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# 1 **CRITICAL SUCCESS FACTORS FOR SUBWAY CONSTRUCTION**

## 2 **PROJECTS – MAIN CONTRACTORS’ PERSPECTIVES**

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7 **Keywords:** Project Success, Critical Success Factors, Subway Projects, Construction Management

### 8 **Abstract**

9 Successful subway construction projects involve many socio-economic, cultural and environmental  
10 challenges. These projects enhance public convenience, and are complex and uncertain, involving  
11 multiple governmental organisations. The critical success factors (CSFs) of these projects have been  
12 identified and prioritised from a main contractors’ perspective, to enable project managers to prioritise  
13 their efforts and concerns. This study sheds light on critical success factors (CSFs) in subway  
14 construction projects and contributes to the project delivery success literature with an overarching focus  
15 on the contractors' perspectives. Our investigation revealed that, for subway construction projects in Iran,  
16 goal setting through clear and realistic project goals, project management competency, competent project  
17 team, good cultural fit, top management support, and adequate funding throughout the project are the top-  
18 ranking CSFs. An extensive body of literature is reviewed, and 140 potential success factors are  
19 identified. Then a focus group has been conducted in which the potential CSFs reduced to 39 success  
20 factors. The priorities and ranking of the success factors were evaluated according to the views of 63  
21 project managers of subway projects. The Correlation coefficients analysis was used to analyse the

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22 results, and it revealed that 23 success factors such as goal setting, top management support and PM  
23 competency were perceived to be critical by the respondents. No other research has, until now, found the  
24 critical factors leading to success in subway construction industry in Iran. The results have been verified  
25 against other research done in other countries.

## 26 **1. Introduction**

27 The Iranian economy is growing at a relatively rapid pace. From 2013, the growth rate has significantly  
28 increased from -1.9% to 4.6% in 2014 (<https://data.worldbank.org>). Massive investments for the  
29 construction and development of subway systems have been injected through the years to reduce  
30 transportation problems, particularly in Tehran (the 24th largest city in the world, according to  
31 <http://www.citymayors.com>). These efforts have not only to cope with the demands of a rapidly  
32 developing economy but also to ensure that the country's competitiveness in global markets is not  
33 compromised by the lack of a reliable, quality transportation system. Although Tehran as a metropolis  
34 enjoys a massive network of highways (280 km) and an extensive bus rapid transit (BRT) line (100 km),  
35 traffic congestion is one of the most irritating problems in Tehran which has become intolerable and at  
36 times agonizing for locals during rush hours, due to the growing population and increasing private  
37 vehicle ownership (Forouhar, 2016).

38 Subways are constructed in major cities like Tehran to overcome the transportation problems associated  
39 with urbanisation. Statistics from TUSROC's website indicate that more than 129 million trips using  
40 subway happened during spring of 2011 in Tehran, and more than two and a half million people are now  
41 using the subway daily (Bagheri 2017). "Almost 60% of Tehranies use the metro on a regular basis, and  
42 over half of the trips are either for shopping (28%), work (19%), or going to Tehran's CBD (15%).  
43 Worldwide, Tehran's subway ranks 15<sup>th</sup> in terms of the number of passengers per day and 20<sup>th</sup>  
44 regarding network length which was 128 km in 2012" (Bagheri 2017, p.7). Looking at these figures, the

45 economic benefits of subway construction are clear. Thus, subway construction projects are essential in  
46 Tehran given the city's traffic congestion. The success of such projects is vital for sustainable economic  
47 growth and social well-being (Ghanbaripour et al., 2015).

48 Through the years, the Iranian government has made considerable investments in transportation systems  
49 and expended substantial effort in expanding its network. According to Jin et al. (2012), infrastructure is  
50 vital for the development of the country. These projects play a crucial role in the construction industry of  
51 the country. It acts as a key to attracting foreign capital to developing countries (Jin et al., 2012). In this  
52 regard, public transportation in Tehran (population over 9 million) should mitigate the problems arising  
53 from the lack of an adequate transportation system and consequently reduce air and sound pollution. As  
54 a result, subway projects have received a significant share of public sector development expenditure.

55 Thus, improving the project and construction management processes of these projects by identifying the  
56 critical success factors should be beneficial.

57 However, subway construction is not without problems. The main reasons for unfavourable outcomes  
58 fall into several categories. Construction projects rely on the integrated efforts of several hierarchically  
59 linked parties (including architects, engineers, surveyors, general contractors, subcontractors and  
60 suppliers) using their specialist skills, knowledge and technology. Normally, these parties are  
61 independent organisations with separate objectives and goals, management styles and operating  
62 procedures (Chen and Chen 2007). “A metro system is usually designed to be utilised for the crowded  
63 area of cities. The process of constructing such systems, obviously, interrupts daily civilian life. This  
64 issue illustrates the importance of adequate management and planning to deliver metro projects on time  
65 and budget with high quality and efficiency (Khosravi and Kähkönen, 2015)”. These projects are  
66 complex and dynamic, and their success or failure cannot be measured with a simple test like the

67 compressive strength of a concrete mix. Constructing public infrastructure projects successfully,  
68 requires economy, efficiency, quality, fairness and transparency (Tabish and Jha, 2011).

69 This study of identifying CSFs is timely, as it is one of the essential ways to understand the main factors  
70 leading the projects of a particular industry to success at a specific time. The importance of this  
71 endeavour is of high significance since a shared understanding of these CSFs facilitates effective  
72 monitoring and controlling of these projects' performance for project owners and managers, who need  
73 specific and measurable frameworks for tracking key project outcomes. It is also well known that CSFs  
74 are necessary for the appropriate allocation of various project resources (Ahadzie, 2007; Cox et al.,  
75 2003; Chua, 1999).

76 Achieving success in public projects is difficult because it requires economy, efficiency, quality, fairness  
77 and transparency (Tabish and Jha, 2011). Many factors contribute to project success. In this study, CSFs  
78 are ranked based on contractors' perspectives since construction projects, and their success is highly  
79 dependent on contractors (Alzahrani and Emsley, 2013; Banki et al., 2009; Ng et al., 2009). According  
80 to Alzahrani and Emsley (2013), when the contractors begin their main duties, it impacts upon project  
81 success when the project reaches the construction or execution stage. Therefore, this study aims to  
82 discover the factors contributing to subway construction projects' success from a contractors'  
83 perspective.

84 Toor and Ogunlana (2006) observe that most studies on CSFs for construction projects are context-  
85 specific. Therefore, the specific implications of studies on success factors are limited to the countries  
86 and cultures in which these studies have been conducted. Toor and Ogunlana (2008) suggest that more  
87 studies should be performed in other states to account for the nature and structure of the local  
88 construction industry, the scale of construction projects, procurement strategies, the maturity of the  
89 organisations concerned, and local cultural values and norms. Also, ever-changing socio-economic and

90 cultural changes have become increasingly sophisticated and perplexing. This, together with the  
91 globalisation of the construction industry, poses numerous challenges to those concerned at all levels  
92 (Lewis, 2006; Ofori, 2007; Raftery et al., 1998).

93 This paper is divided into five further sections. A comprehensive literature review of project delivery  
94 success and CSFs is provided in the next section, and a set of 140 potential factors are extracted for  
95 subway construction projects from past research. Then the methodological approach of the study is  
96 presented, and the process of identifying possible factors is explained that how the authors condensed  
97 the factors mentioned above into 39 success factors, and it is followed by an analysis and discussion of  
98 the results. The final section reflects on the conclusion and verification of the results.

## 99 **2. Context to the study**

### 100 ***2.1. Project Success***

101 Project success has been discussed at length in project management literature (Carvalho and  
102 Rabechini Junior, 2015), revealing the social and political contextualization of performance in project  
103 management (Sage et al., 2014). The traditional view of project success is associated with fulfilling  
104 time, cost and quality objectives (the iron triangle), and this view arises from Martin Barnes's 'iron-  
105 triangle' consisting of the core project constraints that he introduced in 1969 (Langston, 2013;  
106 Carvalho et al., 2015).

107 Project success may be assessed regarding efficiency in the short term and effectiveness in achieving  
108 the expected results in the medium and the long-term (Jugdev et al., 2001; Müller and Jugdev, 2012).

109 There seems to be no simple definition of this construct. Project success may be measured differently  
110 for different types of projects, from different perspectives, at various stages, and in absolute or relative  
111 terms (Samset, 1998). It is a multidimensional construct (Carvalho and Rabechini Junior, 2015;  
112 Samset, 1998; Shenhar and Dvir, 2007) and different stakeholder groups have their perceptions of

113 project success (Chou and Yang, 2012; Davis, 2014, Toor and Ogunlana, 2010; de Vries, 2009).  
114 However, despite different success criteria for different projects, Langston (2013) introduced a model  
115 using six generic key performance indicators (KPIs) that were ratios of the core constraints of the  
116 project namely scope, cost, time and risk to enable comparison of projects in terms of delivery success  
117 regardless of type, industry, size or time.

118 Several valuable studies have been conducted on project success, mostly focusing on two dimensions,  
119 namely success criteria (the measures by which success or failure of a project or business will be  
120 judged) and success factors (the inputs to management systems that lead directly or indirectly to the  
121 success of the project or business) (Cooke-Davies, 2002). Criteria for success and critical success  
122 factors are two relevant keywords used in project and project management contexts. While ‘success  
123 criteria’ are the standards on which a judgment or decision about project success are based (Gibson  
124 and Hamilton, 1994), ‘critical success factors’ (CSFs) are the key areas of activity in which favorable  
125 results are necessary for a particular manager to reach his or her goals (Rockart, 1982). Understanding  
126 the distinction between these terms is essential for the formation of CSFs for construction projects.  
127 This provides researchers with a clear direction of the subject matter to avoid possible confusion  
128 (Yong and Mustaffa, 2013). Authors argue that being aware of the CSFs relevant to a specific project,  
129 particularly in subway construction projects in Tehran, will help project managers to allocate their  
130 resources and practices advantageously and lead to successful outcomes.

## 131 ***2.2.Critical Success Factors in the construction industry***

132 From a project management perspective, CSFs are the characteristics, conditions, or variables that  
133 have a significant impact on the success of projects when adequately sustained, maintained, or  
134 managed (Milosevic and Patanakul, 2005). Different studies have identified different CSFs. There is

135 a lack of consensus among researchers about the criteria for judging project success and the factors  
136 that influence that success (Fortune and White, 2006).

137 Success has always been the ultimate goal of every activity, and a construction project is no  
138 exception. The construction sector is distinct from other areas of the economy and is characterised by  
139 a high rate of failures (Elattar, 2009).

140 It is believed that the definition of success factors is a prerequisite for an organisation's success and a  
141 way for measuring its maturity level (Khandelwal and Ferguson, 1999). The most common CSFs have  
142 been presented by Cooke-Davies (2002), Judgev and Muller (2005), and Ika et al. (2012).

143 Attempts have been made to identify and validate the relevance of CSFs for diverse types of  
144 construction projects such as mass housing projects (Ahadzic et al., 2008), design and build projects  
145 (Chan et al., 2001; Lam et al., 2008), BOT projects (Tiong, 1996), and public-private partnerships in  
146 infrastructure development (Zhang, 2005). Most of these studies have adopted research approaches  
147 that first extracted sets of project success factors based on reviews of relevant literature and project  
148 characteristics, and then validated them quantitatively or qualitatively through questionnaire surveys  
149 (Yu and Kwon, 2011). Research conducted in Australia presents a more recent perspective on  
150 construction project management success (Doloi and Lim, 2007). Several CSFs were identified  
151 including detailed planning of project budgets and cost control, project time planning and schedule  
152 control, human resources management (including support and communication), project quality  
153 control, abilities of team members to perform the required tasks, the information and specification  
154 available, project complexity, personnel with construction industry experience, project contingencies,  
155 well-defined and detailed breakdowns of project structures and project milestones (Doloi and Lim,  
156 2007; Ribeiro, 2013). The Construction Industry Institute of the University of Texas (CII, 2011)  
157 proposed a set of 14 areas of expertise derived from extensive research and benchmarking processes



158 to be mastered to guarantee project management success in the construction sector. These areas of  
159 knowledge also address technical and management factors including project planning, design  
160 optimization, materials procurement and management, construction start-up and operations, human  
161 resources management, project organization management, business and project processes, project  
162 control, risk management, safety and health, environmental protection, information and technology  
163 systems management, globalization issues and security (Ribeiro, 2013).

164 However, there are few studies on CSFs for subway construction projects. As mentioned before, in  
165 this study 140 CSFs are extracted from relevant academic papers. Then a focus group approach  
166 adopted to identify the potential pertinent CSFs to subway construction projects. After this  
167 consolidation process, a more manageable number of 39 success factors remained. Focus group  
168 discussions allow participants' perceptions, feelings, and experiences to be interwoven and stimulated  
169 to widen the range of opinions on specific topics and avoid individual bias (Morgan et al. 1998).

170 Previous research has categorised CSFs in different ways. Jin et al. (2012) suggested that the potential  
171 CSFs for infrastructure projects may be grouped under the following main categories: (1) Project  
172 Management-related (PM) factors; (2) Client-related (CL) factors; (3) Design team-related (DS)  
173 factors; (4) Contractor-related (CN) factors; and (5) Business and Work Environment-related (EN)  
174 factors. Inayat et al. (2014) used four categories of project characteristics, contractual arrangements,  
175 project participants and interactive process. In a study of critical success factors for construction  
176 projects in Lithuania, Gudiene et al. (2014) classified the CSFs into seven groups of external factors,  
177 institutional factors, project-related factors, project management/team-related factors, project  
178 manager-related factors, contractor-related factors and client-related factors. All the CSFs presented in  
179 these texts have been distilled into the four categories shown at the bottom of Table 1 (i.e. Client-  
180 related, Project management and planning-related, Project team-related and External Factors).

181 “Insert Table 1 here”

182 Table 2. shows 140 all potential success factors extracted from relevant references: *Walker (1995), Toor*  
183 *and Ogunlana (2008), Songer and Molenaar (1997), Chua et al. (1999) Dissanayaka and Kumaraswamy (1999),*  
184 *Kumaraswamy and Chan (1999), Mayer et al. (1995), Munns (1995), Hartman (2002), Cheung et al. (2003), Walker and*  
185 *Hampson (2003), Kadefors (2004), Nguyen et al. (2004), Pinto et al. (2009), Pinto and Slevin (1988), Chua et al. (1999),*  
186 *Cooke-Davies (2002), Nicolini (2002), Andersen et al. (2006), Fortune and White (2006), Sambasivan and Soon (2007),*  
187 *Belassi and Tukel (1996), Sanvido et al. (1992), Meng (2012), Songer and Molenaar (1997), Lim and Mohamed (1999),*  
188 *Kong and Jason (2006), Takim et al. (2004), Chan and Kumaraswamy (1996), Low and Chuan (2006), Dainty et al. (2005),*  
189 *Munns and Bjeirmi (1996), Belout and Gauvreau (2004), Akintoye (2000), Alaghbari et al. (2007), Construction Industry*  
190 *Development Board Malaysia (2006), Construction Industry Development Board Malaysia (2006), Sambasivan and Soon*  
191 *(2007), Narayanan and Lai (2005), Eriksson (2006), Abdul Rahman et al. (2010), Jha and Iyer (2007), Lam et al (2008), Yu*  
192 *and Kwon (2011), Yong and Mustaffa (2013), Gudienė et al (2014), Inayat et al (2012)*

193 “Insert Table 2 here”

### 194 **3. Research Method**

195 This research identified and analysed the CSFs based on main contractors’ perspectives considering the  
196 following facts. Firstly, main contractors make major contributions to the development of subway  
197 projects in Iran. Their actions and decisions affect all aspects of these projects. For example, many of  
198 them are selected based on their ability to provide sufficient financial resources since they may be paid  
199 months or years after a project’s termination. Hence, contractors play an important role not only in the  
200 construction phase but also in the program, design, and post-construction phases of these projects.

201 Secondly, there is insufficient research that deals with main contractors’ views of CSFs for subway  
202 projects in Iran. Thirdly, these contractors have longstanding and extensive experience of construction  
203 projects, and their perspectives on success factors are robust, informative and valuable to stakeholders  
204 such as the government, consultants and academic researchers. These reasons motivated the authors to  
205 conduct this study from the perspectives of main contractors.

206 The focus of this research is to identify and evaluate the success factors of subway construction projects.  
207 An extended literature review was conducted and 140 potential success factors for construction projects  
208 were extracted. A focus group reduced these success factors to 39. Then, a questionnaire-based survey  
209 was undertaken to achieve the views of experienced subway construction professionals on these success  
210 factors and to rank them based on the mean score of each factor. The whole process was conducted in  
211 four steps as follows:

212 *Step 1: Focus group*

213 Focus group discussions allow participants' perceptions, feelings, and experiences to be interwoven and  
214 stimulated to widen the range of opinions on specific topics and avoid individual bias (Morgan et al.  
215 1998). Hence, focus groups emphasise the results of interactive discussions among representative  
216 participants rather than those of individuals within a group (Leung et al., 2014).

217 All success factors extracted from literature (shown in Table 2) were considered to develop a list of  
218 factors for empirical testing. These factors were reduced during a two-session focus group (each session  
219 lasting two hours), attended by some professionals experienced in subway construction projects. A total  
220 of seven project managers participated in this exercise. These participants were selected based on the  
221 following criteria:

- 222 • All focus group participants had at least ten years of experience in the construction of subway  
223 projects (predominantly in Tehran).
- 224 • Furthermore, all participants had been involved in at least five projects, meaning that they had  
225 accumulated diverse experiences which enabled them to provide informed opinions about the factors  
226 that contribute to the success of subway projects.
- 227 • All participants held senior positions in their companies and were project managers.

228 The candidate project managers were identified from a list of companies involved in this industry. They  
229 took part in a focus group meeting to reduce the number of potential factors. Invitations were sent via  
230 email to project managers working on these projects. Finally, the meeting was held with seven PMs.  
231 In this meeting, each factor was voted on and the plurality method according to PMBOK 2012 (Fifth  
232 Edition) was used to eliminate less critical factors. “Plurality is a decision that is reached whereby the  
233 largest block in a group decides, even if a majority is not achieved. This method is generally used when  
234 the number of options nominated is more than two” (PMI, 2013, p. 115). The plurality or simply ‘first  
235 past the post’ is the simplest form of voting. Each voter has one vote, which can be cast for any success  
236 factor. The factor with the highest number of votes remains on the list. The benefits of the plurality  
237 method are its simplicity and ease of use (Van Erp et al., 2002).

238 The fact that the factors could be summarised in such a drastic way indicates that there seems to be a  
239 standard base of CSFs over different domains (Gepp et al., 2014). Finally, 39 success factors were  
240 determined as shown in Table 3, and these constituted the basis for the empirical survey questionnaire.

241 “Insert Table 3 here.”

#### 242 *Step 2: Questionnaire development*

243 A questionnaire was developed based on 39 success factors resulting from the focus group. These  
244 success factors were presented to respondents using a paper-based survey. Respondents were invited to  
245 judge the importance of the 39 CFSs. All respondents were project managers as senior staffs of their  
246 organisations and all of them were engaged in subway construction works for at least one year. Since  
247 there are 63 running projects with project managers working for subway projects’ contractors, all of  
248 them were asked to participate in this research. These attendants were asked to rank the CSFs for the  
249 project they were currently involved with (their ‘case project’). The rating for each success factor was  
250 sought on a five-point Likert scale in which ‘1’ represented ‘strong disagreement’ and ‘5’ represented

251 'strong agreement'. The five-point scale includes immediate values among adjacent values and helps the  
252 respondents express their judgments subjectively and in an effective way (Tabish and Jha, 2011). Likert  
253 scales imply that the actual number of choices may be left to the tastes of individual researchers. In  
254 practice, researchers often do assign the number of choices arbitrarily according to personal taste or past  
255 convention (Munshi, 2014). Nevertheless, it is argued that the inclusion of midpoints on a scale is  
256 necessary. This is because it cannot be definite whether the meaning of "agree" or "disagree" response,  
257 for instance, really implies the respondents' agreement or disagreement towards the items. Some  
258 respondents may select these two options because there is no an option referring to "neutral",  
259 "undecided" or "don't know". In this sense, authors may need to take a risk that they may make an  
260 inaccurate conclusion due to the scale without such midpoints (Tsung, 2012).

261 The Cronbach's  $\alpha$  coefficient was used to determine the responses' reliability. An " $\alpha$ " exceeding 0.9  
262 indicates high reliability,  $\alpha$  between 0.9 and 0.7 indicates acceptable reliability, and  $\alpha$  below 0.35  
263 indicates low reliability (Fowler, 1993; Gay, 1996). For this questionnaire, Cronbach's  $\alpha$  of 0.928 was  
264 achieved. This result confirmed the appropriateness of further analysis of the data.

265 In this study, validity was used to ensure accurate measurement of the factors. As the selection of the  
266 initial items (CSFs) was based on a review of the theoretical and empirical literature, it is vital to assess  
267 internal validity. Authors brought the questionnaire to seven participants, and via face-to-face meetings  
268 they were asked to complete a pilot survey and to present a critique of the questions. Results  
269 demonstrated the validity of the questionnaire.

### 270 *Step 3: Selection of respondents*

271 A list of ongoing subway construction projects was developed by the information obtained from  
272 TUSROC (<http://metro.tehran.ir/>). To examine the characteristics of a target population, a representative  
273 sample should be selected, representing the features and attributes of the community in question. The

274 target population for this study was all 63 PMs of subway construction projects in the metropolis of  
275 Tehran who were working for the contractors of subway projects at the time.  
276 The questionnaires were distributed personally by the first-named author. From April to November  
277 2015, the author travelled around Tehran to places where, according to TUSROC, a subway station or  
278 tunnel was being constructed and conducted face-to-face meetings to explain the purpose of the study  
279 and to hand in the questionnaire personally to the project manager and then collected each of them after  
280 one week. Sixty three Tehran subway construction PMs were located, and questionnaires were  
281 distributed among all of them. According to Baruch and Holtom (2008), when conducting such research,  
282 scholars depend on the willingness of people to respond to the questionnaire. However, Rogelberg and  
283 Stanton (2007) state that a 100 percent response rate (RR) is unlikely to be achieved unless the  
284 questionnaire is coercively administered to the target population (Baruch and Holtom, 2008). In this  
285 study, although the authors handed in the questionnaires to the project managers personally, they used to  
286 follow it up with PM's assistants several times to ensure that the project manager would fill out the  
287 questionnaire.

288 Subway construction projects in Tehran are awarded to contractors based on a structured process.  
289 Although some minor changes happen because of the location, financial issues and organisational  
290 culture of the contractor firm, these projects are planned to be typical in scale, size, cost and duration.  
291 Needless to say, all these mentioned parameters for tunnel projects differ from stations.

#### 292 *Step 4: Analysis method*

293 The analysis included identifying the significant success factors based on their mean ratings by the  
294 following formula (Lew et al., 2003):

$$MS = \frac{\sum(f \times s)}{N} \quad (1 \leq MS \leq 5)$$

295 Where “f” is the frequency of responses to each rating, “s” is the score given to each factor by the  
296 respondents and ranges from 1 to 5 and “N” is the total number of responses concerning that factor. It is  
297 important to note that the ranking exercise is based on perceived importance (Yong and Mustaffa, 2012).

## 298 **4. Analysis and Discussion**

### 299 ***4.1. Background***

300 A brief characterisation of the responding PMs shows that the majority were male (90.5%), over 36  
301 years old (71.4%), although almost 30 percent are under 35 years old. As can be seen from Table 4,  
302 more than 65 percent have been involved in the project management of subway construction projects as  
303 a PM for more than six years and 23.8 percent for more than a decade. Moreover, all of the participants  
304 have a university degree, 42.8 percent of which have a post-graduate degree. The majority (74.6%) have  
305 more than five years of experience in civil engineering, and 57.1 percent have more than ten years of  
306 experience.

307 “Insert Table 4 here”

### 308 ***4.2. Ranking of CSFs***

309 Table 5 presents the result of the analysis of the success factors. A total of 39 success factors were  
310 ranked according to their mean values.

311 Analysis results of this study are in line with numerous other studies conducted in the other parts of the  
312 world (Yong and Mustaffa, 2013; Toor and Ogunlana, 2009; Inayat et al. 2014). Rating of success  
313 factors in Table 5 reveals high-scoring success factors are mostly related to three main factors which are:  
314 Project Management (e.g. Goal Setting, PM Competency, Performance Management); Project Team  
315 (e.g. effective allocation of human resources, competent project team, good cultural fit); and  
316 involvement of client (e.g. top management support, adequate funding).

317 “Insert Table 5 here.”

318 Figure 1 depicts the main CSFs (with a mean more than 4.05), categorised into three major parts of  
319 projects.

320 “Insert Figure 1 here.”

321 All CSFs are classified into three categories. This classification is suggested by the authors and then  
322 confirmed by the all seven participants of the focus group. All seven experts agreed with this  
323 categorisation.

#### 324 ***4.3. Project Management and Planning Factors***

325 Table 6 indicates the results of the analysis of the questionnaire responses with regards to project  
326 management and planning-related factors. Nine factors were identified in this category. Goal setting and  
327 PM competency are the top two factors, having a mean score (MS) of 4.714 and 4.460, respectively.  
328 While the adoption of innovative management approaches scored an MS of 4.159, clear and detailed  
329 written contracts have a lower MS of 4.095, suggesting that it has a less significant influence on the  
330 success.

331 The first ranked CSF was ‘goal setting’, indicating that apparently identified goals at various levels were  
332 highly crucial to subway projects success. Several investigations have found this CSF to be essential for  
333 the success of construction projects around the world (Nicolini, 2002, Nguyen et al., 2004, Fortune and  
334 White, 2006, Toor and Ogunlana, 2009, Yong and Mustaffa, 2013, Zhao et al., 2013).

335 Project manager’s competency ranked second. While many researchers emphasised the skills of  
336 consultants and contractors, some focused on the competencies of developers and project managers. In  
337 this regard, developers and project managers must be competent to respond to different situations to  
338 avoid ambiguities throughout the project period (Yong and Mustaffa, 2013).

339 The success of a project can be achieved by the diligence and competence of a project manager.

340 Competence is a critical factor affecting a project’s planning and implementation (Gudiene et al. 2013).



341 According to Bourne and Walker (2004) in most organisations, project managers are accountable for the  
342 successful delivery of entire projects. Increasingly, this success depends on project managers’  
343 processing and utilising skills and competencies that may initially appear contradictory. A successful  
344 project manager must demonstrate flexibility and competency in many areas, including hard and soft  
345 skills, as well as introverted and reflective, extroverted and social behaviours. Inayat et al. (2014) found  
346 that PM competencies were ranked among the top 10 CSFs by construction managers and design firms,  
347 and in Lithuania, Gudiene et al. (2014) ranked several CSFs in the construction industry and their study  
348 revealed that the project managers’ competence ranked in the top ten of 71 success factors. Also, Jin et  
349 al. (2012) studied the CSFs of developing infrastructure projects in Malaysia, and PM competency  
350 ranked ten among 33 factors.

351 The third-ranked success factor is “performance management at each phase”. This involves monitoring  
352 progress and goal achievements. To control them appropriately, project performance should be managed  
353 in an appropriate manner (Yu and Kwon, 2011). Effective performance management in each phase of a  
354 project should reduce rework which helps project teams to finish the project on time and within the  
355 planned budget. Cooke-Davies (2002) found that maintaining the integrity of the performance  
356 measurement baseline is a real success factor in European construction industry.

357 As can be seen in Table 6, effective allocation of human resources is a significant critical success factor  
358 in subway construction projects. Yong and Mustaffa (2012) showed that this factor ranked first in the  
359 category of project-related factors in the Malaysian construction industry. Having adequate resources  
360 but weak planning will result in loss of control and poor outcomes. This should be done in the very  
361 initial stage of a project (Toor and Ogunlana, 2009).

362 “Insert Table 6 here.”

#### 363 ***4.4. Project Team Factors***

364 Table 7 presents the results of the analysis of project team-related factors that contribute to the success  
365 of subway construction projects. The findings suggest that the first component that seemed to capture  
366 the PMs' general attention was "multidisciplinary/ competent team", having an MS of 4.381. The need  
367 for competent project teams has been mentioned in several studies (Belout and Gauvreau, 2004; Rogers,  
368 1990; Sommerville and Dalziel, 1998). The active contribution and assistance rendered by key project  
369 players depend significantly on the capability of the critical personnel and the overall competency of the  
370 team assigned to the project (Hwang et al., 2013). A team with expert, knowledgeable, experienced, and  
371 skilled team members are essential for the successful accomplishment of project goals. Kulatunga et al.  
372 (2009) emphasised that selecting a competent team is necessary, ranking this as the third most important  
373 factor in construction R&D projects.

374 Good cultural fit ranked third with a mean of 4.302 among project team-related success factors.  
375 Partnering parties have their preference for their organisations. Because of cultural diversity, individual  
376 parties tend to be dominated by their own goals and objectives, which can be conflicting and  
377 consequently may cause adversarial relationships (Love et al., 1998). Effective communication can  
378 facilitate the exchange of ideas and visions, reducing misunderstandings and stimulating mutual trust.  
379 Such communication involves the formation of active communication channels, which can be used to  
380 motivate partners to jointly participate in planning and goal setting and thus cooperate to create  
381 compatible expectations (Chen and Chen, 2007).

382 Favorable working conditions are an essential success factor in subway projects with a mean of 4.238  
383 (Table 7). The physical environment is part of the human environment that includes purely physical  
384 factors (natural disasters, weather, pollution, noise). It affects project participants, their working  
385 conditions and the successful implementation of projects (Gudine et al., 2013). According to Jha and

386 Iyer (2007), factors such as “favourable working condition” were found to be essential factors enhancing  
387 the cost performance of projects, which is a vital factor leading the project to success.

388 “Insert Table 7 here.”

#### 389 ***4.5. Client-Related Factors***

390 Table 8 shows the ranking of the client-related factors. Among the six CSFs affecting subway  
391 construction projects, the highest mean (4.492) was given to top management support from client  
392 organisations. The least important was the client’s responsiveness to the needs of the other stakeholders  
393 with the mean of 4.127. When all 39 factors are considered, there are six client-related factors among the  
394 top critical success factors ( $MS > 4.055$ ). Adequate funding throughout the project is ranked sixth, and  
395 project consultant’s competence (consultants who were chosen by the client in the initiating phase of  
396 projects) is listed the tenth.

397 “Top management support” which ranks first in the category of client-related factors, has been  
398 considered as a significant success factor in an overwhelming number of investigations. Jin et al. (2012)  
399 found that adequate support from top management is a “very significant” CSF in developing  
400 infrastructure projects in Malaysia (ranked 11 among 33 factors). According to Belout and Gauvreau  
401 (2004), it is understood that top management support is a necessary condition for conducting subsequent  
402 operations. Moreover, the commitment and dedication of all related parties in the project, especially the  
403 support from top management, as well as clear communication of mutual needs, issues, and solutions  
404 among the stakeholders will significantly improve overall project performance (Yong and Mustaffa,  
405 2012). Jha and Iyer (2007) stated that essential factors like top management support tend to keep the cost  
406 performance of projects at the same level and contribute significantly in enhancing project quality  
407 performance from its existing level.

408 In most construction projects around the world, adequate funding throughout the project is considered a  
409 critical success factor. In this study, it ranks second among other client-related factors with a mean of  
410 4.444. This shows that how important it is for subway projects to obtain financial support. The factor,  
411 adequacy of funding, refers to the timely provision of monetary resources by the owner to the contractor  
412 as an acceptance of the work done by the latter (Inayat et al., 2012). Clients should adequately address  
413 the financial needs of other stakeholders (Toor and Ogulana, 2009). Inayat et al. (2014) found that  
414 adequacy of funding and site inspections qualified among the top 10 CSFs for contractor organisations  
415 and construction managers but not for design firms. It is understandable that overall project performance  
416 for contractors and managers is dependent on the adequacy of funding and site inspections. Delayed site  
417 inspections cause a backlog in managers' verifications of contractor payment requests, which result in  
418 reduced funding for contractors, which in turn hampers contractors' abilities to finance upcoming  
419 construction activities. Hwang et al. (2013) stated that adequate funding for project completion is crucial  
420 as illiquidity may result in projects being heavily burdened by debts. With inadequate cash flow to meet  
421 operating needs, contractors in Singapore have a right to stop work under the Security of Payment (SOP)  
422 Act upon nonpayment and can even claim losses against the owner for work postponement. In regards to  
423 the construction industry in Malaysia, the financial capability of clients ranked first among client-related  
424 CSFs (Yong and Mustaffa, 2012).

425 Since there are numerous severe conflicts between consultants and contractors in subway construction  
426 projects, the competency of project consultants is a significant critical success factor. Consultants are  
427 expected to furnish adequate design details, specifications and advice to their clients and contractors  
428 (Yong and Mustaffa, 2012). According to Inayat et al. (2015), for overall project performance, designers  
429 ranked competency of contractor teams, the capability of consultant key personnel, and competency of  
430 consultant teams among the top 10 CSFs in an Agency Construction Management Environment.

431 “Insert Table 8 here.”

432 In this study, the relationship between the variables was determined by the 39 identified CSFs measured  
433 by the correlation coefficients of each pair of variables. Tables 9 and 10 illustrate the matrix of the  
434 correlation coefficients among the CSFs for subway construction projects. The correlation coefficients  
435 demonstrate that the CSFs share common factors. The Bartlett test of sphericity is 3220, and the  
436 associated significance level is 0.000, indicating that the population correlation matrix is not an identity  
437 matrix. Moreover, the value of the Kaiser–Meyer–Olkin (KMO) measure of sampling accuracy is 0.663,  
438 which exceeds 0.5 and thus is considered acceptable.

439 For this research, values greater than 0.50 were accepted as indicators of significant correlation. “Goal  
440 setting” and “performance management at each phase” have a significant correlation with “top  
441 management support from client organisation” with values of 0.762 and 0.746, respectively.

442 “Contractor’s competence and experience” and “PM competency”, “adequate funding throughout the  
443 project” and “favourable working condition”, “financial security” and “top management support from  
444 client organization”, “favourable working conditions” and “PM competency”, “Performance  
445 management at each phase” and “financial security” are all significantly correlated.

446 “Insert Table 9 here”

447 “Insert Table 10 here”

#### 448 ***4.6. Comparing the results to that of other contexts***

449 From the previous sub-section, goal setting ranked first among all other CSFs for subway construction  
450 projects. For Verburg et al. (2012), goal setting showed significant importance as a factor for successful  
451 project execution in a dispersed setting. For Sudhakar (2012), both goal setting and top management  
452 support were identified as essential success factors in software projects. Looking at electrics and  
453 electronics industry, Wittstruck and Teuteberg (2012) found that the support of Sustainable Supply

454 Chain Management (SSCM) activities at top management level should be considered as a success factor  
455 since it is of central importance for mutual learning processes. In another study, Tarhini et al. (2015)  
456 stated that top management support, clear goals, and project management are top CSFs in enterprise  
457 resource planning.

#### 458 ***4.7. Analysing participant perspectives regarding their experience in subway projects***

459 In accordance with participants' experiences of subway projects, a one-way ANOVA was performed on  
460 the 39 CSFs. Table 11 summarises the analysis of variance procedure. The p-value indicates the  
461 statistical significance of the factors. In this test, the p-value is considered significant when it is below  
462 the threshold value of 0.05. As shown in Table 11, the p-value of the analysis of variance exceeds 0.05.  
463 Consequently, it is concluded that no significant differences exist among the perspectives of project  
464 managers with different years of experience in this industry.

465 "Insert Table 11 here."

466 The importance rankings of the CSFs for all project managers with various amounts of experience in  
467 subway project can be seen in Table 12 and Figure 2. Chan and Kumaraswamy (1996) stated that  
468 "experience" affects the respondents' perception of the importance of CSFs, so it cannot be overlooked.  
469 Thus, this variable has to be considered as it may be the cause of differing opinions among the  
470 respondents. The results demonstrate that 28 out of the 39 factors received an average of 4 and above,  
471 which means they are considered by PMs with any amount of experience as very important. According  
472 to Gepp et al. (2014), a high level of expertise of interviewees and experts could positively contribute to  
473 the quality of results. It can be attributed to the fact that it takes a significant number of years to gain  
474 adequate experience which would enable one to consult or undertake challenging projects. Hence, the  
475 experience could enhance the likelihood of a project manager being successful (Garbharran et al. 2012).

476 In their study, no significant differences were found between years of service among project managers  
477 or contractors and their perceptions of critical success factors.

478 Project managers working in subway construction projects in Iran assume that goal setting is one of the  
479 essential CSFs. Some other interesting information may be generated from the data shown in Table 12.  
480 For example, participants with more than ten years of experience were of the view that contractor and  
481 project manager competency improved the performance of projects and hence their success. Yong and  
482 Mustaffa (2013) stated that Contractor's competence and experience is among the top five CSFs for  
483 construction projects. Chong et al. (2006) stressed the importance of expertise among project managers  
484 to increase the chances of project success. In line with contractor's competency, Phillips et al. (2008)  
485 advocated the use of multiple criteria when selecting contractors such as track record, safety practices,  
486 quality management and technical ability. Numerous subway projects in Iran are administered under  
487 design and build (D&B) contracts. The implications of Ashley et al.'s (1987) findings on D&B projects  
488 are that the contractor's project manager should understand and commit to achieving project objectives  
489 since the contractor has the sole responsibility for the D&B project. The contractor's capability,  
490 competency and experience in managing these projects is critical to project success (Chan et al., 2001).  
491 According to Agarwal (1994), more significant experience, understanding, competence and confidence  
492 in managing projects will result in a more accurate perception of risk, which increases the chances of  
493 project success.

494 Conversely, project managers with less experience emphasised the role of project cost control, adequate  
495 funding throughout the project, and effective allocation of human resources. This hints at the less-  
496 experienced project managers' concerns about access to financing and controlling the resources.

497 "Insert Table 12 here."

498 It can also be observed from Figure 2 that most PMs agreed on the three top-ranked factors. Moreover, it  
499 can be seen that “Mutual trust among project stakeholders”, received the least consensus among the  
500 project managers. It was ranked thirty seconds by the PMs with more than ten years of experience but  
501 ranked lower from the view of PMs with less than five years of experience. This shows that project  
502 managers with more experience were more appreciative of the importance of mutual trust within the  
503 industry. Project managers with more than five years of experience ranked the CSFs close to each other,  
504 especially for the factors with MS above the overall average.

505 “Insert Figure 2 here.”

## 506 **5. Conclusion**

507 This study identified and ranked the CSFs for subway construction projects according to their  
508 importance, based on the views of contractors’ PMs of subway projects in Iran. The success factors  
509 found to be critical in subway construction projects in Iran are similar to those of many other developed  
510 and developing countries. The literature on critical success factors indicates that research on this subject  
511 has been conducted in so many countries including the UK, the USA, Australia, Hong Kong, China,  
512 Singapore, Brazil, Canada, Malaysia, Thailand, Vietnam. However, to the extent of our knowledge, no  
513 such research has ever been done in Iran, particularly in the context of Tehran subway construction  
514 projects. Table 13 shows that type of project aside, the CSFs identified in this paper are of high  
515 significance in other countries’ construction industries around the world.

516 “Insert Table 13 here.”

517 Most of the CSFs are common among diverse types of construction projects. It may be concluded that  
518 these CSFs could be used in other construction projects as the triggers of success.

519 Analysis of the survey data was conducted using the MS, and factors with an MS more than 4.05 were  
520 divided into three main groups namely project management and planning-related CSFs, project team-



521 related CSFs and client-related CSFs based on the professionals' opinions from the focus group. The  
522 survey results provide a strong foundation for future research exercises aimed at establishing the success  
523 of subway and other construction projects. Regarding practical application, project managers can use the  
524 results of this study to develop CSFs for their subway construction projects. Project managers can also  
525 compare these CSFs with the success factors which they have already experienced in the past. This can  
526 prove to be an appropriate knowledge management exercise and may be used as a baseline to establish  
527 and implement performance improvement strategies for subway construction projects. Also, project  
528 managers can devise measures for improvement to raise the probability of success and reduce the  
529 chances of any setbacks in their projects.

530 The results of this survey suggest the following findings. Goal setting, top management support, PM  
531 competency, performance management at each phase, effective allocation of workforce, adequate  
532 funding throughout the project, contractor's competence and experience, multidisciplinary/competent  
533 project team, and other factors are shown in Figure 1 are the significant factors critical to the success of  
534 a subway construction project.

535 This study shows that, from the view of contractors, the client can drive the project towards success by  
536 providing sufficient support, and adequate funding. Based on the findings and discussions, it is  
537 recommended that more emphasis should be placed on improving the project management and planning  
538 factors such as competence, goal setting and performance management to ensure the successful  
539 implementation of a subway construction project in the future.

540 Further research should be conducted to determine appropriate strategies to be applied to the Iranian  
541 construction environment to achieve success in such developing industry.

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838 Table 1. Categorization of CSFs

Reference	Categories
Jin et al. (2012)	Project Management-related Client-related Design team-related Contractor-related Business and Work Environment-related
Inayat et al. (2014)	Project characteristics Contractual arrangements Project participants Interactive process
Gudiene et al. (2014)	external institutional project-related project management/team-related project manager-related contractor-related factors client-related
This study	Client-related Project management and planning-related Project team-related External Factors

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845 Table 2. Potential Critical Success Factors

Critical Success Factors
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## Client-related

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Mutual trust among project stakeholders	Project financing
Effective communication among project stakeholders	Project consultant's competence
Strong commitment among project stakeholders	Availability of resources
Well-defined scope of work and project constraints	Well-understood and accepted project purpose
Involvement of different project stakeholders in the	Conflict among project participants
Early planning of projects	Commitment of the project participants
Clear and detailed written contract	Coordination among project participants
Client's confidence in construction team	Clear understanding
Client's experience of construction project organization and management	Financial security
Client's responsiveness to the needs of the other stakeholders	Minimization of conflict between stakeholders
Constructability	Optimization of legal and administrative services
Top management support from client organization	Cooperation in solving problems among project stakeholders
Nature of client whether she/he is privately or publicly funded	Client's responsiveness to the needs of the other stakeholders
Early and continuous involvement in the project development	Client track record
Involvement to monitor project progress	Transparency in awarding the job
Adequacy of funding	Contractual incentives

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## Project management and planning-related

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Complexity of the project	Establishment of appropriate organizational structure
Urgency in meeting project deadline	Cooperativeness of stakeholders on project
Working relationships with other project stakeholders	Performance management at each phase
Project planning	Contractor's competence and experience
Goal setting	Stakeholder endorsement of project plans
Effective allocation of human resources	Rich project communications
Legal and contractual risk management	Well-structured and formal project approach
Implementation of effective project monitoring mechanism	Top management support (contractors' organization)
PM competency	Adoption of innovative management approaches
Awarding bids to the right designers/ contractors	Commitment from senior management (Contractor)
Competence (technical and managerial skills)	Consistent with objectives
Leadership and authority	Flexibility to change
Cooperation in solving problems among project Stakeholders	Commitment to quality
Contractor's competence and experience	Commitment to continuous improvement
Implementing an effective safety program such as SHASSIC	Long-term perspective
Implementing an effective quality assurance program such as QCLASSIC	Total cost perspective



Well-defined project scope	Partnership formation at design stage
Effective project budget monitoring	Company wide acceptance (contractor)
Site management and supervision	Questioning attitudes
Competitive procurement	Equal power/empowerment
Transparency in the procurement process	Standardization of decision making process
Tendering method	Good communication and information sharing
Adequacy of plans and specifications	Implementation of effective project monitoring mechanism
PM commitment and involvement	Project value
Budget updates	Project size
Mutual understanding of the scope of work between the Owner and the contractor	Uniqueness
Competent project manager	Innovations
Reasonability of project master and implementation plans	Materials and equipment
Suitability of project management system	Dispute resolution process
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<b>Project team-related</b>	
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Adaptability to amendment in project plan	Technical expertise
Providing adequate design details and specifications	Team leader's early and continuous involvement in the Project development
Skillful workers	Team leader's adaptability to amendment in project plan
Emphasis on high quality workmanship instead of low and quick construction	Effective project budget monitoring
Project cost control	Team experience
Supervision of subcontractors' works	Troubleshooting
Schedule updates	Decision-making effectiveness
Site inspections	Control system
Team leader's competence	Self-motivation
Multidisciplinary/competent project team	Project organization structure
Project team commitment to project	Personnel issues
Favorable working conditions	Level of automation in project
Dedicated team	Level of skill
Good cultural fit	Training Procedures
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<b>External Factors</b>	
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Economic	Mutual trust
Social (public acceptance towards the project)	Physical environment
Political	Technological environment
Demand and variation	Logical environment
Nature (weather conditions)	Construction permits
Industry-related issues (availability of resources)	Construction regulations
Construction technology	Product and service certification
Economic risks	Global standards
Balanced adjustment between the public and the private interests	National standards
Owner's competence	Site access limitation
Project nature	Public opinion

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866 Table 3. Final Selected Critical Success Factors

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Critical Success Factors	
CSF-1	Urgency in meeting project deadline Project planning
CSF-2	Mutual trust among project stakeholders

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CSF-3	Effective communication among project stakeholders
CSF-4	Strong commitment among project stakeholders
CSF-5	Goal Setting
CSF-6	Involvement of different project stakeholders in the early planning of projects
CSF-7	Effective allocation of human resources
CSF-8	Clear and detailed written contract
CSF-9	Legal and contractual risk management
CSF-10	Implementation of effective project monitoring mechanism
CSF-11	Project financing (cash flow)
CSF-12	Client's experience of construction project organization and management
CSF-13	Client's responsiveness to the needs of the other stakeholders
CSF-14	Top management support from client organization
CSF-15	Adaptability to amendment in project plan
CSF-16	Leadership and authority
CSF-17	Providing adequate design details and specifications
CSF-18	Cooperation in solving problems among project stakeholders
CSF-19	Contractor's competence and experience
CSF-20	Supervision of subcontractors' works
CSF-21	Skillful workers
CSF-22	Effective project budget monitoring
CSF-23	Site management and supervision
CSF-24	Transparency in the procurement process
CSF-25	PM competency
CSF-26	PM commitment and involvement
CSF-27	Schedule updates
CSF-28	Site inspections
CSF-29	Adequate funding throughout the project
CSF-30	Multidisciplinary/competent project team
CSF-31	Conflict among project participants,
CSF-32	Favorable working conditions,
CSF-33	Adoption of innovative management approaches.
CSF-34	Flexibility to change
CSF-35	Commitment to quality
CSF-36	Good cultural fit
CSF-37	Financial security
CSF-38	Performance management at each phase
CSF-39	Project consultant's competence

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872 Table 4. Characteristics of Respondents

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Items	Construction
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Gender		
Male	57	90.5
Female	6	9.5
Age		
Less than 25 years	4	6.3
25 to below 35 years	14	22.2
36 to below 45 years	38	60.3
More than 46 years	7	11.1
Experience in Subway Construction Project Management		
Less than 2 years	7	11.1
2 to below 5 years	15	23.8
6 to below 10 years	26	41.3
More than 10 years	15	23.8
Experience in Civil Engineering		
Less than 2 years	2	3.2
2 to below 5 years	14	22.2
6 to below 10 years	11	17.5
More than 10 years	36	57.1
Educational Background		
Bachelor of Science	36	57.1
Master of Science	20	31.7
MBA/ DBA	3	4.8
PhD	4	6.3

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881 Table 5. Ranking of perceived importance of the success factors

Success Factor	Mean	SD	Rank
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Goal Setting	4.714	0.669	1
Top management support from client organization	4.492	1.400	2
PM competency	4.460	0.872	3
Performance management at each phase	4.460	1.090	4
Effective allocation of human resources	4.444	0.547	5
Adequate funding throughout the project	4.444	1.013	6
Contractor's competence and experience	4.413	0.637	7
Multidisciplinary/competent project team	4.381	1.330	8
Project cost control (e.g. cash flow)	4.365	0.973	9
Project consultant's competence	4.317	1.161	10
Good cultural fit	4.302	1.199	11
Effective project budget monitoring	4.254	1.126	12
Favorable working conditions,	4.238	0.882	13
Site management and supervision	4.190	0.794	14
Financial security	4.190	0.678	15
Supervision of subcontractors' works	4.175	0.990	16
Adoption of innovative management approaches	4.159	1.258	17
Providing adequate design details and specifications	4.143	0.628	18
Client's responsiveness to the needs of the other stakeholders	4.127	0.705	19
Clear and detailed written contract	4.095	0.702	20
Skillful workers	4.063	0.664	21
Strong commitment among project stakeholders	4.048	0.590	22
Cooperation in solving problems among project stakeholders	4.048	0.753	23
Client's experience of construction project organization and management	4.032	1.198	24
Schedule updates	4.032	0.793	25
Adaptability to amendment in project plan	4.016	1.061	26
Effective communication among project stakeholders	3.968	0.796	27
Site inspections	3.905	0.830	28
Urgency in meeting project deadline	3.889	0.972	29
Flexibility to change	3.825	0.744	30
Leadership and authority	3.810	1.115	31
Commitment to quality	3.746	1.123	32
Transparency in the procurement process	3.730	0.820	33
Legal and contractual risk management	3.683	0.968	34
Implementation of effective project monitoring mechanism	3.619	1.234	35
PM commitment and involvement	3.619	0.658	36
Mutual trust among project stakeholders	3.571	0.923	37
Involvement of different project stakeholders in the early planning of projects	3.365	0.957	38
Conflict among project participants,	2.794	0.638	39

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885 Table 6. Ranking of project management and planning-related critical success factors

Critical Success Factor	Mean	SD	Ranking
Goal Setting	4.714	0.669	1
PM Competency	4.460	0.872	2
Performance management at each phase	4.460	1.090	3

Effective allocation of human resources	4.444	0.547	4
Contractor's competence and experience	4.413	0.637	5
Effective project budget monitoring	4.254	1.126	6
Site management and supervision	4.190	0.794	7
Adoption of innovative management approaches	4.159	1.258	8
Clear and detailed written contract	4.095	0.702	9

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900 Table 7. Ranking of project team-related critical success factors

Critical Success Factor	Mean	SD	Ranking
Multidisciplinary/ Competent project team	4.381	1.330	1
Project cost control (e.g. cash flow)	4.365	1.199	2
good cultural fit	4.302	0.990	3
Favorable working conditions	4.238	0.973	4
Supervision of subcontractors' works	4.175	0.664	5
Skillful workers	4.063	1.330	6

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920 Table 8. Ranking of client-related critical success factors

Critical Success Factor	Mean	SD	Ranking
Top management support from client organization	4.492	1.013	1
Adequate funding throughout the project	4.444	1.161	2
Project consultant's competence	4.317	0.678	3
Financial security	4.190	0.628	4
Providing adequate design details and specifications	4.143	0.705	5
Client's responsiveness to the needs of the other stakeholders	4.127	0.590	6

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939 Table 9- Correlation matrix of CSFs for subway construction projects (a)

	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6	CSF7	CSF8	CSF9	CSF10	CSF11	CSF12	CSF13	CSF14	CSF15	CSF16	CSF17	CSF18	CSF19	CSF20	
CSF1	1.000																				
CSF2	0.068	1.000																			
CSF3	0.184	0.405	1.000																		
CSF4	0.029	0.440	0.636	1.000																	
CSF5	0.043	0.379	0.413	0.635	1.000																
CSF6	0.128	0.450	0.229	0.001	0.012	1.000															
CSF7	0.331	0.481	0.340	0.633	0.410	0.093	1.000														
CSF8	0.113	0.508	0.317	0.490	0.430	0.297	0.531	1.000													
CSF9	0.043	0.378	0.418	0.792	0.635	0.076	0.381	0.305	1.000												
CSF10	0.054	0.241	0.208	0.378	0.304	0.159	0.637	0.270	0.385	1.000											
CSF11	0.048	0.226	0.102	0.375	0.401	0.112	0.536	0.396	0.412	0.716	1.000										
CSF12	0.068	0.703	0.179	0.387	0.478	0.497	0.533	0.613	0.357	0.458	0.450	1.000									
CSF13	0.185	0.378	0.150	0.423	0.338	0.336	0.267	0.504	0.472	0.264	0.572	0.571	1.000								
CSF14	0.076	0.589	0.435	0.615	0.762	0.105	0.635	0.602	0.592	0.617	0.628	0.728	0.523	1.000							
CSF15	0.136	0.174	0.055	0.428	0.354	0.055	0.131	0.139	0.561	0.133	0.090	0.020	0.235	0.162	1.000						
CSF16	0.064	0.002	0.044	0.156	0.134	0.137	0.218	0.062	0.250	0.118	0.115	0.020	0.228	0.099	0.312	1.000					
CSF17	0.528	0.413	0.105	0.227	0.244	0.465	0.099	0.258	0.167	0.222	0.228	0.646	0.484	0.390	0.244	0.137	1.000				
CSF18	0.050	0.005	0.206	0.321	0.271	0.302	0.145	0.318	0.103	0.068	0.082	0.334	0.304	0.335	0.073	0.142	0.273	1.000			
CSF19	0.232	0.517	0.305	0.222	0.182	0.211	0.405	0.551	0.029	0.309	0.367	0.544	0.299	0.403	0.279	0.251	0.542	0.135	1.000		
CSF20	0.094	0.415	0.009	0.115	0.212	0.201	0.146	0.169	0.011	0.315	0.094	0.374	0.010	0.358	0.039	0.021	0.062	0.091	0.239	1.000	
CSF21	0.409	0.142	0.298	0.136	0.125	0.365	0.255	0.151	0.215	0.072	0.011	0.103	0.230	0.119	0.108	0.163	0.445	0.374	0.046	0.058	
CSF22	0.232	0.555	0.324	0.573	0.520	0.182	0.460	0.252	0.527	0.419	0.362	0.728	0.396	0.614	0.188	0.083	0.507	0.224	0.244	0.314	
CSF23	0.357	0.318	0.420	0.453	0.440	0.008	0.353	0.220	0.343	0.465	0.380	0.517	0.346	0.507	0.223	0.122	0.642	0.216	0.510	0.003	
CSF24	0.077	0.707	0.037	0.107	0.294	0.612	0.282	0.574	0.117	0.177	0.201	0.653	0.363	0.557	0.142	0.104	0.278	0.312	0.376	0.622	
CSF25	0.053	0.678	0.549	0.525	0.486	0.008	0.632	0.605	0.313	0.484	0.507	0.534	0.370	0.699	0.014	0.151	0.300	0.179	0.711	0.283	
CSF26	0.075	0.713	0.433	0.483	0.578	0.196	0.533	0.656	0.452	0.566	0.484	0.781	0.510	0.844	0.030	0.127	0.469	0.218	0.550	0.537	
CSF27	0.036	0.269	0.067	0.346	0.422	0.349	0.254	0.252	0.587	0.528	0.553	0.548	0.582	0.553	0.146	0.189	0.407	0.219	0.146	0.160	
CSF28	0.190	0.170	0.223	0.065	0.185	0.393	0.020	0.353	0.139	0.226	0.322	0.343	0.385	0.360	0.172	0.210	0.028	0.283	0.040	0.382	
CSF29	0.046	0.467	0.166	0.489	0.686	0.133	0.553	0.556	0.585	0.656	0.759	0.712	0.582	0.847	0.182	0.071	0.402	0.173	0.404	0.305	
CSF30	0.340	0.072	0.068	0.369	0.462	0.037	0.112	0.284	0.321	0.242	0.396	0.364	0.410	0.381	0.043	0.206	0.671	0.267	0.306	0.158	
CSF31	0.137	0.057	0.124	0.162	0.033	0.123	0.072	0.206	0.177	0.098	0.145	0.068	0.043	0.025	0.227	0.079	0.036	0.009	0.028	0.116	
CSF32	0.049	0.681	0.316	0.380	0.550	0.146	0.584	0.686	0.331	0.606	0.619	0.797	0.499	0.848	0.026	0.012	0.414	0.186	0.578	0.430	
CSF33	0.379	0.377	0.162	0.453	0.313	0.223	0.078	0.014	0.620	0.180	0.215	0.338	0.433	0.343	0.195	0.272	0.578	0.015	0.161	0.035	
CSF34	0.005	0.020	0.025	0.098	0.064	0.081	0.126	0.418	0.126	0.124	0.109	0.053	0.197	0.136	0.270	0.035	0.188	0.091	0.383	0.021	
CSF35	0.023	0.782	0.199	0.257	0.316	0.599	0.386	0.460	0.290	0.365	0.170	0.737	0.321	0.581	0.014	0.064	0.473	0.179	0.449	0.637	
CSF36	0.148	0.485	0.404	0.157	0.063	0.332	0.210	0.366	0.026	0.150	0.001	0.480	0.180	0.232	0.295	0.277	0.408	0.311	0.622	0.126	
CSF37	0.137	0.309	0.441	0.669	0.736	0.108	0.342	0.515	0.686	0.334	0.468	0.528	0.516	0.716	0.249	0.161	0.386	0.368	0.245	0.027	
CSF38	0.069	0.467	0.455	0.710	0.706	0.157	0.524	0.502	0.737	0.430	0.573	0.546	0.495	0.746	0.356	0.026	0.222	0.360	0.236	0.049	
CSF39	0.231	0.312	0.104	0.090	0.169	0.425	0.074	0.526	0.042	0.142	0.014	0.494	0.295	0.287	0.305	0.096	0.458	0.160	0.450	0.443	

941 Table 10-Correlation matrix of CSFs for subway construction projects (b)

CSF2 1	CSF2 2	CSF2 3	CSF2 4	CSF2 5	CSF2 6	CSF2 7	CSF2 8	CSF2 9	CSF3 0	CSF3 1	CSF3 2	CSF3 3	CSF3 4	CSF3 5	CSF3 6	CSF3 7	CSF3 8	CSF3 9
1.000																		
0.121	1.000																	
0.071	0.570	1.000																
0.121	0.344	0.039	1.000															
0.176	0.395	0.518	0.481	1.000														
0.101	0.611	0.508	0.681	0.737	1.000													
0.206	0.422	0.387	0.309	0.228	0.484	1.000												
0.155	0.082	0.098	0.581	0.115	0.373	0.653	1.000											
0.005	0.523	0.491	0.471	0.578	0.765	0.699	0.426	1.000										
0.369	0.394	0.551	0.116	0.133	0.264	0.382	0.018	0.490	1.000									
0.347	0.162	0.104	0.137	0.054	0.013	0.082	0.013	0.062	0.018	1.000								
0.127	0.508	0.472	0.650	0.768	0.903	0.524	0.450	0.819	0.233	0.153	1.000							
0.127	0.572	0.414	0.060	0.156	0.325	0.551	0.069	0.310	0.421	0.277	0.183	1.000						
0.042	0.244	0.129	0.164	0.288	0.204	0.199	0.396	0.170	0.216	0.371	0.312	0.015	1.000					
0.020	0.525	0.325	0.802	0.476	0.739	0.461	0.426	0.491	0.002	0.142	0.639	0.353	0.077	1.000				
0.008	0.212	0.461	0.285	0.525	0.347	0.164	0.082	0.113	0.025	0.366	0.397	0.088	0.341	0.446	1.000			
0.020	0.465	0.496	0.190	0.422	0.593	0.532	0.189	0.719	0.588	0.100	0.553	0.358	0.176	0.237	0.167	1.000		
0.146	0.440	0.429	0.288	0.537	0.533	0.564	0.235	0.719	0.311	0.074	0.593	0.291	0.050	0.301	0.284	0.853	1.000	
0.140	0.123	0.171	0.486	0.244	0.531	0.293	0.447	0.284	0.247	0.337	0.493	0.086	0.450	0.526	0.453	0.275	0.073	1.000

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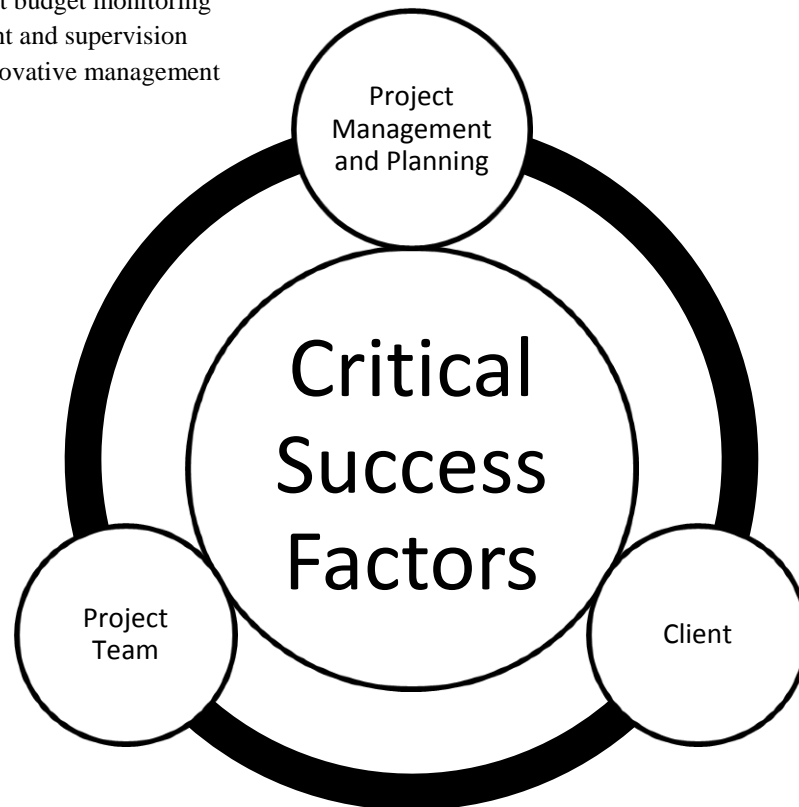
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1. Goal Setting
2. PM Competency
3. Performance management at each phase
4. Effective allocation of manpower
5. Contractor's competence and experience
6. Effective project budget monitoring
7. Site management and supervision
8. Adoption of innovative management



1. Multidisciplinary/ Competent project team
2. Good cultural fit
3. Favorable working conditions
4. Supervision of subcontractors' works
5. Skillful workers
6. Project cost control (e.g. cash flow)

7. Top management support from client organization
8. Adequate funding throughout the project
9. Project consultant's competence
10. Financial security
11. Providing adequate design details and specifications
12. Client's responsiveness to the needs of the other stakeholders

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955 Figure 1. Consolidated Framework of CSFs for subway construction projects

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960 Table 11. Analysis of variance for CSFs from the perspective of project managers with  
961 different amount of experience

Source	Sum of Squares	D.f.	Mean Square	F	Sig.
Between Groups	1.397	3	0.466	2.706	0.061
Within Groups	26.167	152	0.172		
Total	27.564	155			

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983 Table 12. Comparison of CSFs for subway projects among PMs with different amount  
 984 of experience

ID	CSFs by overall ranking <i>n</i> = 63	PMs with more than 10 years of experience <i>n</i> = 15		PMs with 6 to 10 years of experience <i>n</i> = 26		PMs with 2 to 5 years of experience <i>n</i> = 15		PMs with less than 5 years of experience <i>n</i> = 7	
		Rank	MS	Rank	MS	Rank	MS	Rank	MS
1	Goal Setting	2	4.667	1	4.692	1	4.733	2	4.857
2	Top management support from client organization	7	4.533	4	4.385	4	4.533	6	4.714
3	PM competency	3	4.667	2	4.423	7	4.333	12	4.429
4	Performance management at each phase	16	4.467	5	4.385	5	4.533	9	4.571
5	Effective allocation of human resources	5	4.600	3	4.385	9	4.267	4	4.714
6	Adequate funding throughout the project	4	4.667	7	4.269	8	4.333	3	4.857
7	Contractor's competence and experience	1	4.733	6	4.269	6	4.333	11	4.429
8	Multidisciplinary/competent project team	8	4.533	12	4.154	2	4.600	13	4.429
9	Project cost control (e.g. cash flow)	11	4.467	16	4.038	3	4.533	1	5.000
10	Project consultant's competence	10	4.533	9	4.231	18	4.133	10	4.571
11	Good cultural fit	9	4.533	8	4.269	15	4.200	25	4.143
12	Effective project budget monitoring	13	4.467	10	4.192	17	4.133	17	4.286
13	Favorable working conditions,	15	4.467	14	4.115	25	4.000	7	4.714
14	Site management and supervision	14	4.467	18	4.038	10	4.267	29	4.000
15	Financial security	19	4.333	19	4.038	12	4.267	18	4.286
16	Supervision of subcontractors' works	12	4.467	15	4.077	24	4.000	16	4.286
17	Adoption of innovative management approaches	18	4.400	22	4.000	11	4.267	31	4.000
18	Providing adequate design details and specifications	6	4.600	28	3.923	21	4.067	21	4.143
19	Client's responsiveness to the needs of the other stakeholders	24	4.133	17	4.038	19	4.067	8	4.571
20	Clear and detailed written contract	23	4.133	13	4.115	29	3.733	5	4.714
21	Skillful workers	25	4.133	26	3.962	31	4.133	22	4.143
22	Strong commitment among project stakeholders	22	4.133	20	4.000	23	4.000	19	4.143
23	Cooperation in solving problems among project stakeholders	29	4.000	21	4.000	13	4.200	28	4.000
24	Client's experience of	17	4.400	24	3.962	31	3.667	15	4.286

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	construction project organization and management								
25	Schedule updates	21	4.200	30	3.808	14	4.200	23	4.143
26	Adaptability to amendment in project plan	36	3.733	11	4.154	20	4.067	27	4.000
27	Effective communication among project stakeholders	28	4.000	23	3.962	26	3.933	26	4.000
28	Site inspections	31	4.000	34	3.692	22	4.067	24	4.143
29	Urgency in meeting project deadline	27	4.000	31	3.769	28	3.800	29	4.286
30	Flexibility to change	34	3.800	27	3.962	33	3.600	33	3.857
31	Leadership and authority	37	3.667	25	3.962	27	3.933	38	3.286
32	Commitment to quality	20	4.267	35	3.654	37	3.333	34	3.857
33	Transparency in the procurement process	33	3.867	29	3.808	36	3.333	33	4.000
34	Legal and contractual risk management	35	3.733	33	3.692	30	3.667	36	3.571
35	Implementation of effective project monitoring mechanism	26	4.067	38	3.269	34	3.533	20	4.143
36	PM commitment and involvement	30	4.000	36	3.462	35	3.400	32	3.857
37	Mutual trust among project stakeholders	32	3.933	32	3.692	38	2.933	35	3.714
38	Involvement of different project stakeholders in the early planning of projects	38	3.267	37	3.269	32	3.600	37	3.429
39	Conflict among project participants,	39	2.533	39	2.923	39	2.867	39	2.714

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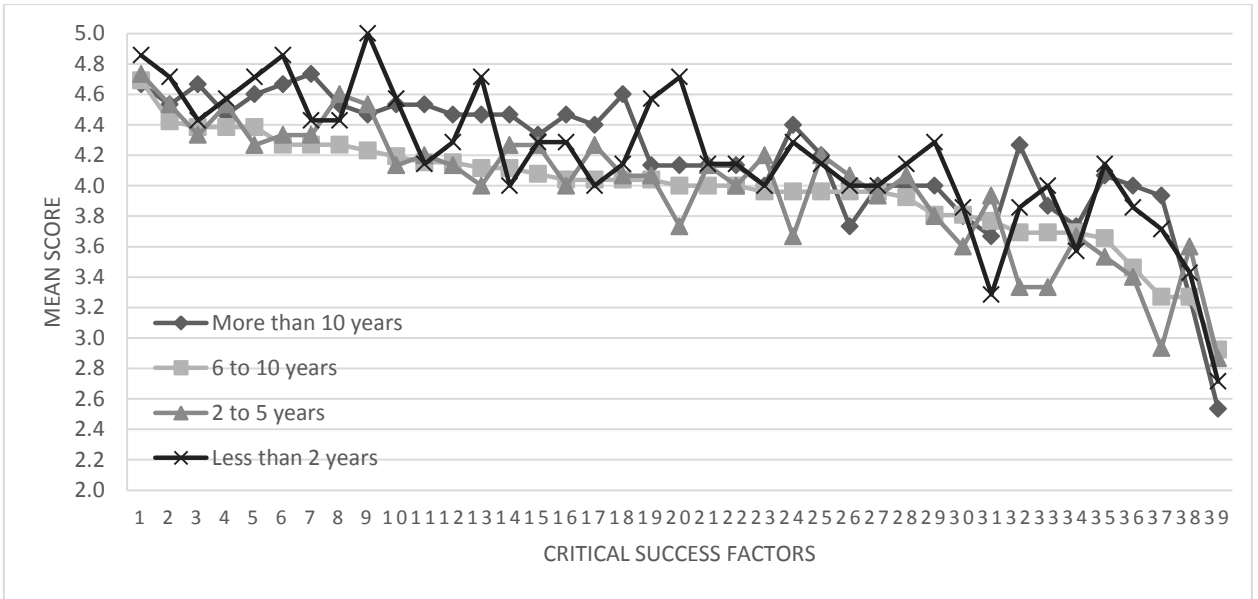
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995 Figure 2. Cross-comparison of CSFs' importance among PMs with different experience.

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1012 Table 13. Conformity of CSFs

Rank	Critical Success factor	Country	Reference
1	Goal setting	Vietnam, UK, Thailand, China, Canada, Brazil	<i>Nguyen et al. (2004), Fortune and White (2006), Toor and Ogulana (2009), Elwakil et al. (2009), Zhao et al. (2013), Osorio et al. (2014)</i>
2	Top management Support	Canada, Thailand, India, Malaysia, Global, Brazil	<i>Belout and Gauvreau (2004), Toor and Ogulana (2009), Tabish and Jha (2011), Jin et al. (2012), Gepp et al. (2014), Osorio et al. (2014)</i>
3	PM Competency	Lithuania, Ukraine, Malaysia, Global	<i>Gudiene et al. (2013), Didenko and Konovets (2009), Jin et al. (2012), Gepp et al. (2014)</i>
4	Performance management at each phase	Europe, UK	<i>Cooke-Davies (2002), Banfield (2005)</i>
5	Effective allocation of human resources	UK, Thailand, Malaysia	<i>Fortune and White (2006), Toor and Ogulana (2009), Yong and Mustaffa (2013)</i>
6	Adequate funding throughout the project	UK, Singapore, Global, Malaysia	<i>Fortune and White (2006), Hwang et al. (2013), Inayat et al. (2012), Yong and Mustaffa, (2012)</i>
7	Contractor's competence and experience	Hong Kong, Global	<i>Chan et al. (2001), Inayat et al. (2012)</i>
8	Competent Project Team	UK, USA, Australia, Hong Kong, Brazil	<i>Yu and Shen (2014), Osorio et al. (2014)</i>
9	Project cost control (e.g. cash flow)	Global, Brazil, India	<i>Inayat et al. (2012), Osorio et al. (2014), Gadekar and Pimplikar (2014)</i>
10	Project consultant's competence	Global, Malaysia	<i>Inayat et al. (2012), Yong and Mustaffa (2013)</i>

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