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Six-Sigma project selection using national quality award criteria and Delphi fuzzy multiple criteria decision-making method

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ABSTRACT

Six-Sigma is a tactical tool of significant value in achieving operational excellence. The project selection decision, under a resources constraint, is the early stage of implementation for a Six-Sigma intervention. The project selection decision is challenging due to its fuzzy group decision-making aspect inherent to the problem. The present study proposes to adopt national quality award criteria as the Six-Sigma project selection criteria, and proposes a hierarchical criteria evaluation process. The strategic criteria are evaluated by the management team using a Delphi fuzzy multiple criteria decision-making method. Then, the tactical sub-criteria which contain additional operational issues are evaluated by the Six-Sigma Champion. The proposed methodology is successfully applied in solving the project selection problem deriving from a component manufacturer. The empirical outcomes are promising. Moreover, the results show that the higher a project's priority is, the greater the financial gains will be on completion of the project. Accordingly, the proposed methodology can prioritize the financial gain – which is the key performance indicator for a Six-Sigma project. Additionally, the quality status of the case company has been significantly improved through implementation of the Six-Sigma project. The systematic evaluation process also influences employees to adopt an analytical operations philosophy. Moreover, the commercial objectives of the company are brought into focus by the proposed methodology.

1. Introduction

Continuous improvement towards *business performance excellence* is the competitive edge for commercial firms to survive in highly competitive markets (Deming, 1986). Among the many business improvement approaches available, the Six-Sigma approach has been recognized as one of the most effective methods.

Six-Sigma has been launched all over the world and many companies testify to its pivotal role in their success (Hutchins, 2000). Its application focuses resources on reducing variation in all processes, including manufacturing processes, administrative processes etc. The unambiguous measure on the improvement work is referred to as Six-Sigma. Eminent examples of Six-Sigma companies include Motorola, General Electric, AlliedSignal (now Honeywell), Lockheed Martin, Polaroid, Sony, Honda, America Express, Ford, and Solectron. Indication of significant success at Motorola, quickly become apparent. From 1987 to 1997 Motorola achieved a fivefold growth in sales, with profits climbing nearly 20% per year, cumulative saving at 14 billion US dollars and stock price gains compounded to an annual rate of 21.3%. Motorola was also cited as the first winner of America's Malcolm Baldrige national quality award in 1988 (Eckes, 2006).

Six-Sigma is a tactical tool of great value in achieving operational excellence. Operational excellence is required for the overall attainment of business excellence – a notion that also requires customer-related, financial, and marketplace performance excellence (Edgeman, 2000). Six-Sigma explicitly links the tactical activities with those strategic ones. Thus, an appropriately configured and deployed Six-Sigma program may be highly consistent with the results-orientation underlying international quality awards, such as the European Quality Award, America's Malcolm Baldrige national quality award (MBNQA), Canada' Excellence Award, and the Australian Quality Award (Klefsjö, Wiklund, & Edgeman, 2001).

One of the key emphases of a quality award is, for a company to achieve sustainable financial success. In the instance of MBNQA, the award winning firms reported a 44% higher stock-price return, 48% higher growth in operating income, and a 37% higher growth in sales than the control group of firms (Davis & Stading, 2005).

Organizations are using various criteria to help them during implementation efforts to evaluate themselves against criteria to determine how well their improvement efforts are progressing. Sets of criteria that the majority of organizations uses include Deming prize categories, Juran's ten points, Crosby's fourteen points, and the MBNQA criteria (Ritter, 1993).

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A comparison between the national quality award and the Six-Sigma program conducted by Przekop (2006) shows that the core emphases of both are similar. For example, similarities are evident in the procedure-focusing, customer-focusing, cooperation, data driven management, and the strategic planning. Therefore, the quality award criteria are also logically exacting for the project selection criteria of a successful Six-Sigma program. The project selection is a priori for the implementation of a Six-Sigma program. In fact, the project selection for Six-Sigma program is often the most important and difficult part (Pande, Robert, & Roland, 2002).

The Six-Sigma project selection problem falls within fuzzy multiple criteria decision-making (FMCDM). The present study proposes to adopt the national quality award as the selection framework and proposes a FMCDM method for the criteria evaluation and project selection. The FMCDM methods have been developed due to the imprecision in assessing the relative importance of criteria and the performance ratings of alternative techniques. Imprecision may arise from a variety of reasons: unquantifiable information, incomplete information, unobtainable information, and partial ignorance. To resolve this difficulty, fuzzy set theory has been adopted for the decision-making process (Bellman & Zadeh, 1970).

For the FMCDM problem, the decision-makers use *linguistic variables* to evaluate the importance of criteria and the ratings of alternatives (or projects) with respect to various criteria. The present study will adopt a case from Taiwan for empirical examples. Accordingly, *Taiwan National Quality Award* (TNQA) criteria will be adopted as the Six-Sigma project selection criteria (as shown in Appendix A1). The TNQA has a hierarchical structure. It has eight strategic criteria. Each strategic criterion has its associated sub-criteria. In total, there are 33 sub-criteria.

For the strategic criteria, it is logical to incorporate group opinions from the different management positions. Accordingly, it is a group decision-making problem that will be solved by the *Delphi method* in this study. The fuzzy concept was embedded in Delphi methods by calculating the average weighting of all the criteria based on experts' experience (Chang, Huang, & Lin, 2000). Then, the sub-criteria, with respect to each candidate project, will be evaluated by the Champion who is a qualified Six-Sigma expert (Master Black-belt).

The remainder of this paper is organized as follows: Section 2 reviews the pertinent literature. Section 3 provides details of the proposed Delphi FMCDM methods. The background information for the case study and empirical illustrations are discussed in Section 4. Conclusions and future research opportunities are addressed in the final section.

Appendix A1
Taiwan national quality award criteria and sub-criteria

Criteria	Sub-criteria
C_1 Leadership	C_{11} Business concepts/values
	C_{12} Organization mission/vision
	C_{13} Senior executive leadership
	C_{14} Total quality culture
	C_{15} Corporate citizenship
C_2 Strategic management	C_{21} Innovation values
	C_{22} Business model and strategic planning
	C_{23} Strategy development and development
C_3 Research and innovation	C_{31} Research and innovation strategy and process
	C_{32} Research and innovation input
	C_{33} Research and innovation result measurement
C_4 Customer/market development	C_{41} Product/service and market strategy
	C_{42} Customer and business information management
	C_{43} Customer relationship management
C_5 Human resource and knowledge management	C_{51} Human resource planning
	C_{52} Human resource development
	C_{53} Human resource usage
	C_{54} Employee relationship management
	C_{55} Knowledge management
C_6 Information strategy application and management	C_{61} Information strategy planning
	C_{62} Application of computer network
	C_{63} Information application
C_7 Process management	C_{71} Product/process management
	C_{72} Management for off-line activity
	C_{73} Organizational relationship management
C_8 Business result	C_{81} Customer satisfaction
	C_{82} Market development performance
	C_{83} Company financial performance
	C_{84} Performance of human resource development
	C_{85} Information management performance
	C_{86} Process management performance
	C_{87} Performance on innovation and core competitive
	C_{88} Social evaluation

2. Literature review

The Six-Sigma method utilizes a well-disciplined approach. The unique features of the Six-Sigma approach are as follows: (1) sequences and links improvement-tools into an overall approach (known as DMAIC), (2) integration of the human and process elements for improvement using a belt-based organization (Champion, Black Belt, and Green Belt), (3) attention to bottom-line results and the sustaining of gains over time (Su, Chiang, & Chiao, 2005).

Six-Sigma is already successfully applied in individual activities and industries such as witnessed by the improvement in the automobile industry's manufacturing flow (Kalamdani & Khalaf, 2006), and in quality of integrated-circuit design (Su et al., 2005). Das (2005) applied Six-Sigma to reduce procurement delay. Six-Sigma is applied using a project management, under resource constraints. The project selection-decision, to maximize the financial outcomes, is often challenging for a company.

Breygogle (1999) suggested that companies can consider four dimensions of the balanced score card, namely financial, customer, internal business process and learning, and growth as the criteria for project selection. Snee and Rodebaugh (2002) identified that projects need to link with the strategic goal. Mark (2001) stated that projects should focus on activities critical to quality (CTQ) and financial performances. Brue (2002) considers that project selection should acknowledge resources and time. George, Rowlands, Price, and Maxey (2006) argues for recognition of the business voice, customer voice, and process voice for project selection.

Przekop (2006) argued that Six-Sigma has the same content with that of the American national quality award criteria. Seetharaman, Sreenivasan, and Boon (2006) found that a national quality award winner also showed improved performance in both sales and revenue. Thus, national quality award criteria should be a potential framework for the Six-Sigma project selection criteria.

The project criteria evaluation is a FMCDM problem where fuzzy assessments and multiple expert opinions can be considered. Human opinions are often in conflict because of group decision-making in a fuzzy environment. Various approaches to different aspects of decision problems with vague data have been published, and a significant amount of literature is available on FMCDM, such as: Chang, Wang, and Wang (2006), Chou, Chang, and Shen (2008), Coffin and Taylor (1996), Greco, Matarazzo, and Slowinski (2002), Ölcer and Odabasi (2005), Wang and Lin (2003), Wang (2008),