UTILIZING ANALYTICAL HIERARCHY PROCESS TO PRIORITIZE CRITICAL SUCCESS FACTORS IN CONSTRUCTION PROJECTS

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Construction managers work towards meeting the cost, quality and time targets of the construction projects they lead. There is, to a certain extent, consensus amongst construction management academics and practitioners about which are the main critical success factors (CSF) for a construction project; the 'iron triangle' considers three CSF, namely cost, quality and time. Although the literature has widely addressed this topic, the specific weightings of each CSF within the overall performance outcome has not been explored in depth. Evidence shows that the specific weighting of each CSF may vary according to the project and the client's needs or expectations. Furthermore, the importance one CSF has over the others will determine, it has been suggested, which skills are more desirable in a construction manager, in order to achieve a better project outcome. This article presents results of an online survey sent undertaken by 54 construction professionals. In this survey, Analytical Hierarchy Process (AHP) method is applied to identifying how CSFs are weighted and prioritized by construction professionals within the industry. Clients' and Contractors' comparison of prioritization show that they weight CSF similarly; differences in weightings are always below the 10% of the overall success of the project. This shows alignment of opinions, which provides a good backdrop for project development, specifically between the contractor and the client. For cost and quality constraints, both contractor and client showed more responsiveness; providing evidence to show that their goals are aligned to a certain extent, and they both make decisions with the interest of the project in mind.

Keywords: analytical hierarchy process, critical success factors, project management

INTRODUCTION

The identification of key factors for construction project success measurement enables the appropriate allocation of limited resources (Chua 1999) and improves the overall effectiveness of the project, since the construction industry is extremely dynamic in terms of technologies, budget and the specific contexts upon which projects develop.

There is, to a certain extent, consensus amongst construction management academics and practitioners about which performance objectives are the main critical success factors (CSF) for a construction project. These objectives have been coined as 'the iron triangle' and consider three CSF; namely cost, quality and time. They have been the criteria traditionally used to assess the success of a construction project (Chua *et al.* 1999). Research into the variations of the specific weightings of each CSF and the

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relationship they have to each other, within overall performance, has not been explored in depth and justifies the need for this research outcome.

Evidence shows that the specific weightings of each CSF may vary according to the project and the client's needs or expectations. Furthermore, the importance one CSF has over others will determine, it has suggested, which skills are more desirable in a construction manager, in order to achieve a better project outcome (Latorre 2009).

In this study, one hundred construction professionals were contacted and invited to complete an online survey, where they were asked to consider the three most commonly referred to CSF, cost, quality and time. The analytical hierarchy process (AHP) method was then adopted in order to determine the relative importance of these three CSF, and used to identify how the CSF were weighted and prioritized by the construction professionals, who are all working in different areas of the construction industry.

The purpose of this paper is to present research which explores and determines the effective use of the AHP methodology and its ability to capture both subjective and objective criteria and provide a useful mechanism for checking the consistency of the evaluation measures and alternatives. This would reduce bias in decision making and identifying potential gaps between the views of different stakeholders.

LITERATURE REVIEW

In 1982, CSF are defined for the first time by Rockart as the few areas of activity in which favourable results are absolutely necessary for a manager to achieve the goals stated for the project (Li *et al.* 2005, Chan *et al.* 2004, Sanvido *et al.* 1992). Evidence indicates that construction managers work with a qualitative and a quantitative concept of success. The quantitative concept of success can have between two and four success factors which are prioritized according to the needs of the client; there is always one critical success factor that leads the project; the subjective concept of success incorporates aspects of the end user and personal satisfaction, and the specific characteristics of the project (Latorre 2009). The fact that there are few CSF might be arguable; furthermore, it could also be said that success factors are viewed by the literature as targets to meet, rather than areas of activity.

Critical success factors are the key aspects of the project and lead to the accomplishment of project objectives. Identifying the critical factors to a project's success enables adequate resource allocation (Chua *et al.* 1999). The two factors most frequently identified by the literature as critical success factors are time and cost (Naaranoja and Uden 2007).

Rubin and Seeling (1967) use the tangible performance data of cost, schedule and quality/performance as a measure of success (Belassi and Tukel 1996). These performance objectives were coined as 'the iron triangle', and have been the criteria traditionally used to assess the success of a construction project (Chua *et al.* 1999). De Wit (1988) suggests, however, that overall project success should be measured against broader objectives from the viewpoint of all concerned stakeholders, contending that a project can be a success for one party but a disaster for another. With results from 236 questionnaires, White and Fortune (2002) agree with the three 'iron triangle' criteria being significantly the most important, although their list also included another 5 criteria; these results were from a wide range of industrial sectors and not just construction.

Recently, however, many authors have contended that these technical performance objectives may lead to an incomplete assessment of a project with, for example, a project that meets time and budget constraints being deemed successful even though it does not meet the needs of the end user (Shenhar *et al.* 2001).

It is, therefore, widely recognized that the traditional iron triangle of objective success criteria cannot provide an accurate measure of project success. Several authors believe that a completely incorrect conclusion regarding project success could be arrived at if the traditional project success criteria only are considered, while on the other hand, subjective measures are only meaningful when considered from the point of view of a particular observer (Hughes *et al.* 2004). Consequently, it may be suggested that in order to measure the performance of a project, one must identify a particular observer, and use both objective and subjective criteria.

Chua *et al.* (1999) provide a multicriteria decision making approach in order to determine critical success factors to project success. This is achieved by consulting "experts" and using the Analytical Hierarchy Process (AHP) as proposed by Saaty in 1980. This approach contributes to answering the question of what is a critical factor by demonstrating that there has to be consistency in nomenclature and scope in order to effectively determine this set of factors. This need for consistency and clarity is a key aspect and has only been taken into consideration in the literature by Chua *et al.*

It is important to note therefore that "Project success factors" may be defined as ‘those […] key areas of activity in which favourable results are absolutely necessary for a manager to reach his / her goals’ (Rockart 1982). "Project success criteria", on the other hand, are defined as ‘the measures by which the success or failure of a project […] will be judged’ (Cooke-Davies 2002: 185).

Although a study by Baccarini and Collins (2004) assessing success criteria across and within a range of different industries found no significant differences. White and Fortune (2002) derived results across a wide range of industrial sectors with no analysis of results between sectors; it is clear however that such a wide review is less useful to particular sectors and that, for example, integrating data from short duration company based internal IT projects with construction industry data, with a quite different project structure, organization and financing system, is less useful. There is also a general recognition that project success criteria also vary from project to project. What is acceptable in one project, whilst not impacting perceived success, may be seen as abject failure in another project (Muller and Turner 2007, Belassi and Tukel 1996). Therefore, Wateridge (1995) suggests that it is the project manager or project client’s responsibility to identify success criteria from an early stage, and then determine the success factors that ncrease the chances of achieving the success criteria. Furthermore, Latorre (2009) identifies variations in the weightings of the traditional CSF according to client and to context.

It is evident from the review of current literature that project success is subjective in nature and as a consequence, in order to determine the performance of a project, one must first identify a particular observer from whose perspective to assess.

This raises a second issue in that one must determine whether the observer perceives success from a project management perspective, or from a product perspective. Ideally, as Baccarini (1999) proposed, project success should be determined using both project management and product success criteria. However, Turner (1999) points out that success is affected by time. As a consequence, the determination of product success tends to be long-term in nature and often orientated toward the total life span of a completed project, while project management success is measured during and at the end of the project (Munns and Bjeirmi 1996).

A third issue to emerge is that many authors agree in that success has both 'hard' and 'soft' dimensions, and therefore, from whichever perspective project success is measured, both objective and subjective criteria must be taken into account to gain a complete assessment (Baccarini 1999, Baker *et al.* 1988, de Wit 1988).

Other authors, however, have specifically identified leadership and management as success factors. Cooke-Davies (2002) identified what he called the twelve 'real' success factors, derived from both 'hard' and 'soft' data from large national and multi-national organizations, and again none of these factors were directly concerned with 'human factors'. However Cooke-Davies contends that it is becoming accepted wisdom that it is people who deliver projects, and so there are human dimensions to nearly every success factor identified. Using AHP allows the incorporation of both objective and subjective aspects into the CSFs in order to understand how their relative importance varies according to the several criteria.

Analytical hierarchy process

The analytical hierarchy process (AHP) provides a proven, effective means in which to deal with and improve complex, unstructured and multi-attribute decision making (Partovi 1994). The strength and value of this approach is that it organizes tangible and intangible factors in a systematic way, providing a structured, simple solution to assist a decision making process (Skibniewski and Chao 1992).

The AHP consists of three basic steps; hierarchic structure, prioritization procedure and calculation of results. The overall objective of the decision lies at the top of hierarchy, the criteria and decision alternatives are on each descending level of the hierarchy. To define the priority (or weight) of each criterion, non numerical methods are based on a rank, or comparison between a set of variables are used (Pongpeng and Liston 2003). Elements in each level are compared pair-wise with respect to their importance to an element at a higher level, starting at the top of the hierarchy and working down (Harker 1989). The calculation of results is subjective and objective; dependent upon the relative weights given to each element and its comparison to another element on the next level.

Analytical Hierarchy Process (AHP) has been successfully applied in many of construction industry research works (Hemanta 2008, Lin *et al.* 2008, Soliman 2005, Brown 2003, Mahdi *et al.* 2002, Mahdi 2001 and Fong and Choi 2000) because it is a useful tool in dealing with multi-criteria decision-making problems. Researchers and the members of the construction industry have applied the AHP model to a variety of situations and approached it in many different ways. Fong and Choi (2000) used the AHP model as an alternative method to measure the aggregate scores of construction contractors based on questionnaire results, then rank the aggregate scores of their contractors with regard to their performance against each of the criteria, and the candidate associated with the highest scores is the best contractor on this occasion. The decision to use the AHP model was based on the idea that some of the other contractor selection methods currently in existence are criticized as incomplete and biased, and lacking consideration in terms of the contractor's ability to achieve simultaneously, time, cost, quality and safety standards (Fong and Choi 2000).

It should be noted that most research into critical success factors has used questionnaire and ranking methodologies rather than the comparative method used in AHP (for example see Baccarini and Collins 2004, White and Fortune 2002, Baker *et* *al.* 1988, de Wit 1988, Cooke-Davies 2002). Thus AHP uses the direct comparison and assessment of CSFs and derives different output data. As such, AHP has not been used to analyse the specific weightings of project critical success factors, and leads therefore to the research described in this paper.

METHOD

The CSFs used in this research were derived by Latorre (2009) and supported by White and Fortune (2002), and are cost, quality and time. In order to determine how CSF are weighted by different professionals, an online survey was developed. The survey had the following 5 sections:

1. Informed Consent and Screening questions – Experience, job and company.
2. Overall Experience.
3. Quality constrained project profile.
4. Time constrained project profile.
5. Cost constrained project profile.

For the three different profiles and their overall experience, respondents were asked to express their preference between pairs of CSF according to how much more important they thought one was against the other. For each response, they were provided a 5-point scale that went from equally important (allocated a value of 1) to extremely more important (allocated value of 5); they were given values from 1 to 5.

In AHP terms, the hierarchy had CSF as the criteria and the different project profiles as alternatives. This allows the weightings to be determined.

The online survey was available online for seven days. 104 email invitations were sent to construction professionals; each one contained with a unique random password to participate and a link to the survey. At every stage respondents were allowed the opportunity to comment, without word or character limit. The online survey automatically collected the data on a spreadsheet. 54 responses were received in total. Excel™ was used to analyse the AHP process using a spreadsheet.

RESULTS

The responses were received from 54 construction professionals who had between 2 and 41 years of professional experience, with an average of 10.6 years. They were separated into three groups based on their professional experience; 5 or less years (37% of respondents), 6 and over, but maximum of 10 years (26% of respondents), and over 11 years of professional experience (37% of respondents).

Table 1: Overall analysis of the AHP results

	Overall Experience			**Quality Constraints**			**Time Constraints**			**Cost Constraints**		
Years	**Cost**	**Time**	**Quality**	**Cost**	**Time**	**Quality**	**Cost**	**Time**	**Quality**	**Cost**	**Time**	**Quality**
≤ 5	0.33	0.25	0.41	0.14	0.29	0.57	0.24	0.64	0.12	0.64	0.12	0.24
6 ≤ and ≥ 10	0.33	0.33	0.33	0.12	0.24	0.64	0.26	0.64	0.1	0.69	0.15	0.16
≥ 11	0.33	0.33	0.33	0.33	0.33	0.33	0.20	0.49	0.31	0.62	0.24	0.14

As shown in Table 1, the overall highest weighting (69%) was given to the cost CSF by professionals that had between 6 and 10 years of experience, for projects which had cost constraints. When looking at the average weightings for the whole data set, cost is the most relevant, as it goes up to 0.5 for cost constrained project.

Respondents with the least experience always considered quality more important than time, except for the case in which the project's profile suggests that the delivery date is the most important of the three CSF, in which case they prioritize time by giving a weighting of 0.64 out of 1. This suggests that when it comes to delivery dates, this group is more sensitive or reactive to the context of the project, giving it 2/3 of the weight of the overall success to time.

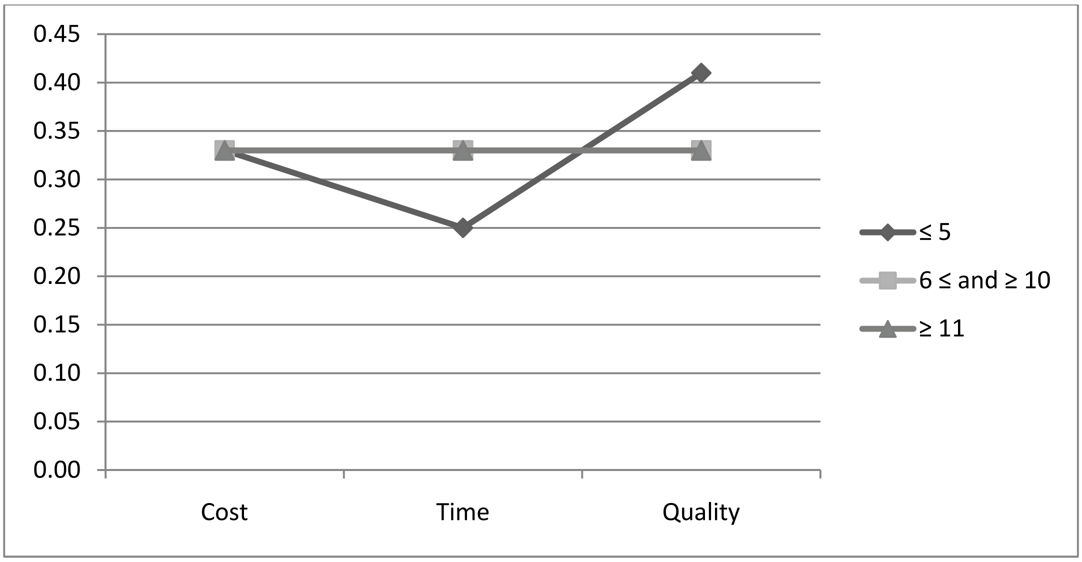

Figure 1: Average Results per According to Years of Experience

As shown in Figure 1, the overall averages show 0.35 for cost, 0.34 for time and 0.31 for quality; therefore demonstrating that quality is a valid CSF according to construction professionals. The variance between the higher and the lower average weighing is 0.04, which shows that the different constraints a project can have regarding CSF is annulled when they are looked at all together

The 54 responses were distributed as follows; 35% of were currently working as construction managers, 22% as clients or project managers, 4% were suppliers (including concrete and formwork providers), and 39% declared to be working within the industry in "others" (which included the consultants and designers).

Table 2: Results of clients and Contractors

	Overall Experience			**Quality Constraints**			**Time Constraints**			**Cost Constraints**		
Stakeholder	Cost	Time	Quality	Cost	Time	Quality	Cost	Time	Quality	Cost	Time	Quality
Contractors	0.38	0.29	0.33	0.27	0.31	0.41	0.27	0.45	0.28	0.48	0.28	0.24
Clients	0.35	0.28	0.36	0.38	0.28	0.34	0.32	0.41	0.27	0.48	0.25	0.27

Table 2 and Figure 2 shows clients and contractors with a similar distribution of weightings for experience and projects' constraints. This evidences that both client and contractor share a view regarding the priorities of a project.

A closer comparison between clients and contractors shows several differences. For the contractor, time becomes more relevant than cost when delivering a project that is associated to quality constraints. For the client, on the other hand, the more relevant aspect to delivering that kind of project is cost, which may reflect that in this case, due to the emphasis being on the specifications, there is a concern regarding overprice.

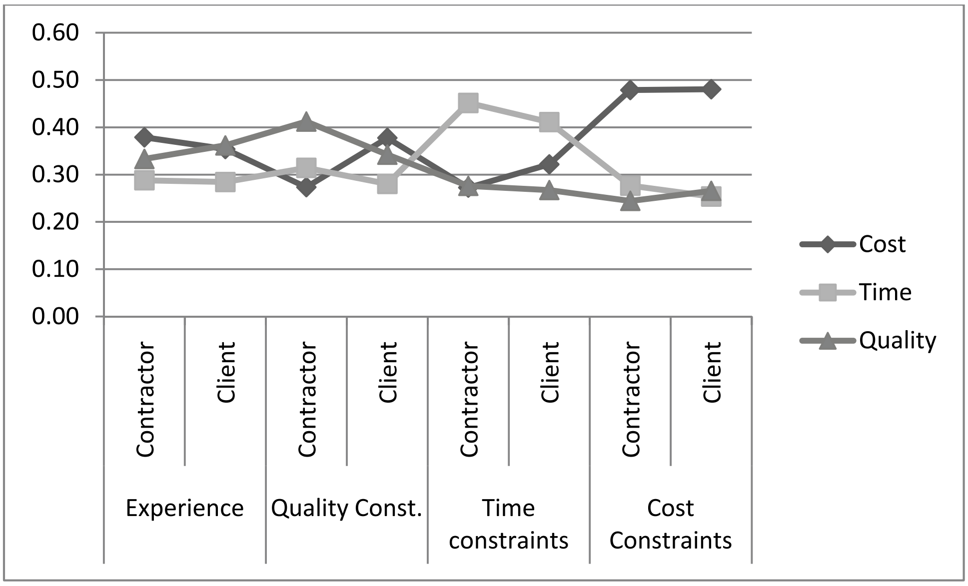

Figure 2: Comparison of Client and Contractor

For cost and time constraints, both client and contractor demonstrate more responsiveness to these constraints than quality, which probably relates to quality being seen as a 'meet-the-spec' target. Overall, both contractors and clients agree that cost constraints are the ones that have the highest impact on CSF prioritization, reaching almost half of the overall success criteria.

The analysis for the suppliers generally show a focus on cost and are more reactive to cost constraints than time or quality issues, whereas professionals (under the category of 'others') show higher responsiveness to quality constraints.

Written comments from the survey mention the importance of developing working relationships with clients for future business; particularly how credibility works towards the overall construction company's interests.

CONCLUSION

The alignment of clients' and contractors' results demonstrates that when the contractors' decision making processes are based on the specific priorities for the projects, they will also meet the client's expectations. Therefore, this research has provided evidence which reveals that the contractors and clients should support one another when making decisions in the best interest of the project. However, for the projects with time and quality constraints, results indicate that contractor and client may have different views about how to deliver success for the three CSFs. This gap leads to potential disagreement over the project, which will in turn, impact the overall outcome on its success.

The analysis clearly shows that CSFs do change weightings according to project profile and this confirms and supports Latorre's previous findings. This is still an area which requires further research, as it sheds light onto the real views within the construction industry regarding the outcome assessment of construction projects.

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