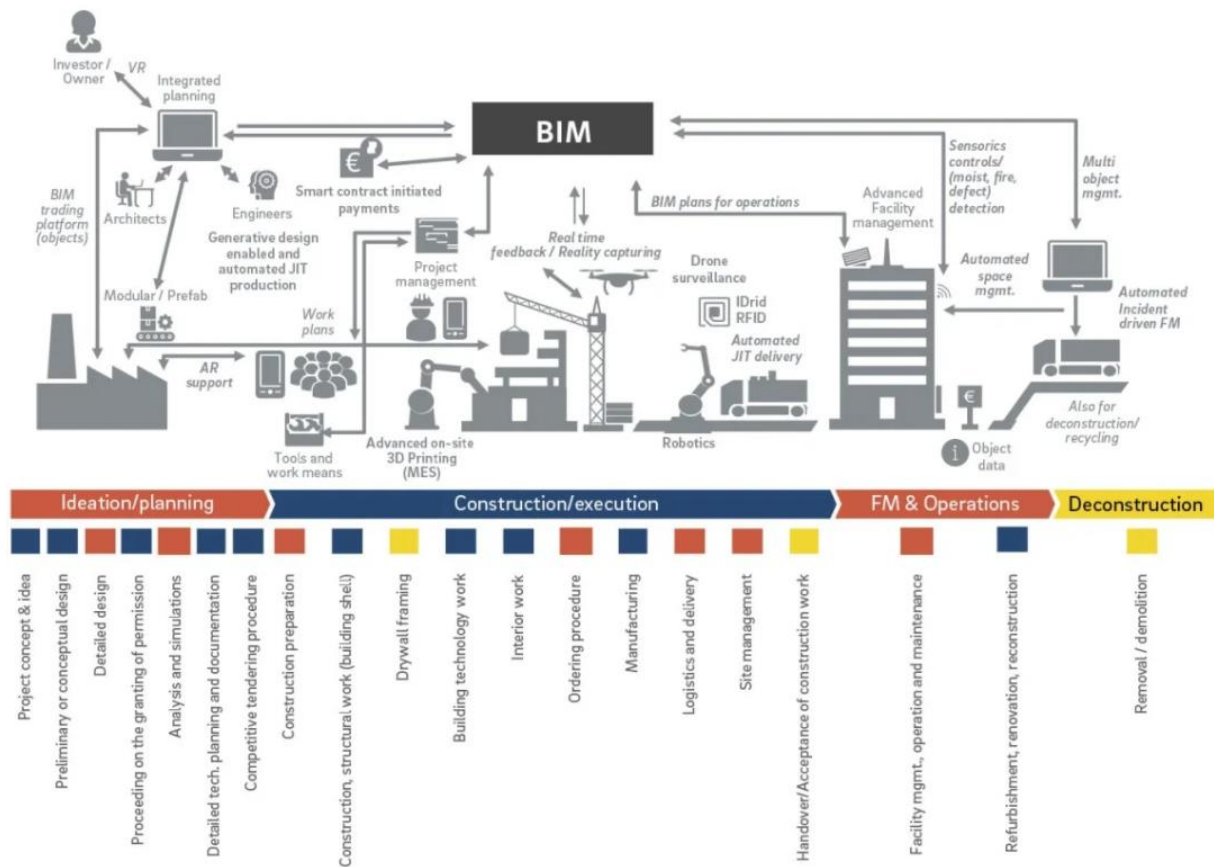


Figure 1.6.1: BIM Impact on the Construction Industry in Singapore

(Source: Verhoef *et al.* 2021)

“Cost Issues” – For example material cost. Cost and budget are the most fundamental issues faced by every business segment (SULEMAN, 2019). Due to trade conflicts, tariffs and global inflation, the construction industry is facing challenges in planning budgets for its project management. On the other hand, due to the pandemic situation, the cost of materials has increased from 3% to 7% (Verhoef *et al.* 2021). Secondly, the Singapore government is now trying to control this worrying trend, which has been spiralling upwards in the last five years. Worst still, compounded by the current pandemic situation it is not an easy feat to resolve this issue. Due to technological upgradations, as per changing behaviours of customers and clients, private residential segment demand has also increased (Rics.org, 2021). Due to the current restriction of construction activities, labour shortages, cost increments of raw material and the squeeze in tender pricing have also been a cause for concern.

“Alignment of Technologies with Project Work” – As a result of the current global pandemic situation, it has changed the business world drastically. Many construction companies are undergoing corporate restructuring, for example through mergers and acquisitions, to recover from their loss. However, tackling digital transformation is still a challenge due to poor organisational structure (Rics.org, 2021). Apart from IT, AR, VR, 3D printing and physical robots, there are also various forms of technologies being adopted by the business organisation (Lu *et al.* 2017). The inability to align all the technologies with their project work is a significant loss for these construction companies. Also, poor research and development is partly to be blamed as well.



Figure 1.6.2: Global Growth Rate Trends in the Construction Industry to Predict the Growth of the Construction Project Management of Singapore

(Source: Verhoef *et al.* 2021)

This research has shed the light on how digitisations, digitalisation and digital transformations have been implemented in the construction project management of Singapore. Several challenges and issues have arisen here due to vigorous technological upgradations, for which most of the construction companies are unable to understand the proper implementations of those techniques in their projects (Verhoef *et al.* 2021). With technology advancements, it has enabled business activities to be more viable and easily accessible to the public. As a result, businesses are worried in losing their data and information. For example, in Singapore, the building of Changi's Coastal Road's **“permanent racetrack project”** is still being postponed due to poor IT infrastructures (Lu *et al.* 2017). Engineers are still unable to remove the steel and concrete piles left on that site. Hence,

this research report will show how due to poor IT infrastructure, several construction companies face challenges and obstacles as a consequence, which would jeopardise their projects' success (Toh, Goh and Guo, 2017). In addition, this research will show some positive results as well, like digital transformation and some positive “green environment” changes in the construction industry of Singapore. Through the use of digital tools and highly sophisticated designed software, it has changed the vision of engineers dramatically. Even so, project managers are still facing challenges when adopting those techniques. The implications have been highlighted through this project report too.

1.7 Research Contribution

Project research contribution analysis is the crucial part, through which, aligning the issue with research aim and objective helps to extract proper research results at the end. The research aspect plays an important role and is a significant contributing factor which makes this report more meaningful. This research report has focused on those values and the significance of the role that technology plays which has changed the process of construction works. From the literature discussion of this report, cloud computing, physical robots, tracking suppliers' movement through digital trackers in a second, 3D painting for making blueprints of sustainable building and digital lean management for making the construction project viable has changed the overall construction landscape (Rics.org, 2021). Correspondingly, as a result of technologies adoption, it has also increased some of the risk issues faced by projects, such as cyber-attack, stealing of information from the company, loss of tender documentation; to name a few, which have been very prominent lately. An analysis has been performed via this research report to determine the main factors that had made an impact on digitalisation, digitisations and digital transformations of construction project management in Singapore. As opined by Verhoef *et al.* (2021), analysing statistical data regarding failed projects and substandard construction companies in the literature sections has also contributed to aligning it with the research aim and objectives.

Apart from that, this research paper has focussed on some relevant research methodology; there are primary data analysis as well as direct contact with three major construction companies of Singapore to assess the situation at ground level. Additionally, interpreting secondary existing information, such as the current digital transformation of Singapore construction industry, positive or negative changes due to technical adoptions, changing requirements due to globalisation along

with digitisation are vital in order to know what are the current issues that are happening now. In addition, as commented by Toh, Goh and Guo (2017), due to digital transformation, this research paper will attempt to provide significant information on the issues facing the industry, such as the lack of skill and knowledge availability in the company, poor training management and poor support, declining market share, cost increments of raw materials, unsustainable project budgets and other existing issues of the construction industry. In addition, as a result of digital transformation, human resources involvement has been reduced but on the other hand, other expenses have increased as well. This research report has been prepared through the use of primary and secondary data analysis and will also explain how the construction companies are handling these negative impacts of digital transformation.

1.8 Significance of Research

There is little difference between significance and contribution. Contribution is defined as the efforts made and significance is defined as the importance of the contribution (Yin *et al.* 2018). Apart from the contribution, this research paper is significant for construction business owners too, as it would also bring to the attention the risks of digital transformation. In Singapore, with regards to digital adoptions, there are many organisations that lack technical competencies during its course of implementation (Ferronato and Torretta, 2019). This research report will help those organisations to be aware of the risk issues associated with digital transformation. Construction project managers as well as those who still have not made any plans to change their training process to accommodate or to speed up their learning process with regards to the handling of the digital technology will realise that through this report, it is necessary to take immediate steps to enhance their skill set and knowledge in this respect; to brace themselves for the digital age soonest possible. Apart from that, based on the study discussion, (LAU *et al.* 2019) several secondary analyses regarding statistical data and information about the current construction project management of Singapore will also help other countries to choose the right strategies and make the necessary arrangements for digital adoption.

1.9 Summary

This introduction chapter is very crucial for starting the research report, as it outlined as well as framed all essential research components and facts for extraction of proper results. This research

introduction chapter has been framed with significant research aim, objectives and proper research questions to shape the research methodology. Research backgrounds have defined the sources of this research topic and the reason to choose this research. Research problems are designed here with proper justifications, that later can be used to help to develop the literature themes as well. In addition, the research rationale has depicted all justifications for the business issues and challenges faced, justified with current scenario evidence. At the end of this chapter, research contribution and significance have been interpreted by mentioning the differences between significance and contribution here.

Chapter 2: Literature Review

2.1 Introduction

Project management in construction is done by following several methods and techniques. The use of digitisation in construction and project works performed utilising digitalisation is referred to in this research. The literature review will discuss how the project management of construction sites in Singapore has gone through changes and challenges due to the impact of digitisation, digitalisation and digital transformation of project management practices. In this chapter, some of the prominent works of subject matter experts in construction project management will be discussed in respect of the research topic. It will share the analysis and understanding of the more relevant works to deliver the facts of the research topic.

2.2 Overview of the Construction Industry in Singapore

The construction industry in Singapore is one of the largest industries in the country. Four percent of Singapore's total gross domestic product comes from construction works of the country. As opined by Prušková, Dědič and Kaiser (2019), 293,000 people work in the Singapore construction industry in 2019. Migrant workers from India, Bangladesh, Myanmar and neighbouring countries work in the construction sites of the country. The construction industry contributed an amount of 12.1 billion SGD to the GDP of the country in 2019 (www.bca.gov.sg, 2021). Almost 8 billion SGD constitutes as Foreign Direct Investment in the construction works of Singapore (www.bca.gov.sg, 2021). In 2019, the construction works of the country used to grow at a 2.8% growth rate (www.bca.gov.sg, 2021). However, the outbreak of the COVID-19 pandemic has put a brake to the growth rate and somehow it came to a grinding halt.



Figure 2.2.1: Construction Demand 2019 in Singapore

(Source: www.bca.gov.sg, 2021)

The figure shows that the construction works in 2019 in Singapore requires a huge amount of capital to carry out its development. There are three main sectors of construction, as mentioned by Toh, Goh and Guo (2017), and they comprised of “*residential constructions*”, “*non-residential constructions*” and “*engineering constructions*”. In the Singapore Market Insight report, it is mentioned that the construction work of the country will be led mainly by the development of the public sectors. About 65% of the construction works in 2021 will comprise of the development of the public sectors (www.bca.gov.sg, 2021).

Many companies in the construction industry of Singapore are striving hard to build a reputation in the face of stiff competition, ultimately to increase their market standing. Among some of the local notable construction companies of Singapore, “*Paramount Eco Hub Pte Ltd.*”, “*KTC Group*”, “*Lum Chang Building Contractors Pte Ltd.*”, “*Hwa Seng Builder Pte Ltd.*”, to name a few, stands out. These companies along with many others have contributed to the growth and development of the country’s construction works. They have been in the forefront of innovation and development in the realms of construction project management with their expertise and the many years of established and proven experience.



Figure 2.2.2: GDP from Construction in Singapore in 2019

(Seymour, 2019)

The construction companies of Singapore have contributed significantly to the country's economy. Therefore, the Government should accord greater attention to their needs and understand the challenges that they faced. However, looking into the cases of construction development works of the country, each construction project is different from one another. The amount of complexity is different. Time required and taken for the completion of the project works are different. However, some commonalities can be found among them. As mentioned by Seymour (2019), one of them is that changes are inevitable in these project works. The changes in the construction projects and in their development are very common occurrences in Singapore. This causes certain negativity to the development of the construction work (Agyekum-Mensah and Knight, 2017). The project management of these constructions fails to meet the expected outcome or the deadline of the project development. There are various reasons behind the changes in the project development in the construction works, which poses many risks to a project's completion. The management of the project works would be disrupted and thrown into jeopardy. Hence, it is necessary to resolve this issue at an early stage. The earlier the issues are resolved, the chances of project failure would be reduced significantly.

Many companies have reported a lack in the use of digitalised methods to carry out construction projects. This can be deemed as a negative aspect of the Singapore construction industry. As mentioned in the study of Alaloul *et al.* (2018), many companies are taking the digital paths and methods to prevent failures in the construction industry. This will be a good starting point to stave off the problems that were stopping the construction works from growing effortlessly.

2.3 Impact of Digitalisation in the Construction Industry in Singapore

Construction works are one of the most complex works to be managed. It is a complete package of successful planning, engineering, project management and execution of the plan. In order to perform everything successfully and maintain the works of the construction projects in good order, it is imperative that construction firms switch to using digital methods (Seymour, 2019). 2021 has seen many hurdles that the construction industry needs to overcome globally, one of which is digitalisation. The development of technology and the advancement of software have brightened up the growth of construction works. In Singapore, digitalisation in the construction industry is comparably new. According to Bilal *et al.* (2016), the traditional methods of developing the construction works are still followed by many companies and worksites. People depend on the

physical methods of communication to resolve issues. Most of the construction companies are found to deliberately to either ignore or to take advantage of the benefits of using digitalisation methods.

Around the world, digitalisation is becoming the buzzword in the construction industry. The scope of development of construction works through digitalisation is widening rapidly. As opined by Chan and Owusu (2017), in order to enhance the efficiency of the construction projects and to increase their effectiveness and growth rate, digitalisation has been proven to be advantageous for the development of the construction industry. It also helps in creating sustainable constructions thus reducing the cost and increasing the environmental value of the products. However, companies still seemed to be hesitant to implement digitalisation for their projects in the construction industry. Digitising the information of the construction works also helps in keeping and storing them without any chances of getting distorted (Dutta, 2017). Digitising also helps in keeping, storing, accessing and sharing the data with the relevant personnel that are involved in the construction projects.



Figure 2.3.1: Impact of Digitalisation in the Construction Industry

(Source: LAU *et al.* 2019)

In Singapore, the construction industry is slowly undergoing a dramatic change in the way on how it works. It is beginning to accept the fact that using digital methods to carry out some of the project scope of the construction work would augur well for the project's success. As said by LAU *et al.* (2019), the process for the digitisation of the data and information related to construction has been

applied by many construction companies in the country. They understand that digitisation of the data would resolve the issues of information retention and sharing. Through digitisation it enables ease of access and use. The digitalisation methods along with the information about the construction works is well received by many companies and feedback given so far by companies is that the progress of construction works has been smoother and easier with the application of digital methods. Consequently, it has brought about some positive changes towards the project management processes. The digital transformation of project management is rapidly gaining importance in many companies' construction projects within the construction industry. According to Emmanuel, Omoregie and Koloko (2018), many companies have mentioned that the digital transformation of the project management processes has brought about increased revenue and enhanced performance. In Singapore, the construction companies that appreciate and understand the importance of the digital transformation of project management are found to have developed better communication network, enhanced strategies, are more informed, have structured collaborations and more successful outcomes than others (based on the study of Elghaish *et al.* 2020). It shows that the digital transformation of project management is beneficial for the growth of the construction industry as well as in the quality of its deliverables.

The result of digitisation, digitalisation and transformation of project management methods of the construction works has been beneficial for Singapore. As opined by Yin *et al.* (2018), the growth and development of sustainable cities and buildings are the results of applying digital methods to the construction industry. Aside from going green, the dawn of the digital era has provided Singapore with the technology know-how to develop buildings that would be eco-friendly and less harmful to the environment.

2.4 Value of Digitalisation in the Construction Industry in Singapore

The construction industry in Singapore is deeply associated with digitalisation. However, there are many entities in the construction industry that are still not acquainted with the digital methods and techniques that can be applied to the construction works in the country, despite digitalisation becoming more common and increasing in the number of applications. As suggested by Seymour (2019), digitalisation in the construction industry helps with project performance. With digitalisation, construction projects can be handled in a more efficient manner. In many constructions works, it is proved that the quality of the construction can be enhanced through

digitalisation. The analysis of the plan and the place where the construction will take place can be done easily through digitalisation. The compatibility of the project with the soil can be checked through digital methods. According to Aghimien *et al.* (2020), by using AI and other advanced technologies, construction works can be developed and enhanced further. Therefore, digitalisation can be seen as a process that can define the scope of development in construction works.

In Singapore, there are a significant number of companies that had implemented and adopted the digitalisation process in their projects. The construction works developed through digitalisation methods and digitalised project management works have produced a higher level of quality outcomes and deliverables. The efficiency of the work using digital approaches has increased (Agyekum-Mensah and Knight, 2017). There have been fewer delays in project completion, fewer failures of projects and fewer flaws in the project management works. With the transformation of project management, the construction works are developed with greater efficiencies via the digitalisation of traditional project management methods, coupled with the skills and experiences of the project managers. According to Bilal *et al.* (2016), digitalisation has made it possible for the projects to have higher quality infrastructure with eco-friendly features and characteristics that supports the sustainable approaches of construction works. Digitalisation has helped in developing projects in a more organised way. In Singapore, the advantages of digitalisation far outweigh the disadvantages as can be seen so far. Singapore values digitalisation because it has helped to increase the safety of the construction sites (Chan and Owusu, 2017). Through the digitalisation of project management processes, the construction sites can be kept safe and secured from any theft or other interruptions. It has also reduced the cost of construction works. With the rising prices of construction costs, digitalisation has helped companies in making cost-effective decisions in the selection of building and raw materials that would be more cost-efficient without sacrificing quality in the construction of buildings. Not only that, but digitalisation has also helped in producing higher profit margins by promoting digital automation in some of their works, by replacing physical, manual and mundane processes. As mentioned by Elghaish *et al.* (2020), it has helped in reducing the time of the project delivery and enhanced the project quality too. Singapore has realised the significance of digitalisation and many construction companies are presently training their staff to adopt the digitalisation processes in their work to increase their work efficiency level. So far results have shown that it has been effective in getting the attention of the companies and the progress made augurs well for the construction industry.

2.5 Changes in Project Management of Construction Works after Digitalisation

Singapore has slowly adapted to digitalisation in the construction industry. According to Peshkov (2019), with the initiative of the Singapore government, the construction industry in the nation is slowly moving towards the adoption of digitalisation. The government has initiated the training of employees, who will be trained to be equipped with the necessary technical skill set and knowledge to perform their daily tasks in a digitalised environment. This is a great initiative as the companies will be benefiting from this initiative. **BATU** (Building Construction and Timber Industries Employee Union) has ensured that the training would help the employees to know the ***digital skills applicable for design and build, construction and inspection of the construction sites and safety aspects***. According to Emmanuel, Omoregie and Koloko (2018), this shows how digitalisation has brought about positive changes to the construction project management. Many companies have opted for **Digital Management Offices** which include **BIM** (Building Information Modelling), **AR** (Augmented Reality) and **VR** (Virtual Reality). After the implementation of digitalisation, construction companies are now trying to look into more effective ways on how to tap on the various digital methods for their construction works. Drone technology is one of them. Project management in construction works is increasingly being taken care of through digitalisation. This includes supply chain management as well. As opined by Kudryavtseva and Vasileva (2020), the data of the construction works are kept through digitisation. The digital texts and information are kept and treated as valuable assets of the construction work. The trained employees, who know how to work with the digital methods, are assigned to the works based on their knowledge and efficiency (Liao, Teo and Chang, 2019). This has increased the scope of earnings for many employees.

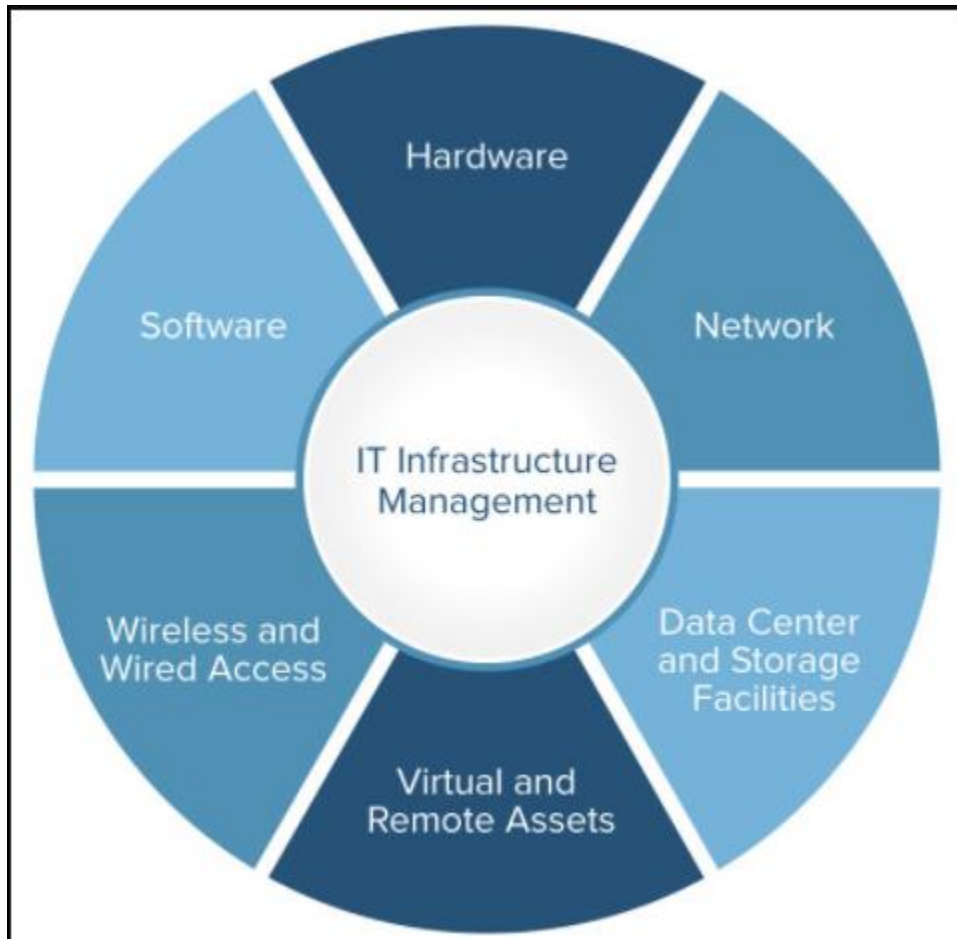


Figure 2.5.1: Digitalisation in the Construction Industry

(Source: Elghaish *et al.* 2020)

After digitalisation took place in Singapore's construction works, the focus has been shifted to fixing the problems faced by the assigned employees in this digital environment. There is no longer a need to employ and utilise IT solutions or IT experts to provide solutions to some of the common problems after digitalisation. As mentioned by Elghaish *et al.* (2020), through digitalisation it has been possible to recruit large number of workers and employees in a construction site while carrying out the collaboration works with other companies as well. As a result, construction works in Singapore have been more organised and structured, particularly in the areas of planning and development.

2.6 Growth and Development of Construction Work with the Adoption of Digitalisation

The adoption of digitalisation in construction works has changed the ways on how the construction projects are run. As opined by Mhetre, Konnur and Landage (2016), digitalisation has addressed some of the aspects of risk management in the construction industry. Prior to digitalisation, the construction works used to get disrupted due to the inadequacies of traditional processes in project management and construction development. The issues regarding the construction project management and development have been lessened with the adoption of digitalisation. As mentioned by Daniotti, Gianinetto and Della Torre (2020), it has increased the chances of using sustainable approaches to construction works. The development and planning of project works that are appropriate for eco-friendly construction, can be delivered through digitalisation. The compatibility of the construction plan can be checked through the use of digital methods. The supply chain management can be performed using the digital applications. The project works are monitored through a digital progress tracking system and these employees can be assigned and communicated through digital platforms. All these would not be a reality if not for digitalisation.

Singapore has been very adaptive in its digitalisation process in certain circumstances. The high number of fatalities in the construction sites which is a critical issue can be resolved with digitalisation. With the application of digital monitoring, the companies have been successful to some extent in reducing the fatality rate. The implementation of AI in the construction project management has been helpful in analysing the past data of the construction works of the company. As opined by Peshko (2019), AI identified the areas that had flaws which pose a risk to the entire project and environment. It helped in nullifying further risk from the same issue for future construction works. In short, Singapore has successfully applied digitalisation in its construction industry and construction works can be carried out without a repeat of the past mistakes by utilising the digitalisation process (Liao, Teo and Chang, 2019). Digitalisation in the construction industry has also enabled construction companies in Singapore to share knowledge and experience of the construction development works with one another. It has not only increased the chances of knowledge sharing, but also help to develop and define the scopes of identifying flaws communally.

2.7 Positive Changes in the Construction Industry in Singapore

Digitalisation has brought about a number of positive changes in the construction industry in Singapore. It has led the project managers as well as the projects to benefit from the introduction of digitalisation. There have been several benefits that have come from the use of ICT tools. The ICT tools help in saving time in many cases as well as in making the process of the project works to be more efficient. ICT tools help in storing the documents in a structured manner. As stated by Aghimien *et al.* (2020), it helps the project manager and the stakeholders to look for the necessary document in the right places. More knowledge is gained regarding controlling and structuring work with the help of the ICT tools. The role of the project manager also changes over time with the help of digitalisation.

BIM technology is used in order to save time. BIM technology helps in saving time by lessening the alterations and revisions as well as the additional work required. The project managers have to deal with several additional tasks which require a significant amount of additional time. With the help of digital meetings, communication barriers can be broken down and provided the much-needed conveniences for everyone in the company aside from saving time and effort. Meetings are now just a zoom-call away. Technology also helps in resolving any problem that surfaces because of locational boundaries. According to Agyekum-Mensah and Knight (2017), the transportation time, as well as the possibilities of the participant's inability to join the meeting, is also mitigated. ICT tools are helpful when the team members and the stakeholders are separated by geographical distances. It also helps in recruiting experts from different areas in order to increase the project's competency level and also increase the "quality of work" produced.

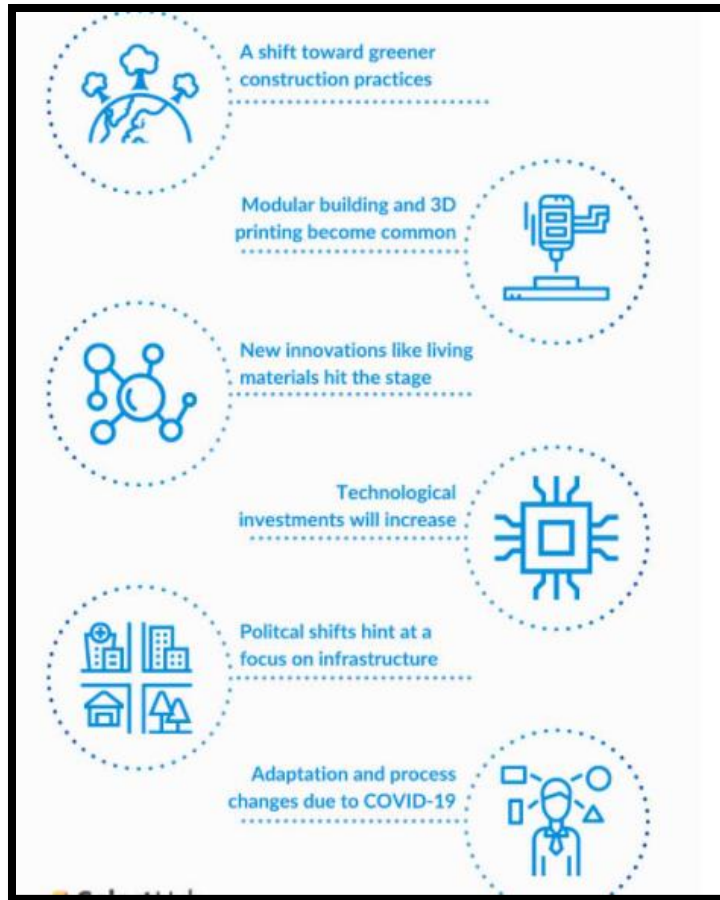


Figure 2.7.1: Trends in the Construction Industry

(Source: Alaloul *et al.* 2018)

There are communication benefits of using ICT tools. The tools enable the members to have different “chat functions”, which helps in having digital meetings on digital platforms. It helps in resolving issues and conversations can be recorded and “saved” for future references. BIM is also helpful and provides many advantages from the communication perspective. With the help of BIM, the project can use 3D modelling that helps in simplifying the communication process by giving a visual of the finished project (Alaloul *et al.* 2018). This is considered to be a benefit for the client and the project manager, and helps in the creation of a common goal and vision. Coherence and coalesces are created among the team and the organisational objectives are also specified. With the increase in integration, the benefits of communication can increase as well.

BIM also helps in the detection of clashes during the early stages of the project. This is helpful for enhancing the quality of the project as well as reducing its risks. More control is established in the hands of the project manager regarding the end product. BIM also influences cost management positively. The BIM's maturity model is connected to the cost management for the project as well (Chan and Owusu, 2017). Thus, digitalisation has a crucial and positive effect on the projects of the construction industry in Singapore.

2.8 Challenges Faced by Project Managers in Coping with the Digitalisation of the Construction Work Management Process

Digitalisation and technology come with several advantages which are helpful in enhancing the processes in the construction industry and producing works that are more efficient. It also helps with bringing out the most effective way to achieve the goals of the organisation. However, there are also a number of challenges that are faced by the project managers while coping with the digitalisation of the various processes of construction work management.

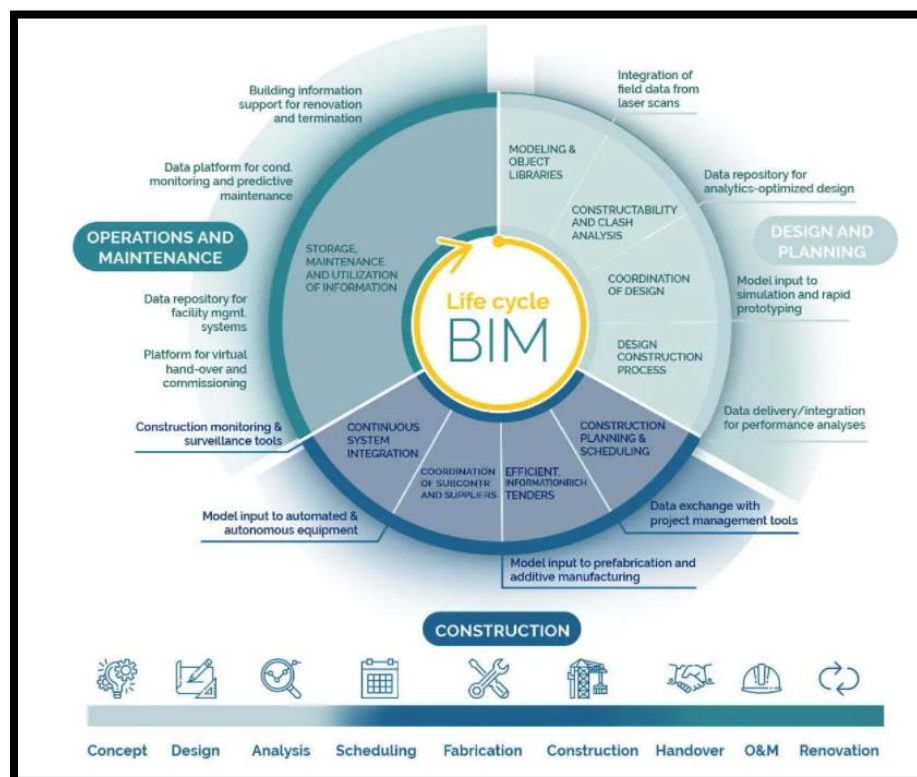


Figure 2.8.1: Lifecycle Management in BIM

(Source: Chan and Owusu, 2017)

- Digital tools are used for the organisation of digital meetings to enhance communication within projects. However, it is difficult to maintain the focus of the participants of the meetings. It is not possible for the project manager to know if the participants are attentive. A physical meeting is more “captivating” than a digital meeting. A digital meeting would present obstacles regarding opportunities for display of body language, facial expressions, and gestures (Kudryavtseva and Vasileva, 2020). Often poor network connection during video conferences challenges the attentiveness of the participants too.
- The spontaneity of communication decreases with the help of the ICT tools. Without the existence of the physically spontaneous meeting, it becomes difficult for the co-workers to gain knowledge from each other.
- Lack of cooperation and integration from all the stakeholders involved in the project is one significant challenge. The stakeholders are used to the traditional techniques of the construction industry and do not tend to cooperate with the rest of the management regarding the inclusion of technologies in the construction industry.
- Tough time pressure and lack of standardisation pose challenges as well. The environment of construction is a “tight and dynamic project environment”. Without proper standardisation, problems arise as there are risks involved on a sectorial basis. The construction industry of Singapore is dynamic and evolves very rapidly. The standards need to be implemented rapidly in the processes of data management and others during the procedure of digital transformation (Peshkov, 2019). Proper scrutiny helps in “uninterrupted interactive communication” with the suppliers of the company.
- The absence of technical resistance like traditional staff and access to the internet is another challenge faced. The main objective of digitalisation is to decrease the dependency on manual labour. However, in order to reap these benefits, it is essential to understand and prioritise the required software. According to Mhetre, Konnur, and Landage (2016), a competent team needs to be recruited to establish the “IT change process” properly. The existing staff is often unable to keep up with the digital change which increases the risk of failure and slows down the process of transformation.

- Problems of cultural resistance to change mindset also pose a challenge in the process of digitisation. The traditional employees who are used to the existing traditional practices might put up a strong resistance to the digitalisation of the processes of the construction industry. This poses problems to the project managers in coping with digitalisation.
- “Return on Investment (ROI)” needs to be considered for the performance of the “cost-benefit analysis” in the process of investment (Liao *et al.* 2019). Support from top management is essential for digital transformation in order to increase efficiency and reduce costs.

2.9 Theoretical Perspective

Theories of Construction Project Management

Theories are the “*theory of planning*”, “*theory of execution*” and “*theory of control*”. According to the theory of planning, there is a concept behind it. It states that there is a “managerial part” and an “effectors part” in a project. The “managerial part” does the planning of the project, while the “effectors part” plays the role of translating the “resultant plan into action”. According to Mhetre, Konnur, and Landage (2016), the next part “execution” is followed for despatching the work to different workstations. Here authorisation is needed for the execution of the tasks. The third is the theory of control. Here the need to control the process is justified. In this sense, the unit of measuring the performance and control is aggregated so that greater accuracy can be reached along with standard performance.

This theory is important in the case of this research because the whole process of planning and execution of a project is clarified here. It is essential to perform proper planning of a project, which includes planning of the process of execution (Mhetre, Konnur, and Landage, 2016). The determination of the accuracy of the planning process is also necessary in this research.

Theory of management	Theory of planning	Conceptualization: There is a managerial part and an effector part in the project; the primary function of the managerial part is planning, and the primary function of the effector part is to translate the resultant plan into action. Principles: 1 Knowing the current state of the world, the desired goal state, and the allowable transformations of state that can be achieved by actions, a series of actions, the plan, can be deduced. 2 The plan is translated into reality by the effector part of the organization. Assumptions: 1 Translating a plan into action is a simple process, by following directions. 2 The internal planning of a task is a matter of the person to whom the task has been assigned
	Theory of execution	Conceptualization: Managerially, execution is about dispatching tasks to work stations. Principle: When, according to the plan, the time has arrived to begin task execution, it is authorized to start, in speech or in writing. Assumptions: 1 The inputs to the task and the resources to execute it are ready at the time of authorization. 2 The task is fully understood, started and completed according to the plan once authorized.
	Theory of control	Conceptualization: There is a process to be controlled, a unit for performance measurement, a standard of performance and a controlling unit (thermostat control). Principle: The possible variance between the standard and the measured value is used for correcting the process so that the standard can be reached Assumptions: 1 The process is of continuous flow type, the performance of which is measured at aggregate terms 2 The process can easily be corrected by the control available.

Figure 2.9.1: Theories of Construction Project Management

(Source: Mhetre, Konnur and Landage, 2016)

Bew-Richards Model for BIM Maturity

The “***Bew-Richards Model for BIM Maturity***” is also an important concept in the case of this particular research. It is a model that is helpful for a higher level of lifecycle management of construction projects in the digital era. The model consists of “four levels”, “level 0 up to level 3”. Level 0 is “almost no BIM maturity at all”, and level 3 is the “highest with different kinds of integrated BIM:” This is where “lifecycle management” is implemented (Chan and Owusu, 2017). This model has been extremely helpful in the integration of BIM technology in the construction industry of Singapore. This model has been helpful in leading the industry onto the path of digitalisation.

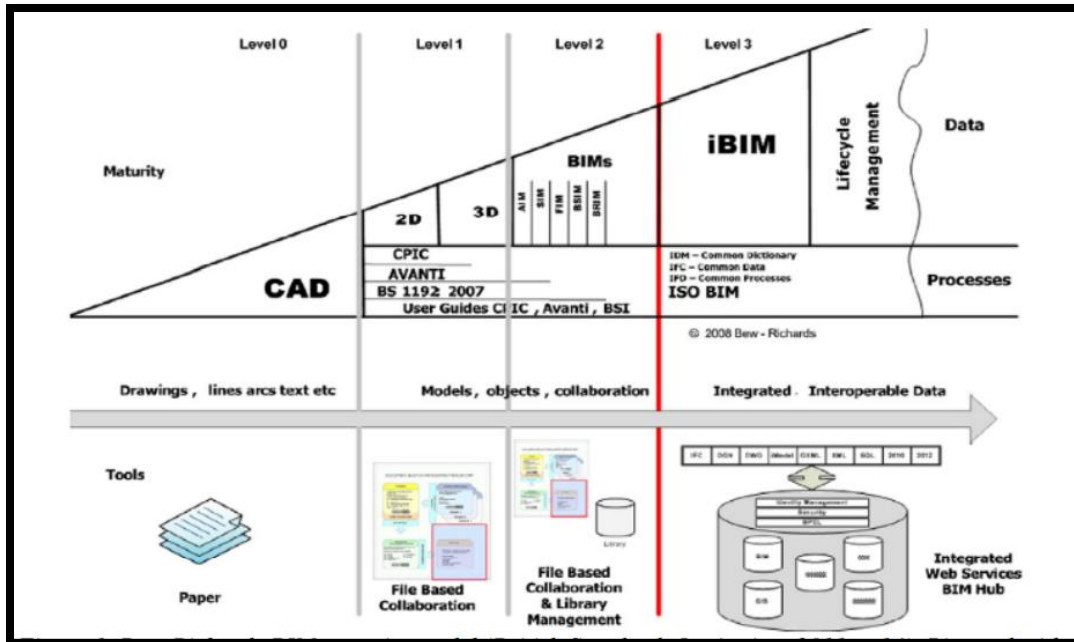


Figure 2.9.2: Bew-Richards Model for BIM Maturity

(Source: Chan and Owusu, 2017)

2.10 Conceptual Framework

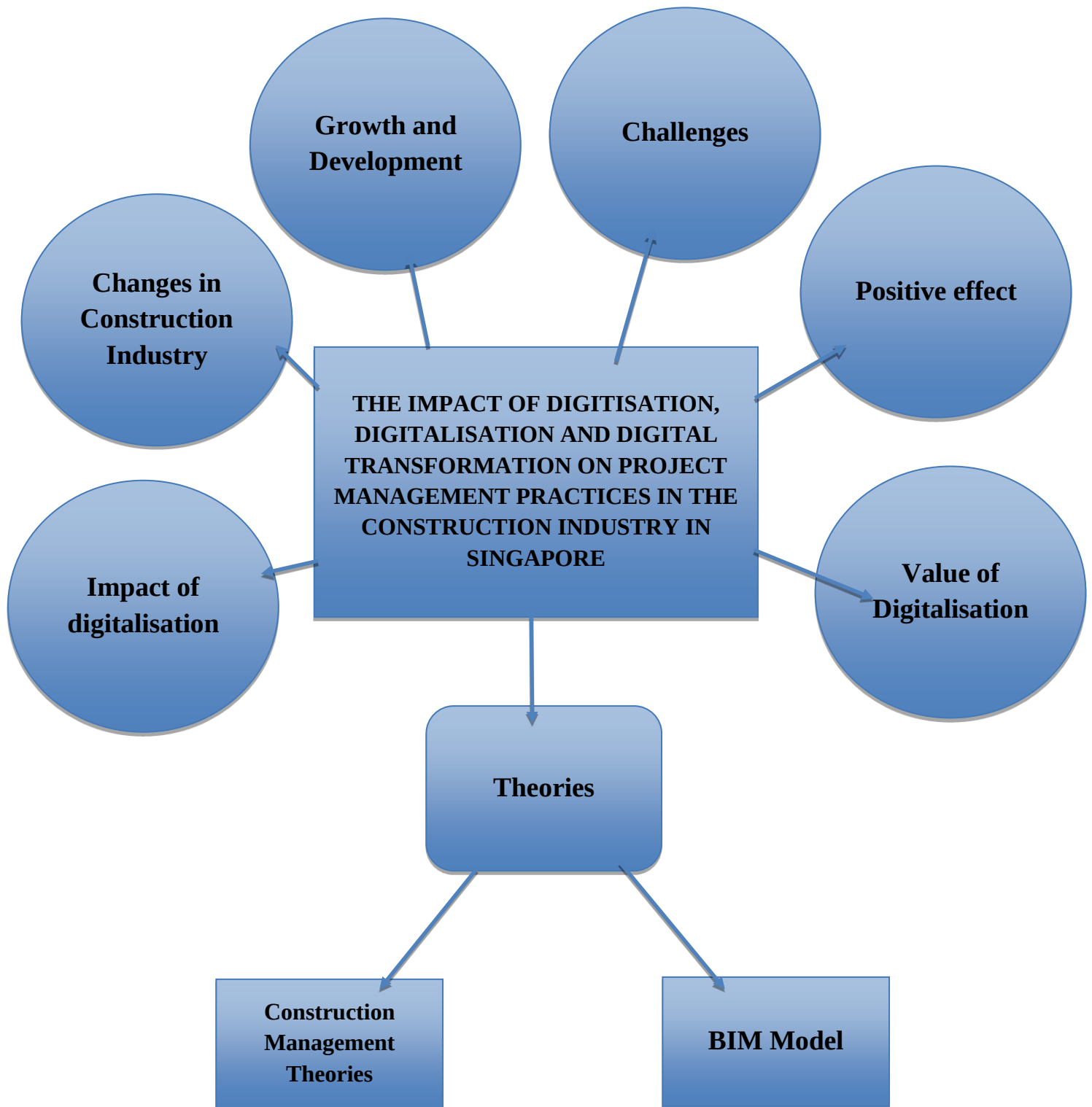


Figure 2.10.1: Conceptual Framework

2.11 Literature Gap

The study has shown how digitalisation has brought about positive changes and increased efficiency in the construction industry of Singapore. However, the study fails to show whether the digitalisation is proven to handle the construction works in the long term. It also fails to show whether the companies and the employees who are being trained to work with the digital methods are actually able to work efficiently after the training. This chapter also has a very brief description of the literature of selected authors. Their thoughts and perspectives are shared in the study, which can differ from one another.

2.12 Summary

In the literature review section of the dissertation, the published literature in the field of the current research has been discussed in order to extract data and gain knowledge regarding the various aspects and impacts of digitising the processes of the construction industry in Singapore. An overview has been provided on the construction industry of Singapore. The impact of digitalisation in the construction industry in Singapore has also been discussed. The value of digitalisation in the construction industry in Singapore has been evaluated along with the changes in project management of construction works after digitalisation. The growth and development of construction work with the adoption of digitalisation have been discussed. The positive changes brought about in the construction industry in Singapore with the help of digitalisation and the challenges faced by project managers to cope with the digitalisation of the construction work management process has also been discussed in detail. A theoretical perspective has also been given in the literature review where the relevant theories have been discussed.

Chapter 3: Methodology

3.1 Introduction

This chapter of the dissertation gives detailed information regarding the methods and processes that have been used in order to conduct the research. The philosophies, designs, approaches, strategies, sources, and types of data and other details that have been used for the conduct of the research have been discussed here. The population and sampling have been mentioned as well as the data analysis plan has been discussed in detail. The milestones and the timeline have also been provided in this section.

3.2 Method Outline

Key Components	Chosen Attributes
“Research philosophy”	Realism
“Research approach”	Deductive
“Research design”	Descriptive
“Data source”	Primary and secondary

“Data collection techniques”	Interview and journal review through mixed method
“Population and sampling”	2 managers each from 3 different companies have been chosen for an interview
“Data analysis plan”	Qualitative

Table 3.2.1: Method Outline

3.3 Research Onion

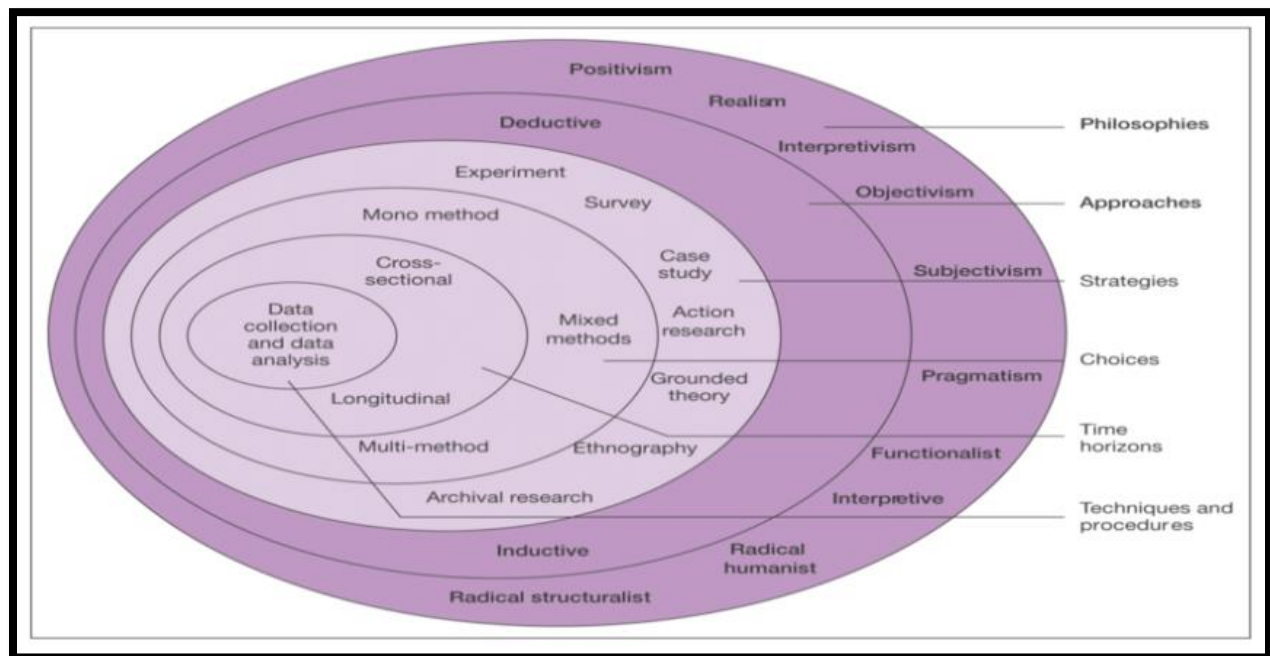


Figure 3.3.1: Research Onion

(Source: Saunders *et al.* 2015)

3.4 Research Philosophy

Research philosophy is an important part of the research methodology. It is a belief regarding the way that data shall be “gathered, analysed, and used” regarding a phenomenon. There are generally four different types of research philosophies that are used in the case of research work. They are “Realism research philosophy”, “Positivism research philosophy”, “Interpretivism research philosophy”, and “Pragmatism research philosophy”. In the case of this particular research, the “Positivism research philosophy” has been used. This research philosophy has been used in the case of this research because here the researchers can think freely as well as separately regarding meeting the objectives of the research. Here the researchers can consider the methods of the research in an argumentative manner. This research philosophy has been used as it is the most compatible with qualitative research (Taherdoost, 2016). The causal processes are verified with the qualitative methods in this case. The validity is inferred from the methods of extracting the data.

The other research philosophies have not been used in this research as they were not deemed to be appropriate and in line with the methods of this research. Realism has not been used as it regards only factual knowledge which is generally obtained from quantitative data. The researcher in this case interprets the data in an objective manner and limits his role to data collection. Interpretivism has not been used as it depends on the researcher’s view of the social world but here the view of the managers has been taken into consideration (Igwenagu, 2016). Pragmatism has not been used as it also dwells on facts and figures, whereas this research is based on qualitative analysis of data. Thus, positivism is the most appropriate choice.

3.5 Research Approach

The research approach is the procedures and plans of the research that traces the steps starting from broad assumptions to the “detailed methods of data collection, analysis and interpretation”. The two groups of research approaches are the “inductive research approach” and “deductive research approach”. In the case of this research, the “deductive research approach” has been used.

The “deductive research approach” has been used in this case as the researcher is deducing the findings from the research. An interview is being conducted from which the opinions of the managers of the three different construction companies are taken into consideration. According to Kumar (2018), data is also extracted from the secondary sources of literature that have been published regarding this topic. Information has been collected and the results have been deduced from the sources. The interview has been conducted and themes have been developed from the outcomes of the interview to fulfil the objectives of the research. The deduction has helped in answering the questions that have been provided by the research.

“Inductive research approach” has not been used in the case of this research as new theories are built with the help of this approach. In this research, only ideas have been deduced and new theories or ideas have not been induced. The main aim of the “inductive research approach” is the development of a new theory which is not the case of this research. In this research, the “deductive research approach” has been used as the existing theories have been tested and strengthened. The “inductive research approach” has not been used because the specific observations are generalised more broadly. Whereas, in the case of “deductive research approach”, the generalised observations of a topic are scrutinised in order to find out specific results.

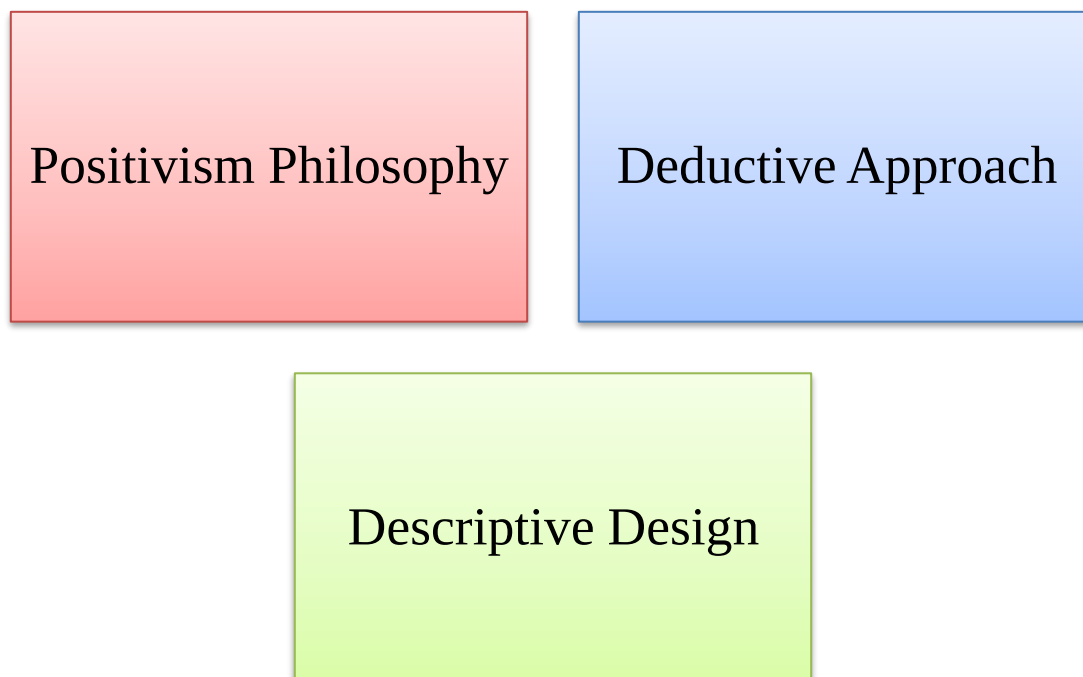


Figure 3.5.1: Selected Research Strategies

3.6 Research Design

The research design is the strategy through which the various elements of a study are integrated with each other in a logical and coherent manner. It helps in the effective addressing of the research problem and it is a part of the blueprint of the measurement, together with the collection as well as analysis of data. There are generally three different kinds of research designs. They are “exploratory research design”, “explanatory research design” and “descriptive research design”. In the case of this particular research, the “descriptive research design” has been used (Kumar, 2018). “Descriptive research design” has been used in this case as the population has been systematically and accurately described here. The descriptions regarding the findings of the research have been provided in order to understand them as well as to provide answers to the research questions in hand.

The other research designs have not been used because of a few reasons. The “explanatory research design” has not been used because here explanation has not been given regarding the interviews or the literature. Descriptions have been given of the themes that have been formed from the results of the interview and the journal review (Snyder, 2019). Exploratory research design has not been used as new ideas and theories have not been explored in this case as well. Thus, “descriptive research design” is the most appropriate choice for this research.

3.7 Research Strategy

This research is mainly focused on the construction industry and the throughputs of the decision clearly lie on the fact where **interview studies** are to be made. In this primary qualitative research, data can be evaluated with the factual bifurcation of the overall response. In order to justify this strategy, it can be stated that an “**attempt**” has been made “**to record and analyse the critical events**” encountered at the specified geo-locations (Nayak and Singh, 2021). In this way, the managers’ paradigms and their decision making can be evaluated in the course of research. The strategy must be divided into **6 different stages** which can be stated as:

- “**Identification and Defining the Problem**”: This will help to attain an overall understanding on the basis of which a point of concentration can be made. As opined by Seymour (2019), based on the impacts of digitisation, there is a high likelihood that it

would yield both positive and negative effects, which would serve as the basis for further analysis.

- **“Composing Statement of Research Objectives”:** This will help to narrow down the specific areas where the major work will be made, hence the desired outcomes for which this research is to be constructed can be identified.
- **“Planning the Research Design”:** In this way, a cumulative understanding can be obtained on the standardised way of approaching this research (Weber, 2017). Considering it will help to maintain a guided approach for structuring the overall study.
- **“Planning of Sample”:** This has been already identified where a depth understanding of respondents will be made in such a situation (Nayak and Singh, 2021). What and how much to be used from the responses can be determined in such aspects.
- **Data Collection:** Required primary and secondary sources of data be collected further so that deeper research can be made. Based on the data collected further process can be carried out.
- **“Discussion, Conclusion and Recommendation”:** This will be a composite step for determining the overall discussion and analysing the data so that it can be formulated into information (Weber, 2017). In this way, results can be obtained in respect to its proper recommendation and suggestion.

3.8 Data Sources and Data Types

In every research data source is the basis on which this research will be constructed hence it is essential to determine the source required for commencing this study. There are mainly two types of data sources: **Primary and Secondary** sources, thus, mixed method approach has been used. In this study, primary and secondary **both have been utilised**. Taking into account of the facts that primary sources content will help to provide **“a first-hand account of an issue”** (Nayak and Singh, 2021), persons who are involved in the construction industry can provide such data, thus primary sources are important for this discussion. In this way, by involving a decent amount of **time** through which the outcomes of discussions can be accumulated, an average response can be formed and be identified. In the case of secondary data sources, it will help to **synthesise, interpret and evaluate processes** of existing studies that have been made in a similar field (Kumar, 2018). In

this way *describing and explaining* the primary sources can be made. Ultimately, a clear identification can then be obtained. Hence, both sources are required for this study.

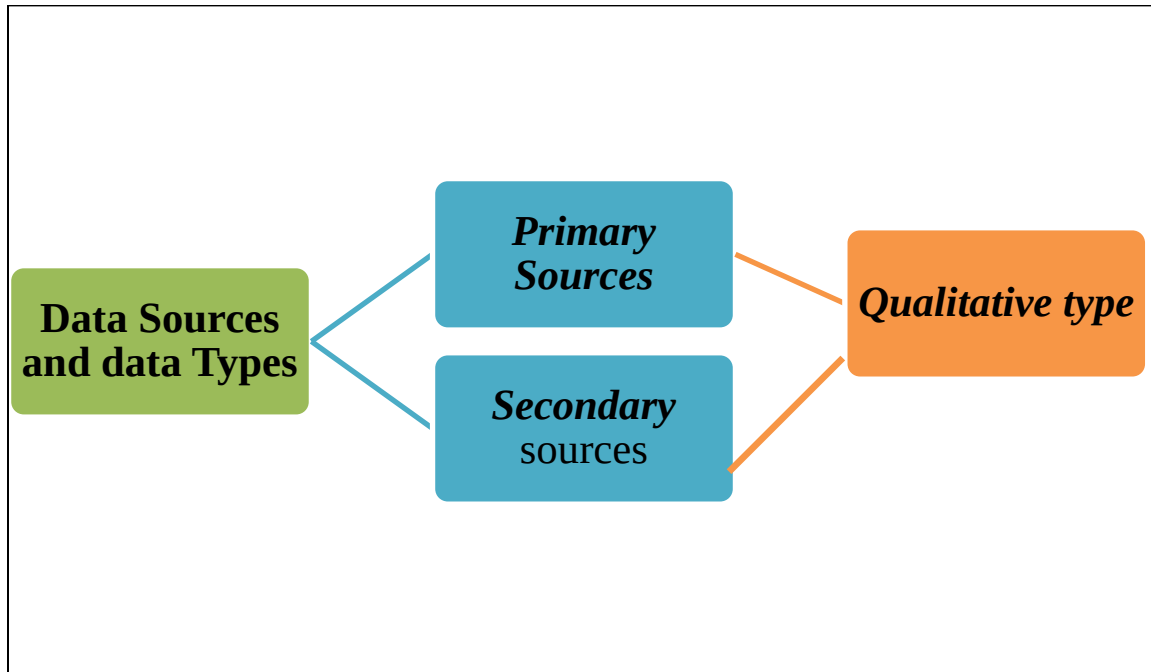


Figure 3.8.1: Data Sources and Data Types

An overall understanding of the sources has been obtained whereas there are mainly two types of data: *“Quantitative” and “qualitative” types which are considered as mixed method.* In this study, one type will be utilised which is the *“qualitative” type* of data. In this way *“research can be carried out in detail”* using a concentrated and focused approach (Nayak and Singh, 2021). Also, vast differences can be ironed out to meet the research objectives. In addition, a *flexible* way of commencing the research can be made as well. The most important concern for choosing a *“qualitative”* type is to understand *“human observations and experiences”* which can be aligned to this study (Weber, 2017). Highlighting the merit of qualitative research will help to *anticipate* the outcomes prior to analysing it.

3.9 Population and Sampling

In this way, an understanding can be obtained where *“KTC Group, EX Design Build & Construction Pte Ltd and Wan Chung Construction (Singapore) Pte Ltd”* have been identified as the sources of primary data in the form of an Interview (Seymour, 2019). *Two managers from each of the companies* will be interviewed, hence a cumulative understanding can be obtained

from the responses. In this way, a proper **assessment of the issue** can be maintained. As opined by Seymour (2019), determining the overall obsolescence of actual data and the gap they are facing while implementing a digital approach can be obtained. Aside from the facts, the busy schedule of the managers needs to be taken into consideration. Hence time is of the essence, which is why the other approach will not be a feasible option for them.

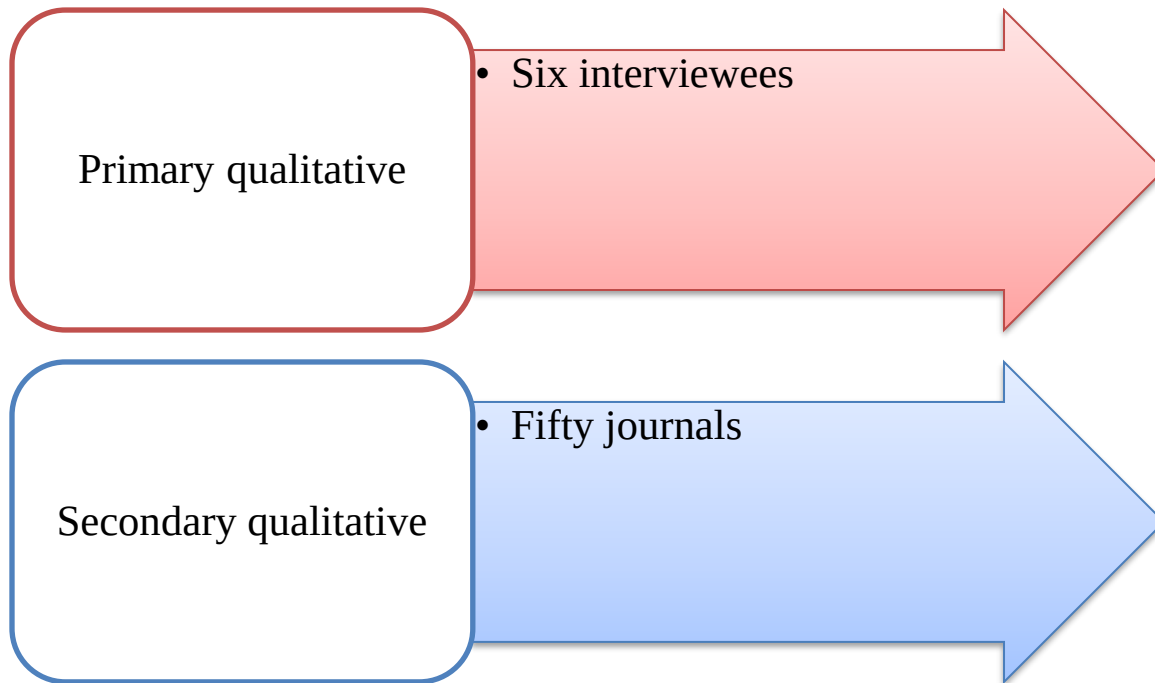


Figure 3.9.1: Sample Size and Population

A **range of choices** can be identified while responding to the same question hence a standardised response or irregularities can be determined. In this way, **specific questions** have been asked to every manager so that different scales and obligations of business in the construction industry can be determined. In this way, determinants can be identified where "**responses to be rendered in order to obtain a clear context**" (Nayak and Singh, 2021). Along with the fact "interviewees of the same questions" will be asked hence a focus can be established. In order to collect **secondary data**, **fifty journals** have been shortlisted.

3.10 Data Collection Process

Interview Transcripts have been designed for **primary qualitative data** collection. In this aspect "**collection of data by asking questions**" will be made (Taherdoost, 2016). Along with facts,

listening skills will be utilised so that **decoding the data** properly and noting it in the transcript accordingly can be made. In this way, writing modules will be utilised where the information noted will be directly typed into transcripts for later phases of analysis. Each of the managers will be asked **4 open-ended questions** hence further processes will be carried out similarly.

In the case of **secondary qualitative data**, it is essential to understand that “**newspapers, a government website, digital index, journals and articles**” are to be used (Igwenagu, 2016). In this aspect, 50 different sources **of existing research work** will be encountered under this situation. In the case of government websites and digital indexes, Singapore's official websites operated by the government will be utilised. On the other hand, sourcing journals and articles from sources like Google Scholar and Microsoft Academic will be beneficial for this study. A major aspect that can be stated is that the most recent literature and **not more than five years of publication** will be used in this study (Taherdoost, 2016). This will help to standardise regularity while using such information. Effectively utilisation of data and aligning with primary sources is essential and it can be made in such a way that surveys were commenced by other researchers so that statistical aspects are to be identified.

3.11 Data Analysis Plan

It is highly imperative to understand the data analysis plan as it is a **roadmap on how the analysis and evaluation** are to be made (Snyder, 2019). Initially, planning of analysing primary and secondary data can be structured with **theme development**. In other words, it can be stated that thematic analysis will be the data analysis plan through which overall evaluation will be made. **Different theories** can be aligned with raw forms of data so that utilising them to structure the study can be done. In this way Analysing **big texts** will be possible, and short and easily understandable outputs can be presented. As the literature has volumetric complexity hence developing themes will help to **synchronize** every aspect of the research objectives. In this way, an observation can be made in the sense that “**Theoretical and personal knowledge**” both can be aligned at the same time to establish the task simultaneously in order to conclude the study (Igwenagu, 2016). Major commencement of “**identifying, analysing and interpreting patterns**” on the existing literature will be allowed under this prospect of analysis through which a standardised framework of research can be obtained. As opined by Seymour (2019), in this way

outputs that will arrive at the end of this discussion will satisfy both “*philosophical and conceptual*” paradigms.

Furthermore “*framework, transcript and matrix analysis*” of the interview transcript can be made so that verbal observations can be structured into information that will have the potential to justify research objectives. In this way “*organising and analysing*” of interview data can be done (Mohajan, 2018). Cross-reference mode of commencing the research to “*achieve the objectives that relate to the research aim*” can be determined and presented at the end of the discussion (Igwenagu, 2016). Smaller fragments can be made so that analysis is easier for the overall situation of the construction industry and to determine the acceptance of digital tools usage in Singapore.

3.12 Ethical Consideration

Accumulating the data from both the sources requires certain ethical considerations which can be stated as:

- Keeping confidentiality throughout the discussion where personal information such as the name and identity of the respondents has been kept confidential. In this way, only the responses and company designation has been disclosed throughout this study.
- Followed by the legal sources of data that are accessible and do not contain any sensitive information (Snyder, 2019). This rule has been strictly followed so that information such as the future plans of the company, marketing strategies and pre-formed or fundamental blueprints have been excluded in this research.
- Data Protection Act and any legal requirements of the legislations have been complied with in this study so that the maximum amount of truthfulness can be attained (www.gov.uk.com 2021). Along with the fact, rules and rights of the actual author can be preserved in this way hence this study will have a universal acceptance.
- Proper referencing has been followed throughout this study where principles and values of the actual work can be preserved (Mohajan, 2018). In this way, works of the actual author can be recognised by giving proper referencing to the literature. In this way, it will help to refrain from any conduct, whether intentional or unintentional, and infringements against any specific organisation or individual.

3.13 Limitations of Methodology

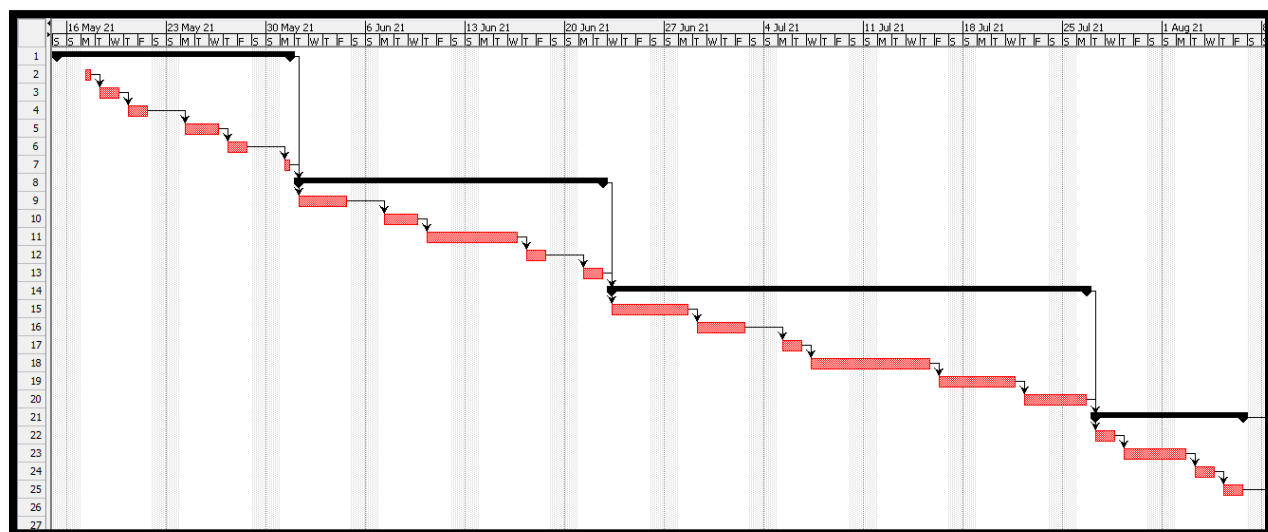
I must state the following aspect which I think act as a refrain to this discussion where “***design of methodology***” is bound to have differences as there are many approaches that can be considered while constructing the most ideal research method. In this way, abbreviated output could have been obtained if other approaches can be considered in this situation. It can be stated that it might have “***influenced the interpretation***” where overall objectives and legalities are obstructed due to such reasons. Stating the facts where interoperation can pull the chain of commands together and where overall finding might get differed in such a situation are important.

“***Initiating***”, the fact where “***research philosophy***” is the paradigm that pulls every string, helps in deciding the chosen method. In this aspect, choosing other alternatives could have changed the approach of commencing this study. It can be stated that the methodology chapters do not contain any “***suggestions for further research***” hence it can act as a potential boundary of obstruction to make this study as a reference to other researchers. Understanding the research problem was unclear whereas determination was based on existing studies. This might constitute as a differentiated measure and also becomes a hindrance for the commencement of this study in a proper manner.

3.14 Timeline

		Name	Duration	Start	Finish	Predecessors
1		introduction	11 days	15/5/21 8:00 AM	31/5/21 5:00 PM	
2		selection of the topic	1 day	15/5/21 8:00 AM	17/5/21 5:00 PM	
3		identifying aim and objectives	2 days	18/5/21 8:00 AM	19/5/21 5:00 PM	2
4		developing research questions	2 days	20/5/21 8:00 AM	21/5/21 5:00 PM	3
5		significance analysis	3 days	24/5/21 8:00 AM	26/5/21 5:00 PM	4
6		problem analysis	2 days	27/5/21 8:00 AM	28/5/21 5:00 PM	5
7		rationale of the research	1 day	31/5/21 8:00 AM	31/5/21 5:00 PM	6
8		literature review	16 days	1/6/21 8:00 AM	22/6/21 5:00 PM	1
9		developing themes	4 days	1/6/21 8:00 AM	4/6/21 5:00 PM	7
10		identification of literatures	3 days	7/6/21 8:00 AM	9/6/21 5:00 PM	9
11		discussion of the themes	5 days	10/6/21 8:00 AM	16/6/21 5:00 PM	10
12		conceptual framework	2 days	17/6/21 8:00 AM	18/6/21 5:00 PM	11
13		identifying gaps	2 days	21/6/21 8:00 AM	22/6/21 5:00 PM	12
14		methodology	24 days	23/6/21 8:00 AM	26/7/21 5:00 PM	8
15		identifying research methods	4 days	23/6/21 8:00 AM	28/6/21 5:00 PM	13
16		selecting the sample	4 days	29/6/21 8:00 AM	2/7/21 5:00 PM	15
17		developing interview question	2 days	5/7/21 8:00 AM	6/7/21 5:00 PM	16
18		conducting the interview	7 days	7/7/21 8:00 AM	15/7/21 5:00 PM	17
19		extracting interview data	4 days	16/7/21 8:00 AM	21/7/21 5:00 PM	18
20		recording bothe primary and secondary data	3 days	22/7/21 8:00 AM	26/7/21 5:00 PM	19
21		results	9 days	27/7/21 8:00 AM	6/8/21 5:00 PM	14
22		extracting the interview data	2 days	27/7/21 8:00 AM	28/7/21 5:00 PM	20
23		developing themes for secondary analysis	3 days	29/7/21 8:00 AM	2/8/21 5:00 PM	22
24		extracting data	2 days	3/8/21 8:00 AM	4/8/21 5:00 PM	23
25		linking with qualitative data	2 days	5/8/21 8:00 AM	6/8/21 5:00 PM	24

26		analysis and discussion	13 days	9/8/21 8:00 AM	25/8/21 5:00 PM	21
27		analysis of the qualitative data	5 days	9/8/21 8:00 AM	13/8/21 5:00 PM	25
28		thematic analysis	5 days	16/8/21 8:00 AM	20/8/21 5:00 PM	27
29		discussion of the results	3 days	23/8/21 8:00 AM	25/8/21 5:00 PM	28
30		conclusion	8 days	26/8/21 8:00 AM	6/9/21 5:00 PM	26
31		summarizing observations	2 days	26/8/21 8:00 AM	27/8/21 5:00 PM	29
32		linking with objectives	3 days	30/8/21 8:00 AM	1/9/21 5:00 PM	31
33		identification of the limitations	1 day	2/9/21 8:00 AM	2/9/21 5:00 PM	32
34		recommendations	1 day	3/9/21 8:00 AM	3/9/21 5:00 PM	33
35		final submission	1 day	6/9/21 8:00 AM	6/9/21 5:00 PM	34



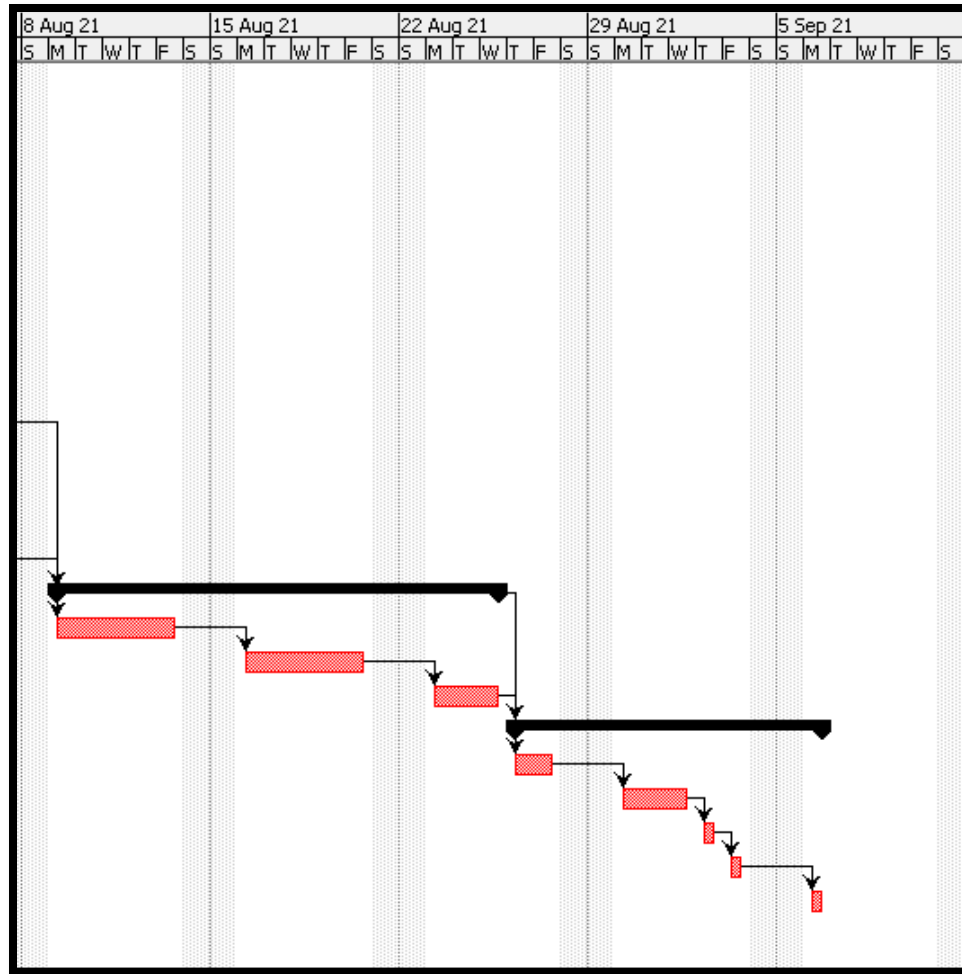


Figure 3.14.1: Research Timeline

3.15 Summary

The chapter on Methodology has been structured in a way so as to determine the fundamental on which the overall discussion will be organised. In this aspect, the analysis of the facts of the data gathered and process to identify the actual sources has been determined. Along with it, a structured way of understanding the philosophy and approach of this research has been ascertained as well. To understanding the facts and data better, a compilation is made on the data source and types on which this research is premised on. On the other hand, proper justification has been provided on the choice of methodology, and why it is optimal for this study. The limitations encountered have been identified and are taken into consideration while developing this chapter, and how it has influenced individual understanding, all of which have been determined thoroughly.

Chapter 4: Data Analysis

4.1 Introduction

This part of the research report aims to showcase all the information obtained through primary and secondary qualitative data collection. A short interview session guided by open ended questions and empirical literature review are the tools that have been used to collect all of that data. To analyse all the collected data, a thematic analysis method has been employed here. Theme-based analysis of secondary data and interview transcript-based analysis of the primary qualitative data are the two central parts of the discussion of this section. The summary section briefly and precisely outlines the entire work made in this section.

4.2 Analysis of Primary Qualitative Data

Six project managers were chosen as interview participants. All of them currently work at KTC Group, EX Design Build & Construction Pte Ltd, and Wan Chung Construction (Singapore) Pte Ltd respectively. The transcripts for the interviews conducted are attached below:

Question 1: What is your opinion regarding the value of digitalisation in the construction projects of Singapore?

Respondent 1 (KTC Group)	According to my perception, the adoption of digitalisation in project management works directly greatly influences a project manager's ability to save cost and time incurred for the completion of project works.
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Respondent 2 (KTC Group)	I have found that ensuring the highest level of accuracy in delivering the final project product is the main value that digitalisation holds for construction projects.
Respondent 3 (Wan Chung Construction Pte Ltd)	As per my gathered knowledge and experience, I find that adoption of digitalisation is beneficial, it helps to improve the efficiency and productivity of the workforce.
Respondent 4 (Wan Chung Construction Pte Ltd)	Work automation is the fundamental value that the adoption of digitalisation can provide to every project. During the construction of a building, I have been appointed as the main project manager for this particular construction project. In that project, I utilised several digital tools and also cloud-based software, which provided me with the ability to perform many tasks at the same time. As a result, I have delivered the final project product in less time than the time determined in the final project plan.

Respondent 5 (EX Design Build & Construction Pte Ltd)	Among the many benefits, I consider the increased profitability as the highest value that digitalisation can offer to any construction projects.
Respondent 6 (EX Design Build & Construction Pte Ltd)	I consider that the ability to supervise employees with much more transparency is the highest value that digital tools and software can offer to any construction projects.

Table 4.2.1: Interview Transcript 1

Question 2: What changes have you managed to observe after the adoption of a digitisation and digitalisation approach in construction projects?

Respondent 1	I have noticed that project management tasks have experienced some tremendous changes after going digitally in some of the project works. I would consider the more strategic and efficient communication among the project team as well as companies as a major change.
Respondent 2	According to my perception, more collaboration with teams is the change that digitalisation has brought in contemporary construction projects.
Respondent 3	In my perception, the traditional project management approach adopted before the adoption of digitalisation used to focus on the process rather than results.
Respondent 4	In my perception, the project management approach has now become more data-driven than ever after the adoption of digitalisation in my company.

Respondent 5	Among the various changes, I have found the improved safety level as the main change brought in by digitalisation in contemporary construction projects in Singapore.
Respondent 6	In my opinion, the very new opportunity to monitor construction works from remote or distant locations is the main change that is being enjoyed by project managers after the adoption of digitalisation. Through the use of digital technologies like mobile, laptop, and tablet, project managers can monitor many projects' works from any location without having to make trips to remote sites.

Table 4.2.2: Interview Transcript 2

Question 3: What digital tools are mainly used by you in the construction projects within Singapore?

Respondent 1	In my 5 years of experience in the construction industry, I have used many tools like 3D printing and “Building Information Modelling (BIM)”. In one of my more significant projects, I used HoloBuilder which is an "AI-driven enterprise-grade 360° progress documentation and analysis tool".
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Respondent 2	In my opinion, field chat, 3D printers, high-tech laptops and tablets, Traxxco, and BIM are the most used digital tools in contemporary construction projects.
Respondent 3	Among the various digital tools that are being used in contemporary construction projects in Singapore, I have noticed that BIM, 3D printers, PlanRadar and Leica's "iCon build" are the most used ones.
Respondent 4	Artificial Intelligence (AI), Machine Learning (ML) data analytics tools, BuilderStorm, BIM, and 3D printers are some of the potential tools used in contemporary construction projects to improve the efficiency and productivity level of the construction work.
Respondent 5	In my 3 years of construction experience, I have used BIM, 3D printers, Tool Tracking Devices wearables as digital tools to manage every construction work that was assigned to me.
Respondent 6	As per my experience, 3D printers, Time Tracking Apps, AI, and cloud-based software are some of the digital tools that brings about a revolution in traditional construction projects in Singapore.

Table 4.2.3: Interview Transcript 3

Question 4: What are the challenges experienced by you and your team in coping with the digitalisation of the construction works during the project management process?

Respondent 1	In my 5 years of experience, the main challenge I have experienced while adopting digitalisation and using digital tools is the lack of knowledge of some of the project team members.
Respondent 2	In my opinion, lack of cooperation or integration of all project stakeholders in using some of the digital tools was the main challenge that I have experienced with the digitalisation of the construction works.
Respondent 3	Reduction of dependency on people is the main benefit of digital transformation of project works. However, the lack of sufficient competent staff in utilising the advanced digital technologies was perhaps the biggest challenge that I have experienced.
Respondent 4	In my perception, the lack of top management's support in investing and championing the cause in the adoption of digital technologies is a major challenge that every project manager faces.
Respondent 5	The construction process is characterised as highly complex and requires the knowledge of workers on the way to tackle all complex processes created by the use of digital technologies. I have found that ensuring that every staff possesses the required knowledge and skills is a challenging task for project managers.

Respondent 6	According to my knowledge, the task of defining an integrated strategy to make use of digital tools in specific project works is the main challenge that project managers experience while conducting project works through digital transformation.
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Table 4.2.4: Interview Transcript 4

The aforementioned information obtained from the interview makes it quite clear that digital transformation in construction projects improves work efficiency, integrates communication, promotes collaboration, and provides a better management for both cost and time ***[Refer to Appendix 1]***. To understand this in a better way, a summary of the main points from the interviews conducted and the following themes have been developed especially on the collected primary qualitative data:

Summary of the Main Points from the Interviews

From the live interviews conducted and responses recorded, it can be inferred from the six interview respondents that all of them are agreeable to the fact that digitisation, digitalisation and digital transformation in the construction project management industry is the next normal in this digital age. Accuracy, transparency, value engineering and value management, meeting stakeholders' demands, project quality enhancements / standards and project life cycle management are some of the key components of project management that displayed marked improvements and positive results after the implementation of digitisation, digitalisation and digital transformation, according to the respondents. Even though every respondent has different perceptions / views, all of them agreed that the implications / impacts of digital transformations in the construction industry have been a positive one. Most of the interview questions have yielded positive answers and shared a common ground and similar point of view, in the sense that every project manager has faced issues / challenges in the course of adopting new technologies, when undergoing digital transformations, and during the process of acclimatising to new changes in project management activities. Beyond those issues, every project manager utilises digital tools for their projects. It is also evident from the interviews conducted that project managers are not

regressing from the impediments facing them or shirking from their tasks or responsibilities to adopt these new initiatives. On the contrary, they have risen to the challenges facing them and have taken positive steps to ensure success in the adoption and implementation of digitisation, digitalisation and digital transformation in their project management works, and subsequently in the adaptation to these changes. The followings are the emerging themes that can be gathered from the interviews: -

Theme 1: “Digital transformation helps project managers to design building construction structures with the highest accuracy rate.”

This theme tries to showcase the major benefit that construction project managers obtained from using digital tools in project works. Organisations are now using 3D printers in the structural designing process for creating prototypes. In this context, Sakin and Kiroglu (2017) have mentioned that 3D printing refers to the process through which physical objects can be created by depositing materials in layers, which are based on the digital model. By this, the printed layout of the construction becomes more visualised and understandable with the highest accuracy. The introduction of digital technologies like "cloud-based project management technology" helps to track project tasks effectively under the full control of the project manager. This ability of tracking guides us to manage both time and cost of the project wisely by avoiding any disruption during project task completion.

Theme 2: “Changes in the ability and flow of communication are the main changes that the use of digital tools has brought about in the construction projects in Singapore.”

This theme has been developed to outline the changes in communication brought in by digital technologies construction projects. Digital technologies like IT and ICT have changed the way by which communications among team members used to be conducted. IT refers to equipment and technologies that help in storing, retrieving and transmitting, and manipulating data (www.designing buildings.co.uk, 2021). With the use of these data, communication became much easier. The use of digital tools enables us to avoid making the wrong calculations or using incorrect data. This ability helps us to ensure the required efficiency as well as productivity to complete every sub-works of a particular project accurately. Sakin and Kiroglu (2017) have mentioned that in one of the delivered projects on behalf of "EX Design Build & Construction Pte Ltd", they used

digital tools and "cloud-based software" for buying required materials at lower costs. These savings were quite large and helped them to increase their profitability.

Theme 3: “BIM, 3D printing and data analytics technologies are the three most used digital tools in contemporary construction projects.”

This theme aims to outline the most used digital technologies in contemporary construction projects. Shi *et al.* (2020) have mentioned BIM (5D, 4D, and 6D) and 3D printing is the most used digital tools in construction projects. Additionally, organisations are using data analytics technologies to utilise all relevant data and information regarding the project. The uses of “collaborative work management software” and “email communication” have enhanced the approach by which cross-team communication used to be conducted previously. Through the use of various "work management software", it has become possible for project managers to create engagement and to make connections and interaction with co-workers and teams across departments like Finances, Designing, IT, Procurement Departments and henceforth. With more automated processes boosted by digital tools, project managers can hone-in on the best ways to align their business strategies and goals with each project. The uses of digital tools like clash detection technologies, intelligent apps, on-site sensors, and robots are now being used by project managers not only to boost productivity but also to improve the level of safety during the completion of each construction work.

Theme 4: “Lack of knowledge and cooperation amongst project stakeholders are major challenges being experienced in coping with digitised construction works.”

The above-developed theme outlines the two major challenges being experienced by project managers in coping with digitised construction works. According to Miklosik *et al.* (2019), workers' knowledge is required for using tools like machine learning-based analytical technologies. Alongside that required knowledge, ensuring the cooperation of project stakeholders is relatively a challenging task for project managers in the adoption of digital transformation and also in managing digitised tasks. By using these tools, a project manager can simply track the progress of works assigned to each personnel. Additionally, requirements for minor changes can also be observed and done by the information generated by cloud-based software about work progress. Artificial Intelligence (AI), Machine Learning (ML) data analytics tools, BuilderStorm,

BIM and 3D printers are some of the potential tools used in contemporary construction projects to improve the efficiency and productivity level of the construction work. However, Shi *et al.* (2020) have stated that the lack of sufficient competent staff in utilising the advanced digital technologies was perhaps the biggest challenge experienced. The construction process is characterised as highly complex and requires the knowledge of workers all the way to tackle the complex processes created through the use of digital technologies. I have found that ensuring that users possess the required knowledge and skill set is a challenging task for project managers.

4.3 Analysis of Secondary Qualitative Data

All the secondary data have been analysed using the thematic analysis method. Thematic analysis is a powerful and flexible tool to analyse qualitative data. Using that flexibility, the developed themes for secondary qualitative data are as follows:

Theme 1: "Digitisation has a definitive value in the construction industry and it can bring growth and development to the construction industry".

This theme will help to understand the worth and relevance of digitalisation in the overall construction industry. In this way determination of the facts that have the highest relevance can be identified. In this way, tasks can be arranged in order from most important to least important tasks. This will help to establish a step-by-step approach through which digitalisation can be integrated. In other dimensions, it can be stated that "growth and development" parameters can be determined so that important aspects and points where companies are missing out can be determined (Agyekum-Mensah and Knight, 2017). This will also help to eliminate parameters that are least required in construction projects, and to determine which are the most essential digital tools. In this way, an overall idea can be developed on the tools as well so that the point of actual implementation can be smoother. Developing the essential needs and importance of such tools through productivity and higher efficiency rate can be determined. Lack of cooperation or integration of all project stakeholders in using some of the digital tools was the main challenge that managers have experienced in coping with the digitalisation of the construction works. 3D printers, Time Tracking Apps, AI, and cloud-based software are some of the digital tools that has revolutionise contemporary construction projects in Singapore.

Theme 2: “A rapid transformation in Singapore can be seen in context to construction project management after implementing the digitalisation process”.

A concentrated approach can be maintained under this theme where a compilation of the facts can be made in respect to Singapore's present construction project situations. In this way, which of the companies that are deemed as pioneers in the industry in this aspect and the existing approaches that are already present in this country can be determined. Collective development is not only confined to just organisational benefits alone but includes the overall country's benefits too, and after utilising digital tools for construction project work the results can be identified more clearly (Chan and Owusu, 2017). In this aspect how much time construction companies have for implementing digitisation in their operations can be identified as well. This will help to ascertain the ways through which digitalisation can be implemented according to the geographies of Singapore. Relevance can be established on the globally competing companies and Singapore based companies so that primitive lacks can be identified throughout the process. During the planning stage of a construction project on behalf of the "KTC Group", a manager used 3D printing technologies for the designing work. As a result, it enables the project manager to focus on every little aspect of the entire infrastructure design, which led the company to deliver the final construction project accurately. Field chat, 3D printers, high-tech laptops and tablets, Traxxco, and BIM are the most used digital tools in contemporary construction projects.

Theme 3: “The ability to work under a data-driven approach is a major change brought by digital transformation in construction project management”.

This theme has been developed to mention the change in the project management approach made by digital technologies in contemporary construction projects. Hanna *et al.* (2018) have mentioned that project managers are ultimately the responsible persons to complete a construction project works following the owners' requirements. To meet all of the requirements as well as to keep the project details in mind, they now seek the use of various data analytical tools not only for designing the project structure but also to ensure the success of the project, which is tracked from the early stages of project work. PowerBI, Tableau, Qlik Sense, and Dundas BI are some of the important data analytical tools (Marr, 2020). The use of these tools helps construction project managers to follow a proactive strategy guided by the data-driven approach for gaining the right insights and analysis of each project task. During the construction of a building, project managers have been

deployed by "Wan Chung Construction Pte Ltd", who is the main contractor for that particular civil construction project. In that project, the managers utilised several digital tools and also cloud-based software, which provided them with the ability to perform many tasks at the same time.

Theme 4: “Lack of top management’s support is a major challenge that is being experienced by construction project managers while adopting the digital transformation process”.

Top management support in adopting and using digital tools has always been an integral aspect in delivering the digitally driven project successfully. As per the opinion of Chu *et al.* (2017), lack of top management's support would result in disruption. Therefore, the aforementioned theme here tries to mention that the lack of top management's support in digital adoption is deemed as a major challenge for project managers in coping with the tasks that require the use of digital tools. A significant amount of investment is always required for implementing digital technologies. Considering the "Return on Investment ", the project governing body always does not permit the use of digital technologies. Moreover, the use of digital technologies requires some specific knowledge and skill set from the involved stakeholders. This would create a need for a training program to bridge this gap, which also requires financial support from the management. As stated by Ksenofontova, Emtseva, and Khayrova (2020), the lack of availability of top-management support cannot make these things possible. The very new opportunity to monitor construction works from remote or distant locations is the main change that is being enjoyed by project managers after the adoption of digitalisation. Through the use of digital technologies like mobile, laptop, and tablet, project managers can monitor many projects' works from any location without having to make trips to remote sites.

The below-mentioned discussion has been made with the objective of coming up with a proposal from the findings of secondary qualitative data alongside this themes-based discussion:



Figure 4.3.1: The Four Steps Process to be Followed for the Deployment of Digital Tools

(Source: Blanco *et al.* 2017)

Figure 4.3 visualises a four-step based procedure that every engineering and construction company must follow in order to deploy digital tools effectively. The creation of a focused digital strategy and organisation is the first step of the entire process of digital adoption. Blanco *et al.* (2017) have mentioned that followed by this step, project managers can go for a pilot test first before actual project commencement by identifying potential use cases and measuring key performance indicators. After that, determination of the data-led-way and investment in digital solutions are the steps to be followed for deploying digital tools. Figure 4.3.2 exhibits the most used digital technologies in construction projects:

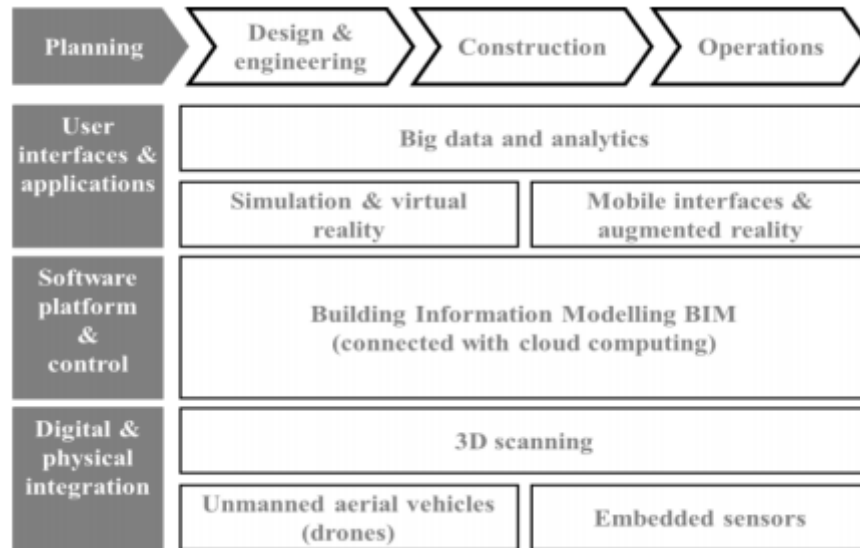


Figure 4.3.2: Applied Digital Technologies in Construction Projects

(Source: Alaloulet *et al.* 2018)

The use of digital technologies depends on various stages or phases of a construction project. Alaloul *et al.* (2018) have mentioned that tools like "big data and analytics" are mainly used in the construction phase based on "user interface and application". On the other hand, 3D scanning is used in digital and physical integration processes. To perform the task involving software platform and control, BIM is used by project managers. Therefore, it is obvious that project managers utilise specific digital tools only to perform particular tasks to ease complexities in the allocated construction tasks.

4.4 Summary

This chapter has been formulated with the purpose of understanding and analysing the data that has been obtained from two different sources. The major focus that has been given in this chapter is to develop the themes for further reference and analysis. In this way, an understanding has been obtained based on the interview transcript and responses recorded in it. This will help to discern the facts that were presented by the managers and of the issues that were constantly faced by them. Carrying the discussion further based on the themes presented, both the primary and secondary data has been structured and prepared in an orderly manner for ease of information gathering. Deriving secondary sources of data, proper justification for each theme and how it can be useful in further commencement of this study can be determined with the help of circumstantial data.

Chapter 5: Discussion, Conclusion and Recommendation

5.1 Conclusion

This chapter of this study is the conclusion of the research. In this research study, the analysis of the information is properly done. From the analysis section, it can be seen that from the primary qualitative data, the outcome of the interviews has significantly shown the value of digitalisation in construction projects. The outcomes of the information selection from primary and secondary qualitative data have not only shown the major benefits but also the challenges within the study.

5.2 Discussion of Data

In this study, primary and secondary qualitative data have been selected. The primary qualitative data have shown that digitalisation tools are almost valued by each of the respondents. As opined by Kudryavtseva and Vasileva (2020), the digital technologies in project management are not only guiding and tracking the time and cost of the project but also ensuring that it can achieve the highest level of accuracy. In construction projects, digitised software is useful. It can also be seen that after adopting digitalisation in construction projects, the changes are significant and approachable. The approach towards communication and perception of the projects has improved after the adoption. In recent times, almost all projects are data-driven as manually massaging the data makes it time-consuming. Moreover, manual “fixing” may lead to human error. As a result, it became easier for project managers to manage after adopting digitalisation in their project works.

In construction projects, several digital tools are used by the project managers. BIM and 3D printing tools are used by the managers in the current scenario. In most cases, the managers used these digital tools because it is necessary for their projects. The most common challenge in adopting techniques of digitalisation was a lack of knowledge about the tools. In addition to this, a lack of cooperation and integration for those involved in the projects. The utilisation of these tools creates competent users. According to Bilal *et al.* (2016), people become less reliant on each other as the tools become data-driven. On the other hand, complex processes within the adoption have created a great challenge for the project managers. In addition, it is also difficult for the managers to use specific digital technologies and strategies for their projects.

In the case of the secondary qualitative data, it can be seen that a change has been noticed in the construction industry after adopting the methods and techniques. The data-driven approach has made people less reliant on human help. Digital transformation among the industries has significantly brought a major change. The construction project managers faced challenges such as a lack of support from the top of the management. In order to adopt a new technique or method, an important task is to understand the procedure in a proper way. In most cases, the manager faced the same issue of support from the upper management. Moreover, the lack of support in most cases disrupted the projects. Deploying digital tools is becoming a painful procedure for them.

Another challenge that has been discovered through secondary data analysis was the lack of investments in projects. In current times, the entire world has become competitive in nature. Moreover, the internet has made the data so transparent that any technological advancement by any company can easily influence another company. In this case, a lack of investment in the organisation or the company becomes an immense challenge for the managers. As mentioned in the value of using digitalisation in the project works, it can be seen that the use of digital tools not only reduces the invested time but also reduces the cost of labour in some ways. For example, in a data-driven world, manual handling of data causes more errors than any machine. In this case, instead of using one individual, the company has to invest money in more than one individual as the workload increases. This extra cost of labour can easily be reduced by deploying the right digital tools. As suggested by Seymour (2019), it is expensive to invest in a digital tool. However, investments in the right digital tools can easily improve efficiency and productivity level in view of the competitive landscape of the construction industry. Moreover, in order to remain relevant in the business, it is imperative and inevitable that the companies invest in these tools.

5.3 Linking with Objectives

In this section, the research is on how successful research is, in meeting the aim and objectives that have been discussed. Hence, this section is important from the research standpoint.

Objective 1: “To recognise the value of digitisation in the construction projects of Singapore.”

This objective is discussed in the ***Literature Review Section 2.4***. This objective is to analyse the value of digitalisation. This section discussed whether Singapore was using digital tools in construction projects. It can be seen that the value of digitisation was in fact significant for the

construction industry. However, to-date, many companies are still not using digital tools in their projects. The methods and techniques of digitalisation are becoming more and more beneficial for this industry. The purpose of this objective is to identify the value of digitalisation, which was discussed in detail. It can be seen that the quality of products and services, and infrastructural facilities has improved after the adoption of digital tools within the projects. Also, workplace safety has improved as well in the construction sites (based on the study of Elghaish *et al.* 2020). Moreover, the tools have helped the industry to identify an efficient way to construct buildings. Digitalisation has become increasingly useful and important for construction companies in Singapore and they are using digital tools in order to be more efficient and productive.

Objective 2: "To understand the transformation in construction project management after implementing digitalisation."

This objective was discussed in the ***Literature Review Section 2.5***. The transformations are significant in the construction projects after the adoption of digital tools. In Singapore, the Government has taken steps towards adopting digital techniques in the construction industry. After evaluating the benefits of digital tools, it can be seen that the Singapore government has implemented digital methods and techniques with the aim towards improving or replacing the current traditional techniques as it creates better workplace safety in the construction sites. The changes within the organisation have made the industry more efficient. Understanding the transformation within this industry is very crucial. One has to understand that in order to implement the techniques and methods, it is important to understand the procedure and benefits of using the digital method beforehand.

In a fast-changing world, it can be seen that most construction project managers use digital tools in their procedures to improve their work process. It can be seen that the initiatives taken by the Government are quite helpful for the economy. As suggested by Seymour (2019), the supply chain management of the project is aimed at improving each and every process within the system. The process of digitisation has not only changed the entire system but also changed the concept of the project. The adoption of digital tools has changed the entire perspective towards construction project management in Singapore.

Objective 3: "To examine the growth and development of construction work by adopting digital transformation strategies."

This objective was discussed in the ***Literature Review Section 2.6***. In this section, the growth and development of the construction industry in Singapore were discussed. It can be seen that few construction industries in Singapore have used digital tools in their projects. However, so far, they have shown impressive results. Those companies are seen to have significant growth results in their projects after adopting the digitalisation process. Companies need to examine the benefits of using digital tools in their projects. These new methods and techniques require heavy investments by the companies. In order to find an efficient way of using the digital methods, it is necessary to examine the benefits before actually implementing the techniques (Prušková, Dědič and Kaiser, 2019). In this section, the developments and growth of the construction industry has a great impact on the country's economy. The changes within the industry after adopting the technique will depend only on the process. The project managers will play an important role in demonstrating the usefulness of the adoption.

Objective 4: "To recognise the positive changes that came about from digitalisation in the construction project management in Singapore."

The ***Literature Review Section 2.7 and Primary Qualitative Data Section 4.2*** have discussed this objective. In the literature review, a gainful discussion about positive changes that were seen in the construction industry after the emergence of digitalisation has been stated. In the table of interview transcripts, the perceptions of various project managers regarding these changes have been observed. Hence, this objective has been met properly.

Objective 5: "To find out any challenges faced by the construction project manager, or any project issues faced by them while adopting digitalisation, digitisation or any digital transformation in their construction management work process."

The ***Literature Review Section 2.8 and Table of Interview Transcripts 4.2.1 – 4.2.4*** have analysed this objective. Challenges faced by construction companies before digitalisation as well as during the incorporation of advanced technologies have been discussed in a literature review. In addition, the perspectives and experiences of managers in the construction industry also have been identified. Hence, these objectives have been met.

5.4 Recommendation

Throughout this research paper, various aspects of digitisation and transformation in the construction industry of Singapore have been discussed. In this aspect, various problems and issues existing within this sector of Singapore have been observed. Based on these discussions and improvements that are necessary to be done, some recommendations are as follows:

Utilising technological resources: In this 21st century technological era, digitisation is the most important “weapon” to be utilised for improving the project management processes. In this research, the main aim is to improve “construction project management processes” in Singapore. **“Labour productivity”** can be affected by any kind of **“technological improvement”**. In the case of Singapore, it has been seen that the construction sector has lagged behind other sectors in terms of productivity. Along with that, it has also been seen that they are spending very little amount of capital to incorporate information technology. Various project management software is readily available in the market, which can be used here for effective tracking of the daily work. Also, the project management software is capable of hosting all kinds of construction management documents and enables them to be placed in a centralised location.

Construction project planning based on data: In the case of managing any construction projects smoothly, sometimes complications arise which makes the work challenging. It has been seen that these types of problems occur in cases of **“lack of proper project planning in an organisation”** which can ruin the project, which in turn will decrease the **productivity rate** of the team. Hence, a proper plan needs to be done at the very beginning, containing important and useful data. This strategy is known as **“data-driven strategy”** that helps in driving planning efforts for increasing productivity. One of the most facilitated digital technologies here is **BIM (“building information modelling”)** which helps in managing projects and ensure timely delivery.

Using prefabricated building systems: One of the most recent and advanced trends in the construction industry is that construction companies are using **“prefabricated” and “modular building systems”**. Prefabrication refers to the process of **“making components of building”** in a different manner and different locations. After fabrication, these components are then transported to an actual job site in terms of completing the entire setup. This process takes less time as

compared to traditional processes. Hence, this advanced process helps construction companies to run multiple projects at the same time.

Organised project sites and updating of inventory: In the case of construction sites, one of the most important reasons for "low productivity" is due to the disorganised process of project site management. Most of the construction sites in Singapore are facing problems that can be attributed to the lack of organisation in the project site. Many useful technologies and software can be used for tracking everyday tasks, incomplete jobs, timely completion, managing inventory and tracking of resources. All these would help in the proper management of construction projects.

5.5 Limitations

This research has the potential to cover most of the important factors related to digitalisation and digital transformation in the construction industry. However, some limitations can be observed here, avoidance of which could make it more effective and purposeful from research perspectives. It has been seen that no **quantitative research** has been conducted here. Quantitative research contains numerical values, which are important for any research. In this case, if the previous year's numerical data related to construction industry in Singapore is available, it would give a gainful insight for comparison purposes (Aghimien *et al.* 2020). The trend can be understood more much more clearly. Apart from that, how digital innovation can address the challenges faced by the construction industries has not been stated here. Hence, it is a limitation. Along with the interview, if a **survey on the construction industry's workforce of Singapore** can be done, their viewpoints and insights can be obtained in order to have a better understanding and a clearer picture of the current situation. Moreover, upcoming technologies that can boost up this industry also have not been mentioned here. If these technologies were mentioned, an insight could have been reached regarding this.

5.6 Future Prospect of Study

This study has taken a long hard look at the various aspects of the construction industry in Singapore, at the time where digitisation, digitalisation and digital transformation is taking place. Without doubt, by analysing the recent trend compared to the previous ones, a high degree of change can be observed easily. With new technologies and innovations taking place at a rapid pace globally, the construction industry is evolving and is slowly embracing the advances in technology

in this digital age (Yin *et al.* 2018). Inevitably, many technologies are disruptive. However, it has been found that after the implementation of digitised technologies and digitalisation, new challenges begin to emerge.

In terms of observing and predicting the prospects of the construction industry and digitalisation in Singapore, some factors can be mentioned here. As opined by Wengang *et al.* (2020), Based on the current trend, we can expect some upcoming and emerging trends that we could experience in the near future such as "**high-definition surveying and geo-localisation**", "**next-generation 5D building information modelling**", "**digital collaboration and mobility**", "**internet of things and advanced analytics**" and "**future proof design and construction**".

"High-definition surveying and geo-localisation" is a process that can overcome delays in project delivery. It can provide "high-definition survey images of areas" but the weakness is in converting it into **"usable format"**. **"Next-generation 5D building information modelling"** will take the construction industry to another level as it can provide an integrated platform for performing **"advanced project planning"**, **"design and construction"**, **"operation and maintenance"**. According to Toh, Goh, and Guo (2017), this technology helps in providing an advanced functional and physical characteristic of a project. Hence, all these technologies mentioned over here are going to propel the construction industry to greater heights in the near future.

This study has analysed all important aspects of the construction industry such as, "how digitalisation can help in infrastructure building construction", "how digitalisation can help in project management", "process in which digitalisation help to meet the requirements of scope for time and in budget management", "issues faced by the construction industry in Singapore", "proper recommendation for more facilitation of this industry" and many more. All have been mentioned in this research (Prušková, Dědič, and Kaiser, 2019). Hence, the present trend of this industry can be understood, and based on this, future trends can also be predicted. Consequently, this research is useful for understanding the prospects of the research subject.

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Appendix

Appendix 1: Interview Questionnaires

- **Question 1: What is your opinion regarding the value of digitalisation in the construction projects of Singapore?**

- **Question 2: What changes have you managed to observe after the adoption of a digitisation and digitalisation approach in construction projects?**

- **Question 3: What digital tools are mainly used by you in the construction projects within Singapore?**

- **Question 4: What are the challenges experienced by you and your team in coping with the digitalisation of the construction works during the project management process?**