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Abstract

Purpose - This paper aims to identify and analyse the factors affecting the selection of effective cost control techniques in the UK construction industry and assess their importance. The study examines these key areas; (i) the factors that have significant impacts on cost overruns, (ii) the most effective cost control techniques, and (iii) the factors for selecting cost control techniques for a project.

Design/methodology/approach - The study relies on a mixed-method research approach; a qualitative exploration of the most effective cost control techniques and the factors affecting the selection of cost control techniques, followed by a questionnaire survey and follow-up interviews. Relative Importance Index (RII) is used for ranking the factors.

Research limitations/implications - Although the scope of the study was limited to the UK construction industry, the results could be interpreted for critical learning in other developed/developing countries.

Findings - Budgeting technique is ranked first with-0.821RII, followed by cost forecasting-0.800RII and cashflow monitoring-00.733RII, as the most effective cost control techniques. On factors that influenced the choice of the techniques used, cost information/cost-related factors is ranked first with-0.611RII, followed by the size of the company-0.509RII and the effectiveness of the technique-0.572RII.

Originality/value – Identifying and ranking the factors affecting the selection of effective cost control techniques in the UK construction industry has been the focal point of this study. The study also proposes a simple but effective model that can be used for critical learning on mitigating cost overruns and the effective use of cost control techniques in the construction industry.

Keywords: cost control techniques, construction projects, cost overruns

Introduction

Construction projects have three main aims; projects delivered on time, within budget, and to the necessary quality (Potts, 2013). The problems associated with cost overruns cannot be over-emphasised. A study by UK Construction Media indicates in the three years to 2015, less than one in three projects (31%) came within 10% of the originally planned budget (UK Construction Media 2017). A good example is the Wembley stadium where the cost of the project rose by 36% between the bid being accepted and the contract being signed. The stadium was "mired in controversy with questions over adequate cost planning and budget management" (Kirkham, 2015). The cost was expected to be approximately £200 million and the final project cost was £757 million.~~,~~ This could have been due to the failure of budget management (Kirkham, 2015). The cost overrun of the Scottish parliament was staggering, the planned cost was £50m and the final cost was £414m an increment of 730% (Global Construction Review, 2019). Due to the slender profit margins in the construction industry (2% to 7%), without adequate cost control techniques, substantial risk of cost overrun due to liquidated damages and delay is placed on the contractor (Oyegoke and Kiyumi, 2017).

The HS2 (High-Speed Railway) an ongoing project in the UK is a recent example, the expected final cost of the project is to be £56 billion, which is up 71% on the first estimate of £32.7 billion in 2010 (BBC, 2018). Although the reasons could be put down to poor cost planning at the planning stage and design stages, it is during the construction stage that the costs spiral out of control. According to Jayaraman (2016) and Oyegoke (2003), large projects can easily have costs overruns of several millions. Ensuring the project is within budget is crucial to the project's success.

Selecting the most effective cost control techniques is vital to the overall cost control mechanism. It is evident from the study carried out by Olawale and Sun (2010) that many

companies simply develop their own techniques from an individual's experience of what methods have been most effective for them. In turn, many different techniques are utilised within the industry, making it hard to establish which technique is most effective. There is no 'set-in stone' technique that is viewed by all as the most effective (Jayaraman, 2016). A cost control system can be described as an overall approach a company takes to controlling costs. Cost systems, for instance, include life cycle costing, Kaizen costing, building information modelling (BIM), and traditional costing systems (Omotayo, 2017). All the cost control systems have their merits in controlling costs, but this study focuses on the factors used to make the cost control systems successful. Ranking the factors and the techniques is more important since techniques are often used across all the cost control systems.

The aim of this paper is to examine the most effective cost control techniques and the factors that affect the selection of cost control techniques in construction projects in the UK. The issue on cost overruns and controlling cost overruns has been a popular topic in academic literature since the 1980s. Many authors such as Chan and Kumaraswamy (1997); Jackson (2002); Olawale and Sun (2010); Memon *et al*. (2011); Park and Papadopoulou (2012); Rosenfeld (2013) have conducted research on identifying the factors affecting project cost overruns. However, the research carried out on identifying the effective cost control techniques to date is subject to a number of limitations. Olawale and Sun (2010) for example, conducted a study on identifying the cost overrun factors and the techniques used for project cost control in the UK construction projects, however, they did not identify the significance of factors affecting the selection of effective cost control techniques in construction projects. Therefore, this article extends the existing research gap by identifying factors affecting the selection of effective cost control techniques in the UK construction industry and proposing a simple but effective model that can be used for

critical learning on mitigating cost overruns and the effective use of cost control techniques in the construction industry. This research utilises primary data as defined by Farrell (2016) and relies on a questionnaire survey that utilised both open and closed questions producing quantitative and qualitative results. A pilot study was undertaken to ensure that the questionnaire is to the highest quality and easily understood by the participants. Additionally, 3 follow-up interviews were carried out to allow for a greater insight into the information provided. Thematic analysis is used to ~~develop~~ identify themes across the dataset to develop a conceptual model to identify the challenges for monitoring and controlling costs, factors with significant impacts, and the most effective techniques.

The general design of the study is to determine the challenges faced in monitoring and managing cost control, and the most appropriate techniques used to mitigate the challenges. It also examines the impacts of standardisation and digitisation in cost control and proposed a solution. The study was carried out in the UK with wider cost control and techniques application in different practices.

Controlling costs in construction projects

Controlling costs in construction projects to ensure the cost objectives are met has always been essential to any project's success. According to Ashworth and Perera (2015), in recent years there has been a need for a better understanding of cost control from both the client and contractor's perspectives. Cost overrun problem is affected by many factors which may include; psychological biases in estimating and monitoring costs, political intervention in decision-making, geological and weather conditions, contractor's profit margins being reduced, environmental aspects such as greater elimination of waste and more consideration on the environment, economic recession producing a shortage of

funds available, high inflation and higher interest rates leading to construction prices soaring, etc. (Mansfield *et al*. 1994; Jergeas, 2008; Cantarelli *et al.*, 2010; Ahiaga-Dagbui and Smith, 2014). These factors, together with a greater trend towards producing cost efficiencyies and the availability of better tools and techniques, have led to greater importance being placed upon controlling costs as well as expecting more accurate results (Olawale and Sun, 2010). Seeley (1996), emphasises the importance of cost control, labelling cost management as the single most important role undertaken by a Quantity Surveyor (QS).

An extensive review of the literature was carried out to identify and categorised cost overrun factors into nine (9) broader themes of price and cost, delay and extension of time, project management, design issues, construction issues, payments, contractor specific factors, consultants' specific factors, and force majeure. In total, 35 cost overrun factors were identified as shown in Table 1.

Insert - Table 1. Cost Overrun Factors

Cost control techniques - challenges of implementing effective cost controls

The three main aims of cost control are to give the employer value for money, distribute logically available funds between various parts of the building, and to keep the costs within the employer's budget (Seeley, 1984). A good cost control should ensure that the funds available are allocated effectively to various elements, ensure that the tender figure is as close as possible to the first estimate, and achieve good value at the desired level of expenditure (Kirham, 2015). Ashworth and Perera (2015), postulate that the purpose of cost control is to limit the client's expenditure to the desired amount, achieve a balanced design expenditure between the elements of the building, and to provide value for money.

Bergerud (2012), believes the main challenge faced when implementing cost control is controlling the costs. Indicating that merely monitoring and reporting can easily be done. Jayaraman (2016), believes that the reasons for difficulties in controlling costs lies in the difficultly of estimating a budget. He concludes that even with knowledge of common cost overruns, the development of a "fool-proof" system in practice is extremely difficult. Likewise, Potts (2013), believes developing and operating effective cost control is challenging due to the unique nature of a project. Table 2 presents cost control techniques, merits and demerits.

Lewis (2007) believes that techniques are not the main factor in how effectively costs are controlled, but the individuals within the business. He postulates further that the most effective way to control a project's cost is for every person to control their own aspects, emphasising the 'human aspect' to cost control.

However, these factors reduce the influence that the cost consultants have on controlling the costs. Potts (2013) cites research conducted in 1994 which found that traditionally, a cost consultant would only monitor costs rather than control them. This would make the role of a cost consultant in controlling costs, reactive rather than proactive.

Insert - Table 2. Cost Control Techniques Description, Merits and Demerits

Digitisation has also played a role through advances in technology that has changed the way cost control techniques are used. Planning and budgeting, resource scheduling, and activity costing can all be done with software packages, making it easier than in the past and tasks have become increasingly time-efficient (Webb, 2017). Jayaraman (2016)

agrees to note that tracking and monitoring costs in fine detail has become possible and easier. They both also agree that although the monitoring and tracking have been made easier, the same attention to detail is needed.

Selecting cost control techniques

When selecting a cost control technique, the balance between the technique and the benefits it offers the project is important (Potts, 2013). Potts (2013) postulates that operating an extensive cost control system can become a "monster", deflecting other important tasks a cost consultant has on a project. Sears (2015) agrees, stating that how costs are controlled on a project is dependent upon the "size and character" of the business. A smaller project would require a simple easy to follow cost control technique, whereas a complex project would require a more elaborate technique. This shows that the most effective technique could depend on the type of project it is applied to. A cost control technique needs to be an investment, not an expense, it has no value to the business if the data produced is not used or not reported in the relevant time frame (Sears, 2015).

According to Sears (2015), "the details of a specific cost control system vary substantially from one construction firm to another, the ensuring treatment can be regarded as being reasonably typical of current practice" (Sears, 2015). This statement indicates that even though the specific cost control techniques are different, the overall cost control method is relatively typical of those in similar businesses. Jayaraman (2016), mentioning standardisation of cost control is difficult, he believes there is no unanimity in the industry to which cost control technique is most effective and therefore should be utilised. Sears' (2015) believes that cost control systems of businesses are of the same nature could be sceptical as projects are unique and often have different demands meaning often different techniques are utilised. However, Bergerud (2012) disagrees, he concludes that

companies are standardising methods across their business but allowing for flexibility at the project level. Table 3 presents the important factors for selecting cost control techniques.

Insert - Table 3. Important factors when selecting cost control techniques

Research methodology

Questionnaire survey

Selecting appropriate research methodology is vital in a study (Oyegoke, (2011; and (Sahu, (2013). This study relied on an extensive literature review to identify 35 cost overrun factors categorised into nine (9) broader themes, 10 cost control techniques, and 6 factors for selecting appropriate cost control techniques which were used in the questionnaire survey. ~~T~~Prior to conducting the survey, a pilot survey was conducted among three participants who are working as cost consultants in the construction industry in the UK with 35, 10, and 1-years' experience. Naoum (2013) suggests that a pilot study provides a test run for the questions, which involves evaluation of the wording of the questions, identifying any ambiguous questions, testing the technique that the researchers use to collect the data. Based on Naoum (2012~~3~~), the pilot survey was used to achieve two things; to ascertain that the local cost overrun control factors are not excluded and to prevent misunderstanding and ambiguities. Few issues that were raised in the pilot to improve the clarity of the question were addressed before questionnaires were rolled out.

A non-random sampling technique – convenience sampling~~s~~ was used in the study. A convenience sample is a non-random sample containing individuals who can be accessed readily, where the researcher collects data from a conveniently available pool of respondents in a population who own qualities/experience that a researcher expects from

the target population (Fellows, 2015). The selected sample of participants consisted of professionals with extensive construction experience in the industry personally known to the researchers. The questionnaire used for the survey contained a five-point Likert scale under two main categories: ranking of the cost control techniques and Usage of cost control techniques. The questionnaire also included a few open-ended questions for participants to elaborate more on their responses. The questionnaires were emailed to 50 Royal Institution of Chartered Surveyors (RICS) accredited cost consultant firms and~~,~~ 30 large-scale contracting firms in the UK selected by the researchers. Additional 20 questionnaires were shared on LinkedIn with professionals with extensive construction experience in the industry known to the researchers. ~~A~~Out of 100 questionnaires distributed, a total of 57 individuals completed the questionnaire accounting for a 57 per cent response rate. In addition to this, 3 respondents accepted a follow-up interview to further elaborate their answers and verify the results of the research.

Analysis of data

72% of participants work in the building industry, 19% in civil engineering, and 9% in other industries (e.g. local authority and wider client's organisations). 42% of participants work for contracting firms, 39% for consulting, 19% for the local authority. 49% of participants are quantity surveyors (cost consultants), 25% are project managers, 7% are company directors and 19% are others, which include; buildings surveyors, facilities managers, construction managers. 40% of participants have experience in £0-1 million projects, 30% with £1-10 million, 16% with £10-30 million, and 14% with £30+ million. On participants' years of experience, 22% have 0-5 years, 18% have 6-10, 18% have 11-20 and 42% have 20+ years. This indicates that most participants have a wealth of experience that will enable them to give detailed insights into cost control techniques and cost overrun factors.

A five-point Likert scale ~~1-5~~ was used for ~~the~~ rating and the Relative Importance Index (RII) method was used for the analysis of data: ranking the level of perceived importance of the identified factors. This approach and the formula used in the analysis have been previously used by Oyegoke and Kiyumi (2017), Muhwezietal (2014), and Khoshgoftar *et al*. (2010), in their studies on ranking the most significant construction delay factors. The purpose of this study was to identify and rank the most effective cost control techniques, therefore, based on the previous studies, a five-point Likert scale and the Relative Importance Index (RII) method and the formula (i) were deemed appropriate for the analysis of data. ~~.~~ Responses were assigned numerical values of 1 to 5 to the ratings as follows: 'extremely important' = 5, 'important' = 4, 'neither important/unimportant' = 3, 'unimportant' = 2, 'extremely unimportant' = 1.

$$\text{Relative Importance Index} = \frac{\Sigma W}{A \times N} \quad (0 \leq RII \leq 0.8) \qquad (i)$$

Where:

W = the weight given to each factor by the respondents ranges from 1 to 5 (where "1" is "lowest" and "5" is "highest");

A = highest weight which is 5 in this study; and

N = total number of respondents.

The relative range= 0.80.

The analysis was done and RII outputs were interpreted cautiously. After the ranking of 10 different cost control techniques and 6 cost control technique determining factors, the researchers used thematic analysis which is a~~n~~ flexible analytic induction approach to identify patterns through clustering to arrive at themes based on triangulated data from the survey responses, follow-up interviews, and the literature review on cost overruns. An analytic inductive approach allows research findings to emerge from the frequent,

dominant or significant themes inherent in raw data, without the restraints imposed by structured methodologies (Thomas, 2006). The approach adopted by the researchers followed the steps outlined by Braun and Clark (2006): 1. familiarisation with data, 2. the generation of initial codes, 3. search for themes among codes, 4. review of themes and the definition and naming of themes before the production of the final report. Thise thematic ~~approach~~analysis started with identifying initial themes and concepts from literature on cost overruns and cost control techniques, continuously revising/developing the themes based on the survey responses and the follow-up interviews, and sorting the themes into broad categories. Subsequently, a simple but effective illustration (Figure 3) base on the themes identifying the challenges for monitoring and controlling costs, factors with significant impacts, and the most effective techniques was developed and validated using the follow-up interviews with 3 survey participants.

Findings and discussion of results

Establishing the most effective cost control techniques

The results of this study illustrate that the most effective cost control techniques are budgeting and cost forecasting. As shown in Table 4, budgeting ranked first with 0.821 RII, followed by cost forecasting 0.800 RII and cashflow monitoring 0.733 RII. If successfully implemented and followed, budgeting will be effective in controlling costs as the cost will not overrun the budget (Kirkham, 2015). Participant three in the follow-up interview agrees with this point stating that if budgeting is undertaken correctly the project will not experience cost overruns. Cost forecasting gives an indication in advance of the expected costs. Identifying cost overruns early will allow for corrective action to be undertaken (Ashworth and Perera, 2015). Agreeing with Ashworth and Perera (2015), participant one

believes to effectively control costs, cost forecasting is the most effective as it allows for early identification of cost overruns, allowing for controls to be put in place to mitigate them. These techniques are cheap and simple to implement, which could be another explanation of why they are viewed as effective. Individuals will have experience utilising them and will understand them clearly. The techniques being cheap to implement will enable them to be used on all projects as they will be cost-effective.

The least used techniques are earned value ranked 10th with 0.579 RII, resources monitoring 0.664 RII, interim valuation and payment 0.678 RII and value engineering ranked 7th with 0.684 RII. As earned value is not a traditional technique, some participants may not have used it, therefore viewing it as ineffective. Participant two in the follow-up interview solidified this point stating they have never used this technique, therefore, view it as the least effective. Additionally, as Webb (2017) states, this technique is more complicated and involves advanced software, therefore becoming costlier and only suitable for larger projects. Ranked the second least effective is monitoring labour, material, equipment, and overheads (costs). Potts (2013) postulates that only monitoring costs is ineffective as once the costs have been incurred there is nothing the cost consultants can do, indicating a lack of control. Participant one in the follow-up interview agrees, expressing the usefulness of monitoring costs to understand the project's progress but the ineffectiveness of the technique in controlling costs.

Insert - Table 4. Ranking of the cost control techniques

Figure 1 presents the usage of cost control techniques across different disciplines. In consulting ranking, cost forecasting and budgeting top the list with 0.762 RII, followed by

variation/change management. the least ranked factors are:; resources monitoring 0.524, earned value 0.552 RII, and interim valuation/payment 0.638 RII.

Budgeting also top in the contracting discipline with 0.861 RII, followed by cost forecasting 0.843 RII and cashflow monitoring 0.791 RII. Budgeting also tops the local authority discipline with 0.836 followed by cost forecasting 0.818, cost reporting and cashflow monitoring 0.745 RII.

Insert - Figure 1. Usage of cost control techniques

The least rated are earned value 0.455 RII, value engineering 0.618, post-project review and site visits 0.691 RII.

Earned Value is lowest ranked in all the disciplines except under contracting with 0.655 RII. As earned value is a technique used mainly by contractors (PMI, 2005), it is unlikely that other disciplines will have used it and therefore may not understand its effectiveness. According to Webb (2017), earned value is not suitable for all project types, only projects with specific characteristics. Interim valuations and certificates for payments gains a low score across all projects illustrating that it is ineffective at controlling costs. Monitoring costs received a high rating on projects less than £10 million, however on projects over £10 million it is scored the lowest and second lowest, showing that on higher-value projects it is less effective. Therefore, on larger projects, more controls must be put in place to ensure the costs do not overrun, merely monitoring costs will not be enough.

On the different opinions relating to the experience of working on various project value ranges. Earned value is scored the lowest on £0-1 million and £1-10 million projects, and close to the lowest on £10-30 million and £30+ million projects. This demonstrates that

earned value is viewed as the least effective, with it being more effective on larger projects than smaller projects. Similarly, post-project reviews and site meetings are viewed as more effective on larger projects than smaller projects, suggesting that even though collaboration and communication is important on all projects is it essential on larger projects. The effectiveness of interim valuation and certificates for payment is consistently scored lower as the projects increase in value, exemplifying the higher value the project, the less effective this technique. Using this technique on larger value projects may, therefore, be more of a hindrance than an advantage.

Figure 2 shows how insights differ depending on an individual's years of experience. Cost forecasting is scored the highest for all experience levels except those with 20+ years. Budgeting is scored the highest by those with 20+ years of experience and second by those with less than 20 years of experience.

Insert - Figure 2. Individual's Years of Experience Comparison

This confirms that budgeting and cost forecasting are the most effective cost control techniques. However, those with 20+ years of experience view variation/change management as the second most effective technique. The opinion of those with 20+ years of experience should be valued highly as they have used the techniques more therefore their judgement was considered rational. Earned value is rated lower by those with more than 11 years of experience but received higher scores by those with less experience. Confirming that participants with more experience who use more traditional cost control techniques may not have experience with earned value, therefore, view it as ineffective.

When asked if there are any techniques the participants found effective but were not in the study, some different techniques were identified. Firstly, time management was listed,

having effective time management will be effective at controlling costs as any delays will lead to cost overruns. Risk management was also identified as an effective technique. Effectively managing risks is an important and effective technique, as common causes of cost overruns have already been identified through risk management. Therefore, if these risks were successfully managed, fewer cost overruns would occur.

Finally, the technique that was identified multiple times was controlling the design. Avoiding complex design, less design changes, and the design being as complete as possible at the time of tender were all identified as ways to minimise cost overruns. As design related factors have been established as the main cause of cost overruns, controlling the design is essential to effectively control costs. However, at the post-contract stage, little can be done if there is a complex design, therefore the cost consultants must be involved in the design stage to give cost advice. More emphasis must be placed on reducing design changes as these are the main factor causing cost overruns. As identified by participants in this study, controls must be put in place to effectively manage the design changes. Controlling design changes could be considered as one of the most effective techniques for reducing cost overruns. However, changes in design are often out of the cost consultants' control, therefore emphasis must be put on controlling the design changes and managing them properly.

Selecting the most effective cost control technique

The overall result as in Table 5 indicates that cost information/cost-related factors is ranked first with 0.611 RII, followed by the size of company 0.509 RII and the effectiveness of the technique 0.572 RII. The result for contracting discipline is similar except the third factor are resources available and project duration 0.496. The consulting discipline sees

resources available, project duration and cost information/cost-related factors as equally important with 0.619 RII. Under local authority, the effectiveness of the technique ranked first 0.709 RII, followed by size of company 0.673 RII and cost information/cost related factors 0.600.

A main factor listed by participants on the reason why cost control should change due to project requirements was because of the unique nature of construction projects. With each project being different, techniques must be able to adapt to suit project requirements, this is consistent with Sears' (2015) point that projects are unique and have specific demands therefore different techniques are utilised. The size of a project, contract type and different requirements are all factors that mean cost control should be flexible across a company. Additionally, contractors or individuals may have their own techniques, therefore a company with many individuals working for them using different techniques.

Insert - Table 5. Selection of Cost Control Technique Factors

Standardisation of cost control

The participants stated standardising cost control would allow for benchmarking and consistency. Standardising can improve accuracy as it allows for standards to be set. These results support Bergerud (2012) that there should be some standardisation of cost control across companies, but it should be flexible and be able to change due to a project's requirements. 28 per cent thinks that cost control should be standardised to maintain a consistent benchmark of cost and presentation to the client to set minimum standards. The respondents argued that it will improve accuracy, certainty, repetition of good practices, and avoid errors – "*Standardisation makes it easier to establish control across the entire*

company and projects can accurately be compared". –Another respondent stated "*to support consistent and repeatable successful cost control utilising methods and reviews that the team are comfortable with. Whilst utilising a standard approach there should be a degree of tailoring to the project requirements around size, complexity, financial model, etc.*"

72 per cent thinks changes should be made due to project requirements. The resources secured for the project, appropriateness of techniques, projects specific demands, project peculiarities, resources availability, unforeseen circumstances, size of the contracting firm, size and type of the project, and client-specific requirements are the reasons according to the respondent to justify unstandardised approach to cost control. One of the respondents states that "larger projects can benefit from more procedural cost control methods. Smaller or fast projects may be hindered by cost control procedures. The uniqueness of each project requires flexibility. Changes in the design and contract team for each project requires re-thinking of approach each time. If a variable such as industry, client, laws and regulations change then this may have an impact. Flexibility in contract and cost control management is needed to meet changing situations."

Challenges for implementing effective cost control

When asked about the main challenges faced when trying to monitor and control costs, common themes highlighted are; information issues, client changes, and project management issues. Distinctively the challenges faced in monitoring cost is different from controlling cost. Similarly, design changes were identified as the main cause of cost overruns, indicating that that client changes or design changes are a key issue in implementing effective cost control. A simple solution to this would be to limit design changes and ensure the client is happy with the design when the contract is awarded,

however, this is sometimes impossible as changes may be necessary. Project management related factors featured more in the challenges of controlling costs, factors such as lack of communication, lack of experience and poor planning represented some of the main challenges of effective cost control. This demonstrates that when costs need to be controlled rather than monitored, effective project management is essential. Ensuring project members work collaboratively is essential in guaranteeing a project's success and that the project does not experience cost overruns. If budgeting, forecasting and reporting are completed more effectively, costs could be better controlled but to undertake these methods correctly the cost consultant often must reply on the quality of information they receive, another challenge presented by the participants.

The impact of digitisation on cost control

When asked if advances in technology have improved cost control, 84 per cent of participants believed it has made controlling costs easier. Participants expressed how data had become easier to collect, easier to store, and easier to analyse. Advances in technology has allowed individuals to monitor costs more effectively and has made it more time-efficient. It has allowed faster and better communication between parties, therefore allowing for better collaboration and control. Measurement tools are also available, allowing for more accurate and easier measurement. Tools presented by participants included IT, Microsoft packages such as excel, Evolution M, online resources such as Building Cost Information Service (BCIS) and software programs such as CCS WinQS, CostX, Asta Power project, and EDMS. This indicates that there is a readily available supply of technology that can enhance cost control, making it easier and more effective. However, 16% believed technology had not made cost control easier, one reason given for

this is tools are not being adopted widely enough. Nonetheless, with the majority of participants believing cost control is easier with advances in technology, it shows that technology is improving cost control.

Table 6 presents the challenges in monitoring and controlling costs. The thematic analysis described earlier was used to arrive at six themes.

Insert - Table 6 Challenges in monitoring and controlling costs

Figure 3 presents the summarised illustration of the key findings and themes. It shows the factors with significant impacts and challenges in monitoring and controlling cost and suggests some key elements in managing cost overrun.

Insert - Figure 3 Managing cost overrun in a project – controlling and monitoring

The illustration is based on the findings of the study and key determinant factors in selecting cost control techniques and the most appropriate techniques in different project types and sizes. The model was checked and verified using the follow-up interviews with 3 survey participants from the industry. As illustrated in the diagram, cost overrun can be managed through clear scope definition, client direct involvement, preconstruction cost planning, completeness of design and application of appropriate cost control techniques. Three key determining factors for selecting cost control are identified: size in terms of project and company, appropriateness of the techniques and availability of cost information. Three most significant techniques were identified:- budgeting, cost forecasting, and cash flow monitoring. Although this is a simplified representation of the

broad, complex issue of cost overrun and effective cost controlling techniques, the model can be utilised for critical learning on mitigating cost overruns and the effective use of cost control techniques in the construction industry.

Conclusions

It has been established that cost overruns occur on projects and there are effective cost control techniques that should be put in place. Design management, a thorough cost planning exercise, client's involvement and the use of digitisation can solve some of the problems associated with design leading to additional cost. To minimise cost overruns more accurate time and cost estimations must be produced and better coordination between parties is needed. If budgeting is done effectively and followed by the project team the cost of the project will come within budget. Cost forecasting is also an effective technique as it gives an early indication of costs therefore potential cost overruns can be detected and controls can be put in place to minimise overruns. Variation/change management is another simple and effective way to manage project costs to prevent overrun. The use of different cost control techniques will depend on the different factors (project, size, time, etc.) as identified in the study. Therefore, selecting the most effective cost control technique depends on the nature and size of the project, resources available, and project duration.

Budgeting and cost forecasting are viewed as very effective and should always be utilised. Techniques such as earned value can only be used on specific projects and would not be cost-effective on lower-value projects therefore would be ineffective on most projects. Due to the unique nature of construction projects, a company's cost control techniques should not be standardised and should be able to change due to project requirements. Advances

in technology have made controlling costs easier as data can now be collected, stored and analysed easier as well as making it more time-efficient and improving communication.

Building upon the scholarly works of Chan and Kumaraswamy (1997); Jackson (2002); Olawale and Sun (2010); Memon *et al*. (2011); Park and Papadopoulou (2012); Rosenfeld (2013), this study should be viewed as an extension of developing solutions for factors affecting the selection of effective cost control techniques in the UK construction industry. Although identifying and ranking the factors affecting the selection of effective cost control techniques in the UK construction industry has been the focal point of this study, clearly, further research is needed as this study is subject to a number of limitations. The study was only limited to the UK's construction industry and was based on a survey using the participants from the industry personally known to the researchers which may restrict the generalisability of its findings to be applied to other countries and specific project types. In addition to this, the effectiveness of these effective cost control techniques during the project execution phase needs to be thoroughly investigated in future research as it is evident that despite the use of cost control techniques many notable construction projects still experience cost overruns. Findings of this study and the proposed model, however, can be used as a learning tool for mitigating cost overruns and the effective use of cost control techniques in the construction industry.

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Table 1 Cost overrun factors

Cost overrun factor	Reference No.	Sources
Price and cost		1. Memon *et al*. (2011) 2. Wanjari and Dobariya (2016) 3. Jackson (2002) 4. Jergeas (2008) 5. Flyvbjerg (2005) 6. Membah and Asa (2015) 7. Doloi (2012) 8. Akanni, Oke and Akpomiemie (2015) 9. Sun and Meng (2009) 10. Chan and Kumaraswamy (1997) 11. Timothy *et al*. (2013) 12. Semple *et al*. (1994) 13. Larsen *et al*. (2016) 14. Forcada *et al*. (2014) 15. Kim, Lee and Jung (2017) 16. Rostami and Oduoza (2017) 17. Rosenfeld (2013) 18. Kim *et al*. (2017) 19. Park and Papadopoulou (2012) 20. Wu *et al*. (2005) 21. Olawale and Sun (2010) 22. Hadipriono and Tahir (1990) 23. Greiman and Warburton (2009) 24. Doloi (2012) 25. Jarkas and Haupt (2015) 26. Patel *et al*. (2013) 27. Aziz (2013) 28. Müller (2014) 29. Garvin (2007) 30. Winch (2013) 31. Lu *et al*. (2017) 32. Sudirman and Hardjomuljadi (2011) 33. Love and Li (2000) 34. Love *et al*. (2004)
Inaccurate time and cost estimations	1,3,4,5,6	
Fluctuation of prices of materials	1,2,7,8	
Lack of information available	3,4,9	
Delay and extension of time		
Delays in material and equipment procurement	1,10,11	
Delays in decision making	1,11,12	
Delays in planned activity	2,10,11	
Project management		
Lack of experience	1,13	
Lack of coordination/poor relationship between parties	1,2,14,15	
Inadequate planning and scheduling	1,16,17	
Inadequate monitoring and control	1,2,3,14,17	
Poor contract management	1,3,17,18	
Procurement and tendering	1, 3,17,19	
Design		
Poor design and delays in design	1,2,3,20,21	
Design changes	1,2,3,20,21,22	
Changes in material specification and type	1,9,23	
Design team performance	3,24,25	
Construction		
Mistakes during construction	1,2,14,18	
Additional works	1,2,23,18	
Shortage of site workers	1,4,26	
Poor site management and supervision	1,14,19	
Waste on site	2,18,27	
Payments		
Financial difficulties of owners	1,17,28	
Mode of financing, bonds and payments	1,29,30	
Dispute on bill settlements	2,12,17	
Claims	3,12,17	
Contractor specific factors		
Cashflow and financial difficulties faced by contractors	1,16,31	
Incompetent subcontractors	1,3,18,19	
Insolvency	1,32	
Rework	1,33,34	
Inaccurate site investigations	3,16,31	
Consultants specific factors		
Unrealistic contract duration and requirements	1,16,19	
Commercial pressures	3,16,18	
Inaccurate quantities and omissions in the bills	2,16,34	
Force majeure		
Severe weather	1	
Unforeseen circumstances	1,2,3	

Table 2 Cost control techniques description, merits and demerits

Technique	Description	Merits	Demerits	References
Earned Value	Mainly utilised by contractors to measure a project's progress by comparing the estimated cost against the actual cost at intervals throughout the project.	Indicate how the project is progressing and forecasting the total cost and time for the project; insight on problematic areas and their level of criticality and how to achieve progress.	Involves a lot of calculations and advanced software packages to collect and analyse the vast amount of data. Suitable for projects that have a structured plan of work, a cost structure and a suitable data collection system.	PMI (2005), Webb (2017)
Value Engineering	Part of the value management process used to identify and eliminate unnecessary cost, while providing the same quality and function.	It reduces unnecessary costs therefore providing value for money for the client and contractor. It is cheap to implement as the costs are often offset by the cost savings.	Often involve abortive actions therefore although saving money, quality can be comprised.	Cheah and Ting (2005), Ashworth & Perera (2015)
Monitoring project resources	Keeping check on costs incurred from labour, equipment and overheads.	Gives indication of the costs incurred compared to the budget. If over budget, it will give an understand of where the cost overruns are occurring.	It only monitors the costs, once the costs have been incurred, they cannot be controlled.	Day (1994), Kirkham (2015), Omotayo (2017)
Cashflow monitoring	To ensure money is available to meet outgoings and used by the contractor to calculate expenditure and income.	It gives indication if the project has slipped by comparing the current cash out flows against the estimated cash out flows. Early indication of cash expenditure and cash income therefore corrective action can be taken.	Merely monitoring cashflow is ineffective in controlling costs. It should be analysed and if needed, corrective action must be taken to ensure smooth running of the project.	Ashworth & Perera (2015), Kirkham (2015)
Cost forecasting	Estimating the future costs that are going to be incurred on the project. Separated into elements to understand where the expenditure is coming from.	Useful in identifying potential cost overruns to the budget. Identifying factors early can allow for corrective action to be taken.	Forecasts can often be inaccurate, unexpected events often occur in construction project making forecasting difficult.	Fellows (2008), Ashworth & Perera (2015), Omotayo (2017)

Budgeting	Involves estimating the costs and setting a fixed budget, which is used to compare expenditure against to understanding how the project is performing.	Gives indication of how the project is performing. Sets limits on cost expenditure, therefore if followed the project will remain in budget.	Rigorous budgeting can lead to quality being compromised; therefore, it is important to understand the client's objectives.	Kirkham (2015), Fellows (2008), Ashworth & Perera (2015)
Cost reporting	This includes expenditure, profit, total cost and forecasted final cost. Cost reports can be used by senior staff members to get an understanding of the project's progression.	Gives clear indication to all parties involved on how the project is performing.	Cost reporting does not assist in controlling cost, it simply gives an indication of how the project is progressing. Once the costs have been incurred, they cannot be controlled.	Kirkham (2015), Fellows (2008)
Variation/ change management	Alternation to the scope of works, this can be an addition, omission or substitution from the original scope of works in the construction contract.	Can lead to significant increases in costs. Managing variations effectively and spotting potential variations early will significantly reduce costs.	The design should be as complete as possible, and the contract should be adequate in describing all the works. More emphasis is put on the pre-contract works.	Oladapo (2007), Ashworth & Perera (2015)
Post project reviews and site meetings	The final meeting and progress meetings during the project. Cost, expenditure, profit and variations are discussed.	Extremely useful for reviewing a project's success and allows for a more experienced view on future projects. Useful for communication of potential cost overruns, allows for better communication between project members.	Meetings must be done regularly and should involve all project parties which can often be demanding which some may see as unnecessarily time consuming. Post project reviews will also be in effective at controlling the costs of the current project as it will be too late.	Omotayo (2017), Ashworth & Perera (2015)
Interim valuations and certificates	Valuing the work completed on site, agreeing the values between the client and contractors QS,	Allows payments to be made on the work completed.	Delays and variations could obstruct payments being made therefore creating financial difficulties.	RICS (2015), Ashworth & Perera (2015)

Table 3 Important factors when selecting cost control techniques

Important factors	Reference No.	Sources
Size of Project	1,4,7	1.Oyegoke, A.S. (2006); 2. Flyvbjerg (2005); 3. Ashworth and Perera, S (2015); 4. Membah and Asa (2015); 5. Webb (2017), 6. Sun and Meng (2009); 7. Rostami and Oduoza (2017); 8. Kim *et al*. (2017).
Size of Company	1,3,6	
Resources Available	2,5,6	
Project Duration	1,2,3	
Effectiveness of the Technique	4,6,8	
Cost information / cost related factors	1,4,5	

Table 4 Ranking of the cost control techniques

	Themes	Variables	Overall		Contracting		Consulting		LA	
			RII	Rank	RII	Rank	RII	Rank	RII	Rank
Cost control - techniques	Effective cost control - techniques	Earned Value	0.579	10	0.655	10	0.552	9	0.455	10
		Value Engineering	0.684	7	0.678	8	0.724	4	0.618	9
		Monitoring labour, material, equipment and	0.664	9	0.748	5	0.524	10	0.740	5
		Cashflow monitoring	0.733	3	0.791	3	0.657	7	0.745	3
		Cost forecasting	0.800	2	0.843	2	0.762	1	0.818	2
		Budgeting	0.821	1	0.861	1	0.762	1	0.836	1
		Cost reporting	0.726	5	0.748	5	0.686	5	0.745	3
		Variation/ change management	0.730	4	0.722	7	0.733	3	0.727	6
		Post project reviews and site meetings	0.719	6	0.783	4	0.676	6	0.691	8
		Interim valuation and certificates for payment	0.677	8	0.678	8	0.638	8	0.727	6

Table 5 Selection of cost control technique factors

	Themes	Variables	Overall		Contracting		Consulting		LA	
			RII	Rank	RII	Rank	RII	Rank	RII	Rank
Cost control - techniques	Cost control techniques - selection criteria	Size of Project	0.509	6	0.487	6	0.505	5	0.509	6
		Size of Company	0.604	2	0.565	2	0.590	4	0.673	2
		Resources Available	0.558	5	0.496	3	0.619	1	0.564	4
		Project Duration	0.568	4	0.496	3	0.619	1	0.527	5
		Effectiveness of the Technique	0.572	3	0.487	5	0.590	4	0.709	1
		Cost information / cost related factors	0.611	1	0.609	1	0.619	1	0.600	3

Table 6 Challenges in monitoring and controlling costs

Cost	Time	Management	Risk/Decision-making	Design and Information	Client Issues
• resources forecasting • estimation • accuracy-cost information • establishing cost • price increase • cost report • hidden costs • all costs reported • delayed-Claim payments • estimating variations • cost risk items • unexpected delays • budget constraints	• time pressure • time availability • lead in times for production • time constraints • time lag • timely input from design team	• customer expectation • management discipline • urgency around project delivery • miscommunication between consultants • lead in times for production • market trend • site conditions • lack of due diligence • anticipating the future • poor management • unexpected circumstances • contractor laxity • programme constraints	• inadequate risk register • risk pricing • client decision making • reporting and assessment • faulty site reporting	• design changes • design information • timely input from design team • incorporating change against baseline plan • accuracy of cost information • accuracy of data • access to data might be challenging • false information • accuracy of information • obtaining information	• clients tend to be over-ambitious • client decision making • client changes • client wants

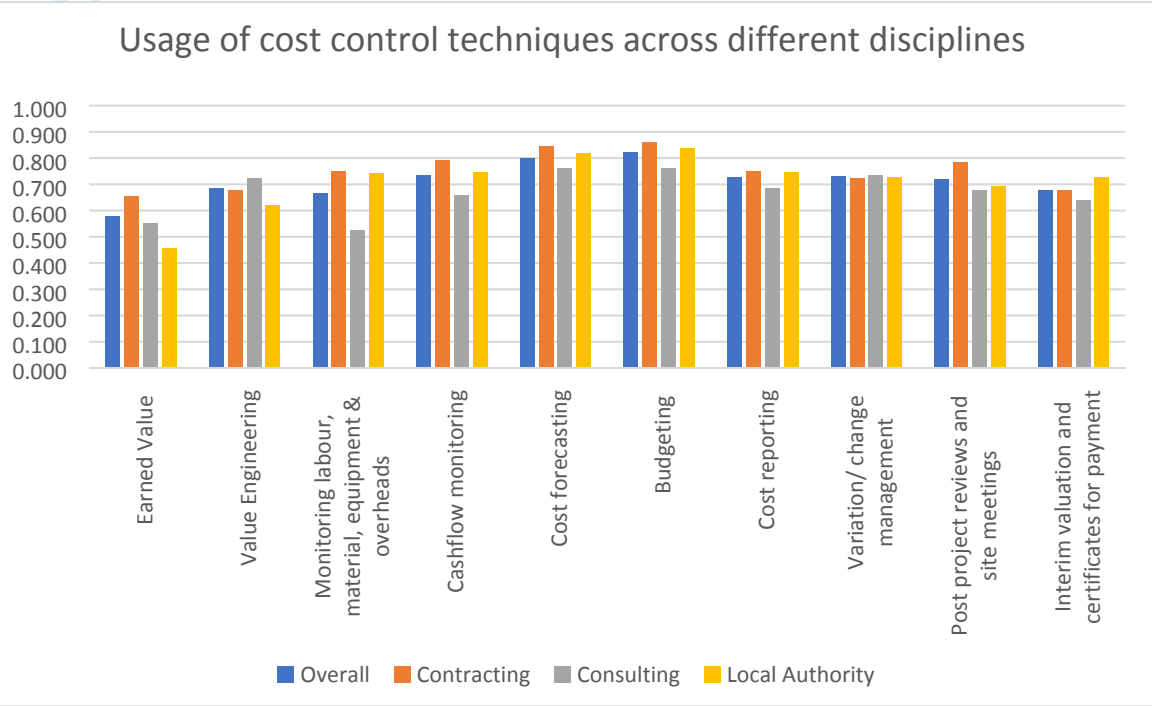

Figure 1 Usage of cost control techniques

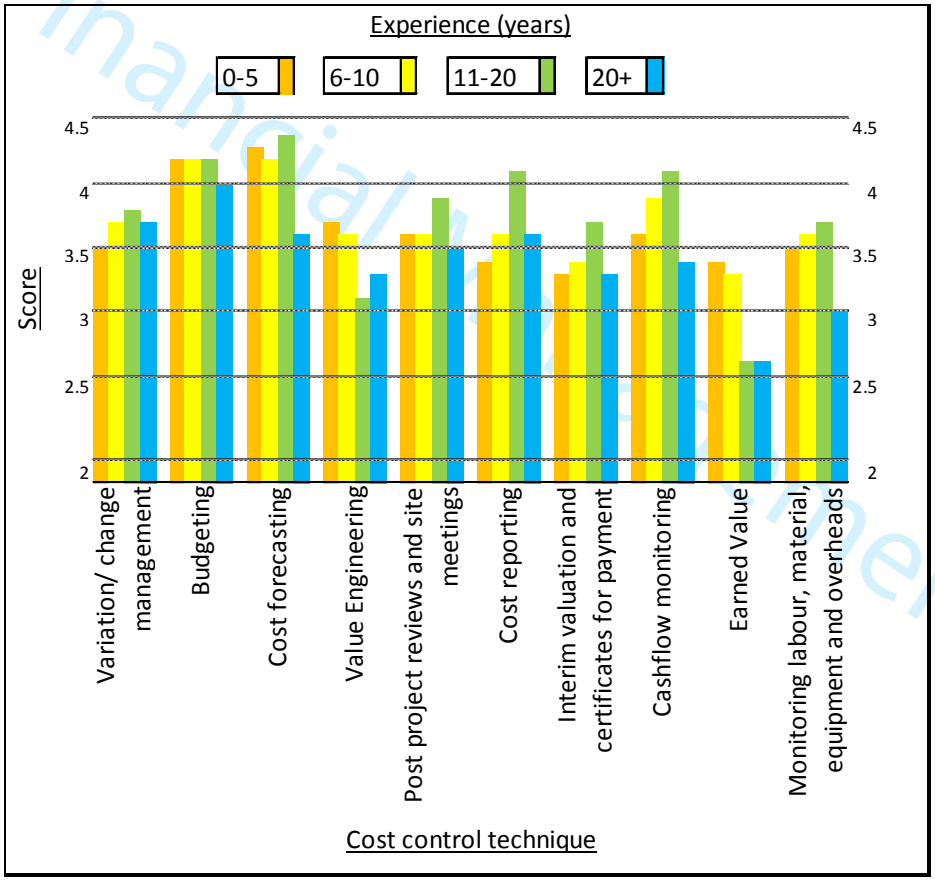

Figure 2 Individual's years of experience comparison

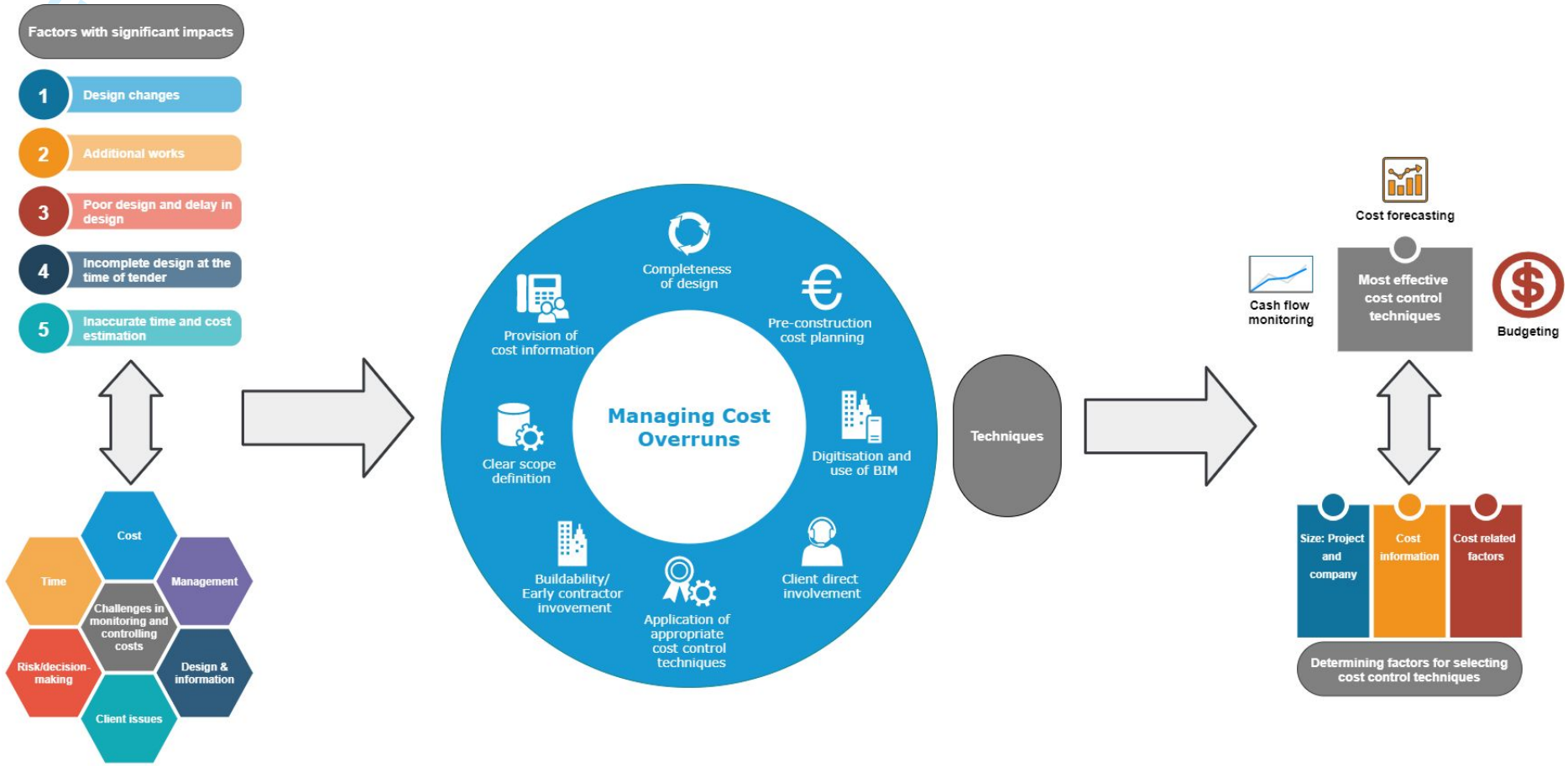

Figure 3 Managing cost overruns in a project – controlling and monitoring