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The selection of technology forecasting method using a multi-criteria interval-valued intuitionistic fuzzy group decision making approach

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ABSTRACT

Technological forecasting is a tool for organizations to develop their technology strategies. The quality of forecasting is extremely important for the accuracy of the results and in turn company future. Therefore a proper selection methodology of forecasting technique that considers the characteristics of technology and resources needed such as cost, time is essential. On the other hand, although many forecasting techniques are available, there is a high uncertainty in choosing the most appropriate technique among a set of available techniques. In this paper interval valued intuitionistic fuzzy technique for order preference by similarity to ideal solution (TOPSIS) method is proposed for the solution of technological forecasting technique selection problem. The proposed method includes seven selection criteria and twelve forecasting technique alternatives. The methodology is applied for 3D TV technology. The results revealed that Fisher Pry method is found as the most appropriate method for forecasting since it has the highest closeness coefficient.

1. Introduction

Technology forecasting is the systematic process of describing the emergence, performance, features or impacts of a technology at a time in the future (Technology Futures Analysis Methods Working Group., 2004). It is a tool used for responding the emerging needs of private and public sector organizations in the competitive global environment. The purpose of any type of forecasting and foremost role of the forecaster is to support the decision-makers in making business plans. A primary recommendation in strategy literature is; managers should abandon a maturing technology and embrace a new one to stay competitive (Christensen, 1997). A central, practical problem that managers face is; when to shift investments from the current to the future technology. In other words, deciding between 'the optimization of existing technologies' or 'the development of a new core technology' is one of the most challenging problem of research and development staff of an organization (Slocum & Lundberg, 2001). Seeking answers to these problems make technological forecasting is an important tool for organizations. Although many decision techniques are available, there is a high uncertainty in choosing the most appropriate technique. Beside, all decision making techniques cannot be applied to all forecasting cases. Some of the technological forecasting techniques cannot incorporate the organizational and political scenarios that will influence future technologies. In addition while some techniques consider only expert opinions while some others just consider historical data. The main objective of this study is offering a multi attribute decision making tool to help the decision makers to select the most appropriate technological forecasting technique among a set of available techniques.

Selection of appropriate technological forecasting technique have two main problems. One is; a multi criteria decision making (MCDM) problem where many criteria should be considered in decision-making. And the other one is; a problem containing subjectivity, uncertainty and ambiguity in assessment process (Dağdeviren, Yavuz, & Kılınc, 2009). Therefore this study utilizes interval-valued intuitionistic fuzzy numbers to obtain the performance ratings of the feasible alternatives and proposes a TOPSIS method with interval-valued intuitionistic fuzzy numbers to solve technological forecasting technique selection problem.

2. Literature review

2.1. Technology forecasting techniques

The following table presents a variety of techniques that are commonly used in technology forecasting (Table 1)

Technology trend analysis: If there is a steady stream of technological change and improvement, trend is determined with

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Table 1
Technology forecasting techniques and relevant citations.

Forecasting techniques	Relevant citations
Trend analysis	Coates et al. (2001), Eto (2003), Firat A. K. and Madnick S. (2008), Levary and Han (1995), Meredith and Mantel (1995), Miller and Swinehart (2010) and Mishra et al. (2002)
Growth curve analysis	Bengisu and Nekhili (2006), Chen et al. (2011), Coates et al. (2001), Daim et al. (2006), Kucharavy and De Guio (2011b). Levary and Han (1995), Martino (2003), Meredith and Mantel (1995) and Vanston (2003)
Fisher Pry analysis	Daim et al. (2006), Kucharavy and De Guio (2011b), Tseng et al. (2009), Vanston (2003)
Analogy	Firat et al. (2008), Vanston (2003) and Watts and Porter (1997)
Morphological matrices	Martino (2003), Meredith and Mantel (1995), Vanston (2003) and Watts and Porter (1997)
Patent analysis	Chen et al. (2011), Dubaric et al. (2011), Vanston (2003), Watts and Porter (1997) and Daim et al. (2006)
Scanning, monitoring, tracking	Firat et al. (2008), Martino (2003), Meredith and Mantel (1995), Vanston (2003) and Watts and Porter (1997)
Scenarios	Coates et al. (2001), Daim et al. (2006), Firat et al. (2008), Levary and Han (1995), Martino (2003), Miller and Swinehart (2010), Meredith and Mantel (1995), Tseng et al. (2009), Vanston (2003) and Watts and Porter (1997)
Monte Carlo models	Vanston (2003) and Watts and Porter (1997)
Delphi survey	Coates et al. (2001), Eto (2003), Firat et al. (2008), Levary and Han (1995), Martino (2003), Meredith and Mantel (1995), Miller and Swinehart (2010), Mishra et al. (2010), Tseng et al. (2009), Vanston (2003) and Watts and Porter (1997)
Relevance trees	Levary and Han (1995), Meredith and Mantel (1995) and Miller and Swinehart (2010)
Cross impact analysis	Firat et al. (2008), Levary and Han (1995), Meredith and Mantel (1995) and Miller and Swinehart (2010)

historical data and future is inferred from this trend by extending this pattern (Vanston, 2003).

Growth curves: The growth curve forecasting method is based on the parameter estimation of a technology's life cycle curve (Levary & Han, 1995). It is also helpful in predicting when the technology will reach a particular life cycle stage.

Fisher-Pry analysis: This technique uses logistic curve formulations to project the pattern and rate of adoption of a superior new technology (Vanston, 2003).

Analogy analysis: This technique uses one or more analogous situations project future trends or events (Vanston, 2003) by utilizing similarities between events.

Morphological matrices: It allows envisioning new products and services by defining essential functions involved in current products and services and then postulating alternate ways for accomplishing each of these functions and new ways of combining them (Vanston, 2003).

Patent analysis: In this technique numbers, types and patterns of patents are analyzed to derive information about a particular industry or technology.

Scanning, monitoring and tracking: Scanning seeks to identify any trend or event that might impact the organization. Monitoring is designed to follow general trends in specified areas. Tracking is designed to follow developments in a limited area carefully.

Scenarios: Scenario analysis provides a structured method for integrating a number of individual forecasts into a series of comprehensive, feasible narratives about how the future might develop.

Monte Carlo models: In this technique, all steps involved in the development of a new technology are identified, and their interrelationships specified in a mathematical model. Probability values are assigned to each event and then computer model is run numerous times to determine the overall probabilities.

Delphi survey: It is a qualitative approach that a panel of experts used as the source of information to forecast the likelihood and timing of future event (Levary & Han, 1995).

Relevance trees: It is a normative approach to identify the hierarchical structure of the technological development. The goals and objectives of a proposed technology are broken down into lower level goals and objectives in a tree like format (Levary & Han, 1995).

Cross-impact analysis: This method is an extension of Delphi method and designed to identify cases involving several interrelated future events that may affect the likelihood of a given technology being developed (Levary & Han, 1995). The purpose of this method is to investigate the mutual influence of events.

Technology forecasting techniques are widely studied by various authors. Growth curves are applied to industries by many researchers (Chen, Chen, & Lee, 2011; Moona & Jeon, 2009; Ryu & Byeon, 2011). The most commonly used models on growth curves are *S*-curves and Pearl and Gompertz curves. Franses (1994) developed a model which identified the differences between these two curves and defined the specific application areas for them. Later, Bengisu & Nekhili (2006) used the same model for forecasting. Kucharavy and De Guio (2011a, 2011b) also made detailed research on *S* curves. Daim, Rueda, Martin, and Pisek (2006) suggested using bibliometrics and patent analysis in technology forecasting when sufficient historical data is not available. They provided data from patent and bibliometric analysis and used scenario planning, growth curves and analogies for technology forecasting. Dubaric, Giaznnocarro, Bengtsson, and Ackermann (2011) also used patent data for forecasting wind power technology. Bengisu and Nekhili (2006) used both bibliometric and patent data to form *S*-curves and investigated the correlation between them. Morris, DeYong, Wu, Salman, and Yemenu (2002) used a computer program that helps to perform bibliometric analysis of collections of scientific literature and patents for technology forecasting. Kim et al. (2010) used dual AHP to select the best electrical device technology in Korea.

Some articles are about choosing the best forecasting techniques. Eto (2003) studied logical fundamentals of extrapolation and Delphi techniques. Levary and Han (1995) identified main factors affecting forecasting and studied 11 technological forecasting techniques. Then, they prioritized them according to five criteria to find the best method. Similarly, Cheng, Chen, and Chen (2008) used fuzzy AHP for choosing the most appropriate technique considering 8 criteria and found that Delphi technique was the best forecasting method for new materials development. Mishra, Deshmukh, and Vrat (2002) used a decision making technique to find the best method by using 31 forecasting techniques. They found that normative techniques gave better result for defense systems whereas Delphi technique was better for IT. Meade and Islam (1998) surveyed a wide range of possible models on technological forecasting in literature. They suggested three group of curves namely symmetric, nonsymmetric and flexible curves according to data sets they used and applied discriminant analysis for classification purpose.

Some researchers used combinations of multiple techniques. Yoo and Moon (2006) claimed that using multiple techniques gave better results and decreased errors. Tseng, Cheng, and Peng (2009) used a combination of scenario analysis, Delphi method and technological substitution model to analyze the development of a new