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Title: Do human critical success factors matter in adoption of sustainable manufacturing practices? An influential mapping analysis of multi-company perspective

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Keywords: Change management; Human Critical Success Factors (HCSFs); Sustainable Manufacturing (SM); Sustainable HRM; DEMATEL

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Abstract: Sustainable human factors and change management systems have been gaining significant attention at global level for implementation of sustainable practices within organisations. With the rise in environmental degradation, the automotive sector has made efforts to adopt Sustainable Manufacturing (SM) practices to decrease the adverse effects on the environment instigated by emissions. Human Critical Success Factors (HCSFs) may play an important role in adoption of SM but in literature, no study has yet discussed the influence of HCSFs on the adoption of SM practices. The current work is an effort to fill this gap and to analyse the importance of HCSFs in adopting SM practices from a multi-automotive company perspective. In the first phase study, HCSFs were identified from existing literature and an empirical analysis was carried out to finalise identified HCSFs. In the second phase, to understand the influential relationship among these HCSFs, a DEMATEL approach was employed for developing a cause-effect model for each company. The result suggested that 'Green motivation', 'Customer relationship management', 'Management leadership', 'Communication' and 'Strategic alignment' are the highly significant causal HCSFs in efficient adoption of SM practices. The results of the study will help industry practitioners and managers to make strategic plans in the context of SM practices and its relationship with human factors for sustainable business development.

Research Highlights

- Focused on the adoption of Sustainable Manufacturing (SM) practices
- Identified and analysed Human Critical Success Factors (HCSFs) in adoption of SM
- Conducted a two-phased study to build cause-effect model of identified HCSFs
- Presented the real-life applicability by taking data from automotive companies
- Proposed various implications to make strategic plans in the context of SM

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Do human critical success factors matter in adoption of sustainable manufacturing practices? An influential mapping analysis of multi-company perspective

Abstract: Sustainable human factors and change management systems have been gaining significant attention at global level for implementation of sustainable practices within organisations. With the rise in environmental degradation, the automotive sector has made efforts to adopt Sustainable Manufacturing (SM) practices to decrease the adverse effects on the environment instigated by emissions. Human Critical Success Factors (HCSFs) may play an important role in adoption of SM but in literature, no study has yet discussed the influence of HCSFs on the adoption of SM practices. The current work is an effort to fill this gap and to analyse the importance of HCSFs in adopting SM practices from a multi-automotive company perspective. In the first phase study, HCSFs were identified from existing literature and an empirical analysis was carried out to finalise identified HCSFs. In the second phase, to understand the influential relationship among these HCSFs, a DEMATEL approach was employed for developing a cause-effect model for each company. The result suggested that 'Green motivation', 'Customer relationship management', 'Management leadership', 'Communication' and 'Strategic alignment' are the highly significant causal HCSFs in efficient adoption of SM practices. The results of the study will help industry practitioners and managers to make strategic plans in the context of SM practices and its relationship with human factors for sustainable business development.

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1. Introduction

Rapid growth in industrialisation is leading to growing concerns around climate change problems (Tseng et al., 2018). Changing climatic conditions is recognised as crucial for the global economy (Renukappa et al., 2013). Moreover, this trend is likely to intensify further due to an estimated addition of around three billion customers by 2030 at global level (Mangla et al., 2018). Manufacturing organisations are under enormous pressure to investigate environmental aspects along with economic factors due to the increasing rate of carbon emissions (Hajilary et al., 2018). Therefore, with this rapid increase in natural resource consumption, greenhouse gas emissions, degradation of soil and water etc. sustainability in manufacturing has become a major point of concern (Jabbour et al., 2019; Kumar et al., 2019).

Sustainable organisations aim to achieve lower production costs along with minimisation of harmful effects of their business operations on the environment (Senthilkumaran et al., 2001; Srivastava, 2007; Hajilary et al., 2018). Moreover, due to pressure instilled by the government in the form of statutory requirements, organisations are compelled to adopt green systems (Georgiadis and Vlachos, 2004; Jabbour et al., 2019). For instance, many companies have adopted ISO 140001 (Zhu and Sarkis, 2006). Additionally, positive linkage between business performance and green management practices also drives organisations to adopt green practices and contribute towards reducing carbon emissions by decreasing their carbon footprints (Zhu et al., 2007; Zhu et al., 2013; Abdul-Rashid et al., 2017).

Nowadays, business organisations are viewing Sustainable Manufacturing (SM) practices as a strategic initiative. But there are various challenges in implementing SM practices at organisational level (Jabbour et al., 2019) such as economic, social and technological factors. A study conducted by Sindhwani et al. (2019) has described the barriers in adopting green, lean and agile manufacturing practices. Human Critical Success Factors (HCSFs) are observed to be as equally important as other factors such as technology and supply chain initiatives to execute SM practices (Daily and Huang, 2001; de Sousa Jabbour et al., 2018; Kumar et al., 2019). Masri and Jarron (2017) also observed that green HR practices impact organisations' environmental performance. Jackson et al. (2011) highlighted the significance of employee support in enabling an organisation to take environmental management initiatives. However, this area of study started to gain importance after some remarkable research highlighted the status of HR practices (Jabbour and de Sousa Jabbour, 2016). Dumont et al. (2017) also observed that green HRM practices impact on employee behaviour directly as well as indirectly. Similarly, in a more recent study conducted by Anthony (2019), employee behaviour is observed to be crucial for the environmental performance of organisations.

Dubey et al. (2017) have indicated that human-related dimensions need to be explored further in order to comprehend their relevance for adoption of green practices. To the best of our knowledge, no study has attempted to model the human related factors in the context of SM practices and hence, a gap exists in current literature. In a more recent study, Prakash et al. (2019) indicated that the Indian economy provides a crucial setting for conducting research that focuses upon environmental aspects of business organisations as it is amongst the fastest growing economies around the globe; to keep up this status, economic activities need to be boosted further through innovation. They also indicated that carbon emissions by India are likely to exert a significant influence on global warming. Yet, environment related studies in the Indian context are very limited. Additionally, India has become an international player in the automobile market. The contribution of this sector to the Gross Domestic Product (GDP) is increasing (The Economic Times, 2017). With growing industrialisation, there are certain factors, such as carbon emissions, which have a negative impact on public health. The Government of India (GoI) has realised this and has picked up the pace in reducing emissions by creating a standard road map for cleaner vehicles and fuels. For instance, the government has announced January 1, 2020 as a deadline to adopt Bharat Stage IV emission norms; subsequently Bharat Stage VI emission norms will place even stricter restrictions on emissions. Therefore, SM practices become even more critical in the context of this industry. Consequently, the current study attempts to explore and model the key HCSFs and their significance in adopting SM practices. The study intends to attain the following objectives:

i) To identify key HCSFs for adoption of SM practices
ii) To assess the listed SM oriented HCSFs by identifying their inter-relationships in adoption of SM practices
iii) To outline key practical implications and strategies that may facilitate decision makers to achieve a system of SM practices.

The primary aim of the study is to identify the HCSFs related to SM practices and to identify their inter-relationships. In this work, a DEMATEL technique approach for identifying inter-relationships of HCSFs in adoption of SM practices is used. DEMATEL technique (Gabus and Fontela, 1972) helps in evaluating the inter-relationships between HCSFs with the help of an inter-relationship digraph (Hsu et al., 2013; Mangla et al., 2016; Li and Mathiyazhagan, 2018). The case example of multiple Indian automobile companies shows the real-world applicability of the proposed model. The study aims to provide practical implications and strategies to implement SM practices in the workplace.

The entire work of this study is organised into six sections. Section 2 outlines the relevant literature in the area. This is followed by research methodology in Section 3. Analysis and related results are presented in Section 4. Findings are discussed with their practical and theoretical implications in Section 5. Finally, conclusions and future research directions are provided in the last section.

2. Literature Review

There is a rising interest in executing the pro-environmental manufacturing processes across industries to advance those ecological standards which enhance sustainability (Gholami et al., 2013; Strandberg and Kjellström, 2019). Organisations are under incessant pressure to implement responsible practices across all layers of their supply chain (Mathiyazhagan et al., 2013) in order to develop excellence in sustainable management (Dubey et al., 2017). SM brings sustainability into an organisation's business operations. The human dimensions, such as employee motivation and leadership, also hold relevance along with operational variables (e.g. green supply chain, green processes) for implementing SM practices (Nejati et al., 2017). Ramus (2001) identified employee motivation to eco-innovate through support from top management as critical for organisations that are aiming to improve their environmental sustainability. Similarly, Uusi-Rauva and Nurkka (2010) and Massoud (2011) also point towards the relevance of human factors in the context of achieving environmental sustainability. Therefore, policies and procedures must be formulated in a way which provides support to the employees for transforming organisational operations to attain environmental sustainability.

Sustainable initiatives are becoming a crucial part of strategic planning in manufacturing organisations (Gholami et al., 2013). Jabbour et al. (2014) analysed the theoretical model proposed by Jabbour and Santos (2008) to explore the relationship between human resource dimensions and environmental management. It was found that organisations that consider human resource practices as important and understand their role in an environmental management system tend to make continuous improvement in their environmental performance. Sangwan and Choudhary (2018) conducted a study on benchmarking green manufacturing industries on green practices. This found that the success of green manufacturing practices depends greatly on top management commitment and design of the products.

The automotive sector was found to be one of the high performing sectors in adopting green practices. Kumar et al. (2019) investigated how human factors are playing a very important role in adoption of GSCM practices. Because of increasing climate threats, organisations are forced to link human resource practices with environmental issues to improve organisational sustainability (Zaid et al., 2018). Guerci et al., (2016) highlighted the relationship between green HR practices and environmental performance as a response to stakeholder pressures. A study conducted by Nejati et al. (2017) reported a significant and positive impact of Green Human Resource Management (GHRM) and Green Supply Chain Management (GSCM), where the role of change management was explored. Findings suggested that resistance to change has a moderating effect on the GHRM and GSCM relationship and tends to hamper the development of a sustainable corporate culture. A number of other studies also describe the association between green HR practices and environmental sustainability (Cherian and Jacob, 2012; Opatha and Arulrajah, 2014; Mittal and Sangwan, 2014; Renwick et al., 2016; Jabbour et al., 2019). The current literature also notes the significance of human resource practices of an organisation in the context of its ability to innovate (Beugelsdijk, 2008); this indicates the crucial role played by its people to develop and adopt environmentally friendly products and processes. These studies, however, did not discuss the role of human factors in adoption of SM. As far back as 1987, Schuler and Jackson (1987) strongly recommended aligning human resource practices with the organisational goal of environmental protection. In the above context, human critical success factors are identified below.

2.1 Human Critical Success Factors (HCSFs)

A Systematic Literature Review (SLR) approach was followed to identify those HSCFs that contribute to sustainable manufacturing practices. Databases such as Science Direct, Emerald, Scopus, Taylor & Francis, DOAJ, EBSCO, Wiley and Inderscience were used. Google Scholar was used to check references and citations and to apply inclusion and exclusion criteria for papers. The following journals, and others, were explored to review relevant literature; Journal of Operations Management; International Journal of Operations and Production Management; International Journal of Production Economics; Journal of Cleaner Production; European Journal of Operational Research; International Journal of Production Research; Production, Planning and Control, Supply Chain Management; An International Journal, Benchmarking; An International Journal, Technological Forecasting and Social Change. Some other journals were examined, depending upon the suitability of the articles. The main intent was to explore the HCSFs in adoption of SM practices. Hence, multiple searches were conducted, and the papers were filtered accordingly i.e. using soft dimensions. The following approach was followed for inclusion and exclusion of research articles from all available literature in the field.

1. Our search was conducted on broad-based terms and strings associated with the field of SM and GSCM/SSCM; we explored the same search strings further in Google Scholar. Research papers were identified from the above-mentioned databases using

keywords such as "human dimensions", "green manufacturing", "sustainability", "environmental sustainability", "sustainable manufacturing practices", "leadership", "teamwork", "organisational culture and sustainable manufacturing" and "human resource management".

2. All relevant articles were listed.
3. In the next step, indexing of journals for selected papers (from the previous step) was verified. The journal listing either in ABDC or ABS classification was ensured.

The corresponding papers were then downloaded, reviewed and analysed. Initially, 127 papers were considered, out of which 46 were chosen to meet the criteria of this study. The identified HCSFs have been explained as follows.

2.1.1 Mutual trust and respect

Due to lack of mutual trust between management and employees, employees may feel that management does not care about them while management may feel that employees lack commitment to their work. Such situations will hamper an organisation's ability to adopt sustainable practices (Yauch and Steudel, 2002). Moreover, trust is identified as an important variable in the context of adopting SM practices (Liker and Choi, 2004; Kumar et al., 2019). Therefore, this paper proposes the existence of mutual trust and respect as a critical success factor for an organisation in implementing SM practices (Sindhwani et al., 2019).

2.1.2 Strategic alignment

Strategic alignment is the fit between an organisation's practices and goals which it aspires to achieve (Avison et al., 2004). The Information Technology (IT) expertise of an organisation is used to get efficient results (Bergeron et al., 2004). Organisations need to be ready for the competition in the market by aligning technological expertise. Green IT is a planned technology whose basic role is to decrease carbon footprints (Kumar et al., 2019). A study conducted by Jabbour et al. (2018) explains the role of strategic alignment - an important tool for developing Industry 4.0 technologies to assist SM decisions. Organisations with strategies that align support to enable full integration of technology and their sustainable goals will be more successful.

2.1.3 Green training

Training is a significant activity for any organisation. Green training is necessary as it identifies those employees competent to use environmentally sustainable practices (Govindarjulu and Daily, 2004). Training provides expertise to face challenges related to our degrading environment. Green training is critical for employee environmental consciousness (Jabbour and de Sousa Jabbour, 2016; Teixeira et al., 2016) and also for adoption of the latest ecological practices (Sarkis et al., 2011). Green training programs can also boost employee motivation and encourage innovation in this regard **(**Massoud et al., 2011).

2.1.4 Employee involvement

Implementation of SM practices in an organisation largely depends upon the involvement of its employees as environmental management is largely driven by the employees themselves (Dahlmann et al., 2008). Hanna et al. (2000) suggested that incessant development of production managers by involving members of the workforce can establish a significant foundation for environmental enhancement. Hence, employee involvement plays an important part in adoption of SM (Kumar et al., 2019). In a study conducted by Dubey et al. (2017) an attempt was made to link the importance of employee involvement with sustainable supply chain practices; this emerged as one of the important drivers of green supply chain network.

2.1.5 Teamwork

Teamwork helps in creating a group of people with various levels of intelligence, diverse information and skills to work jointly, resolve multi-faceted problems and to attain a shared goal. Achieving sustainability is one such goal that organisations are targeting. Therefore, green teams are now being formed in organisations to implement pro-environmental processes in the workplace (Jabbour and Santos, 2008; Jabbour et al., 2019).

2.1.6 Organisational Culture

Organisational culture is crucial in a business. A list of basic conventions developed to provide organisations with inflexible administrative structures will find it difficult to manage change compared to organisations with dynamic structures. Culture builds employee motivation to use sustainable practices (Schein, 1984; Govindarjulu and Daily, 2004). The culture of an organisation acts as a catalyst in building novel organisational methods for SM (Jabbour and de Sousa Jabbour, 2016).

2.1.7 Communication

Implementation of sustainable practices in the workplace requires open communication channels. Communication involves knowledge sharing and skill building amongst group members (Ngai et al., 2008). Communication helps in creating a collective work setting (Prahinski and Benton, 2004). Low employee involvement in building sustainability is a result of closed communication (Rehman et al., 2016; Jabbour et al., 2019).

2.1.8 Employee Commitment

Employee commitment plays an important role in adapting SM practices (Meyerson and Kline, 2008). High levels of employee commitment prove to be an asset of any organisation. Committed employees feel more satisfied with their jobs, carry greater motivation to work, take better decisions and become better performers at work (Kumar et al., 2019). Therefore, employee commitment will impact on implementation of SM practices in an organisation (Govindan et al., 2015; Gandhi et al., 2018).

2.1.9 Green motivation

Green motivation is imperative to encourage people for successful execution of any strategy (Olugu et al., 2011) including SM practices. Renwick et al. (2013) also supported the crucial significance of employee motivation for adopting eco-friendly processes and systems in an organisation.

2.1.10 Green innovation

Green innovation is stated as management's capacity to implement and introduce new ideas, products and processes which minimise the harmful impact of its operations on the environment (Adner, 2006; Muduli et al., 2013). Green innovation may lead to saving energy, pollution preclusion, efficient waste management, green product strategies and environmental management; all are crucial elements in the context of putting SM systems in place (Rennings, 2000; Chen, 2008; de Sousa Jabbour et al., 2018).

2.1.11 Management leadership

Organisations must design environmental policies which state objectives of adopting green practices and to strengthen the commitment towards the same (Welford, 1994). Management leadership has an important role to play in this regard. Leadership style affects employee morale and can motivate the workforce to adapt green practices (Elenkov and Manev, 2005).

Leaders can trigger the implementation of SM practices in multiple ways. This is necessary to create a sustainable workplace (Sindhwani et al., 2019). Muduli (2013) also identified top management support as the crucial behavioural factor that drives other factors to implement sustainability in the workplace.

2.1.12 Customer Relationship Management (CRM)

It is vital that customers not only accept, but also value, an organisation's efforts to protect the environment by purchasing their products. CRM helps in ensuring the endurance of an organisation's business operations, as it can promote the differences in the organisation from its competitors on ecological grounds (Ruhwinkel, 2013). CRM is a tool to build strategic and positive relationships with customers and suppliers; this is important for implementing SM (Maskell, 2001; Kumar et al., 2019).

2.1.13 Change management

The phrase 'Change management' was first coined in the 1940s. It gained recognition from Lewin's model (1947) which states that the forces that shake the symmetry state need to be in place to implement change (Brightman and Moran, 2001). Oakland and Tanner (2007) presented the cyclic context stating that there are two cycles i.e. planning change and implementing change. Changes can be more easily adopted if they are linked to environmental values (Kurkland and Zell, 2011; de Sousa Jabbour et al., 2018). Readiness for change aids in implementing SM process without any incongruity. Resistance to change will slow down the process and create a negative impact on implementing sustainable practices (Nejati et al., 2017).

After selecting HCSFs from the literature review, these identified HCSFs were presented to experts from the sector to finalise the same. The details are provided in Section 4. A questionnaire was given to the same experts to explore the inter-relationships between the factors. There is a dearth of studies on HCSFs and SM practices (Ruhwinkel, 2013) – this research will help to fill the gap.

2.2 Research Gaps and Problem Definition

The reasons why sustainability started gaining importance are twofold. Firstly, with the increase in emissions, carbon footprint and environmental degradation became important areas for business organisations to take account of their impact on society. Secondly, business organisations were forced to adopt sustainable practices due to the introduction of legislative requirements (Beder and Beder, 2002). However, in sustainability research, human-related factors were never given priority as technological factors remained as the main focus (Gunasekaran et al., 2014; Kumar et al., 2019). Therefore, we have identified the following gaps to explain the rationale behind this study.

Gap1: India is a growing nation and aspires to become fully developed soon; therefore, commercial activities are developing at an increasing rate. The automobile industry in India is one area that has seen a rapid growth in the last decade (IBEF, 2018), adapting SM practices to build a sustainable culture into their business ecosystem. Critical success factors must be effectively managed for business organisations to achieve their goals and to find a better fit between plans and actions (Wijen, 2014). Hence, it is necessary for the industry managers to identify and appreciate the critical factors involved if they are to achieve implementation of sustainability practices.

Gap 2: To gauge business success, organisations have always used an array of financial indicators (Engida et al., 2018). It has been recently observed that some business organisations such as 3M, Shell, Amoco and Interface have started using Environmental, Health and Safety (EHS) as well as social indicators as per Triple Bottom Line (TBL) framework (Huang and Badurdeen, 2018). A survey of fifty corporate sustainability reports indicates that organisations are unable to cater for major issues relating to environmental and social aspects (GreenBiz Report, 2000; Veleva and Ellenbecker, 2001). Hence, there is a strong need for business organisations to identify ways to become environmentally and socially sustainable while maintaining a strong financial performance (Jabbour et al., 2019). Moreover, due to the changing regulatory framework regarding emission norms, it becomes more crucial for this industry to show improvement in the parameter of its environmental and social performances.

Gap 3: Factors related to human resource and behavioural aspects have been largely ignored in sustainability research (Tokar, 2010). A profusion of studies has been conducted to explore the impact of hard dimensions on SM. Organisations have tended to ignore softer aspects and consider only hard dimensions while planning to implement SM practices (Masri and Jaaron, 2017; de Sousa Jabbour et al., 2018; Zaid et al., 2018). That is why the proportion of studies conducted to explore softer dimensions for adoption of green/sustainable practices remains very small in the current literature concerning environment sustainability (Dubey et al., 2017).

Gap 4: Knowing the behavioural aspects about SM is not sufficient. It is imperative to unveil the interplay of these dimensions for charting out and executing a plan of action to achieve the successful implementation of the desired strategy (Kumar et al., 2019). However, there is no study available that covers the modelling of people related critical success factors of SM practices.

3. Research Methodology

The main objective of this study is to determine the influential strength of HCSFs in adoption of SM in the context of a multi-company perspective. Thus, the methodology of this research is twofold; in the first stage, HCSFs for SM were identified from a review of existing literature and field experts' opinions. In the second stage, the causal inter-relationships among the human factors are analysed using DEMATEL method. Compared to other multi-criteria decision methods such as AHP, TOPSIS and SAW, DEMATEL is one of the widely used multi-criteria decision methods with various advantages; 1) this method analyses the causal inter-relationships among factors 2) with help of this method, the influential weight of each factor is easily calculated 3) it also divides all the factors into cause-effect groups (Xia et al., 2015; Su et al., 2017; Liu et al., 2018). This further helps practitioners to understand the influential strength of HCSFs in adopting SM concepts and sustainable business growth. Methodology of the study is presented in Figure 1.

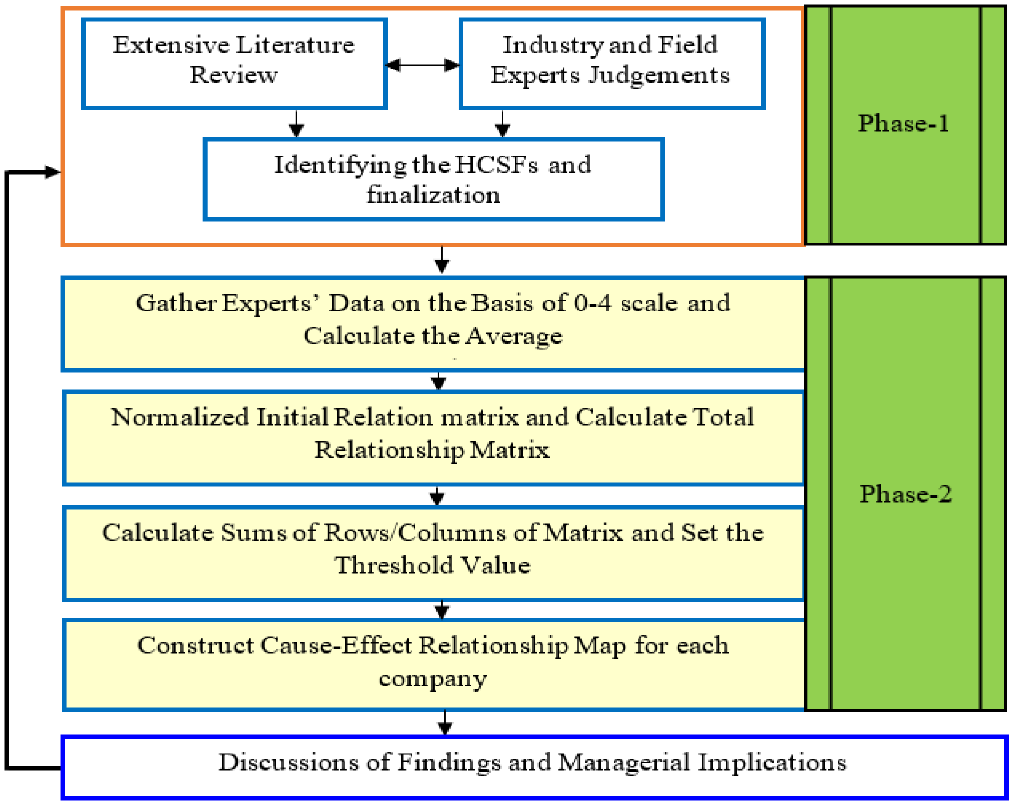

Figure 1: Methodology of the study

3.1 DEMATEL

DEMATEL is a widely used method to build a cause-effect model of selected factors (Xia et al., 2015; Su et al., 2017; Kumar et al., 2019). This method was originally developed by Gabus and Fontela (1972). DEMATEL technique has been widely used in business in decision making situations such as green/sustainable SCM (Lin, 2013; Su et al., 2017; Kumar et al., 2019), remanufacturers (Xia et al., 2015), supplier selection (Liu et al., 2018) and sustainable recycling partners (Zhou et al., 2018). The steps for DEMATEL technique are outlined below.

Step 1: To outline the factors/variables for the research, the potential factors need to be recognised.

Step 2: To frame the direct relation matrix, the respondents were asked to rate the impact based on 0-4 scale (i.e. '0' means no influence and 4 means very high influence); the average direct relation matrix (*A*) is formed using Eq. (1) for all experts' (*p*) opinions

$$A = a_{ij} = \frac{1}{p}\sum_{K=1}^{p} x_{ij}^{k}\; i,j \; = 1,\dots n \tag{1}$$

Step 3: To compute the normalisation matrix by applying Eqs. (2-3):

$$U = k \times A, \tag{2}$$

$$k = \min\left(\frac{1}{\max_i\left(\sum_{i=1}^{n} a_{ij}\right)}, \frac{1}{\max_j\left(\sum_{j=1}^{n} a_{ij}\right)}\right), i, j = 1, 2, \ldots..n. \tag{3}$$

Step 4: To compute the total relation matrix (*T*) using Eq. (4):

$$T = U(I - U)^{-1} \tag{4}$$

The sum of rows and columns of matrix (*T*) are obtained by Eqs. (5-6) as below

$$r = [r_i]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} \tag{5}$$

$$c = [c_i]_{1\times n} = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} \tag{6}$$

where t_{ij} is total relation matrix, for $i, j = 1, 2, \ldots., n$.

Step 5: In order to obtain the digraph and to eliminate minor effects Eq. (7) is used.

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left[t_{ij}\right]}{N} \qquad (7)$$

where N represents all elements in matrix T. The values greater than α are considered and plotted on the digraph.

3.2 An Analysis of multi-companies' perspective

Case based research is very beneficial in situations where a limited amount of research is available (Govindan et al., 2017) and very significant in understanding real-life practice (Yin, 2009). Case based research also enables face-to-face communications and interactions with experts, as a result of which, an in-depth insight can be attained about the real-world applicability (Subramanian et al., 2014; Govindan et al., 2017).

This study is based on the Indian automobile industry; this industry contributes 9.4% to India's GDP. The auto component industry in India is expected to be the third largest in the world by 2025. There is a segregation of this industry into automobile and ancillary units (IBEF, 2018). Based on an increase in production forecast by 2020, SM practices become more crucial as industries aim to reduce their carbon footprints. Therefore, we feel that there is a need to carry out a sectoral analysis. In view of the above, the present research examines three automobile companies to understand HCSFs in adoption of SM practices in a real-world scenario with the help of an influential mapping analysis. Case companies' profiles are provided below and details regarding data collection are provided in Section 4.

3.2.1 Case company profile

Company A, established in 1981, is the leading four-wheeler automobile manufacturer in India. Currently, its total assets are valued at INR 593,701 million with a workforce of 40,000 employees. Predominantly, it manufactures and sells passenger vehicles in the four-wheeler category. It is a globally recognised company and ranked as one of the major organisations in India. It is committed to contributing towards protection of the environment.

Company B is a top two-wheeler manufacturer in India; it came into existence in 1984. It has a strong asset base of INR 167,388 million and has 5842 employees. Company B is known for rolling out the most fuel-efficient vehicles in the industry and for its commitment towards protecting the environment.

Company C is an ancillary company which supplies parts to automobile manufacturers in India. It was founded in 2006 and employs 1,936 people. This company employs the best technology and expertise in the sector to implement environmentally sustainable practices. It is actively involved in numerous CSR activities such as road safety, skills development, health check-ups and tree plantations; there is a clear commitment to ensuring a clean environment for future generations.

4. Analysis and Results

This section presents the cause-effect analysis of 13 HCSFs identified from literature and experts' opinions based on a multi-company perspective along with the corresponding diagraphs.

A detailed review of relevant literature in environmental sustainability was carried out to identify the best HCSFs for organisations to implement SM. The field experts were contacted and requested to assess the relevance of the literature driven HCSFs. A questionnaire was prepared, with experts asked to specify the relevance of each HCSF in implementing SM practices on a binary scale ("1" for relevant and "0" for irrelevant). The experts were also requested and allowed to make any addition to the existing list of HCSFs based on their practical exposure and experience in the field. The sample questionnaire is provided in Appendix-A. All experts indicated consensus for the relevance of all 13literature driven HCSFs (refer to Table 1).

Another questionnaire was then developed to collect data from the selected experts with a view to conducting DEMATEL analysis. A comprehensive process was followed to collect data from industry experts through convenience sampling, taking into account that group size affects efficiency of group decision-making. The size of a decision-making group should be roughly 5–50 (Gumus, 2009) and 5–20 experts should participate in the validation (Anderson et al., 2001). To identify the most critical factors, fifteen experts from different companies were selected. The average work experience of the experts in the sample stands at 12.3 years with selected experts representing different areas of manufacturing activity. Details of experts' characteristics are presented in Table 1.

Table 1: Experts' characteristic details and major responsibilities

Experts	Education	Experience (in years)	Key responsibilities	Job Title	Company
1	B. Tech,	10	Production planning and	Assistant	A

	MBA		responsible for overall channel distribution; training employees on use of sustainable practices for manufacturing and problem solving	General Manager-Operations	
2	B. Tech.	12	Business excellence, strategy building, production planning and forecasting	Service Operations Manager	A
3	B. Tech, MBA	11	Planning, monitoring, initiating and reporting the challenges in implementing systems on floor, environmental policy implementation, escalation management	Escalation Manager	A
4	B. Tech	10	Running processes efficiently and organising the production schedule, waste management	Material Planner	A
5	B. Tech, MBA	12	Reviewing, monitoring and checking quality of the spare parts produced, waste analysis and management, ensure product quality conformity and approval by customer	Customer Quality Engineer	A
6	B.Tech, MBA	12	Deducing precise methods for manufacturing, being cost effective and environmentally friendly, reducing emission percentage	General Manager-Lean & Manufacturing Excellence	B
7	B.Tech, MBA	11	Running manufacturing processes to meet deadlines, negotiation, designing environmental practices and maintaining a track of carbon emissions	Head-Operations	B
8	B. Tech.	12	Production quality check, competitor analysis and maintaining quality records	Quality Assurance Analyst	B
9	B.Sc,	13	Maintaining the production	Assistant	B

	MBA		schedule and monitoring the manufactured product quality, project management, organising inspections under QAC	Project Manager	
10	B. Tech.	12	Devising objectives for the production team, calculating productivity and efficiency	Production Manager	B
11	B. Tech., MBA	15	Charting out the use of environmentally friendly practices, employee training on sustainability, examining pro environmental behaviour	Manager-HR	C
12	MBA	10	Driving the initiatives of TPM, Six Sigma, Malcolm Baldrige Business Excellence model, learning and development, TEI, ISO	Chief, Business Excellence	C
13	B.Tech, MBA	17	Establishing communication between different lines/assemblies and validating quality production, maintaining CSR records, optimisation of quality management tools, handling floor operations	Section Head - Operation Excellence	C
14	B. Tech.	13	Checking and maintaining the inventory management, use of Kaizen	Assistant Manager-Quality Assurance	C
15	B. Tech.	14	Preparing the production schedule for total quality management implementation	Sub-Section Head-Quality Planning	C

4.1 Cause-Effect Analysis of HCSFs

Based on procedural steps of DEMATEL, the average direct relation matrix (*A*) is formed using Eq. (1) for all experts' opinions of companies A, B and C. Using Eq. (2) and Eq. (3), the normalisation matrixes are calculated for the three companies as shown in Appendix-B. By using Eq. (4) the total relation matrixes are computed for the companies as shown in

Appendix-C. The sum total of rows and columns of Total Relation Matrix (*T*) for all companies are compiled by Eqs. (5-6) as mentioned in Table 2, Table 3 and Table 4.

Table 2: Total relation matrix– Company A

HCSFs	R sum	C sum	R+C	R-C	Cause/Effect
F1	8.1345	8.8287	16.9633	-0.6942	Effect
F2	8.5899	8.3694	16.9594	0.2205	Cause
F3	8.3709	8.9066	17.2775	-0.5356	Effect
F4	8.6881	8.9749	17.6630	-0.2869	Effect
F5	7.7968	9.0956	16.8924	-1.2987	Effect
F6	9.4317	9.0676	18.4993	0.3641	Cause
F7	9.2276	8.3403	17.5680	0.8873	Cause
F8	8.5239	8.0822	16.6061	0.4416	Cause
F9	8.8806	7.5814	16.4620	1.2991	Cause
F10	8.7231	8.8729	17.5960	-0.1498	Effect
F11	8.1685	7.9624	16.1309	0.2060	Cause
F12	8.4453	7.9235	16.3688	0.5217	Cause
F13	7.5112	8.4865	15.9977	-0.9753	Effect

As per analysis as shown in Table 2, in total seven HCSFs are in the cause group with the remainder in the effect group. The cause group HCSFs influence others; the effect group are influenced by others. Among all HCSFs, 'Green motivation (F9)' has the highest influence with a value of 1.2991.

Table 3: Total relation matrix -Company B

HCSFs	R sum	C sum	R+C	R-C	Cause/Effect
F1	10.9864	11.1691	22.1556	-0.1827	Effect
F2	12.2109	11.4516	23.6625	0.7594	Cause
F3	11.1330	11.6271	22.7601	-0.4940	Effect
F4	11.3099	12.0528	23.3627	-0.7428	Effect
F5	10.5434	10.9209	21.4643	-0.3775	Effect
F6	11.7347	12.0089	23.7436	-0.2742	Effect
F7	12.2210	10.9929	23.2138	1.2281	Cause
F8	10.8705	10.0829	20.9534	0.7877	Cause
F9	11.9714	11.4130	23.3844	0.5584	Cause
F10	10.8842	11.2016	22.0858	-0.3175	Effect
F11	11.7944	11.4821	23.2765	0.3123	Cause
F12	11.1401	9.7544	20.8945	1.3857	Cause
F13	8.3330	9.4368	17.7697	-1.1038	Effect

As per analysis of company B, Table 3 shows that six HCSFs are in the cause group with the remainder in the effect group. ‘Customer relationship management (F12)’ is identified as the most crucial cause-group HCSF followed by ‘Communication (F7)’.

Table 4: Total relation matrix -Company C

HCSFs	R sum	C sum	R+C	R-C	Cause/Effect
F1	5.0289	6.4312	11.4602	-1.4023	Effect
F2	5.8640	5.4619	11.3259	0.4021	Cause
F3	5.2616	5.6792	10.9407	-0.4176	Effect
F4	5.2786	5.9725	11.2512	-0.6939	Effect
F5	5.6038	6.5700	12.1738	-0.9662	Effect
F6	5.6802	6.4800	12.1602	-0.7999	Effect
F7	6.2820	5.9104	12.1924	0.3716	Cause
F8	6.0487	6.1716	12.2203	-0.1229	Effect
F9	6.1299	5.5610	11.6909	0.5688	Cause
F10	6.3410	5.5717	11.9127	0.7694	Cause
F11	6.6880	5.9394	12.6274	0.7486	Cause
F12	5.6664	4.6458	10.3122	1.0206	Cause
F13	4.2670	5.6419	9.9089	-1.3749	Effect

As per analysis as shown in Table 4, in total six HCSFs are in the cause group; the remainder are in the effect group. Among all HCSFs, ‘Customer relationship management (F12)’is the foremost significant cause-group HCSF with a value of 1.0206.

To avoid minor impact, the threshold value (α) is computed by using Eq. (7) for each company. The α value for company A is given below.

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left[t_{ij}\right]}{N} = 0.6538$$

Those values in the total relationship matrix (as shown in Appendix C) are > α (0.6538) and signified by ‘1’ in Table 5.

Table 5: Inter-relationship among HCSFs – Company A

HCSFs	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13
F1	0	0	1	1	1	1	0	0	0	1	0	0	0
F2	1	0	1	1	1	1	1	0	0	1	0	0	1
F3	1	0	0	1	1	1	0	0	0	1	0	0	0
F4	1	0	1	0	1	1	1	0	0	1	0	0	1
F5	0	0	0	0	0	1	0	0	0	0	0	0	0
F6	1	1	1	1	1	1	1	1	1	1	1	1	1
F7	1	1	1	1	1	1	0	1	0	1	1	1	1

F8	1	1	1	1	1	1	1	0	0	1	0	0	1
F9	1	1	1	1	1	1	1	1	0	1	1	1	1
F10	1	1	1	1	1	1	1	0	0	0	0	0	1
F11	0	0	1	1	1	1	0	0	0	1	0	0	0
F12	1	0	1	1	1	1	0	0	0	1	0	0	0
F13	0	0	0	0	0	0	0	0	0	0	0	0	0

The values in Table 5 are used to build the inter-relationship digraph and are presented in Figure 2.

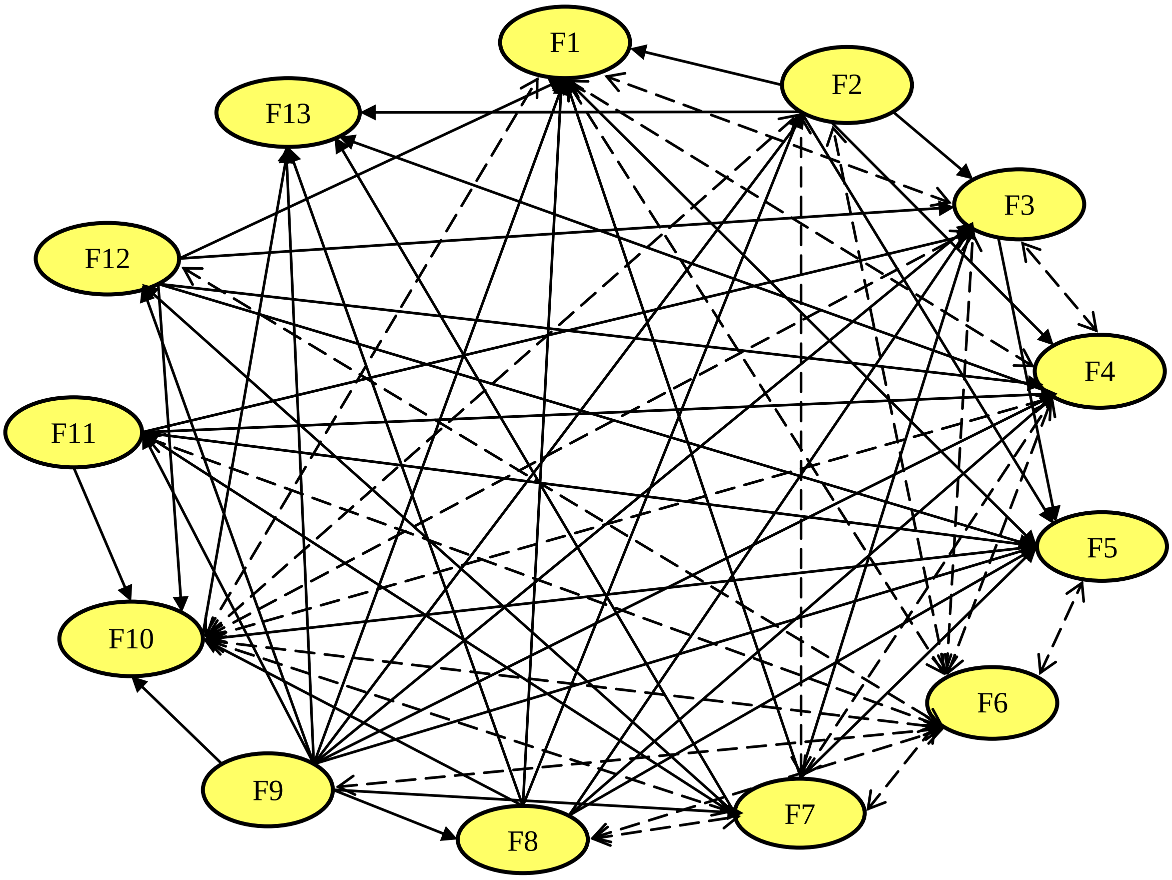

Figure 2: Inter-relationship digraph among HCSFs – Company A

In Figure 2, solid lines show the single relationship and dotted lines show the mutual relationship. The inter-relationship digraph presents the picture of relations among the HCSFs. As per the inter-relationship digraph, 'Green motivation (F9)' has the maximum relationship amongst all other HCSFs; 'Organisational culture (F6)' has maximum mutual relationship with all HCSFs for company A.

By using Eq. (7), the α value for company B is calculated as 0.8678. Values greater than the α value are used to build the influence network relationship map; these values have been given '1' in Table 6.

Table 6: Inter-relationship among HCSFs - Company B

HCSFs	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13
F1	0	1	1	1	0	1	0	1	0	0	0	0	0
F2	1	0	1	1	1	1	1	1	1	1	1	1	0
F3	0	1	0	1	0	1	0	1	1	0	1	0	0
F4	0	1	1	0	0	1	0	1	1	1	1	0	0
F5	0	0	0	0	0	1	0	0	0	0	0	0	0
F6	1	1	1	1	1	0	1	1	1	1	1	1	0
F7	1	1	1	1	1	1	0	1	1	1	1	1	0
F8	0	0	0	1	0	1	0	0	0	0	0	0	0
F9	1	1	1	1	1	1	1	1	0	1	1	1	0
F10	0	0	1	1	0	1	0	1	0	0	0	0	0
F11	1	1	1	1	1	1	1	1	1	1	0	1	0
F12	0	0	0	0	0	0	0	0	0	0	0	0	0
F13	1	1	1	1	0	1	0	1	1	0	1	1	0

The corresponding inter-relationship digraph is presented in Figure 3.

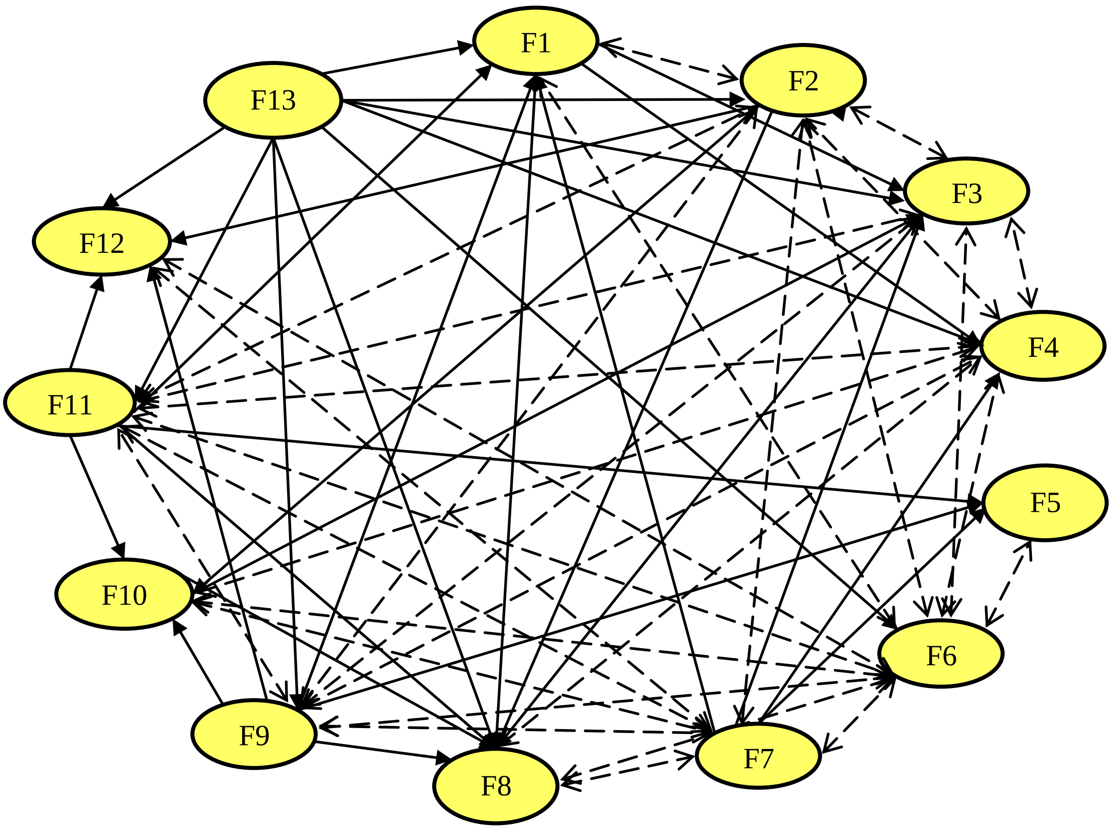

Figure 3: Inter-relationship digraph among HCSFs – Company B

For company B, as per digraph shown in Figure 3, again the HCSF 'Organisational culture (F6)' has maximum mutual relationship with all HCSFs. Again, by using Eq. (7), the α value for company C is 0.4414. Those values greater than the α value are used to build the influence network relationship map; these values have been given ‘1’ in Table 7.

Table 7: Inter-relationship among HCSFs - Company C

HCSFs	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13
F1	0	0	0	0	1	1	1	1	0	0	1	0	0
F2	0	0	0	1	1	1	1	1	0	0	1	0	0
F3	0	0	0	1	1	1	1	1	0	1	1	0	0
F4	0	0	0	0	1	1	1	1	0	0	0	0	0
F5	0	0	0	1	0	1	1	1	0	0	1	0	0
F6	0	0	0	1	1	0	1	1	0	0	1	0	1
F7	0	0	0	1	1	1	0	1	1	1	1	0	1
F8	0	1	1	1	1	1	1	0	1	0	1	0	1
F9	0	1	0	1	1	1	1	1	0	1	1	0	1
F10	0	1	1	1	1	1	1	1	1	0	1	0	1
F11	1	1	1	1	1	1	1	1	1	1	0	0	1
F12	0	0	0	1	1	1	1	1	0	0	1	0	0
F13	0	0	0	0	0	0	0	0	0	0	0	0	0

The corresponding inter-relationship digraph is presented in Figure 4.

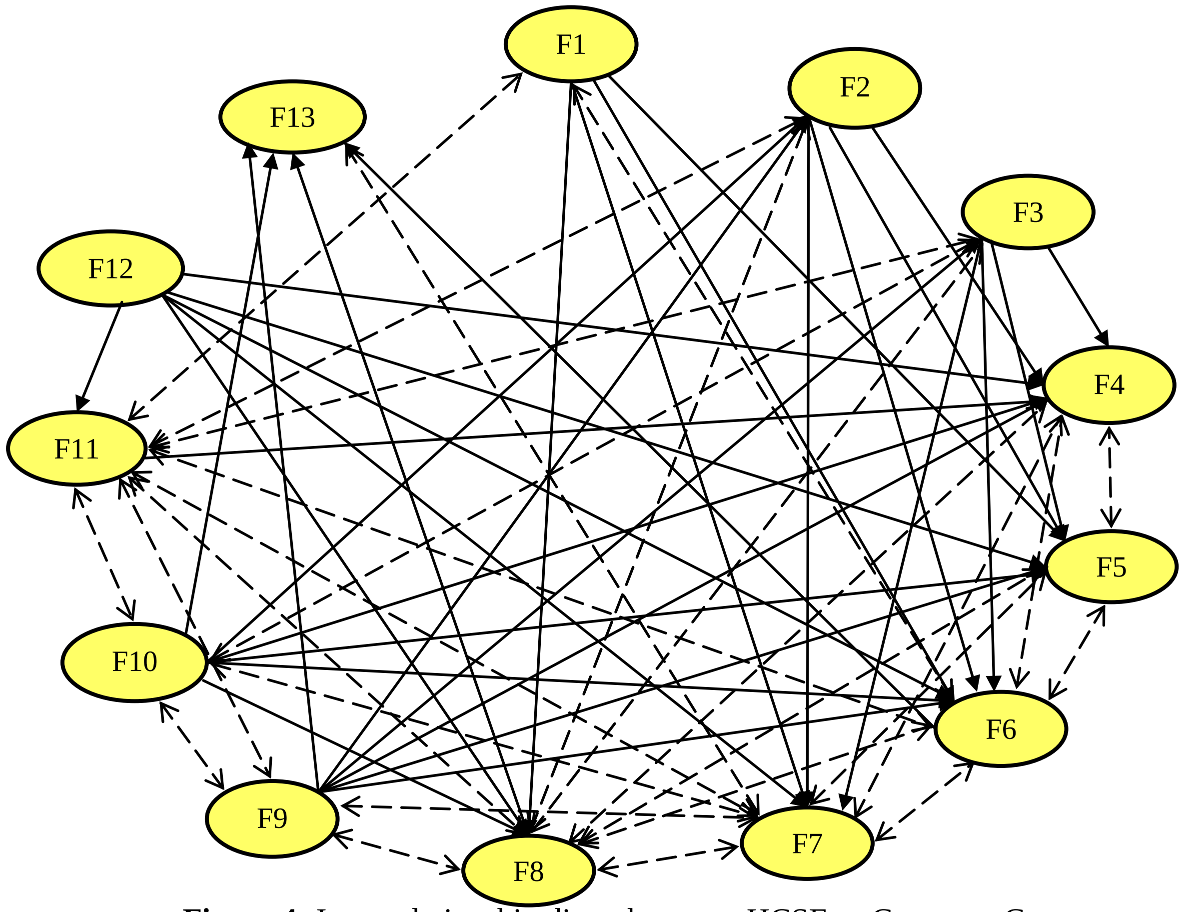

Figure 4: Inter-relationship digraph among HCSFs – Company C

For company C, as per digraph shown in Figure 3, again the factor 'Management leadership (F11)' has maximum mutual relationship with all HSCFs except 'Employee involvement (F4)'.

5. Findings and Discussion

For company A, seven HSCFs have been identified in the "cause-group" category. 'Green motivation (F9)' is found to be the most important cause-group factor as it has highest (r-c) value; it also influences all of the remaining twelve HCSFs. 'Communication (F7)' emerges as the second most crucial factor in the cause group followed by 'Customer relationship management (F12)' and 'Employee commitment (F8)'. 'Organisational culture (F6)', 'Strategic alignment (F2)' and 'Management leadership (F11)' take fifth, sixth and seventh places among other cause-group variables. Six HSCFs, namely 'Teamwork (F5)'; 'Change management (F13)'; 'Mutual trust and respect (F1)'; 'Green training (F3)'; 'Employee involvement (F4)' and 'Green innovation (F10)' (in order of importance) comprise the effect group.

For company B, 'Customer relationship management (F12)' has been identified as the most crucial cause-group factor with the highest (r-c) value. 'Communication (F7)', 'Employee commitment (F8)' and 'Strategic alignment (F2)' take second, third and fourth positions in the cause group, respectively. 'Green motivation (F9)' and 'Management leadership (F11)' remain (in order) as HSCFs in the cause-group. The effect-group comprises of seven HCSFs for company B. 'Change management (F13)' is the most important effect-group factor. 'Employee involvement (F4)'; 'Green training (F3)'; 'Teamwork (F5)'; 'Green innovation (F10)'; 'Organizational culture (F6)' and 'Mutual trust and respect (F1)' are other HCSFs (in order of significance) in the effect group.

For company C, six HSCFs fall into the cause-group; the effect-group comprises of the remaining seven HCSFs. 'Customer relationship management (F12)', 'Green innovation (F10)' and 'Management leadership (F11)' are foremost significant cause-group HSCFs (in that order). 'Green motivation (F9)'; 'Strategic alignment (F2)' and 'Mutual trust and respect (F1)' occupy fourth, fifth and sixth positions in the cause-group. Among effect-group factors, 'Mutual trust and respect (F1)' is the most crucial factor. 'Change management (F13)'; 'Employee commitment (F8)'; 'Teamwork (F5)'; 'Organizational culture (F6)'; 'Employee involvement (F4)' and 'Green training (F3)' claim second, third, fourth, fifth, sixth and seventh positions of relevance in the effect-group respectively.

The overall findings of the research have been tabulated in Table 8.

Table 8: The overall findings of the research

Group	**Company A**	**Company B**	**Company C**	**Common between selected companies**
Cause	F2, F6, F7, F8, F9, F11, F12	F2, F7, F8, F9, F11, F12	F2, F7, F9, F10, F11, F12	F2, F7, F9, F11, F12
Effect	F1, F3, F4, F5, F10, F13	F1, F3, F4, F5, F6, F10, F13	F1, F3, F4, F5, F6, F8, F13	F1, F3, F4, F5, F13

From Table 8, it can be observed that 'Strategic alignment (F2)'; 'Communication (F7)'; 'Green motivation (F9)'; 'Management leadership (F11)' and 'Customer relationship management (F12)' have consistently appeared in the cause-group across all three companies. Additionally, 'Employee commitment (F8)' is found to be a cause-group variable for company A and company B. Similarly, 'Mutual trust and respect (F1)'; 'Green training (F3)'; 'Employee involvement (F4)'; 'Teamwork (F5)' and 'Change management (F13)' have appeared in the effect-group for all three selected companies.

Comparing all three companies, results show that "Green motivation (F9)" is one of the key HCSFs to SM. An interesting finding is that "Customer relationship management (F12)" is an important cause HSCF identified in Group B and Group C companies. Similar to the findings of Jabbour and Santos (2008) and Muduli et al. (2013), current analysis also indicates that "Strategic alignment (F2)" is a key factor that influences both management leadership and organizational developments. Our analysis also suggests that green motivation is a pre-requisite to boosting green innovation and to effectively manage any change originating from adoption of SM practices. Green motivation demonstrates a bi-directional relationship with organizational culture. Hence, similar to Harvey et al. (2013) and Huffman and Klein (2013), current analysis also recommends the need of motivating employees to contribute towards adopting sustainable practices at work. Additionally, motivated employees will shape organisational culture that promotes using eco-friendly processes. Consequently, organizational culture that promotes green innovation often leads to competitive advantage (Chen et al., 2014).

The present work also shows that "Communication (F7)" plays a vital role in adopting sustainable practices through employee motivation, managing change and employee involvement. CRM is also seen to be significant in building mutual trust and respect and has a direct influence on employee involvement, organizational culture and communication; effective communication in managing customer relations will influence them to buy environmentally sustainable products (Ruhwinkel 2013). Current analysis also indicates the importance of "Management leadership (F11)" in implementing a SM system.

The companies chosen for the current analysis perfectly demonstrate how strategic alignment and leadership influence the success of organisational efforts towards achieving environmental sustainability. These companies have successfully aligned actions at various functional units such as green procurement and green supply chains to achieve the desired objective of SM practices. These companies have clearly communicated their goals to each stakeholder and are taking initiatives to motivate them, providing necessary support and training as required. For instance, company A has reported that 77% of its regular employees have undergone various training programs during FY 2017-18. These companies are motivating their employees to remain committed towards contributing to environmental sustainability. Management of these companies is committed to using innovative approaches to become environmentally and socially responsible manufacturers. For instance, two manufacturing facilities of Company B are named as "Garden Factory"; various measures have been taken to ensure green manufacturing. Similarly, company A uses cleaner and renewable energy sources; this accounts for 95% of its total energy use. The energy requirement of its manufacturing facilities is fulfilled by natural gas-based captive power generation, supplemented by grid power. It has implemented various other measures to lower the harmful effects of its operations on the environment. Companies A and B are also working towards developing more fuel-efficient products.

These companies are extending the scope of their efforts beyond their own operations. For instance, company B is providing training to its customers on how they can use their two-wheeler vehicles in a more efficient manner. To follow the principles of circular economy, company A is facilitating the buying process of pre-owned cars by making this process more seamless, engaging and transparent. By these efforts, these companies are encouraging sustainable consumption among customers through effective CRM. These companies have also effectively managed the transition from traditional manufacturing methods to environmental and social friendly manufacturing operations. As an outcome of these various initiatives taken, these companies have demonstrated a significant reduction in the environmental footprints of their manufacturing activities.

5.1 Implications of the Study

This section presents the practical and theoretical implications of the current study for various stakeholders such as academicians and decision makers at different levels. A more comprehensive understanding of the relevance of human-related factors and support can be built; supports have been provided to draft action plans for implementing and managing sustainable manufacturing.

5.1.1 Practical implications

Identification of HCSFs can help managers and practitioners in drawing up action plans to implement SM practices. The cause-effect framework among HCSFs can assist decision makers to minimise their costs and prioritise by assessing the influencing (cause-group) and influenced (effect-group) factors. In addition to decision makers and managers at organisational levels, this work offers key implications for policy-makers as well. We list the practical implications for use throughout society:

- Increase in carbon footprints and global warming are the critical and urgent issues for the entire world to address. Current analysis indicates that strategic alliance and leadership are important determinants for adoption of SM practices. This learning can also be adopted at macro levels; not only organisations, but also governments worldwide, are responsible for contributing towards environmental protection. For instance, governments must ensure strategic alliance between various stakeholders while formulating various policies for environmental protection. Conflicting policies will hinder the impact of any effort made in this direction. Similarly, an appropriate leadership style is required to develop a culture of valuing the environment and making efforts to save it. Moreover, to bring change at a national level, formulating policies to protect the environment is possible through strong political leadership with a focus on a long-term goal rather than short-term practices. Customer awareness about environment protection or examining the pro-environmental behaviour is not enough to create a sea change; therefore, political leadership is necessary to ensure environmental protection (Lee and Koski, 2012). The carrot and stick approach of motivation can be followed to formulate and implement government regulations as statutory compliance is the best method to enforce organizations to use sustainable practices.
- The findings of this current work are likely to contribute to improving the understanding of decision makers and practitioners in defining the HSCFs that influence effective implementation of SM practices at organizational level.

- Results of the current study also add towards setting out priorities to streamline the HCSFs under consideration to achieve implementation of SM practices. For instance, findings of the current study indicate that green motivation and CRM hold critical significance in implementing the desired strategy; organisations must ensure that both of these HCSFs are optimised, keeping in mind the strategic linkage of these variables with other HCSFs in order to achieve maximum gains with minimum effort and cost.
- A degrading environment negatively influences the health of people; the current work may guide employees of manufacturing organisations to better understand their roles in reducing the harmful effect of business operations on the environment.

5.1.2 Theoretical implications

The current research highlights the following unique specific theoretical implications:

- The current study tries to fill an existing gap by proving the relevance of HCSFs for adopting SM practices.
- The present work identifies and validates HCSFs for effective adoption of SM practices in an emerging economy such as India by taking the automotive industry perspective. The major contributions establish the relevance of behavioural components as well as the technical variables. A comprehensive literature review and expert opinions helped in considering these soft dimensions.
- The proposed DEMATEL method can be used to analyse HCSFs and provide a deep understanding of the causal relationships amongst these HCSFs.
- The study provides a conceptual framework to help industry practitioners and experts to engage in more precise planning to move towards SM practices via the human related critical success factors.

6. Conclusions, Limitations and Scope for Further Research

India, as a developing nation, is increasingly focusing upon manufacturing activities to fuel its economic growth. The launch of the “Make in India” campaign is one among the various other steps that the Indian government has put forward to boost manufacturing activities within the country. In such a scenario, it becomes more critical to ensure the implementation of SM systems as manufacturing operations cause the maximum damage to the environment; the cost of environmental damage can overtake the economic benefits of business activities in the long run. Therefore, it is necessary for manufacturing organisations to strategize their operations in such a way as to minimise environmental damage. Consequently, various organisations have started to implement environmentally sustainable practices such as green marketing and GSCM etc. to protect the environment.

This paper seeks to assess the significance of the human dimensions in adopting SM in the context of the Indian automobile industry. The DEMATEL method was employed to meet the stated objective. DEMATEL was used to identify inter-relationships among human related dimensions and to recognise the cause and effect relationships between them. In this study, thirteen HCSFs were identified through a rigorous process of literature review and validation from practitioners in the automobile industry and experts in the domain.

In order to explore and model the inter-relationships between these thirteen HCSFs, data from three Indian automotive companies was used (Company A: four-wheeler passenger vehicle manufacturer; Company B: two-wheeler manufacturer and Company C: automobile ancillary unit). Data was collected from practitioners from each company separately and likewise the analysis was also carried out separately for each company to establish the robustness of the results.

The study identifies 'Strategic alignment (F2)'; 'Communication (F7)'; 'Green motivation (F9)'; 'Management leadership (F11)' and 'Customer relationship management (F12)' as the most crucial cause-group HCSFs. 'Mutual trust and respect (F1)'; 'Green training (F3)'; 'Employee involvement (F4)'; 'Teamwork (F5)' and 'Change management (F13)' are found to be the most sensitive effect-group HCSFs. These findings are concrete and provide a sound basis for policy makers and practitioners to design effective policies on employee motivation e.g. rewarding a right behaviour and punishing a wrong behaviour (using operant conditioning) to implement sustainable practices and create a pro-environmental behaviour. Similarly, employee involvement can be increased in decision making, while providing continuous training about environmental awareness and sustainability. The findings of the study will help industry practitioners, change agents and decision-makers to understand the role of HCSFs in a more detailed and comprehensive manner in the context of successful implementation of SM practices. This understanding is likely to help them in more successful planning in this regard by optimising the required resources.

The current study has some limitations which form the basis to conduct future work in the area. Current work is restricted to companies in the Indian automotive industry and hence, researchers can extend this to other manufacturing industries as well. Researchers can empirically test the significance of these identified HCSFs and cause-effect relationships of these HCSFs in any given context. Future studies can also apply DEMATEL in conjunction with various other developed theories such as grey, rough sets theories or D-Number theory. Researchers can also use other MCDM techniques such as ISM, BWM and AHP to explore other dimensions of the mutual connections of HCSFs. A comparative analysis can also be conducted for both developing and developed economies.

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Appendix-A

Sample Questionnaire

Finalisation of Human critical success factors

Greetings!!!!

Dear respondent, current research attempts to identify the relevance of factors related to human resource in implementing Sustainable Manufacturing (SM) practices. Thirteen human dimensions focusing on SM practices were identified from the current literature. We request you to provide your response to confirm the relevance of the presented human resource related factors (identified from the literature in the area) in SM implementation by choosing 1 or 0 (1 if the factor is relevant and 0 otherwise). You may also reword/add/merge the factors presented below in the context of SM in Indian automotive company in question.

Human critical success factors	**Response**
Mutual trust and respect	
Strategic alignment	
Green training	
Employee involvement	
Teamwork	
Organisational culture	
Communication	
Employee commitment	
Green motivation	
Green innovation	
Management leadership	
Customer relationship management	
Change management	

Causal interrelationships among human critical success factors

Dear respondent, current research also attempts to explore and define the causal interrelationships between human dimensions in the context of SM implementation. Therefore, the following questionnaire is prepared to measure the interrelationship of the presented dimensions on the following scale:

4 = Very high influence, 3 = High influence, 2 = Low influence, 1 = Very low influence, 0 = No influence

Interrelationship (impact of one to other) of Human Critical Success Factors of SM practices.

Main factors → ***Main factors*** ↓	Mutual Trust & Respect	Strategic Alignment	Green Training	Employee Involvement	Teamwork	Organisational Culture	Communication	Employee Commitment	Green Motivation	Green Innovation	Management Leadership	Customer Relationship Management	Change Management
Mutual trust and respect	0												
Strategic alignment		0											
Green training			0										
Employee involvement				0									
Teamwork					0								
Organisational culture						0							
Communication							0						
Employee commitment								0					
Green motivation									0				
Green innovation										0			
Management leadership											0		
Customer relationship management												0	
Change management													0

Appendix-B

Normalisation Matrices

Table B1: The normalisation matrix for company A

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13
F1	0	0.0688	0.0734	0.0826	0.0734	0.0734	0.0734	0.0688	0.0688	0.0780	0.0550	0.0596	0.0780
F2	0.0734	0	0.0826	0.0872	0.0734	0.0826	0.0780	0.0596	0.0688	0.0872	0.0826	0.0550	0.0734
F3	0.0872	0.0642	0	0.0688	0.0734	0.0734	0.0872	0.0734	0.0596	0.0826	0.0780	0.0550	0.0780
F4	0.0780	0.0550	0.0826	0	0.0872	0.0872	0.0734	0.0826	0.0642	0.0780	0.0596	0.0826	0.0872
F5	0.0780	0.0872	0.0642	0.0688	0	0.0872	0.0550	0.0413	0.0413	0.0826	0.0734	0.0642	0.0734
F6	0.0872	0.0872	0.0872	0.0872	0.0780	0	0.0872	0.0780	0.0780	0.0872	0.0826	0.0826	0.0780
F7	0.0872	0.0688	0.0872	0.0872	0.0780	0.0872	0	0.0872	0.0734	0.0780	0.0780	0.0872	0.0780
F8	0.0688	0.0780	0.0872	0.0872	0.0780	0.0872	0.0826	0	0.0780	0.0688	0.0505	0.0550	0.0734
F9	0.0872	0.0780	0.0642	0.0780	0.0872	0.0734	0.0688	0.0734	0	0.0780	0.0872	0.0872	0.0780
F10	0.0780	0.0780	0.0872	0.0872	0.0872	0.0780	0.0688	0.0780	0.0596	0	0.0596	0.0780	0.0826
F11	0.0688	0.0780	0.0780	0.0734	0.0780	0.0734	0.0688	0.0688	0.0596	0.0780	0	0.0642	0.0688
F12	0.0780	0.0780	0.0826	0.0872	0.0872	0.0826	0.0688	0.0734	0.0688	0.0780	0.0596	0	0.0413
F13	0.0596	0.0596	0.0642	0.0550	0.0826	0.0734	0.0642	0.0642	0.0734	0.0596	0.0688	0.0596	0

Table B2: The normalisation matrix for company B

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13
F1	0	0.0820	0.0820	0.0874	0.0820	0.0929	0.0765	0.0710	0.0492	0.0710	0.0710	0.0546	0.0710
F2	0.0765	0	0.0874	0.1038	0.0656	0.0874	0.0765	0.1038	0.0710	0.0820	0.0984	0.0765	0.0710
F3	0.0765	0.0874	0	0.0710	0.0437	0.0929	0.0820	0.0765	0.0874	0.0820	0.0765	0.0765	0.0492
F4	0.0601	0.0820	0.0874	0	0.0656	0.0710	0.0874	0.0874	0.0929	0.0820	0.0656	0.0656	0.0710
F5	0.0656	0.0765	0.0710	0.0546	0	0.0820	0.0820	0.0710	0.0765	0.0656	0.0820	0.0765	0.0492
F6	0.0765	0.0710	0.0710	0.0984	0.0874	0	0.0820	0.0820	0.0656	0.0820	0.0820	0.0929	0.0710
F7	0.0929	0.0929	0.0820	0.0820	0.0820	0.0984	0	0.0929	0.0820	0.0874	0.0765	0.0710	0.0601
F8	0.0710	0.0656	0.0601	0.0820	0.0929	0.0765	0.0601	0	0.0820	0.0601	0.0765	0.0820	0.0601
F9	0.0765	0.0929	0.0765	0.0820	0.0929	0.0874	0.0765	0.0765	0	0.0820	0.0874	0.0765	0.0710
F10	0.0820	0.0546	0.0929	0.0820	0.0546	0.0710	0.0710	0.0820	0.0765	0	0.0820	0.0765	0.0601
F11	0.0765	0.0820	0.0820	0.0929	0.0820	0.0710	0.0874	0.0601	0.0874	0.1038	0	0.0710	0.0656
F12	0.0656	0.0656	0.0710	0.0710	0.0710	0.0710	0.0437	0.0710	0.0820	0.0546	0.0710	0	0.0492
F13	0.0929	0.0820	0.0874	0.0765	0.0656	0.0820	0.0656	0.0984	0.0765	0.0546	0.0656	0.0874	0

Table B3: The normalisation matrix for company C

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13
F1	0	0.0546	0.0492	0.0656	0.0710	0.0710	0.0765	0.0820	0.0492	0.0656	0.0820	0.0601	0.0765
F2	0.0656	0	0.0820	0.0601	0.0929	0.0765	0.0929	0.0765	0.0601	0.0601	0.0765	0.0656	0.0601
F3	0.0656	0.0492	0	0.0765	0.0710	0.0765	0.0710	0.0710	0.0710	0.0820	0.0656	0.0765	0.0656
F4	0.0383	0.0820	0.0546	0	0.0874	0.0656	0.0874	0.0820	0.0492	0.0820	0.0546	0.0328	0.0601
F5	0.0710	0.0546	0.0546	0.0710	0	0.0820	0.0656	0.0656	0.0874	0.0710	0.0874	0.0546	0.0601
F6	0.0656	0.0820	0.0492	0.0710	0.0984	0	0.0765	0.0546	0.0492	0.0710	0.0765	0.0656	0.0874
F7	0.0656	0.0710	0.0710	0.0820	0.0874	0.0820	0	0.0874	0.0710	0.0765	0.0546	0.0656	0.0656

F8	0.0710	0.0710	0.0820	0.0874	0.0984	0.0929	0.0929	0	0.0820	0.0383	0.0820	0.0383	0.0656
F9	0.0656	0.0710	0.0710	0.0820	0.0984	0.0874	0.0874	0.0765	0	0.0656	0.0656	0.0656	0.0820
F10	0.0765	0.0820	0.0710	0.0765	0.0874	0.0984	0.0710	0.0874	0.0710	0	0.0874	0.0656	0.0710
F11	0.0601	0.0874	0.0820	0.0874	0.0874	0.0929	0.0874	0.0929	0.0929	0.0929	0	0.0601	0.0765
F12	0.0546	0.0656	0.0601	0.0656	0.0710	0.0710	0.0874	0.0765	0.0656	0.0710	0.0820	0	0.0656
F13	0.0383	0.0328	0.0492	0.0601	0.0273	0.0710	0.0437	0.0710	0.0710	0.0492	0.0710	0.0328	0

Appendix-C

Total Relationship Matrices

Table C1: The total relationship matrix for company A

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13
F1	0.5864	0.6199	0.6598	0.6722	0.6725	0.6706	0.6223	0.6012	0.5678	0.6615	0.5811	0.5828	0.6365
F2	0.6877	0.5867	0.7010	0.7095	0.7062	0.7121	0.6573	0.6235	0.5958	0.7027	0.6350	0.6084	0.6642
F3	0.6835	0.6322	0.6088	0.6776	0.6897	0.6880	0.6503	0.6209	0.5745	0.6825	0.6163	0.5938	0.6528
F4	0.6986	0.6461	0.7080	0.6363	0.7254	0.7235	0.6599	0.6495	0.5981	0.7015	0.6208	0.6383	0.6821
F5	0.6341	0.6131	0.6275	0.6356	0.5788	0.6573	0.5833	0.5545	0.5226	0.6415	0.5753	0.5644	0.6087
F6	0.7601	0.7245	0.7662	0.7714	0.7726	0.6982	0.7226	0.6949	0.6561	0.7635	0.6893	0.6864	0.7259
F7	0.7454	0.6948	0.7514	0.7564	0.7575	0.7633	0.6285	0.6894	0.6396	0.7407	0.6718	0.6772	0.7116
F8	0.6792	0.6545	0.7001	0.7048	0.7052	0.7114	0.6571	0.5626	0.6001	0.6820	0.6030	0.6041	0.6597
F9	0.7201	0.6793	0.7060	0.7230	0.7397	0.7258	0.6686	0.6539	0.5494	0.7156	0.6573	0.6546	0.6873
F10	0.7010	0.6681	0.7145	0.7192	0.7279	0.7182	0.6584	0.6476	0.5961	0.6319	0.6232	0.6362	0.6808
F11	0.6531	0.6305	0.6664	0.6668	0.6788	0.6731	0.6206	0.6032	0.5617	0.6642	0.5310	0.5885	0.6306
F12	0.6817	0.6497	0.6908	0.6996	0.7073	0.7018	0.6397	0.6256	0.5867	0.6847	0.6053	0.5465	0.6259
F13	0.5978	0.5700	0.6062	0.6025	0.6340	0.6243	0.5716	0.5555	0.5330	0.6005	0.5531	0.5423	0.5204

Table C2: The total relationship matrix for company B

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13
F1	0.7733	0.8687	0.8810	0.9153	0.8316	0.9169	0.8331	0.8887	0.8377	0.8424	0.8614	0.8236	0.7127
F2	0.9303	0.8811	0.9752	1.0226	0.9022	1.0041	0.9174	1.0079	0.9453	0.9384	0.9733	0.9284	0.7848
F3	0.8549	0.8839	0.8159	0.9133	0.8094	0.9279	0.8472	0.9041	0.8811	0.8627	0.8773	0.8527	0.7026
F4	0.8533	0.8923	0.9093	0.8593	0.8400	0.9227	0.8641	0.9271	0.8992	0.8746	0.8805	0.8559	0.7316
F5	0.8038	0.8321	0.8386	0.8535	0.7263	0.8739	0.8064	0.8547	0.8294	0.8066	0.8393	0.8114	0.6673
F6	0.8966	0.9130	0.9262	0.9809	0.8882	0.8877	0.8887	0.9534	0.9061	0.9041	0.9246	0.9089	0.7563
F7	0.9452	0.9669	0.9711	1.0047	0.9173	1.0149	0.8471	0.9994	0.9544	0.9437	0.9559	0.9243	0.7759
F8	0.8176	0.8326	0.8393	0.8868	0.8213	0.8792	0.7971	0.7986	0.8443	0.8110	0.8442	0.8258	0.6851
F9	0.9136	0.9491	0.9484	0.9853	0.9092	0.9864	0.9009	0.9667	0.8611	0.9214	0.9472	0.9116	0.7705
F10	0.8418	0.8379	0.8827	0.9026	0.8012	0.8901	0.8205	0.8894	0.8543	0.7688	0.8631	0.8349	0.6969
F11	0.9014	0.9271	0.9408	0.9811	0.8869	0.9591	0.8983	0.9395	0.9291	0.9281	0.8538	0.8941	0.7554
F12	0.7475	0.7656	0.7807	0.8073	0.7381	0.8044	0.7186	0.7954	0.7775	0.7409	0.7725	0.6849	0.6210
F13	0.8900	0.9013	0.9180	0.9400	0.8492	0.9416	0.8535	0.9455	0.8934	0.8589	0.8891	0.8835	0.6728

Table C3: The total relationship matrix for company C

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13
F1	0.3153	0.3948	0.3772	0.4365	0.4782	0.4730	0.4648	0.4631	0.3966	0.4108	0.4485	0.3473	0.4251
F2	0.4027	0.3698	0.4325	0.4616	0.5307	0.5101	0.5107	0.4888	0.4341	0.4345	0.4733	0.3767	0.4386
F3	0.3914	0.4058	0.3448	0.4631	0.4974	0.4962	0.4782	0.4711	0.4310	0.4415	0.4511	0.3758	0.4317
F4	0.3448	0.4094	0.3734	0.3644	0.4822	0.4573	0.4634	0.4520	0.3869	0.4151	0.4141	0.3155	0.4001
F5	0.3920	0.4064	0.3925	0.4534	0.4261	0.4956	0.4684	0.4611	0.4407	0.4274	0.4649	0.3526	0.4226
F6	0.3911	0.4338	0.3919	0.4576	0.5201	0.4249	0.4823	0.4569	0.4124	0.4319	0.4610	0.3658	0.4504
F7	0.4051	0.4393	0.4253	0.4836	0.5296	0.5182	0.4289	0.5013	0.4458	0.4510	0.4576	0.3783	0.4465

F8	0.4176	0.4480	0.4432	0.4982	0.5498	0.5377	0.5241	0.4306	0.4644	0.4276	0.4898	0.3620	0.4558
F9	0.4174	0.4527	0.4383	0.4986	0.5550	0.5391	0.5247	0.5074	0.3938	0.4559	0.4818	0.3900	0.4751
F10	0.4397	0.4764	0.4517	0.5086	0.5624	0.5647	0.5266	0.5321	0.4737	0.4080	0.5158	0.4017	0.4797
F11	0.4457	0.5031	0.4827	0.5423	0.5891	0.5862	0.5658	0.5617	0.5151	0.5155	0.4585	0.4156	0.5068
F12	0.3812	0.4196	0.4016	0.4529	0.4968	0.4908	0.4919	0.4752	0.4261	0.4311	0.4644	0.3040	0.4307
F13	0.2848	0.3026	0.3066	0.3518	0.3525	0.3861	0.3522	0.3704	0.3405	0.3215	0.3584	0.2607	0.2788