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# MODELLING MULTI-CRITERIA DECISION ANALYSIS FOR BENCHMARKING MANAGEMENT PRACTICES IN PROJECT MANAGEMENT

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## ABSTRACT

The link between management practices and worker's motivations impacting construction productivity is being considered as significant among the research community. This research aimed to identify and analyse the underlying attributes impacting construction productivity from the site management perspective. This research presents a framework designed to analyse and quantify the relative relevance of different drivers in the determination of productivity levels and the degree of effectiveness of potential opportunities for improving performance of overall projects. Owing to the complexity of construction projects and underlying conflicting drivers influencing higher worker's productivity, the Analytical Hierarchy Process (AHP) is employed to deal with interdependent relationships within a multi-criteria decision-making model. In the analytical approach, the large unstructured decision parameters are identified first and then are broken down into the manageable and measurable components using a top down hierarchical structure. This paper demonstrates an example to illustrate how to empirically analyse and prioritise a set of influencing parameters as selection criteria in devising appropriate management practices to ensure higher productivity vis-à-vis optimum performance of projects.

## KEYWORDS

Management practices, workers productivity, AHP, construction

## 1. INTRODUCTION

Measuring the performance in any construction projects in terms of worker's productivity is a very complex process. Modern construction projects even moderate in size are generally multidisciplinary in nature and they involve various contractors and subcontractors range from routine to very specialized jobs. With increasing size and sophistications in construction projects, it is really difficult to motivate the employees to utilize for optimal outputs. Research reveals that the motivation level of employees has a direct influence on their individual output, and furthermore on the level of output of a team of employees. There are many factors that influence the level of motivation of employees. Throughout history employers have sought to find the most successful ways of motivating employees. Historically motivation was thought to be achieved by having punishments associated with non-performance, whereas today's thinking is more along the lines of rewarding success (Adrian, 2001; Bullinger and Menrad, 2002). Incidentally, past researchers have employed various criteria such as bonus and penalty schemes, overtime payments, paid leave, work study techniques etc. to motivate employees and monitor performances in construction industries. However, this paper focuses on the factors associated with the incentive programs (normally coordinated programs) through which employees are rewarded for optimal productivity in the work place. Appropriate incentive programs can be developed incorporating various socio-cultural motivational factors in competitive business success.

Researchers in the past have identified various causes or reasons (known as attributes in this paper) for measuring worker's productivity (Cox et al., 2003). Most of the works are either area-specific or project-specific and are mostly for the management and business objectives. However, focus of this research has been on the benchmarking of critical factors influencing satisfaction and motivation of employees in Australian context. There are certainly many critical factors such as financial, non-financial, tangibles and intangibles that influence the employees work environment in any given project (Jin et al., 2006). These attributes, if not understood and handled properly, may be detrimental for the success of future projects (Casteneda et al., 2005; Chan and Kumaraswamy, 1997). This study tries to identify all such positive and negative attributes for

construction projects in a developed country like Australia.

## 2. RESEARCH OBJECTIVES

Two major challenges have been identified in this research. Firstly, understanding and benchmarking the factors associated with the workers productivity impacting project performance and secondly, multi criteria decision analysis in devising appropriate management decisions for optimum project performance.
The overall objectives of this study are as follows:

- To identify the relative importance of positive and negative attributes influencing the productivity in construction projects as perceived by the construction professionals;
- To benchmark a framework incorporating the critical attributes in devising appropriate incentive and motivational schemes in achieving higher productivity in construction industry;
- To examine and devise the optimal solution facilitating appropriate management decisions.

The study focuses mainly on the construction stage of projects and it required a huge amount of documented data on completed projects. Due to non-availability of documented data on locally completed projects for this study, a questionnaire survey approach is considered to establish the impact of various attributes on productivity of projects. This research includes the survey of over 100 individual employees within various construction industries with regards to their attitude towards the implementation of incentive programs. Results indicated that 78% believed that the prospect of rewards would positively their work productivity. The research found a strong synergy between factors affecting worker's output and coordinated incentive programs which could have a significant impact on overall business outcomes. In the first part of the research, the results were analysed using a statistical factor analysis. The process identified the most influencing factors associated with worker productivity and determined the relative importance and impacts of the same on increased worker's output within the construction industry. In the second part of the research, theoretical work has been done to extend Analytical Hierarchy Process (AHP) for decision makers expressing approximate preferences based on relative importance of two factors at a time. The ultimate aim of this research to develop an automated decision support system (DSS) forecasting the best possible configuration of remuneration schemes incorporating project specific variables. The output of this research will significantly influence the management approached in senior management levels that contributes in project success (Doloi et al., 2004; Hanna et al., 2005).

## 3. FRAMEWORK AND METHODOLOGY

Figure 1 shows 7 wide spectrums of motivational drivers influencing project's success. These broad drivers have been identified based on the review of the current best practices as well as the ongoing industry practices (Harada, 2004). In order to derive the project's performance outputs, motivational drivers must be understood in terms of their underlying dependencies and integrate them accordingly for holistic decision making process.

Selecting the most appropriate alternative from a set of alternatives and eliciting the consistent subjective judgment from the decision makers in the selection process require a holistic analysis (Hargreaves, 1994). In general, this selection process is more effectively performed with the aid of computerized decision support systems. Some of the past researchers have adopted questionnaire survey approach for data collection in measuring project success and failure attributes and employed mathematical tools such as Analytical Hierarchy Process (AHP) (Saaty, 1980), Artificial Neural Networks (ANN) (Doloi et al., 2004; Lootsma and Schuijt, 1997) and statistical techniques such as factor analysis and multivariate regression etc. (Iyre and Jha, 2005) for analysis and drawing conclusions.

Leading from the existing knowledge in data collection and analysis methodologies in the field, this study focuses on the current practices and experiences through the personal interviews with construction professionals in Australia. Total of 25 project attributes were identified in relation to workers status and working environments. Though the list of this 25 attributes may not be called exhaustive due to the vast magnitude and fragmented nature of construction industry and construction environments, the list covered attributes pertaining to a large variety of construction projects. In order to understand the impact and

contributions of these attributes in project productivity, two different methods have been employed, multi-criteria decision making approach based in Analytical Hierarchy Process (AHP) (Saaty, 1980) and the statistical approach based on multivariate regression and factor analysis using Statistical Package for Social Sciences (SPSS) software package. For the sake of brevity, this paper discusses only the AHP approach and focus of the remainder of the paper will be on the analysis of data and the overall findings.

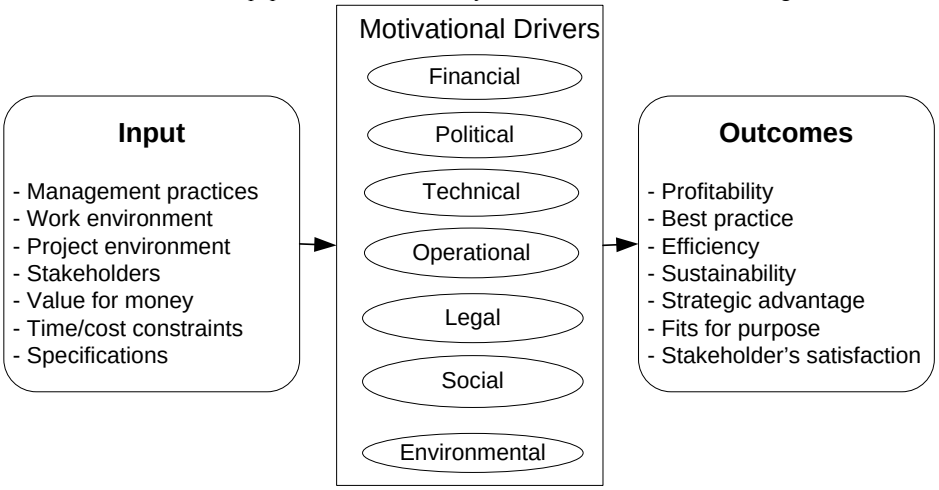


Figure 1: Motivational Drivers and their impacts

## 4. APPROACH ADOPTED

In order to benchmark the impacts of influencing parameters for decision analysis, an extensive fieldwork were undertaken as part of a two honour theses under the authors' supervision (Johnson and Sims, 2004). There were three staged approaches for the analysis of the raw data collected in the field. The first is the descriptive approach with direct interpretation of the survey results, the second is the factor analysis and the third is multi-criteria analysis as mentioned above. For the sake of brevity, this paper discusses only the multi-criteria analysis in following sections.

## 5. MULTI-CRITERIA ANALYSIS

As mentioned earlier, the Analytical Hierarchy Process (AHP) has been utilized for multi criteria analysis. The AHP is a powerful technique to deal with complex decisions where interdependence exists in a decision model (Cheng and Li, 2005). The AHP incorporates both quantitative and qualitative criteria influencing decisions in a hierarchical approach. This involves breaking the decision problem down into a hierarchy of interrelated decision elements (Figure 2). At the top of the tree is a statement of the most general objective of the decision problem, e.g. find the optimal solution. Then the criteria of the decision are set out below the structure. At the next level in the tree these criteria can be broken down into more detail, and so on. Simply the AHP structures a decision into a hierarchy of factors and determines the relative importance of criteria and sub-criteria against feasible technical solutions in pair-wise comparison. In essence, the hierarchical levels comprehend the objective of the decision, the criteria and the alternatives. Detail of the AHP application has been discussed in following section.

## 6. MCDM ANALYSIS

The first step in the AHP analysis was the creation criteria and sub-criterion that influence decisions on a number of technical solutions. In this research, a two layered hierarchy was formulated comprising criteria at the top level and sub-criteria at the lower level as shown in Figure 2. Total of three criteria, *Commitment*,

*Motivation* and *Skill*, have been identified at the top level hierarchy in AHP calculation These criteria was decided upon in reference to the optimum solution and in conjunction with interviews conducted with senior management personnel within the construction industry. A questionnaire was developed and 30 senior management personnel from eight big organisations in Australia were interviewed and quizzed on the optimum solution, "*to increase the output and work productivity of employees in the construction industry*". The interview was aimed at establishing key employee traits that contribute heavily to the optimum solution. Three traits were consistently iterated from the interviews, Commitment, Motivation and Skill. Secondly, the senior management was required to compare these three traits against one another in reference to the optimum solution. Example of the calculation of priority matrices for criteria against a single technical solution is shown in Figure 3. The rest of the calculations and results have not been shown for brevity. The results were then transformed into a three criteria matrix in order to establish a priority matrix using AHP calculations (Saaty, 1980).

## 7. AHP DECISION HIERARCHY

Figure 2 represents the hierarchical links between alternatives and criteria used in AHP to find the optimum solution. The optimum solution is at the top of the decision tree followed by a series of criteria that affect the outcome of the solution, through the use of technical solutions. The various solutions and their relationship between criteria is the process by which the AHP matrices are determined, and the technical solution, which fits the optimum solution, is chosen (Saaty, 1980).

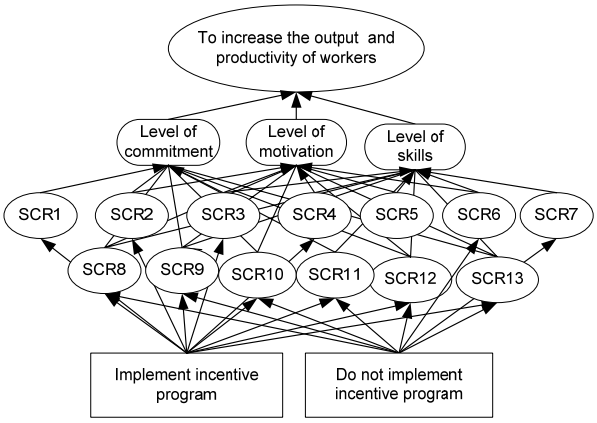


Figure 2: Hierarchical links between alternatives and criteria

The AHP tree diagram for this particular study also includes sub criteria. These sub criteria formed the basis for the questions that formed the aforementioned survey. It is interesting to note that there is not always a relationship between the sub criteria, criteria and the technical solution, in this case the sub criteria are said to be independent of a particular criterion (Harada, 2004). Total of 13 sub-criteria out of 25 project attributes have been identified to use in the AHP analysis. These sub criteria form the second level of decision hierarchy are abbreviated as shown in Figure 3. Details of these sub criteria are discussed below.

- *SC 1: Training*: The level of training directly influences the level of output of an individual and it is therefore a relevant sub criteria. Training influences the level of skill that the employee possesses, however it can also be perceived as negative due to the fact that corporations that are known as "*trainers*" are often used for this purpose and then employees often move on to new firms.
- *SC 2: Number of Labour Hours*: The number of hours that an employee works may or may not increase their level of output. Combined with other sub criteria such as improved work environments however the number of labour hours worked will increase output.

- *SC 3: Level of Experience*: Level of experience is fairly self explanatory as to why and how it affects the level of output of an individual.
- *SC 4: Work Environment*: Of those participants that responded to survey number 1, the greatest percentage of respondents reported that work place environment was the number 1 factor that influenced their motivation at work, and therefore it must be included as a factor effecting level of output.
- *SC 5: Rewards*: Rewards here refers to the giving by the employer of an object or cash to an individual employee in thanks for work completed. It is important that this factor be included as it relates directly to the idea of incentive programs. Rewards are the most basic form of incentive programs.
- *SC 6: Superannuation*: An individual level of commitment to an organisation can be affected by their level and payment of superannuation. Superannuation in its basic form is not a key factor influencing the level of output due to the fact that the majority of employees in Australia take it for granted, however bonus superannuation payments do often for part of incentive programs and therefore it has been included within the analysis.
- *SC 7: Level of Salary*: The salary level of an individual, or rather the change in salary through successive pay reviews is an influence on the level of a worker output, even if literature suggests that it is of diminishing importance as a motivation tool.
- *SC 8: Challenging nature of Occupation*: There has been much research that suggests that the challenging nature of an employee's job is a large factor in their motivation. It doesn't relate to incentive programs however it is important in this study to not bias the questions towards ones that only relate to the implementation of incentive programs.
- *SC 9: Employee Innovation*: The innovative nature of employees is the greatest resource that an employer can tap. Incentive programs that encourage innovation can be very helpful in this regard.
- *SC 10: Employee Efficiency*: Efficiency by its definition means to increase the level of output with a fixed amount of resources. It stands to reason therefore that it is important for employees to be efficient in order to increase output.
- *SC 11: Prospect of Promotion*: The prospect of being promoted, is a large motivator for many employees, however it can't be guaranteed to motivate all employees, due to the fact that many employees do not aim to "climb the corporate ladder" the purpose for its inclusion is to ensure once again that the survey is not biased toward the implementation of incentive programs.
- *SC 12: General Manner*: This question was posed within the survey due to the effect that an individuals personality has on their output, it is generally recognised that people with a good attitude perform better in the workplace.
- *SC 13: Communication Skills*: Communication skills are perhaps the most important skill that an employee can possess. Incentive programs have no bearing on this however it is included due to the fact that a good communicator often can allow for the efficient functioning of a workplace.

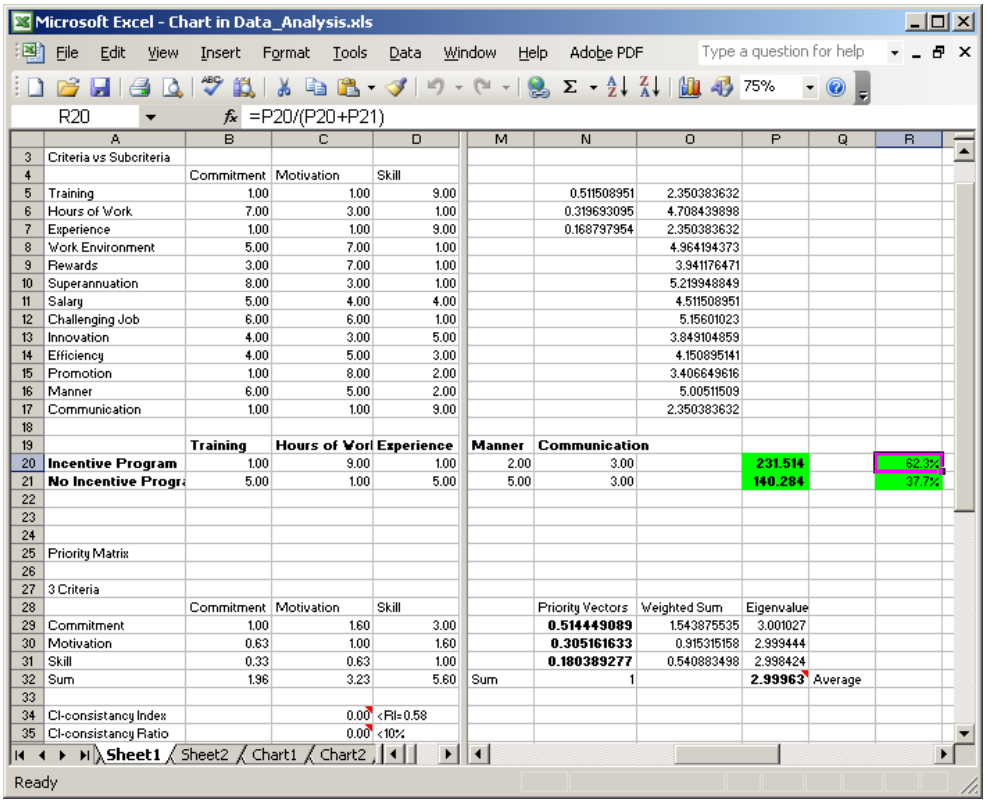

Figure 3: Priority matrices using AHP calculations

## 8. TECHNICAL SOLUTIONS AND THE OPTIMUM SOLUTION

AHP calculations were computed using the survey responses on relative importance of project attributes and performed using Microsoft Excel as a dry run in developing the overall framework (Figure 3). The sequence of calculations involves the analysis of the three criteria, followed by the analysis of the sub-criteria, which leads to ascertaining the appropriateness of the technical solutions in reference to the optimum solution.

Technical solutions, as contained within AHP analysis, are in place as a means of determining the most preferable method of achieving the optimum solution. The technical solutions are indirectly related to the sub criteria to which it is tested. In this study the author seeks to prove whether or not incentive programs increased worker output as against not implementing such a system. Therefore the two technical solutions tested were: "*to implement an incentive program*", or "*not too*" as shown in Figure 2. This study proposes that the use of incentive programs helps achieving the optimum solution by "*increasing the output and work productivity of employees in the construction industry*".

## 9. ANALYSIS AND RESULTS

The literature review undertaken in this study revealed the fact that incentive programs have achieved significant improvements in employee productivity. It was indicated however that incentive programs were not widespread within the construction industry. This research aimed at determining whether or not the implementation of incentive programs within the construction industry would be a wise decision for management.

It is a general perception of the public that flashy names or badges do not affect construction workers. However close to half of the recipients noted that it was important for their employer to have a high profile. This result may have been slightly biased due to the fact that the majority of the construction workers surveyed worked for large companies. The question begs 'what does such a response have to do with incentive programs?' The answer is that feelings associated with pride are one of the key factors in employee motivation, if an employee feels that his/her work may affect their employer in a major way then studies have found that their work will be of a higher standard.

Other interesting results included the fact that many construction workers responded that they were de-motivated when they worked under the influence of management pressure, suggesting that common industry practices of 'stand over' tactics should not only cease due to legal reasons, but also because it was in the best interests of the employer that such practices ceased. Only eight percent of respondents were against workplace recognition. In an industry dominated by males, and a very 'macho' workplace, it is unexpected that almost all respondents wanted to be recognised and thanked for their contribution. This result is very interesting due to the fact that it opens the door for all kinds of recognition based incentive programs.

The most significant results came from this research are the influence of incentive programs on workers motivation. Over eighty percent of respondents said that being part of an incentive program was important to them, and that if subject to incentive payments over ninety percent of respondents said that their work productivity would increase. Two of the most expected responses came however in regards to respondents feeling about their current contract and what type of incentive reward they would be most happy with. The majority of respondents said they were unhappy with their current contract and that they would most prefer cash as the form of incentive bonus. These findings were also validated from the factor analysis.

In order to understand the significance of the results derived from the AHP analysis, one must understand the criteria on which the analysis was based. The literature revealed that the level of output of an employee was directly related to three board criteria being an employee's level of *Skill*, *Motivation* and *Commitment*. With these factors in mind the author sorts the opinion of employers as to how to rank these criteria. The consensus of employers was that the three criteria were of differing levels of importance, from the most important to least important; *Commitment*, *Motivation* and then *Skill*. This fact is very important in the analysis of this study as incentive programs are much more likely to affect an employee's level of commitment and motivation then their level of skill.

The result of the AHP analysis was very conclusive as to whether or not incentive programs would increase the level of output of workers. Technical solution number 1 - *Implement incentive programs* came out at a weight vector of ***0.62*** versus technical solution number 2 - *do not implement an incentive program* with a weight vector of ***0.38***. It is worthwhile to mention that in the AHP calculation, all the judgment matrices were iterated to their consistency ratio was less than 10%. The consistency ratio based on the maximum eigenvalue was calculated using following formula

$$CI = \frac{(\alpha - n)}{(n-1)},$$

where, 'α' is the maximum eigenvalue and 'n' is the size of judgment matrix.

$$CR = CI / RI \qquad \text{(less than 0.1 for consistent matrix)}$$

where, RI = Random index is based on the mean CI value of random matrices

## 10. CONCLUSION

Employee output is the single greatest driver behind business success. The labour intense nature of the construction industry most certainly then relies very heavily on its workforce to remain competitive and profitable. This study has proven that it is possible for employers to determine what factors will influence employee motivation and thus increase employee output contributing to overall project success. The questionnaire survey on an extensive project attributes influencing workers performance in project has revealed the important success and failure attributes. The preliminary study has concluded that the conductive

work environment and incentivised employment contracts in the construction industry will increase the output of industry employees. This study has opened the door for further studies to be conducted to investigate appropriate the incentive programs that will best suit the construction industry. The hypotheses and the preliminary results presented in this paper are based on a joint industry study in Australia. Factor analysis of responses on the project attributes has extracted four major factors. Stepwise regression analysis technique was further performed on the factors to investigate the impacts of each factor and determine the most critical one. It was found that the work environment and employment contract are the critical drivers influencing positive construction in workers productivity in Australian construction industry. It has been realised that the identification of the critical factors resulted from this research may still be inadequate in terms of benchmarking the conducive work environment due to limited case studies. The results from AHP analysis conclusively highlighted the importance of incentive programs in achieving strategic business intents.

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