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Evaluation of sustainable supply chain risk management using an integrated fuzzy TOPSIS- CRITIC approach

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ABSTRACT

Supply chain risk management research has mainly mistreated the important of sustainability issues. Moreover, there is little knowledge about sustainable management of risk and supply chain and the way they impose losses for firms. Risk management's duty in the supply chain is to identify, analyze, and provide solutions for accountability, control and monitor the risks in the economic and production cycle. This study aims to develop a framework for the sustainable supply chain risk management (SSCRM) evaluation. To this end, an integrated fuzzy multi-criteria decision-making (MCDM) approach is proposed based on the technique in order of preference by similarity to ideal solution (TOPSIS) and criteria importance through inter-criteria correlation (CRITIC) methods. The literature was reviewed and the potential criteria were identified. Through an expert panel the criteria were filtered. Seven main criteria and forty-four sub-criteria were developed for the final evaluation SSCRM framework. The most dominant sub-criteria in each group found to be as; machines & equipment risks, key supplier failures, demand fluctuations, government policy risks, IT security, economic issues, and lack of proper sewage infiltration. Besides, A2 (Nouri complex) found to be the best practitioner. The methodology is successfully implemented in a real case company. The detailed account of implications and limitations are presented as the concluding remarks.

1. Introduction

Todays, organizations have acknowledged the significance of ecological thinking and sustainability in business due to the quality uprising and supply chain (Mangla et al., 2015b; Seuring and Müller, 2008) and it is turn out to be the most important subjects in the modern study of operations management (Lim et al., 2017; Rajeev et al., 2017; Stindt, 2017). Attention to the issues related to risks has been grown because the number of relevant uncertainties has increased. The essence and the type of uncertain developments or the influence of any action have become difficult or even impossible to forecast because modern supply chains' interrelation and communication have been increased (Fahimnia et al., 2015). Additionally, following factors, in general, displayed a loss of readiness for supply chain managers coming to uncertain developments: political issues, technological replacement, demand fluctuations and major disruptions such as flooding, earthquake, global financial crisis, and tsunami.

Company's sustainability highly depends on its purchasing, and supply management function highly depends on implementing sustainable supply (Schneider and Wallenburg, 2012). It has been stated that the adoption and implementation of green supply chain (GSC) not only helps industries to conserve resources, which in turn enhances their ecological and economic performances, but also it corporates the sustainable development of industries (Hu and Hsu, 2010; Mangla et al., 2015b; Rostamzadeh et al., 2015). It can be said that organizations' decisions influence the future condition of the natural environment and societies, and overall business

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achievements are presented by a degree of sustainability (Krysiak, 2009). In addition to the investment costs that are needed to make supply chains more sustainable; sustainability strategies, with this great description, should take the degree of future uncertainty into account and also the risks that decisions may affect the natural and social environments (Giannakis and Papadopoulos, 2016). However, according to (Seuring and Müller, 2008), there is a research gap in examining the connections of supply risks and the sustainable supply chain management. Furthermore, (Ghadge et al., 2012) have pointed that there are two main streams lacking in supply risk research: behavioral perceptions in risk management and sustainability factors (Lintukangas et al., 2014). Many firms are expanding their supply chain to the global level to reduce costs. However, in doing so, such firms encounter new risks because their supply chain could be affected by a natural disaster or an emergency on the other side of the planet (Ellis et al., 2011). Christopher and Lee (2004) proposed that a supply chain with high risk cannot be effective. A company, which only pursues high efficiency and ignores risk management, is doomed to failure in this era (Dong and Cooper, 2016; Fan et al., 2016). In addition, responsiveness, efficiency, and reliability are the important drivers for supply chain profitability (Hendricks and Singhal, 2005). Besides, an important source of cost reduction is supply chain sustainability, and it is also very important for a company's lengthy profitability (Wang and Sarkis, 2013). Managers of supply chains, in order to minimize sustainability-related risks and reduce costs, have the responsibility to decide on asset recovery and relationship management, sustainable sourcing, and local content development. Therefore, the assessment of risk management improvement and sustainability-related influence, and their identification for risk tools and managers of the supply chain are turning to be very important subjects (Giannakis and Papadopoulos, 2016; Hofmann et al., 2014). Supply chains in order to keep their profitability must have the ability to fastly react to external and internal risk incidents, and keep their businesses active and productive. In addition, supply chains must be flexible to unpredicted disastrous matters. To do so, one needs to deeply understand supply chain risks and the way to manage them. There are impreciseness and uncertainty in essence of risk analysis. Any analysis made, which ignore this impreciseness and uncertainty, may cause serious mislead of information and consequently cause large mistakes. According to Waters (2011), supply chain risks happen because of future uncertainty. There is an economic value in uncertainty reduction. Also, the validity of risk management decisions improves by uncertainty reduction. In order to increase supply chain's sustainability, and at the same time to decrease its vulnerability, uncertainty and factors that generate risks must be considered. Furthermore, risks can cause the failure of supply chain and can have a meaningful effect on organization performance. Formal concepts of sustainability that explain uncertainty will be scarce in the literature if uncertainty is unconcerned without conforming to its analysis of the specific problems caused by uncertain results and uncertain favors, and if studies only favor the risk (Krysiak, 2009).

Fuzzy set theory and knowledge management principles can be used to cut off the uncertainty integrated with risk measures. Sustainability risks' conceptualizations, without a deep understanding of this materialization process, will continue to be unclear and development of effective management frameworks cannot be fulfilled. The novel contributions of this research is the application of the methodology. To our knowledge, there is only one prior research (Song et al., 2017) linking sustainability-related issues and supply chain risks using multi-criteria decision-making (MCDM). Considering the results of Song et al. (2017) which will be discussed in the literature review section, our contribution in this paper is two-fold. First, for sustainable supply chain risk management (SSCRM) evaluation, a framework is created. Then, a technique for an order of preference by similarity to ideal solution (TOPSIS), and criteria importance through inter-criteria correlation (CRITIC) method is developed in a fuzzy environment, as we have not come across any application of this technique in SSCRM assessment.

The rest of this paper is as follows: the second section discusses SSCRM related literature. The proposed framework for the evaluation of SSCRM using a TOPSIS-CRITIC method developed in the fuzzy environment is presented in the third section. The suggested framework application for risk evaluation in a real case environment is discussed in the fourth section. Discussions and results are provided in section 5, and finally, the sixth section presents the future work and conclusions.

2. Review of literature

This session discusses the theoretical background of prior studies on the topic and the proposed criteria and measures.

2.1. Sustainable supply chain risk management

Ahi and Searcy (2013) defined sustainable supply chain as “the creation of coordinated supply chains through the voluntary integration of social, environmental, and economic considerations with key inter-organizational business systems designed to effectively and efficiently manage the capital, information, and material flows associated with the production, procurement, and distribution of services and products, or in order to improve the resilience of the organization over the long and short-term and increase the profitability and competitiveness and meet stakeholder requirements”. In Christopher et al. (2003) point of view, supply chain risk is as “any risk to product, material, and information flow from original supplier to the delivery of the end product”. Sustainability is often characterized as having three pillars which also is referred as the triple bottom line: environmental sustainability, social responsibility, and organizational sustainability. Environmental concerns that are complexly connected to different facets of the supply chain include resources that are nonrenewable, landfill deposits, reducing any kind of energy usage and carbon emission. Resale, rebuild, reuse, and recycle are key concepts in minimization efforts to increase its effectiveness. Social responsibility consists of labor relations, living wage payment, ethical behavior, gender equity, and use of proper labor. The violation in any factors could cause a high risk for the firm (Buddress, 2014). Organizational sustainability requires acting with social responsibility and minimal environmental impact while it maintains financial viability. As a result, profitability will be upheld, customers will be fulfilled, and activities that will damage its perception will refrain by both current and potential customers and suppliers. All of this leads to long-term viability.

Atherton (2011) in his report proposed environmental damages during logistics and transportation, packaging waste, natural disasters, greenhouse gas emissions, accidents, and energy usage are typical sustainability-related risks for many industries. No attention is done by researchers in combining sustainability issues into the existing literature on supply chain risk. (Chopra and Sodhi, 2004; Harwood and Humby, 2008). To understand that how sustainability issues materialize as risks, in fact, current frameworks of supply chain risk management (SCRM) do not provide any means (Hofmann et al., 2014). For example, Cucchiella and Gastaldi (2006) by using a real options approach to reduce firm risks, investigated risk management in supply chain. In order to protect the firm against the risk originating from every source of uncertainty, a useful theoretical framework has been individualized enabling the selection of possible options. Ritchie and Brindley (2007) by