Faculty of Science and Engineering

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Assessing Productivity in Off-site Construction Methods for Managing Engineering and Building Projects: an Operational Management Approach

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DECLARATION

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signed

Faisal Abdullah Alazzaz

ABSTRACT

The desire to improve labour productivity in the building industry has long been of interest due to the magnitude and cost of construction. Off-site Construction (the development of prefabricated components towards increasing construction productivity) has been a building-sector trend which has proliferated, particularly over the past four decades, given its potential to offer increased effectiveness and efficiency. Despite the benefits suggested for off-site construction, there has been rather limited research with respect to the factors that affect productivity directly in this area; most of the investigations and commentary thus far appear to compare the benefits of off-site construction with those of traditional onsite/in-situ construction methods. Thus limited investigation has been reported thus far of the practices and factors that underpin productivity, particularly labour productivity, in off-site construction.

This study aims to address the gap in knowledge related to a lack of structured approach and assess the productivity of off-site construction, through a focus on employee empowerment with reference to operational management tools and techniques. An operational management approach is believed to provide a novel way of measuring productivity in off-site construction and is held to offer insights able to improve the performance of the industry. In particular, the research attempts to show the extent to which a focus on employee empowerment would be able to bring about improvements in labour productivity and quality, thereby maximising the benefit of off-site construction to the greater good of the building industry.

Three case studies of off-site construction companies were conducted with quantitative and qualitative data sources used. Semi-structured interviews were carried out with 36 representatives from the off-site construction sector in Saudi Arabia. Data analysis involved the use of two-sample t-test to compare relative usage of nine employee empowerment factors and their relative importance to labour productivity between companies. Pearson's product-moment correlation was used to measure the strength of the relationship between the current usage of each employee empowerment factor, and the rating of the importance of that factor for labour productivity. The study also investigated the relative importance of 43 factors that negatively affect labour productivity and analysed these results in terms of the potential for each of the nine employee empowerment factors towards moderating the impact of these factors. Operational management tools and techniques, particularly brainstorming, development of cause and effect diagrams, and statistical process control, were used to support findings.

The study revealed that there is a significant relationship between the factors of employee empowerment and labour productivity. The study was able to contribute to knowledge in the area through providing a validation of a nine factor model of employee empowerment and highlighting links with each of the factors and labour productivity. The study also was able to measure empirically the productivity of companies using statistical process control charts. This technique and the development of cause-and-effect diagrams were found to enhance operational awareness of labour productivity and quality issues.

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Contents

List of Figures

List of Tables

CHAPTER ONE - INTRODUCTION

1.1 Background of the study

In many countries around the world, the construction industry is a key sector in the economy due its contribution to infrastructure, investment and employment (Abdel-Wahab&Vogl, 2011; Enshassi et al., 2007). Nevertheless, the construction industry has historically suffered from poor performance in comparison with other industries (Nadim &Goulding, 2010). One of the greatest challenges is securing skilled and motivated employees. Studies in Australia and the United Kingdom, for example, have reiterated the issue of poor employee skills (Nadim & Goudling, 2010; Blismas & Wakefield, 2009). Labour skills are a determinant of productivity in the industry (Abdel-Wahab et al., 2008). Indeed, at least since the late 1980s, productivity growth in the construction industry has been lower than in most other industries according to studies. In the United States, for example, the decline in relative productivity has been officially reported at approximately 4–6% (Abdel-Wahab & Vogl, 2011; Eastman & Sacks, 2008; Doloi, 2007; Sveikauskas et al., 2014). One reason for this may be the predominance of traditional onsite production, which suffers from numerous internal and external productivity constrains (Durdyev & Mbachu, 2011).

Productivity, defined as the amount of output per unit of input, is a key concern for the construction sector (Durdyev & Mbachu, 2011). Given the labour-intensive nature of this sector, a key determinant of overall sector productivity is labour productivity, measured as the output per unit of labour input (Song, 2008; Shen et al., 2011). Despite the apparent simplicity of the definition of labour productivity, this indicator is difficult to track consistently, largely because of the complexity of quantifying and comparing diversified outputs in the construction industry (Song, 2008, Eastman & Sacks, 2008). Thus, a number of approaches have developed to assessing productivity.

Off-site production provides one potential solution for resolving contemporary productivity problems in the construction industry (Pasquire & Connelley, 2002). ‘Off-site’ refers to the production of a significant proportion of construction components in factories and fabrication shops outside the construction site, components which are then transported to the site for assembly or erection (Alvanchi et al., 2011). It includes processes such as prefabrication and modularisation (Bernstein et al., 2011; Pasquire & Connelley, 2002). Off-site production allows construction to be transformed from a craft into a more standardised and controlled manufacturing process, in turn (alledgedly) producing greater efficiency, reducing costs and increasing quality (Johnsson & Meiling, 2009). The key factor driving uptake of off-site production methods has been the potential for productivity improvements (Bernstein et al., 2011). As shown by Eastman and Sacks (2008), off-site (fabrication of element and sub-element components) production has been found to result in up to a 40% gain in efficiency per employee in the United States construction industry.

Nevertheless, off-site production itself faces a series of productivity limitations that need to be comprehensively analysed (Alvanchi et al., 2011). Similar to onsite construction, a significant cause of defects with prefabricated units in off-site construction is poor craftsmanship (Johnsson & Meiling, 2009). In fact, Johnsson and Meiling (2009) hypothesise that continuous improvement and employee motivation policies, of which employee empowerment sits, within organisations would go some way towards improving craftsmanship quality, and in turn allowing for a reduction in defects occurrence in relation to prefabrication activities.

Employee empowerment may therefore provide a means of improving productivity within off-site construction and construction in general. Notwithstanding this, the concept remains relatively difficult to define in precise terms. The upshot is that there are a number of definitions of employee empowerment. Liu et al. (2007), for example, define empowerment in terms of decentralisation, a process whereby the power, authority and responsibility of the superior is relinquished to subordinates. A similar definition is provided by Holt et al. (2000), who perceive empowerment as "giving employees greater control and freedom, but in such a way as to generate self-responsibility and encourage self-efficacy". Empowerment is taken to increase the motivation of employees, as well as their commitment to their organisation. In turn, this increases productivity due to greater effectiveness and responsibility and a reduction in absenteeism (Liu et al., 2007).

However, there is a shortage of literature analysing more comprehensively the benefits of employee empowerment in the construction industry; there is also a lack of research that links the application of a skill-base for off-site construction with empowerment techniques, neither is there a means to measure empirically such a link. This research project has attempted to address this knowledge gap, by identification of productivity variables in off-site sub-element fabrication, and then by addressing these with regard to the full range of operational management techniques and tools, present a detailed measurement of the key factors of an efficient process and ultimately seek to go towards an improvement in productivity levels for the (continuous improvement and) construction of built assets.

1.2 Research aim and objectives

The aim of this research is to assess the productivity of the off-site construction industry through a focus on employee empowerment and with reference to operational management tools and techniques.

The main objectives of this study are as follows:

1. *Investigate and compare the current usage of employee empowerment and in terms of its relative importance to labour productivity between two off-site companies*
2. *Investigate the relationship between labour productivity and employee empowerment*
3. *Identify the factors affecting the productivity of off-site construction industry*
4. *Empirically examine the relationship between the perceived relative usage of nine employee empowerment factors across 43 productivity factors*
   (to extend studies independently posited by Nesan 1997; Enshassi 2007; et.al.)
5. *Measure empirically the current productivity of off-site construction industry fabrication methods with application of operational management tools & techniques.*
6. *Seek to improve future productivity of the off-site construction industry through validation and application of operational management tools and techniques*

1.3 Statement of the problem

In the past few decades, the construction industry in many countries has suffered from poor performance and low productivity (Eastman & Sacks, 2008). The United States. Bureau of Statistics reported that labour productivity in the construction sector declined at least an average of 0.26% per year between 1987 and 2011, with productivity of residential construction exhibiting the greatest declines (Sveikauskas et al., 2014). The labour-intensive nature of the industry and diminishing levels of specialist skills and craftsmanship have been major factors hampering productivity growth in construction (Johnsson & Meiling, 2009). A key solution for resolving the productivity constrains of traditional onsite (in-situ) construction has been posited as off-site construction, which uses methods such as prefabrication and modularisation in order to improve efficiency and standardise the management of quality (Pasquire & Connelley, 2002). Off-site production has so far produced positive results, with one study showing that productivity levels per employee can be up to 40% greater than onsite production (co-called in situ activities) (Eastman & Sacks, 2008). Nevertheless, such studies remain largely anecdotal and lack an empirical objective means to clearly define the parameters that lead to positive gains; there has been little research that comprehensively analyses and charts the full range of latent conditions related to the productivity of off-site construction, including its limitations and ways of improving it.

This study addresses the limitation of the lack of structured approach and assesses the productivity of off-site construction through a focus on employee empowerment and with reference to operational management tools and techniques. An operational management approach provides a novel way of measuring productivity in off-site construction and offers insights that can improve the performance of the industry. This research has attempted to demonstrate the extent to which an employee empowerment focus can cause improvements in labour productivity and quality in off-site construction.

1.4 Scope of the research

The majority of studies concerning construction labour productivity and factors relevant to this concept have dealt with traditional onsite residential construction. The scope of this study is to investigate factors related to labour productivity in off-site construction. Thus, while literature concerning productivity in onsite and off-site settings is reviewed, primary research, firsthand data is only collected from the off-site sector. Moreover, within off-site construction, this study was only concerned with productivity in relation to the manufacture of prefabricated elements as opposed to the in situ installation of the elements. The management of off-site production includes: value-chain management and business partnership development; logistics; procedures and policy. However these are outside of the scope of this research. Similarly, the scope of the study sought off-site construction companies from one geographical area in Saudi Arabia; participants were also sourced from this setting. This sampling and selection method means that the findings, whilst extremely robust, cannot be generalised uniformly to global cohorts of participants in the off-site construction sector. Nonetheless, consistencies with findings from international context are reported with confidence.

The scope of the study is limited to the constructs for employee empowerment and labour productivity factors adopted from models selected from the literature. For the former, Nesan's nine employee empowerment factors were selected due to their academic acceptance. For the latter, 43 productivity factors used in Enshassi et al.'s (2007) study were selected due to their comprehensiveness and academic acceptance. Thus, the study adopted pre-established, theoretical models deemed relevant by the research community. With respect to employee empowerment, a broad review of the concept and its application to construction projects is conducted and presented. Such a comparison between employee empowerment in construction with other industries such as manufacturing and services are outside of the scope of this research. The model of employee empowerment chosen for this study builds upon and extends Nesan's (2004) nine-factor model, alongside the forty-three variables deemed relevant to labour productivity from work by Enshassi et-al (2007).

1.5 Significance of the study

The scarcity of current resources makes review of operational management approaches and practices a highly necessary endeavour. There is a *gap* in the current research in relation to labour productivity in off-site construction and the ways through which such productivity can be improved in the overall delivery of an engineering/built asset on site. Despite the gap in research, application of off-site techniques such as prefabrication and modularisation have been reported to be on the increase. In the United States, approximately a third (37%) of engineers, contractors and architects indicated that they used such off-site techniques in at least half of their projects during 2011. Researchers expected this proportion would exceed 45% within a few years (Bernstein et al., 2011). Statistics such as these support the need for greater empirical interest in the effect of off-site construction techniques on productivity. Such a focus will go some way to ensuring that the benefit(s) of off-site, sub-element manufacture are maximised for building construction and engineering assets.

This research is significant, because the literature concerning the effects of operational management tool application in the construction industry is relatively sparse to date. There is also limited discussion of the application of operational management tools in a civil engineering context in general. Moreover, there are few studies that deal with employee empowerment in the context of the construction industry. Given the potential productivity gains that can result from greater empowerment, studying the application of employee empowerment interventions is deemed a great use to the civil engineering and construction industry.

As outlined above, the construction industry in many countries has suffered from poor performance and low productivity. However, given its importance to the economy in many countries, gains in the productivity of the construction sector can have economy-wide benefits. While the increasing importance of off-site construction may bring productivity gains, this process will be of limited value if no comprehensive attention is paid to improving productivity through a continuous improvement (*Total Quality Management*) or operational management approach. In particular, a greater focus on employee empowerment may provide a new way of resolving (perceived/ anecdotal) levels of low productivity in the civil engineering and construction industry.

1.6 Research approach and design

A mixed-methods case study approach was used for this research project. Given the objectives of the study, it was determined that quantitative and qualitative data would be collected and analysed in order to provide the best description of the research concepts within the settings. The primary data collection activity was semi-structured interviews with 36 respondents from three off-site construction companies. Respondents were asked to answer a number of questions and respond to statements concerning factors of employee empowerment and factors that could negatively affect labour productivity. The data collection instrument, the interview schedule, was developed by adopting Nesan's nine factor model of employee empowerment and Enshassi et al.'s (2007) 43 factors important to construction productivity.

Responses from these interviews were used to determine relative scores on scales so that quantitative comparisons could be made. This mixed-methods approach was used to combine the benefits of qualitative data with those of quantitative data and specifically be able to measure the relative importance of particular factors overall.

The project also involved the application of operational management tools and techniques primarily statistical process control measuring daily productivity, and brainstorming technique as an input to develop of two cause-and-effect (fishbone) diagrams, one concerning productivity delay and one concerning quality defects. These well-known techniques were selected and applied in order to assess their utility with respect to off-site construction productivity.

1.7 Research contributions

Research has suggested that there is an extensive lack of knowledge on employee empowerment within the construction industry (Tuuli & Rowlinson, 2007; Sackey et al. 2011). As part of this, it has been suggested that there is a need to focus on the complexity of employee empowerment and explain this phenomena as well as its potential relationships with key performance criteria such as labour productivity (Tuuli & Rowlinson, 2007; Tuuli & Rowlinson, 2010b; Sackey et al. 2011). Yin (2009) suggests that a case study research is a useful method for the exploration of complex phenomena. This research adopts this advice and investigates employee empowerment in relation to off-site construction. This study is believed to the first of its kind, as to-date there appear to be few publications relating to off-site construction exclusively, and even fewer considering the potential for employee empowerment to improve production in this important sector. Another contribution of this research is that it has attempted to link empirically, employee empowerment with productivity quantitatively. Thus far, such an endeavour appears to have been overlooked.

Tuuli and Rowlinson's (2007) study measured employee empowerment generally using a qualitative interview methodology. One of the limitations of their approach was the small and culture-specific sample size, as well as the presence of a selection bias, whereby participants were purposely selected because of their willingness to share their experiences. As the authors themselves acknowledged, a resolution to this limitation would be to use quantitative statistical methods to carry out a larger-scale survey into employee empowerment. By adopting a mixed methods approach and using quantitative statistical methods, this research project has attempted to fill the gap in the literature concerning employee empowerment.

It is argued that the operational management approach applied in this study has demonstrated a useful way to measure off-site construction productivity. It offers insights that can improve the production performance of the industry; in particular, the study presented here argues that a focus on employee empowerment, statistical process control, brainstorming and cause and effect diagrams might bring about improvements in productivity and product quality, thereby maximising the benefit of off-site construction methods.

1.8 Structure of thesis

The thesis is organised into five chapters. The first chapter, "Introduction", as the name suggests introduces the study through providing a background to construction labour productivity and off-site construction. The first chapter also lists the six research objectives, provides a statement of the problem, and provides an overview of the significance, research approach and design, and contributions. The second chapter, "Literature Review" attempts to trace the history of off-site construction, employee empowerment and investigations into labour productivity. The second chapter also traces the history of quality management and refers to the use of operational management tools and techniques in construction thus far. Overall, the second chapter discusses previous research conducted in these three areas and attempts to emphasize the outstanding gaps in the literature.

The third chapter is the "Methodology". This chapter provides an explanation of different theoretical perspectives concerning research designs and provides a justification for the selection of a case studies approach in this project. This is followed by chapter four, "Results and Discussion" which provides an in-depth explanation of the results of investigations carried out and the implication of these with respect to the research objectives. Chapter five, "Conclusions and Recommendations" provides the final statements in relation to each objective as well as a summary of the limitations and implications of the study.

1.9 Chapter summary

This chapter introduced the topics of off-site construction, employee empowerment and labour productivity. The chapter provided the primary aim and six research objectives of the study. The chapter also provided a statement of the research problem as well as the scope and significance of the study. Importantly, the chapter provides a summary of the research approach and design as well as the contributions to the knowledge made by the project. Finally, the chapter outlined the structure of thesis by providing a brief outline of the purpose of each of the five chapters.

CHAPTER TWO - LITERATURE REVIEW

2.1 Introduction to literature review

The previous chapter "Introduction" provided a background to the research problem and a summary of the research objectives, strategy, scope, significance and contributions. This chapter, "Literature Review" provides a definition and a historical background of off-site construction. The contemporary application and value of the activity was explored as were it benefits, namely, time, quality, relieving skills shortages, costs, productivity and drawbacks. The chapter considered stakeholder resistance, and considered the future growth potential for the sector. The chapter also provided a review of the definition and history of the concept of employee empowerment. Structural, psychological, critical and multi-dimensional approaches to the concept were explored as well as benefits and barriers to employee empowerment. The use of empowerment was considered in relation to the construction sector and more specifically the off-site construction sector. The chapter investigated productivity considering approaches to assess construction labour productivity and the results of studies into the factors underpinning productivity. The chapter then explored the potential relationship between employee empowerment and labour productivity. Finally, the chapter concluded with an investigation into the quality system in the construction industry.

2.2 Off-site construction

2.2.1 Definition

Off-site construction, broadly, refers to a construction method where units or modules and by implication components of sub-element are built away from the work site and transported to the work site, where they are installed (Gibb, 1999). It can be better understood by distinguishing such installation of pre-fabricated components, from traditional onsite (in situ) construction, where the majority of the units and structures are built directly on the work site and where only very minimal processing (e.g. base materials) is done off-site (Pasquire & Connelley, 2002).

There have been several definitions of off-site construction given by various authors, which reveal some of its most important aspects. Among the earliest definitions is that provided by Tatum et al. (1987, cited in Gibb, 1999), who define off-site construction as a "process by which various building materials, prefabricated components and/or equipment are joined together at a remote location for subsequent installation" in the desired location.

A more detailed definition was provided by Gibb (1999), who interprets off-site construction as

> a process which incorporates pre-fabrication and pre-assembly, involving the design and manufacture of units or modules, usually remote from the work site and their installation to form the permanent works at the work site. A project strategy that will change the orientation of the project process from construction to manufacture and installation

There are several salient features to this definition. The first is perhaps the obvious point that off-site construction takes place away from the work site, usually in a factory setting. Another important element is that what actually takes place away from the work site is the process of pre-fabrication and pre-assembly, upon which the units are transported onsite for installation. Finally, and perhaps most significantly, off-site construction involves sub-element component *manufacturing* (Pasquire & Connelley, 2002). Units or modules are not ‘constructed’ as in the case of onsite construction, but are instead produced like other manufactured goods, after which they are installed on site. The term ‘off-site construction’, then, should not be seen as referring only to the process of creating the modules in the factory, this is, only the part that physically takes place away from the site. Instead, ‘off-site construction’ as a method incorporates both the component *manufacture off-site* and the worker-*installation onsite* (Pasquire & Connelley, 2002).

According to Gibb (2001), and Gibb and Isack (2003), there are four different categories of off-site construction: 1) component manufacture and sub-assembly such as door furniture and light fittings) referring to small components usually annexed to larger units onsite, 2) non-volumetric pre-assembly (those units that do not enclose usable space, such as wall panels, structural sections and pipe work assemblies), 3) volumetric pre-assembly (those units that enclose usable space, such as toilet pods, plant room units, service risers and modular lift shafts) and 4) modular buildings (units that themselves form usable buildings with only minor work left to be completed onsite, as in the case of prison cell or school building modules). Gibb and Isack (2003) point out that many people equate off-site construction and pre-assembly exclusively with the fourth category, complete modular buildings. For them, this is an incomplete picture of what pre-assembly means, given the other three categories that they enumerate above.

Off-site construction is also referred to as off-site prefabrication, off-site manufacturing, prefabrication and modularisation (Taylor, 2010). Gibb (2001) uses the term 'standardisation and pre-assembly', while Venables et al (2004) note that off-site construction methods are sometimes referred to as a sub-set of 'modern methods of construction' (MMC). The term 'off-site construction' might be suggested as gaining prevalence in relatively recent times (i.e. 1998 onwards), whereas pre-assembly and prefabrication were more commonly used in the past (Pasquire & Connelley, 2002). In this paper, 'off-site construction' has been chosen due to its inclusivity (as opposed to the perhaps more narrow 'prefabrication') as well as to neatly distinguish it from *onsite construction* (Pasquire & Connelley, 2002).

2.2.2 Historical Background

As Taylor (2010) points out, the use of manufactured buildings is not a new phenomenon. In the 1830s, John Manning created a portable colonial cottage and there were several other examples of off-site production throughout the nineteenth century. Gibb (1999) points out that prefabricated houses were used during the process of colonial expansion by European nations, given that there was a demand for 'European-style housing' and using local labour and materials was not favoured. Prefabricated hospitals were also used during the Crimean War, while the Industrial Revolution led to the "industrialised building method" coming into fashion, leading to the use of prefabricated cast-iron buildings (Gibb, 1999).

After the Second World War, off-site construction began to be utilised on an even larger scale. The population growth following the Second World War led to a demand for new housing, and prefabrication was seen as an effective way of catering for this demand (Venables et al., 2004). In particular, the rise of the welfare state in the Western world particularly around the 1970s led to a boom in public housing (Tam et al., 2014). Prefabricated units were ideal for this purpose due to their standardised approach, which at the time was culturally valued due to its ordered nature (Finnimore, 1989). Prefabrication was also popular due to the economies of scale which could be generated from standardised mass production (Venables et al., 2004).

One area of proliferation of off-site construction techniques occurred in Hong Kong in the 1980s as a result of increasing land scarcity, population density and government incentives. The use of prefabricated concrete components in high rise buildings was subsidized (Jaillion & Poon, 2009; Chan, 2011). In fact, between the late 1980s and 2002, approximately 17% of the volume of concrete products used in residential projects in that setting had been fabricated off-site (Li, Shen, & Xue, 2014). During the late 1980s and 1990s there was also a pattern of relying on off-site constructed concrete components in Singapore; a setting also dealing with scarcity of land at the time (Chan, 2011).

Towards the end of the twentieth century, off-site construction began to be used in a more diversified range of areas, such as hotels, schools, hospitals and prison buildings. In Denmark, 40% of the volume of concrete products was recorded in 1996 as prefabricated largely as a result of supportive legislation (Jaillion & Poon, 2009). Yet as societies have become wealthier, demanded for ‘welfarist’ public projects have declined; The upshot is that pre-fabrication and pre-assembly approaches have been reallocated to commercial projects such as airport developments, hotels, petrol stations and other retail outlets, and a range of franchise hubs that use uniform repetitive designs and specification (Bernstein et al., 2011; Li, Shen, &Xue, 2014). However, Gibb (2001) mentions that some rapidly developing countries currently have housing needs similar or exceeding those of the Western world after the Second World War, and that off-site construction has yet again become a way of addressing these needs and providing cheap standardised housing for large numbers of people. Germany and Japan both invested heavily in prefabrication and preassembly in residential building construction after the Second World War, and according to Gibb (2001) have retained this inclination since.

The history of off-site construction is one that ‘waxes and wanes’ according to Gibb (2001). Thus, rather than seeing off-site construction as an emerging trend that represents a sort of teleological progress, it may be more useful to perceive it a cyclical phenomenon. Off-site construction is on the upswing in periods when its inherent advantages (or perhaps its *perceived* advantages) are more useful. At other times, it may fall out of fashion. As Gibb (2001) and Venables et al. (2004) point out, perception of off-site construction is a key predictor that influences its use throughout history. In turn, perception is heavily influenced by social, cultural and economic contexts. While these are beyond the scope of this research, it is important to keep this in mind when thinking about the deeper reasons why off-site construction is valued in some time periods and for some uses but not in others.

2.2.3 Current adoption and value

Off-site construction methods have played an increasing role in the construction sector in the past few decades. In the United Kingdom, a greater use of off-site methods such as pre-fabrication was recommended in the Egan Report (1998) as a way of boosting the productivity of the construction industry. It was also recommended by the Housing Forum Report (2002) as a way of overcoming the shortage of skilled labour in the onsite construction sector and improving the quality of housing in a cost-effective manner. Studies and reports in several other countries have recommended greater adoption of off-site construction, including in Australia (Hampson & Brandon, 2004)

In the Saudi Arabian construction sector, one of the largest in the Gulf Region, there have also been calls for increased adoption of off-site construction methods. One of the rationales for this is the capacity of off-site construction techniques to deal with the delays and inefficiencies that plague the construction sector in Saudi Arabia (Alkharashi & Skitmore2009).

Notwithstanding such calls, the relatively small manufacturing sector and the lack of principal experience in Saudi Arabia have been cited as barriers to the uptake of off-site construction (Aburas, 2011).

Off-site construction produces a significant amount of value for the construction industry and the economy more generally. Taylor (2010) conducted a comprehensive study of the value of the off-site construction industry in the United Kingdom. The results suggested that, in 2008, the total gross output of the off-site construction sector was approximately £5.8 billion. This represented a substantial rise from 1998, when it was £2.3 billion (Taylor, 2010). According to Taylor (2010), a more appropriate measure than gross output is value-added, since it indicates the contribution that off-site construction makes to gross domestic product (GDP). The total value added of the sector rose from £731 million in 1998 to £1.537 billion in 2008, more than doubling in value (Taylor, 2010).

It is important to note, however, that the overall share of off-site construction in the construction sector remains low according to most reports (Jaillion & Poon, 2009; Chan, 2011). For example, off-site construction only makes up 2.2 per cent of the total value of the UK construction sector according to Goodier and Gibb (2005). Furthermore, the global financial crisis arising out of the United States in 2007 and 2008 affected the wider construction sector deeply. Taylor (2010) notes that while the sector was worth £2.08 billion in 2007 in the UK, representing the high point in the past decade, by 2008, it had declined to £1.537 billion.

It is unknown whether the trends reported by Taylor (2010) in the UK are observable in other countries. For example, it would be interesting to assess whether the off-site construction industry in Australia was affected by the global financial crisis to the same extent. It is likely that, due to Australia's relatively more robust economy in the past few years, the off-site construction sector here has not suffered the same decline since 2008. Nevertheless, it is also possible that the sector did not experience the same amount of growth as the UK sector did in the early 2000s whilst in-situ brick and block still dominates domestic Australian market, prefabrication and "tilt-up" construction has begun to be seen as very important in the proving of ware housing and less complex structures and venues (Taylor, 2010).

According to Venables et al (2004), as mentioned, the uptake of off-site construction is partly influenced by the perception that key players have of the benefits and disadvantages of off-site construction.Pan, Gibb, and Dainty (2012) conducted a case study with the aim to investigate the impacts of the use of off-site production technologies in two residential complexes in the UK; one with 102 units, and the other with 152 units.. The two complexes each used precast concrete cross wall panels and floor planks. One interesting difference between the two complexes studied was that the 102 unit complex was that company's first cross-wall multi-story project whereas the 152 unit complex was the respective corporation's sixth cross-wall multi-story project.

The team also found that, according to stakeholder views, the benefits that are attainable from using off-site production technologies are optimised when contractors are able to engage with suppliers as early as possible. Early contact and planning was found to increase business efficiency and minimise resistance from stakeholders who may be more comfortable with conventional approaches (Pan et al., 2012). This advice was supported by O'Connor, O'Brien, and Choi (2014) who found that "timely freeze of scoping and design" was a critical success factor with respect to the adoption of off-site construction technologies.

Another interesting lesson from this study was the positive learning effects that could be produced once stakeholders had become more familiar with off-site construction techniques (Pan et al., 2012). Learning effects and productivity have been focused on in other studies (Yi & Chan, 2014). Yet despite the positive learning effects possible through increased familiarity with novel interventions such as off-site construction techniques, there still appears a heavy reluctance by managers in construction projects to use innovative practices even if those practices have historically been successful. Caldas, Kim, Haas, Goodrum, and Zhang (2014) argue that the adoption and value of off-site construction techniques and other innovative practices will increase if managers are given more information and instruction on methods to assist the planning and implementation of such practices (Pasquire & Connelley, 2002).

2.2.4 Benefits

There are numerous studies advocating the need for improved productivity in the construction sector (Pasquire & Connelley, 2002). For example, Vogl and Abdel-Wahab (2014) extrapolate that a 10% improvement in productivity in the construction sector in the United Kingdom would enable the construction of at least 30,000 more residential houses. Off-site construction can bring about several benefits to the construction process. Indeed, it was identified in the seminal Egan Report (1998) in the United Kingdom as playing an important role in improving performance in the construction industry, which suffers from low productivity. While there has been a substantial body of research which has focussed on the *perceived* benefits of construction projects, there has been relatively little empirical evidence of real benefits vis-à-vis traditional onsite construction. Indeed, Pasquire and Gibb (2002) and Blismas and Wakefield (2009) note that evaluations of off-site construction are largely grounded in anecdotal evidence rather than rigorous data. More recently, Blismas and Wakefield (2009) state that there is a lack of research that objectively measures the benefits of off-site construction; instead, most research has focused on case studies or subjective studies on experiences with off-site construction.

Nevertheless, research on perceived benefits is useful for two reasons. First, because it provides a benchmark to measuring the actual performance of off-site construction; it enables one to ascertain whether the perception is empirically valid and provides a good starting point for any empirical research (Pasquire & Connelley, 2002). Second, because knowing about how various groups perceive the benefits of off-site construction is itself beneficial; it is, after all, these groups that drive adoption of off-site construction, and to this end, perceived benefits may be more important to determining the future of the industry than real benefits (Pasquire & Connelley, 2002). In particular, it would appear to be very useful to look at the benefits that off-site construction provides from the perspective of key stakeholders in the construction process, such as clients, designers, contractors and building companies (Pasquire & Connelley, 2002). This then provides the foundation of a need to establish explicitly and empirically the extent to which off-site manufacturing can provide a benefit and more importantly the *variables that need to be identified to measure and record and improve upon existing prefabrication techniques.*

2.2.4.1 Time

The most significant benefit of off-site construction would appear to be the time savings that it brings about. By transferring a significant proportion of the construction work to an off-site facility, the time spent onsite is argued to reduce (Pasquire & Connelley, 2002). The more predictable conditions of the factory and the economies of scale that they generate can also ensure that construction deadlines are met more effectively than in a traditional onsite environment. Gibb and Isack (2003) interviewed senior personnel from the largest construction clients in the United Kingdom of their opinions towards pre-assembly, one of the main forms of off-site construction. Over 40 per cent of all responses chose time/speed as the main reason for choosing off-site construction. Pre-assembly enabled less time to be spent on site and a reduction in commercial *risk* as a result of faster time frames for projects (Pasquire & Connelley, 2002).

In another British study of clients, Goodier and Gibb (2007) found *time* to be the greatest advantage of off-site construction methods: 87 per cent of clients and designers listed it as an advantage, with 38 per cent placing it as greatest advantage. Contractors perceived time to be an even greater benefit arising from off-site construction, with 68 per cent placing it as their first choice (Goodier and Gibb, 2007). This is supported by Lu and Liska (2008), who interviewed both general contractors and designers (architects and engineers) in the United States. Among contractors, the most frequent reported benefit of off-site construction was the reduction in overall project schedule and the reduction in construction duration, both of which are related to time. Together, these two benefits were reported by 64 per cent of the surveyed group as part of their top three reasons for using off-site construction techniques. In a study of housebuilding companies in the United Kingdom, ensuring time certainty was cited by 54 per cent of respondents as a driver for using off-site construction methods (Pan et al., 2007). Venables et al (2004) studied the perception of off-site manufacturers and found that a reduction in onsite assembly time was one of the main benefits which they felt that off-site methods had over traditional methods. Finally, in Blismas et al. (2005), shorter project time scales were held to be the main benefit of off-site construction methods.

2.2.4.2 Quality

Another significant benefit cited by the majority of stakeholders was an improvement in *quality*. The main advantage of off-site construction in this regard is that it enables a tighter control over quality than an onsite environment. Venables et al (2004) found that quality of production and finish was the single most important perceived benefit of off-site construction over traditional onsite construction. Gibb and Isack (2003) discovered a perception among clients that elements made off-site, in a factory, were more consistent and had gone through a greater degree of quality control and testing than elements made onsite. Less time spent on snagging (remedial works) was also mentioned as a benefit. Overall, the study found that quality was the second most significant factor reported by clients for choosing off-site construction. Goodier and Gibb (2007) found increased quality to be the second most significant benefit of off-site construction methods: 28 per cent of clients and designers cited it as their first choice, while 15 per cent of contractors did the same.

In Lu and Liska (2008), the increase in quality was not ranked as highly: it was only the fourth most common response among designers and the seventh most common among contractors. In Pan et al (2007), quality was ranked fourth among house building companies among relevant factors, with 50 per cent holding that it was a driver for them adopting the use of off-site methods. It is unknown whether the discrepancies between these two surveys and those of Gibb and Isak (2003) and Goodier and Gibb (2007) are significant or merely the result of survey variance.

Gibb (2001) states that a key 'quality' benefit of off-site construction is its potential for continuous improvement and quality management over time. Due to standardisation, modules constructed off-site can be continuously improved as time goes by, something which cannot be done with the 'one-off, unique project approach' in traditional onsite construction. This is significant for this study in that, given industries more towards *continuous improvement* globally (as the *BECHTEL Corporation* and other dominant players appear to be doing) there are *opportunities* to seek future improvement through the application of operational management (total quality management) tools and techniques towards *measurement* of current and improvement of future efficiency.

Support for quality enhancement via off-site construction is not however universal; other issues relevant to quality have been noted by researchers such as Thomas and Sanvido (2000) who found in their study that off-site construction was plagued with out-of-sequence late deliveries, double-handing of components raising production and transportation costs, incompatibility between site requirements and fabrication rates, and fabrication errors at large.

2.2.4.3 Relieving skills shortages

A third factor underpinning stakeholder support for off-site construction appears to be its capacity to relieve *skills shortages* in the construction industry. Off-site construction essentially enables the construction process to be 'outsourced' to another environment, requiring less labour to be invested into traditional onsite processes and addressing the shortage in this area. Indeed, Pan et al (2007) found this to be the single most important driver for the adoption of off-site construction methods among British house building companies. In fact, 61 per cent cited it as a driving force in this regard. While not as significant as in the case of building companies, compensating for the skill shortage of craft workers remained within the top six reasons for general contractors using off-site construction (Lu and Liska, 2008).

From a developed European standpoint Gibb and Isack (2003) found this to be a minor reason in their study of clients: less than 10 out of 117 unprompted responses mentioned 'people'-related reasons, which included the lack of skilled labour and the fact that off-site construction meant that there were fewer people on-site. This discrepancy may arise from the fact that, in comparison to contractors and building companies, clients have less awareness of the dynamics of the construction industry and the skill shortage problems within it. Indeed, Gibb and Isack (2003) point out that clients are less likely to understand the benefits and disadvantages of off-site construction methods in comparison to other stakeholders. As such, they may be more likely to favour off-site construction for 'visible' reasons such as shorter time frames and higher quality.

Another problem might be the fact that, according to Gibb and Isack (2003), off-site construction itself suffers from fabricator-(un)availability 'supply' shortages. Lack of availability was the third highest reason why building companies did *not* use pre-assembly methods of off-site construction. This is supported by Goodier and Gibb (2007), where only about 40 per cent of off-site suppliers interviewed felt that supply was enough to meet demand for off-site construction.

2.2.4.4 Cost

Of the perceived benefits of off-site construction, *cost* is the most controversial. *Cost* was cited to be a major advantage in several surveys but has also been listed as a major disadvantage in others. According to Pan et al. (2007), the improved cost *certainty* of off-site construction was a major driver for its use by house building companies. This may be explained by the fact that off-site construction is more predictable and less likely to suffer from cost blowouts caused by unknown factors such as the weather. Among architects and engineers, the *reduction* of overall project cost was the second most frequent response for using off-site techniques, raised by 36 per cent of respondents (Lu & Liska, 2008). In Gibb and Isack (2003), cost was cited as the third most important benefit by clients. The key focus in the responses was on the fact that off-site construction could lead to lower cost, with some responses also mentioned an increased cost certainty of off-site methods (Pasquire & Connelley, 2002).

These results are contradicted by Nadim and Goulding (2010), who found that 92 per cent of respondents believed that higher initial costs of off-site construction were an inhibitor to the wider use of off-site methods. This research work seeks to address these conflicting perceptions in cost and value savings by going beyond subjective opinion towards empirical identification, *measurement* and improvement of the variables involved in the off-site supply of subcomponent elements. Indeed a number of researchers strongly dispute the cost saving "truism". Goodier and Gibb (2007) found that higher costs were the most significant limitation to off-site construction. 54 per cent of clients and designers listed it as their main barrier, while 38 per cent of contractors did the same.

However, as Goodier and Gibb (2007) themselves point out, these results are somewhat 'perverse', since 44 per cent of clients and designers cited reduced initial cost as an *advantage* of off-site construction, while 41 per cent cited reduced whole life cost as an advantage. Indeed, this direct inconsistency of views is reflected in Pan et al (2007), where despite the fact that improved cost certainty was perceived to be a major advantage of off-site construction, higher capital cost was cited by 68 per cent of house building companies as a hindrance to adopting off-site construction, while 43 per cent stated that it was difficult to achieve economies of scale.

The cause of this inconsistency may be that there is a perception problem in relation to cost: some clients may believe (on the basis of initial direct costs) that off-site construction is too expensive and choose not to use it, while those that do may find that, in reality, it has a net benefit for project costs. Gibb (2001) discusses the inconsistent perception of costs in an article on distinguishing ‘myth from reality’ in off-site construction (standardisation and pre-assembly). The author states that from an isolated, elemental perspective, pre-assembled units may appear more expensive, since in their price is internalised the cost of labour and other factory costs. Furthermore, ‘many of the benefits [of standardisation and pre-assembly] are realised elsewhere in the construction process’, such as through reduced labour onsite (Gibb, 2001).

Goodier and Gibb (2007) make a similar point when they note that other benefits of off-site construction, such as better quality and reduced remedial work, are often not included in costings. For instance, Pan et al (2008) show that the cost of maintaining off-site bathroom modules can often be as low as one-third those of bathrooms constructed on site. This ‘life cycle cost’ across an asset’s usable life being an often overlooked aspect for an industry that emphasises initial capital costs predominantly. Blismas et al (2006) similarly note that the main advantages of off-site production are not direct, but rather come from indirect cost savings and non-cost value-adding items. As a result, while initial costs may appear higher, the actual cost of off-site construction methods (particularly over the whole-life of the project) may be cheaper than the use of traditional onsite methods (Pasquire & Connelley, 2002).

Gibb and Isack (2003) conducted a survey of 59 senior personnel from 42 of the largest construction client organisations concerning what the participants perceived as the benefits and drawbacks of the use of off-site production technologies in the United Kingdom. The respondents were able to comment that due to advances in technology, the cost of constructing hotel rooms had decreased by 20% in the last 20 years. They also commented that within the same timeframe, the cost of constructing airport pavements, petrol stations, restaurants, and prison house blocks had reduced by 18, 15, 18, and 25% respectively. These statements are consistent with more recent publications concerned with enhanced productivity with respect to particular building sectors as a result of off-site construction practices (Bernstein et al., 2011).

2.2.4.5 Productivity

Productivity is largely defined as the relationship between inputs in a production process and the respective outputs. *Productivity* is also defined in terms of being a power, a rate, or a level of efficiency (Yi and Chen, 2014). The Organisation for Economic Cooperation and Development defines it as "the output produced by a unit of study as a proportion of the inputs required to produce it (2001, cited in Loosemore, 2014).

The concept of productivity provides another way of conceptualising the benefits of off-site productions. Some studies, such as Gibb and Isack (2003) mention productivity gains as a distinct category – in their study of construction clients, productivity is cited as the fourth most important benefit of off-site construction methods. Nevertheless, only slightly more than 15 per cent of respondents listed productivity as their main reason for choosing off-site construction.

However, a broader view indicates that greater productivity can be viewed as the overriding benefit of off-site construction, with the reduced time, higher quality and lower cost of projects ultimately meaning that the process is more productive per unit of input than onsite construction. Eastman and Sacks (2008), for example, argue that the productivity advantages are possible in construction due to using off-site approaches, is greatly underestimated. Indeed, the work proposed by this study has, as one of its aims a structured means and method to *identify* and *measure* the *variables* of *productivity* objectively. These areas will be expanded thoroughly in section 2.4.

2.2.5 Disadvantages

For all of its perceived benefits, there are also significant perceived *disadvantages* to off-site construction among key stakeholders. While many studies discuss the different disadvantaged and adoption barriers of off-site construction, few of them measure the level of satisfaction with off-site construction. One of the few is the UK survey of house building companies by Pan et al (2007), which found that only 31 per cent of respondents were satisfied with the performance of off-site methods within their own organisations and only 49 per cent were satisfied with the performance of off-site construction in the industry generally. This compares poorly with satisfaction rates of traditional construction methods: in the same study, 82 per cent of respondents were satisfied with the performance of traditional onsite methods in their own organisations and 59 per cent were satisfied with performance across the whole industry. This indicates that, on balance, off-site construction is still perceived negatively and is seen as being *less* effective than onsite construction, even if it brings a number of perceived benefits. Again given industry's desire towards *continuous improvement* an opportunity and indeed exists to not only identify and measure the *variables* of off-site *performance* but also to seek *improvement*. The current project seeks to do this by addressing *operational management* tools and techniques in off-site production to fill the need for *performance enhancement* and *continuous improvement*.

2.2.5.1 Increased cost, time and poorer quality

One of the most commonly cited *disadvantages* are its *cost*, which has been discussed above and which is problematic given that it is often simultaneously perceived as a benefit. Perhaps surprisingly, many of the factors which survey respondents cited as being the greatest advantages were also cited as the greatest disadvantages. According to Gibb and Isack (2003), the biggest disadvantages aside from cost for clients were the poor build quality of pre-fabricated components, incorrect designs, delayed delivery time and the volatile nature of the supply chain. In Gibb and Goodier (2007), aside from cost, the second-largest barrier to clients, designers and contractors was longer lead-in times. Similarly, in Blismas et al (2005), time issues were reported to be among the top three constrains inhibiting implementation of off-site construction methods.

These findings contradict almost entirely the fact that, in the same studies, clients praised the higher quality and consistency of off-site components, as well as the shorter construction time frames. The reason for this may have to do with inconsistent experiences of off-site construction among the different stakeholders. They suggest that while some off-site construction products from specific vendors may have particular benefits for some projects and stakeholders, other units produced off-site may have negative effects for other projects and stakeholders. Overall, the findings are indicative of the importance of factors such as time, quality and cost to stakeholders *generally*, meaning that they will almost always appear near the top of the list in qualitative studies of stakeholder perception.

Gibb and Isack (2003) also investigated what stakeholders in the United Kingdom believed were the disadvantages or issues of off-site production technologies. Responses indicated that prefabricated components could sometimes be poorly built due to the fact that contractors were not experienced enough. Another issue was that the original design of the items had been, for whatever reason, incorrect. Late delivers of materials and even supplies going into receivership were cited as issues. Stakeholders were also critical of the potential for cost savings in some cases. Some believed that similar outcomes were achievable using conventional methods while others believed that only high volume projects with sufficient repetition applications would worthwhile (Gibb & Isack 2003).

In Korea, one study found that using precast concrete and other components produced off-site for the purposes of enhancing productivity and saving cost has largely been unsuccessful in that setting. The authors suggested that traffic control on site, and other costs related to transportation plagued the installation of this prefabricated item (Hong, Lee, Lee, Kim, 2014). The authors also found that costs related to providing an appropriate clearance area and a temporary stockyard for finished precast concrete led many contractors to avoid off-site construction in Korea (Hong et al., 2014).

2.2.5.2 Lack of flexibility and limited options

In a study by Lu and Liska (2008), architects and engineers held that the *inability to make changes* onsite and *transport restrains* were the two major challenges of using off-site construction methods. As Blismas and Wakefield (2009) opine, the geography and low population density of Australia means that transport constraints may be a particular issue for the use of off-site manufacturing in Australia. Particularly perhaps in Western Australia (the largest yet least densely populated state), albeit somewhat paradoxically mining operations in the very remote Pilbara and Kalbarri regions are increasingly being drawn towards *modular solutions* for the residential units to accommodate mining staff and worker. The third most cited challenge was *limited design options*.

These three challenges were also most frequently identified by contractors in Lu and Liska (2008). The inability to freeze design and specifications early was also cited as the most important hindrance to off-site construction methods in a study by Blismas et al (2005). This same limitation was also expressed by 29 per cent of house building companies in Pan et al (2007), constituting the third most significant limitation to the use of off-site construction methods. Similar findings were made in Gibb and Isack (2003). Grouped under the category of 'availability', the study found that many clients felt that off-site construction presented limited solutions and placed limitations on design. This indicates that, despite its perceived (if contested) advantages in areas such as quality and time, off-site construction cannot always substitute onsite construction. Its inflexibility in some situations means that for many projects it is not always an optimal choice. On the other hand however component supply and installation for *uniform* design solutions, embraced by mining operations in Western Australia are currently much less inclined towards any need for architecturally significant design.

As Venables et al (2004) states, there is a tension between the interests of off-site manufacturers and, building companies or clients. Particularly in the past few decades, the focus of the construction industry is on delivering customisation rather than standardisation. However, in order to improve manufacturing efficiency and economies of scale, off-site manufacturers have an incentive to minimise variations, limit choices and standardise components. The fact that it is to some extent a naturally occurring economic force makes it a significant limitation of off-site construction. Albeit that arguments towards flexibility and 'freezing designs' onsite are one of the main contributory factors in contracted conflict and related variation and extension their claims.

It is important to note, however, that, as with cost and time, some stakeholders reported (conversely) *increased* flexibility and greater customisation options in off-site construction. In Goodie and Gibb (2007), 33 per cent of clients and designers raised each of these two benefits, while 15 per cent of contractors cited increased flexibility.

Jonsson and Rudberg (2013) were also interested in a trade-off that appeared to be emerging in relation to the uptake of off-site production technologies. While the pair acknowledged that industrialised construction approaches involving the use of prefabricated components tended to lead to greater labour productivity, better quality, lower construction cost, and better on-time delivery, the disadvantage could be a loss of flexibility. In other words, customers would be faced with lower variety and lower flexibility concerning the choice of components for the project. The upshot of this it appears is that off-site production can provide the greatest benefits when economies of scale can be developed. Thus, the use of prefabricated components may be more beneficial for larger scale projects as opposed to smaller more unique buildings such as detached single houses (Jonsson and Rudberg 2013).

Similarly, Pan et al., (2012) focused on the need for long-term planning. The team found that while stakeholders believed that labour productivity had been increased through the use of off-site production technologies, one consideration that the team alluded to was that the client's design requirements needed to be confirmed in contract much earlier when off-site production technologies are used. This is because of the key decisions concerning the building project will need to be made earlier when prefabrication is intended to be used, and the contractor will probably need to make a substantial commitment to those materials (Pan et al. 2012).

2.2.5.3 Lack of knowledge and regulatory guidance

A lack of regulatory guidance was a major barrier preventing the full exploitation of off-site construction. According to Goodier and Gibb (2007), 46 per cent of contractors cited a lack of guidance and information as being a problem, while 23 per cent cited the lack of standards and codes available. This was the third most significant barrier cited after higher cost and longer lead-in times. Among clients and designers, 33 per cent identified a lack of guidance and information as a barrier, while the same amount mentioned lack of standards and codes. This issue might be suggested as being linked to clients that seek their own *bespoke design* rather than an *off- the- peg* solution already available.

In Blismas and Wakefield (2009), a lack of adequate knowledge was identified as a significant constraint against the adoption of off-site construction methods. Aside from a lack of 'general guidance' regarding off-site construction in the marketplace, another problem was the fact that designers and constructors had limited experience of off-site methods and still often applied traditional onsite ways of thinking.

In a related manner, several studies show that regulatory and planning law limitations are a moderate barrier to the adoption of off-site construction methods. In Lu and Liska (2008), 11 per cent of contractors and 8 per cent of designers mentioned that local zoning ordinances restricted the use of off-site construction, while 6 per cent of contractors and 9 per cent of designers mentioned that local building regulations restricted the use of off-site construction.

2.2.6 Evaluation and implications

2.2.6.1 Stakeholder resistance

The perception of stakeholders towards off-site construction is a mixed one, with key groups identifying both significant advantages and disadvantages. Nevertheless, as indicated in Pan et al (2007) above, there appears to be relatively low satisfaction with off-site construction methods, with only 31 per cent of respondents in that survey being satisfied with off-site methods in their own companies. More broadly, most of the surveys showed that off-site construction methods suffered from stakeholder resistance and a *negative* image.

In Goodier and Gibb (2007), 38 per cent of clients and designers reported 'client resistance' to be a major barrier hindering their adoption of off-site construction methods, with 13 per cent identifying it as the main barrier. Since part of the target group of this survey was clients themselves, it may be hypothesised that these findings show that many clients have a self-reported negativity towards off-site construction. Among contractors, 31 per cent found client resistance to a major barrier, with 23 per cent listing it as the most important barrier (the second highest result after increased cost). 28 per cent of clients and designers and 46 per cent of contractors reported that off-site construction had a negative image. In the study of contractors by Lu and Liska (2008), 31 per cent of respondents noted that among their top three challenges to using off-site construction techniques was the fact that project owners or financial institutions would *not allow* such techniques to be used.

Both Blismas and Wakefield (2009) and Nadim and Goulding (2010) found that there was a culture against change in the industry. Blismas and Wakefield (2009) and Venables et al (2004) propose that the bias against off-site construction may partly be caused by its reputation for standardisation and the fact that it was used in constructing many affordable housing projects in the 1960s and 1970s. Often clients, particularly in the residential sector, may not be aware of the advantages of prefabrication and modularisation. It was found in a study by Bernstein (2011) that between 39 and 54% of architects indicated that their clients *did not want* to use these off-site construction technologies.

Pan et al (2007) also discuss the reasons for the low levels of satisfaction towards off-site construction among house builders. They situate the cause in the low level of usage of off-site methods, in a context where builders are supportive of their existing work practices (i.e. traditional onsite construction). Furthermore, as Pan et al (2007) point out, the construction industry is traditionally risk-averse and not an early adopter and there is insufficient knowledge of the benefits of off-site construction. This last point is particularly illustrated by the survey findings, with, for example, many respondents citing cost as a major negative aspect of off-site construction without understanding that in fact off-site methods can reduce costs over the life of the project.

2.2.6.2 Future adoption and value

That the aforementioned negative perception of off-site construction does not appear to translate into low future adoption prospects is not, however, indicated by the research. Indeed, in Pan et al (2007), 64 per cent of surveyed house building companies believed that the industry needed to increase its use of off-site construction methods, with larger builders being more favourable towards the increase. While building companies did not favour the use of complete modular buildings, there was significant support for increasing the use of modular kitchens and bathrooms, external walls, timber frame structures and roofs (Pan et al, 2007). On a similar note, Gibb and Isack (2003) found that 52 per cent of clients interviewed would definitely increase their use of pre-assembly in the future, while only 20 per cent would probably not or definitely not do the same. Finally, in Nadim and Goulding (2010), 73 per cent of respondents indicated that off-site construction was important to the future of the UK construction industry. Anecdotally this might be also argued to be the case in the remote northern areas of Western Australia as it strives to facilitate infrastructure for mining operations.

Independently, of stakeholder perception, the future growth prospects for off-site construction appear to be moderate. While there is no data for gross output or value added beyond 2008, Taylor (2010) includes a series of forecasts until 2013, based on research by Ormerod (2008) and CPA (2009). According to the forecasts, growth in the off-site construction industry resumed in 2011, although rates of output growth were relatively low – 0.5 per cent per annum in 2011, rising to 3.1 per cent per annum in 2013. This suggests that, in a post-financial crisis world, the off-site construction sector will not see the surge it experienced in the late 1990s and early 2000s, when annual growth rates were often in double digits (Taylor, 2010).

2.2.6.3 Implications

The negative perception and resistance that some stakeholders have towards off-site construction appears to be one a factor holding back its growth. As Pan et al (2007) suggest, one of the main ways of increasing growth is to make stakeholders recognise fully and engage with the potential benefits of off-site construction. Towards this end a greater focus on *objective* research on the *identification*, *measurement* and *monitoring* of the *variables* that differentiate off-site construction, from more traditional in situ supply and installations activities which can then be used to guide industry in the off-site methods can add value to a project and in particular seek to address explicitly *performance variables*.

As pointed out previously and noted by Blismas and Wakefield (2009), while there is a significant body of literature on case studies and stakeholder perceptions of off-site construction, there is little *objective* comparison between perception-alone alongside off-site construction actual productivity, and more importantly that *objectively* clarifies *performance variables identification* and *measurement* in off-site work exclusively. In particular, as Venables et al (2004) state, more research needs to be carried out to assess the cost of off-site construction relative to onsite construction; in other words *performance factors*. The confused perception of cost that most stakeholders have can only be conclusively addressed through comprehensive objective research in this regard.

Pan et al (2007) recommend a number of other possibilities for the future: improving procurement, providing better cost data and comparative costing methods, reforming the planning process and improving knowledge on the decision-making process and site integration of off-site construction methods. Blismas and Wakefield (2009) state that more research should be conducted into how manufacturing principles from other industries, such as steel, chemicals and machinery, can be applied to the construction industry. They note that principles from other manufacturing industries have successfully been applied to off-site construction of homes in Japan. This point, which is often ignored, is a highly valuable one. Insights from more established manufacturing industries and their means to *measure performance* through *operational management* can ensure that off-site construction, a relatively young and *local* industry, has opportunities to develop perhaps in an efficient and *productive* way. This would add value to guidance in the utilisation of off-site construction.

Despite the promise offered by some advocates of off-site construction methods, Gibb (2001) notes that a total or even predominant switch to standardisation and prefabrication is untenable. Instead, he argues that the focus should be on optimisation rather than maximisation of use (Gibb, 2001). Similarly, Venables et al (2004) state that off-site construction ‘is not, and is unlikely to become, a universal construction solution for all built assets. Instead, stakeholders should focus on determining the *appropriate* use of off-site construction, finding areas where the advantages of off-site construction can add the most value and where opportunities for continuous improvement exist. For example, off-site construction, due to its more precise and fast time frames, may add a lot of value to projects that need a more standardised and uniform design solution to a repetitive (non-complex) design brief, to be completed by a fixed time, but may not be so useful in circumstances where this is not an important factor.

This reflects the findings of the studies which showed both that off-site construction was limited through its lack of flexibility as well as the fact that the very benefits of off-site construction in some circumstances can also be its biggest disadvantages in other circumstances. In this way, the focus shouldn’t be on promoting growth in off-site construction at all costs, but rather in finding out where off-site construction is most effective and seeking to optimise *objectively* its *performance parameters* in that area.

2.3 Employee empowerment

2.3.1 Historical background

As the comparative cost of human resources rises, particularly in developed nations, there is an increasing need for managers to develop systems of work that provide greater benefits both for the *individual employees* and for the *client organisations* (Tzafrir et al., 2003). One system that gives improved rewards to the workers and to the companies who hire them, includes performance-related pay schemes (Bloom and Van Reenen, 2010), which have become increasingly popular ever since the 1970s (Bloom and Van Reenen, 2010). Since the 1980s, other areas of management practice have also increased in popularity: regular employee training, self-managed teams, feedback programs concerning performance, job rotation, regular meetings, coaching and mentoring are all believed to be commonly practised in the modern workplace; although, some experts argue that it is difficult to assess the prevalence of these practices accurately (Bloom and Van Reenen, 2010).

The use of models from psychology and human behaviour in resources management has proliferated recently. Since the 1950s, there has been strong interest in the relationships that link performance in the workplace with motivation, trust, justice and loyalty (Nelson and O'Donohue, 2006; Tzafrir et al., 2003). One such model was the psychological contract, in which permanent employees pledge their loyalty to their employers in exchange for job security [Argyris (1960) and Rousseau (1989): cited in Coyle-Shapiro, 2008; Tzafrir et al., 2003]. The model of meaningful work by Hackman and Oldham (1980, cited in Nelson and O'Donohue, 2006) hold that the variety of skills required, identity of tasks and significance of tasks each contribute to giving a job more meaning.

The concepts of meaningful employment, loyalty and trust were integrated by Spreitzer (1995) and Tzafrir et al. (2003) to form the single empowerment concept. Spreitzer (1995) described the condition of psychological empowerment as 'increased intrinsic task motivation manifested in a set of four cognitions reflecting an individual's orientation to his or her work role, namely: meaning, competence, self-determination and impact (Spreitzer, 1995; Zhu et al., 2012). The four cognitions of Spreitzer's definition of psychological empowerment require further explanation.
In brief:

- Meaning refers to the positive sentiment that an individual feels when they believe their work is important, and when they are given higher responsibilities.
- Competence is an individual's sense of personal mastery over their dedicated tasks of employment, and is closely related to self-efficacy.

- Self-determination refers to the extent of the individual's control over their tasks; their self-determination level is high when they can choose the amount of time, effort and techniques they use to complete a given task (Fulford and Enz, 1995).
- Impact in the context of empowerment may be bracketed with salience, prominence or conspicuousness in the workplace; Spreitzer (2008) defined it as 'the degree to which an individual believes that his/her work makes a significant difference in achieving the purpose of the task, and the extent to which the individual believes that he or she can influence organisational outcomes'.

Lawler et al. (2001) estimated that at least 70% of workplaces in the United States, that were listed in the Fortune 1000 (ranked in order of revenue) had resources management programs based on the psychological empowerment theory. Spreitzer (2008) has suggested that it is more than likely that three out of four of all U.S. workplaces actively implement some kind of empowerment initiative for at least part of their workforce.

Employee empowerment is one aspect of operational management techniques that has attracted continuing attention from leaders in management, both academic and professional. Thus, it is hardly surprising that representatives of a range of industry sectors are seeking the best techniques, methods and approaches for introducing best-practice empowerment of employees in their particular workplaces (Belasco and Stayer, 1994; Bowen and Lawler, 1992, 1995; Byham and Cox, 1998; Herbert, 2009; Ogden et al., 2006; Otley, 1994; Spreitzer, 2008).

Employee empowerment consists of 'giving employees greater control and freedom, but in such a way as to generate self-responsibility and encourage self-efficacy' (Holt et al., 2002). The primary theme is to enhance feelings of 'self-efficacy' through the adoption of appropriate motivational and involvement techniques, including 'identification and removal of conditions that foster powerlessness' (Nesan and Holt, 2002). Moreover, this pattern has become an alternative to inflexible and expensive bureaucratic systems, and aims at adapting enterprises to rapidly changing contemporary conditions and ongoing technological progress (Argyris, 1998; Bowen and Lawler 1992, 1995; Byham and Cox, 1998; Ezzamel et al., 1994; Herbert, 2009; Johnson, 1992; Peters and Waterman, 1982; Teece, 2007) and is apparent from both theoretical and empirical perspectives (Tuuli & Rowlinson, 2007).

It is important to consider the concept of employee empowerment within the broader context of management and production theory (Jung 2009; Taher et al. 1998). According to Nesan and Holt (2002), employee empowerment can be situated within the broader context of ‘new production philosophies’ such as total quality management (TQM) and re-engineering, which focus on improving the ‘process’ and the ‘people’ in order to bring about productivity gains and reduce defects (Hackman and Wageman, 1995; Lawler et al., 2001). A positive relationship between implementation of new production philosophies (especially related to what was previously termed total-quality-management TQM and now might be termed continuous-improvement in the construction indsutry), and improved company productivity has been supported by numerous studies (e.g. Flynn et al., 1995; Black and Porter, 1996; Choi and Eboch, 1998; Samson and Terziovski, 1999; Sun, 2000). Employee empowerment thus forms part of organisational ‘realignment’ in response to the changing business environment brought about by globalisation, increasing competition and increasing customer expectations (Holt et al., 2000).

The literature on TQM has tended to focus on seven sub-elements: leadership, strategy and planning, customer focus, information and analysis, people management, process management, and business performance (Jung & Wang, 2006), and these may be grouped into four categories: ‘employee relations’, ‘leadership’, ‘customer/supplier relations’, and ‘product/process management’ (Jung and Wang, 2006). In this sense, employee empowerment can be thought of as part of the ‘leadership’, ‘strategy and planning’, and ‘people management’ sub-elements of TQM.

In the construction industry, several authors have described the relationship between TQM/continuous-improvement and employee empowerment (Price et al., 2004; Nesan, 2002; Jung, 2009). It is generally assumed that people and processes are interrelated; it follows that poor performance by employees may hinder organisational improvement (Nesan, 2002). Employee empowerment emphasises an idea that leadership, communication within the organisation and communication with the client, all work to improve overall productivity and client satisfaction (Price et al., 2004).

2.3.2 Definition: empowerment

The term "power" is usually used in explanations of empowerment, being derived from the literal meaning of the word. However, the concept of empowerment is flexible; hence, its definition for different organisations is not obvious (Dainty et al, 2002). The concept is still not defined appropriately and so is quite often used in an abstract manner (Greasley et al., 2008; Mondros and Wilson, 1994). Psoinos and Smithson (2002) and Price et al. (2003) also suggest that there has been a lot of discussion on the definition of empowerment, which is a concept that has not been defined properly.

While there is no single definition of employee empowerment, most definitions frame the concept in terms of decentralisation and providing greater control to employees at lower levels. It can be described as "the process of enabling employees to make workplace decisions for which they are accountable and responsible, within acceptable parameters, and as a part of the organizational culture" (Geroyet al. 1998). Thus, for Holt et al. (2002), empowerment consists of 'giving employees greater control and freedom, but in such a way as to generate self-responsibility and encourage self-efficacy'. Similarly, according to Nesan and Holt (2002), the primary theme is to enhance feelings of 'self-efficacy' through the adoption of appropriate motivational and involvement techniques, including identification and removal of conditions that foster powerlessness'.

For Dainty, Bryman and Price (2002), empowerment is 'the process enabling employees to make workplace decisions for which they are accountable and responsible'. Liu et al. (2007) define empowerment as the process whereby the power, authority and responsibility of the superior is relinquished to subordinates, and where the individual's belief in their own effectiveness is strengthened. Employee empowerment can thereby be regarded as movement away from the traditional organisational hierarchy, where managers are responsible for the majority of decisions and lower level employees merely implement such decisions.

Nevertheless, as Hammuda and Dulaimi (1997) point out, empowerment does not necessarily represent a lessening in the role of management. While employee empowerment may mean that a different relationship is created between managers and employees, it does not mean that their importance within the organisation will diminish. Managers are particularly important as 'organisational emancipators' who can use their leadership skills to motivate employees. Indeed, as Dainty, Bryman and Price (2002) suggest, empowerment initiatives that are conducted without careful management are more likely to lead to abandonment, as employees are given more responsibility but without a meaningful structure or direction within which to exercise it.

Thus, as can be argued, there appears to be no generally accepted definition of the term 'empowerment'. Some researchers describe it as a structural and a psychological concept (Cooper, 2007); others define the concept as multidimensional construct (Kanter, 1977, 1993); yet others appear to see empowerment as merely a 'quick fix' (Spreitzer, 2005). Nonetheless, most conceptions of employee empowerment are framed in terms of decentralisation and providing greater control to employees at lower levels.

2.3.3 Different empowerment approaches

Empowerment/employee-empowerment is often articulated using theoretical models (Tuuli & Rowlinson, 2007a; Sackey et al., 2011); approaches include *structural empowerment* approaches, *psychological empowerment* and, *critical* and *multi-dimensional* approaches (Honold, 1997; Nesan, 2004; Spreitzer and Doneson, 2005; Spreitzer, 2007). These are discussed in more detail below.

2.3.3.1 Structural empowerment

Structural empowerment, concerned with power/powerlessness in accessing information and resources (Liden and Arad 1996; Spreitzer, 2007; Tuuli & Rowlinson, 2007a) has been associated with increases/improvements in individual and team performance (Tuuli & Rowlinson, 2009b). Structural empowerment pertains to the organizational procedures, structures and practices through which employees receive the authority to make decisions and retain greater control of their work (Liden and Arad, 1996, Eylon and Bamberger, 2000, Mills and Ungson, 2003). This aspect is pertinent to the idea of power sharing between the managers and their subordinates where the employees are not only awarded material power through structural empowerment, rather, they also receive knowledge, information and benefits which are all deemed to be critical elements of a structural point of view. This means that the employees at the lower level receive access to the organizational hierarchy which means that there is an increase in the information, opportunity, encouragement and resources at their disposal (Spreitzer, 2005).

Structural empowerment is considered as giving material power to employees as well as knowledge, information and rewards. Generally, these are considered to be the crucial factors of a structural perspective. Thus, lower-level employees are able to gain access to the hierarchy of the organisational, in other words, their opportunity, information, support and resources are increased (Spreitzer, 2005); however, it should be pointed out that this perspective focuses on the influence of social factors on the power/powerlessness in the workplace (Liden and Arad, 1996).

2.3.3.2 Psychological empowerment

Psychological empowerment (in lieu of structural empowerment described in 2.3.3.1 above), views empowerment as seeing one's (competent) input as important (Spreitzer, 1995; Tuuli & Rowlinson, 2009a, Tuuli & Rowlinson, 2010a; Tuuli & Rowlinson, 2010b; Tuuli et al., 2012). According to this view, empowerment is "a constellation of experienced cognitions" and these manifest theselves as four positive sentiments of meaning (feeling one's work is important), competence (personal mastery), self-determination (autonomy), and impact (importance of work) (Tuuli & Rowlinson, 2009a). Similarly, mutual interaction in completing tasks was found to be positively related to psychological empowerment (Tuuli et al., 2012).

Psychological empowerment is described in most of the literature as the necessity for individuals to feel a *sense of control* in relation to their work (Spreitzer, 2007). It is also an act of building, developing and increasing their power by working at greater interrelation with others (Honold, 1997). The main idea is that rewarding individuals encourages their creativity, flexibility and commitment to organisational goals (Belasco and Stayer 1994; Bowen & Lawler 1992; Byham & Cox 1998; Seibert et al., 2011).

The idea of psychological empowerment deviates from the conventional management practices in the sense that the emphasis is on perceptions and emotions of employees (Peccei and Rosenthal, 2001; Holt et al., 2000; Thomas and Velthouse, 1990). As mentioined at the beginning of this section, there are four elements of the psychological empowerment concept: meaning, competence, self-determination, and effect (Spreitzer, 1995; Thomas &Velthouse, 1990). As alluded to above, Lee and Koh (2001) defined by stating that the four elements were, in fact, a depiction of the psychological state that the subordinate possessed: meaning (feeling that one’s task is significant), competence (personal expertise), self-determination (independence) and impact (the significance of work).

The psychological model of empowerment is based on a premise that empowerment is experienced by the individual to have effect. A number of studies refer to this suggesting that productivity issues cannot be sufficiently addressed when individual cognition of empowerment is neglected (Tuuli and Rowlinon 2009; Tuuli 2010a; Tuuli 2010b; Tuuli et al. 2012;Tuuli & Rowlinson, 2007b). Key issues include: direct relationships between psychological empowerment and performance; leadership style and team context; task purpose; an interaction between the perceptions of employees and the empowerment environment employee perceptions of independence; and, comprehension of empowerment’s impact on performance.

2.3.3.3 Critical approaches

The central tenet of the *critical* approach to empowerment (as opposed to structural empowerment described in 2.3.3.1, and psychological empowerment in2.3.3.2 above), is that *feeling* empowered is not the same as being empowered (Spreitzer, 2005) and can in fact be disempowering (Wendt, 2001) when power is always concentrated at the top. This state of affairs is then constantly criticised by employees who cannot advance in the organisation at this particular moment, since criticism is the only 'power' they have been given.

An important aspect of *critical* approaches are that they tend to maintain that an empowerment initiative, conducted without careful management, is likely to lead to its abandonment, as employees are given more responsibility but without direction or a meaningful structure within which to exercise it (Wendt, 2001; Price et al., 2003; Dainty et al.,2002; Spreitzer and Doneson, 2005). This argument might be suggested to extend earlier work on (the limited availability of) employee empowerment structures in the top-down construction sector by Hammuda and Dulaimi (1997), as well as the conceptual frameworks proposed for the manufacturing sector by Nesan (1997), Holt et al. (2000), and Nesan and Holt, (2002).

2.3.3.4 Multi-dimensional approaches

More sophisticated (beyond structural empowerment-2.3.3.1, psychological empowerment-2.3.3.2, and critical empowerment-2.3.3.3 above), is the *multi-dimensional perspective* approach to the question of empowerment in the workplace. It *combines* the above models but it suggests that, in order to be effective, empowerment must encompass six-factors (according to Honold, 1997) or ***nine-factors of empowerment as posited by Nesan*** (2004) (defined below in 2.3.5.1), namely:

> *leadership, empowerment-system, resources, involvement, education & training, teamwork, process-improvement, measurement, and recognition.*

These critical elements are fundamental to the transformational empowerment process (Nesan, 1997, 2004), but it seems that there is a significant lack of knowledge about empowerment in organisations both at the conceptual level and in practice (Huq, 2010;

Logan and Ganster, 2007; Seiber et al., 2004). The research presented here seeks address this knowledge gap.

An integrative multi-level approach towards empowerment and job performance has been suggested by Tuuli and Rowlinson (2009b) that is an expansion of the social cognitive theory (SCT), finding a direct positive link between structural empowerment and task and situational performance behaviours, as well as a positive and direct relationship with task work and team work attitudes; but, suggesting that there is no mutually exclusive relationship between structural empowerment and psychological empowerment. Questions remain however (Sackey et al., 2011a: 2011b), such as: do organisations manage to attain corresponding consistent objectives; how is empowerment demonstrated over the different project stages; does location/geography play a part; does space, time and level have express linage; and, might chaos/complexity theory assist understanding.

Mathieu et al. (2006) support an integrative approach to empowerment. The authors believe that an interlinked description (empowering work designs with enhanced team effectiveness) should include its inputs, processes, and outcomes. The process of empowerment, according to Sackey et al. (2011a) is argued as, better thought of as being an interactional process where the environmental factors (structural approach) play a part in forming the perception of empowerment (psychological approach), towards behavioural outcomes.

One consideration related to employee empowerment is whether it is to be understood as empowerment of the individual employee or collective-employee, i.e. *team, empowerment* (as experienced in the construction industry), as pointed out by Price et al. (2004). It is very important to distinguish between these two kinds of employee empowerment because they operate at different levels, namely the individual (autonomous) or the collective (organisational) (Price et al., 2004).

The *'culture'* within an organisation is another consideration in the employee empowerment debate. Firstly, it has often been said that, in terms of organisational culture, companies should work towards so-called horizontal management structures and shifts in culture that facilitate teamwork and improve employee participation (albeit an unorthodox idea for a building-site or fabrication-yeard) (Eylon and Eu, 1999; Spreitzer, 2007). Secondly, an individual employee's cultural background may also influence the effectiveness of overall employee empowerment (Eylon and Eu, 1999; Spreitzer, 2007), as exemplified by the inability of monoglot English-speaking employees to communicate—and therefore work, in some cases—with colleagues from non-English speaking countries. Moreover, a set of factors that may contribute to employee empowerment in one culture may not be applicable in another.

Training is also an important consideration of employee empowerment. Firms should ensure that they invest in keeping workers skilled and up-to-date with technological trends in the industry, but also that they respect the employees' need for 'belonging, recognition, achievement and self-actualisation' (Price et al., 2004) Knowledge management is also a central element of employee empowerment programs. In this regard, various studies have made the point that effective employee empowerment can only take place if employees have adequate knowledge support; otherwise, attempts at empowerment are a sham (Price et al., 2004).

As Tuuli and Rowlinson (2010) put it, 'Empowerment means different things to different individuals as a result of different socialisation and the varied interpretations individuals make regarding actions, policies and practices within their work environment'. It is difficult to develop a precise model for employee empowerment and makes the area complex and indeterminate in ensuring total-quality-management continuous-improvement in off-site fabrication of construction elements and sub-elements.

2.3.4 Benefits: employee empowerment

Various authors have recognized that *employee empowerment has* several *benefits*. Through empowerment, an organization can enhance its efficiency and quality, decrease operating expenses, achieve greater flexibility, and improve job satisfaction and motivation (Swenson, 1997). Improvements in different areas of economic performance have been observed in organizations employing empowerment techniques (Greasley et al., 2005). Sackey et al. (2011b) asserts that there seems to be a positive relationship between employee involvement and job satisfaction, motivation and performance, as well as personal commitment and corporate success. Furthermore, there is an increase in efficiency when there is empowerment, with motivation and dedication leading to an improvement in performance and productivity.

Patil et al. (2012) asserts that through empowerment, there will be: Greater motivation to make fewer errors; Increase in individuals taking responsibility for their actions; Greater opportunities for innovation and creativity; Continuous improvement in procedures, products and services; Increase in efficiency by an increase in employee self-worth and self-esteem; Increase in profits by employing techniques like decreasing waste and building quality; Increase in competitiveness; Increase in long-term competitiveness with greater market share; Increase in trust and support on the management; and, Greater communication between employees and departments.

2.3.5 Employee empowerment in the construction industry

Empowerment is a particularly important aim for the construction industry, given the low productivity associated with the sector which has been explored in several studies, including the landmark Egan Report Rethinking Construction (Egan, 1998; Dainty et al., 2002). Employee empowerment is a relatively new concept in the construction industry, and provides a way of enhancing productivity in construction, both off-site and onsite.

The importance of employee empowerment has been emphasised through a discussion of recent trends in the construction industry; for example, respect for people emphasised in the Rethinking Construction report, which highlighted the central role of empowerment in improving people management practices in the construction sector.

Empowerment in construction has been linked with many leading-edge practices in recent years including TQM, as mentioned, as well as construction (continuous) performance measurement, benchmarking, organisational change, job enrichment, high-performance systems, teamwork and motivation (Nesan, 2000, 2002, 2004; Holt, 2000).

2.3.5.1 Models

Of the variety of employee empowerment models in the literature on management in the construction industry, ***Nesan's (1997) nine-action empowerment model*** (mentioned above) is one of the most commonly cited conceptual frameworks. Because of its importance in the present context, it bears further discussion and elaboration here.

Nesan's (2004) most recent concept concerned the correlation of employee empowerment with the learning process. Much recent literature has indicated that construction organisations should act like teaching and learning organisations if they aimed at maintaining continuous improvement (e.g. the investigations by Jawahar-Nesan, 1997; Jawahar-Nesan and Holt, 1999; Kululanga et al., 1999; Knuf, 2000; Ford et al., 2000; DeVilbiss and Leonard, 2000; French and DeVilbiss, 2000). Although not unique in providing a comprehensive approach to the implementation of 'learning', these studies concentrated mainly on certain critical issues related to learning.

Nessan (2004) stated that a culture of 'empowerment' is an essential prerequisite to achieve a learning atmosphere in an organisation. Consequently, most of the issues around implementation, including organisational structure, leadership style, resources development, teamwork and performance measurement are common to both empowerment and learning. This point of view has had the support of others (Luthans, 1998), which emphasises that empowerment should be promoted throughout the structure of the organisation to implement learning (Nesan 2004).

Hammuda and Dulaimi (1997) provided another model for employee empowerment. It begins with the external forces creating a need for change, such as technology, globalisation and competitiveness. It then proposes a commitment by management to remove all barriers to empowerment, such barriers including rigid management structures and fear. This factor must be combined with the employees' involvement and their expectation that the process will eventually empower them. The involvement stage is seen as a transition towards empowerment; employees are allowed to take a more involved role in the running of the organisation, including making suggestions and decisions. The empowerment that this will eventually produce is expected to bring about a number of employee experiences—autonomy, flexibility, control and authority—which lead to a range of positive feelings in employees: job satisfaction, motivation, commitment, self-respect. This ultimately generates, in theory, creativity and innovation, with the end result being high performance, quality and productivity.

Holt et al. (2000) developed a three-stage model for implementing empowerment in traditional, onsite construction contractor organisations. The first phase is preparation, which involves an assessment of the organisation and development of an implementation plan. The second stage is implementation, where employees are trained about both the concept of empowerment and the skills they needed to perform in the new environment. The third stage, sustaining, requires continual training and performance management. This stage is particularly important, since it is only through a sustained approach that empowerment can be entrenched throughout the organisation and bring about the changes necessary to eliminate old management structures.

Tuuli and Rowlinson (2007) looked at employee empowerment at four levels: individual, team, organisation and project. At the individual level, they suggested that quality of relationships, work experience and openness were the factors that mainly contribute to empowerment. Team-level factors of empowerment are mainly team size, support from colleagues, leadership and the nature of the demands of the task; and the main organisational-level factors are an enabling work environment, HR practices, incentives and remuneration levels, top management involvement and the level of compliance with rules. Finally, the main project-level factors of empowerment are the level of information processing, common goals or visions, project priorities, and the size of, and uncertainty inherent in the project.

As mentioned, some researchers have suggested that an important factor is the potential cultural specificity of employee empowerment. This statement was supported by the study on employees in China carried out by Tuuli and Rowlinson (2007). It may explain the particular importance of relationship quality in bringing about individual empowerment according to China's Confucian tradition. Therefore, in any effective model of employee empowerment, cultural factors are essentially variable. Tuuli and Rowlinson's study measured employee empowerment using a qualitative interview methodology. One of the limitations of their approach was the small sample size, as well as the presence of a selection bias, whereby participants were purposely selected because of their willingness to share their experiences. Another limitation was the culture-specific nature of the sample. The participants were all Chinese and employees as opposed to principals. As the authors themselves acknowledged, a resolution to this limitation would be to use quantitative statistical methods to carry out a larger-scale survey into employee empowerment. Indeed this paves the way for the approach adopted here by this project.

2.3.5.2 Current adoption and value

Given the local nature of construction, it is difficult to ascertain the extent to which employee empowerment initiatives are used by management. Hammuda and Dulaimi's (1997) UK-based review provides an interesting perspective on the prevalence of empowerment in the *construction sector* compared to those of the service and *manufacturing* industries. The survey, which concentrated on construction managers, found that there was a relatively high degree of empowerment, but in a narrow sense; that is, construction managers had control, authority and access to information over their own projects. Overall, however, empowerment in construction was found to be 'inferior' to that in the service and manufacturing industries.

In particular, while construction managers had a great deal of authority over their own project, they had little influence over the company's general strategy. Building industry business planning was seen to be much more 'top down' rather than 'bottom up', unlike in many service industries. This was particularly a problem in high-risk projects, where management styles were more autocratic, with construction project managers having little work flexibility and most decisions coming from senior management.

Also in the UK, Nesan and Holt (2002) looked at the extent of implementation of the nine empowerment activities described above; they found that, on the whole, empowerment activities were more common in the manufacturing sector than in construction. Indeed, no single empowerment activity was more commonly adopted in construction than in manufacturing. The discrepancies were particularly noticeable in the areas of education and training, and process improvement. Nesan and Holt (2002) argued that successful education and training requires a 'continuous education' approach, where the organisation constantly seeks to learn new skills in order to improve processes. If no coherent organisation exists in a particular industry, 'continuous education' is rarely possible. It should perhaps be emphasised that construction continues to be one of the most labour-intensive business areas, and requires its employees to continually look for and apply knowledge to improve their performance in the business. The capacity to learn from both the internal and external business environments keeps construction organisations constantly alert for change, which in turn may encourage continuous growth.

Price et al. (2003) considered the delivery of employee empowerment programs in the UK construction industry. The authors outlined three key strategies – organisational culture, training and knowledge management – which act as performance enablers within an organisation. In terms of organisational culture, firms should work towards flatter management structure and cultural changes that facilitate teamwork and improve employee participation. . In terms of organisational culture, firms should work towards a flatter management structure and cultural changes that facilitate teamwork and improve employee participation, but also respect the needs of employees for 'belonging, recognition, achievement and self-actualisation' (Price et al., 2003). In terms of training, firms should ensure that they invest adequately in professional development sessions for their employees. An important part of this training is to ensure that employees are kept up-to-date with technological developments.

Further, in terms of knowledge management, the authors make the point that effective employee empowerment can only take place if employees have adequate knowledge support; otherwise, attempts at empowerment will be (as mentioned previously) a 'sham'. In Hong Kong, in another study Tuuli and Rowlinson (2007) studied employee empowerment across four levels: individual, team, organisation and project. At the individual level, they suggested that quality of relationships, work experience, and openness were the factors that mainly contribute to empowerment. Team-level factors of empowerment are mainly team size, support from colleagues, leadership and the nature of the demands of the task; and the main organisational-level factors are an enabling work environment, Human Resources (HR) practices, incentives and remuneration levels, top management involvement, and the level of compliance with rules.

Finally, the main project-level factors of empowerment are the level of information processing, common goals or visions, project priorities, and the size of, and uncertainty inherent in the project. In Hong Kong, Liu et al. (2007) carried out a study of perceptions of empowerment. They divided empowerment into 4 elements: opportunity, access to information, access to support and access to resources. Although not directly measuring the rate that the 4 elements were used, a positive correlation between empowerment and organisational commitment was argued. Again previous studies have, thus far, been unable to link empowerment and productivity directly. This study has attempted to bridge this gap.

2.3.5.3 Barriers to employee empowerment

Lincoln et al. (2002) writes that there is often little clarity in the management literature concerning employee empowerment. According to the author, employee empowerment is often considered by many industry and academic leaders to be a concept difficult to tackle in practical terms (Lincoln et al., 2002). Hence, there are a few concerns with respect to the deficient knowledge on empowerment in organisations, both conceptually, as well as practically (Huq, 2010; Logan & Ganster, 2007; Seibert et al., 2004), with the construction industry being no exception (Sackey et al., 2011b).

Outside of exceptional success stories such as within the banking sector, there has been limited implementation of employee empowerment initiatives according to Dainty et al. (2002) and Naaem and Saif (2010). In terms of construction, there has also been a lack of interest, with key stakeholders generally disregarding the potential of employee empowerment for the sector (Dainty et al., 2002). In terms of academic research, content on empowerment in the construction industry is particularly scarce and disjointed (Tuuli & Rowlinson 2007a). There is also concern amongst researchers regarding gaps in application and practical results of the concept at the organizational level (Sackey et al., 2011b).

Hurdles to employee empowerment in construction were also revealed in the study of Holt et al. (2000), who found that the most important barriers included lack of management commitment, underestimation of the extent of change, resistance to behavioural change, failure to adopt continuous learning, too much bureaucracy and ineffective communication. It is challenging to ascertain which of the hurdles arose due to management practices and which may have arisen merely due to the nature of construction itself. As the authors pointed out, a particular problem was the failure to follow-up on the initial implementation of empowerment, which may result in the creation of a two-tier management system; resultantly a blend of the old and new systems.

Another problem is that the concept of empowerment is often resisted by management (Dainty et al., 2002). The reason for such resistance is a matter of speculation. However, it has been argued that such opposition is likely to be particularly prevalent in the construction industry, which is known for its aversion to change. Dainty et al. (2002) identified a series of barriers to employee empowerment specific to the construction industry, one of which is that it suffers from ‘ingrained employment practices’ and ‘time-honoured organisational delivery structures’ (Dainty et al., 2002). Furthermore, the supply chain in traditional construction is typically fragmented, with a high incidence of subcontracting and self-employment. Implementing employee empowerment is therefore difficult when there is no unified organisation, and a range of specialist subcontractors across the contractual relationship(s), charged to build a design solution.

In addition, team associations might fall apart when greater authority is provided to employees in a supply chain. Two main impediments to employee empowerment initiatives have been recognized by Greasley et al. (2005); Occupational Health and Safety laws and the influence of the immediate manager.. Concerning the former, empowerment may be futile where unskilled employees might not understand hazards in the workplace (Greasley et al., 2005). Concerning the latter, empowerment programmes that were implemented often fail to realise their expected positive outcomes due to the disinclination of the manager to relinquish power (Tuuli et al., 2010a). As a result, participants' awareness and perception of their own leadership styles should be discussed, such as by using the well-established self-assessment questionnaire by Blake and Mouton. This managerial grid is based on two dimensions: concern for people and concern for production.

The tool (Black & Mouton, 1964), allows five leadership styles to be identified based on the interaction of the scores of the two dimensions. The leadership styles are authoritarian, team, country club, middle-of-the-road and impoverished.

2.3.6 Employee empowerment and off-site construction

As mentioned, in off-site construction the sub-elements are built remotely then transported to and installed on site, as opposed to the whole construction being carried out on site in a more-or-less ad hoc manner by individual tradespeople (Alazzaz and Whyte, 2012).

There have been no studies to date on empowerment of employees engaged in off-site construction, but the concept of empowerment may hold more promise in off-site construction than in traditional construction, where empowerment is under-utilised and faces many barriers. As both Nesan and Holt (2002) and Hammuda and Dulaimi (1997) found, empowerment is more prevalent in manufacturing than in traditional construction, in part due to the structural management exigencies in the traditional construction industry outlined above.

Having discussed employee-empowerment towards an implicit improvement in productivity, the following section discusses productivity explicitly.

2.4 Productivity

2.4.1 Definition

The productivity concept is largely defined as the relationship between inputs in a production process and the respective outputs (Yi & Chan, 2014). In economics and accounting, productivity is typically defined as the "real output per hours worked" (Yi & Chan, 2014). In economics and accounting terms, it is generally accepted that there are at least three board approaches for studying productivity. These are macro-economic study, case studies, and pricing studies (Edkins & Winch, 1999). These three ideas are discussed below.

2.4.2 Productivity in construction

Productivity is a common focus of studies of construction. Yi and Chan (2014) note that, "Because of its critical importance to the profitability of most construction projects, productivity is one of the most frequently discussed topics [in the industry]." Productivity as it relates to construction is usually discussed under three separate topics. The first is the *delimitation* of construction that is the definition of the particular aspect of construction under investigation. Analysts may be interested in conventional onsite construction projects or off-site activities such as prefabrication. The second is the precise *measurement* of productivity (Sezer & Brochner, 2014). This topic concerns how productivity will be measured whether total employee hours, or another input will be used, and whether output will be measured in valued of products, volume of products, produced volume, installed volume and so on. The third is the *identification of the factors* that explain productivity growth or decline. These may be human resource related or linked with external factors such as material quality and state regulation (Sezer & Brochner, 2014).

The following sub-section will deal with the second topic of productivity in construction, namely, the precise *measurement of productivity*.

2.4.3 Challenges to studying productivity in construction

2.4.3.1 Lack of a unified approach

A number of authors have commented on the lack of a uniform approach to studying productivity (Loosemore, 2014; Abdul Kadir et al., 2005). There is a lack of consensus concerning how labour productivity should be evaluated in the construction sector. Jarkas (2010) reports that, 'labour productivity is the most important productivity to study due to the reliance of human effort and performance in construction'. Loosemore (2014) notes that labour productivity is "the simplest measure of productivity" and is based on output per worker most typically measured as quantity produced per employee or value added per employee. In this sense, hourly inputs are commonly used to measure labour productivity. Typically, the labour hour will be used as the input while the quantity of completed work will be used as the output (Yi & Chan, 2014). This measure, referred to as construction labour productivity, by Yi and Chan (2014) can be determined by dividing the *installed quantity* by the actual work hours. Thus, the lower the value obtained from the calculation, the higher the productivity. The equation is shown following (Yi & Chan, 2014).

$$\text{CLP} = \frac{\text{Work} - \text{hour}}{\text{Output}} = \frac{\text{Actual work hours}}{\text{Installed quantity}}$$

Yi & Chan (2014) believe that *installed quality* is a superior method to cost-based output measures which are affected substantially by external factors Nonetheless, the authors comment that one of the challenges of measuring construction labour productivity is determining what installed quantity will be measured. For example, concrete placement and steel placement are largely different tasks, with the former being possible to measure in terms of cubic metres and the latter more suitably measured in linear meters (Yi & Chan, 2014).

Another example of this general approach, as used by Abdul Kadir et al. (2006), was referred to as actual labour productivity. The team calculated actual labour productivity by multiplying the crew size by the working time (hours) and then dividing the product of that by the building floor area (m^2), as shown in the following equation (Abdul Kadir et al. 2006).

$$\text{Actual Labour Productivity} = \frac{\text{Crew size} \times \text{working time (hours)}}{\text{Building floor area } (\text{m}^2)}.$$

However, these approaches have been criticised by Loosemore (2014) who states, inter alia, that researchers can have great difficulty in identifying, gathering data, and reporting the most valid factors. The scholar notes "increased output per worker is not necessarily an accurate measure of productivity since it does not take into account how new technologies can affect productivity" (Loosemore, 2014). The author writes more favourably in relation to approaches to determining labour productivity which take into account a broader range of variables.

One such example is *total factor productivity*, an approach which involves considering as wide a selection of variables as possible including management practices, the extent of change on a site, and the work environment in order to determine productivity (Talhouni, 1990). As the name suggests total factor productivity offers to present a more holistic and considered measure of labour productivity for a given setting by taking into account the moderating effect of a wide range of variables. Loosemore (2014) applied this approach to a study of 72 sub-contractors and found that "poor site management, poor coordination and planning, trust and respect between managers and workers and supervisory training and skills" each had a significant moderating effect on labour productivity. Yet Loosemore (2014) did note that despite the theoretical advantages of taken into account a broad base of factors, studies using total factor productivity are often seen as unreliable due to the difficulty in, as mentioned, in identifying, gathering data, and reporting the most valid factors. Abbott and Carson (2012) note that there are comparatively very few studies in the construction sector that report using a total factor productivity approach. This can be contrasted with the manufacturing sector in which total factor productivity has been assessed in numerous settings (Ikhsan-Modjo, 2006; Mahadevan, 2003)

2.4.3.2 Neglect of relevant variables

Neglect of relevant variables is a second issue in studies of productivity thus far. As mentioned, leading scholars are dissatisfied with narrow conceptions of productivity in construction (Loosemore, 2014). There are concerns raised regarding the focus on labour productivity at the expense of other arguably important considerations such as material productivity and transportation productivity (Poh & Chen, 1998; Abdul Kadir et al., 2006). For example, Loosemore (2014) describes *capital productivity*, yet another variable, as "the technology-related elements of productivity...the output return on capital investment", and argues that while it is a critical variable concerning productivity in construction generally, it is very difficult to determine independently of labour productivity.

Vogl and Abdel-Wahab (2014) included tangible and intangible inputs in their determination of productivity. Referring to their approach as average labour productivity, the pair considered the effect of labour (L), capital (K), and materials (M), using the production function (f) to make conclusions on how the construction output

(Y) could be viewed in terms of labour productivity. This is shown in the following equation.

$$Y = af(L, K, M)$$

The authors report that one of the limitations of generalising the results of such an approach is international differences in the way that labour is used in construction. More specifically, it is challenging to accurately isolate certain components of productivity and factors affecting productivity. For example, it may be difficult to discern labour productivity from materials productivity (Vogl and Abdel-Wahab, 2014).

However, while Vogl and Abdel-Wahab (2014) considered labour, capital, and materials, arguably additional factors were not considered. For example, in the broader construction research, environmental conditions, such as the impact of harsh weather conditions, tends to feature less and more in the different methodologies, as do regulation matters such as employee relations and even intellectual property issues (Loosemore, 2014). This can be said to impact on the generalisability of the research findings with respect to labour productivity (Yi & Chan, 2014). Related to this, it is argued that studies of labour productivity in the construction setting are highly dependent on setting-specific variables.

Eastman and Sacks (2008) raise other concerns regarding measurements and conclusions based on labour productivity. For example, they find that labour productivity can increase due to labour shortages and investment in technology. Having said this, they also comment that the construction sector often lags behind other sectors such manufacture when it comes to investment in technology. Eastman and Sacks (2008) argue that the construction workforce and its training is most often in a state of flux, which also confounds measures of productivity. Testimony to this, in a different context, would be Zakeri, Olomolaiye, Holt and Harris's (1996) study in Iran in which it was found that only 2% of construction employees had remained with their current employer for five years or more.

2.4.3.2 Limited generalisability

Limited generalisability has been another issue plaguing productivity research. It has been very difficult to compare and contrast findings from studies of productivity due to not only the differences in research methodologies but also in differences in the nature of the construction projects being studied (Loosemore, 2014). Even some of the leading professional association definitions recognise this difficulty. For example, the American Association of Cost Engineers ('AACE') (2013) defines productivity as a "relative measure of labour efficiency, either good or bad, when compared to an established base or norm". The focus on the relativism undermines the body of research through greatly reducing its generalisability.

One approach to studying productivity that has emerged in more recent years reflecting the relative definition just mentioned, has been to compare expected productivity with actual productivity (Allmon et al., 2000). The following equation shows this, where i = the relevant workday and m = the relevant activity within the project (Yi & Chan, 2014).

$$\text{Performance ratio}(\text{PR})_{im} = \text{Actual productivity}_{im} / \text{Expected productivity}_{im}$$

Overall, the theme thus far is that, studies of productivity have adopted different approaches with different inputs and outputs and producing results which are largely not general-*isable*, to a large extent, outside of the immediate research location.

2.4.4 Factors of labour productivity in construction

The current sub-section will deal with the third topic of productivity in construction, namely, *identifying* and analysing *factors* that impact on *productivity*. This task is critically important for engineering, construction, and architectural researchers. In the construction industry, reports repeatedly indicate poor productivity and productivity growth, and a need for innovation (Eastman & Sacks, 2008). Identifying and analysing factors that impact on productivity is an endeavour that promises to deal with these issues. One of the leading researchers in the field of productivity factor analysis is Paul Olomolaiye who has focused on factors relevant to labour productivity and motivation, since the 1980s and in settings including Indonesia, Nigeria, the United States, and the

United Kingdom (Olomolaiye, Wahab, & Price, 1987; Olomolaiye & Ogunlana 1989; Olomolaiyi, 1990; Olomolaiyi, Jayawardene, & Harris, 1998).

In the 1980s, Olomolaiye et al. (1987) visited seven construction sites in Nigeria and after interviews with employers and employees found that a lack of materials/tools, duplicated efforts or repeated work, instruction delays, inspection delays, absenteeism, incompetency of supervisor, and changing crew members were the eight most influential groups of problems undermining labour productivity. In the same setting, a few years later, Olomolaiye and Ogunlana (1989) reported that from a sample of 83 tradespersons including 32 joiners, 26 bricklayers, and 25 steel fixers, that unavailability of materials and tools, absenteeism, poor supervision and again changing crew members were the major factors negatively affecting productivity.

Many of these groups of problems were repeated nearly a decade later in a study of Indonesian construction with 243 craftsman as participants by Olomolaiye, Kaming, Holt and Harris, 1996). The team concluded that "lack of materials, rework, absenteeism, lack of equipment and tools and gang interference" were the main categories of productivity problems (Olomolaiye, Kaming, Holt & Harris, 1996).Olomolaiye et al. (1996) noted that lack of materials and rework were expected to be the most significant factors adversely affecting productivity in developing settings. Olomolaiye participated in another important study in Iran concerning construction labour productivity (Zakeri et al. 1996). In this setting, it was found that amongst 141 construction operatives a lack of materials was cited as the dominant reason for poor productivity. Other relevant factors were equipment breakdown, poor supervision, absenteeism, and crew turnover.

In another study conducted around the same time, Lim and Alum (1995) having received questionnaires back from 67 construction contractors in Singapore, also found that a lack of materials, stoppages including rework, absenteeism, poor supervision, lack of tools/equipment, safety and interference were influential factors affecting productivity. While Singapore is not usually referred to as a developing country, it was noted in Lim and Alum's (1995) study that the setting, particularly in construction, placed a higher reliance on a unskilled or semi-skilled foreign workers.

Enshassi et al. (2007) also studied factors relevant to productivity in construction in a developing setting. Drawing from Lim and Alum's (1995) study and Olomolaiye et al.'s (1996) study, Enhassi used 43-45 productivity factors and grouped these into categories of factors relevant to productivity in construction in Palestine were ***manpower, leadership, motivation, time, materials/tools, supervision, project safety, quality, and external factors***. The validity of these groups was affirmed through interviews with personnel from 83 contracting companies in the Gaza Strip. It was found that a lack of materials was the most important factor. This was consistent with (1996) Lim and Alum's (1995) and Olomolaiya et al.'s (1996) study. Enshassi et al. (2007) also concluded that there was a need for increased use of modern construction methods and technologies.

The researchers were able to make a number of conclusions on the importance of management with respect to the productivity of employees in a construction activity. For example, the researchers argued that personnel management measures and motivational measures were particularly important (Enshassi et al., 2007). They suggested tying compensation to performance, and ensuring that the pay, fringe benefits, workplace safety, and other employment conditions were at least competitive in the relevant context. They noted that respondents from 83 contracting companies in Gaza gave answers that suggested there was a need for expand job descriptions so that there was more challenge and variety of tasks (Enshassi et al., 2007). It was also found that the respondents indicated a desire to have more access to training. As part of the recommendations, the researchers argued that contracting companies should maintain historical records of productivity.

These groups of factors relevant to productivity, or very similar ones, have since been used in a number of studies (Rivas et al., 2011; Jarkas & Bitar, 2012; Tsehayae & Fayek, 2014; Yi & Chan, 2014). For example, the same year as Enshassi et al.'s study, Alinaitwe, Mwakali, and Hansson (2007) found from interviewing 167 contractors in Uganda that supervision, poor construction methods, rework, materials/tools, project safety, and external factors such as weather were the most relevant factor impacting on productivity. Dai, Goodrum and Maloney (2007) found that materials and tools were the most dominant factors adversely affecting productivity according to 1997 tradespersons in the United States. Commenting on the same study, Dai, Goodrum, Maloney, and Srinivasan (2009) also found that leadership, motivation related factors were relevant.

More recently, Ghouddousi and Hosseini (2012) received responses from 93 construction companies in Iran. The researchers found that materials/tools, construction technology and method, planning, supervision system, reworks, weather, and jobsite condition were the most relevant groups of factors from most to least. These results were consistent with the earlier findings of Zakeri et al. (1996). Also the same year in Kuwait, Jarkas and Bitar (2012) used the same 45 productivity factors to investigation construction productivity. The results of the study were that poor communication, quantity of change orders, poor coordination, lack of supervision, and labour-related issues such as having a high turnover and high quantity of work subcontracted were the major five factors adversely affecting productivity.

Hafez, Aziz, Morgan, Abdullah, and Ahmed (2014) following a methodology similar to Enshassi et al. (2007), and a survey based on Mistry and Bhatt's (2013) 27 productivity factors, in order to studied labour productivity in Egypt. In Hafez et al.'s (2014) study it was found that the motivation of employees was the dominant factor influencing productivity. The authors noted that the delay of payment for employees was a factor that sharply decreased motivation, and thus, productivity according to the study. The researchers also found similar to Enshassi et al. (2007) in Palestine, that there was a lack of skills and experience evident amongst the employees and that this was believed to be a factor adversely affecting productivity. A third dominant factor causing attrition of performance was reported to be a lack of supervision. This finding is consistent with the reports from studies in Kuwait by Jarkas and Bitar (2012) which found that difficulty in attracting competent supervisors adversely affected productivity, and also consistent with the findings of Jarkas, Kadri, and Younis (2012) in Qatar.

2.4.5 Factors of labour productivity in off-site construction

While the factors that impact on labour productivity in the construction sector internationally have been largely demystified by Olomolaiye, Lim and Alum, and Enshassi et al., on the whole these studies appear to have focused largely on conventional onsite construction. Increasingly scholars of construction assert that there is a need for greater attention to be paid to the role of off-site production activities in increasing the labour productivity of construction in general. They write "Ignoring the off-site segments of construction has led to a significant underestimation of construction productivity" (Eastman & Sacks, 2008).

Eastman and Sacks (2008) conducted one of the few comprehensive studies on comparing productivity growth in the off-site construction sector with the general construction sector in the United States. They found that while productivity growth for onsite construction was 1.43% per annum in the few years before 2008, productivity growth for off-site construction was 2.42% (Eastman & Sacks, 2008). It is interesting to note that official statistics in most developed nations will point to a much slower growth in productivity in the construction sector when compared with the growth of productivity in the manufacturing sector (Davis, 2007; Sezer & Brochner, 2013; Eriksson, Olander, Szentes, and Widen, 2014). With this result in mind, and given that off-site construction based in specialised plants or factories shares a number of similarities with manufacture it would appear that there is a need for a better understanding of productivity in this sector (Sezer & Brochner, 2013).

With respect to off-site construction methods, as mentioned, the high cost of investment generally means that information concerning which factors may increase or decrease productivity is especially valuable (Rivas et al., 2011). Studies of off-site construction productivity in this regard not only need to identify relevant factors but also must provide information concerning how these variables can be used in order for these investigations to have practical value (Rivas et al., 2011). In other words, it is important that factors that positively affect productivity are made use of, and factors that negatively affect productivity are minimised.

Authors in this field tend to believe that once the various factors of productivity are accounted for and considered, in this context, construction productivity forecasts, including off-site construction, productivity forecasts will be possible (Thomas & Sakarcan,1994; Ezeldin & Sharara, 2006; Enshassi et al., 2007; Song & Abourizk, 2008). For contractors, an improved understanding of productivity, and improved productivity itself, helps these persons to be more efficient and profitable (Aliabouni, Painting, and Ashton, 2009). This will allow them to make more accurate and competitive quotes and help the construction sector overall.

There are a limited number of published empirical studies relating to productivity in off-site construction. The consequence of this is that it is harder to ascertain validity and reliability of the data gathered and the conclusions made in such studies. While a number of studies and reports advocate the use of off-site construction approaches, there have been very few dedicated studies to matters of quantitative productivity (Huang, Chapman, & Butry, 2009; Chan, 2011). As mentioned, Eastman and Sacks (2008) conducted an investigation into the relative annual productivity of construction industry sectors, known as the architecture, engineering, and construction industries, specifically aiming to compare the productivity of those sectors with larger components of off-site production with those which were primarily conducted onsite. In the study, the pair focused on net production output as a measure of productivity, which they considered to be the value of shipments for the off-site sectors and the value of the erected materials minus the value of externally contracted work, electricity, fuel, and input materials. The pair used data from national censuses to estimate labour input. The study did not take into consideration the varying hours that could be worked by employee per year, non-human inputs, and wage levels. Thus, in order to determine annual productivity, p_i for a construction employee in each of the research segments i, the following equation was applied.

$$p_i = v_i / n_i$$

n_i refers to the number of employees, and v_i equals the total value added according to the study.

Eastman and Sacks (2008) were also interested in the industry activity by industry activity aggregate production output. The results of the broad study appear to indicate that relative annual productivity in sectors with larger components of off-site production was superior to those construction activities which were primarily conducted onsite. The pair speculated that a slower adoption of information technologies and a greater reliance on drawings, including digital drawings, led to lower productivity in the case of onsite activities (Eastman & Sacks, 2008). Interestingly, reliance on drawings, including digital drawings, was found to be the third greatest factor underpinning poor productivity according to analyses of 141 construction operatives in Iran (Zakeri et al. 1996).

2.4.6 Effect of off-site construction on labour productivity

One of the earliest published and cited studies in the field of off-site construction productivity was conducted in Israel. Peer and Warszawski (1972) investigated the relationships between labour costs, total costs, and construction method, specifically comparing conventional onsite construction with partial prefabrication and comprehensive fabrication. The pair expressed their findings as percentage and reported that the use of prefabrication led to reduction in labour costs of up to 70%. The presentation of the results in this study largely combining construction approach and effect on labour productivity and effect on cost arguably started a pattern in the field of study in which improvements of labour productivity achievable through off-site construction where expressed in terms of anticipated cost savings. The study of Peer and Warszawski (1972) has been widely quoted in subsequent studies (Poh & Chen, 1998; Abdul Kadir et al., 2006).

Abdul Kadir et al. (2006), much more recently, also conducted a study concerned with comparing different construction approaches including onsite and off-site with regards to labour productivity and cost of construction amongst other measures. This was a study concerned with the relative productivity of conventional residential construction projects ('onsite') compared to that of residential construction projects that involved at least some prefabrication ('off-site') in Malaysia. The authors refer to the concept of industrialised building systems which is a phrase that is used to refer to the inclusion of off-site construction components (Abdul Kadir et al., 2006; Wakisaka, Furuya, Inoue & Shiokawa, 2000).

The team investigated 100 residential building projects, in which either apartments, condominiums, terrace houses, bungalows, and/or semi-detached houses were constructed. Of the 100 residential building projects, on 55 of the projects, contractors used an onsite construction approach. This approach, as mentioned, was referred to as conventional. Thus, the 45 remaining projects were non-conventional. Amongst these 45 projects, 16 used a cast in situ table form, 9 used a cast in situ tunnel form, 15 used full precast system, which involved a precast concrete wall and a precast half slab system, 3 used a composite system, which involved precast concrete walls used together with a cast in situ, 1 was a block system and 1 a timber framing system. It is most convenient to refer to these 45 projects as off-site construction projects due to the fact that each reportedly involved at least some element of prefabrication (Abdul Kadir et al., 2006).

Similar to Peer and Warszawski (1972), Kadir (2006) was interested in the difference that construction method would have on variables such as labour productivity, sub-variables such as crew size, cycle time - that is the time to complete one residential unit of any description, and as Peer and Warszawski (1972), variables related to cost, namely, total structural cost and daily salary versus labour productivity relationship.

2.4.6.1Increased actual labour productivity

With regards to labour productivity amongst the 100 projects, Kadir (2006) calculated actual labour productivity for each project and then calculated the means. Actual labour productivity in this case, as mentioned, was determined by multiplying the crew size by the working time (hours) and then dividing the product of that by the building floor area (m^2), as shown in the following equation. He found that while for wholly onsite projects, the conventional projects, the mean actual labour productivity was 7.0 manhours/m^2, in the case of non-conventional projects, namely, those 45 involving some off-site component, mean actual labour productivity was 2.1 manhours/m^2. Thus, the results of the team's study in this regard were able to suggest a 70% productivity advantage in favour of using off-site components (Abdul Kadir et al., 2006). This result was remarkably similar to the outcome found decades ago in Peer and Warszawski's (1972) study in Israel as well as largely consistent with studies in Singapore by Poh and Chen (1998) and by Wakisaka et al. (2000) in Japan.

2.4.6.2 Smaller onsite crew sizes

In Abdul Kadir et al.'s (2006) study one likely determinant of labour productivity was identified, *crew size*. The team investigated the number of employees or independent contractors directly involved in the physical work that could be required to work at the site at any time. This was referred to as crew size, and the team found that the use of off-site components decreased the mean crew size with respect to those construction projects that used off-site construction. While it was found that 22 workers on average could be required to be on site during a conventional construction, only 18 persons were found to be required on average in projects that used some aspect of off-site construction. Other studies have found similar magnitudes of reduction in onsite labour. For example, Court et al. (2009) found a 35% reduction in labour requirements due to the use of a modular assembly approach inclusive of off-site construction components.

The effects of smaller crew sizes on construction sites have been identified and discussed by a number of authors. For example, Gibb and Isack (2003) conducted a survey of 59 senior personnel from 42 of the largest construction client organisations in the United Kingdom concerning what the participants perceived as the benefits and drawbacks of the use of off-site production technologies. There were numerous comments made with respect to the positive effects that the use of smaller crews can have on productivity. It was noted that there is less risk of disruption. For example, with fewer onsite employees needed there is less onsite congestion (Gibb and Isack, 2003).

2.4.6.3 Reduced onsite congestion

Haas et al. (2000) interviewed 29 construction managers in the United States concerning their perceptions on the impact of prefabrication approaches to construction. There was a general consensus amongst the responses of the participants that using prefabricated components as part of the construction process resulted in higher labour productivity and safety levels compared to conventional approaches. Haas et al. (2000) also found that construction managers had indicated that using prefabricated components as part of the construction process led to reductions in onsite interference and congestion of workers onsite.

In the responses from the senior personnel in Gibb and Isack's (2003) study, there was also a high incidence of comments that alluded to improvements in productivity as a result of increasing off-site production technology use. As mentioned, it was noted that there is less risk of disruption. For example, with fewer onsite employees needed there is less onsite congestion. In addition moving tasks off-site means that work can continue undisturbed onsite, independent of off-site production. The more difficult tasks, where practical, can be moved off-site. There is a reduce reliance on wet trades. And from a materials point of view, there is less snagging and more success at interfaces. It was also reported that materials produced off-site tend to work the first time (Gibb & Isack 2003).

2.4.6.4 Reduced cycle time

Another likely determinant of labour productivity was *cycle time*. Abdul Kadir et al. (2006) also compared the cycle time, this being the *time required to complete the structural element of one residential unit*, for conventional and off-site projects. It was found that conventionally constructed projects required on average 17 days. In contrast, those projects that involved an off-site component averaged 4.66 for less involved prefabrication and 3.10 days for more substantially prefabrication. This dramatic difference is at some point expected to pass on cost savings to the contractor in the form of lower site staff overheads, lower equipment rental fees, amongst other categories.

Wakisaka et al. (2000), was also concerned with the *sustainability* of the construction sector in Japan (a location facing serious labour shortages) and investigated the impact of pre-fabrication of components and increased automation of the high rise building construction process on labour productivity, terms of employment, and working conditions. The project involved the use of precast concrete, and prefabricated finishing materials such as air conditioning ducts, horizontal drainpipes, vertical drainpipes and an automated crane system to facilitate the positioning and installing of these components. The team reported that the use of prefabrication building components enabled a shorter construction period compared to conventional construction (Wakisaka et al., 2000).

2.4.6.5 Reduced total structural cost

Abdul Kadir et al. (2006) also compared the total structural cost per residential unit constructed. Despite the noticeable differences in actual labour productivity, crew size required, and cycle-time, they reported nominal difference in total structural cost between onsite and off-site-based construction projects. The team found that once labour, materials, and transportation costs had been taken into account there was an insignificant different between the total structural cost of onsite and off-site projects. In fact, they found that the mean structural cost of conventionally constructed (onsite) residential units was 330 RM/m^2 (Ringgit Malaysia, the Malaysian monetary unit) and that of units in which construction involved off-site elements was approximately 250-260 RM/m^2. However, this difference in means is not a reliable indication of impact on total structural cost due to the fact of wide variation in onsite total structural costs ranging from 35 to 1804 RM/m^2.

The team also commented that since contractors in Malaysia were accustomed with onsite construction, and since guest workers from Bangladesh, Indonesia, Thailand, and Myanmar, offer access to affordable labour, the benefits in labour productivity that arise from using off-site construction, at least in 2006 did not result in total structural cost savings. They also noted that there was an insignificant correlation between the daily salaries of the construction employees, by considering the mean salaries of un-skilled, semi-skilled, skilled workers, and site leaders, and actual labour productivity, which could underpin or even support the prevailing construction paradigm in Malaysia.

However, increasing levies imposed by the governments on companies that use guest (itinerant) workers, and a higher cost of living in general, may suggest that the cost of labour will eventually impact on total structural costs of projects in the setting (Abdul Kadir et al., 2006).The researchers mentioned, believe that there is a need for further investigation into other factors that impact on total structural cost such as material productivity and transportation productivity.

Chan (2011) conducting case studies in Perak, Malaysia, and Melbourne, Australia concluded with similar findings to Abdul and Kadir et al. (2006). Chan (2011) found that the infrastructure concerning employment relations and market for labour in Malaysia was not conducive to the adoption of off-site construction practices in spite of the reported benefits. In contrast, Chan (2011) found that the conditions in Australia with respect to labour wages and other fiscal incentives meant that this context would benefit more substantially from the introduction of increased off-site construction approaches.

Similarly much earlier and in contrast to Abdul Kadir et al.'s (2006) study that found despite marked increases in labour productivity, there was almost negligible reduction in total structural cost amongst 100 residential building projects in Malaysia, the managers surveyed in Haas et al.'s (2000) study tended to emphasis the significant potential cost savings that could arise from using off-site fabrication. In the context of the United States, they noted that local labour sources may be too expensive, too inefficient, or too unskilled.

2.4.6.6 Improved constructability

Poh and Chen (1998) investigated the relationship between construction approach and building cost. The pair conducted empirical studies of 37 completed building projects in Singapore. The pair found that the use of prefabricated materials greatly improved the buildability of the projects, as measured by the Singaporean buildable design appraisal system, and that this in turn led to greater labour productivity and more efficient labour usage.

Despite a significant positive relationship between the use of prefabricated materials, buildability and labour productivity, the pair found that a relationship between the use of prefabricated materials, buildability and construction cost was much harder to ascertain. As an example of the wide host of factors that impact of total construction cost, the pair noted that despite the fact that labour costs were up to 500% higher in Perth, Western Australia, comparable buildings were being constructed at only 5% higher than in Singapore. The pair alluded to the characteristics of the works, weather, site conditions, and contractor styles and experience as potential confounders (Poh & Chen, 1998). More recently, Jarkas and Bitar (2012) in the context of Kuwait have reported on the link between design, constructability, and productivity.

2.4.6.7 Reduced debris

Another benefit of using off-site construction approaches, reported by Wakisaka et al. (2000) in Japan, was a reduction of debris. This is arguably a particularly important advantage in areas of high population density such as central business districts. Moreover, reducing debris would arguably lead to safer workplaces. Tam, Tam, Zeng, and Ng (2007) found that the use of prefabricated materials in construction projects in Hong Kong could reduce the generation of onsite wastage by as much as 84.1%. Similar results were found by Tam, Fung, Sing, and Ogunlana (2014) in Hong Kong, where a reduction of debris onsite due to the use of prefabrication techniques led to safer worksites. Yunis and Yang (2014) found that reductions in material consumption, the generation of waste, improvements in waste disposal, were factors that led to improvements in the productivity of off-site construction projects in Malaysia.

Hanafi, Khalid, Razak, and Abdullah (2010), who were interested in installation of prefabricated components onsite, note that it appeared that the previous studies to that point in time did not focus specifically on identifying and listing the dominant factors that influence labour productivity in relation to the onsite installation works of prefabricated components. While Hanafi et al. (2010) were concerned with labour productivity in relation to installation of prefabricated components in Malaysia; one of the primary aims of this study was to gather information concerning labour productivity during the off-site prefabrication process.

2.5 Employee empowerment and productivity

Strategies to increase (labour) productivity in construction are essential; as the comparative cost of human resources rises there is an increasing need to develop systems of work that lead to a growth in productivity (Tzafrir et al., 2004). However, evaluating the benefit of such strategies is challenging. Despite the apparent simplicity of the definition of labour productivity, this indicator is difficult to track consistently, largely because of the complexity of quantifying and comparing diversified outputs in construction (Song and AbouRizk 2008, Eastman & Sacks, 2008). Broadly speaking, the link between productivity and empowerment is the presumption that empowered employees perform better than those less empowered, such that, greater productivity arises from the empowered employee’s superior ability to resolve problems at the operations level, without the delay needed to contact line-managers (Tuuli & Rowlinson, 2009a), leading to greater productivity via localised workplace decisions that increase individual/organisational performance (Dainty et al., 2002; Liu et al. 2007).

Gaps in understanding the relationship between employee empowerment and productivity still exist (Seibert et al., 2004; Logan & Ganster, 2007; Huq, 2010). The results of Tuuli and Rowlinson (2009a) highlight the influence of mediating factors that suggest that the empowerment/productivity relationship is more complex than first thought. The mediating effects of other important constructs in building-management literature such as trust, culture, and identity need to be further explored (Rowlinson & Cheung, 2008; Phua, 2013). Moreover, the specific nature of employee empowerment in off-site construction settings (site environment/culture/language, training and knowledge/change management requirements) is yet to be comprehensively assessed and taken into account in empirical studies (Hammuda and Dulaimi, 1997; Eylon and Au, 1999; Price et al., 2003; Spreitzer, 2007; Tuuli and Rowlinson 2010b).

Whilst support for employer empowerment interventions exists (Argyris, 1998; Bowen and Lawler 1992; Tuuli & Rowlinson, 2007a, 2007b; Herbert, 2009;), the issues are yet to be fully explored (Holt et al. 2000; Dainty et al. 2002); There is also need for investigation into the hurdles to implementing employee empowerment programs in the construction sector, so that management can deal with barriers to empowerment strategies to help shed light on the limited implementation of employee empowerment interventions in the construction industry.

Tuuli et al. (2012) believe that an obstacle to successful employee empowerment implementation is a lack of awareness of how empowerment can be applied to the specific industrial context. Indeed might Nesan's model, as applied in the manufacturing industry, reshape the construction industry pre-fabrication yards (Nesan and Holt, 2002; Hammuda and Dulaimi 1997).

The research presented here towards investigation into employee empowerment and labour productivity through a case study of three off-site production companies is a step towards enhancing the field of construction management knowledge, with Nesan's (1997; 2002) nine empowerment implementation activities evaluated against observational and survey data. One of the aims of this research is to provide a more precise definition of performance in the construction industry by taking into account the impact of employee empowerment on construction output variables.

2.6 Quality management in construction

This section discusses the literature concerning quality, quality management, and quality management in the construction industry.

2.6.1 Definitions of quality

Quality is most simply defined as fulfilling requirements; Hoonakker et al. (2010; cited in Loushine et al, 2006) examined the various definitions of quality performance used by the following authors in their review of the literature on quality and safety management in the construction industry, citing the following interpretations of quality, 'Meeting expectations of the customer' (Chase, 1998; Kanji & Wong, 1998; McKim & Kiani, 1995; Torbica & Stroh, 1999), 'Reduced rework or defects' (Love et al., 1999; McKim & Kiani, 1995), 'Repeat business' (Sommerville, 1994), 'Conformance to ISO 9000 criteria' (Bubshait & Al-Atiq, 1999), and 'Completion on-time and within budget' (Love et al., 1999; McKim & Kiani, 1995).

Quality management most simply can be thought of the organising of resources to best fulfill organisational requirements.

2.6.2 Historical background to quality management

Notions of quality management arguably are most often associated with the manufacturing sector. Similarly there is a history of applying quality management and manufacturing techniques to construction in general. As Gann (1996) points out, there are two particularly notable historical instances of this trend: industrialised housing production in Europe and North America from the early 20th century onwards, and Japanese industrialised housing production from the 1940s onwards.

The European and North American approach will first be examined. In the early 20th century, architects such as Walter Gropius, Le Corbusier, Buckminster Fuller and Bemis promoted the mechanisation and industrialisation of construction. The car industry was particularly drawn upon for inspiration, with Gropius writing that the 'industrial production of complete buildings could be analogous with the mass production of the motor car' (Herbert, 1959, in Gibb, 2001). Their goals were to increase the performance of construction by using a scientific management approach and rationalising production. In particular, Buckminster Fuller and Le Corbusier believed that the production of houses could be conducted along similar lines to the production of cars. Le Corbusier's Domino House (1914) provides a good early example of this; the architect's emphasis was on using simple, flexible and standardised features. This industrialised method of construction become particular important from the 1960s, with a rise in the popularity of systems building.

The rise of industrialised manufacturing and prefabrication in the Western world had similar impacts for the construction industry as the rise of mass production did for the automobile and manufacturing industry. The shift from traditional craftsmanship in the construction industry to industrialised construction can be likened to the earlier shift from automobile production as a craft to Ford's production line manufacturing system. One of the most important goals of industrialised construction was to reduce dependence on the craft worker through adopting new management practices that could enable more efficient, standardised forms of production. As Winch (2003) points out, in the United States the traditional craft system had several limitations, the key ones being lack of consistency between products and expense. In response to this, the 'American System' was created, which was based on interchangeable parts which were fitted with each other to get a final product.

The Japanese approach also requires discussion. In Japan, a shift towards industrialised manufacturing techniques initially took place in the automobile industry after the Second World War. Mirroring the Ford production line system in the United States, Japan adopted the Toyota production system (Winch, 2003). According to Gann (1996), Toyota emphasised new management approaches, quality control and a connection between producers and customers. In the 1980s, these systems were refined to create a system of lean production. Winch (2003) mentions that, lean production is driven by the implementation of just in time (JIT) and total quality control (TQC) methods, leading to better performance. Human resources are also emphasised, with a focus on motivating people through team work and training, resulting in the implementation of continuous improvement, reduction in lead times and quality enhancement. In addition, this system results in a close relationship between the supplier and the customer (Gann, 1996).

As a result of these techniques, Toyota has become a leading car manufacturer over the past 40 years, gaining a competitive edge over other manufacturing companies. The interconnection between technical and organisational progression of Toyota's production system maximises the achievement of both economies of scale and economies of scope. It appears that if the Japanese car industry could improve its performance in meeting customer expectations, the construction industry generally would also be able to learn from this development (Gann, 1996).

Industrialised production in the construction sector in Japan began at the end of the 1950s. The demand for modernised construction process was driven by a shortage of skilled labour, low quality housing, population growth, economic growth, fluctuations in the price of oil and the requirement of earthquake protection (Winch, 2003). In 1955, the Japanese government found that the productivity growth of the housing industry was very low compared to other manufactured industries. Industrialised housing producers focused on design flexibility and customised their products to individual consumer need. This was a particularly important development given the traditional association of industrialised housing with standardisation rather than customisation. As a result of this emphasis on customisation, the market share of prefabricated houses in Japan doubled between 1980 and 1992. By 1994, prefabricated houses accounted for 10 per cent of total housing output, or approximately 2000 houses per year. Indeed, in the 1990s, the use of aforementioned 'leans production' methods started making its way into the construction industry in a more substantial way (Winch, 2003).

Within Japan, Toyota is a good example of cross-sector learning from the automobile industry to the construction industry. While Toyota is currently one of Japan's top three car manufacturers, it also creates several thousand factory-made houses every year. However, Toyota still needs to learn from other housing manufacturers how to manage production of a huge amount of customised products, in a context where automated techniques are limited because of the complexity of the product and the range of component parts (Winch, 2003).

2.6.3 Benefits and challenges of applying manufacturing techniques to construction

According to Gann (1996), the existing manufacturing techniques of the car industry have been successfully adopted to make attractive, customised and economical homes. This experience provides a new example of learning and transfer of professional knowledge between different industrial sectors. The automobile industry can be regarded as a leader in production management practices, while the construction industry is viewed as a craft-dominated industry that is very slow to change. The manufacturing approach used in the automobile industry has some positive aspects when compared with traditional craftsmanship. First, economies of scale can be easily achieved through the manufacturing process, with costs per unit decreasing sharply. Secondly, technical possibilities allow greater deployment of capital equipment. Finally, the manufacturing approach allows for tighter managerial control. These aspects were first adopted by Henry Ford, who is regarded as the creator of the mass-production line that allows high output volumes and standardised production.

There are limits to the extent to which insights from automobile manufacturing can be applied to manage the assembly of different component parts in order to achieve complex customised houses (Gann, 1996). As Gibb (2001) argues, the 'trite' comparisons between the car and construction industries are 'hard to substantiate'. While cars are mobile, buildings are fixed to the ground, requiring a construction site where materials, machines and people are transported to. The building site environment is thus fundamentally different to the automobile factory.

Another shortcoming to the cross-industry learning process is the customisation/standardisation issue. The construction industry requires a relatively high degree of customisation to allow for consumer choice. Such customisation may erode some of the benefits drawn from automobile-style manufacturing process, which are based on interchangeable parts and a high degree of repetition and standardisation. As Gann (1996) recommends, managers should balance the achievement of economies of scale in the production of standardised parts and economies of scope in order to ensure that there is an adequate degree of customisation and flexibility.

2.6.4 Benefits of quality management for the construction industry

As is well-known, in the past few decades construction industry has suffered from poor performance and low productivity compared to other industries (Eastman & Sacks, 2008). Clients, arguably the most important stakeholders in every construction project, increasingly demand high quality outcomes with shorter time frames expecting technological innovation to make such orders possible (Tchidi, He, and Li, 2012). There is an expectation that the construction industry has learnt, or will learn from the manufacturing industry with respect to sources of innovation, benchmarking and quality management in general (Hoonakker et al, 2010). Specifically, such concepts from the manufacturing sector as *Total Quality Management (TQM) / continuous improvement*, (Just in Time) and lean production are expected to have a place in construction management (Formoso & Revelo, 1999; Tchidi, He, and Li, 2012).

The belief is that these quality management philosophies and interventions will be able to be used by managers of construction projects in order to overcome perennial problems related to cost and productivity (Kuprenas & Kiani, 1998; Tchidi, He, and Li, 2012). Lahndt (1999) specifically pointed out that TQM techniques used in the manufacturing industry to control process and avoid defects before they occur, resulted in extensive cost savings, and that such techniques should be applied in the construction sector. Pasquire and Connolley (2002) argued similarly noting that lean management techniques would improve quality in construction.

2.6.5 Perceived barriers to quality management system use

Novessro (2009) cites project size, labour intensiveness, system complexity and demand fluctuation as barriers to the effective use of *Quality Management Systems (QMS)* in construction. Furthermore, others such as Karim et al. (2005) argue that many parties including customer, engineer/designer and contractor are involved in the construction process mean that final products are not identical or repetitive, construction industry is non-standardized. Novessro (2009) mentions the 10 root causes why ISO 9001 implementation and hence he argues that QMSs are ineffectively applied in construction purposes, such as:

1. Obtaining of ISO certification just for prestige
2. Lack of top management commitment
3. Minimum availability of supporting resources
4. Failure in applying continuous improvement concepts
5. Unrealistic timelines set up for rolling-out QMS programs
6. Failure in disseminating QMS programs to all organizational levels since it is assumed that the system is only appropriate for manufacturing processes
7. Unsuccessful human resources training in becoming an agent of change
8. Unsuccessful definition and design of QMS documentation
9. Implementation of QMS as an add-on to standard operating procedures; and
10. QMS's applied without conducting a comprehensive review of existing management system

As an example of quality management difficulty, Tam et al. (2000) introduced an objective quality measure, the Performance Assessment Scoring Scheme (PASS), for public housing construction in Hong Kong but the general level of quality system was not achieved and as a result, the expected continuous improvement was not fulfilled.

In a second case, a study was done on improving the materials supply system in small-sized building. To this end, three companies from the Brazilian building industry, which worked cooperatively through several stages of TQM implementation, were investigated. The applied method was based on simple well-known quality techniques for problem identification, analysis and solving, such as flowchart, brainstorming, checklist and Pareto diagram. Difficulties in applying such techniques were identified. The first was flowchart complexity. The complicated nature of materials supply incorporated over 50 steps for the flowcharts, thus making it difficult for the quality committee members to understand. The second issue was the complexity of the check list application (Formoso & Revelo, 1999).

Another example is related to QMS where it says ISO 9000 is not an appropriate standard for use in construction firms. Studying the Swedish construction sector revealed that ISO 9000 is difficult to be applied by construction companies because its clauses are too general and the nature of construction projects, practices, contracts and specifications are somewhat unique and specific in every case, and usually different specific product and service outcomes are enveloped under a generic system such as ISO 9000 (Landin, 2000). *There is an opportunity in this study to focus on off-site construction and its standardizing process*. Off-site construction can be done systematically and designers and contractors use more prefabricated parts and elements, so it seems easier to carry out standardization in off-site construction. As Hoonakker et al (2010) said, prefabrication is a good solution to overcome quality barriers in construction industry.

2.6.5 Operational management tools & techniques in off-site work

A number of researchers have applied operational management tools and techniques to off-site construction settings. Pasquire and Connolley (2002) wrote at length about the benefits quality management interventions have in the off-site construction sector. They note that quality interventions can be directed applied to off-site construction projects. One quality management technique is the development of *cause and effect diagrams*. These diagrams are used to identify causes and sub-causes of production issues. Tchida, He, and Li (2012) developed a cause and effect diagram amongst other investigations in order to identify and present causes and sub-causes of concrete cracks and slippage effects concerning prefabricated formworks. The authors reported that technical training, insufficiency of steel stiffness, poor laboratory input, poor material control, poor overall maintenance, poor concrete mix, and weather and temperature influence negatively affected concrete quality (Tchida et al., 2012).

Meiling, Sandberg, and Johnsson, (2014) also used cause and effect diagrams as part of their study in industrialised house building in order to identify issues with jamming windows amongst other issues. The researchers reported that "Ishikawa [cause and effect] diagram was useful to breakdown the problem" (Meiling, Sandberg, and Johnsson, 2014). The researchers reported that cause and effect diagrams were able to aid researchers to identify which prefabrication approaches were more cost effective, which suppliers' elements were more reliable, and which parts of the process could be further standardised.

2.7 Chapter summary

The chapter reviewed the literature related in off-site construction specifically making comment on its definition, history, advantages and disadvantages. The chapter also reviewed the contemporary adoption of off-site construction and considered its potential for future adoption. The chapter also reviewed the body of research and commentary on employee empowerment particularly in relation to the construction sector.

Models of employee empowerment were reviewed above and benefits and barriers to the concept's adoption in construction generally and off-site construction specifically were considered.

The final section of the chapter reviewed the literature available on productivity, specifically its definition and approaches to determining labour productivity in the construction industry. This part of the chapter also explored the effect of practices of off-site construction on construction labour productivity generally.

The next chapter is the methodology in which the research design is presented justifying the selection of data collection and data analysis techniques for the purposes of addressing the study's six objectives.

CHAPTER THREE - METHODOLOGY

3.1 Methodology overview

This chapter, the Methodology, follows on from the previous chapter, the Literature Review, and describes how findings from Chapter Two, were used to revise the project's research objectives and also to support the selection of guiding framework for key concepts. The chapter first provides an overview of quantitative and qualitative research paradigms and comments on the benefits a mixed methods approach. After these fundamental methodological considerations for study realization are discussed, the chapter then describes the data sources, collection, and analysis procedures. As part of this, the chapter describes the four-part literature review that was conducted (the project's secondary research) that was conducted, and following this the chapter outlines the primary research, most significantly the conducting of 36 semi-structured interviews two-sample t-tests, Pearson's product-moment coefficient, relative importance index analysis, statistical process control analysis and the qualitative data analysis techniques applied. At the end of the chapter, techniques used to counter threats to research validity and reliability are presented.

3.2 Research objectives

The primary aim of this research is to assess the productivity of the off-site construction industry through a focus on employee empowerment and with reference to operational management tools and techniques.

This primary aim can be broken down further into the six research objectives.

1. The first objective was *to investigate and compare the current usage of employee empowerment and in terms of its relative importance to labour productivity between two off-site companies.*

2. The second objective was to *investigate the relationship between labour productivity and employee empowerment*.

3. The third objective was to *identify the factors affecting the productivity of off-site construction industry.*

4. The fourth objective was to *empirically examine the relationship between the perceived relative usage of the nine employee empowerment factors and the 43 productivity factors.*

5. The fifth objective was to *measure empirically the current productivity of off-site construction industry fabrication methods with application of operational management tools and techniques.*

6. The sixth objective was to *seek to improve future productivity of the off-site construction industry through validation and application of operational management tools and techniques*.

3.3 Research strategy

Qualitative, quantitative and mixed methods were taken into account while considering the research approach whose selection depends on the problem to be investigated (Creswell, 2008). In this section, the strategies of all approaches which contributed to the selection of a mixed research methodology for this study are discussed. Useful definitions assisting to clarify the three approaches are provided by Creswell (2009) as following.

3.3.1 Quantitative approach

In a quantitative approach, in order to develop knowledge the investigator initially makes post-positivist claims (i.e. thinking based on cause and effect, reduction to specific variables, hypotheses and questions, applying measurement and observation and testing theories) uses such inquiry strategies as surveys and experiments and collects data on predetermined mechanisms that provide statistical data (Creswell, 2009). To select methodology, McQueen and Knussen (2002) recommend that quantitative approach is determined by such conditions as whether there are any established theories in the area to be regarded, whether statistical analysis has been used in previous studies, and whether there is a potentially high sample of subjects.

In the case of productivity measurement in off-site construction, there are limited studies published that use quantitative analysis. Given that this context creates a precedence, the current research takes a cautious approach to its use of statistical claims.

3.3.2 Qualitative approach

In a qualitative approach, the inquirer makes knowledge claims initially based on constructivist perspectives (i.e. the multiple interpretations of individual experiences, socially and historically constructed interpretations for developing a pattern or theory), or advocacy/participatory perspective (i.e. political, issue-orientated, collabourative, or change oriented) or both. Furthermore, in qualitative approach such inquiry strategies as narratives, ethnographies, phenomonologies, case studies or grounded theory studies are used. The type of emerging data the researcher collects is open-ended, with the primary aim of developing themes from the data (Creswell, 2009). In addition, McQueen and Knussen (2002), discuss the following conditions about qualitative research. They stated that these indicators suggest that a qualitative paradigm may be appropriate, these being, lack of experience in the field of study, that the bulk of the previous research is qualitative, and that obtaining a representative sample would be very difficult.

These were aligned with the limitations of individuals participating in the study, with the lack of experience in the field of study and with the qualitative nature of previous research. According to Creswell (2009), qualitative approach is appropriate to understand a concept or phenomenon when little research has been done on it. He also believes that when the examiner has no idea of the important variables to examine, qualitative research is exploratory and useful and this approach may be required because the topic is new or never addressed with a particular sample or group of people, or existing theories are not applicable to the sample or group of individuals under study. The assessment of productivity in off-site construction was an area where little research exists, and therefore, the majority of this research will use qualitative approach.

3.3.3 Comparison of quantitative and qualitative research

Before starting to discuss the mixed methods used by this study, a number of contrasts between quantitative and qualitative research may be made; Bryman and Bell (2011) discuss why quantitative and qualitative strategies should be distinguished. Firstly, quantitative and qualitative researches are different in terms of research strategy so that many researchers and research methodology writers approve such differences. Secondly, such a distinction is useful for organising research methods and data analysis approaches. Table 3.1 provides the major differences between qualitative and quantitative research.

Table 3.1: qualitative V quantitative research methods (from Bryman & Bell (2011)

Quantitative Method	Qualitative Method
Numbers	Words
Point of view of researcher	Points of view of participant
Researcher distant	Researcher close
Theory testing	Theory emergent
Static	Process
Structured	Unstructured
Generalization	Contextual understanding
Hard, reliable data	Rich, deep data
Behaviour	Meaning
Artificial settings	Natural settings
Macro	Micro

3.3.4 Mixed-methods research

Mixed-method research often provides a more practical solution and produces a better product (Denzin, 1978). In a mixed methods approach the researcher tends to use pragmatic grounds such as being problem-centred, pluralistic and consequence-oriented, to establish knowledge claims. It adopts inquiry strategies involving the collection of data in either simultaneous or sequential manner to best perceive research problems.

Mixed method data collection includes gathering both numeric information (e.g., on instruments) and text information (e.g., on interviews) in order for the final database to represent both quantitative and qualitative information (Creswell, 2009). Contemporary research has become highly inter-disciplinary and complex, thus there is a need to complement a method using another and a high recognition of multiple methods used by other scholars is necessary for researchers so as to have easier communication and progressive cooperation as well as providing high quality research (Denzin, 1978).

According to a more detailed study of mixed method by Johnson, Onwuegbuzie & Turner (2007), mixed method research is a practical and intellectual synthesis based on qualitative and quantitative research and as the third methodological or research paradigm (together with qualitative and quantitative research), it identifies the significance of traditional quantitative and qualitative research, however, it puts forward a powerful third paradigm choice often providing research results with the highest level of informative-ness, completion, balance, and usefulness.

There are four points of interest concerning the mixed methods research paradigm. Firstly, it is based on a pragmatism philosophy. Secondly, it is logical, leading to the production of usable and defensible research results. Thirdly, it is reliant on qualitative and quantitative viewpoints, data collection, analysis, and inference techniques which are put together based on the mixed methods research logic to respond to researchers' question(s). Finally, it includes local and broader socio-political facts, resources and requirements (Johnson, Onwuegbuzie & Turner, 2007).

The mixed methods research paradigm also offers an important approach towards generating significant research questions and providing authentic answers to those questions. Furthermore, mixed methods research is not aimed at replacing either of quantitative and qualitative approaches but using the strengths and minimizing the weaknesses of both in single research studies and across studies (Johnson & Anthony, 2004). With mixed method this research is able to utilize operational management tools and techniques still uncommon in off-site construction as well as qualitative approach to obtain a solid understanding of productivity in off-site construction and elabourate how these tools and techniques can be used in off-site construction.

Conducting mixed method can have a number of reasons. As noted by Greene et al. (1989), there are five main aims or bases including: (a) triangulation which means to seek, converge and corroborate results from different methods and designs which study the same phenomenon; (b) complementarity which means to seek, elabourate, enhance, illustrate, and clarify the results from one method with results from the other methods; (c) initiation which means to discover paradoxes and conflicts causing are-framing of the research questions; (d) development which is to apply the findings from one method to help to inform the other method; and (e) expansion which means to seek the width and range expansion of research through different methods for different inquiry components.

Moreover, Rossman and Wilson (1985) found three reasons for combining quantitative and qualitative research. First, using combinations makes their mutual confirmation or corroboration possible through triangulation. Second, using combinations makes it possible to develop analysis in order to provide richer data. Third, using combinations makes it possible to begin new modes of thinking by paying attention to paradoxes emerging from the two data sources. This research will use triangulation in data collections in which semi-structured interview and expert opinion is used. The combination of this study between qualitative approach (semi-structured interview and participant comment) and quantitative approach (operational management tools and techniques) will provide rich data.

Some of the strengths and weaknesses of mixed methods research, towards deciding whether or not to use a mixed methods research approach for a given research study (Johnson & Anthony, 2004), include:

Strengths:

- Words, images, and narratives can be used to add meaning to numbers; and, numbers can be used to add precision to words, images, and narratives.
- Researcher can generate and test a reason bearing theory; and, as the researcher is not restricted to a single method or approach, it can answer a broader and more complete range of research questions.
- An additional method can be used for its strengths to overcome the weaknesses in another method; and, through convergence and corroboration of findings. It can provide more reliable proof for a conclusion
- When only a single method is used, less insight and understanding will be available
- Can be used to increase the generalizability of the results.
- When qualitative and quantitative researches are used together, they generate more comprehensive knowledge required to inform theory and practice.

Weaknesses:

- Doing both qualitative and quantitative research can be difficult for a single researcher particularly for two or more approaches to be used simultaneously, a research team may be required.
- Researcher has to learn multiple methods and approaches and understand how to combine them properly; and, according to methodological purists, one should always work in either a qualitative or a quantitative paradigm.
- More expensive; and, more time taking.

Some details of mixed research remain to be fully resolved by research methodologists e.g. problems of paradigm mixing, how to analyse quantitative data qualitatively and how to interpret contradictory results.

The following figure, Fig. 3.1, provides a diagrammatic representation of the research design adopted for this study.

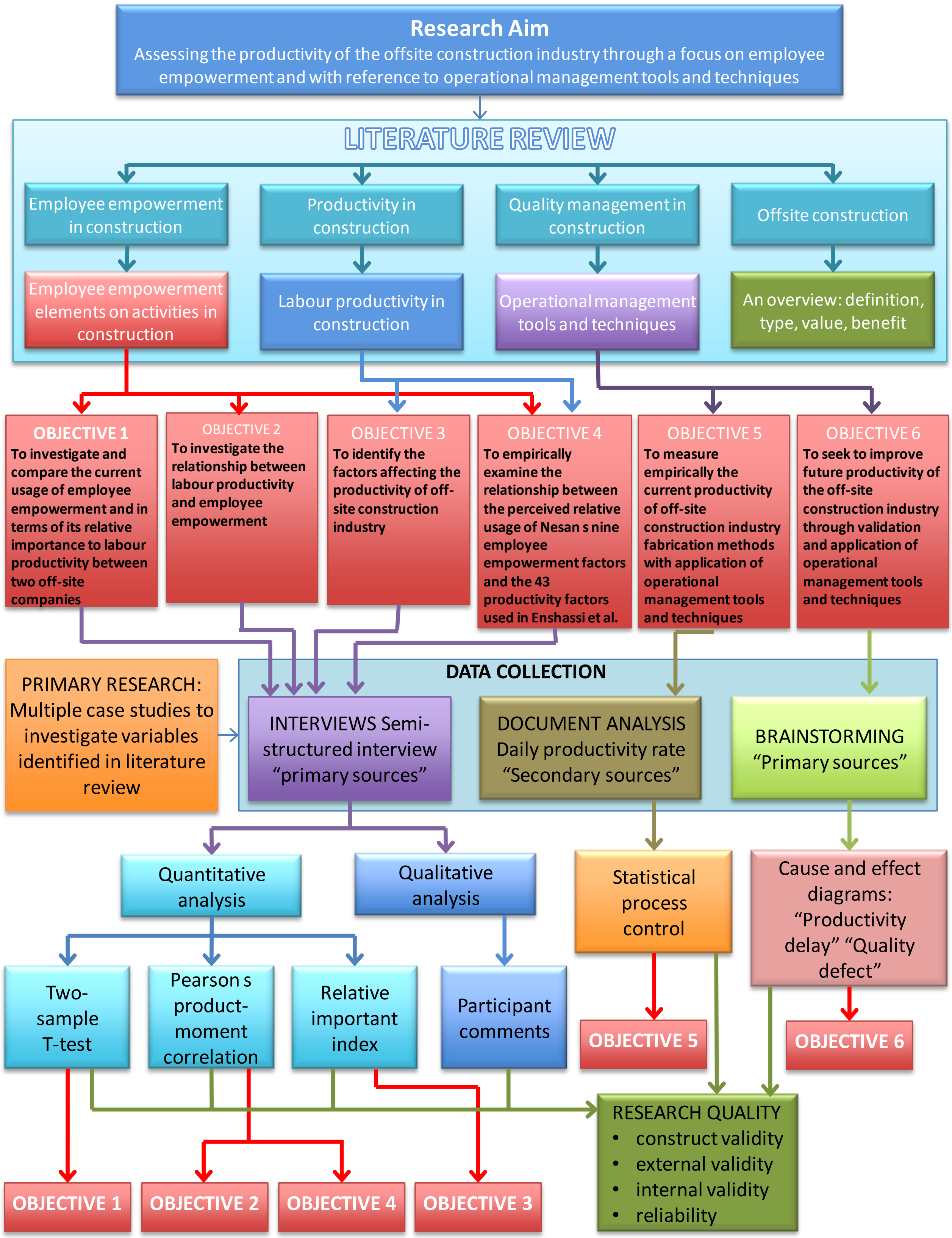

Fig. 3.1 Diagrammatic representation of the research design

3.4 Literature Review

In engineering, as in other fields of study, the researcher has an obligation to ensure that their investigation or study is worthwhile. Preparing and writing a sophisticated literature review is an important part of this. Conducting a literature review is a type of secondary research. The literature review section of a dissertation should be "a comprehensive survey of what researchers have already done in your topic area" (Baxter and Babbie, 2003). The writing of a literature review is important as it gives the researcher an opportunity to identify and analyse the research and commentary that already exists in relation to the researcher's topic. Without doing this, the researcher would be "leaping" into their formal data collection without determining which gaps in the literature exist and what questions need to be answered.

A thorough literature review should enable to the researcher to better contribute to the body of knowledge on a topic by illuminating the topic's past, and likely future. As part of this, conducting a thorough literature review should also inform the researcher and other stakeholders about the most popular research methods to use for a particular phenomenon. For example, Weerakkody (2009) advises that is important not to re-invent the wheel and also to not repeat reported limitations of earlier studies. A well researched and written literature review should help to direct and justify the current study through arguing for the need for particular empirical interventions with respect to particular phenomena.

In this study, the researching and writing of the literature review was an important task in aiding the formulation of the objectives of the study (Fellows and Liu, 2003). Naoum (2012) describes the main purpose of a literature review as being a: "systematic reading of previously published and unpublished information relating to the area of investigation, that it helps improve the study by looking into previous research design or questionnaires which will give some insights into how the researcher can design his/her own study more effectively."

Similarly, Creswell (2009) provides that the literature review should extend the value of previous studies and contribute to an on-going dialogue concerning the topic. Here, the review of literature on themes of employee empowerment, off-site construction, and productivity has been an on-going pursuit commencing at the start of the study and has continued to the final stages of dissertation drafting with recently published studies added along the way.

3.4.1 Literature review of employee empowerment in construction

The primary and original aim of this study was to assess and consider productivity in the off-site construction industry through a focus on employee empowerment and with reference to operational management tools and techniques. Thus, to better understand the research topic it was important for key concepts and their inter-connections to be considered in depth.

The first task was to investigate the concept of "employee empowerment in construction", which involved the first sub-task of investigating "employee empowerment" and/or "empowerment", and the second sub-task, namely focusing on the construction sector to identify and assess how the concept of "employee empowerment" had been understood and applied in relation to construction related activities. Identifying and assessing employee empowerment elements and/or activities in construction was an important goal for this part of the literature review.

This part lead to the eventual development of the final six research objectives and in particular informed the partial construction and wording of the first, *to investigate and compare the current usage of employee empowerment and in terms of its relative importance to labour productivity between two off-site companies*, second, to *investigate the relationship between labour productivity and employee empowerment*, and fourth objectives was to *empirically examine the relationship between the perceived relative usage of Nesan's nine employee empowerment factors and the 43 productivity factors used in Enshassi et al. (2007), as well as* the methodology applied to address those objectives.

3.4.2 Literature review of productivity in construction

The second task was to investigate "productivity in construction." Identifying and assessing factors affecting labour productivity in construction was an important goal for this part of the literature review. This part also lead to the eventual development of the final six research objectives and in particular informed the construction and wording of the third, to *identify the factors affecting the productivity of off-site construction industry, and* fourth, to *empirically examine the relationship between the perceived relative usage of Nesan's nine employee empowerment factors and the 43 productivity factors used in Enshassi et al. (2007)* objectives.

3.4.3 Literature review of quality management in construction

The third task was to investigate "quality management in construction." Identifying and assessing operational management tools and techniques particularly those focused on fulfilling operational requirements was an important goal for this part of the literature review. This part, in particular informed the construction and wording of the fifth, to *measure empirically the current productivity of off-site construction industry fabrication methods with application of operational management tools and techniques,* and sixth, to *seek to improve future productivity of the off-site construction industry through validation and application of operational management tools and techniques* objective.

3.4.4 Literature review of off-site construction

The fourth task was to investigate "off-site construction". Providing a definition and understanding the interdependencies and distinctions between off-site and onsite construction was an important goal for this part of the literature review.

This part also lead to the eventual development of the final six research objectives which each focused on off-site construction, and in particular informed the construction and wording, *to investigate and compare the current usage of employee empowerment and in* *terms of its relative importance to labour productivity between two off-site companies,* third, to *identify the factors affecting the productivity of off-site construction industry,* fifth to *measure empirically the current productivity of off-site construction industry fabrication methods with application of operational management tools and techniques,* and sixth to *seek to improve future productivity of the off-site construction industry through validation and application of operational management tools and techniques* objectives.

3.5 Case study

Case studies are commonly used to investigate variables identified in the literature review as relevant to the research objectives. Case study is a comprehensive research strategy, not a data collection tactic or design feature alone (Yin, 2009). A case study should not be regarded as a pure observational study which captures on what participants practice. It is also not a survey which normally explores what informants perceive. A case study should include both. Yin (2009) defined a case study as; "A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. The case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multi sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis".

A case study may involve both qualitative (e.g. words) and quantitative (e.g. numbers) data and may even consist of one of the types of data only. Bryman (2004) argues that most qualitative research is a form of case study, but not all case studies can be described as qualitative because they often use quantitative research methods. Moreover, Yin (2009) cautions researchers not to confuse case studies with qualitative research, he also notes that “case studies can be based entirely on quantitative evidence”. The case study features a mix of quantitative techniques (that address operational management measurement of key variables) and qualitative data that seeks the expert professional opinion of the key (engineering and construction industry) stakeholders.

The nature of the research project will determine which of the strategies is most suitable, and is linked to the optimal choice of a wide variety of data collecting methods (Fellows and Liu, 2003). In the early stages of different research topics, which have been little researched and with a theory building purpose, a case study is often appropriate (Eisenhardt, 1989). Case studies can be considered the best research strategy when the aim is to solve a problem that requires profound understanding of the context and its practice (Merriam, 1988). Studying productivity of off-site construction through operational management tools and techniques is a new area as well as complex phenomenon, therefore choosing a case study is the most appropriate method of this research.

According to The Productivity Press Development Team (2002), when solving productivity problems it is essential that you actually go to the work site and closely examine the operation or process being improved so that you do not make incorrect assumptions about the actual causes which will lead you to solve the wrong problem, fail to find the root cause and therefore have a return of the problem later or miss the real issues in some other way. Moreover, Liker (2004), describing The Toyota Way 14 Management Principles, describes principle 12, which is to go and see for yourself to be able to thoroughly understand the situation. The key points of this principle are described as follows:

- Solve problems and improve processes by going to the source and personally observing and verifying data rather than theorising on the basis of what other people or the computer screen tell you;
- Think and speak based on personally verified data;
- Even high-level managers and executives should go and see things for themselves so they will have more than a superficial understanding of the situation.

As a result, the most suitable strategy for the assessment of the productivity of off-site construction is single or multiple cases when the researcher become very close to the selected organisation. It can be considered a robust research method particularly when a holistic, in-depth investigation is required.

3.5.1 The number of cases

The literature presents two general approaches to case sampling, these are termed randomised and theoretical. Eisenhardt (1989) states 'the cases may be chosen to replicate previous cases or to extend emergent theory, or they may be chosen to fill theoretical categories and provide examples of polar types. While the cases may be chosen randomly, random selection is neither necessary nor even preferable'. In the theoretical approach, cases are chosen either to literally or theoretically replicate other cases (Yin, 2009). Case selection was important, as these should conform to the purpose of the study, and not chosen randomly (Yin, 2009). The selection of the case studies in this study observed these theoretical considerations and practical considerations as described below:

- The case study organisations were well known to the author; a good relationship had been developed, this assisted in obtaining access to the companies for detailed study;
- The case study companies reflected current use of off-site construction.

3.5.2 Case number

Case studies can be categorised and designed as single or multiple. Yin (2009) argues that 'multiple-case designs have distinct advantages and disadvantages in comparison to single-case designs. The evidence from multiple cases is often more compelling, and the overall study is therefore regarded as being more robust'. Multiple case studies provide wider-ranging information and greater scope for generalisation (Miles and Huberman, 1994). The number of cases is debated in the literature with no ideal number stated. Eisenhardt (1989) argues that a number of between four and ten usually suffices. Miles and Huberman (1994) state that more than 15 cases is not advised as they can result in unwieldy volumes of data with a loss of detail. A number greater than 15 is suggestive of a survey research approach. However, there is a growing recognition that some of the accusations about the limited generalisability of case studies may be based on an erroneous application of statistical notions which treats the case as a sample of one (Bryman, 1989).

Case studies should be evaluated in terms of the adequacy of the theoretical inferences that are generated. The aim is not to generalise the findings from a sample to a population but to create patterns and connections of theoretical importance (Bryman, 1989; Mitchell, 2000; Yin, 2009). On other word, generalisation of results from case studies, from either single or multiple designs, stems on theory rather than on populations. A case study (or series of case-studies) will be performed in order to gain a better understanding of performance and productivity in off-site construction.

3.6 Data collection

3.6.1 Interview

Interviews are one of the most important sources of case study (Fellows and Liu, 2003). Interviewing tends to provide knowledge that other methods are unable extract conclusively (Valentine, 2005). They typically involve a direct exchange of verbal (and non-verbal) questions, cues, and responses between one or more interviewers and one or more interviewees. Interviews can occur in a variety of formats including exploratory interviews, informal interviews, standardised interviews, semi-structured interviews, and group interviews (Oppenheim, 1992).

3.6.1.1 Semi-structured interviews

Semi-structured interviews were used in this study. Semi-structured interviews are a more controlled interview method compared to informal or exploratory interviews (Oppenheim, 1992). While those interview types focus on open-ended questions and even shifting investigation focuses, the semi-structured interview typically follows a schedule of questions, known as items. These items may be categorised into sections.

However, semi-structured interviews differ from structured interviews, in that the interviewer has a greater latitude for re-arranging the sequence of questions asked and can ask additional questions. Typically, open-ended questions can be asked to explore emerging themes that appear in the opinions of the interviewee as relevant to the research endeavour (Bryman, 2004).

In this study, while interviews were being conducted, the interviewer (principal researcher), in situations where it was necessary, took notes to stimulate insights for subsequent interviews, formulated new questions to explore emerging themes, and sought clarification from participants concerning their responses.

3.6.1.2 Participants

Prospective off-site construction companies in Saudi Arabia were recommended to the principal research through personal/professional contacts. Thus, non-random convenience sampling was used for practical purposes. Three out of five general managers contacted were interested to participate in the study. Careful selection (addressing experience and qualifications) of general managers, production managers, operation managers, middle production operators/foremen and lower production operator(s) occurred to ensure participant awareness of trends in productivity and ability to accurately rate the concepts such as factors of employee empowerment with relation to respective daily productivity based on their knowledge and experience in the off-site construction industry.

Company A

Company A employed 250-300 workers, 87 of whom were employed directly by the company, 175-200 were from a manpower supplier, and 7 were independent contractors. Thirteen participants were recruited from Company A.

1. General manager (12 years of experience)
2. Production manager (6 years experience)
3. Quality manager (10 years experience)
4. Quality inspector (4 years experience)

5. Safety manager (13 years experience)
6. Production line manager (8 years experience)
7. Production Forman (4 years experience)
8. Production repair manager (14 years experience)
9. Production line manager (4 years experience)
10. Production technical manager (5 years experience)
11. Production technician (9 years experience)
12. Production technical supervisor (8 years experience)
13. Operation manager (10 years experience)

Company B

Company B directly employed 1400 workers; in 2010 the company won an award for providing the best environment for its employees in a competition encompassing seven countries. Company B was also the second-highest producer in that country, and it has gained ISO 9001 quality management certification. Ten participants were recruited from Company B.

1. General manager (15 years of experience)
2. Production manager (7 years experience)
3. Operation manager (15 years experience)
4. Quality manager (15 years experience)
5. Quality inspector (6 years experience)
6. Production line engineer (3 years experience)
7. Production line engineer (2 years experience)
8. Production Forman (11 years experience)
9. Production Forman (12 years experience)
10. Production technical coordinator (10 years experience)

Company C

Company C directly employed approximately 1300 workers; the national government was the largest client. Similarly to Company B, Company C had gained ISO 9001 quality management certification. Thirteen participants were recruited from Company C.

1. General Manager (16 years experience)
2. Factory 1 Production Manager (7 years experience)
3. Factory 2 Production Manager (5 years experience)
4. Factory 4 Production Manager (6 years experience)
5. Production Efficiency Monitoring and Production Coordinator (3 years experience)
6. Production Supervisor (6 years experience)
7. Production Engineer (10 years experience)
8. Production Engineer (3 years experience)
9. Production Forman (4 years experience)
10. Production Forman (6 years experience)
11. Quality Manger (13 years experience)
12. Quality Engineer (7 years experience)
13. Quality Inspector (4 years experience)

The above-mention companies produced similar precast concrete elements. This includes, but is not limited to: precast concrete beams, columns, stairs, double tee slabs, hollow core slabs and wall panels. Companies B and C have a similar output of around 9000 m3 of concrete, while company A produced around 3000 m3 each month.

3.6.1.3 Interview schedules

An initial instrument, an interview schedule of items (Appendix A, B and C), was developed through a review of the literature available on studies investigating employee empowerment and labour productivity factors. The survey instrument contained a mix of qualitative and quantitative items.

The first section, Section 1, of the instrument aimed to gather information concerning the participant’s views on the effect of factors related to employee empowerment on labour productivity.

The second section, Section 2, aimed to gather information concerning the participants' views on leadership.

The third section 3, Section 3, of instrument aimed to gather information concerning the participants' views on labour productivity factors.

The survey instrument was reviewed in consultation with experienced researchers and industrial contacts.

The design of the instrument and asking of questions was based on recommendations from the literature (Bryman, 2004; Oppenheim, 1992). In brief, this research study endeavoured to motivate respondents through conveying the importance of the research. Confusions/concerns on the part of the respondents were attempted to be clarified as candidly and as informatively as possible by the interviewer. The quality of responses was also monitored by the interviewer to ensure that interviewing attentiveness was consistent.

Section 1 – Factors relevant to employee empowerment

As a result of a comprehensive review of the literature, nine factors were identified. These factors were based on the work of Nesan (1997) and to a lesser extent Holt (2000), Holt et al., (2000), Nesan and Holt (2002) and Nesan (2004). These factors were adopted for this study due to the fact that they had been previously applied, reportedly successfully, in studies of manufacturing in contexts considered to be similar to off-site construction (Nesan, 1997). Another strength of these factors was that they were considered to represent employee empowerment holistically containing aspects of structural and psychological empowerment.

A number of items were formulated for each of the nine factors. These items were largely adopted from Nesan's (1997) study:

> 4 items asked in relation to leadership, empowerment system (4 items), resources development (3 items), involvement (4 items), education and training (7 items),

team work (6 items), process improvement (9 items), measurement (3 items), and recognition (2 items). These items in the first section of the interview schedule sought to identify relative current usage of the nine factors.

In addition, under each factor of employee empowerment, a question such as, “how does the factor affect labour productivity?” was asked in order to understand the effect of the employee empowerment factor on labour productivity.

Participants were asked to indicate their position on against a five-point scale Likert scale ranging from 5 (Using fully) to 1 (No using at all).

Section 2 – Participant leadership style

The second section of the interview schedule sought to identify the participants' awareness and perception of their own leadership styles. This section consisted of 18 questions related to the well-established Blake and Mouton managerial grid leadership self-assessment questionnaire. The managerial grid is based on two dimensions: concern for people and concern for production.

This tool (Black & Mouton, 1964), allows five leadership styles to be identified based on the interaction of the scores of the two dimensions namely: authoritarian leader, team leader, country club leader, middle-of-the-road leader, and impoverished leader.

Section 3 – Factors affecting labour productivity

As a result of a comprehensive review of the literature, ten factor groups, containing a total of 43 factors were selected for inclusion in the third section of the interview schedule. The factor groups and factors were drawn from the research of Olomolaiye (Olomolaiye, Wahab, and Price, 1987; Olomolaiye and Ogunlana 1989; Olomolaiyi, 1990; Olomolaiyi, Jayawardene, and Harris, 1998), and in particular Enshassi et al. (2007). The factors were selected as they were deemed relevant by the research community, particularly those formulated in research led by Olomolaiye. . Moreover, the physical conditions of Enshassi et al.'s (2007) study on the Gaza Strip were considered to share some similarities with the conditions of the current study in Saudi Arabia.

In this part of the interview, participants were asked to rate the relative importance of these 43 factors using a 5-point Likert scale scoring system,

with 1 = not at all important, 2 = not very important, 3 = somewhat important, 4 = very important, and 5 = extremely important. Ten factor groups were for 43 items could be used to form 10 groups of factors, described as follows:

- Materials/Tools group (3 factors): material shortages, tool and equipment shortages, and unsuitability of materials storage location
- Supervision group (4 factors): drawings and specifications alteration during execution, inspection delay, rework, and supervisors' absenteeism
- Leadership group (3 factors): lack of labour surveillance, misunderstanding between labour and superintendents, and lack of periodic meeting with labour
- Quality group (3 factors): inefficiency of equipment, low quality of raw materials, and high quality of required work
- Time group (5 factors): working 7 days per week without taking a holiday, misuse of time schedule, method of employment (using direct work system), increasing number of labours, and working overtime
- Manpower group (8 factors): lack of labour experience, labour disloyalty, labour dissatisfaction, misunderstanding among labour, lack of competition, increase of labourer age, labour absenteeism, and labour personal problems
- Project group (4 factors): working within a confined space, Interference, construction method, and type of activities in the project
- External group (1 factor): augmentation of government regulations
- Motivation group (6 factors): payment delay, lack of financial motivation system, lack of labour recognition programs, non-provision of transport means, lack of place for eating and relaxation, and lack of training sessions
- Safety group (6 factors): accidents, violation of safety precautions, bad ventilation, working at high places, unemployment of safety officer on the construction site, and noise

It should be noted that, concerning Section 3, a conceptual framework derived from general construction studies, as opposed to one derived from manufacture, was applied here to a study focusing on off-site construction. While off-site construction would appear to have similarities to manufacturing, Hook and Stehn (2008) on a review of 14 studies between 1995 and 2005, found that off-site construction was "clearly influenced by a production culture that has similarities to a traditional construction culture."

Eriksson et al. (2014) reported similar findings while some people may think off-site construction, and construction in general, has much to learn from the manufacturing sector, practically there are a number of barriers limiting to applicability of manufacturing management practices to construction whether it be on or off-site.

3.6.2 Operational tools and techniques - Brainstorming

Brainstorming is the activity of group generation of ideas given a particular issue or situation (Hender et al. 2002). Osborn (1952; 1953) in the 1950s reported that group brainstorming led to 44% more ideas than individual problem solving. Thus, as mentioned, brainstorming by definition is a group activity which can occur in person or virtually, such as through internet connection (Kane and Trochim, 2006). Typically, the experts are in one way or another asked to provide ideas as they occur to them, or alternatively, respond in turn. It is generally the role of the facilitator to record the responses from the expert participants.

While there are different beliefs and descriptions about how brainstorming should be conducted, a number of characteristics are generally agreed upon. For example, Tomlinson (1994) believes that brainstorming is concerned with the discovery of new ideas through interaction between two or more experts in the field. Tomlinson (1994) writes that brainstorming should be a constructive process in a comfortable setting where participant responses are respected regardless of their nature. The author writes "in this kind of discussion there is no "right" or "wrong" answer (1994). These are similar to the principles expressed by Osborn earlier when he noted that "criticism is ruled out, wild ideas are welcome, quantity is wanted and a combination and improvement of ideas are sought"

Tomlinson's (1994), key principles of brainstorming detail:

- concerned with the discovery of new ideas
- through interaction between two or more experts in the field
- a constructive process
- a comfortable setting
- participant responses are respected regardless of their nature
- no "right" or "wrong" answer
- provide ideas as they occur to them, or alternatively, respond in turn
- facilitator (researcher) records responses

Hender et al. (2001) provide a summary of brainstorming stating that it is a three step process, namely, "1) Read the problem, 2) Generate ideas by free association, and 3) Continue to generate ideas by free association".

In commercial and industrial practice, brainstorming as an idea generation method is widely acknowledged as an important concept development tool (Seaker and Waller, 1996). Brainstorming is particularly important to the manufacturing sector, and researchers in this field have noted that firms tend to perform better when employees are given an opportunity to articulate their ideas and concerns (Seaker and Waller, 1996).

With respect to the field of off-site construction, thus far there appears to be very limited reporting on the use of brainstorming as a data collection technique. Nonetheless, there are arguably important similarities between manufacturing and off-site construction sectors which would suggest brainstorming would be a useful investigation technique for off-site construction.

Here, in order to better address the third research question, namely, "Identify the factors affecting the productivity of off-site construction industry (prefabrication processes and the like) through operational management tools and techniques" and the sixth research question "Seek to improve future productivity of the off-site construction industry through validation and application of operational management tools and techniques" a brainstorming session was organised with participants from Company C.

3.6.2.1 Participants

Participants from Company C were recruited to participate in a two-hour brainstorming session with the aim to answer the questions relating to factors relevant to production delay and adverse effect on quality. The session was conducted in person, and Hender et al.'s (2001) three step process was used to draw more sophisticated and interconnected responses.

As part of the task, the participants were de-briefed about the purpose of the activity and each agreed to convene in a meeting room at the company's premises and were asked to list causes and sub-causes of poor productivity and quality defects in their respective sectors. The causes and sub-causes that were elicited were then recorded and placed into categories with the goal to support the design of a cause and effect diagram, namely, a fishbone diagram.

Productivity delay participants:

1. Factory 1 Production Manager (7 years experience)
2. Factory 2 Production Manager (5 years experience)
3. Production Supervisor (6 years experience)
4. Production Engineer (10 years experience)
5. Production Engineer (3 years experience)
6. Production Forman (4 years experience)
7. Production Forman (6 years experience)

Quality defects participant:

1. Quality Manger (13 years experience)
2. Quality Consultant (15 years experience)
3. Quality Specialist (9 years experience)
4. Quality Engineer (7 years experience)

5. Quality Inspector (4 years experience)
6. Quality Inspector (2 years experience)
7. Production Efficiency Monitoring and Production Coordinator (3 years experience)
8. Quality Inspector (3 years experience)

3.6.3 Operational tools and techniques - cause and effect diagram

Cause and effects diagrams, also known as Ishikawa diagrams, or fishbone diagrams, are another important operational management tool (Ishikawa, 1982; Majid and McCaffer, 1998). Cause and effect diagrams are often developed in conjunction with brainstorming and are essentially a type of root cause analysis (Doggett, 2005).

An important principle of cause and effect diagrams is that not only should primary causes of phenomena be articulated, but also the secondary causes, that is, those situations or conditions that underpin the dominant causes should be considered and included (Fey et al. 1994).

Ishikawa (1982) reports that the development of a cause and effect diagram is a five-step process. Firstly, the problem needs to be determined. It should be an issue that can be improved or controlled. Secondly, the developer should write the problem on the right side of the of the page, and then draw a straight arrow moving left to right. The next step is to identify the main factors. These are known as the primary causal factors. There will typically be four to seven of these major factors. These can be thought of as the "branches" of the diagram (Doggett, 2005). The next step is for the detailed casual factors to be listed. These can be thought of as the "twigs" of the diagram (Doggett, 2005). Even more detailed "twigs" can be added to the diagram. Finally, the fifth step is to make sure that no factors have been omitted from the diagram. This final step is arguably the most critical part of the activity in terms of ensuring validity and reliability of the findings.

Cause and effect diagrams are typically used to identify factors that hinder productivity in the manufacture and construction sectors (Majid and McCaffer, 1998). In this study, it was believed that the development of a cause and effect diagram set based on responses from 15 middle and senior management at Company C (group of 7 participate brainstorming on productivity delay and group of 8 participate brainstorming on quality defect) would provide insight into specific factors and the relationship between those factors relevant to productivity at the setting. It was believed that firsthand data would need to be gathered in this regard in order to compliment or contrast with findings from the literature. Moreover, it was also believed that a visual representation of factors relevant to productivity would enable the researcher to obtain a richer understanding of potential issues and to re-consider potential inter-concept connections.

Thus, the responses from brainstorming session were used to create two cause and effect diagrams. The researcher relied on the responses from the participants that identified factors as well as those responses that suggested connections between factors. The first diagram represented factors related to productivity delay from the perspective of the participants. The second represented factors relevant to quality defects from the perspective of the participants. These diagrams are presented in the result section 4.6.

3.6.4 Operational tool and techniques - statistical process control

Control charts are one of the seven basic tools of quality. Control charts play an important role in investigations of manufacturing or business process. Specifically, the purpose of using control charts as part of statistical process control is to distinguish and eliminate special causes of variation in the production activity. These charts are also referred to as process-behaviour charts, or Shewhart (also spelt Schewart) charts named after their founder a leading philosopher in the field of variation and control (Wilcox, 2003). Shewart believed that any prediction must be tied into control. He stated

" a phenomenon will be said to be in control when, through the use of past experience, we can predict, at least within limits, how the phenomenon may be expected to vary in the future. Here it is understood that the prediction within limits means that we can state, at least approximately, the probability that the observed phenomenon will fall within given limits…" (Shewhart, 1931:6, cited in Wilcox, 2003)

The basic Shewhart control chart for monitoring the mean of a process is reliant on a centre line which is derived from the historical process level. The Shewhart analysis of individual measurements assumes that the observations follow a normal distribution (Montgomery, 2009). Lower and upper control limits are also determined (Woodall and Montgomery, 1999). The means of the sample are plotted over time. When a signal is recorded that is falls out of the control limits, it is said to be out-of-control. The typical control limits are most often set at ± 3 sigma from the centre line.

Shewart proposed the fundamentals of statistical process control in the 1920s. Despite certain advances, these fundamentals, or principles, remained largely unchanged until the 1980s when increased global competitiveness meant that many industries needed to vastly improve quality and productivity in order to remain competitive. More recently, statistical process control has become highly sophisticated. In some industries production data is available for every second concerning hundreds of factors (Woodall and Montgomery, 1999).

Statistical process control is an important branch of industrial statistics. Statistical process control is used to monitor production processes longitudinally, that is, over time, in order to detect changes in the production performance (Woodall and Montgomery, 1999). Statistical process control can also be used to investigate combination of factors that tend to lead to higher production yields. Statistical process control is also reported to be a versatile method for measuring production at different stages of production process (Woodall and Montgomery, 1999).

Here, in order to address the fifth and sixth research objectives, quantitative data was gathered for a period of two months from Company B and Company C. These two case studies were performed in off-site construction (productivity) to measure empirically the current labour productivity of the off-site construction by implementing statistical quality control. Specifically, data of labour productivity were collected from two companies through December 1, 2012 to January 31, 2013. Two types of labour productivity data were collected: actual manpower deployed (total hours) and volume M3. The labour productivity data were collected under 4 different sections in each company: Hollow core slabs (HCS), circulation tables, structural element, and panel element.

3.6.5 Document analysis

Document analysis is also a common technique used in case studies. Documents refer to agendas, emails, letters, memorandums, performance reports, study reports and/or any other record(s) of information that can be used to provide or support a particular indication of the events in a particular setting (Yin, 1994).

Data from document analysis can be particularly useful for the purposes of corroborating other evidence related to a phenomenon (Yin, 2003). This is because this type of information is usually helpful in providing answers to questions that other research methods may not be able to answer conclusively (Bryman, 2004). Documents obtained as part of a document analysis also should be included and considered as part of the research method. For example, they should be used to shape research objectives and their assertions used to enhance the validity of the empirical findings of the study (Morse and Richards, 2002).

However, document analysis should be conducted with caution. There is a potential for over-reliance on particular documents as evidence of the truth in a given setting (Yin, 1994).This may be particularly true when the authors of the particular records are not available practically to verify the contents of such records. Thus, many scholars recommend that such documents are used inductively and to inform on the reality of the case under investigation.

In this study, the primary record documents collected were labour productivity reports. These reports of labour productivity were collected from Company B and C through

December 1, 2012 to January 31, 2013. Two types of labour productivity data were collected: actual manpower deployed (total hours) and volume M3. The labour productivity data were collected under 4 different sections in each company: Hollow core slabs (HCS), circulation tables, structural element, and panel element.

3.7 Data Analysis

Data was entered and analysed (using SPSS version 21.0 and SAS version 9.3). In this study, the data-set was subjected to Two-sample t-tests, Pearson product-moment correlation, and Relative Importance Index.

3.7.1 Two-sample t-test

To address the first objective, *to investigate and compare the current usage of employee empowerment and in terms of its relative importance to labour productivity between two off-site companies,* data from the semi-structured interviews was assessed and compared through calculating the mean score for each of the factors in order to determine the perceived relative usage of Nesan's nine employee empowerment factors in the two settings.

Two-sample t-test was used. The two-sample t-test is one of the most commonly applied hypothesis tests. The test is generally applied to determine whether an observed difference between two groups is due to random chance or whether it is indeed statistically significant (Lumley, Diehr, Emerson, and Chen, 2002). The equation is shown following.

$$t = \frac{\bar{y}_1 - \bar{y}_2}{s_p(\frac{1}{n_1} + \frac{1}{n_2})^{1/2}}$$

where $\bar{y}_1$is the sample mean of the observations in the first group, $\bar{y}_2$is the sample mean of the observations in the second group,$n_1$is the sample size for the first group, $n_2$is the sample size for the second group,and s_p is the pooled estimate of the common standard deviation,

$$s_p = (\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2})^{\frac{1}{2}}$$

A p-value less than 0.05 indicates a difference of statistical significance. Here, two-sample t-test was employed to determine if the difference in the mean scores for each of the employee empowerment factors between the two companies was statistically significant.

As the number of questions asked for each employee empowerment factor was not the same, to make the relative current usage of each factor comparable for the nine employee empowerment factors, the mean score was calculated by summing the responses of the corresponding interview questions and then dividing by the number of corresponding questions. Thus, the mean score of each employee empowerment factor represents the relative current usage of the factor.

The study also employed a two-sample t-test to determine whether or not the relative importance of employee empowerment to labour productivity is significantly different between the two companies. The normality assumption of the t-test was examined. In the present sample, the skewness was found to be <1 for all measures except for the factor 'Importance of Empowerment for Productivity', which produced a skewness of –1.2. Thus, the data satisfied the normality assumption, validating the use of the two-sample t-test (Fife-Schaw, 2007).

3.7.2 Pearson's product-moment correlation

To address the second objective, *investigate the relationship between labour productivity and employee empowerment*, data from the semi-structured interviews was assessed. The analysis examined the correlation between ratings of the current usage of each employee empowerment factor (e.g., 'Leadership'), and the rating of the importance of that factor for productivity (e.g., 'Importance of Leadership for Productivity'). Pearson's product-moment correlation was used to measure the strength and direction of the relationship. The formula for the sample Pearson's product-moment correlation is

$$r_{xy} = \frac{\sum_i((x_i - \bar{x})(y_i - \bar{y}))}{\sqrt{\sum_i(x_i - \bar{x})^2 \sum_i(y_i - \bar{y})^2}}$$

Where $\bar{x}$ is the sample mean for x and $\bar{y}$ is the sample mean for y.

Normality assumption was examined in the section 3.7.1.

This stage of the analysis again sought to investigate the relationship between labour productivity and employee empowerment. The analysis examined the correlation between ratings of the current usage of each employee empowerment factor (e.g., 'Leadership'), and the rating of the importance of that factor for productivity (e.g., 'Importance of Leadership for Productivity'). Pearson's product-moment correlation. Visual inspection of scatterplots of the joint distributions was used to ensure none of paired variables exhibited a nonlinear relationship.

Pearson's product-moment correlation was also used to assist addressing the fourth objective, *empirically examine the relationship between the perceived relative usage of Nesan's nine employee empowerment factors and the 43 productivity factors used in Enshassi et al. (2007).* Again, data from the semi-structured interviews was assessed. The analysis examined the relationship between the current usage of each employee empowerment factor (e.g., 'Leadership'), and the rating of the importance of each of the 43 factors negatively affecting labour productivity. Pearson's product-moment correlation was again used to measure the strength and direction of the relationship.

3.7.3 Relative importance index analysis

To address the third objective, *identify the factors affecting the productivity of off-site construction industry,* data from the semi-structured interviews was assessed. This analysis was aimed to identify and assess factors relevant to productivity with respect to off-site construction. This involved using a schedule of 43 factors based on early studies in the construction labour productivity field primarily Enshassi et al. (2007). Responses from 36 participants at the three companies were evaluated and using a relative importance index analysis, the importance of factors negatively affecting the productivity of off-site construction in these settings was identified. For each group of factors, an importance index as suggested by Enshassi et al. (2007) and Lim & Alum (1995) was computed. The importance index was computed as follows (Enshassi et al., 2007; Lim & Alum, 1995):

$$\text{Importance index} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5(n_5 + n_4 + n_3 + n_2 + n_1)} * 100$$

where n_1= number of participants who answered “not at all important”, n_2= number of participants who answered “not very important”, n_3= number of participants who answered “somewhat important”, n_4= number of participants who answered “very important”, and n_5= number of participants who answered “extremely important”.

The importance index for all 43 factors was calculated. The group index was calculated by taking the average of factors in each group. The calculation of the importance index was done for each case study (company) independently and for the overall situation (combined the three case-studies). The importance index measures the relative importance of a factor (or a group of factors) to labour productivity. The higher the importance index, the higher degree of importance the factor/group was to labour productivity. The upper bound of the Importance index is 100.

In this study, 43 factors negatively affecting labour productivity in off-site construction have been identified and ranked according to their relative importance. The analysis was performed for each case study (company) independently and for the overall situation (combined the three case-studies).

3.7.4 Statistical process control

To address the fifth objective, *measure empirically the current productivity of off-site construction industry fabrication methods with application of operational management tools and techniques*, and sixth objective, *seek to improve future productivity of the off-site construction industry through validation and application of operational management tools and techniques*, data from the document analysis was used. Industrial statistics were gathered and used to measure the productivity at two off-site construction companies. Specifically information concerning the companies' daily production of four different construction elements was analysed.

Using total hours per employee as the input and volume as the output, the daily productivity rate was determined and presented using statistical process control. In this study, in order to determine if the production process was in statistical control, the Shewhart control chart was used for individual and moving-range control measurements. Note that in this study, the moving range (MR) was defined as

$$R_i = |x_i - x_{i-1}|$$

Note that xi is the ith observation.

The moving range of two successive observations was used as the basis of estimating the process variability. As mentioned, lower and upper control limits are determined (Woodall and Montgomery, 1999).

For both the Shewhart control chart and the moving range control chart, the lower control limit (LCL) and the upper control limit (UCL) were calculated as follows:

Moving range control chart: $\text{LCL} = 0$ and $\text{UCL} = \text{D}\bar{R}$

Shewhart control chart: $\text{LCL} = \bar{x} - k\frac{\bar{R}}{d}$ and $\text{UCL} = \bar{x} + k\frac{\bar{R}}{d}$

Note that $\bar{R}$ is the average of the moving ranges. D = 3.267 (Appendix VI, Montgomery (1991)) for the use of moving range of two successive observations. $\bar{x}$ is the average of the observations. d=1.128 (Appendix VI, Montgomery (1991)) for the use of moving range of two successive observations. k = 3 reflects the use of three-sigma control limits (Montgomery, 2009).

For some time in statistics, it has been suggested that one should conclude that the process is out of control if one point plots outside the three-sigma control limits (Western Electric Handbook, 1956). If the sample values fell within the control limits and do not exhibit any systematic pattern, then we conclude that the process was in control at the level indicated by the chart. A search for an assignable cause should be made and corrective action should be taken if necessary. Here, the purpose of statistical process control was to distinguish and eliminate special causes of variation in the production activity (Western Electric Handbook, 1956).

As mentioned, the Shewhart analysis of individual measurements assumes that the observations follow a normal distribution (Montgomery, 2009). The normality assumption was checked through skewness, kurtosis, and the Shapiro-Wilk test of normality ($p < 0.05$ indicates the data were not from a normal distribution). Skewness and kurtosis indicate how the sampling distribution is like comparing to the normal distribution. Negative skewness means that more data points lie to the right of the mean, and positive skewness means more data points lie to the left of the mean.

The interpretation of kurtosis is as follows: negative kurtosis suggests that the distribution is flatter than the normal distribution, and positive kurtosis suggests that the distribution is taller (more peaked) than the normal distribution.

Exponentially weighted moving average (EWMA) control chart is another statistical process control method. This method is reported to improve sensitivity to smaller shifts from the mean (Lucas and Saccucci, 1990). It is also said to be a method more suitable for the collation of information over time (Woodall and Montgomery, 1999). As pointed out by Montgomery (1991), the Shewhart analysis of individual measurements is very sensitive to the normality assumption. As such, the EWMA control chart (Montgomery,

2009) was also created as an alternative to the Shewhart control chart. EWMA is reported as robust against no-normality (Montgomery, 2009).

The EWMA is defined as

$$z_i = \lambda x_i + (1 - \lambda) z_{i-1}$$

Note that z_0=¯x and λ is a weight parameter, ranging from 0 to 1. Following the same notation of Montgomery (1991), for the EWMA control chart, LCL and UCL were calculated as follows.

$$\mathrm{LCL} = z_0 - L\sigma \sqrt{\frac{\lambda}{2-\lambda}((1-\lambda)^{2i})} \text{and } \mathrm{UCL} = z_0 + L\sigma \sqrt{\frac{\lambda}{2-\lambda}((1-\lambda)^{2i})}$$

Note that L is the width of the control limits, σ is the standard deviation of the sample variable, and λ is a weight parameter, ranging from 0 to 1. L and λ were determined based on the average run length (ARL). "The ARL is the average number of points that must be plotted before a point indicates an out-of-control condition" (Montgomery, 2009).

In this study, L = 3 and λ=0.3. The combination of L = 3 and λ=0.3 yields an in-control ARL of 465.65 (An in-control ARL is the ARL of the chart when the process is in control. In other words, an in-control ARL = 465.65 means that the false alarm occurs on average once every 465.65 observations) and an ARL of 11.70 for detecting a shift of one standard deviation in the process mean.

Autocorrelation of the series up to 1 lag, aka, the 1st order autocorrelation or the autocorrelation coefficient at lag k, was calculated. Wheeler (1991) argued that the usual control limits are contaminated "only when the autocorrelation becomes excessive (say 0.80 or larger)." Thus, if the autocorrelation was less than 0.7, we adopted Wheeler's suggestion that "one need not be overly concerned about the effects of autocorrelation upon the control chart."

If the autocorrelation was greater than or equal to 0.7, we adopted the method proposed by Alwan and Roberts (1988) by removing autocorrelation from the data and constructing an EWMA chart for the residuals (Wheeler, 1991).

3.7.5 Qualitative data analysis

Data analysis of qualitative data typically involves reduction of the data, display of the data, and conclusion drawing and verification. Data reduction is the first process and involves finding themes, clustering ideas, and creating data summaries. Data display is the second process. This involves the organisation and assembling of the data in such a way as the study can be further guided and conclusions pertaining to the research questions can be drawn. Finally, conclusion drawing involves the interpretation of the data in light of other information/knowledge available to the researcher (Huberman and Miles, 1998). In this study, the data generated from the semi-structured interviews was quantitatively analysed as mentioned previously but responses of participants were also analysed for their qualitative value. The process of brainstorming also provided data of a qualitative nature which was able to be analysed, as did the overall case study process.

3.8 Research quality

3.8.1 Validity

Validity is a research characteristic which refers to the extent that data collected provides a 'true' picture of the phenomenon being studied (McNeill and Chapman, 2005). The validity of data will often be determined by analysing the ability of the instrument used to measure what it purports to measure. Validity can also be established through reviewing logic evidence related to the phenomena (Fellows and Liu, 2003). Validity is usually evaluated in terms of three separate tests, the test of construct validity, the test of internal validity, and the test of external validity.

3.8.1.1 Construct validity

Construct validity refers to the extent that the researcher has ensured that the "correct operational measures for the concepts being studied" have been established through the research design (Kidder and Judd, 1986). One of the most commonly applied measures to ensure construct validity is triangulation. Denzin (1978) wrote at length on triangulation methods; he defined the activity as "the combination of methodologies in the study of the same phenomena." Denzin (1978) articulated that triangulation could occur through evaluating two or more different data sets, investigators, theories, and/or methods. Denzin (1978) referred to within-methods triangulation, namely, the use of either qualitative or quantitative data collection, and between-mehtods triangulation, namely, the use of both qualitative and quantitative data collection. Triangulation has been recognised as a major safeguard of data validity (Padgett, 2008).

A review of the literature on construction labour productivity was conducted in an attempt to better ensure the construct validity. Furthermore, both within-method and between-method triangulation was used to enhance data validity.

3.8.1.2 Internal validity

Internal validity refers to the extent that the establishment of certain condition can be shown to lead to other conditions in a causal relationship (Kidder and Judd, 1986). It has been defined more notably by Lincoln and Guba (1994) who refer to the concept as "the extent to which variations in an outcome (dependent) variable can be attributed to controlled variation in an independent variable".

More comprehensive definitions have been provided by more recent researchers. For example, internal validity has been linked with the extent that the study was rigorous and the extent that alternative hypotheses, i.e. alternative explanations for causal relationships encountered (Mitchell and Jolley, 2007). Here, cause/effect modelling will be used as an action to attempt to enhance internal validity.

3.8.1.3 External validity

External validity refers to the generalizability of the findings of a study. As Cook and Campbell (1979) noted external validation is “The approximate validity with which we infer that the presumed causal relationship can begeneralized to and across alternate measures of the cause and effect and across different types of persons, settings, and times”.

Here, the research methodology and limitations are described in depth as at attempt to enhance external validity. Falsification will also be used to test generalizations made in the discussion (Flyvbjerg, 2006). This approach involves comparing cases of data. Flyvbjerg (2006) noted "If just one observation does not fit with the proposition, it is considered not valid generally and must therefore be either revised or rejected."

3.8.1.4 Content validity

Content validity refers to whether the appearance of the research instrument appears to experts to be able to measure what it purports to measure (Sireci, 1998). Here, the content validity of the instrument was verified with five experts (two academic staff and three General Managers in the field of off-site construction).

As part of this study, it was restated that one of the main objective of this study is to investigate the relationship between employee empowerment and labour productivity.

3.8.2 Reliability

3.8.2.1 Cronbach 's Alpha Reliability Test

Reliability refers to the extent that a research technique can be repeated and obtain the same or very similar results (Kvale, 2007; Sproull, 2002). Some researchers, such as, Fellow and Liu (2003) distinguish external reliability from internal reliability. The former refers to the effect that time has or may have on the results of a study whereas the latter refers to the extent that each scale of items is measuring a single variable.

Internal reliability is also referred to as internal consistency. Scale reliability analysis is generally carried out as part of tests of internal consistency (Peterson, 1994). And as part of this, Cronbach alpha is a commonly applied test for internal consistency. The Cronbach alpha is calculated as a function of the number of test items and the average inter-correlation among the items.

This is shown in the following equation

$$\alpha=n/(1+(n-1)r) \qquad \text{(Cronbach, 1951)}$$

where α is the Cronbach's Alpha, n equals the number of items, and r represents the average inter-item covariance among the items. The calculation will give a coefficient value with values closer to 1 indicating a higher internal consistency.

Notwithstanding the near universal application of the Cronbach alpha in this regard there is considerable controversy concerning the magnitude of the acceptable reliability coefficient alpha (Peterson, 1994). For example, scores of 0.8 or greater are widely accepted in most schools of social research. However, lower cut-offs including 0.7, 0.6 and even 0.5 are also considered acceptable depending on the nature of the research interest and aims of the study (Rungasamy et al. 2002; Hadely et al. 2007). For example, for phenomena were there may be multiple relevant factors, or for an exploratory study a lower reliability coefficient may be acceptable.

Here, Cronbach's coefficient alpha was used to determine the internal consistency of items under each of the factors in the three sections.

3.9 Chapter summary

This chapter has provided an explanation of the research design. The chapter first introduces the research objectives and general mixed methods strategy. The chapter describes the purpose and process of a four-part literature review aimed at providing a comprehensive survey of what researchers have already done with respect to employee empowerment and factors of productivity particular in relation to construction generally and off-site construction specifically.

After dealing with the secondary research component of the method, the chapter then describes the primary data collection and data analysis, concerning semi-structured interviews, and the application of three operational management techniques. The chapter comments on the role and application of two-sample t-tests, Pearson's product-moment coefficient, relative importance index analysis, statistical process control analysis and the qualitative data analysis techniques applied.

The chapter also address research quality through an explanation of the techniques used to minimise threats to the validity and reliability of the study.

The following chapter, Results and Discussion, provides the outcomes of the data collection and data analysis technique conducted as part of this study. The chapter also provides some interpretation of the outcomes of this study in relation to the research objectives.

CHAPTER FOUR - RESULTS AND DISCUSSION

4.1 Introduction to results and discussion

The previous chapter, Research Methodology, provided an explanation of the research methodology. This chapter presents the results of the data collection and analysis activities, and provides a discussion of these results as they may be relevant to the research objectives. The chapter first provides the results of an assessment of employee empowerment factors in terms of its perceived relative usage to the organisations investigated and in terms of its relative importance to labour productivity. This is followed by results to the exploratory analysis of ranking of employee empowerment factors and its importance ratings for productivity.

The chapter then provides the results of the assessment of the relationship between employee empowerment and its relative importance to labour productivity, specifically through a correlation of current usage of employee empowerment factors 'scale Average" and its relative importance to labour productivity "Importance" ratings. In addition to the results mentioned, the chapter also provides and describes the results from an investigation of labour productivity factors and the relationship between employee empowerment and these factors. The chapter discusses the extent that aforementioned results support, or do not support, key themes in the construction labour productivity literature.

Finally, the chapter provides the results of statistical process control assessments of productivity rate in two settings.

4.2 Employee empowerment factors, perceived relative usage, and relative importance to labour productivity

Reliability of the instrument was tested. Table 4.1 shows the Cronbach's alpha for each relative usage of employee empowerment factor. The alpha ranges from 0.51 to 0.83 indicating the reliability of the instrument as acceptable (the reliability of the instrument is acceptable according to Nunnally (1978) and (Rungasamy et al. 2002; Hadely et al. 2007).

Table 4.1: Cronbach's alpha

Relative usage of employee empowerment factor	# of items	Cronbach's alpha
Leadership	4	0.57
Empowerment system	4	0.51
Resources development	3	0.65
Involvement	4	0.65
Education/training	7	0.76
Teamwork	6	0.80
Process improvement	9	0.83
Measurement	3	0.59
Recognition	2	0.54

The objective here was to assess the employee empowerment factors in terms of its perceived relative usage to the organisations investigated and in terms of its relative importance to labour productivity. The two-sample t-test was employed to investigate if there was a difference in the mean scores on each of the employee empowerment factors between the two companies. The two-sample t-test was also employed to determine if the relative importance of employee empowerment to labour productivity is statistically significantly different between the two companies. In the present sample, the skewness was found to be <1 for all measures except for the factor "Importance of Empowerment for Productivity", which produced a skewness of –1.2. Thus, the data satisfied the normality assumption, validating the use of the two-sample t-test (Fife-Schaw, 2007).

The following table, Table 4.2, shows the analysis results of the two sample t-tests for the comparison of relative current usage of employee empowerment factors and its relative importance to labour productivity between company A and company B.

Table 4.2 Comparison of relative current usage of employee empowerment factors, in terms of its relative importance to labour productivity between the two companies

	Company	Mean	Std. Dev.	t	p
Importance of Leadership for Productivity	A	3.923	0.760	.801	.432
	B	3.600	1.174		
Leadership Average	A	3.250	0.707	-.692	.497
	B	3.475	0.854		
Importance of Empowerment for Productivity	A	3.769	0.725	.563	.579
	B	3.600	0.699		
Empowerment System Average	A	3.423	0.766	-1.554	.135
	B	3.950	0.856		
Importance of Resource Development for Productivity	A	3.154	0.987	-2.741	.012*
	B	4.200	0.789		
Resource Development Average	A	3.128	0.764	-3.640	.002*
	B	4.333	0.816		
Importance of Involvement for Productivity	A	3.154	1.345	-1.415	.172
	B	3.850	0.883		
Involvement Average	A	2.615	0.939	-2.592	.017*
	B	3.675	1.014		
Importance of Education and Training for Productivity	A	3.000	1.633	.372	.714
	B	2.800	0.919		
Education Training Average	A	1.879	0.559	-1.077	.301
	B	2.271	1.042		
Importance of Team Work for Productivity	A	4.000	1.080	.965	.346
	B	3.600	0.843		
Team Work Average	A	3.410	0.959	-1.814	.084
	B	4.050	0.643		
Importance of Process Improvement for Productivity	A	3.077	1.188	-.300	.767
	B	3.200	0.587		
Process Improvement Average	A	2.915	0.984	-1.272	.217
	B	3.389	0.737		
Importance of Measurement for Productivity	A	3.692	1.109	.454	.654
	B	3.500	0.850		
Measurement Average	A	3.026	0.763	-2.675	.014*
	B	3.833	0.653		
Importance of Recognition for Productivity	A	2.538	1.198	.083	.935
	B	2.500	0.972		
Recognition Average	A	2.038	0.691	-.474	.643
	B	2.250	1.275		

Note: Company A: n = 13; Company B: n = 10. * indicates significance at the 0.05 level.

The results of assessing the employee empowerment factors in terms of its perceived relative usage to the organisations investigated shows that statistically significant differences on the relative usage of the employee empowerment were found between the two companies. Differences are discussed in the following section.

4.2.1 Statistically significant differences

4.2.1.1 "Resource Development”

The first statistically significant difference on the usage of employee empowerment factors between the companies was for "Importance of Resource Development for Productivity" ($t = 2.741$; $p = 0.012$), and "Resource Development Average" ($t = –3.640$; $p = 0.002$).

Company B possessed significantly more material resources than Company A.
In detail, Company A was experiencing financial problems, causing a three-month delay in paying employees' wages, in addition to material shortages. Discussion during the interview with one of the managers from Company A revealed that company was ownership involved two countries; the economy of one country had collapsed (potentially as a result of the GFC in 2008) and had withdrawn financial support. During that same period the other country had bought the remaining market share, and Company A was now owned by one country.

In addition, both Companies A and B had access to limited human resources due to low potential employee numbers together with ongoing absenteeism of their current employees. For example, at one point 22 workers from Company A went absent on a single day because of the delays to their wage payment. In another example, Company B allowed its employees to be released (they were free to leave the company) and, as a result, around 200 employees had left the company in the previous four months.

4.2.1.2 "Involvement"

The second statistically significant difference on the usage of employee empowerment factors between the companies was for "Involvement" ($t = -2.592; p = 0.017$).

This was because Company B is an ISO-9000 certified company with clear job descriptions for each employee, and the extent of "Involvement" was higher at foreman level than in Company A because his knowledge level was higher than his equivalent in Company A.

The extent of "Involvement" of both companies at lower worker levels was poor, especially in Company A where the level was below that in Company B. However, no significant differences were found between the companies in their rating of the "Importance of Involvement for Productivity" category, because both managers was involved in most of the decision-making, even at lower levels, in order to achieve the daily productivity target.

4.2.1.3 "Measurement"

The third statistically significant difference on the usage of employee empowerment factors between the companies was found in the "measurement" ($t = -2.675; p = 0.014$).

This was for two reasons: Company B had significantly higher scores than Company A because it had introduced a system of quarterly evaluations for its employees whereas Company A did not. Also Company B employed a quality control manager on each production line, making measurement checking and approval very simple and accurate, while Company A had only three quality control managers; however, no significant differences were found between the companies in rating the "Importance of Measurement for Productivity" category. This was because Company A had an online system which allowed each constructed element to be tracked from the early design stage until the element was ready for delivery. This allowed Company A to resolve any problems with any element more easily and quickly than Company B, especially in aspects of measurement.

Although Company B did not have a comparable online system, as mentioned above they employed quality control managers at every stage of each production line.

No significant differences were found between the companies in any of the other employee empowerment factors. Specifically, no significant differences were found for the factors of "Leadership", "Empowerment", "Education and Training", "Teamwork", "Process Improvement" or "Recognition".

Firstly, regarding the "Leadership" factor, at top management the managers in both companies had at least a Master's degree and a minimum of seven years' experience in off-site construction, and a very high knowledge level.

Secondly, for "Education and Training", top management in both companies supported or believed in onsite job training rather than special programs for their employees. Both companies adopted similar policies regarding "Empowerment", "Teamwork", "Process Improvement" and "Recognition".

4.2.2 Employee empowerment factors, ranking and importance for productivity

Any employee empowerment factor rated as very important for productivity should also preferably be rated as being the most important characteristic of the organisation, so exploratory analyses were carried out to explore the extent to which this was the case.

Tables 4.3 and 4.4 below show: the mean ratings of perceived current usage of employee empowerment factors; and, the importance of these factors for productivity for the two companies, ranked from highest to lowest.

Table 4.3 Company A: Ranked level of current usage of employee empowerment factors and their importance to productivity

Usage of Employee Empowerment Factor	Mean
Empowerment System	3.423
Team Work	3.410
Leadership	3.250
Resource Development	3.128
Measurement	3.026
Process Improvement	2.915
Involvement	2.615
Recognition	2.038
Education and Training	1.879

Importance of Employee Empowerment Factor	Mean
Importance of Team Work for Productivity	4.000
Importance of Leadership for Productivity	3.923
Importance of Empowerment for Productivity	3.769
Importance of Measurement for Productivity	3.692
Importance of Resource Development for Productivity	3.154
Importance of Involvement for Productivity	3.154
Importance of Process Improvement for Productivity	3.077
Importance of Education and Training for Productivity	3.000
Importance of Recognition for Productivity	2.538

Table 4.4 Company B: Ranked level of current usage of employee empowerment factors and their importance for productivity

Usage of Employee Empowerment Factor	Mean
Resource Development Average	4.333
Team Work Average	4.050
Empowerment System Average	3.950
Measurement Average	3.833
Involvement Average	3.675
Leadership Average	3.475
Process Improvement Average	3.389
Education and Training Average	2.271
Recognition Average	2.250
Importance of Employee Empowerment Factor	**Mean**
Importance of Resource Development for Productivity	4.200
Importance of Involvement for Productivity	3.850
Importance of Leadership for Productivity	3.600
Importance of Empowerment for Productivity	3.600
Importance of Team Work for Productivity	3.600
Importance of Measurement for Productivity	3.500
Importance of Process Improvement for Productivity	3.200
Importance of Education and Training for Productivity	2.800
Importance of Recognition for Productivity	2.500

In Company A, the factors rated as being the most important for productivity were also rated as being the most important characteristic of the company: namely "Team Work", "Leadership" and "Empowerment". In Company B, some discrepancy between the ratings of the importance of the employee empowerment factors to the organisation and its relative effects on labour productivity were found. The two factors with the highest importance ratings were "Resource Development" and "Involvement". While "Resource Development" was the most highly rated as a characteristic of Company B, "Involvement" received a relatively low rating.

This pattern raised the question of whether Involvement was as highly emphasised and practised in Company B as the ratings of importance suggest it should be. The answer to this was that involvement at lower levels of the company was very low, but the foreman of Company B was involved in most decisions, whereas in Company A only the line manager had the power to make decisions, and the foreman was not involved.

One of the lowest-ranking factors in both companies was the "Recognition" factor, as seen in Tables 4.3 and 4.4. Most of the interviewees expressed the view that very high wages, paid on time, was for them the most important recognition factor. The design manager of Company A stated that the application of a production bonus scheme for their employees had resulted in a sharp increase in production, but also in a huge number of defects that exceeded the normal daily work load of the repair department.

The second-lowest-ranking factor in both companies was "Education and Training". Both companies at top management level supported on-the-job training rather than special programs for their employees, arguing that training programs interrupted production work. Also, neither company funded education nor training to any significant extent; for example, a production line manager at Company A said that their employees were being trained every day as they worked, and new workers are trained on the job by experienced workers.

However, onsite job training in both companies may be criticised for several reasons: firstly, a production line manager in Company A had found that effective daily training was not possible for new workers with a poor understanding of English; secondly, the quality control manager at company B said that language difficulties together with inexperience at the lower job levels severely impeded communication between managers and workers, and among workers. Both companies had employees from at least 14 different countries. Such an array of nationalities resulted in poor communication within the labour force. Challenges included language difficulties and cultural misunderstandings caused by different ways of thinking.

However, the manager of the continuous improvement department in Company B argued that lower-level workers were cheap, with very limited knowledge and experience. With that attitude prevailing, education and training at the lower levels of the workforce in either company will be very difficult to achieve.

In the case of Company A, language and communication difficulties occur at production level. When interviewed, the production line manager for the structural section dealing with P. Stress, Double-T and Columns lines at Company A, said:
"*I have a medium level of communication between my subordinate because he speaks Arabic and the East Asian worker speaks a little Arabic. The production line manager(s) for the Panel section is European. They speak only English & 2 European languages; accents are difficult to understand, with problems communicating with East Asian workers. The safety manager is European too, with similar difficulties. He tries to figure out the problem regarding safety to make sure the production line is safe. He put signs [pictures & written text] in each workstation in 3 languages – Arabic, English & East Asian. Safety manager's surprised to find 40% of workers at the lower level cannot understand the written language; [they lack] knowledge of their language*."

This was followed by an interview with the repair department manager, who was from the same East Asian country as the workers in his section. He spoke a language that most of his subordinates also spoke as either their first or second language, and consequently he had no difficulty in fully communicating with his lower-level workers.

As a result, the factory was still operating well because most of the foremen were East Asian and could communicate very well with their subordinates. Because their knowledge and experience were not equal to those of the line manager, some communication difficulties recurred; the problem was not critical, however, because a foreman and the line manager both speak some English. Company B, on the other hand, had fewer communication difficulties because most of its workers speak some English.

Correlation coefficients were employed to measure the strength and direction of the linear relationship between each employee empowerment factor and its rating in importance for productivity. Table 4.5 lists the results of the analyses, in order of correlation from highest to lowest.

Table 4.5 Correlation of current usage of employee empowerment factor with importance for productivity

Employee Empowerment Factor	Correlation	p
Resource Development	.786	<.001*
Involvement	.743	<.001*
Process Improvement	.707	<.001*
Recognition	.692	<.001*
Education and Training	.440	.036*
Team Work	.433	.039*
Leadership	.421	.045*
Empowerment System	.394	.063
Measurement	.362	.090

Note: n = 23. * indicates significance at the 0.05 level.

This finding supports previous research into this area which links psychological empowerment to performance (Tuuli & Rowlinson, 2009a). Several employee empowerment factors were correlated significantly ($p < 0.05$) to the ratings of their importance for productivity.

Particularly strong and significant positive correlations were found between "Resource Development" and "Importance of Resource Development for Productivity" ($r = 0.786$; $p < 0.001$), "Involvement" and "Importance of Involvement for Productivity" ($r = 0.743$; $p < 0.001$), "Process Improvement" and "Importance of Process Improvement for Productivity" ($r = 0.707$; $p < 0.001$), and "Recognition" and the "Importance of Recognition for Productivity" ($r = 0.692$; $p < 0.001$).

Significant but somewhat weaker correlations were found between "Education" and ""Training" with "Importance of Education and Training for Productivity" ($r = 0.440$; $p = 0.036$), "Teamwork" and "Importance of Teamwork for Productivity" ($r = 0.433$; p =

0.039), and "Leadership" and "Importance of Leadership for Productivity" (r = 0.421; p = 0.045).

Sample correlations between "Empowerment" and "Importance of Empowerment for Productivity" (r = 0.394; p = 0.063), and "Measurement" and "Importance of Measurement for Productivity" (r = 0.362; p = 0.090) were not statistically significant.

Variation in the "Measurement" factor resulted in Company B having significantly higher scores than Company A, as explained in the discussion of the results presented in Table 4.2. A similar result showed that "Empowerment" was not statistically significant. This may as well be due to the small variation in the data for this variable (Marin-Garcia et al., 2010). Some concern has been raised regarding the notable lack of knowledge about empowerment in organisations in general, both at the conceptual level and in practice (Seibert et al., 2004; Logan and Ganster, 2007; Huq, 2010), and the construction industry is no exception.

In the present work, most of the interview participants did not fully understand the concept of empowerment. The interviewer took the time to ensure that the participant understood the concept. Empowerment research is piecemeal and fragmented in the construction industry (Tuuli & Rowlinson, 2010b). Academic construction researchers have expressed alarm at the lack of published research on the outcome of empowerment implementation and its consequences in practice at organisational level (Sackey et al., 2011). This work begins to fill the gap.

4.2.3 Employee empowerment factors and leadership style

The results of this study are consistent with the findings of Tuuli et al. (2012), in that those managers working in areas with a greater need for interpersonal communication in the workplace tended to indicate that they favoured person-orientated leadership. More importantly, the link between this style of leadership and a higher awareness of employer empowerment was also evident from the data.

Among the 23 subjects, only two were found to have authoritarian leadership styles, while the other 21 had team-leader styles. Given the homogeneity in leadership styles, it was not possible to carry out inferential tests of statistical significance for the relationship between leadership style and employee empowerment factors in this sample. Therefore, only descriptive statistics were computed for the analysis of leadership styles and employee empowerment factors.

The means and standard deviations for the current usage of employee empowerment factors and their importance to productivity for participants with "Team Leader" and "Authoritarian" leadership styles are listed in Table 4.6 While this analysis must be regarded with caution, as there were only two subjects with "Authoritarian" styles, some suggestive trends were noted. "Authoritarians" had markedly lower ratings than "Team Leaders" for virtually all the topics tested. Overall, the authoritarian managers did not value nor see the importance of or need for most of the processes and practices that were valued by the Team Leaders.

Table 4.6 Exploratory comparison of employee empowerment factor and leadership styles

	LEADERSHIP STYLE			
Employee empowerment factor and its importance for productivity	Team Leader		Authoritarian	
	Mean	Std. Deviation	Mean	Std. Deviation
Importance of Leadership for Productivity	3.810	0.981	3.500	0.707
Leadership Average	3.429	0.734	2.500	0.707
Importance of Empowerment for Productivity	3.667	0.730	4.000	0.000
Empowerment System Average	3.738	0.820	2.750	0.000
Importance of Resource Development for Productivity	3.714	1.007	2.500	0.707
Resource Development Average	3.730	0.992	2.833	0.236
Importance of Involvement for Productivity	3.595	1.114	2.000	1.414
Involvement Average	3.190	1.037	1.875	1.237
Importance of Education and Training for Productivity	3.000	1.342	2.000	1.414
Education Training Average	2.020	0.789	2.357	1.313
Importance of Team Work for Productivity	3.952	0.921	2.500	0.707
Team Work Average	3.778	0.867	2.750	0.354
Importance of Process Improvement for Productivity	3.238	0.875	2.000	1.414
Process Improvement Average	3.217	0.836	2.111	1.257
Importance of Measurement for Productivity	3.714	0.956	2.500	0.707
Measurement Average	3.444	0.791	2.667	0.943
Importance of Recognition for Productivity	2.619	1.071	1.500	0.707
Recognition Average	2.190	0.981	1.500	0.707

Note: Sample includes 21 Team Leaders and 2 Authoritarian subjects.

4.3 Factors affecting labour productivity

In this study, as mentioned, 43 factors negatively affecting labour productivity in off-site construction were identified and ranked according to their relative importance. The factors were classified into 10 groups: materials/tools, supervision, leadership, quality, time, manpower, project, external, motivation, and safety.

The analysis was performed for each case study (company) independently and for the overall situation (combined the three case-studies). The total sample size was 36 (13 for company A, 10 for company B, and 13 for company C).

In this section, the analysis results are presented by each group of factors for each case study and for the overall situation (combined all three case-studies).

Table 4.7 shows the Cronbach's alpha for each group negatively affecting labour productivity for off-site construction. The alpha ranges from 0.53 to 0.83.

Table 4.7: Cronbach alpha. NA = not available.

	# of factors	Cronbach's alpha
Materials/Tools group	3	0.76
Supervision group	4	0.82
Leadership group	3	0.53
Quality group	3	0.65
Time group	5	0.54
Manpower group	8	0.83
Project group	4	0.53
External group	1	NA
Motivation group	6	0.62
Safety group	6	0.71

4.3.1 "Materials/Tools" factor group

The materials/tools group consists of the following 3 factors: material shortages, tool and equipment shortages, and unsuitability of materials storage location. The importance indices for factors in the materials/tools group are presented in Table 4.8. Among the three factors in the materials/tools group, both Company A and Company C have perceived "Tool and equipment shortages" as the most important factor that would negatively affect labour productivity. The importance index for "Tool and equipment shortages" was 64.62 and 73.85 for Company A and Company C, respectively. "Material shortages" also received a relative importance index (63.08) for Company A.

Company B has perceived “Material shortages” as the most important factor in the materials/tools group that would negatively affect labour productivity, with an importance index value equal to 38.

Overall, without distinguishing between the three companies, among the three factors in the materials/tools group, “Tool and equipment shortages” was considered the most important factor that would negatively affect labour productivity, with an importance index value of 57.78, followed by “Material shortages” (52.22) and “Unsuitability of materials storage location” (43.33).

4.3.1.1 Discussion

"Tools and equipment shortages" was found to be most important factor negatively affecting productivity. The results for this scale need to be understood in context. As noted, responses from participants from Company A and Company C suggested that "Tools and equipment shortages" were the most critical to overall productivity for this scale. The responses from participants suggested that there were perhaps underlying reasons for capital shortages in these settings. Specifically, respondents suggested that Company A had financial difficulties whereas respondents from Company C suggested that senior executives did not appreciate the value of capital investment.

In contrast, the responses from Company B suggested that "Material shortages" were the most important factor in this setting. Responses from this company suggested that executives valued capital investment in this regard. This is arguably further reflected by the low overall importance results for Company B (32.00) compared to Company A (56.92) and Company C (60.00) respectively. These results reflect earlier studies which found that respondents from construction operations were resources were scarce tended to indicate that lack of tools and equipment were more relevant (Olomolaiye et al. 1996).

Another interesting finding is that the results overall suggested "Material shortages" (52.22) was significantly more relevant to productivity compared to "Unsuitability of materials storage location" (43.33). This arguably reflects an important advantage off-site construction in that storage of materials plays a less significant role than it may do in conventional construction (Haas et al. 2000; Gibb and Isack, 2003).

Table 4.8: Importance indices for factors in the materials/tools group

	Company A	Company B	Company C	Overall
Material shortages	63.08	38.00	52.31	52.22
Tool and equipment shortages	64.62	28.00	73.85	57.78
Unsuitability of materials storage location	43.08	30.00	53.85	43.33
Overall	56.92	32.00	60.00	51.11

4.3.2 "Supervision" factor group

The supervision group consists of the following 4 factors: drawings and specifications alteration during execution, inspection delay, rework, and supervisors" absenteeism. The importance indices for factors in the supervision group are presented in Table 4.9. For Company A, “Drawings and specifications alteration during execution” ranked the number one factor in the supervision group that would negatively affect labour productivity (72.31).

“Rework” also received a high importance index (69.23). The other two factors, “Inspection delay” and 'supervisors" absenteeism” have received the same degree of importance to labour productivity (55.38).

Company B and Company C also gave the similar ranking for the 4 factors in the supervision group. “Drawings and specifications alteration during execution” was regarded as the most important factor that would negatively affect labour productivity 50.00 for company B and 56.92 for Company C). The second most important factor was Rework 38.00 for company B and 50.77 for Company C), followed by “Inspection delay” 28.00 for company B and 44.62 for Company C) and 'supervisors" absenteeism” 26.00 for company B and 32.31 for Company C).

Overall, without distinguishing between the three companies, among the four factors in the supervision group, “Drawings and specifications alteration during execution” was considered the most important factor that would negatively affect labor productivity, with an importance index value (60.56), followed by “Rework” (53.89), “Inspection delay” (43.89) and 'supervisors" absenteeism” (38.89).

4.3.2.1 Discussion

"Drawings and specifications alteration during execution" was a factor that was emphasised by responses from participants from the three companies. This type of factor is often found as being amongst the most important in construction productivity studies (Jarkas et al. 2012). A large part of this finding is consistent with a number of studies that have reported on the importance of design accuracy with respect to off-site construction. For example, Pan et al. (2012) found that the benefits that are attainable from using off-site production technologies are optimised when contractors are able to engage with suppliers as early as possible.

"Rework" was also found overall to be more important to the respondents, based on the suggestions from their responses, compared to other supervisory issues. This factor shares some similarities with ""Drawings and specifications alteration during execution" in that accurate instructions would be likely to contribute to higher quality production. As the studies suggest early contact and planning was found to increase business efficiency (Pan et al., 2012). This advice was supported by O'Connor, O'Brien, and Choi (2014) who, as mentioned, found that "timely freeze of scoping and design" was a critical success factor with respect to the adoption of off-site construction technologies. In other words, in the off-site construction sector, productivity appear to severely hampered by specification alterations.

Table 4.9: Importance indices for factors in the supervision group

	Company A	Company B	Company C	Overall
Drawings & specifications alteration during execution	72.31	50.00	56.92	60.56
Inspection delay	55.38	28.00	44.62	43.89
Rework	69.23	38.00	50.77	53.89
Supervisors" absenteeism	55.38	26.00	32.31	38.89
Overall	63.08	35.50	46.15	49.31

4.3.3 “Leadership" factor group

The leadership group consists of the following 3 factors: lack of labour surveillance, misunderstanding between labour and superintendents, and lack of periodic meeting with labour. The importance indices for factors in the leadership group are presented in Table 4.10. The three companies have different point of view regarding the ranking of the factors in the leadership group that would negatively affect labour productivity.

For Company A, “Misunderstanding between labour and superintendents” ranked the number one factor in the leadership group that would negatively affect labour productivity (69.23), followed by “Lack of labour surveillance” (60.00) and “Lack of periodic meeting with labour” (55.38). For Company B, “Lack of labour surveillance” ranked the number one factor that would negatively affect labour productivity (70.00), followed by “Lack of periodic meeting with labour” (54.00) and “Misunderstanding between labour and superintendents” (48.00).

For Company C, “Lack of periodic meeting with labour” ranked the number one factor in the leadership group that would negatively affect labour productivity (55.38), followed by “Lack of labour surveillance” (53.85) and “Misunderstanding between labour and superintendents” (46.15).

Overall, without distinguishing between the three companies, among the three factors in the leadership group, “Lack of labour surveillance” was considered the most important factor that would negatively affect labour productivity, with an importance index value of 60.56, followed by “Misunderstanding between labour and superintendents” and “Lack of periodic meeting with labour” (55.00 for both).

4.3.3.1 Discussion

Notably it was the "Leadership group" in which importance values overall were the most similar, and it was also this scale in which overall the responses were the highest (56.85). Also interestingly, company by company there were different leading factors. For Company A misunderstanding was the most relevant. For Company B surveillance of labour, and Company C a lack of meetings with labour. While each of these results could be analysed in relation to the context, the overall theme is that there appears to be a perception of significant communication issues between supervisors and labourers.

"Lack of labour surveillance" was found to be the most significant factor according to the respondents. The connection between surveillance and employees errors has been long alluded to in the literature (Enshassi et al. 2007). In this study, the role of labour surveillance could be particularly important given the nature of the work and constitution of the workforce. As mentioned, each of the companies from which data was collected in this study in one way or another reported a reliance on foreign workers who were predominantly unskilled or semi-skilled.

Not only is there a reliance on foreign workers but the sources of these workers is diverse. Interview responses revealed that worksites featured an amalgamation of persons from a wide range of linguistic and cultural backgrounds.

In the literature, particularly the construction labour productivity literature such as amalgamation has been referred to as a factor that can present operational issues such as misunderstanding and gaps between expectations and results (Lim and Alum, 1995; Makulsawatudom et al. 2004; Jarkas et al. 2012). For example, in the context of Singapore, Lim and Alum (1995, 53) reported that "From the list of nationalities [the authors earlier referred Malaysian, Thai, Bangladeshi, Indians, Sri Lankans, Myanmarese, South Korea, China and Taiwan] of those working on Singapore construction sites, it can be seen that different languages are spoken and it is obvious that there will be communication problems". Thus, it could be arguably that in such diverse settings labour surveillance is particularly important.

"Misunderstanding between labour and superintendents" was also found to be a significant factor most likely tied into poor communication contexts and resulting in low productivity. Makulsawatudom et al. (2004) referred to this issue in Thailand, as did Abdul Kadir et al., (2006) in Malaysia with respect to a reliance on foreign workers in those settings due to tendency for local workers to shun construction in favour of higher paid jobs and more conducive working environments in the manufacture and services sectors.

Studies in the Gulf Region, more recently, have also focused on ‘misunderstanding’ matters and more specifically productivity issues arising from poor exchange of information between site management and labour and other communication-related issues (Ailabouni et al. 2009; Jarkas, Kadri, and Younis, 2012). For example, Jarkas et al.'s (2012) study in Qatar, a setting which will be spending tens of billions of dollars on the construction of airports, hotels, hospitals, railways, seaports and stadiums as a result of being awarded the hosting rights to the FIFA 2022 World Cup, found according to representatives from the construction firms classified on the State's Central Tenders Committee that "communication between site manager[s] and labour" was still one of the top five productivity issues in the nation.

"Lack of periodic meeting with labour" was seen as another significant factor hampering productivity. It appears that respondents believe that there was a need for more formal and controlled communication opportunities with employees. Increasing communication is important. Face-to-face periodic meetings could be a way to improve productivity. Alternatively, Makulsawatudom et al. (2004), who conducted research in Thailand, found that increasing written communication was a useful means of exchanging information with employees. The authors wrote "instead of informal verbal communication, documentation such as work procedures, manuals, charts and guidelines should be used". However the authors did not elaborate on how the written materials could be brought to the attention of employees. Moreover, one limitation of relying on written instructions in some settings is that significant proportions of unskilled employees in Saudi Arabia are illiterate.

Table 4.10: Importance indices for factors in the leadership group

	Company A	Company B	Company C	Overall
Lack of labour surveillance	60.00	70.00	53.85	60.56
Misunderstanding between labour and superintendents	69.23	48.00	46.15	55.00
Lack of periodic meeting with labour	55.38	54.00	55.38	55.00
Overall	61.54	57.33	51.79	56.85

4.3.4 “Quality" factor group

The quality group consists of the following 3 factors: inefficiency of equipment, low quality of raw materials, and high quality of required work. The importance indices for factors in the quality group are presented in Table 4.11. Both Company A and Company B have regarded “High quality of required work” as the most important factor in the quality group that would negatively affect labour productivity (64.62 and 54.00 for Company A and Company B, respectively).

The second most important factor for Company A was “Inefficiency of equipment” (55.38) and for Company B, it was “Low quality of raw materials” (36.00). The least important factor was “Low quality of raw materials” (41.54) for Company A and “Inefficiency of equipment” (28.00) for Company B. Company C has ranked the three factors in the quality group the same (63.08).

Overall, without distinguishing between the three companies, among the 3 factors in the quality group, “High quality of required work” was considered the most important factor that would negatively affect labour productivity, with an importance index value of 61.11, followed by “Inefficiency of equipment” (50.56), and “Low quality of raw materials” (47.78).

4.3.4.1 Discussion

"High quality of required work" was the most important factor from this group. The responses from the participants across all three companies suggest that quality issues or problems arise from the specifications of the end products. This is drawn from the finding that the factor "High quality of required work" was suggested to be more important than "Low quality of raw materials" and "inefficiency of equipment." Two observations can be made from these results. The first is that, as alluded to in the previous section, poor exchange of information between supervisors and labour is most likely undermining productivity (Jarkas et al. 2012). If this is true then it is also likely that the precise specifications and relevant instructions concerning tasks are not being adequately communicated to and/or understood by operations level labour.

Reliance on unskilled and semi-skilled personnel may also be contributing to a perception by management that meeting expectations is generally challenging for the current labour force (Jarkas et al. 2012).

The second observation is that "inefficiency of equipment" and "low quality of raw materials" were ranked comparatively very low. This indicated generally that the plant equipment and materials were satisfactory. Arguably this could be due to capital investment per operation in Saudi Arabia which is most likely relatively high compared to other settings investigated and commented on in the literature such as Indonesia (Olomolaiye et al. 1996), Palestine (Enshassi et al. 2007), Uganda (Alinaitwe, Mwakali, and Hansson, 2007), and Iran (Ghouddousi and Hosseini, 2012). This can also be noted from the participants" responses. For example, a quality engineer respondent at Company C noted that after a period of using lower grade steel, cutters which were "damaged within 15 days" the company had decided to use premium steel cutters for which since very few incidents of tool destruction have been reported.

Table 4.11: Importance indices for factors in the quality group

	Company A	Company B	Company C	Overall
Inefficiency of equipment	55.38	28.00	63.08	50.56
Low quality of raw materials	41.54	36.00	63.08	47.78
High quality of required work	64.62	54.00	63.08	61.11
Overall	53.85	39.33	63.08	53.15

4.3.5 “Time" factor group

The time group consists of the following 5 factors: working 7 days per week without taking a holiday, misuse of time schedule, method of employment (using direct work system), increasing number of labours, and working overtime. The importance indices for factors in the time group are presented in Table 4.12. Company A have regarded two factors “Misuse of time schedule” and “Method of employment (using direct work system)” (63.08) as the most important factors in the time group that would negatively affect labour productivity.

The second most important factor for Company A was “Working 7 days per week without taking a holiday” (53.85). “Working overtime” (44.62) and “Increasing number of labours” (41.54) were the least two important factors for Company A.

Company B has perceived “Increasing number of labours” as the most important factor (56.00) and “Working 7 days per week without taking a holiday” (26.00) as the least important factor in the time group that would negatively affect labour productivity. The other three factors, “Working overtime” (44.00), “Misuse of time schedule” (42.00) and “Method of employment (using direct work system)” (42.00) have similar relative importance in terms of the importance index for Company B.

In contrast, for Company C, “Working 7 days per week without taking a holiday” (70.77) was regarded as the most important factor in the time group that would negatively affect labour productivity. Its importance index is dominantly higher than all the others. The least important factor for Company C was “Increasing number of labours” (36.92). The other three factors, “Misuse of time schedule” (46.23), “Method of employment (using direct work system)” 46.15) and “Working overtime” (41.54) have similar relative importance in terms of the importance index for Company C.

Overall, without distinguishing between the three companies, among the 5 factors in the quality group, both “Working 7 days per week without taking a holiday” and “Misuse of time schedule” was considered the most important factors that would negatively affect labour productivity. They both had an importance index value of 52.22. “Method of employment (using direct work system)” has a similar importance index value of 51.11. Overall, “Increasing number of labours” (43.89) and “Working overtime” (43.33) were less important.

4.3.5.1 Discussion

Time resources are increasingly recognised as one of the most important assets of companies (Borcherding et al. 1986; Wakisaka et al. 2000). Here, the results here were consistent with the results of Enshassi et al. (2007) to the extent that "Working 7 days per week without taking a holiday", "Misuse of time schedule", and "Method of employment" were identified as the first, second, and third most important factors of the group respectively.

"Working 7 days per week without taking a holiday" was regarded as a particularly salient factor. Referring to the effect of prolonged working, as mentioned, the importance value (70.77) attributed to "Working 7 days per week without taking a holiday" based on the responses from Company C, interestingly, was substantially higher than the other two companies. Responses from participants from this factory helped to illuminate the situation by providing that the majority of employees to work 13 hours a day and 7 days a week. For Company A where the majority of employees work

10 hours a day and 6 days a week, the relative importance value for this factor was 53.85.

At Company B where the average was 48 hours, the relative importance value for this factor, was substantially lower (26.00). Thus, there appears to be a pattern where increased prolonged labour appears to leading a situation where productivity is believed to be affected. Rivas et al. (2011) also noted that fatigue affected employee morale and other productivity variables such as absenteeism.

"Misuse of time schedule" was the second most relevant issue on productivity of this group according to the responses of participants. This factor referred to the extent that working hours were not used to meet organisational objectives. In the construction sector generally it is well established that operatives in key trades tend to only spend between 40-60% of attendance time onsite on tasks directly related to their trade (Olomolaiye and Ogunlana, 1989).

Off-task time is a problem. Idleness and timesheet fraud have been reported as issues. Off-task time can also arise because of poor work systems. For example, time is lost when employees are forced to wait for components to arrive or wait for supervisors to provide inductions and instructions. Olomolaiye and Ogunlana (1989) used an activity sampling technique with 36 tradespersons in Nigeria, and found that joiners spent 44% of time on task, bricklayers spent 51%, and steel fixers spent 56%. It was found that idle time (37-27%), taking instructions (5-13%), and waiting (3-16%) were the dominant categories of off-task behaviours.

"Method of employment (using direct work system)" was found to be the third most important factor overall in the manpower group. The result was highest for Company A. In this setting, the company relied on employees from a labour company and it was believed by some of the respondents that the daily pay system resulted in poor productivity for these operatives who had little incentive to intensify their duties. In Borcherding et al.'s (1986) study it was found that unproductive time tended to arise in the construction sector in at least five ways with periods of working slowly waiting, and idleness being major categories. These results suggested direct work system could be an approach to increasing productivity.

Table 4.12: Importance indices for factors in the time group

	Company A	Company B	Company C	Overall
Working 7 days per week without taking a holiday	53.85	26.00	70.77	52.22
Misuse of time schedule	63.08	42.00	46.23	52.22
Method of employment (using direct work system)	63.08	42.00	46.15	51.11
Increasing number of labours	41.54	56.00	36.92	43.89
Working overtime	44.62	44.00	41.54	43.33
Overall	53.23	42.00	48.92	48.56

4.3.6 “Manpower" factor group

The manpower group consists of the following 8 factors: lack of labour experience, labour disloyalty, labour dissatisfaction, misunderstanding among labour, lack of competition, increase of labourer age, labour absenteeism, and labour personal problems. The importance indices for factors in the manpower group are presented in Table 4.13. Company A have regarded two factors “Lack of labour experience” and “Labour absenteeism” (66.15) as the most important factors in the manpower group that would negatively affect labour productivity. The second most important factor for Company A was “Labour personal problems” (63.08). The remaining 5 factors, ranking from high to low, for Company A were: “Misunderstanding among labour” (56.92), “Labour dissatisfaction” (52.31), “Labour disloyalty” (50.77), “Lack of competition” (47.69), and “Increase of labourer age” (41.54).

For Company B, the most important factor in the manpower group that would negatively affect labour productivity was “Labour absenteeism” (60.00), followed closely by “Lack of labour experience” (58.00) and “Labour personal problems” (54.00). The remaining 5 factors, ranking from high to low, for Company B were: “Labour disloyalty" (50.00), "Lack of competition" (48.00), "Labour dissatisfaction" (44.00), "Misunderstanding among labour" (42.00), and "Increase of labourer age" (32.00).

However, for Company C, the most important factor in the manpower group that would negatively affect labour productivity was "Lack of competition" (70.77), followed closely by "Labour absenteeism" 67.69), "Lack of labour experience" (66.15) and "Labour dissatisfaction" (64.15). The remaining 4 factors, ranking from high to low, for Company C were: "Labour disloyalty" (55.38), "Increase of labourer age" (49.23), "Labour personal problems" (49.23), and "Misunderstanding among labour" (47.69).

Overall, without distinguishing between the three companies, among the 8 factors in the manpower group, "Labour absenteeism" was considered the most important factors that would negatively affect labour productivity, with an importance index value 65.00. The second most important factor "Lack of labour experience" has a similar importance index value of 63.89. Overall, "Increase of labourer age" (41.67) was the less important factor in the manpower group.

4.3.6.1 Discussion

Overall the responses from participants from the three companies suggested that factors related to manpower were very influential with respect to productivity. Amongst groups with two or more factors, the overall importance value attributed to the manpower group (54.79) was second only to overall importance value attributed to the leadership group (56.85).

"Labour absenteeism" was found to be the most significant issue related to manpower. One noticeable contrast between the current study and results of Enshassi et al.'s (2007) study is the difference in respective importance attributed to "labour disloyalty" and "absenteeism". "Absenteeism" was the most important factor according to responses from the three companies. Arguably, due to the nature of off-site construction in which tasks can be more time-dependent and rely on fewer personnel, unpaid absences could theoretically have a much larger adverse effect on productivity than such absences have in relation to onsite construction which typically relies on larger work crews per task (Abdul Kadir et al. 2006).

Another reason absenteeism may have been rated more important here could be due to a number of salary postponements. For example, the production manager of Company A stated "the wages were not sent out on time last Monday and the following day 20% of the workers were absent"

"Lack of labour experience" was also an issue consistently referred to by respondents. In Enshassi et al.'s (2007, 247) study on the Gaza Strip, with respect to the same group, manpower, "lack of labour experience", labour disloyalty, and "labour dissatisfaction." Here, the only major consistency was that "lack of labour experience" was found to be a significant factor. It is well-documented that there is a positive relationship between labour experience and productivity. Responses from participants at the three companies often referred to the adverse impacts of using a human resources strategy that focused on low cost at what they appeared to believe the expense of experience and skills.

"Lack of competition" was found to be a significant issue. The factor was given a higher relative importance value in this study compared to the value that was attributed to it in Enshassi et al.'s (2007) earlier study of onsite construction. Overall it was rated at the tenth most important factor overall in this study compared to being the 25th most important in Enshassi et al's study. This could suggest that encouraging a competitive environment in more relevant to off-site construction productivity. Observations and responses from interviews supported this suggested that there was very limited planning concerning promotion and succession in each of the three companies. A foreman from Company B commented "My team leader doesn't want to move to the next level job and become a foreman because the new position has the same salary and more job duties."

"Labour personal problems" was found to be a factor that respondents felt impacted significantly on productivity. For Company A and B this was the twelfth and eleventh was important issue respectively. Some of the personal problems that the participants referred to were requests for foreign workers to return home in relation to family emergencies. Most often such requests were unable to be to granted without severe contractual penalties which lead to a situation where employees either took leave to return and suffered penalties or alternatively remained working notwithstanding significant personal problems. This can be seen as a stark contrast with the results of Enshassi et al.'s (2007) study where "Labour personal problems" was found to be the least important factor within the manpower group. This could be a reflection of local workers in that context being more readily able to take leave for personal reasons than many of the foreign workers in the setting of the current study.

"Labour dissatisfaction" was found to be a significant factor. While it was not found as comparatively high as in Enshassi et al.'s (2007) study, within the manpower group, it was still found to be the 15th most important factor from 43 factors in this study. The circumstances at the settings studied probably go some way to explaining this finding. As mentioned, payment delay at Company A and austere practices by Company C such as the removal of historical employee benefits most likely led to some sentiment of employee dissatisfaction.

"Labour disloyalty", as mentioned, was found to be less of an issue in this study compared to earlier studies such as Enshassi et al. (2006). Nonetheless, it was a significant factor. It is well-documented that the construction sector has a high turnover (Olomolaiye et al. 1996). Lim and Alum (1996) noted that "manpower shortages and acute levels of job hopping" were significant issues affecting productivity in the construction sector in Singapore. Here, employment contractual conditions in Company B were reported by a participant to be a cause of employee attrition. It should also be noted that "Misunderstanding among labour" was a factor that while indicated by participants as less directly relevant to productivity compared to the aforementioned six factors in this group, could arguably have indirectly contributed to those above mentioned issues.

Table 4.13: Importance indices for factors in the manpower group

	Company A	Company B	Company C	Overall
Lack of labour experience	66.15	58.00	66.15	63.89
Labour disloyalty	50.77	50.00	55.38	52.22
Labour dissatisfaction	52.31	44.00	64.62	54.44
Misunderstanding among labour	56.92	42.00	47.69	49.44
Lack of competition	47.69	48.00	70.77	56.11
Increase of labourer age	41.54	32.00	49.23	41.67
Labour absenteeism	66.15	60.00	67.69	65.00
Labour personal problems	63.08	54.00	49.23	55.56
Overall	55.58	48.50	58.85	54.79

4.3.7 "Project" factor group

The project group consists of the following 4 factors: working within a confined space, interference, construction method, and type of activities in the project. The importance indices for factors in the project group are presented in Table 4.14 .

Among the 4 factors in the project group, all three companies have viewed "Type of activities in the project" as the most important factor that would negatively affect labour productivity 66.15, 64.00, 72.31 for Company A, B and C, respectively).

For Company A, the second most important factor was "Interference" 53.85), followed by "Construction method" 50.77). The least important factor in the project group for Company A was "Working within a confined space" 36.92).).

For Company B, the remaining three factors have very importance indices. The importance index was 44.00, 40.00 and 34.00 for "Construction method", "Working within a confined space" and "Interference", respectively. Like Company A, Company C also regarded "Construction method" as the second most important factor in the project group, with an importance index value of 66.15. However, the least important factor for Company C was "Interference" (38.46).

Overall, without distinguishing between the three companies, among the 4 factors in the project group, “Type of activities in the project” was considered the most important factors that would negatively affect labour productivity, with an importance index value of 67.78. The remaining 3 factors, ranking from high to low, were: “Construction method” (54.44), “Interference” (42.78), and “Working within a confined space” (42.22).

4.3.7.1 Discussion

"Types of activities in the project" was the most influential factor. The relative importance value attributed to this factor (67.78) based on the participants" responses was found to be the greatest overall of the 43 factors. It should be noted that, based on participant responses, for Company A it was the sixth most influential factor overall, for Company B, it was the fourth most influential factor, and for Company C it was the fifth most important of 43. What this potentially reflects is the consistent consequence given to this factor across three different off-site construction settings. This significance in this setting can be contrasted with the results of Enshassi et al. (2007) concerning the factor and onsite construction where it was found to be, as mentioned, the least important. Interview responses helped to illuminate the situation. For example, one of the factory managers from Company C commented that "while some elements can be prefabricated in 3 hours, more complicated design elements, particularly those with curvature and unique welder and mold requirements, can take as long as 24 hours [three working days]."

A factory manager at Company B reflected this sentiment noting that while some elements were 'standardised such as components for university facilities, others were non-standardised", and not only were these, "non-standardised" elements more difficult to fabricate, but they were projects in which the proportion of defects were the highest and the respective project productivities, the lowest.

"Construction method" was the second most important factor in this group. These results reflect a reality of off-site construction in that effectiveness and productivity are highly dependent on clarification of specifications, accurate estimates of time-to-complete, and in depth understanding of the potential of the factory, and the associated risks that certain products will impose on the setting. This factor "Types of activities in the project" bears similarities with the factor of "buildability" (Poh & Chen, 1998) or "constructability" (El-Gohary and Aziz, 2014). This factor has received attention with respect to off-site construction due to its relationship with productivity. For example, Tam et al. (2007) commenced a study with the objective to identify more effective prefabrication approaches for various project types.

Responses from interviews with respondents from Company B, as mentioned, supported this, with managers suggesting there was a need for senior representatives of the company to encourage customers to select options which would increase the use of standardised components.

"Interference" was relatively less important. Despite the importance attributed to "Interference" from participants in Enshassi et al.'s (2007) study, here it was the second least important of the group and the ninth least important out of 43 factors overall. The previous studies referred to a range of issues that lead to interference occurring in relation to onsite construction. While it is unnecessary to repeat those conditions here, it is arguably fair to say that off-site construction tends to occurs in a more controlled environment enabling these issues to be minimised although not eliminated.

"Working within a confined space" was relatively much less important. The most important observation from the results with respect to this group appears to be that they are almost opposite to those reported in earlier studies of construction labour productivity. For example, while Enshassi et al. (2007, 250) found that from most to least important the factors were "Working within a confined space", "Interference", "Construction method", and "Types of activities in the project." Here, "Working within a confined space" was found to be the least important followed by "Interference" as the second least important.

There are a number of reasons why a perception would exist that onsite construction labour operates in a more cramp environment compared to off-site construction labour. Firstly, there are typically more employees onsite which would suggest a denser setting (Abdul Kadir et al. 2006). Secondly, onsite construction occurring in situ occurs in a context where the site has not been ergonomically designed and is constrained by surrounding objects. The example of constructing a high rise building in a central business district would exemplify this.

In contrast, off-site construction has the potential to occur in settings that have been specifically designed to support comfort and productivity. For example, in observations of Company A it was noted that the production line was very clean and well-organised. An overhead crane connected directly to the storage yard had been placed to help with the transfer of elements after de-molding. This may go some way to explaining the particularly low importance attributed to "Working in a confined space" in this setting. Responses from participants from Company C which did not feature equivalent ergonomic technology and design reflected a greater concern that "Working in a confined space" was adversely affecting productivity.

Table 4.14: Importance indices for factors in the project group

	Company A	Company B	Company C	Overall
Working within a confined space	36.92	40.00	49.23	42.22
Interference	53.85	34.00	38.46	42.78
Construction method	50.77	44.00	66.15	54.44
Type of activities in the project	66.15	64.00	72.31	67.78
Overall	51.92	45.50	56.54	51.81

4.3.8 “External" factor group

The external group consists of 1 factor, augmentation of government regulations. The importance indices for this factor in the external group are presented in Table 4.15. The overall importance index was 55.00. The importance indices of “Augmentation of government regulations” were 50.77, 26.00, and 81.54 for Company A, B, and C, respectively. It appears that Company C viewed this factor much more important than the other two companies.

4.3.8.1 Discussion

"Augmentation of government regulations" was weighed differently by the respective companies. There was a large company-to-company difference in relation to the responses from participants concerning "Augmentation of government regulations". This can be explained in this case due to the time frame in which data was collected from the respective companies. Data collection occurred first at Company A and then at Company B.

Around this time, the Ministry of Labour in Saudi Arabia issued a *Royal Decree* stating that an increased duty would be levied on corporations employing foreign workers effective immediately. In brief, the new law has made corporations in the Kingdom liable for an additional 2400 SR per foreign worker per annum. After some time, data was collected from Company C. Thus, arguably the relative importance value would have been higher for Company A and Company B had data from those settings been collected at the same time as data was collected from Company C.

The significance of this result is that it reflects advice from earlier studies noting that despite reluctance from contractors to shift from conventional onsite construction to off-site construction in some settings, external factors would in future more likely than not be pushing designers and contractors towards more efficient construction approaches using less onsite personnel and more off-site technology (Poh & Chen, 1998; Abdul Kadir et al. 2006; Chan, 2011). It is arguably likely that other nations, particularly those also in the Gulf region, will incrementally increase incentives to employ domestic workers and in effect make employing foreign workers less attractive to corporations.

One example of a local content incentive scheme that has been in operation in Saudi Arabia since 2011 is the awarding of colour-coded compliance ratings, known as the Nitaqat program (Sadi, 2013). As part of this program, corporations are assessed and granted a colour periodically which represents their status as an employer of local persons. Premium, Green, Yellow, and Red are the four main categories. While corporation with a "Premium" status has certain privileges in relation to employing foreign workers, those corporations with a "Red" status face particular sanctions and restrictions (Sadi, 2013). Whilst confirming the respective statuses of each of the three companies at the time of data collection was outside the scope of this study, it can be noted that one of the manager respondents from Company A made comments to the effect that the company would have trouble maintaining its historical practices of employment if it came under increased liability under the Nitaqat program.

Table 4.15: Importance indices for factors in the external group

	Company A	Company B	Company C	Overall
Augmentation of government regulations	50.77	26.00	81.54	55.00

4.3.9 “Motivation" factor group

The motivation group consists of the following 6 factors: payment delay, lack of financial motivation system, lack of labour recognition programs, non-provision of transport means, lack of place for eating and relaxation, and lack of training sessions. The importance indices for factors in the motivation group are presented in Table 4.16.

Company A have regarded “Lack of training sessions” (63.08) as the most important factors in the motivation group that would negatively affect labour productivity. The second and the third most important factors for Company A were “Payment delay” and “Lack of financial motivation system” (56.92 for both) and “Lack of labour recognition programs” and “Non-provision of transport means” (53.85 for both). The least important factor for Company A was “Lack of place for eating and relaxation” (46.15).

“Lack of training sessions” (66.00) was also the viewed as the most important factors in the motivation group that would negatively affect labour productivity by Company B. The second most important factors for Company B was “Lack of labour recognition programs (62.00). The least important factor for Company B was “Payment delay” (20.00).

For Company C, both “Lack of financial motivation system” (86.15) and “Lack of labour recognition programs” (83.08) have high importance index value, while “Lack of training sessions” (30.00) and “Payment delay” have the lowest importance index value. The ranking of Company C is somewhat different from the other two companies.

Overall, without distinguishing between the three companies, among the 6 factors in the motivation group, “Lack of labour recognition programs” was considered the most important factors that would negatively affect labour productivity, with an importance index value 66.67. The second most important factor “Lack of financial motivation system” has a similar importance index value of 65.00. Overall, “Payment delay” (35.56) was the less important factor in the motivation group.

4.3.9.1 Discussion

Issues of motivation are particularly contentious. The body of construction labour productivity research contains conflicting findings concerning the merits of different compensation schemes (Makulsawatudom et al. 2004; Abdul Kadir et al. 2006). Some of these inconsistencies were reflected here in the responses of the participants. For example, a technical manager from Company A noted that neither a bonus scheme, that is, a unit rate system, nor a daily rate or hourly rate had proven to be without problems.

Co.A’s Technical manager stated that while productivity increased under the bonus system so did the quantity of defects and need for rework, which in his opinion rendered the scheme ineffective. At the same time, the manager believed that daily or hourly rates tended to lead to idleness in his experience.

"Lack of labour recognition programs" and "Lack of financial motivation system", as mentioned, were the two most important factors based on the responses of the participants. It is potentially most helpful to view these results on a company by company basis. In the case of Company A, these two factors were roughly the same in importance as "Payment delay." This was an anomaly in that Company A was the only setting where "Payment delay" was as high as "Lack of financial motivation system" and "Lack of labour recognition programs." However, it should be noted that at the time data was collected, the setting was experiencing solvency issues. Thus, as one respondent commented "We can't think about incentive schemes and recognition before we have received our pay."

The adverse effect pay delay has on construction sector productivity has been noted and confirmed in numerous studies. For example, in Enshassi et al.'s (2007) study "pay delay" was much more related to poor productivity than other factors in the group of motivation according to views of the respondents. While Company C at the time was not experiencing issues related to pay delay, as the results suggest the context at the time was one which emphasized the importance of financial motivation and labour recognition.

On interviewing the respondents it was revealed that the company C had recently re-organised its pay and benefits provisions and had effectively removed a number of benefits including employee meals and recreation. It is speculated that the timing of these events had a significant influence on the responses provided during the data collection.

"Lack of training sessions" was the third most significant factor overall primarily due to the comparably very high importance given to the factor by the respondents from Company B. In this company there were seemingly no issues of pay delay or poor working conditions in contrast to the Company A and Company C. It should be noted that Company B was found to be most well-equipped, and at least superficially or at least from the perception of the principal researcher, the most financially stable setting. This could go some way to explaining why "payment delay" and "lack of financial motivation system" rated lower for the company compared to Company A and Company C. Still in Company B, despite prima facie competitive pay and more flexible employment conditions, respondents from this setting still indicated that "Lack of labour recognition programs" was an important factor. In fact, overall for Company B "Lack of labour recognition programs" was the fifth most important factor of the 43 factors. These conditions in one way or another led to a situation where, "Lack of training" was suggested as particularly important by these respondents, and this factor was the equal second highest overall of the 43 factors for Company B.

While there is not enough evidence to make a conclusive claim on the determinants of the situation, it could be speculated that in terms of motivation, once matters of pay generally had been satisfied then other considerations become more relevant. Such a speculation would appear to be supported by Maslow's hierarchy of needs which provides that once physiological needs, such as food and water, and safety needs, such as financial security are satisfied, then needs of love/belongingness, such as professional recognition and later respect become more sought after (Bartol et al. 2011).

Table 4.16: Importance indices for factors in the motivation group

	Company A	Company B	Company C	Overall
Payment delay	56.92	20.00	26.15	35.56
Lack of financial motivation system	56.92	48.00	86.15	65.00
Lack of labour recognition programs	53.85	62.00	83.08	66.67
Non-provision of transport means	53.85	30.00	61.54	50.00
Lack of place for eating and relaxation	46.15	42.00	47.69	45.56
Lack of training sessions	63.08	66.00	30.00	62.78
Overall	55.13	44.67	60.77	54.26

4.3.10 "Safety" factor group

The safety group consists of the following 6 factors: accidents, violation of safety precautions, bad ventilation, working at high places, safety officer absence officer on the construction site, and noise. The importance indices for factors in the safety group are presented in Table 4.17.

The top four most important factors in the safety group that would negatively affect labour productivity for Company A were: “safety officer absence on the construction site” (52.31), “Bad ventilation” (49.23), “Violation of safety precautions” (47.69) and “Noise” (47.69). The two least most important factors for Company A were “Accidents” 38.46) and “Working at high places” (36.92).

For Company B, “Violation of safety precautions” has a distinctly higher importance index (66.00) than the other factors. The other five factors have relatively similar importance indices with “Working at high places” having the lowest importance index value of 22.00. For Company C, “Noise” has ranked the number 1 factor negatively affecting labour productivity in the safety group, with an importance index value of 60.00. Similar to Company A and B, the lowest ranking factor for Company C was “Working at high places” with an importance index value of 23.08.

Overall, without distinguishing between the three companies, among the 6 factors in the safety group, “Violation of safety precautions” was considered the most important factors that would negatively affect labour productivity, with an importance index value of 53.33. The second most important factor “Noise” has a similar importance index value of 52.22. Overall, “Working at high places” (27.70) was the less important factor in the safety group.

4.3.10.1 Discussion

"Violation of safety precautions" was found to be the most relevant overall. This issue was emphasized by respondents from Company B who tended to have a higher awareness and interest in matters of safety overall. Arguably, a perception exists in this setting that breaches of occupational health and safety protocol adversely affect overall productivity potentially due to the time required to instruct offending persons in relation to workplace safety.

"Noise" was found to be the second most important factor. This factor was ranked comparably high by respondents from Company B and Company C. This result contrasts with the results of Enshassi et al. (2007) who found that "Noise" was the least important of seven factors in this group. This result could potentially be an indication of a salient issue in off-site construction. While in the onsite, in situ, construction setting, noise was found to be least important factor negatively affecting productivity overall, in this study it was perceived to have the same adverse impact on productivity overall as "Material shortages", "Working 7days per week without taking a holiday", "Misuse of time schedule", and "Labour disloyalty"

Thus, the enclosed environment of the prefabrication factory appears to present a much different workplace safety proposition to employees. Not only were "Violation of safety precautions" and "Noise" found to be relevant, but there were other substantial differences can be noted between the relative importance of factors relating to safety concerning onsite in situ construction and the importance of the same or similar factors relating to off-site construction.

In other words, in comparison to similar studies in the construction section (Enshassi et al. 2007) the importance value attributed to factors related to safety was lower in this study. Firstly, while Enshassi et al. (2007) found that "Accidents" were thought as the most significant factor amongst contractors with respect to productivity impact, here this factor was found to be largely unimportant. "Working at high places" was also less relevant. "Bad ventilation" appeared to be comparable in importance with respect to this study and Enshassi et al.'s.

Table 4.17: Importance indices for factors in the safety group

	Company A	Company B	Company C	Overall
Accidents	38.46	30.00	43.08	37.78
Violation of safety precautions	47.69	66.00	49.23	53.33
Bad ventilation	49.23	32.00	43.08	42.22
Working at high places	36.92	22.00	23.08	27.70
Unemployment of safety officer on the construction site	52.31	28.00	35.38	39.44
Noise	47.69	48.00	60.00	52.22
Overall	45.38	37.67	42.31	42.13

4.3.11 Overall ranking of factors negatively affecting labour productivity

4.3.11.1 Company A

Table 4.18 and 4.19 display the ranking of the 43 factors for Company A. With respect to the results, for Company A, the top 6 factors negatively affecting labour productivity were: “Drawings and specifications alteration during execution” (72.31), “Rework” (69.23), “Misunderstanding between labour and superintendents” (69.23), “Lack of labour experience” (66.15), “Labour absenteeism” (66.15), and “Type of activities in the project” (66.15).

Overall, as mentioned, "Drawings and specification alteration during execution" was found to be the most important factor according to the respondents from this setting followed by "Rework" and "Misunderstanding between labour and superintendents". "Lack of labour experience" was also suggested as a dominant factor.

The relevance of effective communication between company and customers was in some ways explained through the data collected and analysed from Company A. It is unclear the extent that communication issues and misunderstanding generally between labour and supervisors contributed to the perception that "Drawings and specification alteration during execution" was the most important factor.

Arguably the agreement on end product specification is one that should occur between customer and more senior representative of the company. This may indicate that Company A is experiencing communication issues not only between labour and superintendents but also between its sales representatives and its customers. Issues relating to instructions appear to be the most relevant for Company A. As the importance index of factor groups for the company reveals "Supervision" and "Leadership" are shown as the most relevant groups.

Table 4.18: Importance index of factor groups, Company A

Group	Importance index	Ranking
Supervision	63.08	1
Leadership	61.54	2
Materials/tools	56.92	3
Manpower	55.58	4
Motivation	55.13	5
Quality	53.85	6
Time	53.23	7
Project	51.92	8
External	50.77	9
Safety	45.38	10

As mentioned, the role of communication between company and customers is particularly important in the off-site construction sector. Numerous studies have found a link between drawing deficiencies, change orders, and other specification miscommunications or misunderstandings on productivity (Zakeri et al. 1996; Abdul Kadir et al. 2006). While most of these studies consider the role of the representatives of the company and the customers in attributing to the issue of poor instruction and specification provision, Makulsawatudom et al. (2004) placed emphasis on the role of designers noting that a respondent in that study commented "clients provide limited time and budget for designer." The researchers there also noted that drawings were often "incomplete, unclear, impractical and contain conflicts" (Makulsawatudom et al. 2004).

The relevance of effective communication between supervisors and labour was also in some ways explained through the data collected and analysed from Company A. Observations of the factory and responses from participant and non-participant supervisors indicated that Company A substantially relied on low cost unskilled and semi-skilled foreign workers and that communication issues plagued operation effectiveness. Arguably respondents in that setting had recognised that inexperience and confusion was undermining productivity.

Not only did these issues appear to manifest in idleness and lack of discretionary effort by labour according to responses from supervisors, but more specific issues such as a low quality, that is a high volume of defects, were probably occurring. Arguably labour inexperience and confusion probably underpinned references to "Labour personal problems", "A lack of training sessions", "A lack of labour surveillance" and "Misunderstanding among labour" which were each in the top 15 most salient factors affecting productivity in Company A. As mentioned, issues of communication in multi-lingual settings have been reported widely in the construction labour productivity literature (Poh and Chen 1998; Makulsawatudom et al. 2004; Abdul Kadir et al. 2006; Jarkas et al. 2012).

The relevance of financial stability was also in some ways explained through the data collected and analysed from Company A. Complicating the situation could have been temporary solvency issues which meant that certain employees had their salaries delayed by up to eight weeks. It should also be noted that temporary solvency issues at Company A probably go some way to explaining the relatively high importance suggested by respondents with respect to "Labour absenteeism", "Tools and equipment shortages", and "Material shortage".

Table 4.19 below presents the ranking of the 43 variables in Company A.

Table 4.19: Ranking of the 43 factors, company A

Factor	**Importance index**	**Ranking**
Drawings and specifications alteration during execution	72.31	1
Rework	69.23	2
Misunderstanding between labour and superintendents	69.23	3
Lack of labour experience	66.15	4
Labour absenteeism	66.15	5
Type of activities in the project	66.15	6
Tool and equipment shortages	64.62	7
High quality of required work	64.62	8
Material shortages	63.08	9
Misuse of time schedule	63.08	10
Method of employment (using direct work system)	63.08	11
Labour personal problems	63.08	12
Lack of training sessions	63.08	13
Lack of labour surveillance	60.00	14
Misunderstanding among labour	56.92	15
Payment delay	56.92	16
Lack of financial motivation system	56.92	17
Inspection delay	55.38	18
Supervisors" absenteeism	55.38	19
Lack of periodic meeting with labour	55.38	20
Inefficiency of equipment	55.38	21
Working 7 days per week without taking a holiday	53.85	22
Interference	53.85	23
Lack of labour recognition programs	53.85	24
Non-provision of transport means	53.85	25
Labour dissatisfaction	52.31	26
Unemployment of safety officer on the construction site	52.31	27
Labour disloyalty	50.77	28
Construction method	50.77	29
Augmentation of government regulations	50.77	30
Bad ventilation	49.23	31
Lack of competition	47.69	32
Violation of safety precautions	47.69	33
Noise	47.69	34
Lack of place for eating and relaxation	46.15	35
Working overtime	44.62	36
Unsuitability of materials storage location	43.08	37
Low quality of raw materials	41.54	38
Increasing number of labours	41.54	39
Increase of labourer age	41.54	40
Accidents	38.46	41
Working within a confined space	36.92	42
Working at high places	36.92	43

4.3.11.2 Company B

For Company B, the top 5 factors negatively affecting labour productivity were: “Lack of labour surveillance” (70.00), “Lack of training sessions” (66.00), “Violation of safety precautions” (66.00), “Type of activities in the project” (54.00), and “Lack of labour recognition programs” (62.00). Remarkably with the exception of "Types of activities in the project" the top five most influential factors as suggested by participants from Company B were each different from those suggested by the participants from Company A.

Non-financial factors affecting productivity appeared to be the focus from respondents from Company B. This may have arisen from a view by the principal researcher and supported by interview responses that Company B is in a stable financial position. Thus, it could be speculated that in environments were monetary needs are being met, other more non-monetary factors become relevant. Also relevant could be the fact that Company B employed a higher quantity of local workers who on average according to interview responses appeared to have remained with the company for a longer period. Thus, while respondents from Company A seemed to be focused on the importance of dealing with the consequences of human error, the respondents from Company B appeared to be more concerned with enhancing productivity increasing the supervision, skills and knowledge, and recognition of their employees.

The importance index of factor groups for the company reflects such "Leadership", "Manpower", and "Project" are suggested to be believed to be the most relevant factor groups on productivity. This company appears to place factors relating to "Materials/tools" and "External" factors as having little significance, which could arguably be said to reflect the participants views that factors more closely related to individual workers were more relevant to productivity.

Table 4.20: Importance index of factor groups, Company B

Group	Importance index	Ranking
Leadership	57.33	1
Manpower	48.50	2
Project	45.50	3
Motivation	44.67	4
Time	42.00	5
Quality	39.33	6
Safety	37.67	7
Supervision	35.50	8
Materials/tools	32.00	9
External	26.00	10

Safety factors affecting productivity also appeared to be the focus from respondents from Company B. Specifically, respondents from Company B were noticeably more concerned with than the respondents from Company A and Company C with a connection between safety and productivity. While it was the least significant group overall and for Company A and C respectively, for Company B factors relating to safety were considered to be more important than supervision, materials/tools and external regulation. Arguably, the interest in safety reflects the higher importance of employee well-being to the respondents from the company. Company B had the least onerous with an average of 48 hours per week per employee. Placing labour safety as a priority from a productivity point of view would appear to be strongly supported by the literature (Enshassi et al. 2007).

Table 4.21 below presents the ranking of the 43 factors in Company B

Table 4.21: Ranking of the 43 factors, company B

Factor	Importance index	Ranking
Lack of labour surveillance	70.00	1
Lack of training sessions	66.00	2
Violation of safety precautions	66.00	3
Type of activities in the project	64.00	4
Lack of labour recognition programs	62.00	5
Labour absenteeism	60.00	6
Lack of labour experience	58.00	7
Increasing number of labours	56.00	8
Lack of periodic meeting with labour	54.00	9
High quality of required work	54.00	10
Labour personal problems	54.00	11
Drawings and specifications alteration during execution	50.00	12
Labour disloyalty	50.00	13
Misunderstanding between labour and superintendents	48.00	14
Lack of competition	48.00	15
Lack of financial motivation system	48.00	16
Noise	48.00	17
Working overtime	44.00	18
Labour dissatisfaction	44.00	19
Construction method	44.00	20
Misuse of time schedule	42.00	21
Method of employment (using direct work system)	42.00	22
Misunderstanding among labour	42.00	23
Lack of place for eating and relaxation	42.00	24
Working within a confined space	40.00	25
Material shortages	38.00	26
Rework	38.00	27
Low quality of raw materials	36.00	28
Interference	34.00	29
Increase of labourer age	32.00	30
Bad ventilation	32.00	31
Unsuitability of materials storage location	30.00	32
Non-provision of transport means	30.00	33
Accidents	30.00	34
Tool and equipment shortages	28.00	35
Inspection delay	28.00	36
Inefficiency of equipment	28.00	37
Unemployment of safety officer on the construction site	28.00	38
Supervisors" absenteeism	26.00	39
Working 7 days per week without taking a holiday	26.00	40
Augmentation of government regulations	26.00	41
Working at high places	22.00	42
Payment delay	20.00	43

4.3.11.3 Company C

For Company C, the top 5 factors negatively affecting labour productivity were: “Lack of financial motivation system” (86.15), “Lack of labour recognition programs” (83.08), “Augmentation of government regulations” (81.54), “Tool and equipment shortages” (73.85), and “Type of activities in the project” (72.31). The responses from participants from Company C tended to reflect considerable concerns of middle management that economic rationalisation at the setting was leading to a reduction in benefits for personnel and productivity was thereby adversely affected. This belief appeared to be a situation-specific notion and it was considered by the principal researcher to have affected the nature of responses from this setting. Supporting this, "Lack of financial motivation system" and "Lack of labour recognition programs" from the point of view of the respondents at Company C were felt to be two factors that could heavily compromise productivity. The respondents also were expressive about the adverse impact that government regulation could have on productivity.

Arguably, these responses from participants from Company C tended to reflect a position that factors not directly related the individual workers were more influential on productivity. This can be seen in the importance index of factor groups for the company as shown following where it can be seen that "External" and "Quality" factors were seen to be more relevant to productivity than "Manpower," or "Leadership" groups.

Table 4.22**:** Importance index of factor groups, Company C

Group	Company C	Ranking
External	81.54	1
Quality	63.08	2
Motivation	60.77	3
Materials/tools	60.00	4
Manpower	58.85	5
Project	56.54	6
Leadership	51.79	7
Time	48.92	8
Supervision	46.15	9
Safety	42.31	10

Another example of this perspective could be drawn from the finding that "Tools and equipment shortages" was reported as the fourth most important factor related to productivity. It was observed during data collection and particularly through the interview process that respondents from Company C believed that the corporation's directors did not acknowledge or appreciate the benefit that would arise from investment in technology and materials. Thus, it is probably not surprising that in addition to "Tools and equipment shortage," "Construction method,""Inefficiency of equipment", and "Low quality of raw materials," were each found in the top 15 most relevant of 43.

The human resources practices of Company C from the view of the principal researcher based on plant observations and interview responses appeared to be the least satisfactory of the three companies. As Company A, Company C was reliant on low cost unskilled and semi-skilled foreign workers. However, extraordinary working hours, as mentioned 13 hours a day and 7 days a week and other matters related to a lack of acknowledgement of the needs of employees appeared to have led to a situation at Company C were employee morale was particularly low. It is possibly for this reason that the respondents from this setting were more inclined to highlight the role of labour dissatisfaction on productivity.

However factor by factor, respondents in Company C did emphasis, as mentioned, the role of "Lack of financial motivation system" and "Lack of labour recognition programs" which were factors from the "Motivation" group highlighting a view of managers from this setting that there were motivational issues. A focus on motivational issues appears to be appropriate given the circumstances and appears consistent with research from construction labour productivity field which often positions employee motivation as the most important factor with respect to productivity (Mistry and Bhatt, 2013).

Table 4.23 below presents a ranking of the 43 factors for Company C

Table 4.23: Ranking of the 43 factors, Company C

Factor	**Importance index**	**Ranking**
Lack of financial motivation system	86.15	1
Lack of labour recognition programs	83.08	2
Augmentation of government regulations	81.54	3
Tool and equipment shortages	73.85	4
Type of activities in the project	72.31	5
Working 7 days per week without taking a holiday	70.77	6
Lack of competition	70.77	7
Labour absenteeism	67.69	8
Lack of labour experience	66.15	9
Construction method	66.15	10
Labour dissatisfaction	64.62	11
Inefficiency of equipment	63.08	12
Low quality of raw materials	63.08	13
High quality of required work	63.08	14
Non-provision of transport means	61.54	15
Noise	60.00	16
Drawings and specifications alteration during execution	56.92	17
Lack of periodic meeting with labour	55.38	18
Labour disloyalty	55.38	19
Unsuitability of materials storage location	53.85	20
Lack of labour surveillance	53.85	21
Material shortages	52.31	22
Rework	50.77	23
Increase of labourer age	49.23	24
Labour personal problems	49.23	25
Working within a confined space	49.23	26
Violation of safety precautions	49.23	27
Misunderstanding among labour	47.69	28
Lack of place for eating and relaxation	47.69	29
Misuse of time schedule	46.23	30
Misunderstanding between labour and superintendents	46.15	31
Method of employment (using direct work system)	46.15	32
Inspection delay	44.62	33
Accidents	43.08	34
Bad ventilation	43.08	35
Working overtime	41.54	36
Interference	38.46	37
Increasing number of labours	36.92	38
Unemployment of safety officer on the construction site	35.38	39
Supervisors" absenteeism	32.31	40
Lack of training sessions	30.00	41
Payment delay	26.15	42
Working at high places	23.08	43

4.3.12 Overall ranking of factors negatively affecting productivity

Overall, the top 5 factors negatively affecting labour productivity were: “Type of activities in the project” (67.78), “Lack of labour recognition programs” (66.67), “Labour absenteeism” (65.00), “Lack of financial motivation system” (65.00), and “Lack of labour experience” (63.89).

As mentioned, a dominant consideration in off-site construction is the "Types of activities in the project." This was a consistent factor suggested by respondents with approximately the same emphasis. Failure to accurately predict the capacity of the factory to fabricate the component was found to lead to a number of problems each likely to compromise productivity, such as repairs, re-work, and delays.

Employee-related factors were the second most important collection of variables affecting productivity. Following from "Types of activities in the project" the next most important factors based on the responses of participants from the three companies related to the individual employees. For example, a "Lack of labour recognition programs" and "Labour absenteeism" were the second and third most relevant factors adversely affecting productivity, with each suggesting that off-site construction could be significantly hindered by unrecognized, disenchanted, and unavailable labour.

Table 4.24 below presents a ranking of the 43 factors across all sample companies.

Table 4.24: ranking of the 43 factors, overall

Factor	**Importance index**	**Ranking**
Type of activities in the project	67.78	1
Lack of labour recognition programs	66.67	2
Labour absenteeism	65.00	3
Lack of financial motivation system	65.00	4
Lack of labour experience	63.89	5
Lack of training sessions	62.78	6
High quality of required work	61.11	7
Lack of labour surveillance	60.56	8
Drawings and specifications alteration during execution	60.56	9
Tool and equipment shortages	57.78	10
Lack of competition	56.11	11
Labour personal problems	55.56	12
Misunderstanding between labour and superintendents	55.00	13
Lack of periodic meeting with labour	55.00	14
Augmentation of government regulations	55.00	15
Labour dissatisfaction	54.44	16
Construction method	54.44	17
Rework	53.89	18
Violation of safety precautions	53.33	19
Material shortages	52.22	20
Working 7 days per week without taking a holiday	52.22	21
Misuse of time schedule	52.22	22
Labour disloyalty	52.22	23
Noise	52.22	24
Method of employment (using direct work system)	51.11	25
Inefficiency of equipment	50.56	26
Non-provision of transport means	50.00	27
Misunderstanding among labour	49.44	28
Low quality of raw materials	47.78	29
Lack of place for eating and relaxation	45.56	30
Inspection delay	43.89	31
Increasing number of labours	43.89	32
Unsuitability of materials storage location	43.33	33
Working overtime	43.33	34
Interference	42.78	35
Working within a confined space	42.22	36
Bad ventilation	42.22	37
Increase of labourer age	41.67	38
Unemployment of safety officer on the construction site	39.44	39
Supervisors" absenteeism	38.89	40
Accidents	37.78	41
Payment delay	35.56	42
Working at high places	27.70	43

Concerning factor groups, *overall*, the top 3 were: Leadership (56.85), External (55.00), and Manpower (54.79). The results here reveal that leadership issues including communication and surveillance are considered, by the sample, to be the most relevant factors impacting on off-site construction productivity. Thus, the accurate exchange of information including instructions, specifications, and expectations appears to be an area of great significance. Given the particularly high relative importance index value for this group it would appear that leadership strategy deserves the attention of the top management.

Following this is a reflection of the increasing influence that regulatory bodies, typically the government can have on the operations of production facilities. This is particularly relevant to settings that rely on a high number of foreign workers. While it should be noted that the high value attributed to this factor group is a result of a very high emphasis given to it at one setting and that this factor group, was in fact, merely one factor, the result still goes some way to highlighting the need for management to include politico-legal considerations in their organisation strategy, particularly in relation to human resources.

"External" was a sole factor. This could emphasise the view of respondents that "Manpower" and "Motivation", in addition to factors relating to "Leadership", were also important to productivity. The major contrast with this finding and the earlier finding of Enshassi et al. (2007) is that in the latter, the factor group "Materials/tools" was found to be considered the most relevant. Arguably this could suggest that the need to focus on effective leadership of employees in off-site construction is even more important than the corresponding need in relation to onsite, in situ, construction.

Table 4.25**:** Importance index of factor groups, overall

Group	**Importance index**	**Ranking**
Leadership	56.85	1
External	55.00	2
Manpower	54.79	3
Motivation	54.26	4
Quality	53.15	5
Project	51.81	6
Materials/tools	51.11	7
Supervision	49.31	8
Time	48.56	9
Safety	42.13	10

4.4 Employee empowerment and productivity factors relationship

As mentioned, Pearson's correlation coefficients were used to investigate the relationship between the relative usage of the 9 employee empowerment factors and the 43 factors negatively affecting labour productivity. The results are presented in Table 4.26.

4.4.1 "Leadership" and productivity factors

The relative usage of the employee empowerment factor, “Leadership”, was statistically significantly correlated with the following factors that would negatively affect labour productivity: Tool and equipment shortages, Unsuitability of materials storage location, Inefficiency of equipment, Low quality of raw materials, Working 7 days per week without taking a holiday, Lack of labour experience, Labour dissatisfaction, Misunderstanding among labour, Lack of competition, Labour absenteeism, Working within a confined space, Augmentation of government regulations, and Lack of training sessions.

Specifically, the relative usage of the employee empowerment factor, “Leadership”, was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.01 level of significance:

- Lack of labour experience (r = -0.56, p< 0.01)

- Labour dissatisfaction (r = -0.52, p< 0.01)
- Augmentation of government regulations (r = -0.52, p< 0.01)
- Unsuitability of materials storage location (r = -0.49, p< 0.01)
- Labour absenteeism (r = -0.48, p< 0.01)
- Inefficiency of equipment (r = -0.45, p< 0.01)
- Low quality of raw materials (r = -0.44, p< 0.01)
- Misunderstanding among labour (r = -0.44, p< 0.01)

The relative usage of "Leadership" was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.05 level of significance:

- Tool and equipment shortages (r = -0.39, p< 0.05)
- Lack of training sessions (r = -0.39, p< 0.05)
- Working 7 days per week without taking a holiday (r = -0.35, p< 0.05)
- Working within a confined space (r = -0.35, p< 0.05)
- Lack of competition (r = -0.34, p< 0.05)

Nonetheless, the negative correlation indicated that an increase rating of the relative usage of "Leadership" would correspond to a decrease rating of the factors negatively affecting labour productivity, including, Lack of labour experience, Labour dissatisfaction, Augmentation of government regulations, Unsuitability of materials storage location, Labour absenteeism, Inefficiency of equipment, Low quality of raw materials, Misunderstanding among labour, Tool and equipment shortages, Lack of training sessions, Working 7 days per week without taking a holiday, Working within a confined space, and Lack of competition.

In other words, the more relative concurrent usage of the employee empowerment factor, "Leadership", the less participants believed that the following factors, would negatively affect labour productivity, namely: Lack of labour experience, Labour dissatisfaction, Augmentation of government regulations, Unsuitability of materials storage location, Labour absenteeism, Inefficiency of equipment, Low quality of raw materials, Misunderstanding among labour, Tool and equipment shortages, Lack of training sessions, Working 7 days per week without taking a holiday, Working within a confined space, and Lack of competition.

4.4.1.1 Discussion

On reflection, most noticeably the results suggested that participants were less likely to believe that "Lack of labour experience" and "Labour dissatisfaction" would negatively affect labour productivity in settings where the company exhibited behaviours consistent with the employee empowerment factor of "Leadership". This appears to be logical as it would be expected that in locations where management from all levels are present in terms of walking in plants and talking to employees, and where management hold professional development programs, and where management valued empowerment ideologies that employees would be more appropriately directed and supported and therefore less likely to compromise productivity due to lack of experience or themselves dissatisfied.

"Labour Absenteeism" and "Misunderstanding amongst labour" were also factors that participants as usage of behaviours related to the employee empowerment factor of "Leadership" were higher were less likely to indicate as relevant arguably due to the same reasoning that more proactive leadership activities encouraged employees to attend and comprehend day to day productivity issues. "Unsuitability of materials storage location", "Inefficiency of equipment," "Low quality of raw materials," and "Tool and equipment shortages" were also less likely to be seen as factors that adversely productivity by those participants in settings where the respondents believed the company exhibited behaviours consistent with the employee empowerment factor of "Leadership."

Arguably the physical presence of senior management in plants, professional development provisions, and an increased two-way communication as would be expected from management who view empowerment favourably would have led to a situation where productivity issues related to materials/tools were identified and addressed. One respondent from Company C highlighted this issue by stating that reports made by middle management to senior management with respect to redundant molds were often neglected reflecting behaviour inconsistent with the employee empowerment quality of "Leadership".

4.4.2 "Empowerment system" and productivity factors

The relative usage of the employee empowerment factor, *"Empowerment system", was statistically significantly correlated with the following factors that would negatively affect labour productivity*: Tool and equipment shortages, Rework, Misunderstanding between labour and superintendents, Lack of labour experience, Misunderstanding among labour, Labour absenteeism, Payment delay, Lack of training sessions, and Noise.

Specifically, the relative usage of the employee empowerment factor, "Empowerment system", was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.01 level of significance:

- Misunderstanding among labour ($r = -0.54$, $p < 0.01$)
- Lack of labour experience ($r = -0.43$, $p < 0.01$)
- Labour absenteeism ($r = -0.43$, $p < 0.01$)

The relative usage of "Empowerment system" was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.05 level of significance:

- Misunderstanding between labour and superintendents ($r = -0.38$, $p < 0.05$)
- Lack of training sessions ($r = -0.37$, $p < 0.05$)
- Rework ($r = -0.35$, $p < 0.05$)
- Payment delay ($r = -0.35$, $p < 0.05$)
- Tool and equipment shortages ($r = -0.34$, $p < 0.05$)

Nonetheless, the negative correlation indicated that an increase rating of the relative usage of “Empowerment system” would correspond to a decrease rating of the factors negatively affecting labour productivity, including, Misunderstanding among labour, Lack of labour experience, Labour absenteeism, Misunderstanding between labour and superintendents, Lack of training sessions, Rework, Payment delay, and Tool and equipment shortages.

In other words, the more relative concurrent usage of the employee empowerment factor, “Empowerment system”, the less participants believed that the following factors, Misunderstanding among labour, Lack of labour experience, Labour absenteeism, Misunderstanding between labour and superintendents, Lack of training sessions, Rework, Payment delay, and Tool and equipment shortages, would negatively affect labour productivity.

The relative usage of “Empowerment system” was statistically significantly positively correlated with the Noise at the 0.05 level of significance (r = 0.38, $p < 0.05$). This indicated that an increase rating of the relative usage of “Empowerment system” would correspond to an increase rating of the factor negatively affecting labour productivity, noise. In other words, the more relative concurrent usage of the employee empowerment factor, “Empowerment system”, the more participants believed that “Noise” would negatively affect labour productivity.

4.4.2.1 Discussion

On reflection, the obvious productivity factor that appears to be most influenced by the extent that a context is perceived to be exhibiting behaviours consistent with the employee empowerment factor of "Empowerment system", is "Misunderstanding amongst labour". Thus, arguably it appears that the provision of job descriptions, organisational structures, quality control and quality assurance measures each can assist to diffuse labour-level confusion and to ensure that personnel are able to achieve organisational objectives individually and importantly collectively.

Interestingly, exhibiting behaviours consistent with the employee empowerment factor of "Empowerment system", was also found to influence the extent that " Misunderstanding between labour and superintendents" would be relevant according to participants. It is interesting to note that exhibiting behaviour consistent with the employee empowerment factor of "Empowerment system" was seen to positively affect employee-employee communication more than it did employer-employee communication, albeit in fact improving each. This may reveal an important overlooked consideration that being that the use of job descriptions, organisational structure charts, and implementation plans primarily improves communication between employees.

These conditions also appear to improve employee competence and attendance. As noted, participants were less likely to perceive that " Lack of labour experience," and "Labour absenteeism," would adversely affect productivity in settings where behaviour consistent with the employee empowerment factor of "Empowerment system" were believed to be exhibited.

4.4.3 "Resources development" and productivity factors

The relative usage of the employee empowerment factor, "Resources development", was statistically significantly correlated with the following factors that would negatively affect labour productivity: Tool and equipment shortages, Unsuitability of materials storage location, Drawings and specifications alteration during execution, Inspection delay, Rework, Inefficiency of equipment, Working 7 days per week without taking a holiday, Lack of labour experience, Labour dissatisfaction, Misunderstanding among labour, Labour absenteeism, Interference, Augmentation of government regulations, Payment delay, Lack of financial motivation system and Increasing number of labours.

Specifically, the relative usage of the employee empowerment factor, "Resources development", was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.01 level of significance:

- Rework(r = -0.48, p< 0.01)
- Working 7 days per week without taking a holiday (r = -0.48, p< 0.01)

- Tool and equipment shortages (r = -0.47, p< 0.01)
- Unsuitability of materials storage location (r = -0.47, p< 0.01)
- Labour absenteeism (r = -0.47, p< 0.01)
- Augmentation of government regulations (r = -0.46, p< 0.01)
- Lack of financial motivation system (r = -0.45, p< 0.01)
- Inspection delay(r = -0.44, p< 0.01)
- Inefficiency of equipment (r = -0.43, p< 0.01)
- Labour dissatisfaction (r = -0.43, p< 0.01)

The relative usage of “Resources development” was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.05 level of significance:

- Lack of labour experience (r = -0.41, p< 0.05)
- Misunderstanding among labour (r = -0.39, p< 0.05)
- Payment delay (r = -0.38, p< 0.05)
- Drawings and specifications alteration during execution (r = -0.34, p< 0.05)
- Interference (r = -0.33, p< 0.05)

Nonetheless, the negative correlation indicated that an increase rating of the relative usage of “Resources development” would correspond to a decrease rating of the factors negatively affecting labour productivity, including, Rework, Working 7 days per week without taking a holiday, Tool and equipment shortages, Unsuitability of materials storage location, Labour absenteeism, Augmentation of government regulations, Lack of financial motivation system, Inspection delay, Inefficiency of equipment, and Labour dissatisfaction.

In other words, the more relative concurrent usage of the employee empowerment factor, “Resources development”, the less participants believed that the following factors, Rework, Working 7 days per week without taking a holiday, Tool and equipment shortages, Unsuitability of materials storage location, Labour absenteeism, Augmentation of government regulations, Lack of financial motivation system, Inspection delay, Inefficiency of equipment, and Labour dissatisfaction, would negatively affect labour productivity.

The relative usage of “Resources development” was statistically significantly positively correlated with Increasing number of labours at the 0.05 level of significance ($r = 0.39$, $p< 0.05$). This indicated that an increase rating of the relative usage of “Resources development” would correspond to an increase rating of the factor negatively affecting labour productivity, across Increasing number of labours.

In other words, the more relative concurrent usage of the employee empowerment factor, “Resources development”, the more participants believed that “Increasing number of labours” would negatively affect labour productivity.

4.4.3.1 Discussion

On reflection, the extent that participants perceived their settings to have sufficient resources to achieve the goals of the organisation, and the extent that these settings offered favourable environments for employees, as expected, impacted on the factors that those participants indicated were the most relevant to productivity. Most noticeably, the participants indicated that "Re-work" and "Working 7 days per week without taking a holiday" would be less likely to negatively affect productivity in contexts that were appropriately resourced in terms of materials, equipment and personnel and in which were favourable for employees. Arguably the participants perceived a connection between paucity of resources and defect occurrence, and therefore productivity hampered by "Re-work", and/or an exacerbation of productivity issues caused by employees working in unfavourable environments for prolonged periods.

The participants also indicated that "Tool and equipment shortages," "Unsuitability of materials storage location," "Labour absenteeism" would be less likely to negatively affect productivity in companies where resource provision was deemed by those participants to be adequate for the purposes of meeting the objectives of the organisation. This was arguably a predictable result as it should be expected that perceptions of a setting with satisfactory resources would be that it would be one less troubled by hindrances to productivity generally.

4.4.4 "Involvement" and productivity factors

The relative usage of the employee empowerment factor, "Involvement", was statistically significantly correlated with the following factors that would negatively affect labour productivity: Tool and equipment shortages, Unsuitability of materials storage location, Drawings and specifications alteration during execution, Inspection delay, Rework, Inefficiency of equipment, Low quality of materials, Working 7 days per week without taking a holiday, Lack of labour experience, Labour dissatisfaction, Misunderstanding among labour, Labour absenteeism, Augmentation of government regulations, Payment delay, Lack of financial motivation system and Increasing number of labours.

Specifically, the relative usage of the employee empowerment factor, "Involvement", was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.01 level of significance:

- Inefficiency of equipment (r = -0.52, p< 0.01)
- Labour absenteeism (r = -0.52, p< 0.01)
- Lack of labour experience (r = -0.48, p< 0.01)
- Unsuitability of materials storage location (r = -0.48, p< 0.01)
- Unemployment of safety officer on the construction site (r = -0.45, p< 0.01)

The relative usage of "Involvement" was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.05 level of significance:

- Tool and equipment shortages (r = -0.39, p< 0.05)
- Inspection delay (r = -0.37, p< 0.05)
- Rework (r = -0.37, p< 0.05)
- Low quality of materials (r = -0.35, p< 0.05)

- Working 7 days per week without taking a holiday (r = -0.34, p< 0.05)
- Labour dissatisfaction (r = -0.36, p< 0.05)
- Augmentation of government regulations (r = -0.41, p< 0.05)
- Payment delay (r = -0.34, p< 0.05)
- Lack of financial motivation system (r = -0.34, p< 0.05)

Nonetheless, the negative correlation indicated that an increase rating of the relative usage of "Involvement" would correspond to a decrease rating of the factors negatively affecting labour productivity, including, Inefficiency of equipment, Labour absenteeism, Lack of labour experience, Unsuitability of materials storage location, Tool and equipment shortages, Inspection delay, Rework, Low quality of materials, Working 7 days per week without taking a holiday, Labour dissatisfaction, Augmentation of government regulations, Payment delay, and Lack of financial motivation system.

In other words, the more relative concurrent usage of the employee empowerment factor, "Involvement", the less participants believed that the following factors, Inefficiency of equipment, Labour absenteeism, Lack of labour experience, Unsuitability of materials storage location, Tool and equipment shortages, Inspection delay, Rework, Low quality of materials, Working 7 days per week without taking a holiday, Labour dissatisfaction, Augmentation of government regulations, Payment delay, and Lack of financial motivation system, would negatively affect labour productivity.

The relative usage of "Involvement" was statistically significantly positively correlated with Increasing number of labours at the 0.05 level of significance (r = 0.34, p< 0.05). This indicated that an increase rating of the relative usage of "Involvement" would correspond to an increase rating of the factor negatively affecting labour productivity, Increasing number of labours. In other words, the more relative concurrent usage of the employee empowerment factor, "Involvement", the more participants believed that "Increasing number of labours" would negatively affect labour productivity.

4.4.4.1 Discussion

On reflection, it was noted that participants indicated that "Inefficiency of equipment" would be less likely to negatively affect productivity in settings exhibiting behaviours consistent with the employee empowerment factor of "Involvement." This was expected to be so as in settings where employees were involved in the decision-making processes and where their grievances and concerns were more likely to be heard, then there would be more opportunity for operation level employees and middle management to appreciate efficiency issues relating to plant equipment. For example, one of the respondents from Company C referred to an on-going issue relating to a factory overhead crane which in the respondent's opinion had needed to be replaced. The respondent commented that while the complaint had been made for some time, the response from the top management was that the overhead crane was to continue to be maintained. This maintenance was believed to adversely affecting plant productivity due to downtime during non-routine maintenance.

When companies exhibited behaviours consistent with the employee empowerment factor of "Involvement", such as through involving employees in decision-making, communicating with customers, and providing formal grievance procedure and employee satisfaction surveys, the participants believed that factors such as "Labour absenteeism" and "Lack of labour experience" would be less likely to negatively affect productivity. Arguably when employees feel more involved with their workplaces then they are more likely to attend and more likely to learn on the job which would arguably mitigate productivity issues arising from the employee's inexperience.

4.4.5 "Education/training" and productivity factors

The relative usage of the employee empowerment factor, "Education/training", was statistically significantly correlated with the following factors that would negatively affect labour productivity: Lack of financial motivation system, Lack of training sessions, Lack of labour surveillance, and Working overtime.

The relative usage of “Education/training” was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.05 level of significance:

- Lack of financial motivation system (r = -0.38, p< 0.05)
- Lack of training sessions (r = -0.38, p< 0.05)

Nonetheless, the negative correlation indicated that an increase rating of the relative usage of “Education/training” would correspond to a decrease rating of the factors negatively affecting labour productivity, including, Lack of financial motivation system and Lack of training sessions. In other words, the more relative concurrent usage of the employee empowerment factor, “Education/training”, the less participants believed that the following factors, Lack of financial motivation system and Lack of training sessions, would negatively affect labour productivity.

The relative usage of “Education/training” was statistically significantly positively correlated with Lack of labour surveillance at the 0.05 level of significance (r = 0.39, p< 0.05) and was statistically significantly positively correlated with "Working overtime" at the 0.05 level of significance (r = 0.43, p< 0.05). This indicated that an increase rating of the relative usage of “Education/training” would correspond to an increase rating of the factors negatively affecting labour productivity, Lack of labour surveillance of labours and Working overtime. In other words, the more relative concurrent usage of the employee empowerment factor, “Education/training”, the more participants believed that “Lack of labour surveillance of labours” and “Working overtime”, would negatively affect labour productivity.

4.4.5.1 Discussion

Four observations may be made from the results concerning the employee empowerment factor of "Education/Training" and the impact its usage was believed to have on productivity as well as through taking into consideration the broader interview responses of the participants. Firstly, it should be noted that the respondents to the interview highlighted that there was very little support for training of labour from company top management. Such a view is consistent with Nesan (2004) who reports that high employee turnover in construction sectors discourages employee development programs.

Notwithstanding this, there were some patterns identified from participants' responses in relation to the impact exhibited behaviours consistent with the employee empowerment factor of "Education/Training" could have on factors relevant to productivity. As mentioned, there was link between the relative usage of behaviour exhibiting "Education/Training" and the extent that "Lack of financial motivation system" was perceived to adversely affect productivity. This could suggest that the respondents knowingly, or unknowingly, considered that formal training could replace to some extent the importance of formal financial motivation systems. Alternatively, the participants may be responding to a phenomena that more informed and knowledgeable personnel are more likely to meet productivity goals and therefore receive better financial motivation.

Another one of the observations that can be made is that the connection between perceived usage of behaviours consistent with the employee empowerment factor of "Education/Training" and relative importance of "Lack of training sessions" on productivity is an indication that respondents believe that certain interventions such as using an employee skill development program, publishing a training-focused newsletter, using educational materials such as posters, could mitigate some of the adverse impact of not having sufficient formal training sessions for labour.

The final observation commented on here was a finding that the responses from the participants suggested that as behaviours consistent with the employee empowerment factor of "Education/Training" were increasingly exhibited, "Working overtime" was increasingly believed to adversely affect productivity. This may reflect a concern by respondents that training related interventions can extend the working day for employees, which can lead to fatigue and therefore lead to increased adverse effect on productivity. Alternatively, this result could be a reflection of the current situation at the three companies in which extensive onsite job training is provided to new employees.

Interview responses from production engineers highlighted the impact that this induction training had on the sites overall, namely, frequently requiring pre-existing employees to work overtime to meet operational goals during onsite job training of new employees. Removing supervisors from surveillance duties in order to place them into educating roles, in this context, could also go some way to explaining the relationship observed between "Education/Training" and "Lack of labour surveillance".

4.4.6 "Teamwork" and productivity factors

The relative usage of the employee empowerment factor, "Teamwork", was statistically significantly correlated with the following factors that would negatively affect labour productivity: Unsuitability of materials storage location, Inefficiency of equipment, and Payment delay.

The relative usage of "Teamwork" was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.05 level of significance:

- Unsuitability of materials storage location (r = -0.42, $p < 0.05$)
- Inefficiency of equipment (r = -0.39, $p < 0.05$)
- Payment delay (r = -0.36, $p < 0.05$)

Nonetheless, the negative correlation indicated that an increase rating of the relative usage of "Teamwork" would correspond to a decrease rating of the factors negatively affecting labour productivity, including, Unsuitability of materials storage location, Inefficiency of equipment, and Payment delay.

In other words, the more relative concurrent usage of the employee empowerment factor, "Teamwork", the less participants believed that the following factors, Unsuitability of materials storage location, Inefficiency of equipment, and Payment delay, would negatively affect labour productivity.

4.4.6.1 Discussion

As mentioned, the results suggested that productivity issues such as "Unsuitability of materials storage location" and "Inefficiency of equipment" could be mitigated through increased exhibition of behaviour related to employee empowerment factor of "Teamwork". This finding bears some similarities to the findings concerning the employment empowerment factor of "Involvement" in that as employees are given more opportunity to work collaboratively and express concerns, it is likely that operation processes will become more efficient.

A relationship was found between perceptions concerning the adverse effect of the productivity factor of "Payment delay" and exhibiting behaviours consistent with the employee empowerment factor of "Teamwork". It was noted that as respondents believed their organisation increasingly held regular meetings, supported advisory committees, developed cross-functional teams, and supported quality improvement teams, then the adverse effect of "Payment delay" on productivity would be decreased. It could be speculated that organisations that include those team-based activities are more likely to engender trust from their employees and therefore are less likely to suffer adverse consequences in the event of temporary solvency issues.

4.4.7 "Process improvement" and productivity factors

The relative usage of the employee empowerment factor, "Process improvement", was statistically significantly correlated with the following factors that would negatively affect labour productivity: Tool and equipment shortages, Unsuitability of materials storage location, Rework, Misunderstanding between labour and superintendents, Inefficiency of equipment, Working 7 days per week without taking a holiday, Lack of labour experience, Labour dissatisfaction, Misunderstanding among labour, Labour absenteeism, Payment delay, and Lack of training sessions.

Specifically, the relative usage of the employee empowerment factor, "Process improvement", was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.01 level of significance:

- Labour absenteeism (r = -0.57, p< 0.01)
- Tool and equipment shortages (r = -0.43, p< 0.01)

The relative usage of “Process improvement” was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.05 level of significance:

- Labour dissatisfaction (r = -0.42, p< 0.05)
- Payment delay (r = -0.41, p< 0.05)
- Misunderstanding among labour (r = -0.40, p< 0.05)
- Lack of training sessions (r = -0.39, p< 0.05)
- Lack of labour experience (r = -0.39, p< 0.05)
- Inefficiency of equipment (r = -0.39, p< 0.05)
- Working 7 days per week without taking a holiday (r = -0.36, p< 0.05)
- Rework (r = -0.36, p< 0.05)
- Unsuitability of materials storage location (r = -0.35, p< 0.05)
- Misunderstanding between labour and superintendents (r = -0.35, p< 0.05)

Nonetheless, the negative correlation indicated that an increase rating of the relative usage of “Process improvement” would correspond to a decrease rating of the factors negatively affecting labour productivity, including, Labour absenteeism, Tool and equipment shortages, Labour dissatisfaction , Payment delay, Misunderstanding among labour, Lack of training sessions, Lack of labour experience, Inefficiency of equipment, Working 7 days per week without taking a holiday , Rework, Unsuitability of materials storage location, and Misunderstanding between labour and superintendents.

In other words, the more relative concurrent usage of the employee empowerment factor, “Process improvement”, the less participants believed that the following factors, Labour absenteeism, Tool and equipment shortages, Labour dissatisfaction , Payment delay, Misunderstanding among labour, Lack of training sessions, Lack of labour experience, Inefficiency of equipment, Working 7 days per week without taking a holiday , Rework, Unsuitability of materials storage location, and Misunderstanding between labour and superintendents, would negatively affect labour productivity.

4.4.7.1 Discussion

Placing employees in control of their respective tasks, increasing two-way communication, and introducing statistical analysis was found to have a significant relationship with "Labour Absenteeism" based on the responses of the participants. Arguably increasing employee autonomy and accountability has a positive impact on worksite attendance.

Exhibiting these behaviours was also found to be perceived as likely to reduce the negative impact of "Tools and equipment shortages" on productivity. This is possibly due to the fact that employees feel more responsible for their respective tasks and the use of these features would most likely lead to more awareness of historical and future requirements relating to tools and equipment. Thus through improving organisational awareness of processes the adverse effects on productivity that factors such as "Inefficiency of equipment" and "Re-work" would have could be reduced.

Features of "Process Improvement" such as jobsite improvement plans can also encourage awareness of personnel and material issues. Thus by implementing these plans it is likely that problems can be resolved or at least anticipated and adverse effects on productivity can be minimised. The connection here found in relation to "Process Improvement" and "Labour Dissatisfaction", "Payment delay", "Misunderstanding among labour" and "Misunderstanding between labour and superintendents" could be evidence, albeit not conclusive evidence, of potential benefits of jobsite improvement plans.

4.4.8 “Measurement” and productivity factors

The relative usage of the employee empowerment factor, “Measurement”, was statistically significantly correlated with the following factors that would negatively affect labour productivity: Inspection delay, Rework, Misunderstanding between labour and superintendents, Working 7 days per week without taking a holiday, Labour dissatisfaction, Labour absenteeism, Interference, Payment delay, Non-provision of transport means, and Increasing number of labours.

Specifically, the relative usage of the employee empowerment factor, “Measurement”, was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.01 level of significance:

- Payment delay (r = -0.54, p< 0.01)
- Interference (r = -0.53, p< 0.01)
- Labour absenteeism (r = -0.46, p< 0.01)
- Misunderstanding between labour and superintendents (r = -0.44, p< 0.01)
- Rework (r = -0.43, p< 0.01)

The relative usage of “Measurement” was statistically significantly negatively correlated with the following factors that would negatively affect labour productivity at the 0.05 level of significance:

- Inspection delay (r = -0.41, p< 0.05)
- Working 7 days per week without taking a holiday (r = -0.37, p< 0.05)
- Labour dissatisfaction (r = -0.37, p< 0.05)
- Non-provision of transport means (r = -0.33, p< 0.05)

Nonetheless, the negative correlation indicated that an increase rating of the relative usage of “Measurement” would correspond to a decrease rating of the factors negatively affecting labour productivity, including, Payment delay, Interference, Labour absenteeism, Misunderstanding between labour and superintendents, Rework, Inspection delay, Working 7 days per week without taking a holiday, Labour dissatisfaction, and Non-provision of transport means.

In other words, the more relative concurrent usage of the employee empowerment factor, “Measurement”, the less participants believed that the following factors, Payment delay, Interference, Labour absenteeism, Misunderstanding between labour and superintendents, Rework, Inspection delay, Working 7 days per week without taking a holiday, Labour dissatisfaction, and Non-provision of transport means, would negatively affect labour productivity.

The relative usage of “Measurement” was statistically significantly positively correlated with Increasing number of labours at the 0.05 level of significance (r = 0.41, p< 0.05). This indicated that an increase rating of the relative usage of “Measurement” would correspond to an increase rating of the factor negatively affecting labour productivity, Increasing number of labours. In other words, the more relative concurrent usage of the employee empowerment factor, “Measurement”, the more participants believed that “Increasing number of labours” would negatively affect labour productivity.

4.4.8.1 Discussion

There were relatively strong connections between the quality of measurement at plants and factors affecting productivity. The strongest of these require mention here. Firstly, the responses of the participants indicated that "Payment delay", "Interference", and "Labour absenteeism" would each be less likely to adversely affect productivity in settings where thorough measurement procedures had been implemented. Arguably the presence of an employee performance evaluation would go some way to decreasing the extent that "Interference" and non-attendance impacts on productivity.

Based on the results it could be speculated that benchmarking and regular inspection each positively impact on productivity through increasing the likelihood that elements will be fabricated accurately the first time and that inspection will take place without delay. Here, responses suggested that participants believed proactive and comprehensive measurement would reduce the adverse effects of "Misunderstanding between labour and superintendents, "Re-work" and "Inspection delay."

4.4.9 "Recognition" and productivity factors

The relative usage of the employee empowerment factor, "Recognition", was statistically significantly correlated with the following factors that would negatively affect labour productivity: Lack of financial motivation system and Unsuitability of materials storage location. Specifically, the relative usage of the employee empowerment factor, "Recognition", was statistically significantly negatively correlated with "Lack of financial motivation system" at the 0.01 level of significance (r = -0.56, p< 0.01) and was statistically significantly negatively correlated with "Unsuitability of materials storage location" at the 0.05 level of significance (r = -0.33, p< 0.05).

Nonetheless, the negative correlation indicated that an increase rating of the relative usage of "Recognition" would correspond to a decrease rating of the factors negatively affecting labour productivity, including, Lack of financial motivation system and Unsuitability of materials storage location. In other words, the more relative concurrent usage of the employee empowerment factor, "Recognition", the less participants believed that the following factors, Lack of financial motivation system and Unsuitability of materials storage location, would negatively affect labour productivity.

4.4.9.1 Discussion

In this study, participants identified that having formal procedures for recognising employee performance and achievement reduced the negative impact that wide selection of productivity factors would have.

The factor which stood out however in relation to the employee empowerment factor of "Recognition" was "Lack of financial motivation system". Arguably as found for the employee empowerment factor of "Education/Training", there could be some event of displacement. In other words, the participants may have found that employees who had been recognised were less likely to respond adversely to a "Lack of financial motivation system" and thereby productivity would be less adversely affected.

Table 4.26 presents the ***correlation*** for 9 ***labour empowerment*** factors across 43 ***labour productivity*** factors.

Table 4.26: Pearson's correlation coefficients for the relative usage of the 9 empowerment factors and the 43 factors negatively affecting labour productivity

	Leader-ship	Empower-ment system	Resource Develop't	Involve-ment	Educat'n Train'ng	Team-work	Process Improvem't	Measure-ment	Recog-nition
Material shortages	-0.22	-0.14	-0.20	-0.18	0.20	-0.02	-0.28	-0.17	0.10
Tool and equipment shortages	-0.39*	-0.34*	-0.47**	-0.39*	-0.08	-0.32	-0.43**	-0.32	-0.08
Unsuitable material storage local	-0.49**	-0.16	-0.47**	-0.48**	-0.13	-0.42*	-0.35*	-0.09	-0.33*
Drawings & specs change at work	-0.17	-0.28	-0.34*	-0.16	-0.01	-0.09	-0.23	-0.20	-0.18
Inspection delay	-0.10	-0.11	-0.44**	-0.37*	-0.03	-0.12	-0.09	-0.40*	-0.26
Rework	-0.28	-0.35*	-0.48**	-0.37*	-0.17	-0.25	-0.36*	-0.43**	-0.27
Supervisors" absenteeism	-0.14	-0.11	-0.14	-0.22	-0.03	-0.25	-0.17	-0.21	-0.02
Lack of labour surveillance	-0.02	0.16	0.14	0.14	0.39*	0.26	0.02	0.13	0.18
Misunderstanding labour & super	-0.28	-0.38*	-0.25	-0.22	-0.03	-0.18	-0.35*	-0.44**	0.08
Lack of periodic labour meetings	-0.24	-0.11	-0.07	-0.13	0.09	0.02	-0.13	0.03	0.06
Inefficiency of equipment	-0.45**	-0.30	-0.43**	-0.52**	-0.09	-0.39*	-0.39*	-0.25	-0.21
Low quality of raw materials	-0.44**	-0.17	-0.24	-0.35*	-0.08	-0.07	-0.20	-0.04	-0.22
High quality of required work	0.00	0.10	-0.01	0.05	0.19	0.03	-0.05	-0.20	0.22
Working 7 dys/wk & no holiday	-0.35*	-0.14	-0.48**	-0.34*	-0.16	-0.24	-0.36*	-0.36*	-0.02
Misuse of time schedule	-0.26	-0.13	-0.17	-0.27	0.00	0.02	-0.15	-0.27	0.03
Method of employmnt direct work	0.03	-0.07	0.06	-0.06	0.21	0.18	-0.07	0.05	0.22
Increasing number of labours	0.24	0.03	0.39*	0.34*	0.25	0.29	0.15	0.41*	0.28
Working overtime	0.16	0.10	0.14	0.25	0.43**	-0.02	-0.02	0.02	0.32
Lack of labour experience	-0.56**	-0.43**	-0.41*	-0.48**	-0.24	-0.17	-0.39*	-0.22	-0.22
Labour disloyalty	-0.29	0.00	-0.09	-0.12	-0.06	-0.08	-0.15	-0.12	0.00
Labour dissatisfaction	-0.52**	-0.29	-0.43**	-0.36*	-0.07	-0.29	-0.42*	-0.37*	-0.29
Misunderstanding among labour	-0.44**	-0.54**	-0.39*	-0.32	0.01	-0.27	-0.40*	-0.25	-0.09
Lack of competition	-0.34*	-0.03	-0.29	-0.26	-0.07	0.06	-0.16	-0.11	-0.17
Increase of labourer age	-0.30	-0.02	-0.15	-0.21	-0.19	-0.05	-0.14	0.11	-0.20
Labour absenteeism	-0.48**	-0.43**	-0.47**	-0.52**	-0.25	-0.23	-0.57**	-0.46**	-0.22
Labour personal problems	-0.12	-0.12	-0.23	-0.21	0.04	0.20	-0.16	-0.13	-0.09
Working within a confined space	-0.35*	-0.08	-0.20	-0.18	-0.02	-0.02	-0.11	0.14	-0.20
Interference	-0.08	-0.28	-0.33*	-0.31	-0.05	-0.16	-0.31	-0.53**	-0.08
Construction method	-0.06	0.01	-0.16	0.02	0.17	0.13	-0.05	0.18	0.00
Type of activities in the project	-0.27	-0.03	-0.13	-0.19	0.09	-0.08	-0.15	-0.12	-0.22
Augmentation of government regs	-0.52**	-0.12	-0.46**	-0.41*	-0.23	-0.30	-0.31	-0.18	-0.31
Payment delay	-0.13	-0.35*	-0.38*	-0.34*	-0.07	-0.36*	-0.41*	-0.54**	-0.11
Lack of financial motivation systm	-0.31	0.12	-0.45**	-0.34*	-0.38*	-0.21	-0.23	-0.26	-0.56**
Lack of labour recognition prog	-0.18	0.02	-0.16	-0.02	-0.08	-0.21	-0.25	-0.12	-0.28
Non-provision of transport means	-0.25	-0.19	-0.32	-0.36*	0.02	-0.24	-0.32	-0.33*	-0.19
Lack of place for eating/rest	0.11	-0.04	-0.01	0.04	0.18	0.06	-0.14	0.00	0.07
Lack of training sessions	-0.39*	-0.37*	-0.04	-0.37*	-0.38*	-0.15	-0.39*	-0.15	-0.20
Accidents	-0.25	0.00	-0.23	-0.29	-0.13	-0.11	-0.18	-0.17	-0.28
Violation of safety precautions	-0.01	0.11	0.26	0.22	0.32	0.14	-0.01	0.15	0.15
Bad ventilation	-0.26	-0.14	-0.28	-0.28	0.00	-0.21	-0.11	-0.13	-0.19
Working at high places	-0.17	-0.01	-0.05	-0.25	-0.10	0.03	-0.17	-0.10	-0.16
Unemployment of site safety officer	-0.28	-0.18	-0.24	-0.45**	-0.10	-0.06	-0.24	-0.18	-0.16
Noise	0.13	0.38*	0.16	0.11	0.12	0.25	0.10	0.20	0.04

Note: * significance at the 0.05 level; ** significance at the 0.01 level. N= 36

4.5 Statistical process control of productivity rate input/output

As explained in section 3.7.4 of the previous chapter, case studies were performed in off-site construction (productivity) to measure empirically the current labour productivity of the off-site construction by implementing statistical quality control.

The data of actual manpower deployed (total hours) and volume m^3 were collected from two companies with respect to four different elements, namely, Hollow core slabs (HCS), circulation tables, structural element, and panel element, through December 1, 2012 to January 31, 2013.

Productivity rate was defined as output/input with total hours = input, and volume m^3 = output. In this section, results of the analysis of statistical quality control for productivity rate are presented.

4.5.1 Productivity rate, hollow core slabs

Table 4.27 shows the descriptive statistics of total hours in the section of Hollow core slabs, by company. The results of the skewness, kurtosis, and Shapiro Wilk test indicated that the data were not from normal distributions. The results of the first order autocorrelation (0.348 for Company B and 0.356 for Company C) suggest that the autocorrelation was not excessive (Wheeler, 1991).

Table 4.27: Descriptive statistics of productivity rate in the section of Hollow core slabs, by company. SW test: p-value of the Shapiro Wilk test of normality

Company	Mean($\bar{x}$)	Standard deviation	$\bar{R}$	Skewness	Kurtosis	SW test	1^{st} order autocorrelation
B	0.36	0.15	0.12	0.09	-0.18	0.3232	0.348
C	2.43	1.20	1.03	0.48	0.44	0.0369	0.356

Figures 4.1- 4.4 show the Shewhart control chart, the moving range control chart, and the EWMA control chart for productivity rate of "Hollow core slabs" in Company B and Company C.

The Shewhart control charts for productivity rate in Figure 4.1 and Figure 4.3 show the distribution of the observations of productivity rate of "Hollow core slabs" in Company B and Company C. The average moving range of Company B was 0.12 and the average moving range of Company C was 1.03, indicating that the process variability was greater in Company C than in Company B. As the data were not normally distributed, we would not use the control limits to conclude if the production process was in statistical control.

The EWMA control chart for productivity rate of "Hollow core slabs" in Company B (Figure 4.2) signalled that the production process was out of control during the following period of time: December 03, 2012 and January 20, 2013. Further investigation should be conducted for the cause of the out of control production activities.

Note that the control limits increased in width asi increased from i = 1, 2, . . . , until they stabilized at the steady state values of (LCL, UCL) = (0.21, 0.51). There were no data available for the following dates: December 7, 2012, December 14, 2012, December 21, 2014, December 28, 2012, January 4, 2013, January 7, 2013, January 11, 2013, January 18, 2013, and January 25, 2013.

The EWMA control chart for productivity rate of "Hollow core slabs" in Company C (Figure 4.4) signalled that the production process was out of control on January 30, 2013. Further investigation should be conducted for the cause of the out of control production activities.

Note that the control limits increased in width as i increased from i = 1, 2, . . . , until they stabilized at the steady state values of (LCL, UCL) = (1.20, 3.67). Further investigation should be conducted for the cause of the out of control production activities.There were no data available for the following dates: December 1, 2012, December 7, 2012, December 14, 2012, December 15, 2012, December 19, 2012, December 21, 2014, December 28, 2012, January 4, 2013, January 11, 2013, January 17, 2013, January 18, 2013, and January 25-27, 2013.

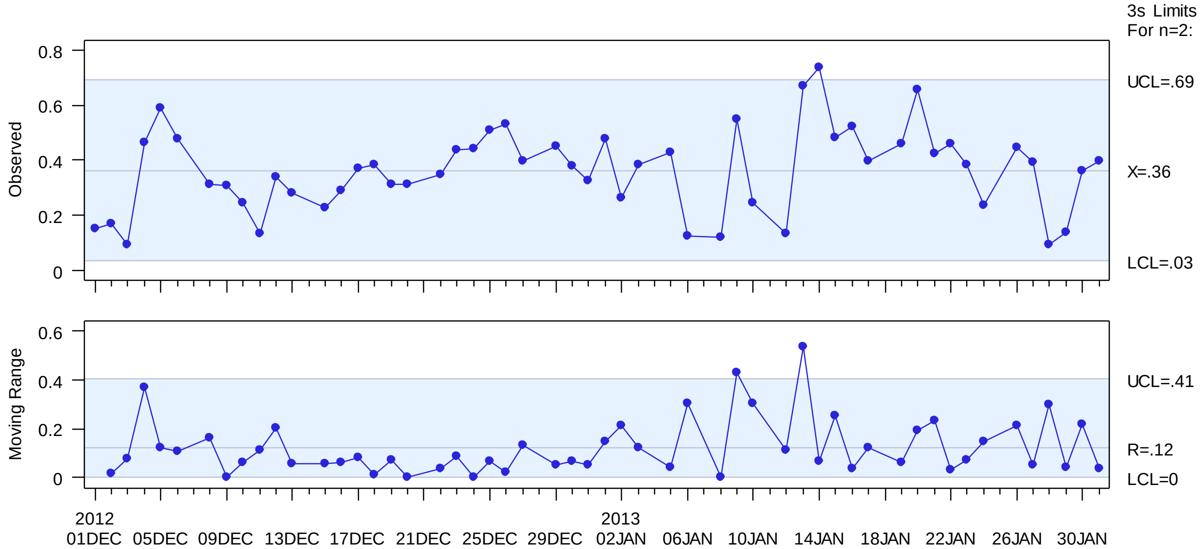

Figure 4.1: The Shewhart control chart and the moving range control chart for productivity rate, Hollow core slabs, Company B

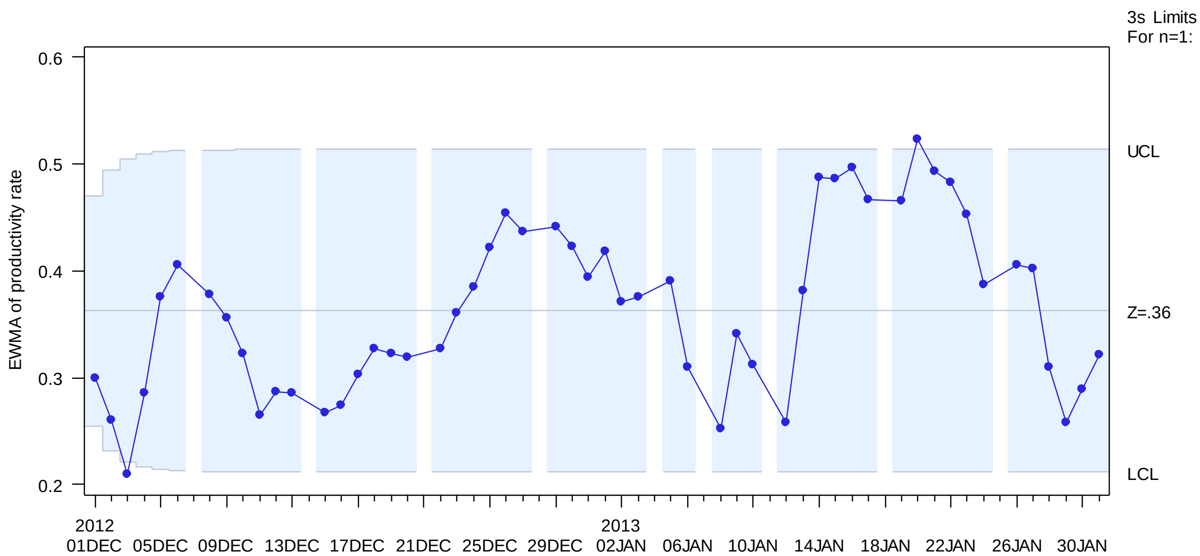

Figure 4.2: The EWMA control chart for productivity rate, Hollow core slabs, Company B

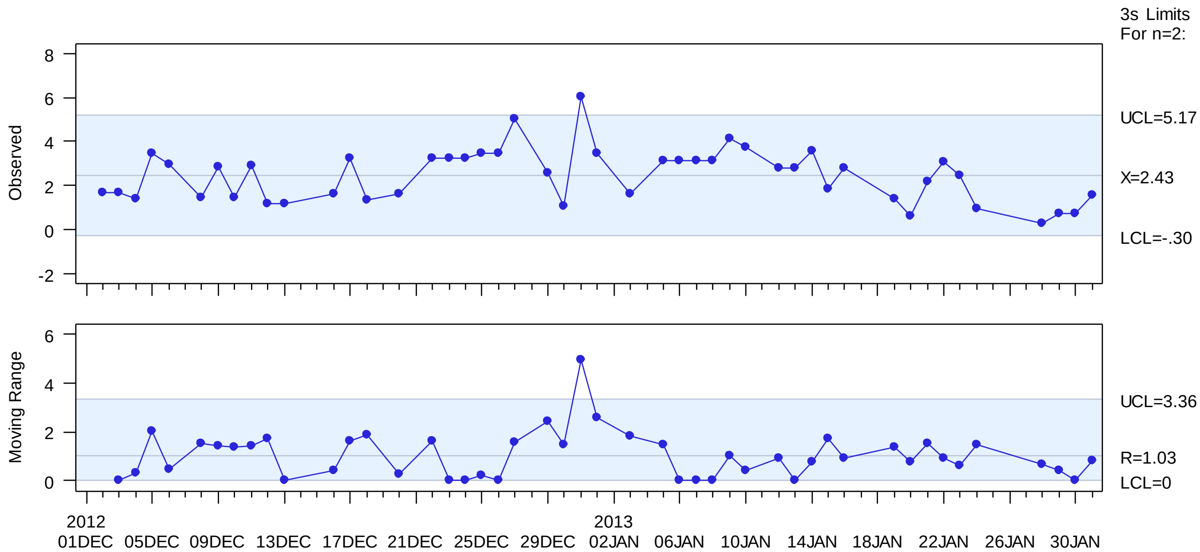

Figure 4.3: The Shewhart control chart and the moving range control chart for productivity rate, Hollow core labs, Company C

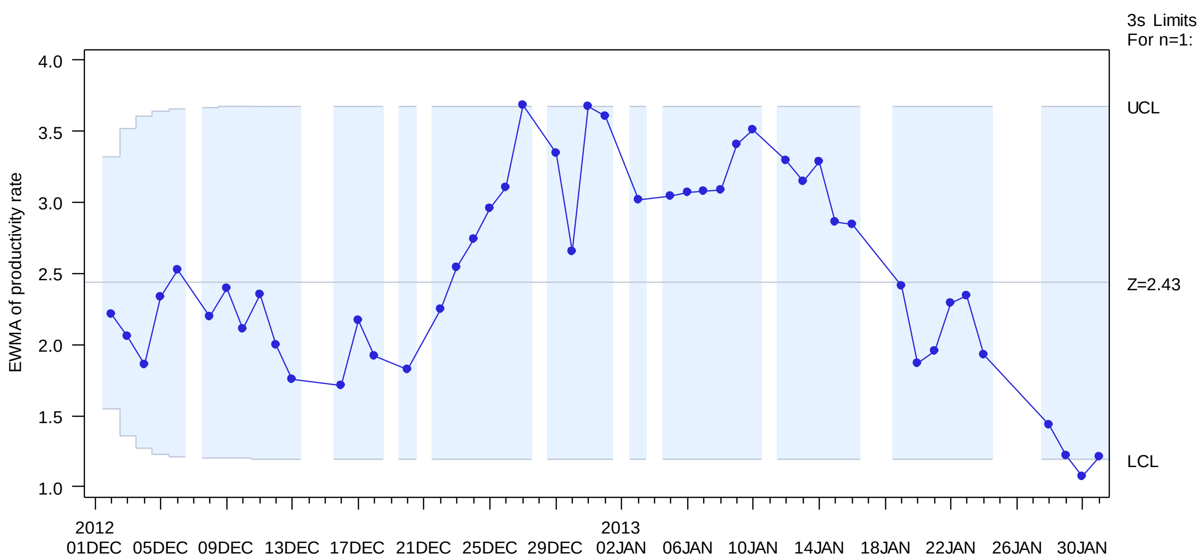

Figure 4.4: The EWMA control chart for productivity rate, Hollow core slabs, Company C

4.5.2 Productivity rate, circulation tables

Table 4.28 shows the descriptive statistics of total hours in the section of circulation tables, by company. The results of the skewness, kurtosis, and Shapiro Wilk test indicated that the data were from normal distributions. The results of the 1st order autocorrelation (0.681 for Company B and 0.497 for Company C) suggest that the autocorrelation was not excessive (Wheeler, 1991).

Table 4.28: Descriptive statistics of productivity rate in the section of circulation tables, by company. SW test: p-value of the Shapiro Wilk test of normality

Company	Mean($\bar{x}$)	Standard deviation	$\bar{R}$	Skewness	Kurtosis	SW test	1st order autocorrelation
B	0.07	0.02	0.01	-0.61	0.28	0.1881	0.681
C	0.04	0.02	0.01	0.23	-0.74	0.3134	0.497

Figures 4.5- 4.8 show the Shewhart control chart, the moving range control chart, and the EWMA control chart for productivity rate of “circulation tables” in Company B and Company C.

The Shewhart control charts for productivity rate in Figure 4.5 and Figure 4.7 show the distribution of the observations of productivity rate of “circulation tables” in Company B and Company C. The average moving range of Company B was 0.01 and the average moving range of Company C was 0.01, indicating that the process variability was similar in both companies. As the data were normally distributed, the Shewhart control charts, the moving average charts and the EWMA control charts were all appropriate to be used to conclude if the production process was in statistical control.

For Company B, the Shewhart control chart indicated that the production process was out of control during the following period of time: December 11-12, 2012, and December 20-24, 2012; the moving average control chart suggested that the production process was out of control on December 31, 2012. The EWMA control chart for productivity rate of “circulation tables” in Company B (Figure 4.6) signalled that the production process was out of control during the following period of time: December 08-16, 2012 and December 20-30, 2012. Further investigation should be conducted for the cause of the out of control production activities.

Note that the control limits increased in width asi increased from i = 1, 2, . . . ,, until they stabilized at the steady state values of (LCL, UCL) = (0.06, 0.08). There were no data available for the following dates: December 7, 2012, December 14, 2012, December 21, 2014, December 28, 2012, January 4, 2013, January 11, 2013, January 18, 2013, and January 25, 2013.

For Company C, the Shewhart control chart indicated that the production process was out of control during the on January 30, 2013; the moving average control chart suggested that the production process was out of control during the following period of time: December 3-4, 2012, December 10-12, 2012, and January 23-31, 2013. The EWMA control chart for productivity rate of “circulation tables” in Company C (Figure 4.8) signalled that the production process was out of control during the following period of time: December 08-16, 2012 and December 20-30, 2012; with further investigation to be conducted for the cause of the out of control production activities.

Note that the control limits increased in width asi increased from i = 1, 2, . . . , until they stabilized at the steady state values of (LCL, UCL) = (0.02, 0.06). There were no data available for the following dates: December 7, 2012, December 11, 2012, December 14, 2012, December 21, 2014, December 28, 2012, January 4, 2013, January 11, 2013, January 18, 2013, and January 25, 2013.

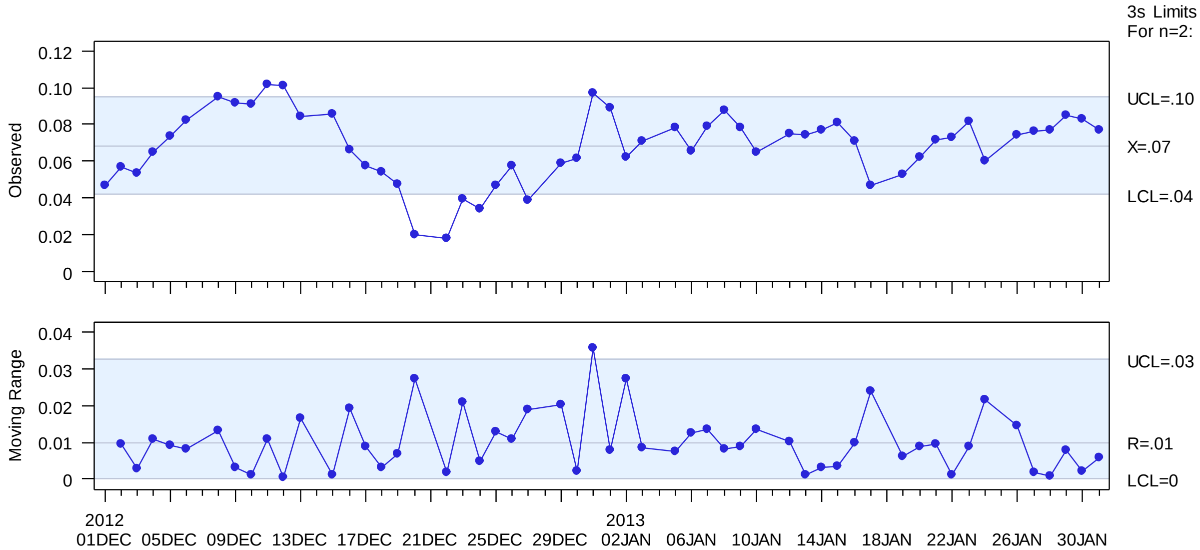

Figure 4.5: The Shewhart control chart and the moving range control chart for productivity rate, circulation tables, Company B

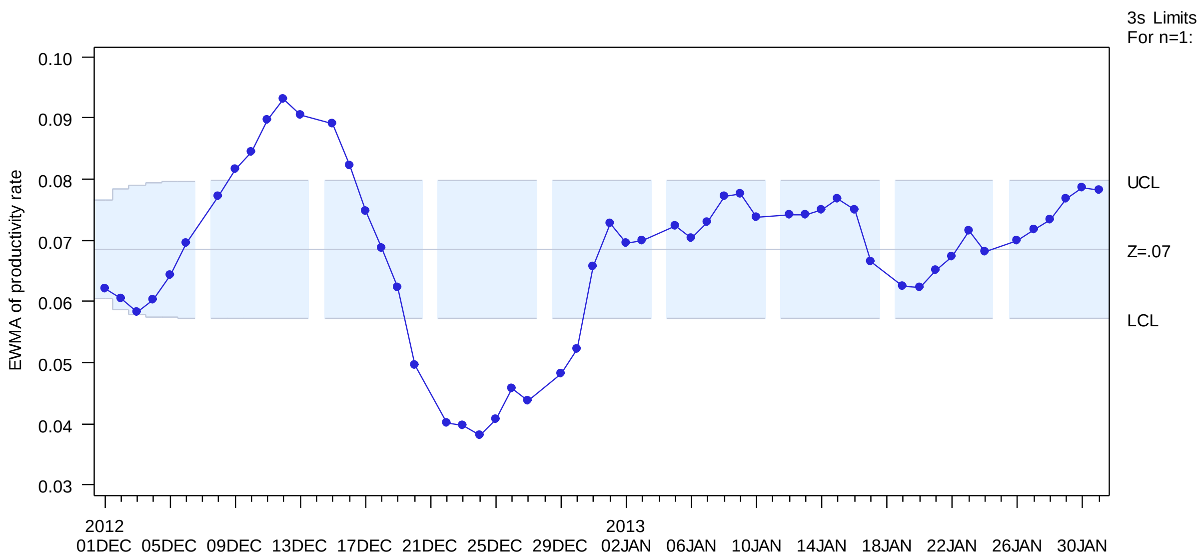

Figure 4.6: The EWMA control chart for productivity rate, circulation tables, Company B

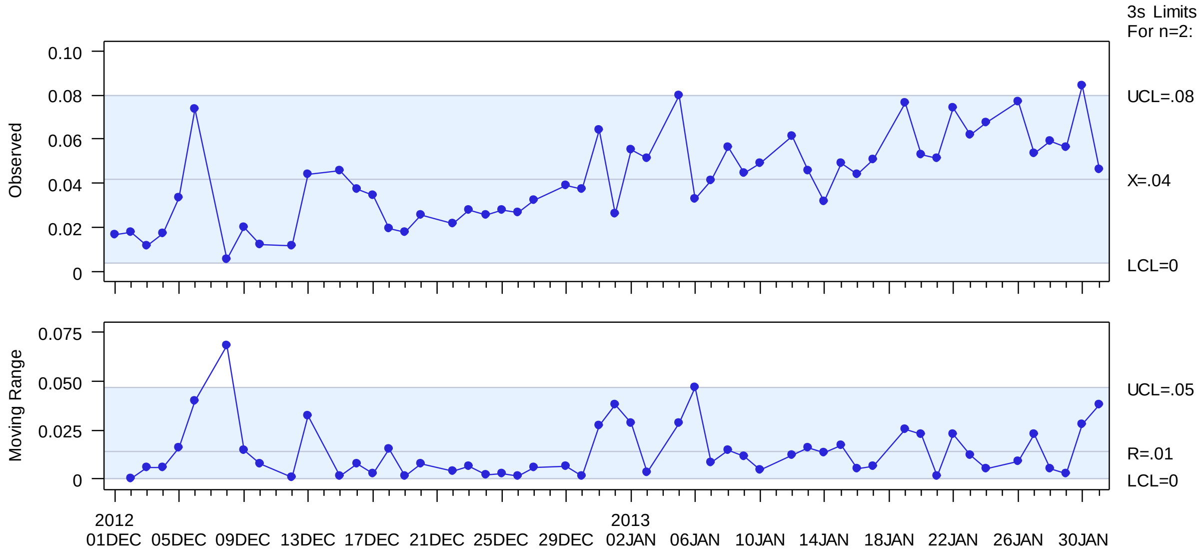

Figure 4.7: The Shewhart control chart and the moving range control chart for productivity rate, circulation tables, Company C

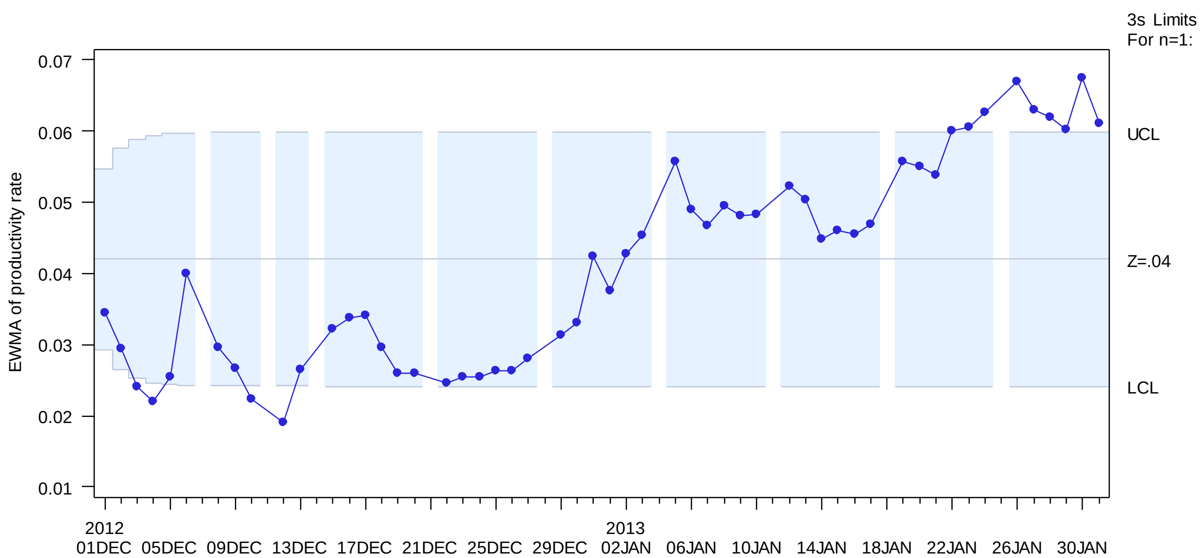

Figure 4.8: The EWMA control chart for productivity rate, circulation tables, Company C

4.5.3 Productivity rate, structural element

Table 4.29 shows the descriptive statistics of total hours in the section of structural element, by company. The results of the skewness, kurtosis, and Shapiro Wilk test indicated that the data were not from normal distributions. The results of the 1st order autocorrelation (0.451 for Company B and -0.065 for Company C) suggest that the autocorrelation was not excessive (Wheeler, 1991).

Table 4.29: Descriptive statistics of productivity rate in the section of structural element, by company. SW test: p-value of the Shapiro Wilk test of normality

Company	Mean($\bar{x}$)	Standard deviation	$\bar{R}$	Skewness	Kurtosis	SW test	1st order autocorrelation
B	0.05	0.02	0.02	1.22	3.45	0.0010	0.451
C	0.07	0.02	0.02	1.25	4.06	0.0019	-0.065

Figures 4.9- 4.12 show the Shewhart control chart, the moving range control chart, and the EWMA control chart for productivity rate of "structural element" in Company B and Company C.

The Shewhart control charts for productivity rate in Figure 4.9 and Figure 4.11 show the distribution of the observations of productivity rate of "structural element" in Company B and Company C. The average moving range of Company B was 0.02 and the average moving range of Company C was 0.02, indicating that the process variability was similar in both companies. As the data were not normally distributed, the EWMA control charts were appropriate to be used to conclude if the production process was in statistical control.

The EWMA control chart for productivity rate of "structural element" in Company B (Figure 4.10) signalled that the production process was out of control during the following period of time: December 4-13, 2012 and December 24-26, 2012. Further investigation should be conducted for the cause of the out of control production activities. It should be noted that:

(noted that:) the control limits increased in width asi increased from i = 1, 2, . . . , until they stabilized at the steady state values of (LCL, UCL) = (0.02, 0.07). There were no data available for the following dates: December 7, 2012, December 14, 2012, December 21, 2014, December 28, 2012, January 4, 2013, January 11, 2013, January 18, 2013, January 25, 2013 and January 31, 2013.

The EWMA control chart for productivity rate of “structural element” in Company C (Figure 4.12) indicated that the production process was in control during the observed period of time.

Note that the control limits increased in width asi increased from i = 1, 2, . . . , until they stabilized at the steady state values of (LCL, UCL) = (0.04, 0.10). There were no data available for the following dates: December 7, 2012, December 14, 2012, December 21, 2014, December 28, 2012, January 4, 2013, January 11, 2013, January 18, 2013, and January 25, 2013.

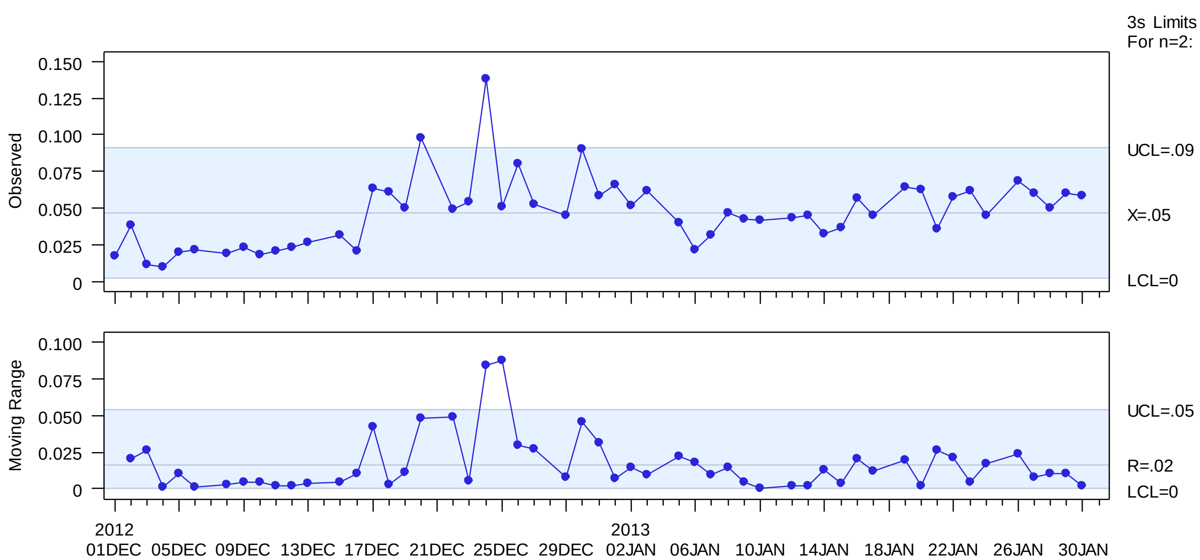

Figure 4.9: The Shewhart control chart and the moving range control chart for productivity rate, structural element, Company B

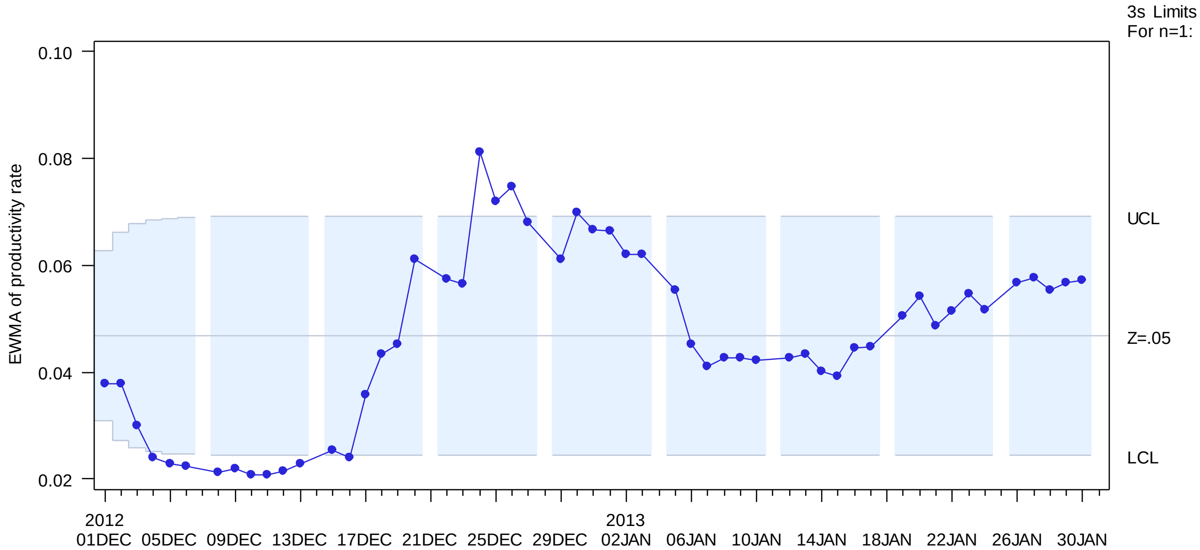

Figure 4.10: The EWMA control chart for productivity rate, structural element, Company B

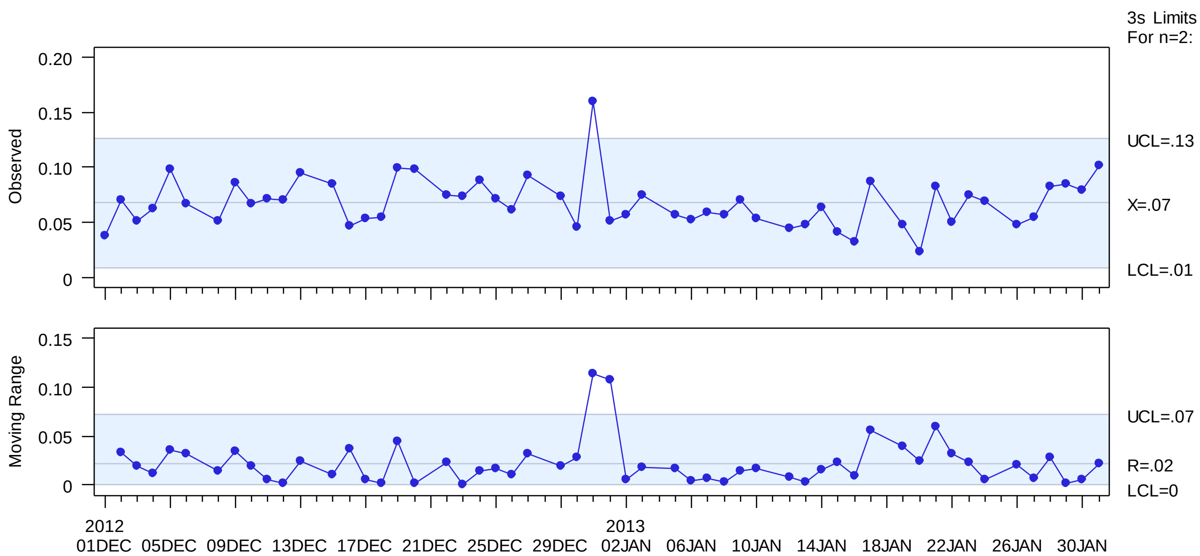

Figure 4.11: The Shewhart control chart and the moving range control chart for productivity rate, structural element, Company C

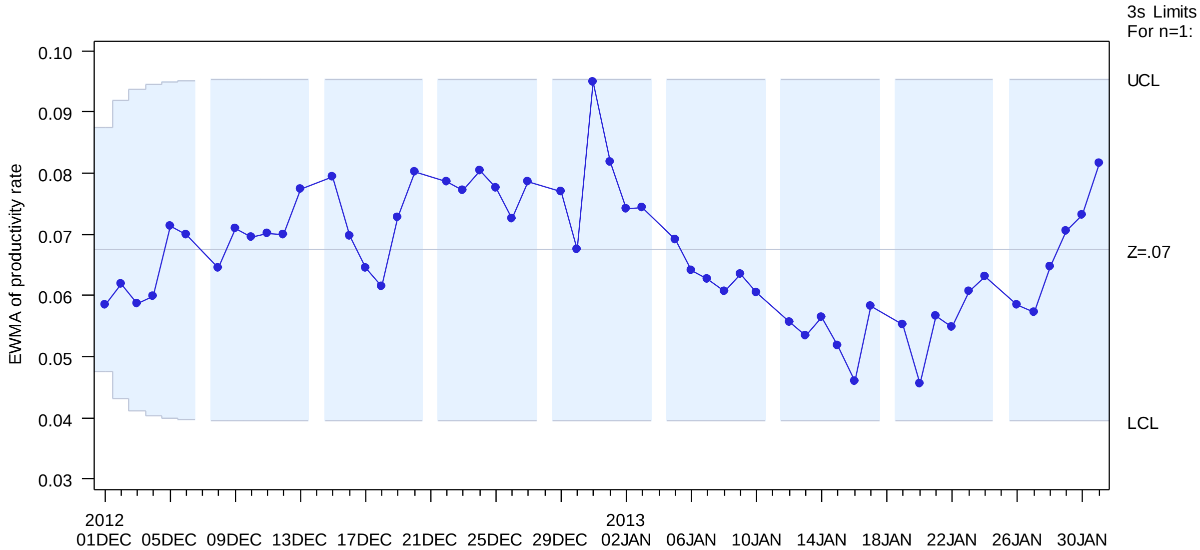

Figure 4.12: The EWMA control chart for productivity rate, structural element, Company C

4.5.4 Productivity rate, panel element

Table 4.30 shows the descriptive statistics of total hours in the section of panel element, by company. The results of the skewness, kurtosis, and Shapiro Wilk test indicated that the data were not from normal distributions. The results of the 1st order autocorrelation (0.712 for Company B and 0.652 for Company C) suggest that the autocorrelation was somewhat excessive (Wheeler, 1991).

Table 4.30: Descriptive statistics of productivity rate in the section of panel element, by company. SW test: p-value of the Shapiro Wilk test of normality

Company	Mean($\bar{x}$)	Standard deviation	$\bar{R}$	Skewness	Kurtosis	SW test	1st order autocorrelation
B	0.03	0.01	0	1.22	2.14	0.0010	0.712
C	0.04	0.01	.01	0.57	-0.64	0.0071	0.652

Figures 4.13- 4.18 show the Shewhart control chart, the moving range control chart, and the EWMA control chart for productivity rate of “panel element” and residuals in Company B and Company C.

The Shewhart control charts for productivity rate in Figure 4.13 and Figure 4.16 show the distribution of the observations of productivity rate of “panel element” in Company B and Company C. The average moving range of Company B was 0 and the average moving range of Company C was 0.01, indicating that the process variability was similar between the two companies.

The observed data of Company B shown in Figure 4.13 suggested there was a time trend. This coincided with the high 1st order autocorrelation of the data (0.712). As suggested by Alwan and Roberts (1988) and Wheeler (1991), the more appropriate method of statistical quality control for autocorrelated data would be removing autocorrelation from the data by fitting a time series model (in this study, an AR(1) model, a linear model that predicts the present value of a time series using the immediately prior value in time) and construct a regular control chart (in this study, EWMA control chart) for the residuals. The EWMA control chart for residuals (Figure 4.15) signalled that the production process was in control during the observed period of time. There were no data available for the following dates: December 7, 2012, December 14, 2012, December 21, 2014, December 28, 2012, January 4, 2013, January 11, 2013, January 18, 2013, January 25, 2013, and January 31, 2013.

The observed data of Company C shown in Figure 4.16 suggested there was a time trend. This coincided with the high 1st order autocorrelation of the data (0.652). As suggested by Alwan and Roberts (1988) and Wheeler (1991), the more appropriate method of statistical quality control for autocorrelated data would be removing autocorrelation from the data by fitting a time series model (in this study, an AR(1) model, a linear model that predicts the present value of a time series using the immediately prior value in time) and construct a regular control chart (in this study, EWMA control chart) for the residuals. The EWMA control chart for residuals (Figure

4.18) signalled that the production process was in control during the observed period of time.There were no data available for the following dates: December 7, 2012, December 14, 2012, December 21, 2014, December 28, 2012, January 4, 2013, January 11, 2013, January 18, 2013, and January 25, 2013.

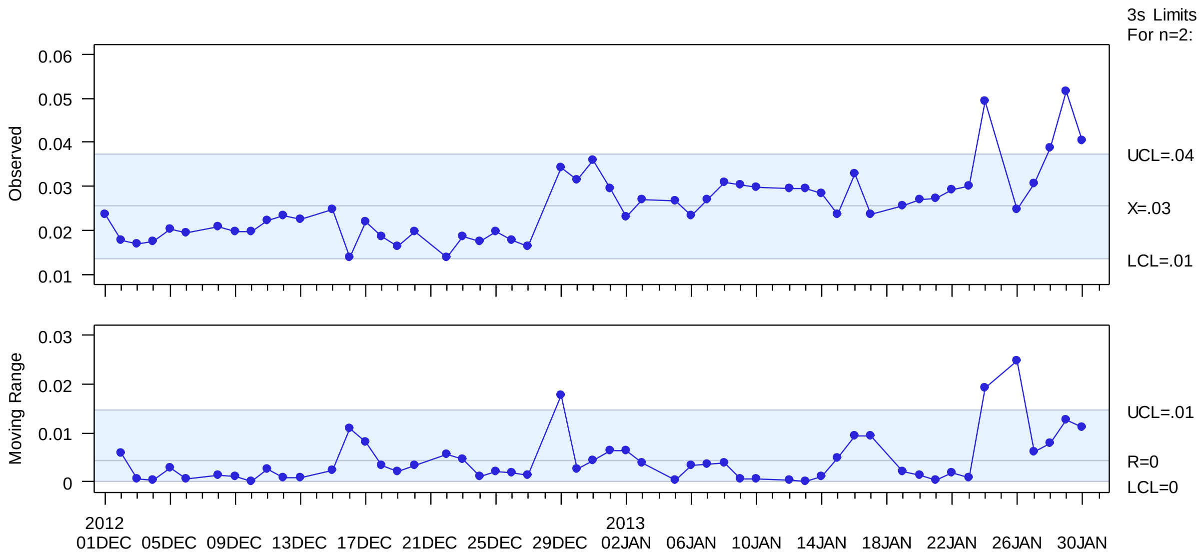

Figure 4.13: The Shewhart control chart and the moving range control chart for productivity rate, panel element, Company B

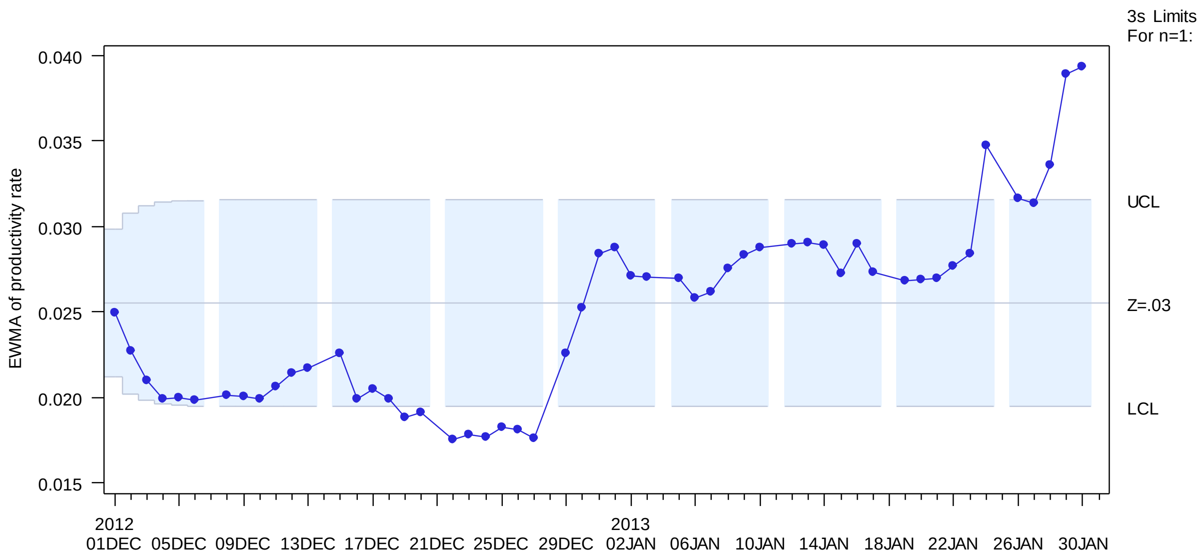

Figure 4.14: The EWMA control chart for productivity rate, panel element, Company B

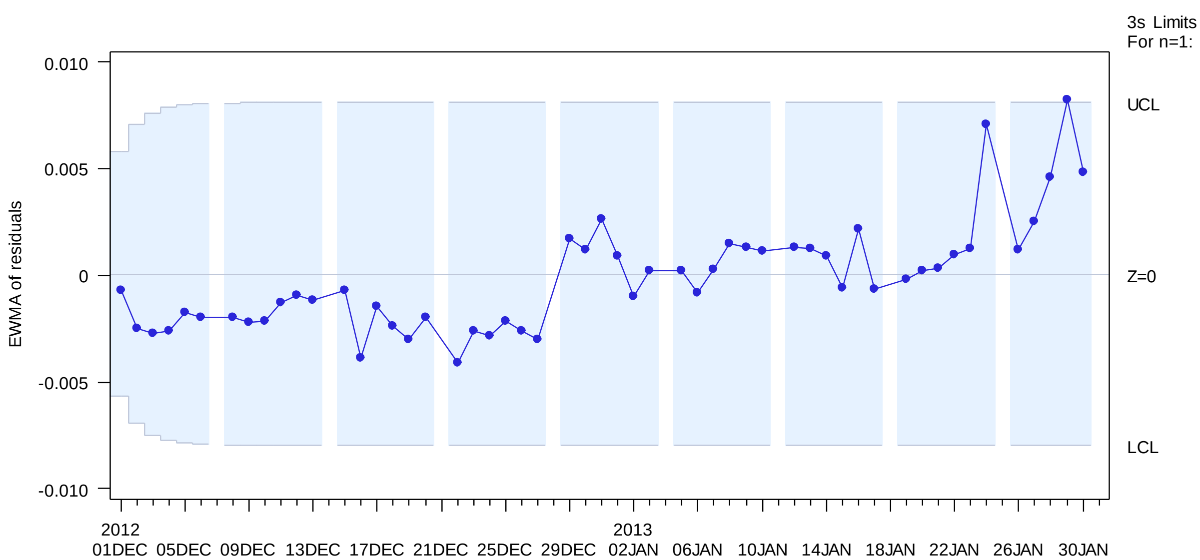

Figure 4.15: The EWMA control chart for residuals, panel element, Company B

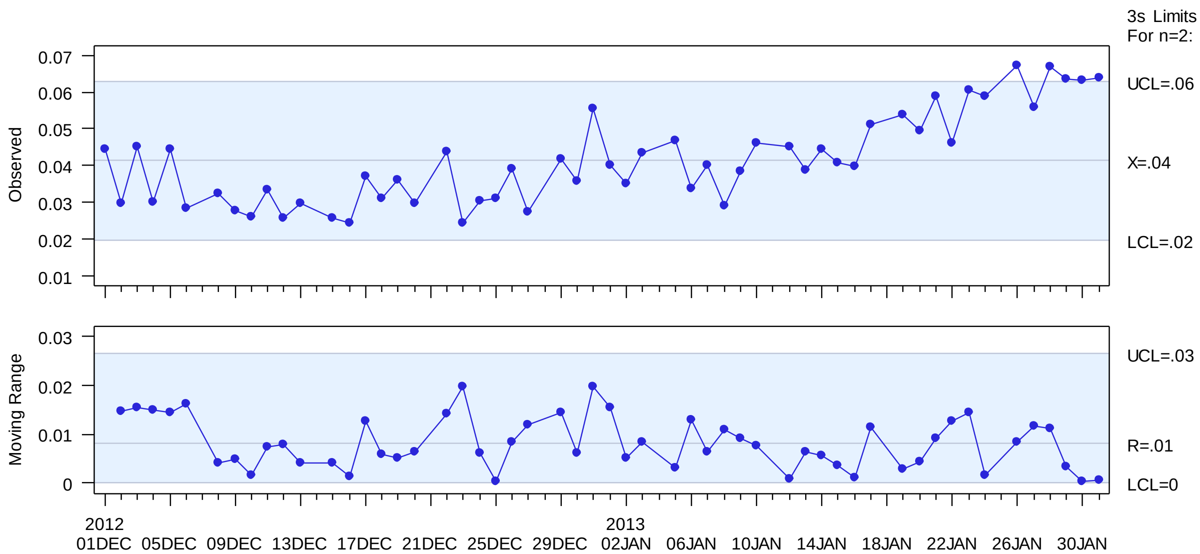

Figure 4.16: The Shewhart control chart and the moving range control chart for productivity rate, panel element, Company C

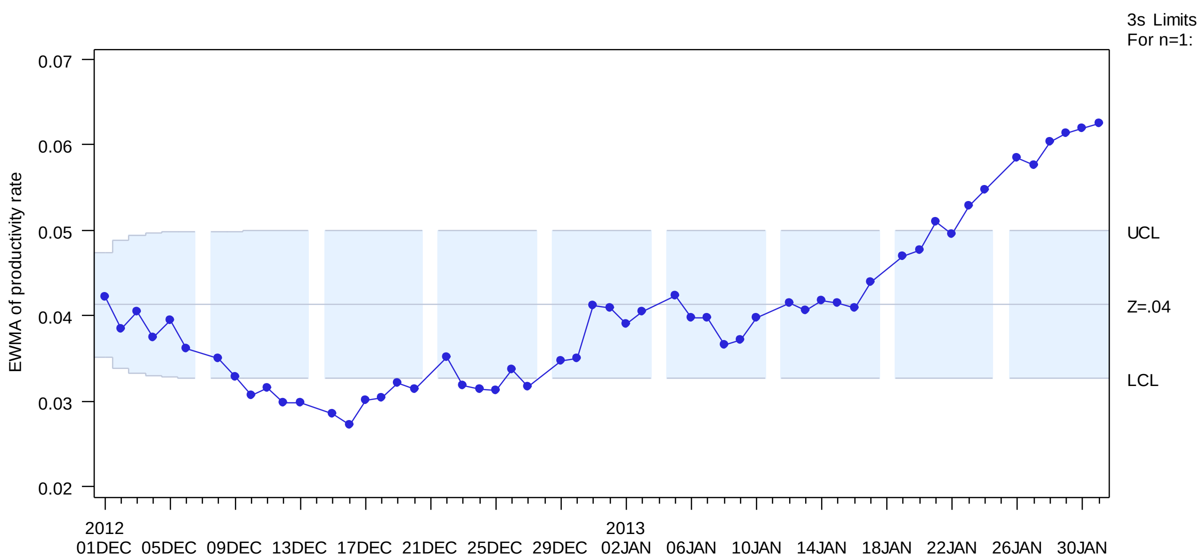

Figure 4.17: The EWMA control chart for productivity rate, panel element, Company C

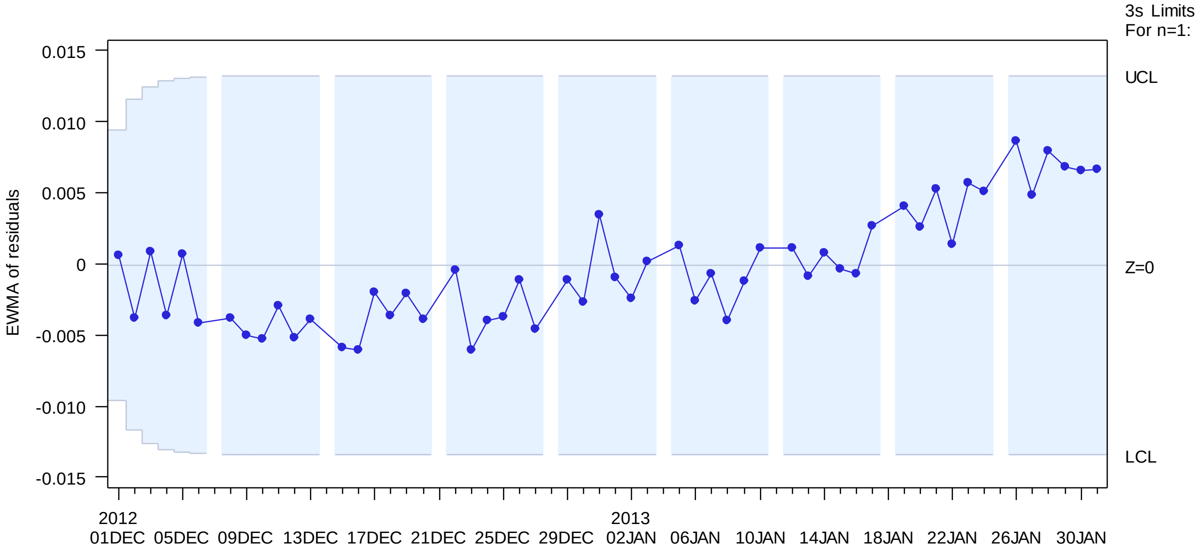

Figure 4.18: The EWMA control chart for residuals, panel element, Company C

4.5.5 Discussion

Overall, the productivity of Company B was found to be superior to that of Company C based on the analysis conducted.

This result is consistent with findings from semi-structured interviews which suggested that Company B had a preferable system to Company C.

The use of statistical process control techniques were found to be a useful strategy in increasing managerial awareness concerning daily productivity and setting achievable goals.

This latter capacity was believed to be particularly important in the case of Company C where some of the respondents indicated that production goals set by top management were often unrealistic and not based on plant precedent.

4.6 Cause and effect diagram

Two *cause and effect diagrams* were developed for this research study through direct consultation by a team of participants from Company C.

The first of these *cause and effect diagrams* sought participants to identify causes and sub-causes of production delay in off-site construction (Figure 4.19). In this diagram, the leading cause groups were causes relating to manpower, method, materials, machines, measurements, and mother-nature.

The diagram was able to reveal these larger groups of causes as well as more specific sub-causes such as display/inventory numbers disappearing from materials. Concerning production delay, it was found that the machine-related causes appeared to be the most important, or at least most numerous. The sub-causes in this section related to shortages of machines and breakdown of those machines. Following this, method-related causes were also found to be numerous.

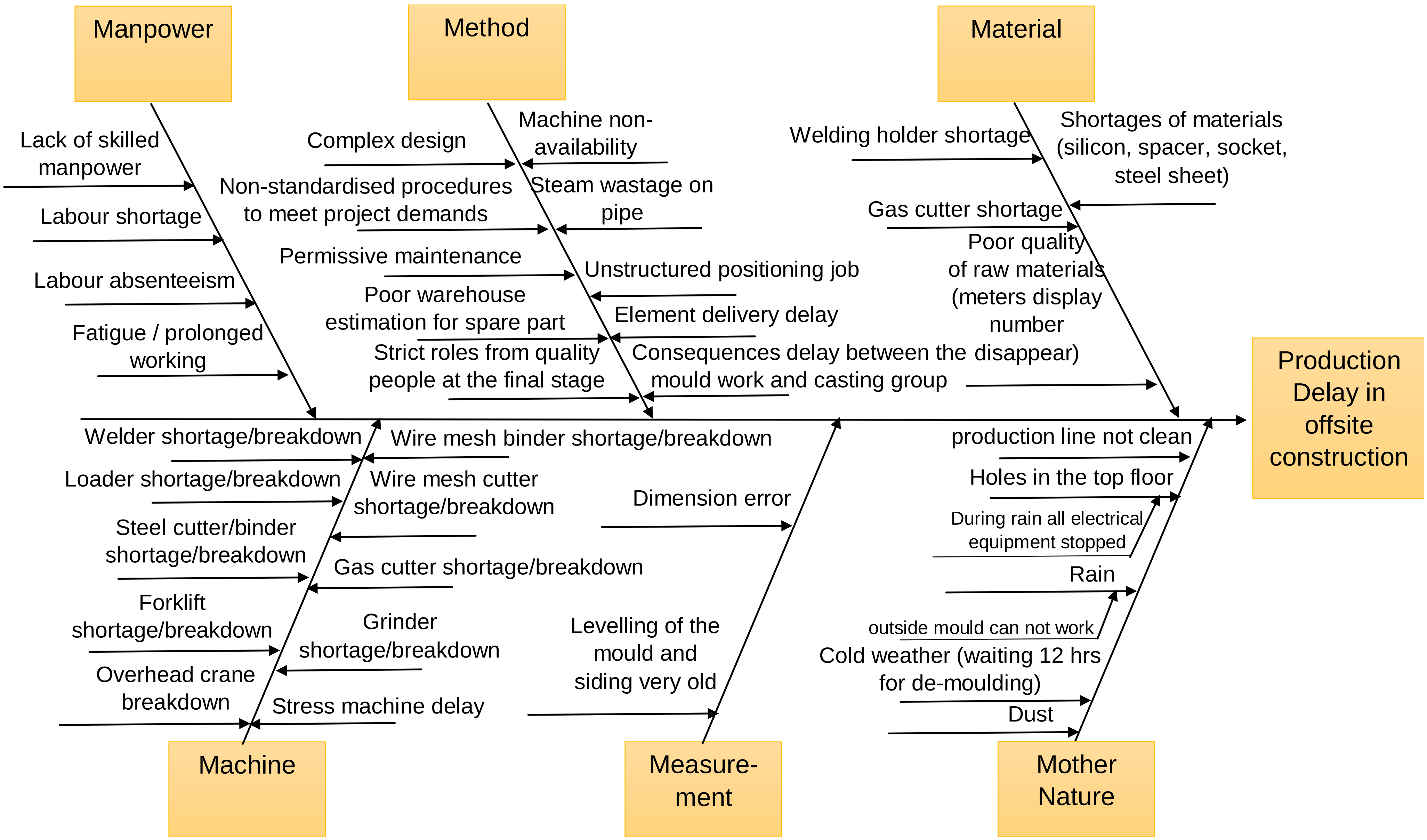

Figure 4.19: Production delay in off-site construction

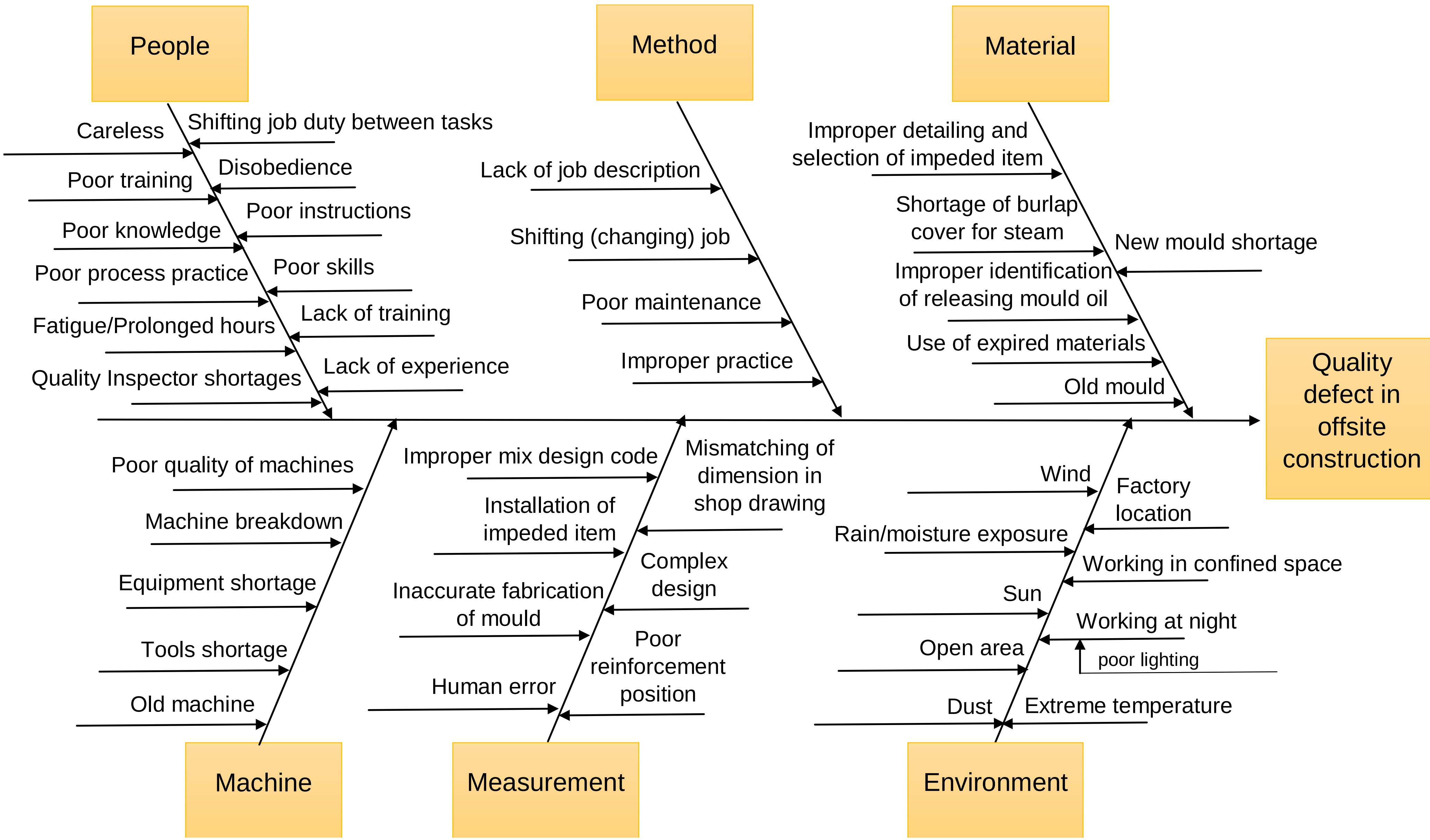

Figure 4.20: Quality defect in off-site construction

The second cause and effect diagram concerned quality defects in off-site construction (Figure 4.20). Similar to the first diagram, cause groups were identified as were more specific sub-causes. Given the complexity of many prefabricated elements it was found that a focus on quality defects was able to aid management.

In contrast to the first diagram on production delay in off-site construction, the second diagram on quality defects was found to have a greater number of causes and sub-causes directly related to people. This finding was consistent with earlier studies with respect to craftsmanship and defects. For example, Johnsson and Meiling (2009) noted that similar to onsite construction, a significant cause of defects in prefabricated components in off-site construction was poor craftsmanship.

Thus, at first glance, it could be said that causes of production delay tend to be more machine and method related while causes of quality defects tend to be personnel related. However, when considering the situation in depth based on interview responses it could be said the people related causes underpinned production delay and quality defects. This is because while machine shortage and breakdown was a major cause of production delay, underpinning the situation was a problematic organisational approach to machine procurement and maintenance. It could be speculated that the numerous method related causes attributed to production delay were also underpinned by poor process management.

Participants reported that brainstorming and developing a cause and effect diagram was a useful activity in terms of enabling collaboration of ideas.

Finding more setting-specific issues was believed to be one of the major benefits of this approach as relationships between causes and sub-causes were able to be visualised and therefore better understood.

4.7 Chapter summary

This chapter has provided the results to the main data collection and analysis activities relevant to this research project.

The chapter also provides a discussion of the extent that the results presented are consistent, or inconsistent, with the key themes in the literature. The purpose of this chapter was to provide an empirical foundation to the research project and to provide data that would be able to be compared and contrasted with knowledge already available on the research topic, specifically, investigating the relative importance of productivity factors.

The chapter above also presented the results of some of the novel aspects of the data collection and analysis such as the assessment of the relationship between: ***employee empowerment*** and ***productivity factors*** and the use of statistical process control to measure productivity rate.

The following chapter, Conclusion and Recommendations, summarizes the six research objectives, how they were investigated, and the implication of the results with respect to those issues.

The contributions to the wider body of knowledge made available by this research study is discussed (alongside, limitations of the research design); suggestions for future study are also presented.

CHAPTER FIVE CONCLUSION

5.1 Introduction to conclusion

This chapter makes conclusions on the results generated in this study. The conclusions are made in order with the six research objectives discussed in detail in the subsequent sub-sections.

The chapter also outlines the contributions to theory and practice that may be said to arise from this research project.

Following discussion of this work's contribution to existing knowledge bases and to practice, the limitations of the study are described as are, areas for future research in the field.

5.2 Achievement of Objectives

5.2.1 Objective one

The first objective was *to investigate and compare the current usage of employee empowerment, in terms of its relative importance to labour productivity between two off-site companies.* In order to achieve this objective, semi-structured interviews were conducted with representatives from two off-site construction organisations. Responses were then assessed and compared through calculating the mean score for each of the factors in order to determine the perceived relative usage of Nesan's nine employee empowerment factors in the two settings. Two-sample t-test was employed to determine if the difference in the mean scores for each of the employee empowerment factors between the two companies was statistically significant. The study also employed a two-sample t-test to determine whether or not the relative importance of employee empowerment to labour productivity is significantly different between the two companies.

It was found that each of the nine employee empowerment factors was perceived to be applied to some extent in the two settings with "Education/Training" and "Recognition" being applied to a lesser extent. At Company A it was found that respondents felt the "Team Work", "Leadership" and "Empowerment" were the most commonly used factors within the company, and these three factors were also believed to be the most important to productivity.

In contrast, respondents from Company B felt that "Resource development" and "Teamwork" were the most commonly used whereas the most important for productivity were "Resource development" and "Involvement."

"Leadership Style" was explored in the two companies, with participants self-identifying as "Team Leaders" and/or "Authoritarian" leaders.

5.2.2 Objective two

The second objective was to *investigate the relationship between labour productivity and employee empowerment*. In order to achieve this objective, semi-structured interviews were conducted with representatives from two off-site construction organisations.

The analysis examined the correlation between ratings of the current usage of each employee empowerment factor (e.g., ‘Leadership’), and the rating of the importance of that factor for productivity (e.g., ‘Importance of Leadership for Productivity’). Pearson’s product-moment correlation was used to measure the strength and direction of the relationship.

It was found that the results supported previous research into this area linking psychological empowerment to performance (Tuuli & Rowlinson, 2009a).

"Resource development", "Involvement" and "Process improvement" were each strongly positively related to ""Importance of Resource Development for Productivity" "Importance of Involvement for Productivity" and "Importance of Process Improvement for Productivity" respectively.

"Recognition", "Education/Training", "Teamwork" and "Leadership" were also positively correlated to their respective indicators of importance to productivity.

"Empowerment" and "Measurement" were not found to be statistically significantly positively correlated to their respective indicators of importance to productivity.

Overall, the results supported a positive relationship between employee empowerment factors and perceptions of productivity.

The previous was deemed as an important finding of this study and supported the further investigation referred to in objective 4.

5.2.3 Objective three

The third objective was to *identify the factors affecting the productivity of off-site construction industry*. In order to achieve this objective, semi-structured interviews were conducted with representatives of three off-site construction organisations.

This part of the interviews aimed to identify and assess factors relevant to productivity with respect to off-site construction. This involved using a schedule of 43 factors based on early studies in the construction labour productivity field, drawing upon work by Enshassi et al. (2007) amongst others.

Responses from 36 participants at the three companies were evaluated and using a relative importance index analysis, the importance of factors negatively affecting the productivity of off-site construction in these settings was identified.

The results revealed that "Types of activities in the project" was the factor most importance according to the responses. The reference to this factor highlights an important aspect of off-site construction in that the elements required may often be non-standardised which places pressure on representatives from the company and labour to contract and produce such elements on time and within budget.

Outside of this factor, the 2nd to 6th factors referred to by participants related in one way or another to the experience and motivation of the employees. In these off-site settings, participants recognised the operations level labour was critical to achieving organisational goals. The relevant factors in this section were "Lack of labour recognition programs", "Labour absenteeism", "Lack of financial motivation system", "Lack of labour experience", and, "Lack of training sessions".

The 7th most important factor was found to the "High quality of required work". Again, this factor would appear to have some similarities with the first most important factor found in this study and the nature of off-site construction. The importance given to this factor could also be a reflection of the issues arising from the 2nd to 6th factors relating to the experience and motivation of the employee.

The next three factors each made reference to the negative effect that the absence of a resource or activity could have on productivity. A "Lack of labour surveillance" referred to a perception that unsupervised personnel were leading to productivity issues, "Tool and equipment shortages" referred to a perception that plant infrastructure was not optimal, and a "Lack of competition", in the context, referred to a perception that labour did not see a meaningful career pathway.

A number of the factors which were found not in the top ten most important, but in the top twenty, according to participants, were related to issues directly related to the setting. For example, "Labour personal problems" were found to affect productivity and these were largely related to contractual issues in which foreign workers were required to commit to a two-year contract before being eligible for leave, and complications related to this. "Augmentation of government regulations" was also relevant to the setting as a levy on foreign workers had commenced since the start of this study, as was "Working 7 days per week without taking a holiday" as at least one of the settings was found to regularly expect employees to work seven days. Similarly, " Misunderstanding between labour and superintendents" was another factor that had significant links with the setting as human resources tended to be constituted primarily by foreign workers. "Lack of periodic meeting with labour" was another issue that arose and which could have had links with communication needs in relation to a diverse cultural and linguistic setting.

"Labour dissatisfaction" and "Misuse of time schedule" were found to be important factors according to the respondents. It was revealed that at least one of the companies had removed a number of historical benefits for employees which appeared to have had an adverse impact of employee morale. Similarly, the use of *agency workers*, that is, employees who are on day by day contracts was found to a factor that led to low output and idleness according to respondents.

Overall, it could be stated that from the schedule of 43 factors related to "Types of activities in the project", factors related to the experience and motivation of the employees were the most important. This is further evident after the context-related factors were treated.

5.2.4 Objective four

The fourth objective was to *empirically examine the relationship between the perceived relative usage of Nesan's nine employee empowerment factors and the 43 productivity factors used in Enshassi et al. (2007).* In order to achieve this objective, semi-structured interviews were conducted with representatives from three off-site construction organisations.

Analysis examined the relationship between the current usage of each employee empowerment factor (e.g., 'Leadership'), and the rating of the importance of each of the 43 factors negatively affecting labour productivity. Pearson's product-moment correlation was used to measure the strength and direction of the relationship.

It was found that the employing behaviours consistent with the employee empowerment factor of "Leadership" were found to positively affect productivity through minimising the adverse effect particular factors. Particularly, it was noticed that there was a strong relationship between exhibiting "Leadership" such as conveying a vision and mission, being able to communicate with individual workers, providing interaction and supervision, and an amelioration of the conditions of " Lack of labour experience", "Labour dissatisfaction", and "Labour absenteeism".

Also, interestingly, strong "Leadership" was also suggested to be a factor that can minimise adverse consequences of "Augmentation of government regulation".

Employing behaviours consistent with the employee empowerment factor of "Empowerment system" was found to positively affect productivity through minimising the adverse effects of factors relating to individual employees.

It was found that the provision of job descriptions, organisational structures, quality control and quality assurance measures each can assist to diffuse labour-level confusion and as evidence of this, the factor of "Misunderstanding between labour" was found to be ameliorated due to increased "Empowerment system"

With respect to the factor of "Resources development", expectedly, the participants indicated that "Re-work" and "Working 7 days per week without taking a holiday" would be less likely to negatively affect productivity in contexts that were appropriately resourced in terms of materials, equipment and personnel and in which were favourable for employees.

Also predictably, "Tool and equipment shortages," "Unsuitability of materials storage location," "Labour absenteeism" where believed to be less likely to negatively affect productivity in companies where resource provision was deemed by those participants to be adequate for the purposes of meeting the objectives of the organisation.

"Involvement" referring to involving employees in decision-making, communicating with customers, and providing formal grievance procedure and employee satisfaction surveys, was found to be a factor that the participants believed would ameliorate "Labour absenteeism" and "Lack of labour experience".

It was believed that increasing "Involvement" would provide more opportunity for operation level employees and middle management to appreciate efficiency issues relating to plant equipment such as those "Inefficiency of equipment."

Of the remaining four empowerment factors, "Process improvement", was found to have the most positive effect on productivity at least in terms of ameliorating a high number of issues. This was followed by "Measurement", and then "Teamwork". The results for "Education/Training" suggested that respondents did not understand or appreciate the impact that the empowerment factor may have

5.2.5 Objective five

The fifth objective was to *measure empirically the current productivity of off-site construction industry fabrication methods with application of operational management tools and techniques.* In order to achieve this objective, document analysis was used.

Industrial statistics were gathered and used to measure the productivity at two off-site construction companies (Company B and Company C).

Specifically, information concerning the companies' daily production of four different construction elements was obtained and compared. Using total hours per employee as the input and volume as the output, the daily productivity rate was determined and presented using statistical process control charts.

It was found that both companies did not use more novel operation management tools and techniques such as statistical process control for the purposes of measuring daily productivity.

The Shewhart control chart for observed data and moving range chart was able to indicate productivity points that were "out-of-control".

The EWMA chart was also able to provide information about the productivity behaviours in the respective companies, particularly small shifts in data which could be indicative of important organisational events.

5.2.6 Objective six

The sixth objective was to *seek to improve future productivity of the off-site construction industry through validation and application of operational management tools and techniques*.

In order to achieve this objective, in addition to the application of statistical process control as adopted as part of objective five, the study also involved application of a brainstorming technique in which representatives from one off-site construction company were asked to identify causes of productivity delay and quality defects for the purposes of developing a cause and effect diagram (fishbone diagram).

It was found that the final product was a helpful visual representation of the causes and sub-causes of productivity issues according to the participants.

It was felt that conducting a brainstorming session and creating a cause-and-effect diagram was a useful operational management tool that should be considered for adoption in off-site construction.

5.3 Contributions to the knowledge

5.3.1 Academic perspective

Research has suggested that there is an extensive lack of knowledge on employee empowerment within the construction industry. There is a need to focus on the complexity of employee empowerment and explain the phenomena as well as its potential relationships with key performance criteria such as labour productivity (Tuuli & Rowlinson, 2007; Tuuli & Rowlinson, 2010b; Sackey et al. 2011).

Yin (2009) suggests that a case study research is a useful method for the exploration of complex phenomena. The current research adopts this advice and investigates employee empowerment in relation to off-site construction.

This study is believed to the first of its kind, as to-date there appears to be few publications relating to off-site construction, and even fewer considering the potential for employee empowerment to improve production in this important sector.

Another contribution of this research is that it has attempted to empirically link employee empowerment with productivity quantitatively. Thus far, such an endeavour appears to have been overlooked /ignored. The link found is that when employee empowerment factors increase, organisation productivity increases, by eliminating factors that can hamper productivity.

Tuuli and Rowlinson's (2007) study measured employee empowerment generally using a qualitative interview methodology. One of the limitations of their approach was the small and culture-specific sample size, as well as the presence of a selection bias, whereby participants were purposely selected because of their willingness to share their experiences. As the authors themselves acknowledged, a resolution to this limitation would be to use quantitative statistical methods to carry out the survey on employee empowerment. By adopting a mixed methods approach and using quantitative statistical methods, this research project has attempted to add to the body of knowledge concerning employee empowerment.

The novel use of an operational management approach in this work has demonstrated a way of measuring productivity in off-site construction. It offers insights that can improve the production performance of the industry; in particular, the study presented here argues that a focus on employee empowerment, statistical process control, brainstorming and cause and effect diagrams might bring about improvements in productivity and product quality, thereby maximising the benefit of off-site construction methods.

Academically, the current investigation into employee empowerment and labour productivity through a case study improves the field of construction management knowledge through providing a description of the concepts in three off-site production companies.

This study addresses a gap in the knowledge available at present concerning the extent that interventions aimed at enhancing employee empowerment in the off-site construction sector are able to positively impact on labour productivity. This empirical study appears to be the first of its type in this regard.

All of these considerations (related to empowerment analysis) have led to the conclusion that empowerment is somewhat dynamic and requires companies to continually adopt techniques such as nine Nesan's model of empowerment.

Any multi-dimensional research should include (towards addressing literature that emphasises structural and psychological empowerment) nine main characteristics, namely: leadership, empowerment system, resources development, involvement, education and training, teamwork, process improvement, measurement, and employee recognition.

5.3.2 Practical perspective

From a practical point of view, proving a relationship between employee empowerment and labour productivity offers important broader benefits for society, namely a rejection of inefficient practices and policy.

In relation to the three companies involved in the study employee turnover was cited as a hindrance to employee empowerment initiatives. The companies also reflected on the negative impact of guest workers spending lengthy periods of time, usually greater than 2 years, away from their families in their home countries. Similarly, there was a reflection on the need for employees to have a minimum pre-requisite of skills in relation to off-site construction in order for empowerment policies focusing on increasing decision-making in workplaces to effectively be implemented.

There is a need for qualitative and quantitative investigation into the hurdles to implementing employee empowerment programs in the construction sector, so that management can deal with barriers to empowerment strategies. There is a need for information to help shed light on the limited implementation of employee empowerment interventions in the construction industry.

Lack of management commitment and adherence to ingrained practices especially across the fragmented supply-chain have been cited as possible reasons for the slow roll-out of interventions but issues have not been explored (Holt et al. 2000; Dainty et al. 2002); in spite of significant empirical support for employer empowerment interventions generally (Argyris, 1998; Bowen and Lawler 1992; Herbert, 2009; Tuuli& Rowlinson,2007a, 2007b).

Most importantly productivity as understood by various stakeholder classes in the off-site construction industry will be able to be (further) explored and further connections between workplace practices and policies will be identified. In addition, by studying relationships between empowerment and productivity, a more precise definition of construction industry performance will be able to be explored. This is deemed to begin to open the way for future studies into the effects of employee empowerment on other construction output variables such as safety, cost, schedule, value, and whole life value (Price et al. 2004), which would be expected to enhance effectiveness and efficiency in this sector.

5.4 Areas for future study

Gaps in understanding of the relationship between employee empowerment and productivity still exist (Huq, 2010; Logan and Ganster, 2007; Seiber et al., 2004). The results of Tuuli and Rowlinon 2009 highlighting the influence of mediating factors suggest that the empowerment/productivity relationship is somewhat more complex than first thought. The mediating effects of other important constructs in the construction management literature such as trust, culture, and identity on the relationship need to be further explored (Phua 2013). There is also a need to consider the role of upstream, downstream, external, internal, and invisible stakeholders on the empowerment/productivity relationship (Rowlinson and Cheung 2008). Moreover, the specific nature of employee empowerment in off-site construction settings has not been comprehensively assessed. Off-site construction settings feature unique collective-employee environments, site cultures and languages, training provisions, knowledge management requirements, and, change-management expectations which need to be taken into account in further empirical studies (Price et al., 2003; Eylon and Au, 1999; Spreitzer, 2007; Tuuli and Rowlinson 2010; Hammuda and Dulaimi, 1997).

One finding in this context, was a consistent view amongst respondents that there was a lack of skills amongst employees employed in the three locations. This was supported by interview responses. The upshot of this finding was that implementing empowerment activities would be in some cases futile where team members did not have engineering skills and knowledge arguably prerequisite for increased participation in operational decision-making. If this finding is valid it suggests that there is a minimum 'entry' level of skills and knowledge required on the part of human-resources before interventions aimed at empowerment are meaningful. This situation suggests that future studies into off-site construction, particularly in similar contexts, should link the application of a skill base perhaps in the form of a skills-efficiency matrix with empowerment techniques to provide a means to empirically measure such a link.

Increased quantitative investigations into factors that adversely affect productivity would also provide greater insight into the influence of various conditions and incidents. One way this could be achieved would be through developing a checklist from a cause-and-effect diagram developed specifically for the setting, and analysing the results.

5.4 Limitations

Whilst already deemed robust, the sample size of 36 representatives from three off-site construction companies could have been made larger in order to increase the generalisability of the study. Similarly, it would have been more appropriate to conduct each of the interventions with the three companies as opposed to gathering data from three companies in some parts of the method and only from two or one company in other parts. While the research design did include some aspects document analysis and statistical analysis, most of the data gathered with respect to employee empowerment and productivity factors was self-reported. It is often difficult to shield self-reported data from political forces which may have meant that some factors were exaggerated while others were overlooked. Similarly, whilst tools adopted sought objectivity in application, each of the respondents is likely to have their own prerogatives and worldviews. The limited applicability of the findings should be noted. In this study, data was gathered from three off-site construction companies in Saudi Arabia, thus no claim as to a statistical representative sample of off-site construction companies globally can be implied.

5.5 Chapter summary

This chapter provided the final conclusions made in relation to each of the six objectives of the study.

The chapter above described the relationship identified between factors of employee empowerment and factors of labour productivity.

The chapter also made final interpretations of the outcomes of the data collection activities in light of the literature.

Contributions to knowledge were outlined, primarily, that the investigation into employee empowerment and labour productivity through a case study of three off-site production companies was the first of its kind and arguably an important step towards improving the field of construction management knowledge.

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7.0 APPENDIX

Appendix A: Semi-structure interview –

Interview Schedule - Section 1

5 = Using fully 4 = 3 = 2 = 1 = Not using at all
5A = Extremely important 4A = 3A = 2A = 1A = Not important at all

1) Leadership To what extent does your company promote a vision and/or mission statement?	**1**	**2**	**3**	**4**	**5**
To what extent does your company encourage and empower employees?	**1**	**2**	**3**	**4**	**5**
To what extent do your company's executives walkthrough plants and talk with employees?	**1**	**2**	**3**	**4**	**5**
To what extent does your company offer coaching, mentoring, and/or professional development for employees ?	**1**	**2**	**3**	**4**	**5**
How important are the above "Leadership" activities for labour productivity?	**1A**	**2A**	**3A**	**4A**	**5A**
2) Empowerment System To what extent does your company use written job descriptions for each employee?	**1**	**2**	**3**	**4**	**5**
To what extent does your company use written guidance materials?	**1**	**2**	**3**	**4**	**5**
To what extent does your company promote an empowerment implementation plan? If there is something need to be implemented when, where, how and who?	**1**	**2**	**3**	**4**	**5**
To what extent does your company use written quality control and quality assurance procedures?	**1**	**2**	**3**	**4**	**5**
How important are the above "Empowerment system" activities for labour productivity?	**1A**	**2A**	**3A**	**4A**	**5A**
3) Resources Development To what extent does your company offer access to resources and participation in decision-making to employees?	**1**	**2**	**3**	**4**	**5**
To what extent does your company use sufficient resources to meet organizational goals?	**1**	**2**	**3**	**4**	**5**

To what extent does your company provide a favorable working environment?	**1**	**2**	**3**	**4**	**5**
How important are the above "Resources Development" activities for labour productivity?	**1A**	**2A**	**3A**	**4A**	**5A**
4) Involvement To what extent does your company involve employees in decision-making processes?	**1**	**2**	**3**	**4**	**5**
To what extent does your company ensure external customer satisfaction?	**1**	**2**	**3**	**4**	**5**
To what extent does your company promote employee grievance filing procedures?	**1**	**2**	**3**	**4**	**5**
To what extent does your company conduct useful employee satisfaction surveys?	**1**	**2**	**3**	**4**	**5**
How important are the above "Involvement" activities for labour productivity?	**1A**	**2A**	**3A**	**4A**	**5A**
5) Education and Training To what extent does your company promote skills development?	**1**	**2**	**3**	**4**	**5**
To what extent does your company identify training needs?	**1**	**2**	**3**	**4**	**5**
To what extent does your company fund employee training?	**1**	**2**	**3**	**4**	**5**
To what extent does your company promote technical cross-training?	**1**	**2**	**3**	**4**	**5**
To what extent does your company promote self-directed learning?	**1**	**2**	**3**	**4**	**5**
To what extent does your company periodically assess employee skill development?	**1**	**2**	**3**	**4**	**5**
To what extent does your company use posters or display boards to provide information to employees, and recognise achievements?	**1**	**2**	**3**	**4**	**5**
How important are the above "Education/Activities" activities for labour productivity?	**1A**	**2A**	**3A**	**4A**	**5A**
6) Team Work To what extent does your company hold regular meetings (to analyse problems, improve processes, solve conflict)?	**1**	**2**	**3**	**4**	**5**
To what extent does your company use advisory committees (with middle and lower management representatives) to solve any problem on a shop floor site?	**1**	**2**	**3**	**4**	**5**
To what extent does your company use cross functional teams (to solve cross functional issues)	**1**	**2**	**3**	**4**	**5**
To what extent does your company promote quality improvement teams?	**1**	**2**	**3**	**4**	**5**
To what extent does your company promote goals setting for process improvement?	**1**	**2**	**3**	**4**	**5**
To what extent does your company empower teams/individuals for process improvement?	**1**	**2**	**3**	**4**	**5**
How important are the above "Team work" activities for labour productivity?	**1A**	**2A**	**3A**	**4A**	**5A**
7) Process Improvement To what extent does your company allow employee control of their tasks?	**1**	**2**	**3**	**4**	**5**
To what extent does your company use statistical analysis?	**1**	**2**	**3**	**4**	**5**
To what extent does your company promote dedication to process improvement?	**1**	**2**	**3**	**4**	**5**
To what extent does your company promote the use of jobsite improvement plans? (to meet jobsite improvement objectives)	**1**	**2**	**3**	**4**	**5**
To what extent does your company use statistical process control?	**1**	**2**	**3**	**4**	**5**
To what extent does your company use process evaluation procedures?	**1**	**2**	**3**	**4**	**5**
To what extent does your company empower employees to make decision related to their business operation?	**1**	**2**	**3**	**4**	**5**
To what extent does your company use two-way communications between management and employees regarding process improvement?	**1**	**2**	**3**	**4**	**5**
To what extent does your company ensure two-way communication between management and employee on process	**1**	**2**	**3**	**4**	**5**

improvement is effective?					
How important are the above "Process Improvement" activities for labour productivity?	**1A**	**2A**	**3A**	**4A**	**5A**
8) Measurement To what extent does your company conduct meaningful evaluations of employees?	**1**	**2**	**3**	**4**	**5**
To what extent does your company benchmark products, processes and services against the products, processes and services of industry leaders?	**1**	**2**	**3**	**4**	**5**
To what extent does your company hold effective product inspections by internal/ external auditors?	**1**	**2**	**3**	**4**	**5**
How important are the above " Measurement" activities for labour productivity?	**1A**	**2A**	**3A**	**4A**	**5A**
9) Recognition To what extent does your company recognise achievements of employees?	**1**	**2**	**3**	**4**	**5**
To what extent does your company hold formal events such as award ceremonies to celebrate individual/group achievements?	**1**	**2**	**3**	**4**	**5**
How important are the above " Recognition" activities for labour productivity?	**1A**	**2A**	**3A**	**4A**	**5A**

Appendix B: Participant leadership style- Section 2

Below is a list of statements about leadership behavior. Read each one carefully, then, using the following scale, decide the extent to which it actually applies to you. For best results, answer as truthfully as possible.

never sometimes always 0

1 2 3 4 5

1. ________ I encourage my team to participate when it comes decision-making time and I try to implement their ideas and suggestions.
2. _______ Nothing is more important than accomplishing a goal or task.
3. _______ I closely monitor the schedule to ensure a task or project will be completed in time.
4. _______ I enjoy coaching people on new tasks and procedures.
5. _______ The more challenging a task is, the more I enjoy it.
6. _______ I encourage my employees to be creative about their job.
7. _______ When seeing a complex task through to completion, I ensure that every detail is accounted for.
8. _______ I find it easy to carry out several complicated tasks at the same time.
9. _______ I enjoy reading articles, books, and journals about training, leadership, and psychology; and then putting what I have read into action.
10. _______ When correcting mistakes, I do not worry about jeopardizing relationships.
11. _______ I manage my time very efficiently.
12. _______ I enjoy explaining the intricacies and details of a complex task or project to my employees.
13. _______ Breaking large projects into small manageable tasks is second nature to me.
14. _______ Nothing is more important than building a great team.
15. _______ I enjoy analyzing problems.
16. _______ I honor other people's boundaries.
17. _______ Counseling my employees to improve their performance or behavior is second nature to me.
18. _______ I enjoy reading articles, books, and trade journals about my profession; and then implementing the new procedures I have learned.

Appendix C: Semi-structure interview - Interview Schedule - Section 3

5 = Extremely important
4 = Very important
3 = Somewhat important
2 = Not very important
1 = Not at all important

Factors negatively affecting labour productivity					
Material shortages	1	2	3	4	5
Lack of labour experience	1	2	3	4	5
Lack of labour surveillance	1	2	3	4	5
Misunderstanding between labour and superintendents	1	2	3	4	5
Drawings and specifications alteration during execution	1	2	3	4	5
Payment delay	1	2	3	4	5
Labour disloyalty	1	2	3	4	5
Inspection delay	1	2	3	4	5
Working 7 days per week without taking a holiday	1	2	3	4	5
Tool and equipment shortages	1	2	3	4	5
Rework	1	2	3	4	5
Misuse of time schedule	1	2	3	4	5
Accidents	1	2	3	4	5
Labour dissatisfaction	1	2	3	4	5
Supervisors' absenteeism	1	2	3	4	5
Inefficiency of equipment	1	2	3	4	5
Misunderstanding among labour	1	2	3	4	5
Low quality of raw materials	1	2	3	4	5
Working within a confined space	1	2	3	4	5
Unsuitability of materials storage location	1	2	3	4	5
Lack of financial motivation system	1	2	3	4	5
High quality of required work	1	2	3	4	5
Violation of safety precautions	1	2	3	4	5
Interference	1	2	3	4	5
Lack of competition	1	2	3	4	5

Method of employment (using direct work system)	**1**	**2**	**3**	**4**	**5**
Increasing number of labours	**1**	**2**	**3**	**4**	**5**
Increase of labourer age	**1**	**2**	**3**	**4**	**5**
Working overtime	**1**	**2**	**3**	**4**	**5**
Lack of labour recognition programs	**1**	**2**	**3**	**4**	**5**
Construction method	**1**	**2**	**3**	**4**	**5**
Type of activities in the project	**1**	**2**	**3**	**4**	**5**
Bad ventilation	**1**	**2**	**3**	**4**	**5**
Augmentation of Government regulations	**1**	**2**	**3**	**4**	**5**
Working at high places	**1**	**2**	**3**	**4**	**5**
Lack of periodic meeting with labour	**1**	**2**	**3**	**4**	**5**
Non-provision of transport means	**1**	**2**	**3**	**4**	**5**
Lack of place for eating and relaxation	**1**	**2**	**3**	**4**	**5**
Labour absenteeism	**1**	**2**	**3**	**4**	**5**
Labour personal problems	**1**	**2**	**3**	**4**	**5**
Unemployment of safety officer on the construction site	**1**	**2**	**3**	**4**	**5**
Lack of training sessions	**1**	**2**	**3**	**4**	**5**
Noise	**1**	**2**	**3**	**4**	**5**

In addition to the mentioned factors, do you think there are other factors that negatively affect productivity in your organisation you may know?