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Knowledge-based decision making for the technology competency analysis of manufacturing enterprises

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ABSTRACT

Innovation, technology and management competency are vital for determining capabilities of enterprises to compete in the sector. These dimensions are very critical and important for innovative researches and development of enterprises. In this study, a new decision making method called decision making based on knowledge (DeBK) and cluster analysis are used to analyse the decision making process and evaluate the performances of manufacturing enterprises in Istanbul, Turkey. The performance evaluation model is structured based on the six main criteria and knowledge of information which is defined by expert evaluations and literature review. Small and medium-sized enterprises are analysed with respect to technology evaluation surveys. This paper suggests an analytical approach for managerial decision making. DeBK method is used to evaluate importance of the information and decision criteria. Multivariate statistical clustering analysis is applied on the appropriate model data to evaluate the enterprises. As a result, technology competency levels of the enterprises are determined in five different groups by the cluster analysis. Different clustering ways represent approximately same results for technology evaluations of the enterprises, depending on the performance clusters.

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1. Introduction

Companies recognize technology as a nature of driver for the growth and development, most managers are aware of deploying technology to support strategic business objectives by using technology as an interface. This study is an important step to explain the necessary for evaluating the technology management capacity, related skills and performance based on a clear infrastructure and the framework is a bridge to prepare a technology competency index to compare and analyse SMEs in an explainable structure. Technology intensive regions as technoparks, industrial zones, technology transfer offices and incubation centres are mainly appropriate places as governmental administrative centres to analyse the technology competency issues of the SMEs. Technology management profiles and features of the firms are investigated to evaluate the level of innovation, entrepreneurship, quality management approaches, information and communication technology usage, strategic planning, management capability

and research and development activity. Technology management, technology competency, technology assessment and innovation management issues are examined again by taking into account small and medium-sized enterprises in the study. The basic aim of the study is evaluating the technology competency level of manufacturing SMEs in order to make comparisons between different performance clusters.

In this study, a strategic framework is developed by the decision making based on knowledge (DeBK) method used for technology competency evaluation of enterprises according to the international literature and expert evaluation.

Although there are many methods that can support decision making, companies tend to rely on a given set of decision criteria to establish whether or not a project should be developed [1]. Additionally, in spite of the existence of quantitative and consistent approaches such as real options [2], fuzzy logic [3] and analytic hierarchy process (AHP) [4], decision makers appear to more readily use simple visual approaches that support clear, shared and collaborative decision making, such as bubble diagrams/portfolio matrices [5], roadmaps [6] and scoring models [7].

The aim of the multiple-criteria decision making (MCDM) or multiple-criteria decision analysis (MCDA) is to obtain the optimum choice that has the highest degree of satisfaction for all of the

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relevant attributes [8,9]. Ashrafi and Murtaza [10] show the use and impact of ICT on SMEs in Oman.

Different descriptions of competence levels are explained by an illustrative study in which employee competencies are analysed for business process management as a different point of view [11]. Information technology (IT) usage is investigated by a national survey of SMEs' use of IT in four different sectors as clothing, finance, food and manufacturing sectors by a structured survey. [12]. Liao [13] analyses the technology management methodologies and applications as a literature review from 1995 to 2003. A flexible framework is proposed for evaluating technology management activities of different sized firms based on technology management as a dynamic capability [14]. An inspirational model demonstrates the links between competitive advantages, competitive priorities and competencies of a firm for determining key capabilities by using fuzzy analytic hierarchy process method in technology management field [15]. A conceptual model is proposed for the process of information technology (IT) innovation adoption in organizations based on the engineering and technology management [16]. Firm performance model is structured on the relationships between firm size, prospector strategy, architecture of information technology and firm performance [17]. The relations between technology sourcing and appropriability regimes are analysed by a conceptual framework based on technology sourcing, appropriability regimes, and new product development [18]. A case study from a university technology transfer office researches on the use of information technology and technology acceptance model for organizations engaged with R&D or innovation process management [19]. A study explores forecasting technology success based on patent data. The study proposed a novel method for forecasting technology success based on technology life cycle, diffusion speed, patent power, and expansion potential. The proposed approach is applied on TFT-LCD, flash memory system, and PDA technologies [20].

Brent and Pretorius [21] suggest a conceptual framework for the technology management field of knowledge and a departure for further research as a sustainable development. Grover and Pretorius [22] study on the technology assessment of demand side bidding within the South African context and research a typical technology balance sheet showing the various matrices of the complete technology balance sheet. Pretorius and Benade [23] propose a systems dynamics approach to competing technologies for exploring uncertainty of interaction and market parameters. Pretorius [24] represents a holistic approach for technology assessment in the manufacturing enterprise.

Levin and Barnard [25] emphasize the fragmentation in the technology management field by identifying and organising the routines used by managers of technology. Lee and Lai [26] present a performance measurement systems for knowledge management in high technology industries by using balanced scorecard framework. The study analyses the data collected from high technology firms in Taiwan, and analyses the relative weights placed on the four perspectives of measurements in a balanced scorecard framework for knowledge management.

A model is proposed to evaluate document-mining techniques and tools for technology intelligence by discovering knowledge from technical documents. The study proposes a method for extracting technology intelligence systematically from a large set of document data [27]. Badawy [28] defines technology management as process of effective integration and utilization of innovation, strategic, operational, and commercial mission of an enterprise for obtaining competitive advantage. Yu [29] has studied on a class of solutions for group decision problems in management science.

A new decision making approach called DeBK represents that before defining which information should be known, the criteria used for the decision-making process must be defined. Based on this suggesting, there is an ideal correspondence between cri-

teria and information that can be used to analyse decisions. The method analyses the knowledge of information and decision criteria to determine whether criteria are in accordance with existing knowledge [30].

SMEs and barriers to eco-innovation in the European Union is analysed by exploring different firm profiles in the six clusters [31]. Brunswicker and Vanhaverbeke [32] use cluster analysis to sort firms applying similar innovation sourcing strategies into homogenous groups based on the open innovation in Small and Medium-Sized Enterprises (SMEs) by external knowledge sourcing strategies and internal organizational facilitators. Different degrees of openness for SMEs are determined by cluster analysis in four clusters regarding to the manufacturing industries in Canada [33]. Questionnaire scores for the four strategic type clusters are calculated by using the values of international strategy and performance variables for clustering strategic types of SMEs [34]. Sila and Dobni [35] conduct an online survey of North American SMEs and obtained 229 responses. The study utilizes several statistical methods, including cluster analysis and profile analysis, to test five hypotheses for identifying the Business to Business e-commerce (B2BEC) usage patterns of SMEs in their supply chains. Important factors of sales and marketing for SMEs are identified by a questionnaire administered to various business owners within South Africa and a total of 105 usable responses are received to determine whether SMEs develop the right product strategies [36].

Tseng [37] emphasizes that marketing information, infrastructure capability, process capability, marketing capability, R&D capability and innovation decision capability are measured qualitatively and quantitatively. The paper suggests that R&D capability is also related to innovation decision capability, which is required for knowledge management innovation and for reducing uncertainty and risk activities. Tseng et al. [38] propose a hybrid method to improve selection decision making in service innovation based on infrastructure capability, knowledge capability, process capability, market capability, R&D capability, innovation capability and technology capability criteria.

Small to medium sized enterprises (SME's) are considered to be the backbone of any economy as they play a major role in the economic development of a country [39]. Kim and Park [40] research on the role of partner communication on cooperative R&D between SMEs and public research institutes in Korea. Park and Kim [41] study on dynamic capabilities and new product development performance based on Korean SMEs. The manufacturing industry is one of the main drivers of the Turkish economy so that a number of manufacturing sub-sectors have been growing in recent years [42,43].

In this paper, the survey interviews, carried out in March and June 2015 and referring to the Istanbul Chamber of Industry database, targeted a random and representative stratified sample of SMEs. There are 45 questions of quantitative and qualitative in the questionnaire. Small and medium-sized enterprises are analysed with respect to technology evaluation surveys in which processes management, products, information and communication technology, marketing strategy, innovation and entrepreneurial activities and research and development (R&D) issues are investigated. This framework is based on many articles using various technology evaluation infrastructures, frameworks and multi-criteria decision making (MCDM) and statistical approaches which focus on technology competency issues that are classified into different categories. There are many methods, models and evaluation frameworks in the technology competency literature, but our framework is available and supportive for qualitative and quantitative variables together by transforming the data into a basic and useful database.

The other parts of the paper are organized as follows. The issues of the technology competency evaluation and steps related to the Decision Making Based on Knowledge (DeBK) method are

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