

A Reflection Note on Applying Quantitative Decision-Making Approaches to Engineering Management

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ABSTRACT

Engineering management is a project management activity full of information composed of specific engineering technology and different social factors. The basic knowledge of quantitative decision-making technology and management economics is conducive to project decision-making, project investment, financing in engineering construction, and real estate. With the development of modern engineering management, quantitative decision-making has become increasingly important. This article discusses quantitative decision-making's significance, importance, and potential limitations in engineering management activities. Different quantitative decision tools have other effects on engineering management and technical management. This article also suggests that effective engineering management needs to combine scientific quantitative analysis methods and quantitative decision-making tools and comprehensively consider the engineering implementation background, the project's technical requirements, and resource sources.

KEYWORDS

Decision-Making, Engineering, Engineering Management, Quantitative Decision-Making

INTRODUCTION

Background Information

There are many tasks within project management. However, the core tasks include target control, schedule target, quality target, cost target, and safety target. On the other hand, the technical elements of engineering management include the core professional knowledge of Engineering Management deliverables, which needs quantitative analysis knowledge in requirements identification, solution development, design, and technical specification control, especially in engineering management projects. The quantitative decision is also called the measurement decision. Project management decision-makers can express the collected engineering information in the form of quantity and can make accurate conclusions for various engineering situations with mathematical methods (Angelou, 1998; Hoon Kwak & Dixon, 2008; J. W.,

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2018; Labeledz & Gray, 2013; Lee, Lapira, Bagheri, & Kao, 2013; Sharon, Weck, & Dori, 2013; Xiong, Zhao, Yuan, & Luo, 2017; Xue, Baron, & Esteban, 2016). The engineering objective of quantitative decision-making requires a certain degree of accuracy, and the optimal engineering management scheme can be obtained through mathematical methods. With the development of technology, the cognition of engineering managers is constantly improving. Thus, the project management method of transforming the non-quantitative form into the quantitative form is also developing. Overall, quantitative decision-making is a significant development trend in scientific engineering decision-making.

Essentially, the quantitative decision-making method can be used to solve problems in the field of engineering management. These problems are solved with mathematical models and formulas to establish and reflect the mathematical model of engineering factors, as well as the relationship between engineering projects (Terweisch, 2002; Almeida & Simões, 2019; Amalnik & Ravasan, 2018; Andersen, 2014; Lichtenthaler, 2020; Marcelino-Sádaba, Pérez-Ezcurdia, Lazcano, & Villanueva, 2014; Xue, Baron, & Esteban, 2017). Quantitative analysis of engineering decision-making can improve the timeliness and accuracy of conventional engineering decision-making. Furthermore, quantitative decision-making can free engineering management to focus on overall major project implementation and strategic decision-making (Stryker, 2008; Arumugam, 2016; Aslani, Akbari, & Tabasi, 2018; Azar, 2012; Badi & Pryke, 2016; Loyd, 2016; Medina & Medina, 2015; Milner, 2016). The advantages and disadvantages of various project implementation schemes can be compared through quantitative decision-making. Each project scheme's success probability and failure risk can be shown through specific data, and the expected project income and cost of different project schemes can be calculated. Also, the potential loss can be calculated, which can be widely used in the decision-making analysis of multi-level quantity, the cost of civil engineering projects, the construction investment, and financing.

LITERATURE REVIEW

Quantitative Decision-Making Tools

Quantitative decision-making in the field of engineering management includes risk decision-making, deterministic decision-making, and nondeterministic decision-making. Risk decision-making refers to the method by that project management decision-makers predict unlikely situations (Terweisch, 2002; Galli, 2018a; Galli, 2018b; Galli, 2018c; Parast, 2011; Parker, Parsons, & Isharyanto, 2015). The most commonly used method to address risk decision in engineering management is the decision tree. The decision tree method is used to express the relationship of various states of different project management decision-making schemes to indicate the corresponding probability of booming construction, as well as the expected project reward value to select the optimal project decision-making scheme (Panitas, 2014; Galli, 2018d; Galli, 2019a; Galli, 2019b; Galli, 2019c; Usman Tariq, 2013; Von Thiele Schwarz, 2017). Additionally, the decision tree method is widely used in quantitative analysis of engineering management decisions (Angelou, 1998; Galli, 2020a; Galli, 2020b; Galli, 2020c; Schwedes, Riedel, & Dziekan, 2017; Winter, Andersen, Elvin, & Levene, 2006a).

Furthermore, there is the deterministic decision-making method. This method emphasizes that there is only a specific natural state of project management, and the decision-makers can act by the methods of scientific projects. The deterministic decision-making methods include linear programming, network technology, other engineering mathematical model methods, the differential extremum method, engineering break, and the analysis method.

Lastly, there is the uncertain decision-making method. This method is a scientific method for project management decision-makers to estimate the possible state of biological engineering projects. This is done to calculate the project profit and loss value of each construction scheme under various natural states by analyzing various factors of the change of project decision-making problems when the decision-making problems cannot be determined (Bosch-Rekveltdt, 2011; Galli & Battiloro, 2019;

Galli & Hernandez-Lopez, 2018; Galli & Kaviani, 2018; Galli, Kaviani, Bottani, & Murino, 2017; Shanbhag & Pardede, 2019). The modern engineering management decision-making theory sums up a convenient and feasible project method according to the characteristics of uncertain decision-making problems because it is difficult to estimate the probability of various biological engineering project states in uncertain decision-making. This includes assuming the criteria, finding out the expected value of the engineering scheme according to the criteria, and then determining the optimal value of each engineering management decision-making problem.

FINDINGS

Scientific and quantitative engineering management can significantly impact the quality of engineering projects. Primarily, scientific decision-making based on quantitative analysis of project management is conducive to quality management and cost control in the process of project engineering (Pence, 2012; Ahern, Leavy, & Byrne, 2014; Aikhuele & Turan, 2018; Al-Kadeem, Backar, Eldardiry, & Haddad, 2017a; Mohamed & Hassan, 2019; Shenhar & Levy, 2007; Sutherland, 2004). Project management should be based on understanding the corresponding project regulations, the preliminary understanding of the corresponding project fund provider, and the use of cost regulations. Thus, a good foundation can be made for cost management.

It is also essential to understand the regulations on a project guarantee form to organize the time limit and transmission mode of project document communication. After mastering the corresponding engineering details, the engineering technology and specific construction characteristics shall be determined. This will be according to the engineering construction so that the corresponding materials meet the requirements of engineering management, quantitative management, the expenditure control of each material project, and can provide data support and technical support (Rajkumar, 2010; Baporikar, 2020; Besner & Hobbs, 2012; Brown & Eisenhardt, 1995; Nabavi & Balochian, 2018; Nagel, 2015; Yun, Choi, Oliveira, Mulva, & Kang, 2016). The quality requirements and control of the project management are realized through the analysis of the project engineering technology. When using drawings and materials related to the project scope and technical content, reasonable and scientific standardized management should be recognized to study the related projects and carry out quantitative prediction and analysis.

After understanding the general requirements and technical control of engineering management, the specific design of the engineering project shall be carried out to realize the specific division of the engineering project (Bosch-Rekveltd, 2011; Burnes, 2014; Cova & Salle, 2005; David, David, & David, 2017; Detert, 2000; Easton, & Rosenzweig, 2012; Nikabadi & Hakaki, 2018; Zelinka & Amadei, 2019). The overall engineering construction shall be divided into blocks, consistent with the design drawings of the related engineering project. The project's design provides the basis for the project quotation, the cost expenditure, and the project's construction management. According to experience, the project-related cost should be controlled and assessed in the project implementation process.

The cost analysis of an engineering project is an important influencing factor in engineering management, as well. Establishing quantitative cost prediction in the project implementation process is conducive to providing a specific quantitative data basis for a project quotation. The prediction of cost control should be based on quantitative data and good project cost management; it should also rely on the professional quality, practical experience, and comprehensive judgment ability of engineering personnel (Panitas, 2014; Ertl, Herzfeldt, Floerecke, & Krcmar, 2020; Eskerod & Blichfeldt, 2005; Gafi & Javadian, 2018; Svejvig & Andersen, 2015; Zhang, Bao, Wang, & Skitmore, 2016; Zwikael & Smyrk, 2012). In the actual analysis process of engineering management, the quantitative analysis method is used to determine the specific forecast cost (Rajkumar, 2010; Omamo, Rodrigues, & Muliaro, 2020; Papke-Shields & Boyer-Wright, 2017; Todorović, Petrović, Mihić, Obradović, & Bushuyev, 2015). When the cost forecast is analyzed through scientific calculation and quantitative data, then it can provide an efficient decision-making basis for engineering management. Furthermore,

bidding quotation summarizes and implements project management and construction planning. According to the corresponding information, the project management personnel make the quotation selection based on the analysis of their actual situation. Based on the cost management and project implementation design, and considering the strength of competitors and the possible risks in the project, the feasible project implementation plan is designed to be more stable and to maximize the competitiveness of project management.

DISCUSSION

Implications and Applications to Fields of Project Management and Engineering Management

As the role of an engineer evolves over the years, so does the definition. An engineer was once defined as a professional applying technological and mathematical problem-solving methods. The problem that an engineer must solve nowadays has economic viability. Thus, the definition of an engineer emphasizes the importance of profit through the use of technological and mathematical tools. These variables, concepts, and models can help in this field and project management. All types of management are linked by causality, so these variables can be applied to project management to create a more strategic method for producing good performances and results. Lastly, this study highlights the need to apply maturity to project management, so stakeholders can optimally utilize system engineering and project management.

CONCLUSION

Future Research

Future research should perform more studies on quantitative analysis in engineering management and how it functions. Also, studying its functionality from different perspectives and areas of management would be beneficial. Furthermore, the future of quantitative decision-making in engineering management relies on the criteria of the uncertain decision-making scheme. This includes engineering optimistic and pessimistic criteria, project equal probability criteria, engineering decision coefficient criteria, and engineering cost regret criteria. By further studying these topics, there can be a deeper understanding of quantitative decision-making in engineering management.

Limitations of Quantitative Decision-Making Tools

Some engineering variables of engineering management are difficult to quantify. Also, mathematical means are difficult to understand because of the complexity of models and calculation formulas; scientific and efficient quantitative decision-making often costs more, which is not suitable for general project decision-making in the field of engineering management (Pence, 2012; Gholizad, Ahmadi, Hassannayebi, Memarpour, & Shakibayifar, 2017; Gimenez-Espin, 2013; Haddad & Otayek, 2019; Hartono, FN Wijaya, & M. Arini, 2014). In addition, the qualitative method is often more scientific and efficient than the quantitative method. Many factors cannot be quantified in the analysis of engineering management policy, so it is not suitable to completely use the quantitative analysis method to solve the problem. The complexity and diversity of realistic factors are where the qualitative analysis methods of non-quantitative decision-making play their roles.

Final Thoughts

Through quantitative analysis, we can make a reasonable judgment and decision-making basis for the project quotation and other data. Essentially, the quantification of engineering data and the quantitative analysis of influencing factors through mathematical models can provide the best implementation decision. Overall, this is of positive significance to modern engineering management and deserves further study.

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