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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-0.733RII, 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

32 Introduction

33 Construction projects have three main aims; projects delivered on time, within budget, and
34 to the necessary quality (Potts, 2013). The problems associated with cost overruns cannot
35 be over-emphasised. A study by UK [Construction Media](#) indicates in the three years to
36 2015, less than one in three projects (31%) came within 10% of the originally planned
37 budget (UK Construction Media 2017). A good example is [the](#) Wembley stadium where the
38 cost of the project rose by 36% between the bid being accepted and the contract being
39 signed. The stadium was “mired in controversy with questions over adequate cost planning
40 and budget management” (Kirkham, 2015). The cost was expected to be approximately
41 £200 million and the final project cost was £757 million. This could have been [due](#) to the
42 failure of budget management (Kirkham, 2015). The cost overrun of [the](#) Scottish
43 parliament [was](#) staggering, the planned cost was £50m and the final cost was £414m an
44 increment of 730% (Global Construction Review, 2019). Due to the slender profit margins
45 in the construction industry (2% to 7%), without adequate cost control techniques,
46 substantial risk of cost overrun due to liquidated damages and delay is placed on the
47 contractor (Oyegoke and Kiyumi, 2017).

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

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

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

68 The aim of this paper is to examine the most effective cost control techniques and the
69 factors that affect the selection of cost control techniques in construction projects in the
70 UK. [The issue on cost overruns and controlling cost overruns has been a popular topic in](#)
71 [academic literature since the 1980s. Many authors such as Chan and Kumaraswamy](#)
72 [\(1997\); Jackson \(2002\); Olawale and Sun \(2010\); Memon *et al.* \(2011\); Park and](#)
73 [Papadopoulou \(2012\); Rosenfeld \(2013\) have conducted research on identifying the](#)
74 [factors affecting project cost overruns. However, the research carried out on identifying the](#)
75 [effective cost control techniques to date is subject to a number of limitations. Olawale and](#)
76 [Sun \(2010\) for example, conducted a study on identifying the cost overrun factors and the](#)
77 [techniques used for project cost control in the UK construction projects, however, they did](#)
78 [not identify the significance of factors affecting the selection of effective cost control](#)
79 [techniques in construction projects. Therefore, this article extends the existing research](#)
80 [gap by identifying factors affecting the selection of effective cost control techniques in the](#)
81 [UK construction industry and proposing a simple but effective model that can be used for](#)

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3 82 critical learning on mitigating cost overruns and the effective use of cost control techniques
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5
6 83 in the construction industry. This research utilises primary data as defined by Farrell
7
8 84 (2016) and relies on a questionnaire survey that utilised both open and closed questions
9
10 85 producing quantitative and qualitative results. A pilot study was undertaken to ensure that
11
12 86 the questionnaire is to the highest quality and easily understood by the participants.
13
14 87 Additionally, 3 follow-up interviews were carried out to allow for a greater insight into the
15
16 88 information provided. Thematic analysis is used to develop-identify themes across the
17
18 89 dataset to develop a conceptual model to identify the challenges for monitoring and
19
20 90 controlling costs, factors with significant impacts, and the most effective techniques.
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24 91 The general design of the study is to determine the challenges faced in monitoring and
25
26 92 managing cost control, and the most appropriate techniques used to mitigate the
27
28 93 challenges. It also examines the impacts of standardisation and digitisation in cost control
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30 94 and proposed a solution. The study was carried out in the UK with wider cost control and
31
32 95 techniques application in different practices.
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40 98 **Controlling costs in construction projects**

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42 99 Controlling costs in construction projects to ensure the cost objectives are met has always
43
44 100 been essential to any project's success. According to Ashworth and Perera (2015), in
45
46 101 recent years there has been a need for a better understanding of cost control from both
47
48 102 the client and contractor's perspectives. Cost overrun problem is affected by many factors
49
50 103 which may include; psychological biases in estimating and monitoring costs, political
51
52 104 intervention in decision-making, geological and weather conditions, contractor's profit
53
54 105 margins being reduced, environmental aspects such as greater elimination of waste and
55
56 106 more consideration on the environment, economic recession producing a shortage of
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3 107 funds available, high inflation and higher interest rates leading to construction prices
4
5 108 soaring, etc. (Mansfield *et al.* 1994; Jergeas, 2008; Cantarelli *et al.*, 2010; Ahiaga-Dagbui
6
7 109 and Smith, 2014). These factors, together with a greater trend towards producing cost
8
9 110 efficiencyies and the availability of better tools and techniques, have led to greater
10
11 111 importance being placed upon controlling costs as well as expecting more accurate results
12
13 112 (Olawale and Sun, 2010). Seeley-(1996), emphasises the importance of cost control,
14
15 113 labelling cost management as the single most important role undertaken by a Quantity
16
17 114 Surveyor (QS).

18
19
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21
22 115 An extensive review of the literature was carried out to identify and categorised cost
23
24 116 overrun factors into nine (9) broader themes of price and cost, delay and extension of time,
25
26 117 project management, design issues, construction issues, payments, contractor specific
27
28 118 factors, consultants' specific factors, and force majeure. In total, 35 cost overrun factors
29
30 119 were identified as shown in Table 1.

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37 121 **Insert - Table 1. Cost Overrun Factors**

38
39 122
40 123 **Cost control techniques - challenges of implementing effective cost**
41
42 124 **controls**

43
44 125 The three main aims of cost control are to give the employer value for money, distribute
45
46 126 logically available funds between various parts of the building, and to keep the costs within
47
48 127 the employer's budget (Seeley, 1984). A good cost control should ensure that the funds
49
50 128 available are allocated effectively to various elements, ensure that the tender figure is as
51
52 129 close as possible to the first estimate, and achieve good value at the desired level of
53
54 130 expenditure (Kirham, 2015). Ashworth and Perera (2015), postulate that the purpose of
55
56 131 cost control is to limit the client's expenditure to the desired amount, achieve a balanced
57
58 132 design expenditure between the elements of the building, and to provide value for money.

1
2
3 133 Bergerud (2012)₁ believes the main challenge faced when implementing cost control is
4
5 134 controlling the costs. Indicating that merely monitoring and reporting can easily be done.
6
7

8 135 Jayaraman (2016), believes that the reasons for difficulties in controlling costs lies in the
9
10 136 difficulty of estimating a budget. He concludes that even with knowledge of common cost
11
12 137 overruns, the development of a “fool-proof” system in practice is extremely difficult.
13

14 138 Likewise, Potts (2013)₁ believes developing and operating effective cost control is
15
16 139 challenging due to the unique nature of a project. Table 2 presents cost control
17
18 140 techniques, merits and demerits.
19

20
21
22 141 Lewis (2007) believes that techniques are not the main factor in how effectively costs are
23
24 142 controlled, but the individuals within the business. He postulates further that the most
25
26 143 effective way to control a project's cost is for every person to control their own aspects,
27
28 144 emphasising the ‘human aspect’ to cost control.
29

30
31
32 145 However, these factors reduce the influence that the cost consultants have on controlling
33
34 146 the costs. Potts (2013) cites research conducted in 1994 which found that traditionally, a
35
36 147 cost consultant would only monitor costs rather than control them. This would make the
37
38 148 role of a cost consultant in controlling costs, reactive rather than proactive.
39

40
41
42 149
43
44 150 **Insert - Table 2.** Cost Control Techniques Description, Merits and Demerits
45

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52
53 153 Digitisation has also played a role through advances in technology that has changed the
54
55 154 way cost control techniques are used. Planning and budgeting, resource scheduling₁ and
56
57 155 activity costing can all be done with software packages, making it easier than in the past
58
59 156 and tasks have become increasingly time-efficient (Webb, 2017). Jayaraman (2016)

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

160

161 **Selecting cost control techniques**

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

172 According to Sears (2015), “the details of a specific cost control system vary substantially
173 from one construction firm to another, the ensuring treatment can be regarded as being
174 reasonably typical of current practice” (Sears, 2015). This statement indicates that even
175 though the specific cost control techniques are different, the overall cost control method is
176 relatively typical of those in similar businesses. Jayaraman (2016), mentioning
177 standardisation of cost control is difficult, he believes there is no unanimity in the industry
178 to which cost control technique is most effective and therefore should be utilised. Sears’
179 (2015) believes that cost control systems of businesses are of the same nature could be
180 sceptical as projects are unique and often have different demands meaning often different
181 techniques are utilised. However, Bergerud (2012) disagrees, he concludes that

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

185

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

187

188 Research methodology

189 Questionnaire survey

190 Selecting appropriate research methodology is vital in a study (Oyegoke, (2011; and
191 (Sahu, (2013). This study relied on an extensive literature review to identify 35 cost
192 overrun factors categorised into nine (9) broader themes, 10 cost control techniques, and
193 6 factors for selecting appropriate cost control techniques which were used in the
194 questionnaire survey. Prior to conducting the survey, a pilot survey was conducted
195 among three participants who are working as cost consultants in the construction industry
196 in the UK with 35, 10, and 1-years' experience. Naoum (2013) suggests that a pilot study
197 provides a test run for the questions, which involves evaluation of the wording of the
198 questions, identifying any ambiguous questions, testing the technique that the researchers
199 use to collect the data. Based on Naoum (20123), the pilot survey was used to achieve
200 two things; to ascertain that the local cost overrun control factors are not excluded and to
201 prevent misunderstanding and ambiguities. Few issues that were raised in the pilot to
202 improve the clarity of the question were addressed before questionnaires were rolled out.
203 A non-random sampling technique – convenience samplings was used in the study. A
204 convenience sample is a non-random sample containing individuals who can be accessed
205 readily, where the researcher collects data from a conveniently available pool of
206 respondents in a population who own qualities/experience that a researcher expects from

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

220 Analysis of data

221 72% of participants work in the building industry, 19% in civil engineering, and 9% in other
222 industries (e.g. local authority and wider client's organisations). 42% of participants work
223 for contracting firms, 39% for consulting, 19% for the local authority. 49% of participants
224 are quantity surveyors (cost consultants), 25% are project managers, 7% are company
225 directors and 19% are others, which include; buildings surveyors, facilities managers,
226 construction managers. 40% of participants have experience in £0-1 million projects, 30%
227 with £1-10 million, 16% with £10-30 million, and 14% with £30+ million. On participants'
228 years of experience, 22% have 0-5 years, 18% have 6-10, 18% have 11-20 and 42% have
229 20+ years. This indicates that most participants have a wealth of experience that will
230 enable them to give detailed insights into cost control techniques and cost overrun factors.

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

$$242 \text{ Relative Importance Index} = \frac{\sum W}{A \times N} \quad (0 \leq \text{RII} \leq 0.8) \quad (i)$$

244 Where:

245 W = the weight given to each factor by the respondents ranges from 1 to 5 (where "1" is

246 "lowest" and "5" is "highest");

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

248 N = total number of respondents.

249 The relative range= 0.80.

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

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

268

269 Findings and discussion of results

270 **Establishing the most effective cost control techniques**

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

1
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3 280 believes to effectively control costs, cost forecasting is the most effective as it allows for
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5 281 early identification of cost overruns, allowing for controls to be put in place to mitigate
6
7 282 them. These techniques are cheap and simple to implement, which could be another
8
9
10 283 explanation of why they are viewed as effective. Individuals will have experience utilising
11
12 284 them and will understand them clearly. The techniques being cheap to implement will
13
14
15 285 enable them to be used on all projects as they will be cost-effective.

16
17 286 The least used techniques are earned value ranked 10th with 0.579 RII, resources
18
19 287 monitoring 0.664 RII, interim valuation and payment 0.678 RII and value engineering
20
21 288 ranked 7th with 0.684 RII. As earned value is not a traditional technique, some participants
22
23 289 may not have used it, therefore viewing it as ineffective. Participant two in the follow-up
24
25 290 interview solidified this point stating they have never used this technique, therefore, view it
26
27 291 as the least effective. Additionally, as Webb (2017) states, this technique is more
28
29 292 complicated and involves advanced software, therefore becoming costlier and only
30
31 293 suitable for larger projects. Ranked the second least effective is monitoring labour,
32
33 294 material, equipment, and overheads (costs). Potts (2013) postulates that only monitoring
34
35 295 costs is ineffective as once the costs have been incurred there is nothing the cost
36
37 296 consultants can do, indicating a lack of control. Participant one in the follow-up interview
38
39 297 agrees, expressing the usefulness of monitoring costs to understand the project's progress
40
41 298 but the ineffectiveness of the technique in controlling costs.
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50 **300 Insert - Table 4.** Ranking of the cost control techniques

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56 302 Figure 1 presents the usage of cost control techniques across different disciplines. In
57
58 303 consulting ranking, cost forecasting and budgeting top the list with 0.762 RII, followed by
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60

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

306 Budgeting also top in the contracting discipline with 0.861 RII, followed by cost forecasting
307 0.843 RII and cashflow monitoring 0.791 RII. Budgeting also tops the local authority
308 discipline with 0.836 followed by cost forecasting 0.818, cost reporting and cashflow
309 monitoring 0.745 RII.

310

311 **Insert - Figure 1.** Usage of cost control techniques

312

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

315 Earned Value is lowest ranked in all the disciplines except under contracting with 0.655
316 RII. As earned value is a technique used mainly by contractors (PMI, 2005), it is unlikely
317 that other disciplines will have used it and therefore may not understand its effectiveness.

318 According to Webb (2017), earned value is not suitable for all project types, only projects
319 with specific characteristics. Interim valuations and certificates for payments gains a low
320 score across all projects illustrating that it is ineffective at controlling costs. Monitoring
321 costs received a high rating on projects less than £10 million, however on projects over
322 £10 million it is scored the lowest and second lowest, showing that on higher-value
323 projects it is less effective. Therefore, on larger projects, more controls must be put in
324 place to ensure the costs do not overrun, merely monitoring costs will not be enough.

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

1
2
3 328 earned value is viewed as the least effective, with it being more effective on larger projects
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5
6 329 than smaller projects. Similarly, [post](#)-project reviews and site meetings are viewed as more
7
8 330 effective on larger projects than smaller projects, suggesting that even though
9
10 331 collaboration and communication is important on all projects is it essential on larger
11
12 332 projects. The effectiveness of interim valuation and certificates for payment is consistently
13
14 333 scored lower as the projects increase in value, exemplifying the higher value the project,
15
16
17 334 the less effective this technique. Using this technique on larger value projects may,
18
19 335 [therefore](#), be more of a hindrance than an advantage.

20
21
22 336 Figure 2 shows how insights differ depending on [an](#) individual's years of experience. Cost
23
24 337 forecasting is scored the highest for all experience levels except those with 20+ years.
25
26 338 Budgeting is scored the highest by those with 20+ years of experience and second by
27
28 339 those with less than 20 years of experience.

30
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32 340

33
34 341 **Insert - Figure 2.** Individual's Years of Experience Comparison

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37 342

38
39 343 This confirms that budgeting and cost forecasting are the most effective cost control
40
41 344 techniques. However, those with 20+ years of experience view variation/change
42
43 345 management as the second most effective technique. The opinion of those with 20+ years
44
45 346 of experience should be valued highly as they have used the techniques more therefore
46
47
48 347 their judgement [was considered rational](#). Earned value is rated lower by those with more
49
50 348 than 11 years of experience but received higher scores by those with less experience.
51
52 349 Confirming that participants with more experience who use more traditional cost control
53
54
55 350 techniques may not have experience with earned value, [therefore](#), view it as ineffective.

56
57
58 351 When asked if there are any techniques the participants found effective but were not in the
59
60 352 study, some different techniques were identified. Firstly, time management was listed,

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3 353 having effective time management will be effective at controlling costs as any delays will
4
5 354 lead to cost overruns. Risk management was also identified as an effective technique.
6
7 355 Effectively managing risks is an important and effective technique, as common causes of
8
9 356 cost overruns have already been identified through risk management. Therefore, if these
10
11
12 357 risks were successfully managed, [fewer](#) cost overruns would occur.

13
14
15 358 Finally, the technique that was identified multiple times was controlling the design.
16
17 359 Avoiding complex design, less design changes, and the design being as complete as
18
19 360 possible at the time of tender were all identified as ways to minimise cost overruns. As
20
21 361 design related factors have been established as the main cause of cost overruns,
22
23 362 controlling the design is essential to effectively control costs. However, at the [post](#)-contract
24
25 363 stage, little can be done if there is a complex design, therefore the cost consultants must
26
27 364 be involved in the design stage to give cost advice. More emphasis must be placed on
28
29 365 reducing design changes as these are the main factor causing cost overruns. As identified
30
31 366 by participants in this study, controls must be put in place to effectively manage the design
32
33 367 changes. Controlling design changes could be considered as one of the most effective
34
35 368 techniques [for](#) reducing cost overruns. However, changes in design are often out of the
36
37 369 cost consultants' control, therefore emphasis must be put on controlling the design
38
39 370 changes and managing them properly.

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49 373 **Selecting the most effective cost control technique**

50
51 374 The overall result as in [Table 5](#) indicates that cost information/[cost](#)-related factors is
52
53 375 ranked first with 0.611 RII, followed by the size of company 0.509 RII and the effectiveness
54
55 376 of the technique 0.572 RII. The result for contracting discipline is similar except the third
56
57 377 factor are resources available and project duration 0.496. The consulting discipline sees

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

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

390

391 **Insert - Table 5.** Selection of Cost Control Technique Factors

392

393

394 **Standardisation of cost control**

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

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3 403 *company and projects can accurately be compared*“._–Another respondent stated “to
4
5 404 *support consistent and repeatable successful cost control utilising methods and reviews*
6
7 405 *that the team are comfortable with. Whilst utilising a standard approach there should be a*
8
9 406 *degree of tailoring to the project requirements around size, complexity, financial model,*
10
11 407 *etc.”*
12
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14

15 408 72 per cent thinks changes should be made due to project requirements. The resources
16
17 409 secured for the project, appropriateness of techniques, projects specific demands, project
18
19 410 peculiarities, resources availability, unforeseen circumstances, size of the contracting firm,
20
21 411 size and type of the project, and client-specific requirements are the reasons according to
22
23 412 the respondent to justify unstandardised approach to cost control. One of the respondents
24
25 413 states that “larger projects can benefit from more procedural cost control methods. Smaller
26
27 414 or fast projects may be hindered by cost control procedures. The uniqueness of each
28
29 415 project requires flexibility. Changes in the design and contract team for each project
30
31 416 requires re-thinking of approach each time. If a variable such as industry, client, laws and
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33 417 regulations change then this may have an impact. Flexibility in contract and cost control
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35 418 management is needed to meet changing situations.”
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44 **420 Challenges for implementing effective cost control**
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46 421 When asked about the main challenges faced when trying to monitor and control costs,
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48 422 common themes highlighted are; information issues, client changes, and project
49
50 423 management issues. Distinctively the challenges faced in monitoring cost is different from
51
52 424 controlling cost. Similarly, design changes were identified as the main cause of cost
53
54 425 overruns, indicating that that client changes or design changes are a key issue in
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56 426 implementing effective cost control. A simple solution to this would be to limit design
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58 427 changes and ensure the client is happy with the design when the contract is awarded,
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3 428 however, this is sometimes impossible as changes may be necessary. Project
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5 429 management related factors featured more in the challenges of controlling costs, factors
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7 430 such as lack of communication, lack of experience and poor planning represented some of
8
9 431 the main challenges of effective cost control. This demonstrates that when costs need to
10
11 432 be controlled rather than monitored, effective project management is essential. Ensuring
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13 433 project members work collaboratively is essential in guaranteeing a project's success and
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15 434 that the project does not experience cost overruns. If budgeting, forecasting and reporting
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17 435 are completed more effectively, costs could be better controlled but to undertake these
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19 436 methods correctly the cost consultant often must rely on the quality of information they
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24 437 receive, another challenge presented by the participants.
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30 31 440 **The impact of digitisation on cost control**

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33 441 When asked if advances in technology have improved cost control, 84 per cent of
34
35 442 participants believed it has made controlling costs easier. Participants expressed how data
36
37 443 had become easier to collect, easier to store, and easier to analyse. Advances in
38
39 444 technology has allowed individuals to monitor costs more effectively and has made it more
40
41 445 time-efficient. It has allowed faster and better communication between parties, therefore
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43 446 allowing for better collaboration and control. Measurement tools are also available,
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45 447 allowing for more accurate and easier measurement. Tools presented by participants
46
47 448 included IT, Microsoft packages such as excel, Evolution M, online resources such as
48
49 449 Building Cost Information Service (BCIS) and software programs such as CCS WinQS,
50
51 450 CostX, Asta Power project, and EDMS. This indicates that there is a readily available
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55 451 supply of technology that can enhance cost control, making it easier and more effective.
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58 452 However, 16% believed technology had not made cost control easier, one reason given for
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453 this is tools are not being adopted widely enough. Nonetheless, with the majority of
454 participants believing cost control is easier with advances in technology, it shows that
455 technology is improving cost control.

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

458

459 **Insert - Table 6 Challenges** in monitoring and controlling costs

460

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

464

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

466

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

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3 477 [broad, complex issue of cost overrun and effective cost controlling techniques, the model](#)
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6 478 [can be utilised for critical learning on mitigating cost overruns and the effective use of cost](#)
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8 479 [control techniques in the construction industry.](#)
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11 481

12 482 **Conclusions**

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17 483 It has been established that cost overruns occur on projects and there are effective cost
18
19 484 control techniques that should be put in place. [Design management, a thorough cost](#)
20
21 485 [planning exercise, client's involvement and the use of digitisation can solve some of the](#)
22
23 486 [problems associated with design leading to additional cost. To minimise cost overruns](#)
24
25 487 [more accurate time and cost estimations must be produced and better coordination](#)
26
27 488 [between parties is needed.](#) If budgeting is done effectively and followed by the project
28
29 489 team the cost of the project will come within budget. Cost forecasting is also an effective
30
31 490 technique as it gives [an](#) early indication of costs therefore potential cost overruns can be
32
33 491 detected and controls can be put in place to minimise overruns. Variation/change
34
35 492 management is another simple and effective way to manage project costs to prevent
36
37 493 overrun. The use of different cost control techniques will depend on the different factors
38
39 494 (project, size, time, etc.) as identified in the study. Therefore, selecting the most effective
40
41 495 cost control technique depends on the nature and size of the project, resources available,
42
43 496 and project duration.

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45 497 Budgeting and cost forecasting are viewed as very effective and should always be utilised.

46
47 498 Techniques such as earned value can only be used on specific projects and would not be

48
49 499 [cost-effective](#) on [lower](#)-value projects therefore would be ineffective on most projects. Due

50
51 500 to the unique nature of construction projects, a company's cost control techniques should

52
53 501 not be standardised and should be able to change due to project requirements. Advances

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

504 Building upon the scholarly works of Chan and Kumaraswamy (1997); Jackson (2002);
505 Olawale and Sun (2010); Memon *et al.* (2011); Park and Papadopoulou (2012); Rosenfeld
506 (2013), this study should be viewed as an extension of developing solutions for factors
507 affecting the selection of effective cost control techniques in the UK construction industry.
508 Although identifying and ranking the factors affecting the selection of effective cost control
509 techniques in the UK construction industry has been the focal point of this study, clearly,
510 further research is needed as this study is subject to a number of limitations. The study
511 was only limited to the UK's construction industry and was based on a survey using the
512 participants from the industry personally known to the researchers which may restrict the
513 generalisability of its findings to be applied to other countries and specific project types. In
514 addition to this, the effectiveness of these effective cost control techniques during the
515 project execution phase needs to be thoroughly investigated in future research as it is
516 evident that despite the use of cost control techniques many notable construction projects
517 still experience cost overruns. Findings of this study and the proposed model, however,
518 can be used as a learning tool for mitigating cost overruns and the effective use of cost
519 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 <i>et al.</i> (2011)
Inaccurate time and cost estimations	1,3,4,5,6	2. Wanjari and Dobariya (2016)
Fluctuation of prices of materials	1,2,7,8	3. Jackson (2002)
Lack of information available	3,4,9	4. Jergeas (2008)
Delay and extension of time		5. Flyvbjerg (2005)
Delays in material and equipment procurement	1,10,11	6. Membah and Asa (2015)
Delays in decision making	1,11,12	7. Doloji (2012)
Delays in planned activity	2,10,11	8. Akanni, Oke and Akpomiemie (2015)
Project management		9. Sun and Meng (2009)
Lack of experience	1,13	10. Chan and Kumaraswamy (1997)
Lack of coordination/poor relationship between parties	1,2,14,15	11. Timothy <i>et al.</i> (2013)
Inadequate planning and scheduling	1,16,17	12. Semple <i>et al.</i> (1994)
Inadequate monitoring and control	1,2,3,14,17	13. Larsen <i>et al.</i> (2016)
Poor contract management	1,3,17,18	14. Forcada <i>et al.</i> (2014)
Procurement and tendering	1, 3,17,19	15. Kim, Lee and Jung (2017)
Design		16. Rostami and Oduoza (2017)
Poor design and delays in design	1,2,3,20,21	17. Rosenfeld (2013)
Design changes	1,2,3,20,21,22	18. Kim <i>et al.</i> (2017)
Changes in material specification and type	1,9,23	19. Park and Papadopoulou (2012)
Design team performance	3,24,25	20. Wu <i>et al.</i> (2005)
Construction		21. Olawale and Sun (2010)
Mistakes during construction	1,2,14,18	22. Hadipriono and Tahir (1990)
Additional works	1,2,23,18	23. Greiman and Warburton (2009)
Shortage of site workers	1,4,26	24. Doloji (2012)
Poor site management and supervision	1,14,19	25. Jarkas and Haupt (2015)
Waste on site	2,18,27	26. Patel <i>et al.</i> (2013)
Payments		27. Aziz (2013)
Financial difficulties of owners	1,17,28	28. Müller (2014)
Mode of financing, bonds and payments	1,29,30	29. Garvin (2007)
Dispute on bill settlements	2,12,17	30. Winch (2013)
Claims	3,12,17	31. Lu <i>et al.</i> (2017)
Contractor specific factors		32. Sudirman and Hardjomuljadi (2011)
Cashflow and financial difficulties faced by contractors	1,16,31	33. Love and Li (2000)
Incompetent subcontractors	1,3,18,19	34. Love <i>et al.</i> (2004)
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 <i>et al.</i> (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
<ul style="list-style-type: none"> 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 	<ul style="list-style-type: none"> time pressure time availability lead in times for production time constraints time lag timely input from design team 	<ul style="list-style-type: none"> 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 	<ul style="list-style-type: none"> inadequate risk register risk pricing client decision making reporting and assessment faulty site reporting 	<ul style="list-style-type: none"> 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 	<ul style="list-style-type: none"> clients tend to be over-ambitious client decision making client changes client wants

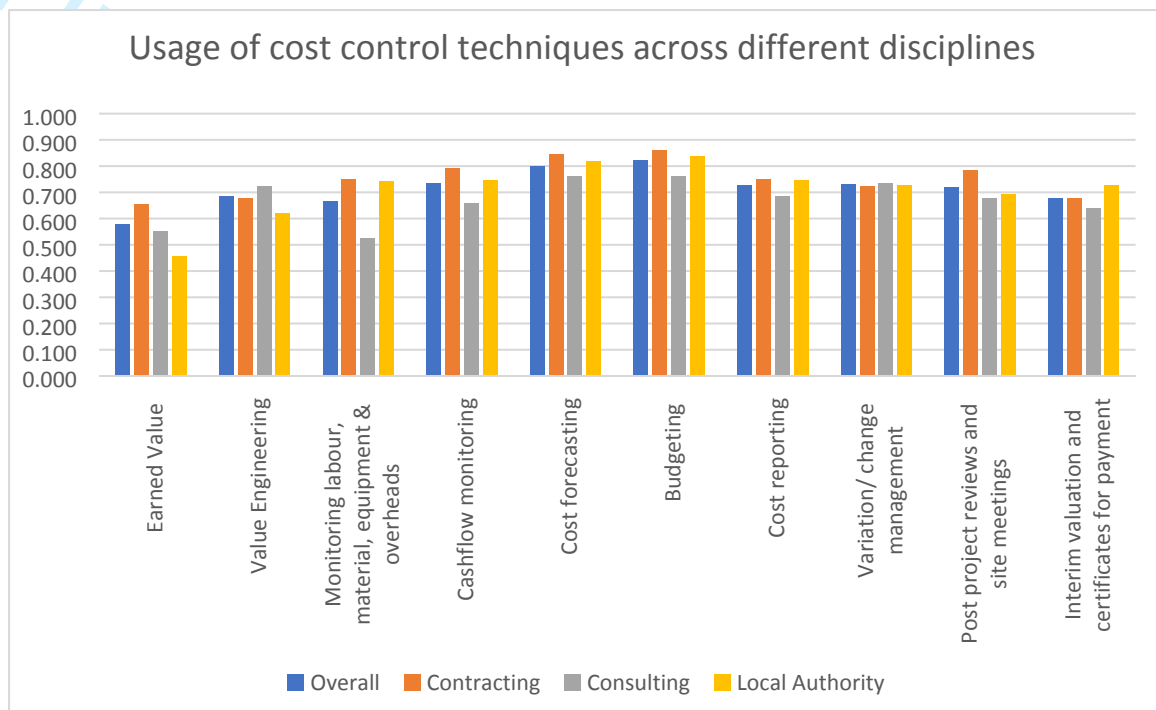


Figure 1 Usage of cost control techniques

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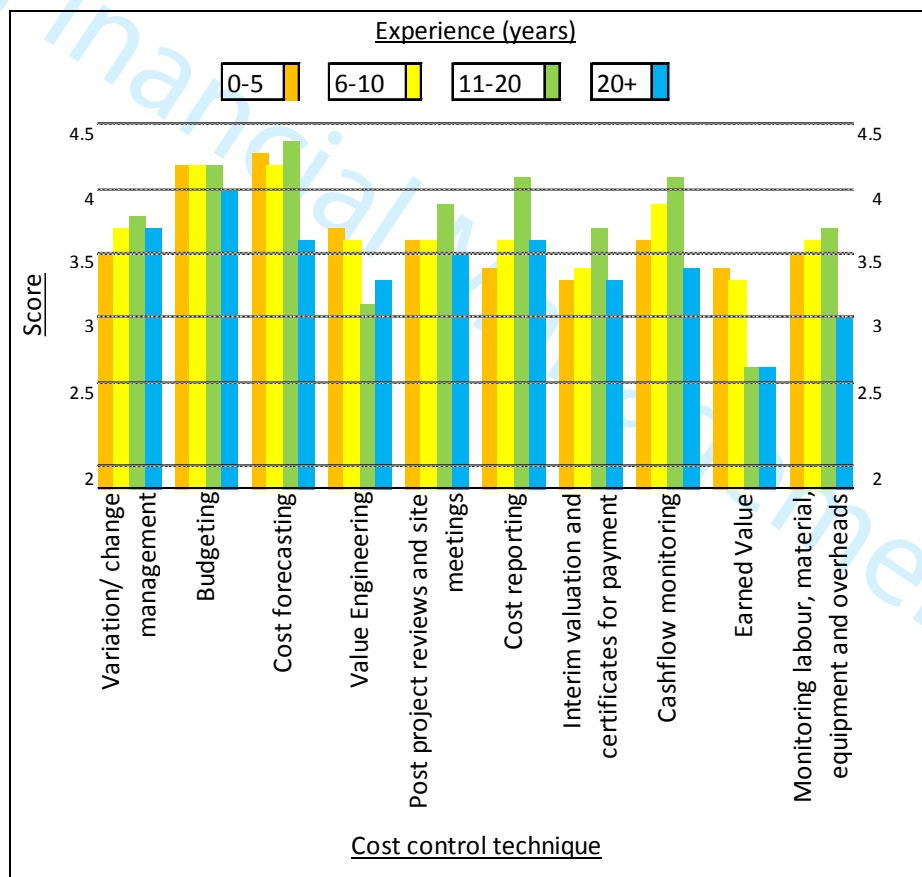


Figure 2 Individual's years of experience comparison

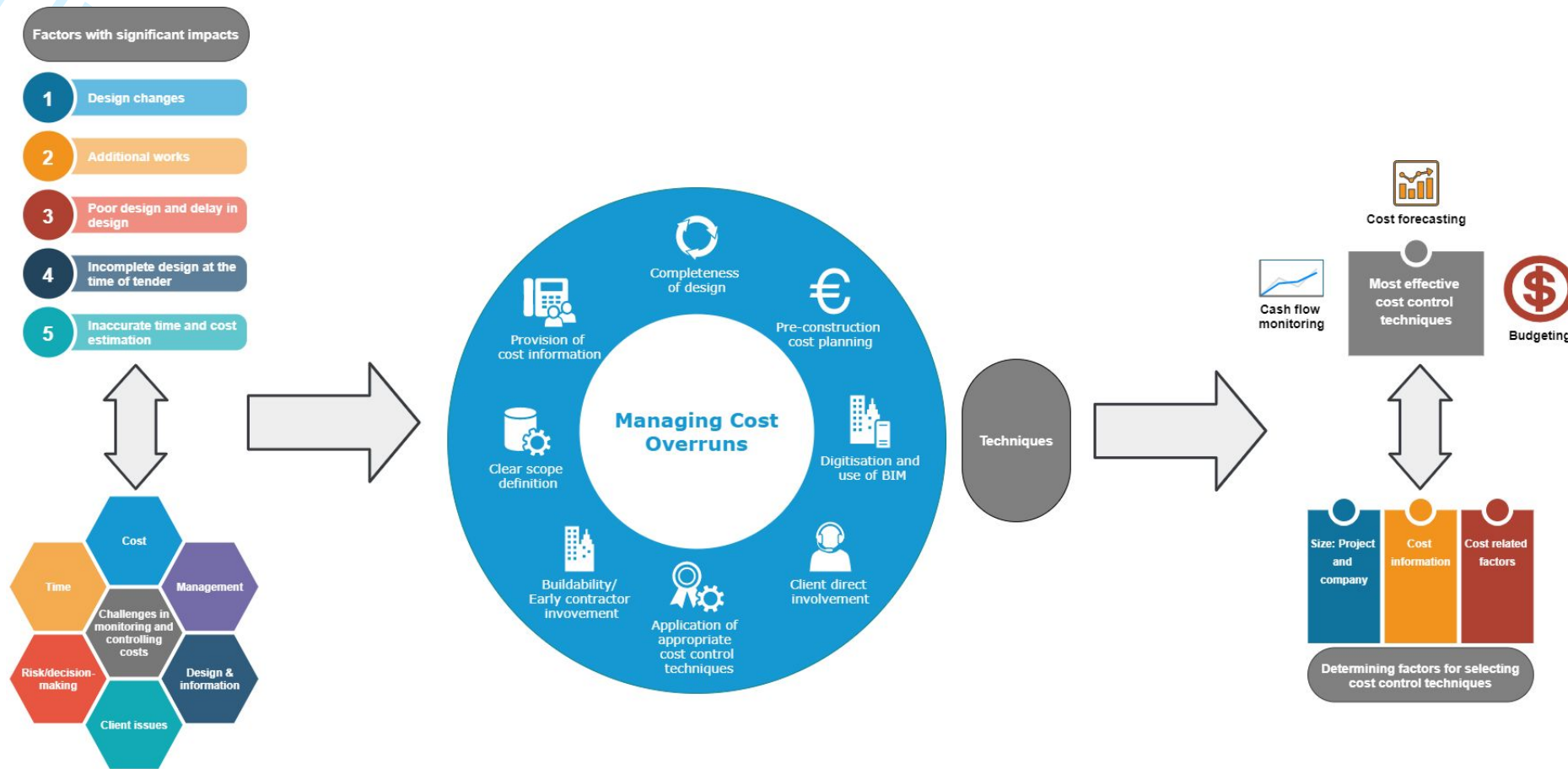


Figure 3 Managing cost overruns in a project – controlling and monitoring