Article

Understanding Interdependencies among Social Sustainability Evaluation Criteria in an Emerging Economy

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Abstract: Organizations need to consider the triple bottom line (3BL) model of sustainability to maintain competitiveness in global markets. Of 3BL, environmental and economic sustainability pillars are more often discussed, as they are most directly related to a firm's bottom line and regulatory compliance. Unfortunately, social sustainability receives relatively little attention even though it remains a significant threat to organizational sustainment, particularly in emerging economies. This study builds upon a social sustainability evaluation framework to investigate the interrelationships among social sustainability criteria in an effort to better understand how to improve social sustainability performance. A unique hybrid of interpretive structural modeling (ISM) and hesitant fuzzy matrix of cross impact multiplications applied to classification (HF-MICMAC) methodology is introduced and employed to determine the interrelationships (drivers and dependences) among social sustainability criteria. Then, a manufacturing company is used as the backdrop to test the efficacy of the expanded framework. The findings can aid industry decision-makers, especially in developing countries, to better understand and manage social issues, improve social dimension of sustainability, enhance the sustainability in operations and shift towards sustainable development.

Keywords: sustainability; social sustainability; ISM; MICMAC; hesitant fuzzy set theory

1. Introduction

Manufacturing companies adopt sustainable supply chain management (SSCM) programs and initiatives in their operations to achieve sustainable production [1,2]. However, an effective implementation of SSCM strategies cannot be fully ensured via considering only economic and environmental aspects of triple bottom line (3BL) model by businesses. In addition to economic and environmental sustainability, becoming truly sustainable requires organizations to consider social sustainability in the managerial decision-making [3,4]. Companies are increasingly confronted with serious social issues and challenges due to their supply chain operations, ranging from strikes resulting from poor health and safety issues at work, to employees' rights violations [5]. To date, the social dimension of sustainability has been given much less consideration compared to economic and environmental sustainability dimensions, particularly in emerging economies where there is a lack of advanced capital market [6–8]. It is indicated that sustainability in supply chain management (SCM) as well as firm productivity can be increased by implementing supply chain social sustainability (SCSS) programs and initiatives [9]. Investigating social problems in supply chain

operations is critical for companies in order to enhance long-term sustainability, due to growing pressures from stakeholders, non-governmental organizations (NGOs) and regulatory authorities [5]. One approach to achieving a sustainable competitive advantage begins by carefully analyzing interrelationships among the sustainable criteria [10]. Thus far, numerous studies [11–14] have been carried out so as to investigate interrelationships between environmental and economic sustainability criteria. Yet, the interrelationships between SCSS criteria have seen less investigation in theory and practice, particularly in developing economies [15]. This motivated the current research, where a social sustainability criteria decision framework is adapted from the literature [5] and subsequently tested using a unique multi-criteria decision analysis (MCDA) model to analyze the interdependencies between social criteria. D'Eusanio et al. [16] reviewed social sustainability within SCM literature and indicated that only 7% of the literature used (MCDA). The applied MCDA method is hybrid (ISM) and hesitant fuzzy MICMAC (HF-MICMAC) in the SSCM realm. The novelty of this research lies in the employment of hesitant fuzzy set (HFS) theory rather than fuzzy set (FS) theory for capturing, more efficiently, ambiguity surrounding decision-makers' (DMs) subjective judgements. HFS, unlike FS theory, is able to handle hesitancy of DMs as it provides an opportunity for DMs to give two or more linguistic phrases when DMs are hesitant about selecting just one of them. Conversely, in conventional FS theory there is no such capability. Additionally, a revised ISM model is suggested to tackle the issue of extremely interconnected system in ISM method to facilitate level partitioning.

The innovative contribution of this study centers on introducing and proposing a social sustainability criteria decision framework by investigating the interrelationships and interdependencies among social sustainability criteria in a way that can improve social sustainability performance. The proposed method, an integrated ISM and HF-MICMAC approach, is the first of its kind in the published literature, and considers the hesitancy in subjective judgements of decision-makers. In particular, employment of HFS theory in combination with MICMAC method is a main theoretical contribution of this study.

An automotive manufacturing industry in Iran is as a real-world developing country example to validate the model by exploring SCSS criteria. This research makes two specific contributions. First, we introduce a social sustainability evaluation framework in order to guide general decision-making in this area, especially in developing economies. Second, a new hybrid multi-criteria decision analysis (MCDA) model that integrates, ISM and HF-MICMAC to analyze the interrelationships between social sustainability evaluation criteria is proposed. Finally, the results offer unique insights into social sustainability implementation and serve as an effective input for informing SSCM decisions.

The rest of the article is structured as follows. Backgrounds on SSCM, the focal social sustainability evaluation framework and research gap are presented in Section 2. The proposed research methodology can be found in Section 3. Section 4 presents the proposed model. In Section 5, the applicability of the methodology is evaluated in a case example. Ultimately, Sections 6 and 7 present discussion of the results and conclusion of the study.

2. Background

This section presents a review of SSCM, a social sustainability evaluation framework and research gap.

2.1. Sustainable Supply Chain Management

Sustainability was defined as satisfying needs of current generation without compromising needs of next generations [17]. However, this most accepted definition has not been always able to fully acknowledge viewpoint of all people in global supply chains. Take an example of those are living at a time and place where they are not even able to meet their own generation's needs shows a bias of understanding between developed or industrialized and developing economies. It would highlight an urgent need for further investigations in both developing and base of the pyramid (BOP-high poverty and low development) countries [18]. SSCM deals with managing materials and information flows via collaborations between supply chain partners in consideration of the 3BL

model [19]. SSCM considers the environmental as well as social matters regarding manufacturing processes and product flows throughout supply chains [20]. Comprehending the 3BL model of sustainability and interrelationships among components is of paramount importance [21]. Numerous studies have explored SSCM from the lens of a traditional SCM approach, trying to maintain and improve the 3BL constancy for achieving long-term sustainable development [22,23]. SSCM consists of several aspects, including multi-operational undertakings, for developing competitive advantage across the entire supply chain network [24,25].

Managing adverse impacts of a corporation's SCM operations on the environment and society is a sophisticated task [26,27]. Hong et al. [28] argued that investigation on SSCM in developing nations is still limited and SSCM factors and initiatives are often underdeveloped in these societies. A vast proportion of studies have investigated SSCM in various contexts [3,29]. A diverse set of authors have tried to explore sustainability dimensions. While dealing with the environmental issues, firms, focus on environmental management programs, trying to decrease environmental impacts [30]. Firms should develop their social duties and not merely focus on the economic side. The economic dimension of sustainability is related to sales, market share, operational efficiency, and financial performance [31]. SSCM initiatives and programs provide developing countries with considerable opportunities in order to reach their sustainability targets [32,33]. Those aspects of products and processes that have an impact on the safety and welfare of people are known as the human side of sustainability, are thus referred to as social sustainability [34]. Maloni and Brown [35] and Martínez-Blanco et al. [36] indicated the significance of social problems such as equity and diversity in supply chains.

Although diverse approaches have been adopted by many researchers to investigate SSCM, to date the social aspect has not properly been recognized in the literature [5,37]. Qorri et al. [38] indicated that social sustainability-related initiatives are difficult to evaluate; however, researchers are taking the lead to develop meaningful measures as a way to begin benchmarking performance. Social sustainability might be achieved when firms adopt measurable SSCM related initiatives in hopes of contributing to social performance [39]. Since companies should function more responsibly and look after worker health, safety, and work conditions, it emphasizes on the point that social sustainability should be treated as an important topic in SCM [40]. According to Silvestre [12], supply chains in emerging economies are confronted with additional barriers to sustainability than those which operate in developed nations. Badri Ahmadi et al. [5] note that more studies need to be conducted in developing nations to investigate the social dimension of sustainability. This research addresses this issue by specifically investigating social aspect of sustainability within a developing country's automotive manufacturing sector.

2.2. Social Sustainability Evaluation Framework

There are few studies in the literature that have introduced a social sustainability criteria decision framework for organizational decision support. None of these previous frameworks have focused on manufacturing in developing economies. As such, studies considering a social sustainability evaluation framework for investigating the interdependencies among social sustainability criteria in these contexts are nearly non-existent. The current research employs a social sustainability evaluation framework as proposed by Badri Ahmadi et al. [5] (see Table 1).

Table 1. The evaluation framework of the study.

Criteria	Description	References
Work safety and labor health (SSC1)	Indicates firms concentrate on safety and health of their operations.	[41–44]
Training, education and community development (SSC2)	This is in association with the employers' influence in training and education on their employees.	[42,43]

Contractual stakeholders' influence (SSC3)	This is related to given attention by potential suppliers to their stakeholders.	[9,43,45]
Occupational health and safety management system (SSC4)	This is related to implementation status of safety management.	[42,46,47]
Interests and rights of employees (SSC5)	This links to promoting employees' related sustainable employment problems.	[41,47,48]
Rights of community (SSC6)	This is about rights of community which have an interest in outcomes of the organization's actions.	[41,47,48]
Information disclosure (SSC7)	This is related to information on materials being consumed during production process or carbon emission information which can be disclosed to clients and stakeholders.	[41,47,48]
Employment practices (SSC8)	This is about practices associated with employees.	[9,46]

2.3. Research Gap

Ehrgott et al. [15] emphasized that quantitative studies of social sustainability criteria in the context of emerging economies are rare. According to the information provided in the literature review, no study has investigated the interrelationships between supply chain social sustainability criteria within a developing economy context. This research addresses this gap by proposing a novel hybrid ISM and HF-MICMAC methodology to explore interrelationships between various social sustainability criteria. HFS theory compared to fuzzy set theory has the advantage of allowing decision-makers to choose a range of possible values. Because decision-makers usually encounter a degree of hesitance or indeterminacy before expressing their subjective judgements, by using the HFS theory this issue is incorporated in the analysis model. As social criteria are complex and intertwined, a method that can effectively study the interdependencies between them while capturing the uncertainty in decision-makers' subjective judgements would be useful. Thus, an automotive manufacturing sector in a developing country context is used as an illustrative case to examine and verify the usefulness of the proposed framework and model. A comprehensive description of the methods can be found in the next section.

3. Methods

3.1. Hesitant Fuzzy Sets (HFS)

Intuitionistic fuzzy set (IFS) theory was generalized to introduce HFS. In HFS, the membership degree of an entity can be a set of potential values within the interval of [0,1]. DMs' subjective judgements can be acquired more properly by giving them the opportunity to choose among a couple of values.

Definition 1. [49] Given X is a fixed set. HFS on X is signified in the form of a function when it is applied to X will return a subset of [0,1]. Xia and Xu [50] represented HFS as Equation (1):

$$E = \{\langle x, h_E(x)\rangle : x \in X\} \tag{1}$$

where $h_E(x)$ signifies a set of values in [0,1], indicating the possible membership degree of a member $x \in X$ to the set E. Moreover, Xia and Xu [50] regarded $h = h_E(x)$ as a hesitant fuzzy element (HFE).

Definition 2. [51] Given $h = U_{\gamma \epsilon h}\{\gamma\} = \{\gamma_j\}_{j=1}^{l(h)}$ is a HFE, in which $l(h)$ signifies the number of values in h. Equation (2) shows a score function S of a HFE h. Where $\{\delta(j)\}_{j=1}^{l(h)}$ is a positive-valued monotonic ascending order of index j.

$$S(h) = \frac{\sum_{j=1}^{l(h)} \delta(j)\gamma_j}{\sum_{j=1}^{l(h)} \delta(j)} \qquad (2)$$

$l(h) = N$ and $\delta(j) = j$ are given then Equation (3) is resulted.

$$S(h) = \frac{\sum_{j=1}^{N} j\gamma_j}{\sum_{j=1}^{N} j} = \frac{2}{N(N+1)} \sum_{j=1}^{N} j\gamma_j \qquad (3)$$

As an example, let $h_1 = \{0.2, 0.3, 0.7\}$ and $h_2 = \{0.1, 0.4, 0.7\}$ be two HFEs. Obviously, $h_1 \neq h_2$. By applying Equation (3), score function values would result in $S(h_1) = 0.483$ and $S(h_2) = 0.5$.

3.2. ISM Approach

The ISM approach is for analyzing the interactions between the system's elements. Researchers would be able to construct a relationship map of complicated relations between a system's elements by using ISM. In ISM, the fundamental notion is to use knowledge and experience of DMs to break up a multiplex system into several subsystems and make a multi-level hierarchical model [52,53].

The required steps to implement ISM are explained below:

Step 1: elements (criteria or variables) regarded for the system under study are determined.

Step 2: then, a contextual relationship is constructed to pair the examined elements.

Step 3: pairwise relationships between elements can be specified by constructing a structural self-interaction matrix (SSIM). Four symbols will be used to unravel the direction of relationships [54,55]:

V: element i will lead to element j

A: element j will lead to element i

X: element i and j will help achieve each other

O: element i and j are unrelated

Step 4: final reachability matrix is developed and its transitivity is examined. First the initial reachability matrix must be developed by substituting V, A, X, O by 1 and 0 based on the explained rules:

1) if the (i,j) entity is V, then the (i,j) entity in the initial reachability matrix will be 1 and the (j,i) entity will be 0

2) if the (i,j) entity is A, then the (i,j) entity in the initial reachability matrix will be 0 and the (j,i) entity will be 1

3) if the (i,j) entity is X, then the (i,j) entity in the initial reachability matrix will be 1 and the (j,i) entity will be 1

4) if the (i,j) entity is O, then the (i,j) entity in the initial reachability matrix will be 0 and the (j,i) entity will be 0

The final reachability matrix can be obtained by encompassing the transitivity feature in the initial reachability matrix.

Step 5: final reachability matrix should be examined regarding amount of direct and indirect (i.e., transitive) relations. In case the system is fairly interconnected and number of 1 and 1* (transitive links) does not considerably outnumber number of zeros and level partitioning is possible then we can proceed to step 6, otherwise we have to do the HF-MICMAC analysis (Section 3.3.) and obtain the revised ISM model as explained in Section 5.3.

Step 6: the obtained final reachability matrix is broken down into various levels. So as to level partitioning we need to define the reachability and antecedent sets. The reachability set includes an element itself and other elements which it may help to achieve, whereas on the other hand, the antecedent set includes an element and other elements which help in achieving it [56]. Then, the

intersection of the previous two sets should also be obtained. The elements with similar reachability and intersection sets lie at the highest level [57].

Step 7: a directed graph is drawn based on the relationships provided in the final reachability matrix while all transitive links are omitted

Step 8: the obtained digraph is transformed into an ISM by substituting statements for element nodes.

Step 9: the developed ISM model is examined for conceptual inconsistency and any required amendments.

3.3. HF-MICMAC Approach

The ISM is able to produce insights about if an element has any impact on others, but it does not help with realizing the extent of impact an element may have on others. The MICMAC method uses the outcomes of ISM as input to define the driving (DR) and dependence (DP) powers of elements under consideration [58]. The DR value shows the degree to which an element helps achieve or influence other elements. The DP value means the degree to which an element is being achieved or influenced by other elements. The conventional MICMAC method regards only binary types of relationships and fuzzy types of links are explored in fuzzy MICMAC [57,59,60]. In this development, HFS is applied to raise its sensitivity and efficiency to better capture subjective judgements of human beings. In the proposed HF-MICMAC, the strength of relationships and uncertainty in subjective judgements of experts are taken into consideration simultaneously [54]. In the proposed HF-MICMAC, DMs are able to offer their opinions by providing multiple linguistic phrases (Table 2) if they are hesitant about selecting just one of them. For instance, a DM can choose Very low (VL), Low (L) and Medium (M) at the same time if she is hesitant to anchor her decision on only one choice. This advantage of HFS compared to FS theory makes the new HF-MICMAC more robust to handling DMs' subjective and hesitant opinions. Steps in the proposed HF-MICMAC are discussed below:

Step 1: developing binary direct reachability matrix (BDRM)

Conventional MICMAC takes into account only binary relationships called BDRM. It is acquired by assessing the direct relations between elements and using reachability matrix in ISM, ignoring the transitivity and making diagonal entries zero.

Step 2: developing linguistic assessment direct reachability matrix (LADRM)

The linguistic assessment scale for the elements (Table 2) and replacing the values in BDRM with the appropriate linguistic terms which can be no, very low, low, medium, high, very high, and full relation.

Table 2. Linguistic terms and fuzzy numbers for strength of relations [61].

Linguistic Terms	Triangular Fuzzy Numbers	Crisp Numbers
None	(0.0,0.0,0.0)	0
Very low (VL)	(0.0,0.1,0.3)	0.1
Low (L)	(0.1,0.3,0.5)	0.3
Medium (M)	(0.3,0.5,0.7)	0.5
High (H)	(0.5,0.7,0.9)	0.7
Very high (VH)	(0.7,0.9,1.0)	0.9
Full	(1.0,1.0,1.0)	1.0

Step 3: developing hesitant fuzzy direct reachability matrix (HFDRM)

HFS is applied to convert LADRM to HFDRM. Using corresponding and appropriate fuzzy values of each linguistic term (shown in Table 2) and superimposing terms on the LADRM, the HFDRM will be constructed.

Step 4: calculating the score function values

In the resulting HFDRM, there will be some aggregated HFE value which can be obtained by Equation (3).

Step 5: obtaining the HF-MICMAC stabilized matrix

The obtained HFDRM from step 4 is our basis for the start of this process. The stabilized matrix is reached by repeatedly multiplying the matrix until the hierarchies of the driver power and dependence stabilize based on the rule of fuzzy matrix multiplication (Equation (4)). In this case, the multiplication of two fuzzy matrices will be a fuzzy matrix [62].

$$C = A, B = \max k[min(a_{ik}, b_{kj})], \text{ where } A = [a_{ik}] \text{ and } B = [b_{kj}] \tag{4}$$

Step 6: constructing the driver-dependence diagram

The DR in HF-MICMAC is computed by summing the entries in the rows and the DP is derived by adding the values in the columns together. The driver-dependence diagram can be depicted while the horizontal axis is driven or DP power and the vertical axis is DR or influence power [63]. The DR indicates the extent to which the risk impacts others and DP is the degree that the risk is influenced by others. The diagram categorizes the area into four clusters as follows:

Cluster I: weak DR and weak DP (autonomous or excluded)

They are situated in the south-west part of the diagram and have only a few relations with the system or are relatively disconnected to the system.

Cluster II: weak DR and strong DP (dependent)

They are positioned in the south-east part of the diagram and are dependent to other elements means more being influenced rather than have influence on other elements.

Cluster III: strong DR and strong DP (linkage or relay)

They are located in the north-east frame of the chart. These elements are also regarded as unstable and any action on these elements will have influence on others and feedback impact on themselves which may amplify the initial pulse.

Cluster IV: strong DR and weak DP (entry, driver, or determinant)

Independent elements with strong driving power make up the fourth cluster. These strategic elements can affect others to the maximum level, hence should be prudently managed. They are key factors in the system.

Step 7: constructing the impact digraph map (IDM)

The net driving power (NDR) or effectiveness power [64] which is the subtraction of DP from DR (DR-DP) can be a proper measure to obtain elements with the highest net driving powers or the most key elements. A new measure is proposed in HF-MICMAC as the summation of DR and DP powers and called prominence (PR=DR+DP) that can show the importance of each criterion. The PR value indicates the degree that an element can be involved interacting with other elements in the system. To construct IDM, PR takes the horizontal axis values and the vertical axis is NDR. The IDM makes four quadrants as explained below:

Quadrant I: independent elements

These elements positioned in the south-west part of the IDM and have negative NDR and low PR values.

Quadrant II: impact elements

Impact elements are in the south-east area of the IDM and have negative NDR and high PR values. These elements are impacted by others and cannot be directly improved.

Quadrant III: core elements

Characterized by high PR values and positive NDR values. These elements are located in the north-east part of the IDM.

Quadrant IV: minor key elements

Minor key elements are in north-west part of the IDM and similar core elements have positive NDR and similar to independent elements have low PR values.

4. Proposed Model

A unique combined method of well-recognized ISM and a novel HF-MICMAC is applied in constructing the social sustainability criteria interrelations evaluation. The HF-MICMAC is the MICMAC method combined with HFS theory. By obtaining the driving and dependence powers, four clusters of social sustainability criteria can be revealed. The driving power indicates the extent to which each criterion impacts others and the dependence power is the degree that each criterion is influenced by other criteria. In the proposed HF-MICMAC method, we introduce a new diagram titled impact digraph map (IDM) (Section 3.3. step 7) as well as the integrated ISM and HF-MICMAC model. The overall research methodology flowchart of the study can be found in Figure 1.
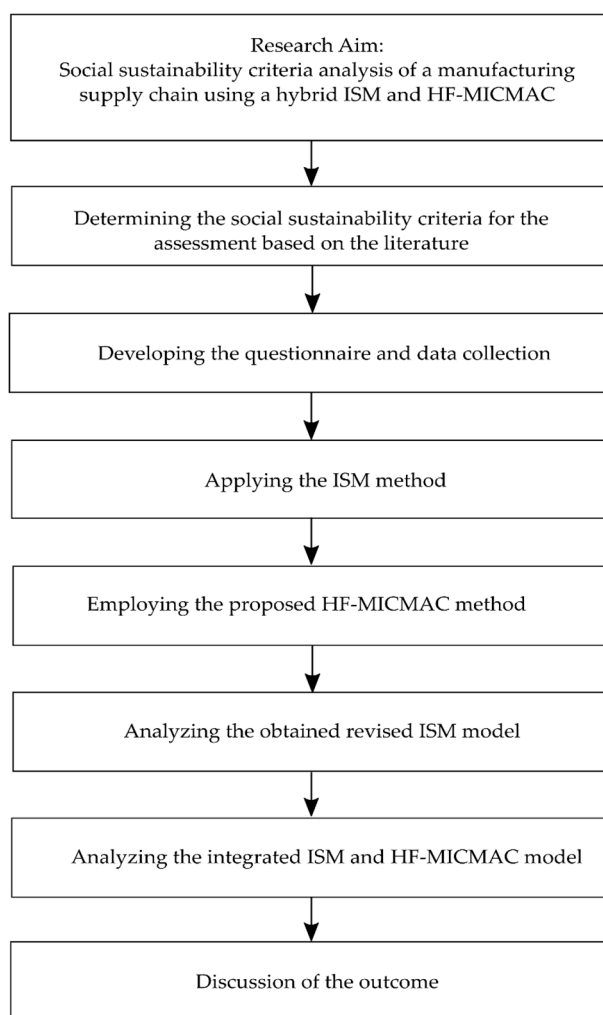

Figure 1. Research methodology.

5. Case Application

Like many other developing nations, sustainability initiatives in Iran are in initial implementation phases, particularly in the manufacturing industry [5]. The case company in this research is a leading automotive corporation in Iran. This firm has a major market share in manufacturing and supplying automobile parts inside the country. Recently the company has decided to evaluate and improve its social sustainability performance. Thus, our study investigated the causal interrelationships among social sustainability criteria as a means to test our framework and help the company develop and attain its sustainability goals.

A group of five supply chain DMs from the case company was formed. This committee was comprised of purchasing, supply chain, logistics, production planning, and marketing managers. Each DM had at least ten years of professional work experience in their respective field. An online questionnaire was designed and sent to the DMs. The research team described the objective of the

study and how to complete the online questionnaire. Furthermore, DMs were requested to evaluate the interrelationships among the eight social criteria.

5.1. ISM Analysis

The eight identified social sustainability criteria as represented in Table 1 are considered in the ISM analysis. The SSIM is constructed based on the integration of contextual relationships between criteria obtained from five DMs' evaluations. To integrate opinions which are in the forms of V, A, X and O (as discussed in step 3 Section 3.2), the voting system is applied which favors the opinions of the majority of DMs or the dominant opinion as all DMs in this research possess equal importance weight. For instance, in evaluation of SSC1 and SSC8, A, V, A, V, A were obtained indicating the integrated value should be A. In case the voting system is not able to determine the dominant opinion, the sum of relationship strengths between criteria which were asked in the questionnaire has been calculated and used to identify the integrated relationship (Table 3).

Table 3. SSIM matrix.

	SSC8	SSC7	SSC6	SSC5	SSC4	SSC3	SSC2
SSC1	A	O	V	A	V	A	A
SSC2	V	A	O	A	V	V	
SSC3	A	V	A	O	V		
SSC4	V	O	A	V			
SSC5	O	X	A				
SSC6	O	V					
SSC7	A						

Based on step 4 of Section 3.2, the above SSIM matrix can be transformed as binary variable 0 or 1. According to step 5, the final reachability matrix is represented in Table 4. In the final reachability matrix, the transitivity feature is incorporated. Transitive relationships in Table 4 are shown as 1*.

Table 4. Final reachability matrix.

	SSC1	SSC2	SSC3	SSC4	SSC5	SSC6	SSC7	SSC8
SSC1	1	0	1*	1	1*	1	1*	1*
SSC2	1	1	1	1	1*	1*	1*	1
SSC3	1	1*	1	1	1*	1*	1	1*
SSC4	1*	1*	1*	1	1	0	1*	1
SSC5	1	1	1*	1*	1	1*	1	1*
SSC6	1*	1*	1	1	1	1	1	1*
SSC7	1*	1	1*	1*	1	0	1	1*
SSC8	1	1*	1	1*	1*	1*	1	1

The number of 1 and 1* together in Table 4 considerably outnumbers the number of 0, meaning that the eight criteria are closely interconnected and large number of direct and indirect relations between criteria exist. In this case, ISM is unable to properly build the hierarchical structure and levels. To deal with the issue, we proposed a revised ISM model in Section 5.3. By incorporating the strength of transitive or indirect relationships (1* in Table 4) to identify and remove weak indirect links.

This drawback shows the ISM model cannot reveal a thorough understanding of the system by ignoring the degree of influences. Moreover, the ISM model in general, casts light merely on relations between criteria, not the degree of relations, and does not provide any insight about which relations are strong. Hence, in the next stage of our research, the HF-MICMAC has been applied to see how the relations between criteria can be interpreted regarding the degree of influences between them and how the most critical criteria can be found via this method.

5.2. HF-MICMAC Analysis

Following the steps explained in Section 3.3, first, the BDRM is constructed by ignoring the transitivity as well as replacing diagonal entries with zero in the final reachability matrix (Table 4). The resulted BDRM is represented in Table 5. According to Table 5, there are 23 direct relations (values 1 in the BDRM).

Table 5. Results of BDRM.

	SSC1	SSC2	SSC3	SSC4	SSC5	SSC6	SSC7	SSC8
SSC1	0	0	0	1	0	1	0	0
SSC2	1	0	1	1	0	0	0	1
SSC3	1	0	0	1	0	0	1	0
SSC4	0	0	0	0	1	0	0	1
SSC5	1	1	0	0	0	0	1	0
SSC6	0	0	1	1	1	0	1	0
SSC7	0	1	0	0	1	0	0	0
SSC8	1	0	1	0	0	0	1	0

Based on Table 2, the LADRM is constructed and represented in Table 6. For instance, values corresponding to SSC2-SSC1 explain that three DMs expressed their opinions as {H, VH}, {L, M} and {H, VH} respectively. It means two DMs have a hesitancy to choose between High (H) and Very High (VH) while one DM has a hesitancy to choose between Low (L) and Medium (M).

Table 6. Results of LADRM.

	SSC1	SSC2	SSC3	SSC4	SSC5	SSC6	SSC7	SSC8
SSC1	0	0	0	{M,H,VH}, {VH}	0	{VL,L}, {VL}	0	0
SSC2	{H,VH}, {L,M}, {H,VH}	0	{M, H}, {L,M}	{H,VH}, {M,H}, {VL,L}	0	0	0	{M}, {M,H}, {VL,L}
SSC3	{L,M}, {L,M}	0	0	{M,H}, {M,H}	0	0	{VL,L}, {M,H}	0
SSC4	0	0	0	0	{H,VH}, {L,M}, {L,M}	0	0	{L,M}, {VL,L}, {L,M,H}
SSC5	{L,M}, {L}, {VL,L}	{H,VH}, {H,VH}, {M,H}	0	0	0	0	{H,VH}, {VL,L,M}	0

	SSC1	SSC2	SSC3	SSC4	SSC5	SSC6	SSC7	SSC8
SSC6	0	0	{H,VH}, {H,VH}	{H,VH}, {M,H}	{M,H,VH}, {M}	0	{M,H}, {L,M}, {VL}	0
SSC7	0	{L,M}, {M}, {M,H}	0	0	{H,VH}, {VL,L,M}	0	0	0
SSC8	{H,VH}, {H,VH}, {H,VH}	0	{L,M,H}, {M,H}, {L,M}	0	0	0	{VL,L,M}, {VL}, {L,M}	0

By using Equation (3), the final aggregated values and then the HFDRM can be obtained as represented in Table 7.

Table 7. Results of HFDRM.

	SSC1	SSC2	SSC3	SSC4	SSC5	SSC6	SSC7	SSC8
SSC1	0	0	0	0.856	0	0.189	0	0
SSC2	0.766	0	0.566	0.666	0	0	0	0.522
SSC3	0.433	0	0	0.633	0	0	0.5	0
SSC4	0	0	0	0	0.633	0	0	0.467
SSC5	0.355	0.800	0	0	0	0	0.678	0
SSC6	0	0	0.833	0.766	0.678	0	0.478	0
SSC7	0	0.555	0	0	0.678	0	0	0
SSC8	0.833	0	0.578	0	0	0	0.311	0

To obtain the HF-MICMAC stabilized matrix (Table 8), the HFDRM has been multiplied three times to reach stabilization following the rule of fuzzy matrix multiplication (Equation 4), which is explained in greater detail in Kandasamy et al. [62].

Table 8. HF-MICMAC stabilized matrix.

	SSC1	SSC2	SSC3	SSC4	SSC5	SSC6	SSC7	SSC8
SSC1	0.678	0.678	0.566	0.678	0.678	0.189	0.678	0.522
SSC2	0.633	0.633	0.566	0.633	0.633	0.189	0.633	0.522
SSC3	0.633	0.633	0.566	0.633	0.633	0.189	0.633	0.522
SSC4	0.633	0.633	0.566	0.633	0.633	0.189	0.633	0.522
SSC5	0.678	0.678	0.566	0.678	0.678	0.189	0.678	0.522
SSC6	0.633	0.678	0.566	0.678	0.633	0.189	0.678	0.522
SSC7	0.633	0.678	0.566	0.678	0.633	0.189	0.678	0.522
SSC8	0.633	0.633	0.566	0.633	0.633	0.189	0.633	0.522

To calculate the DR and DP values and consequently establish the driver-dependence diagram (step 6 in Section 3.3.) we need to sum up values of rows and columns of the stabilized matrix (Table 9). The obtained NDR and PR values are illustrated too. The driver-dependence diagram is depicted in Figure 2. In Figure 3, the IDM, according to the obtained NDR and PR values (Table 9) is illustrated.

Table 9. Driving, dependence, net driving and prominence values.

Criteria	Driving (DR)	DR Levels	Dependence (DP)	DP Levels	Net Driving Power (NDR=DR-DP) (Rank)	Prominence (PR=DR+DP)(Rank)
SSC1	4.667	III	5.154	IV	−0.487 (4)	9.821 (1)
SSC2	4.442	I	5.244	V	−0.802 (6)	9.686 (2)
SSC3	4.442	I	4.528	III	−0.086 (3)	8.970 (3)
SSC4	4.442	I	5.244	V	−0.802 (6)	9.686 (2)
SSC5	4.667	III	5.154	IV	−0.487 (4)	9.821 (1)
SSC6	4.577	II	1.512	I	3.065 (1)	6.089 (5)
SSC7	4.577	II	5.244	V	−0.667 (5)	9.821 (1)
SSC8	4.442	I	4.176	II	0.266 (2)	8.618 (4)
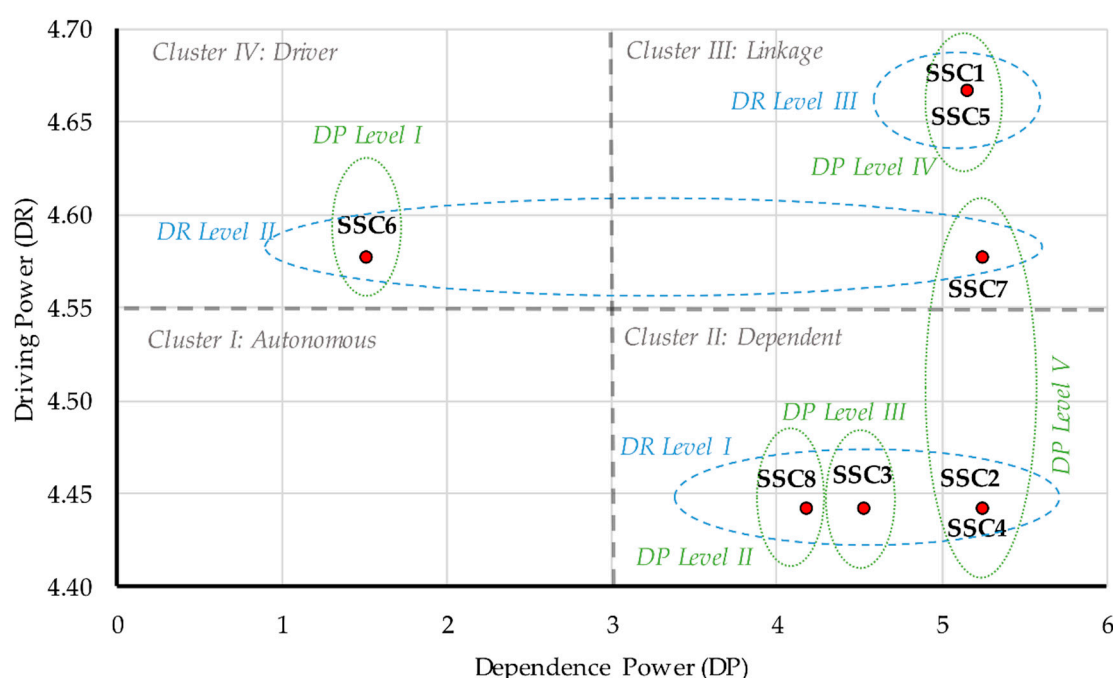
Figure 2. Driver-dependence diagram.

From Figure 2, work safety and labor health (SSC1), interests and rights of employees (SSC5) and information disclosure (SSC7) are recognized as linkage criteria. Any action on these criteria will spread to others while generating feedback upon themselves. These elements are also regarded as unstable. Training, education, and community development (SSC2), occupational health and safety management system (SSC4), contractual stakeholders' influence (SSC3), and employment practices (SSC8) all are recognized as dependent elements. Rights of community (SSC6) is the only criterion in cluster IV (Figure 2) and identified as a driver criterion. This means that this criterion is the most strategic and can affect others to the maximum extent, hence it should receive more emphasis than perhaps other criteria.

Based on Figure 3, rights of community (SSC6) also has the highest NDR power and together with employment practices (SSC8) are found as core criteria. Although employment practices (SSC8) has appeared as dependent in Figure 2, its dependency is the lowest among other criteria in cluster II (i.e., SSC8 is in DP level II, meaning it stands at second to the lowest dependency level which is SSC6 in DP level I). Other than rights of community (SSC6) and employment practices (SSC8), other criteria are also regarded as impactful and situated in quadrant II in the IDM. These six criteria

including contractual stakeholders' influence (SSC3), training education and community development (SSC2), occupational health and safety management system (SSC4), work safety and labor health (SSC1), interests and rights of employees (SSC5), and information disclosure (SSC7) are less likely to be directly managed but instead are influenced by investment rights of community (SSC6), and employment practices (SSC8).
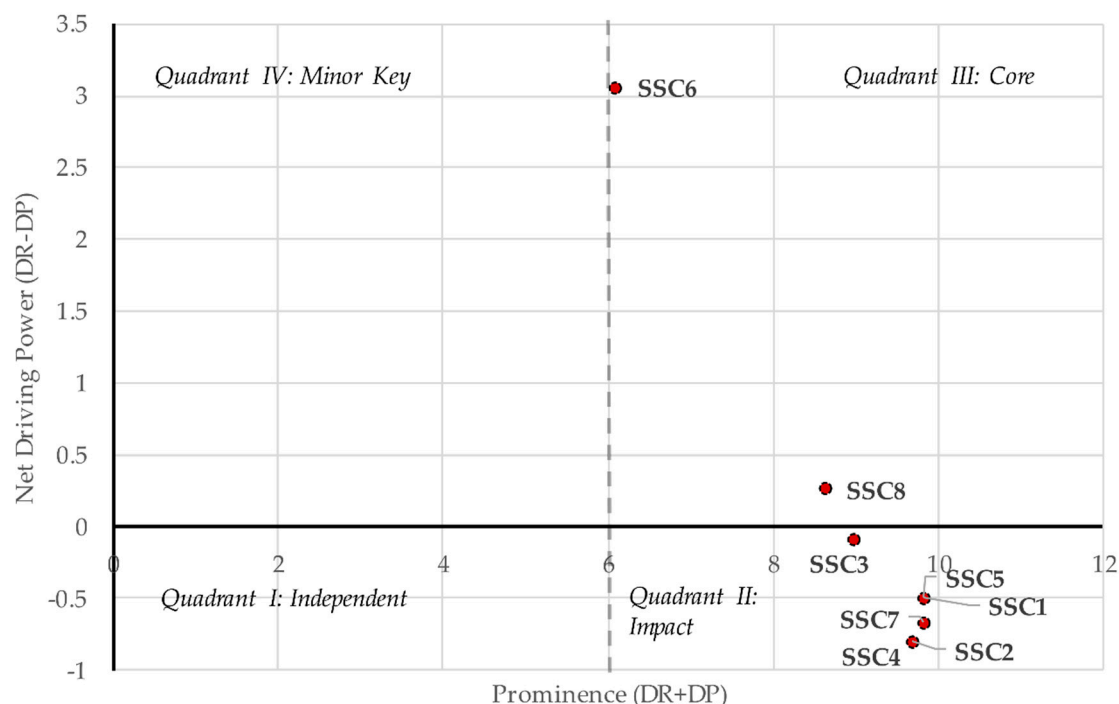

Figure 3. IDM diagram.

As can be seen in Figures 2 and 3, work safety and labor health (SSC1), and interests and rights of employees (SSC5) are representing exactly the same point as training education and community development (SSC2) and occupational health and safety management system (SSC4). That means HF-MICMAC cannot distinguish any difference between them in terms of DR and DP values based on the obtained data. Also, no autonomous (cluster I in Figure 2), independent (quadrant I in Figure 3) and minor key (quadrant IV in Figure 3) criterion are observed.

5.3. Revised ISM Model

By using values in Table 7 (HFDRM), which reveal the strength of the links between criteria we are able to identify weak indirect relations. The threshold we calculated by getting the average of values in Table 7 is 0.600, meaning indirect links with values lower than 0.600 should be removed. All the indirect or transitive relations along with their respective strength values are calculated in Table 10.

Table 10. Strength of indirect links in final reachability matrix.

No.	Indirect Link (1*)	Via	Average Strength
1	1 to 3	6	0.511
2	1 to 5	4 & 6	1.178
3	1 to 7	6	0.334
4	1 to 8	4	0.662
5	2 to 5	4	0.650
6	2 to 6	1	0.478

7	2 to 7	3 & 8	0.950
8	3 to 2	7	0.528
9	3 to 5	4 & 7	1.222
10	3 to 6	1	0.311
11	3 to 8	4	0.55
12	4 to 1	5 & 8	1.144
13	4 to 2	5	0.717
14	4 to 3	8	0.523
15	4 to 7	5 & 8	1.045
16	5 to 3	2	0.683
17	5 to 4	1 & 2	1.339
18	5 to 6	1	0.272
19	5 to 8	2	0.661
20	6 to 1	3 & 5	1.150
21	6 to 2	5 & 7	1.256
22	6 to 8	4	0.617
23	7 to 1	2 & 5	1.177
24	7 to 3	2	0.561
25	7 to 4	2	0.611
26	7 to 8	2	0.539
27	8 to 2	7	0.433
28	8 to 4	1 & 3	1.45
29	8 to 5	7	0.495
30	8 to 6	1	0.511

Indirect links no. 1, 3, 6, 8, 10, 11, 14, 18, 24, 26, 27, 29, and 30 in Table 10 are identified as weak due to with average value less than 0.600. By removing the thirteen weak indirect relations from final reachability matrix (Table 4), the revised final reachability matrix can be achieved (Table 11).

Table 11. Revised final reachability matrix.

	SSC1	SSC2	SSC3	SSC4	SSC5	SSC6	SSC7	SSC8
SSC1	1	0	0	1	1*	1	0	1*
SSC2	1	1	1	1	1*	0	1*	1
SSC3	1	0	1	1	1*	0	1	0
SSC4	1*	1*	0	1	1	0	1*	1
SSC5	1	1	1*	1*	1	0	1	1*
SSC6	1*	1*	1	1	1	1	1	1*
SSC7	1*	1	0	1*	1	0	1	0
SSC8	1	0	1	1*	0	0	1	1

In Table 12, three levels of social sustainability criteria are shown. Numbers of 1 and 1* in rows and columns of the revised final reachability matrix would lead us to calculate the reachability and antecedent sets respectively. Then, intersection of the two sets are computed and shown in a separate column in Table 12 to identify various levels of criteria.

Table 12. Levels of social sustainability criteria.

Criteria	Reachability Set	Antecedent Set	Intersection Set	Level
SSC1	1,4,5,6,8	1,2,3,4,5,6,7,8	1,4,5,6,8	I
SSC2	1,2,3,4,5,7,8	2,4,5,6,7	2,4,5,7	III
SSC3	1,3,4,5,7	2,3,5,6,8	3,5	II
SSC4	1,2,4,5,7,8	1,2,3,4,5,6,7,8	1,2,4,5,7,8	I
SSC5	1,2,3,4,5,7,8	1,2,3,4,5,6,7	1,2,3,4,5,7	II
SSC6	1,2,3,4,5,6,7,8	1,6	1,6	III
SSC7	1,2,4,5,7	2,3,4,5,6,7,8	2,4,5,7	III
SSC8	1,3,4,7,8	1,2,4,5,6,8	1,4, 8	III

5.4. Integrated ISM and HF-MICMAC Model

At this point, we pieced together all of the HF-MICMAC analyses, taking into account DR, DP, NDR and PR values as well as IDM and the driver-dependence diagram. It can be concluded that by considering the amount of influence between criteria as well as the direction and number of relations the following rank order (most important to least important) of criteria is proposed: (1) rights of community (SSC6), (2) employment practices (SSC8), (3) work safety and labor health (SSC1), and interests and rights of employees (SSC5), (4) information disclosure (SSC7), (5) contractual stakeholders' influence (SSC3), and (6) training education and community development (SSC2), and occupational health and safety management system (SSC4)

In Figure 4, a clear illustrative integration of both ISM and HF-MICMAC is provided using the relations between criteria from revised ISM model and orders obtained from HF-MICMAC analysis. The lower levels are depicted with bigger shapes to represent their higher influence values on other criteria. For instance, rights of community (SSC6) has the biggest size compared to others to indicate that it has the highest influence on others. Taking into account both Figure 2 (i.e., driver-dependence diagram) and Figure 3 (i.e., IDM), the order and shape size of criteria in the integrated ISM and HF-MICMAC model (Figure 4) can be realized.
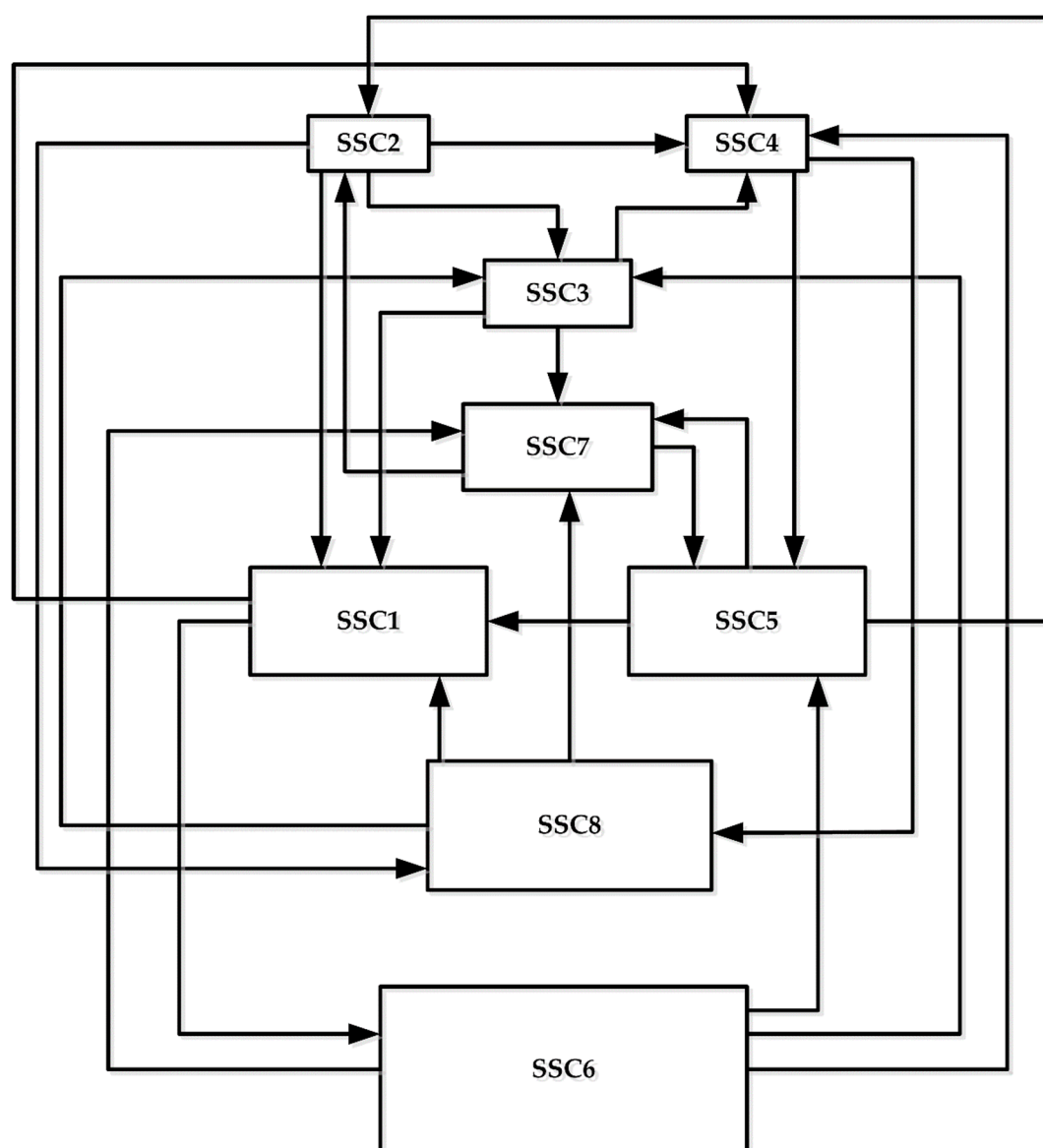
Figure 4. The integrated ISM and HF-MICMAC model.

6. Discussion

The findings of this study can help supply chain managers make strategic decisions and move towards sustainable development. Results show, rights of community (SSC6) and employment practices (SSC8) are the most critical social criteria. Rights of community (SSC6) has the highest net driving power (Figure 3) and the second highest driving power (Figure 2), confirming its strong influence on other criteria. Therefore, once adequate levels of these two most influential criteria are achieved, then it can set the foundation for other factors to be developed.

Findings revealed that five out of eight social sustainability criteria were directly related to primary and/or secondary stakeholders (i.e., direct and indirect interest in a firm). Training, education, and community development (SSC2) and rights of community (SSC6) are connected to community sustainment (secondary stakeholder). Contractual stakeholders' influence (SSC3) is linked mainly to suppliers (primary stakeholders). Interests and rights of employees (SSC5) and employment practices (SSC8) deal with employees (primary stakeholders). Communities, suppliers, and employees all have related by different stake in the sustainment of the focal firm, and what might be a responsible social decision in the eyes of one stakeholder might not be seen in the same light as others [28,65,66]. According to Ehrgott et al. [15], stakeholder views in SCSS research have been started being examined recently. Hence, this issue might be even more crucial to examine in an

emerging economy where less attention has been given to social initiatives emphasizing human wellbeing, particularly in manufacturing industries.

Morais and Silvestre [67] reconfirmed that primary motivations for SCSS development can be either intrinsic or extrinsic [68]. Intrinsic motivations for social sustainability are focused on ethical considerations while extrinsic motivations are often more related to financial gains. Morais and Silvestre [67] found that the participation of secondary stakeholders is the norm for intrinsic motivations for social initiatives. This type of social initiative might be sustained for a longer time frame, achieving more permanent results. As in our study, rights of community (SSC6) is the most salient social sustainability criteria. It can be inferred that DMs in our case were highly concerned about ethical standards and organizational values. This suggests that unjust labor laws and abusive work practices negatively affect social sustainability more than other sustainability dimensions. Thus, DMs might feel pressured from the community to reach a resolution to overcome social sustainability barriers.

Badri Ahmadi et al. [43], in their study also employed "work safety and labor health", "training education and community influence" and "contractual stakeholders' influence" to examine sustainable supplier selection in the telecommunication sector. They understood that "contractual stakeholders' influence" is the lowest weighted social criteria among the three social criteria, which is very close to our findings as contractual stakeholders' influence (SSC3) is ranked second to last (Figure 4). However, Badri Ahmadi et al. [43] identified contractual stakeholders' influence as the most central criterion for achieving social sustainability and sustainable development in manufacturing.

Badri Ahmadi et al. [5] recognized occupational health and safety management system as the least key criterion, which is in line with findings of our study, because it together with training education and community development (SSC2) lie at the lowest level in our integrated ISM and HF-MICMAC methodology (Figure 4). The reason as indicated in Badri Ahmadi et al. [5] might be due to ambiguous employee wellbeing expectations in this developing country (Iran). However, Azadnia et al. [42] identified occupational health and safety management system as the most significant social criterion. It is no surprise that in this early stage of SCSS research in developing countries, there would be contradictory findings that need to be addressed in further research. This study adds several important data points in this new area of study.

7. Conclusions

In this work, the social sustainability aspect of a 3BL model in an emerging economy context was explored. This research used a social sustainability decision framework including eight social sustainability criteria from the literature. Then interrelationships between them was investigated by proposing a novel hybrid ISM and HF-MICMAC method. To this aim, data from an Iranian automotive manufacturer used to test the model and develop findings which can cautiously be generalized to other manufacturing settings, and perhaps in other developing nations and emerging economies. Findings revealed that rights of community (SSC6) and employment practices (SSC8) are the most critical social sustainability criteria.

7.1. Theoretical Contribution

In terms of methodological theory, a novel integration of ISM and HF-MICMAC was introduced in this research, representing a primary contribution of the study. In the previous literature, fuzzy MICMAC was used [57,59]. In this study, HFS has been proposed to overcome FS theory shortcomings and limitations. HFS is a powerful theory to effectively consider the subjective judgements of DMs by capturing their indeterminacy, which cannot be captured via standard FS theory. HFS is able to capture hesitancy of DMs by offering an opportunity to provide two or even more linguistic phrases which DMs have a hesitancy about selecting one of them. Furthermore, we provided more insightful analysis by proposing new tools including IDM in the MICMAC analysis as well as the integrated ISM and HF-MICMAC model. The IDM was presented via introducing two measures of NDR and prominence to provide a better realization of the outputs from HF-MICMAC

(Section 3.3, step 7). A revised ISM model is also suggested to tackle the issue of extremely interconnected criteria in ISM method to facilitate establishing a hierarchical structure. The integrated ISM and HF-MICMAC model (Figure 4) offers a comprehensive outlook on the obtained results. The lower levels are depicted with bigger shapes to represent the higher influence values they have on other criteria.

7.2. Implications for Practice

This research's resultant framework can be useful to both academics and practitioners in developing economies. As social measures interact closely with each other, revealing the interdependencies and interactions among the most significant social sustainability criteria can bring about more insights on the sustainable supply chain field. The following interpretations of the findings emphasize the key implications for practice.

First, rights of community (SSC6) is the criterion upon which practitioners should focus the most attention. Although the community is often regarded as a secondary stakeholder in the literature, its impact on other criteria is significant. As SSCM can benefit people in the long-term, the local community and their engagement can be an important driver for achieving sustainability beyond the walls of the focal firm.

Second, employment practices (SSC8) that deal with employees (primary stakeholders) has the highest NDR and is positioned as core criterion in the IDM. D'Eusanio et al. [16] asserted that social perspective to sustainability with focus on particular social aspect such as wages and employees need more investigation.

Third, work safety, and labor health (SSC1) together with interests and rights of employees (SSC5) are recognized equally important, and both are identified as linkages in the driver-dependence diagram. Due to their strong driving and dependence scores, any action to improve these areas has a corresponding effect on other areas. Interests and rights of employees (SSC5) is more concerned with employee matters than structured managerial processes. For instance, interests and rights of employees (SSC5) are more about to what extent employees are free at work to express their innovative ideas to address sustainability issues in the organization. If work safety and labor health (SSC1) is met with acceptable standards, then we can expect the path through social sustainability would be even more stable.

Fourth, information disclosure (SSC7) provides information to stakeholders related to materials, processes, and techniques used as well as green-house gas (GHG) emissions released during production. This activity is an important step towards developing sustainability in the context of this current research, as determining how stakeholders can access information is not always straightforward in developing economies. The driver-dependence diagram (Figure 2) reveals that the driving power of information disclosure (SSC7) is at the same level as rights of community (SSC6), suggesting its criticality for practitioners and policy makers in developing economies.

Fifth, contractual stakeholders' influence (SSC3), training, education, and community development (SSC2) and occupational health and safety management system (SSC4) are less influential criteria in our study, but it does not mean they are not important. They are identified as dependent or impact criteria (Figures 2 and 3) which means they can be managed indirectly by influencing other criteria. Managers should take this into consideration when making resource commitments.

7.3. Limitations and Future research Directions

The first limitation is that some of the criteria would span a range of potential sub-criteria which have not been studied in this research. Future research might provide more detailed criteria and sub-criteria in order to uncover more granular insights. Another limitation is the exploratory nature of the study. The data were obtained from a limited number of experts who work in a specific manufacturing corporation in Iran and may not be well representative of the whole manufacturing industry. As such, readers are cautioned to generalize the findings too far from this research context. As such, future research can use other developing economies, other manufacturing sectors, and even

other economic sectors (i.e., service, government, etc.) in order to validate generalizability and perhaps even add more depth to the proposed model. Obviously, more and broader empirical studies are required. Other methods such as decision-making trial and evaluation laboratory method (DEMATEL) might be employed in future studies, and findings can be compared to the outcome of the current study by taking into account managers' feedback. There are very few methods in the the MCDA literature, such as ISM and DEMATEL, which are able to analyze the interrelationships among multiple criteria. The KNOWWHY method introduced by Neumann [69] could be another interesting method to qualitatively deal with interrelationships among factors in a complex system.

There is a need for more SCSS research to examine stakeholder perspectives. Thus, future research might take into account various stakeholders (investors, employees, communities, customers) from various positions in the supply chain who play key roles in the value-chain. In addition, stakeholder theory can be used to investigate additional interrelationships between key criteria such as rights of community (SSC6) and other stakeholder needs. In any regard, it is clear that SCSS requires more managerial focus and scholarly research, especially from a developing country or emerging economy perspective.

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