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A new integrated intuitionistic fuzzy group decision making approach for product development partner selection

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ABSTRACT

Globally, customers are getting increasingly demanding in terms of quality, price and performance of products and are asking for shorter product development periods with more predictable cycles. These market pressures drive firms to collaborate with possible partners in product development (PD) processes. Nevertheless, choosing the suitable partner for an effective PD is a challenging, complex decision. This study proposes a combined Intuitionistic Fuzzy (IF) Group Decision Making (GDM) model that consists of the Intuitionistic Fuzzy Analytic Hierarchy Process (IF-AHP) and Intuitionistic Fuzzy Technique for Order Preference by Similarity to Ideal Solution (IF-TOPSIS) methods for effectively evaluating PD partners. In order to obtain a more complete evaluation and more precise results, IF-AHP is used for determining criteria weights, whereas IF-TOPSIS methodology is conducted for ranking partner alternatives. This study contributes to partner selection and IF set literature by providing a combined framework based on IF-AHP and IF-TOPSIS with GDM methodology for the first time. To assess the validity of the proposed integrated IF GDM approach, a case study is also provided. This study contributes to literature as it provides a better insight into the theoretical ground of the PD partner selection problem. It also supports organizations which aim to improve their PD evaluation systems.

1. Introduction

New product development (PD) and innovation tend to be accepted as the most influential processes to gain competitive advantage in many different industries (Drucker, 1999; Prahalad & Hamel, 1994). To be able to maintain and improve corporate competition capabilities as well as to drive sustainability in a market with continuously developing conditions, companies pursue opportunities of collaboration and build connections with those companies with which cooperation can create synergy to improve their PD attempts. Collaborative systems can benefit companies in terms of bringing valuable advantages to its participants, e.g. higher survival chance in cases of unexpected variations and demand shocks and having chance to better achieve common goals (Büyüközkan & Arsenyan, 2012). Moreover, collaborative firms play a very important role in sharing risks, reducing expenses, shortening the period needed to bring a product to the market, improving product features and making good use of the knowledge accumulated in the network through the PD processes in a complementary way (Littler, Leverick, & Bruce, 1995).

When a new product requires advanced technologies, its developer is forced to cooperate with its suppliers to maintain its competitive power and to effectively manage all the relevant technologies necessary to satisfy customers' needs (Yoo, Shin, & Park, 2015). As a matter of fact, collaborative PD (CPD) has become an alternative path for those businesses that aim to operate efficiently, as well as effectively for PD (Arsenyan & Büyüközkan, 2014). In this context, CPD brings partners together from a wide range of organizations which join their forces for a larger but common aim. CPD activities can be difficult, though, like in any other partnership, where inherent risks related to possible structural as well as cultural incompatibilities can occur (Ding & Liang, 2005). Hence, effective CPD bring value, whereas ineffective partnerships can cause to the loss of core competencies and capabilities, exposure to unpredicted risks and even business failures (Liou, Tzeng, Tsai, & Hsu, 2011). Partners hold a critical position in assuring the performance of the collaboration. This makes the partnership decision procedure an important step, which can affect the accomplishment of the whole collaboration process (Chen, Wang, Chen, & Lee, 2010).

Selection of partners is a strategic decision that is bound with many different criteria to think about. Such complex decision

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processes involving several perspectives can be worked around by using multi-criteria decision making (MCDM) techniques. MCDM techniques are recognized for their advantages in dealing with challenges that do not only involve high levels of uncertainty, but also conflicting objectives, numerous interests and dimensions (Büyüközkan & Feyzioğlu, 2004). In addition, MCDM can assist decision makers (DMs-experts) in taking objective decisions based on value judgments with the help of collective group ideas (Ding & Liang, 2005). For this reason, MCDM often necessitates Group Decision Making (GDM) which includes multiple DMs with different opinions. For decision making problems with qualitative and quantitative criteria and alternatives in particular, GDM is a frequently visited method that is preferred over a single DM due to its superiority in avoiding partiality and bias (Büyüközkan & Feyzioğlu, 2005; Herrera, Herrera-Viedma, & Chiclana, 2001).

Analytic Hierarchy Process (AHP) is a popular decision making tool which is originally introduced by Saaty (1980) for management sciences and operations research applications. It can establish priorities within the context of MCDM (Xu & Liao, 2014) and provides a technique for objectively deciding on an alternative among various options. In many situations, DMs might not assign precise numbers for evaluating decision attributes, which can be due to DMs' limited knowledge or the subjectivity about the decision problem (Xu & Liao, 2014). To overcome this issue, fuzzy logic (Zadeh, 1965) can be adapted to AHP to take the ambiguity of qualitative evaluations into account. Although it is a simple and popular way for handling MCDM applications, Fuzzy AHP (FAHP) is often criticized for being inadequate in cases when subjective human judgments need to be assessed (Zhü, 2014). In these cases, Intuitionistic Fuzzy Sets (IFS) present useful and practical tools to deal with vagueness and uncertainty (Atanassov, 1986, 1999). Researchers have explored the integration of AHP with IFS, named as (IF-AHP), which has particularly become popular in recent years (Abdullah & Najib, 2014a; Xu & Liao, 2014). The Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS), a renowned traditional MCDM method introduced by Chen and Hwang (1992), can also be integrated with IFS, which is referred to as Intuitionistic Fuzzy TOPSIS (IF-TOPSIS). These methods are based on human preferences and can successfully handle uncertainties. With the help of IFS, a more accurate description of MCDM problems is obtained in many applications (Joshi & Kumar, 2014).

In this study, the IF-AHP and IF-TOPSIS techniques for GDM is proposed for solving the problem of PD partner selection. These techniques are able to take care of uncertain and incomplete information of DMs' judgments on the evaluation criteria and alternatives. One of the primary advantages of this proposed integrated IF-AHP and IF-TOPSIS method is that it is a flexible and robust way for DMs to better understand a decision problem in case of uncertainty and vagueness in DMs perceptions. Another advantage is that a collective decision can be achieved with this method by combining DMs' assignments in appropriate ways, based on a satisfactory degree of agreement by using GDM. This paper has originality as it is the first application of this integrated approach in literature, considering the lack of studies using IFS for PD partner selection problems. In contrast with the literature employing IF-AHP and IF-TOPSIS separately, this study contributes to the literature by using them together. Also, this study contributes by representing a real case study to show how companies can deal with uncertainties and complexities on the decision making process to select the most appropriate partners.

The integrated evaluation procedure introduced here is based on several consecutive steps. It starts with the identification of the primary main- and sub-criteria of the partner selection process in PD. Once the hierarchy of evaluation criteria is formed, the partner evaluation criteria weights need to be computed by using IF-AHP, and then IF-TOPSIS technique is applied to obtain the final partner rankings. To measure the integrated methodologies' validity and reliability, Fuzzy AHP is compared with the Fuzzy TOPSIS technique and a sensitivity analysis is performed on a case company. Finally, the obtained results and managerial implications are presented.

This study is structured as the following; the next section presents the current state of the literature, whereas Section 3 explains the proposed methodology in detail and summarizes the calculation steps. Section 4 presents an application of the proposed model. The validation of the study is provided in Section 5. The final Section 6 gives the conclusions.

2. Literature survey

2.1. PD partner selection

Partner selection is a common problem businesses frequently face in their everyday operations and is a critical decision that can affect their operational success. On the other hand, it is a rather time consuming and resource intensive process that should be managed with care (Ávila et al., 2012).

For sustainable success, companies need to continuously provide new or improved products, processes and services through their reliable suppliers, partners and efficient supply chains. In many markets the competition is at very high levels, which forces businesses to quickly develop new products with a higher quality so that they can meet their customers' expectations in short time and attain competitive and economical advantage (Tsai, 2009). In order to address this challenge, companies can tap into collaboration opportunities, which often enables multidisciplinary integration, an important aspect when creating new products (Emden, Calantone, & Droge, 2006). Development and manufacturing of new products need the assistance of a reliable supply chain. Therefore, partner selection tends to be named as supplier selection in literature. Collaboration can decrease PD costs, shorten order cycle times, improve product quality and reduce the risk of delivery delays. However, it must be underlined that the dependency on collaboration partners can also pose risks on corporate success or even production capability (Zolghadri, Eckert, Zouggar, & Girard, 2011). Hence, it is necessary to carry out the supplier evaluation process carefully to ensure a suitable selection (Byrne, Heavey, Blake, & Liston, 2013; Rajesh & Ravi, 2015) to reap its benefits with minimal risks.

Many recent publications focus on the supplier selection process including a number of steps. Faris, Robinson, and Wind (1967) and Kraljic (1983) proposed a supplier selection model consisting of the following consecutive steps; defining the problem, formulating the qualification criteria, and the final choice (Junior, Osiro, & Carpinetti, 2014). The first step starts with defining the problem by identifying possible suppliers of a new product and then either replacing current suppliers or selecting them from a set of existing suppliers. Following that, the second step is criteria identification for the model. Here, the best supplier is chosen with a thorough criteria evaluation. Once all the criteria are identified, analytical techniques are applied for the supplier selection process. Next comes the qualification step which aims to reduce the size of the initial supplier set by sorting, based on qualifying criteria. As the final step, potential suppliers are ranked so that the decision can be met (Junior et al., 2014).

2.2. Intuitionistic Fuzzy GDM (IF-GDM) in MCDM

MCDM is one of the popular methods that can be put in use for solving complicated and highly uncertain problems that exhibit conflicting objectives, multiple interests and perspectives