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A resilient-sustainable based supplier selection model using a hybrid intelligent method

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ABSTRACT

Supplier selection literature with contributing sustainability issues observes exponential growth in the number of publications. However, a few studies have focused on the more extensive effects of sustainability paradigm in the supplier selection that arise with disruptions. Hence, a tool is required to help purchasing managers to consider resilience and sustainability approaches in the supplier selection decision under disruption situation. This paper fulfills this necessity with proposing a resilient-sustainable framework based on the supplier selection indicators. Moreover, a fuzzy set theory is applied to cope with the uncertainty in the supplier selection decision. Furthermore, a modular Fuzzy Inference System is designed to calculate the affinity indices of suppliers to resiliency and sustainability issues. The modular FIS system supports to have a comprehensive supplier selection model with any number of indicators and suppliers. Then, the results of the proposed modular FIS are passed to an Assurance Region DEA method (AR-DEA) to determine the weights of indicators to rank the suppliers. The applicability of the proposed integrated intelligent model investigated by a real case. To show the effectiveness of the proposed model, sensitivity analysis has been adopted.

1. Introduction

During the last two decades, sustainability regarding maintaining the physical environment and developing long-term relationship has been focused on carrying out of manufacturing or service activities, extensively. Therefore, sustainability considerations have become a progressively significant issue in supply chain management (Chaabane, Ramudhin, & Paquet, 2012; Singh, Olugu, & Fallahpour, 2014). Advancing the sustainable paradigm in supply chain forces purchasing managers to apply this agenda in the procure occurrences. Supplier selection is a key decision for procure management in the supply chain. Therefore, sustainable supplier selection has gained wide consideration in the literature (Zimmer, Fröhling, & Schultmann, 2016).

Due to the globalization, supply chains are more confronted by natural, human-made or technological threats such as floods, earthquakes, fires, transport accidents, labor strikes, terrorist attacks and so on. These disasters cause the supply chain disruptions, which are harmful from lost productivity, revenue, competitive advantage, profitability and etc. for organizations. Therefore, providing a resilience approach to the supply chain is a necessity to protect the buyer from shortages and disruptions. Since a supplier affects the success of a supply chain, resiliency in supplier selection decision must be considered to reduce the risk of businesses. This concept can be seen in some related supplier selection researches (Hosseini & Al Khaled, 2016; Lee, 2017; Yilmaz-Börekçi, İşeri Say, & Rofcanin, 2015).

Today's, existing of disruptions cause to drop the sustainability objectives of supply chains. Hence, the new challenges for supply chain managers are to propose an efficient supply chain that will be resilient to jump back from any disruption and that also should have sufficient care to offer same sustainability under a disruption (Edgeman & Wu, 2016; Fahimnia & Jabbarzadeh, 2016; Thomas, Byard, Francis, Fisher, & White, 2016). Going through literature, the resiliency and sustainability have been considered together in the supply chain and their relations between these two aspects were explored (readers are referred to Marchese et al. (2018) for more information). However, sustainability concept and resilience theory in selecting supplier literature have been investigated independently (Hosseini & Barker, 2016; Parkouhi & Ghadikolaei, 2017). It can be shown that in the supplier selection previous works the linkage between resilience aspects and sustainability concept is ignored. In other words, in these researches, only resilience criteria are considered to evaluate the suppliers and the sustainable criteria have not been allocated. However, it is unrealistic to discuss a sustainable supplier selection without considering the resiliency aspects, where sustainability is affected by the disasters. Therefore, in this paper, through extensive literature review, a framework has been suggested to come up with a resilient-sustainable

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Table 1
The resilient-sustainable supplier selection literature.

Reference	General Criteria								Sustainable Criteria									Resilient Criteria								Methodology
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
(Hsu and Hu, 2009)										√	√																ANP
(Lee, Kang, Hsu, & Hung, 2009)		√								√	√	√															Fuzzy-AHP
(Awasthi, Chauhan, & Goyal, 2010)									√	√		√			√												Fuzzy-AHP
(AydIn Keskin, Ihan, S., Özkan, C., 2010)	√		√	√			√					√															Fuzzy ART Algorithm
(Bai and Sarkis, 2010)										√		√	√			√											Grey Theory and Rough Set
(Buyukozkan and Çifçi, 2010)		√		√			√				√																Fuzzy-ANP
(Kuo, Wang, & Tien, 2010)	√	√	√		√					√		√	√														Artificial Neural Network –DEA-ANP
(Punniyamoorthy, Mathiyalagan, & Vasishta, 2010)	√	√	√	√	√		√	√			√																Fuzzy Structural Equation Modeling
(Tseng and Chiu, 2010)		√	√	√	√	√		√	√	√			√		√												Fuzzy Grey Relational Analysis
(Yeh and Chuang, 2010)	√	√	√		√				√	√				√													Multi Objectives Genetic Algorithm
(Zhu, Dou, & Sarkis, 2010)	√	√	√	√		√		√	√	√		√	√			√											ANP
(Mafakheri et al., 2011)	√	√	√						√	√	√																AHP Mathematical Programming
(Amindoust, Ahmed, Saghafinia, & Bahreininejad, 2012)	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√											Fuzzy Inference System
(Genovese et al., 2013)	√	√	√			√			√	√	√	√	√														Review
(Haldar et al., 2014)	√	√																	√				√			√	Fuzzy-TOPSIS
(Nielsen et al., 2014)	√	√	√	√	√		√		√	√	√	√															Review
(Azadi et al., 2015)	√	√	√								√					√											Fuzzy-DEA
(Rajesh and Ravi, 2015)	√	√		√		√					√					√			√	√			√	√			Grey Relational Analysis
(Chen et al., 2016)		√	√	√	√		√				√									√							Goal Programming
(Hosseini and Al Khaled, 2016)	√	√	√		√														√		√	√	√		√	√	AHP-Neural Network
(Hosseini and Barker, 2016)	√	√	√		√					√											√	√	√		√	√	Bayesian Network
(Sahu et al., 2016)	√	√			√														√				√			√	Fuzzy-VIKOR
(Zimmer et al., 2016)	√	√	√	√				√		√	√	√	√	√		√	√	√									Review
(Azadeh et al., 2017)	√		√			√													√				√	√			Fuzzy-DEA
(Fallahpour et al., 2017)	√		√		√	√			√	√	√	√		√		√	√										Fuzzy Preference Programming
(Luthra et al., 2017)	√	√	√	√	√	√	√		√	√	√	√			√	√	√	√									AHP-VIKOR
(Parkouhi and Ghadikolaei, 2017)	√	√	√	√		√		√								√			√								Fuzzy ANP-Gray VIKOR
(Pramanik et al., 2017)	√	√	√																√	√			√		√	√	AHP-TOPSIS-QFD
(Awasthi et al., 2018)	√	√	√			√		√	√	√	√	√	√			√		√									Fuzzy AHP-VIKOR
(Goren, 2018)	√	√	√	√	√			√	√	√	√		√			√											Fuzzy DEMATEL Taguchi Loss Function
(Vahidi et al., 2018)	√	√	√						√	√	√	√	√			√	√	√									SWOT-QFD-Mathematical Model

supplier selection model.

Sustainability and resiliency approach includes a lot of qualitative and quantitative dimensions, where qualitative dimensions out pass the quantitative ones. Therefore, the important issue is the development of methods for resilient-sustainable supplier selection taking into the account of all major resilient-sustainable aspects or agendas. Many papers have been applied fuzzy or hybrid fuzzy methods to take the qualitative dimensions into account for supplier selection problem (Simić, Kovačević, Svirčević, & Simić, 2017). However, the applied methods are not comprehensive and they are limited to the number of indicators and alternatives (suppliers). Among the mentioned methods, DEA has received a lot of attention (Amindoust, in press; dos Santos Rubem, de Mello, & Meza, 2017) in spite of having the limitation on the number of inputs and outputs (indicators) in accordance with the number of decision making units (suppliers). The constraint is that there should be at least twice as many suppliers as there are inputs and outputs combined (Toloo & Salahi, 2018). If this is not the case, then the likelihood of most or all suppliers receiving efficiency scores at or near 1.0 is great and this limits the discrimination power of the DEA. So, in this paper, FIS as an intelligent model has been integrated with DEA to overcome this shortcoming. Moreover, using FIS leads to handle with imprecise and fuzzy data instead of numeric and precise ones in stand-alone DEA model. It is noted that in original DEA formulations the assessed decision making units (DMUs) can freely choose the weights to be assigned to each input and output in a way that maximizes its efficiency. This might not be acceptable by decision makers, who after spending time in a careful selection of inputs and outputs sees some of them being entirely neglected by suppliers. To avoid the problem, input and output weights should be constrained in DEA and the Assurance Region DEA (AR-DEA) technique would be applied. However, the AR-DEA model can be implemented for decision makings which may involve a small number of inputs and outputs (Saen, 2010). So, integrating FIS method with AR-DEA, also can be a solution for the latest shortcoming. Therefore, the proposed model under the aforesaid drawbacks, centralizing on DEA technique and integration of it with intelligent methods such as FIS would be taken into account to pave a way to new findings in supplier selection problem, which helps big industries.

In this paper, the affinity indices of candidate suppliers with resiliency and sustainability are obtained from the developed modular FIS model. The outcomes of this modular FIS model are passed to AR-DEA to rank a given set of suppliers. From the literature, it may be pointed out the integration of FIS and DEA techniques that are not yet observed in any area of decision making.

2. Literature review on sustainable and resilient supplier selection

The rigorous literature on supply chain management presents the exponential growth in the number of publications which involved in