The adoption of environmentally sustainable supply chain management: Measuring the relative effectiveness of hard dimensions

Abstract: Adopting green practices in supply chains contribute towards protecting the environment. For the successful adoption of Environmentally Sustainable Supply Chain Management (ESSCM), the dimensions related to technology, strategy and policy etc., termed as hard dimensions in the scholarly literature, play a significant role. However, the independent influence of these dimensions on ESSCM has not been previously studied. Therefore, the present study aims to fill this gap and evaluate the effectiveness of these dimensions. To do this, the most significant dimensions are identified through a thorough literature review and experts' inputs. To determine their priority and cause-effect relationship, a combined approach of Best Worst Method (BWM) and Decision-Making Trial and Evaluation Laboratory (DEMATEL) is used. The analysis indicates that 'Total Quality Management', and 'Technologies for Cleaner Production', are the most important causal dimensions and provides several insights to the decision-makers to formulate robust business strategies to the adoption of ESSCM.
Keywords: Environmentally sustainable supply chain management; Technology; Business strategy; Best worst method; DEMATEL; Carbon emissions.

1. Introduction

Business are increasingly focusing upon implementation of sustainable business practices (such as sustainable purchasing, green manufacturing, green SCM etc.) in order to gain higher long-term sustainability and valuation in global context (Govindan et al., 2015; Tseng et al., 2018). Current literature indicates a positive association of business performance and green management practices (Pullman et al., 2009; Jabbour et al., 2015; Abdul-Rashid et al., 2017; Singla et al., 2018). Due to more emphasis upon environmental sustainability, supply chain and operations management research have gain importance. A number of recent articles suggested a broader systems approach, hence connecting various stakeholders, towards environmental supply chain management (Golicic and Smith, 2013). Environmentally Sustainable Supply Chain Management (ESSCM) is a green business practice that not only advocates the significance of sustainable growth but also ensures an augmented overall performance (e.g. economic, environment, social, and operation) of the business (Vijayvargy et al., 2017; Singla et al., 2018). The concept of ESSCM finds its roots in the growing rate of industrialization that has resulted into higher consumption levels and degraded natural resources (Luthra et al., 2016; Singla et al., 2018).

Nowadays, leading businesses are giving a stiff competition to each other by employing advanced and innovative practices from Kaizen to customer satisfaction to quality assurance etc. in business operations (Abdul-Rashid et al., 2017). Implementing ESSCM helps businesses to gain a competitive advantage (Su et al., 2016; Vijayvargy et al., 2017). Conducive working conditions, minimized cost, easy exchange of information, are some of the benefits of ESSCM adoption (Singla et al., 2018).

Present work considers Indian context to conduct the current analysis due to the following characteristics of this economy:

- Indian economy is anticipated to become the third-largest consumer economy by 2025 driven by growing consumption which is estimated to go triple to reach US$ 4 trillion by then (IBEF, 2019).
- The Indian government has taken several initiatives to support the growth of the economy such as Make in India with the aim to transform the nation into a design and manufacturing hub at the global level. As a fast-growing nation, economic activities are expected to further intensify in India.
- India is particularly more exposed to the consequence of climate change (Mani et al., 2018). For instance, the average temperature in India can touch as high as 29.1° from the current level of 25.1° C by the end of this century, if climate change continues uninterrupted (Livemint, 2019).
- India's ranking on Global Environmental Index has deteriorated from 141 in the year 2016 to 177 in the year 2018 (out of 180 countries) due to its failure to lower down the emission of greenhouse gases and improve the air quality (Cseindia, 2018).
- Environmental governance of India is in a poor state due to the failure of implementation of environmental laws (Pandey, 2019). For an instance, on the matter of solid waste management, Supreme Court has recently expressed disappointment mentioning that larger chunk of the states in the country did not take any steps to comply with the orders passed by the Court and the directions given by the Ministry of Environment, Forests and Climate Change (Pandey , 2019). Additionally, the current literature also indicates the

inadequacies of existence and implementation of environmental rules and regulation to address environmental issues in India (Singh et al., 2015; Sharma et al., 2016; Gandhi et al., 2018).

It is inevitable for Indian economy to further fuel its economic activities. However, science has proved that emissions from industries and other human doings are majorly responsible for climate change in terms of global warming (livemint, 2019). The World Bank has projected that climate change can turn out into a 9.8% decrease in per capita GDP of the more affected Indian regions (Mani et al., 2018). Therefore, it becomes quite crucial for India to ensure the increasing pace of economic growth and simultaneously, minimizing the harmful effects of its economic activities on the environment. Consequently, it is imperative for businesses operating in India to take the responsibility of lowering down the environmental footprint of their operation along with achieving financial performance. As a result, business organisations in India are increasingly focusing upon implementation of sustainable business practices (Mishra and Mishra, 2019).

ESSCM is one such practice that would lead to achieving the stated objective in Indian context. In the light of increasing attention on ESSCM among practitioners and academics, Dubey et al. (2017) developed a model wherein they combined the hard (technology, strategy, and policy-related) and the soft (human-resource-related) dimensions to facilitate its implementation. In this study, they proposed an examination and evaluation of these two groups of dimensions separately by future studies. There are several benefits of exploring these dimensions (hard and soft) separately. Firstly, such analysis may provide a deep and robust framework for decision-makers at various levels to understand the influence of specific dimensions on ESSCM adoption (Jabbour et al., 2018). Numerous studies have been conducted to examine the influence of human-related dimensions in the setting of ESSCM implementation (Jabbour et al., 2018; Kumar et al., 2019; Ahuja et al., 2019). On the other hand, there is a dearth of studies (as mentioned in literature review section 2.3) that have explored hard dimensions which include technology and information paradigm regarding ESSCM implementation (Wicki and Hansen, 2019). Moreover, to the best of our understanding, no study attempts to explore hard dimensions in Indian setting. Considering prevailing gap in the literature, the current work aims to achieve the following objectives:

- To explore the key dimensions – technology, strategy and policy and their significance in ESSCM adoption

- To identify the priority and cause-effect group of identified key dimensions and their cause-effect relationships
- To identify vital practical implications and key strategies which may assist decision makers to implement a system of ESSCM

To achieve these objectives, the current research study employs a hybrid approach of BWM and DEMATEL. BWM is basically employed to rank or prioritization of the selected variables (Rezaei, 2015; Rezaei, 2016a). However, this method is not capable of mapping the effectiveness of the dimensions via there interrelationship. Therefore, DEMATEL analysis is implemented to deduce interrelationships between the dimensions (Bai et al., 2017; Wu et al., 2018; Tseng et al., 2018). A priority-based analysis leads to minimization of implementation cost of strategies to ensure optimum implementation (Luthra et al., 2016; Yang et al., 2019; Wicki and Hansen, 2019) and assists managers to craft a more effective action plan and strategy for ESSCM adoption (Singla et al., 2018). Therefore, mapping the relative effectiveness of the given hard dimensions and cause-effect interrelationship will ensure systematic implementation of ESSCM. Knowing about cause variables (which exert influence on other variables) will help decision-makers to ensure appropriate planning and execution of strategies towards ESSCM adoption.

This study has six sections. Section 2 provides a comprehensive review. Section 3 puts forward the solution methodology. Section 4 documents the application of the proposed framework followed by section 5 that presents the result of the study and its practical implications. The last section of the study envelops conclusion, unique contributions of the current study and proposed further research directions.

2. Literature Review

The first part of this section presents the literature around environmentally sustainable SCM, in the second part proposed dimensions are described and the last part is all about research gaps and problem definition.

2.1 Environmentally Sustainable SCM

Traditional supply chain aims at cost reduction and service improvement with little concern about the environment and societal dimensions (Uygun and Dede, 2016). However, now business organisations consider environment and society as key stakeholders and, focuses upon them also to ensure organisational long-term sustainability along with profit creation (Agi and Nishant, 2017; Singla et al., 2018). Therefore, a framework is for incorporating environmental concerns in business operations is required (Uygun and Dede, 2016). ESSCM can be defined as the embodiment of green practices at every possible step of the supply chain (Mangla et al., 2016). Cousins et al. (2019) have concluded that ESSCM practices reflect as reduction in operational cost as well as better environmental performance. Therefore, organisations can gain a competitive edge by adopting ESSCM (Liou et al., 2016; Haq and Boddu, 2017). ESSCM aspires for optimal utilization of resources with negligible wastage, therefore ensures optimum production and environmental efficiency in operations (Uygun and Dede, 2016). As a result, a large number of companies are replacing their conventional SCM model with ESSCM (Ahmad et al., 2017; Haq and Boddu, 2017). The current literature proposes ESSCM as a strategy to enhance environmental sustainability and to advance the robustness of the supply chain (Luthra et al., 2016). Proper implementation of ESSCM can eradicate the ill effects that supply chain process leaves on the surroundings in which it operates (Tseng et al., 2019). While the ESSCM subsumes different elements of business processes such as the buying, processing and the delivery of the final goods to the customer, it also relates to the value of the products which have been already exhausted (Luthra et al., 2016; Ahmad et al., 2017).

Although, ESSCM brings in a wide range of benefits aligning ecological, social, financial, governmental, and organizational parameters (Lin, 2013; Mangla et al., 2015) but from the industrial standpoint, its implementation is critical (Uygun and Dede, 2016). Therefore, this is a case-based study and considers experts recommendations. We consider the case of an Indian Automobile giant because the Indian automobile industry is projected to contribute significantly in '*Make in India*' program (Delhi, S. I. N., 2015). Moreover, it is the key driver of technological development and macroeconomic growth in India and holds a 7.5% share in the nation's GDP (ICAT, 2019). The Indian automobile industry is demonstrating a remarkable growth. During FY 2018-19, 25 million vehicles were manufactured in India and 3.5 million were exported (Cseindia, 2018). Mckinsey and Company has projected that India will become the third-largest automotive market in the world by 2026 in terms of volume (MacKay and Company, 2018). The automobile industry in India has a competitive edge in terms of availability of semi-skilled and skilled labour, increasing income levels, low cost of labour, favourable policy framework, infrastructural development, government support etc. The case company has expressed the intentions to effectively incorporate green practices in their SCs thus the study's analysis will help not only the case company but also any company in the proper implementation of ESSCM practices.

As mentioned above in literature, many studies examined that proper implementation of ESSCM in an organization demands to focus on both hard (technology, strategy and policy) and soft (human-resource-related) dimensions. Therefore, an independent analysis of dimensions in both categories is desired to better understand their respective roles in ESSCM adoption in order to assist managers/practitioners to craft their action plans accordingly (Kumar et al., 2019; Muduli et al., 2020).

However, current literature does not document enough studies that have investigated strategy, technology and policy dimensions, separately and lack of this knowledge may lead to poor integration of hard dimensions with ESSCM adoption (Singla et al., 2018). On the other side, in today's competitive business environment, corporates are well aware of the fact that organisational commitment towards environment and society is indeed a pre-requisite to have a long-term sustainable business (Luthra et al., 2011). Hence, a comprehensive analysis is required to develop an understanding of the key role that strategy, technology and policy dimensions play in ESSCM implementation. However, researchers have not made warranted efforts in this direction (Luthra et al., 2015; Muduli et al., 2020).

Knowing these key dimensions in the adoption of ESSCM is not sufficient as precise information about their priority and interrelationship is required for right business strategy, planning and decision making (Luthra et al., 2016; Kumar et al., 2020). Therefore, this study also attempts to explore the priority of these dimensions and map their effectiveness by finding out the interrelationship between these dimensions. Both BWM and DEMATEL techniques have been implemented to address problems from various diverse fields, individually (as shown in Table 1 and Table 2).

However, no study has applied a hybrid BWM-DEMATEL approach to evaluate hard dimensions (strategy, technology and policy) of an organisation that is business planning to adopt ESSCM. Therefore, the current study attempts to apply a hybrid approach of BWM-DEMATEL to measure the role of hard dimensions concerning ESSCM adoption by taking the case of an Indian automotive company.

2.2 Proposed Dimensions

Current literature indicates that the dimensions – technology, strategy and policy play a vital role in the effective implementation of ESSCM. Following these dimensions are proposed for evaluation based on a careful review of existing literature in the set context (validation of these dimensions is discussed in Section 4.2).

2.2.1 Lean manufacturing

Lean manufacturing concentrates on improving competitiveness through value creation, quality improvement, waste minimisation and delivery time optimisation (Piercy and Rich, 2015; Meera and Chitramani, 2016). A wide range of studies proposes that integration of lean manufacturing and ESSCM meets a wide range of sustainability outcomes along with improvising productivity and environmental efficiencies (Parveen et al., 2011; Piercy and Rich, 2015; Meera and Chitramani, 2016). Therefore, the application of lean manufacturing may enhance supply chain efficiency (Parveen et al., 2011). Bai et al. (2019) have recently reiterated that lean manufacturing triggers improvement in operational as well as environmental parameters within organisations. Additionally, Yun et al. (2019) have indicated that lean manufacturing helps in enhancing organisation's social, economic, and environmental sustainability.

2.2.2 Total quality management (TQM)

The basis of TQM is to aspire for continuously improving production process (Yu et al., 2017) by minimising the waste during the manufacturing process. TQM aims to improve organisational performance by augmenting productivity, quality, profitability, and customer satisfaction considering the social, financial, and ecological risks (Alonso et al., 2017). TQM requires building state of the art infrastructure and applying the latest technologies to tackle obstacles that might interrupt attaining efficiency by minimising wastages (Yu et al., 2017). Adoption of ESSCM is embedded within the overall input transformation process (Bhandari et al., 2019) and to make that process green, advance technologies are much required (Luthra et al., 2016). Therefore, TQM is assumed to remain crucial for adoption of ESSCM.

2.2.3 Supplier relationship management

Relationship with the supplier has identified a factor for effective adoption of ESSCM identified by previous studies (Luthra et al., 2016). A strong relationship with an organisation may motivate their suppliers to join the new initiatives taken by the firm and the organisation can extend training programmes to educate their suppliers about such initiatives (Parveen et al., 2011). Consequently, a strong association between the firm and its suppliers enhances its ability to implement innovative strategies to make its supply chain operations eco-friendly

(Dubey et al., 2017). Hence, we assume that for adoption of ESSCM by the organisation, supplier relationship management plays a key role (Bag et al., 2018; Kumar and Rahman, 2015; Luthra et al., 2016).

2.2.4 Technologies for cleaner production

The production process in itself is crucial to maintain a balance in the production of goods and via the usage of improved technologies this process can be made more robust (Piercy and Rich, 2015; Meera and Chitramani, 2016). Opting cleaner production process helps organisations to minimise the discharge of harmful elements during the process. However, due to various issues, it is difficult to put this process in place. Often, organisations lack the awareness about such technological advancements, implementation of which may bring in more efficiency in their production processes with respect to environmental protection (Yu et al., 2017). Moreover, cleaner production technologies contribute towards achieving financial and social sustainability in addition to environmental sustainability (Bhandari, 2019). Therefore, employing technologies for cleaner production is a paramount hard dimension to facilitate ESSCM implementation.

2.2.5 Institutional pressures

Increasing consumer awareness about the environment, ecological consciousness of organisations, formulation of strict environmental laws and government policies are not only putting pressure on firms to demonstrate commitment towards environment and society but also directing them to ESSCM (Ahmad et al., 2017). Institutional pressure is found to have crucial implications for adoption of socially sustainable supply chain management (Dubey et al., 2017; Kauppi and Hannibal, 2017). In the beginning, organisations were forced to adopt sustainable practices, but now they have realised that ESSCM is a sustainable practice that can also be taken as a business strategy which works towards bringing in positive reputation and performance at one go in today's competitive market (Andersén et al., 2019). Therefore, companies must gain capabilities to manage this pressure and progress to adopt ESSCM as well as to strategize modification in current activities to develop sustainable business operations.

2.2.6 Green logistics

Nowadays firms are keeping high motivation levels to create global market value and make the business sustainable via adopting green SC practices; wherein, green logistics remains as a central construct (Luthra et al., 2016; Petljak et al., 2018). Vargas et al (2018) also identify green logistics as key enabler of sustainable supply chain management (SSCM). However, it has been quite challenging for the businesses to ensure environmentally friendly transportation to reasonable levels (Luthra et al., 2016). Often, green transportation does not receive warranted attention because the industry lacks knowledge about the significance of green transportation towards environmental protection once it is implemented (Chen et al., 2018). Activities related to green logistics are being strategic as well as operational in nature and therefore, organisations are required to put more attention and efforts in this direction (Petljak et al., 2018). Considering the significance of green logistics, current study assumes it as key dimension for adopting ESSCM.

2.2.7 Green purchasing

For adopting ESSCM, it is imperative that policies that an organisation implement to address environmental concerns align with its buying practices (Petljak et al., 2018). Malviya et al. (2018) and Vargas et al (2018) have identified green purchasing as determinant of ESSCM adoption. The core elements of green purchasing emphasise waste minimisation and increasing use of eco-friendly material (Dallasega and Sarkis, 2018; Tseng et al., 2019). Due to the rising consciousness of firms towards sustainability, green purchasing has gained huge attention from researchers in SC context (Luthra et al., 2016; Petljak et al., 2018).

2.2.8 Innovation

To be able to replace an existing process with a more efficient one requires some novel thinking and an out of the box approach (Luthra et al., 2015). For instance, innovation by employees towards waste minimisation, recycling and reuse turned out into improved environmental performance at Xerox (Muduli et al., 2020). Sustainability related innovations transmit into achievement of sustainability outcomes (social, economic, and environmental) via SSCM (Neutzling et al., 2018). Innovations happen when organisations inspire their employees to divert from conventional ways of looking at organisational processes, problems and facilitate them in bring in changes into the traditional way of paying off their organisational responsibilities and duties (Kumar and Rahman, 2015; Luthra et al., 2016). Firms need to ensure execution of necessary and periodic changes to promote environmentally friendly practices including implementation of ESSCM (Petljak et al., 2018).

2.2.9 Green manufacturing

Green Manufacturing resonates with reduction of hazardous emission during the process of converting inputs into outputs while ensuring the quality of the output produced in the process (Piercy and Rich, 2015; Meera and Chitramani, 2016). Green manufacturing is considered to play a significant role in implementing ESSCM (Malviya et al., 2018). Vargas et al. (2018) also acknowledge green manufacturing as a key enabler of SSCM. During the recent past, a large number of business organisations have adopted Green Manufacturing and have made earnest attempts to imbibe and practice it holistically. Yet, a substantial amount of research is required in order to successfully implement Green Manufacturing (Orji and Wei, 2015; Seth et al., 2016).

3. Research Methodology

The solution methodology framework is presented in Figure 1.

[Figure 1 about here]

In the first phase, Identification of hard dimensions relevant for ESSCM implementation is done through experts' inputs and literature resources. Priority ranks and cause-effect interrelationship of dimensions is determined in the second phase by using hybrid BWM-DEMATEL approach.

There are several benefits of using combined approached, for instance, 1) its help to know the priority weight of the factors, 2) interrelationship among the factors can develop, 3) the combined approach of BWM-DEMATEL would help the managers to take a better decision by knowing the importance of a particular weight but also its relations with other factors. In literature, many authors have used this combined approach (Kumar et al., 2019; Govindan et al., 2020). Therefore, because of these benefits, to achieve the objectives of this study, a combined approach of BWM-DEMATEL is applied. A brief description of these methods is presented in the following sections:

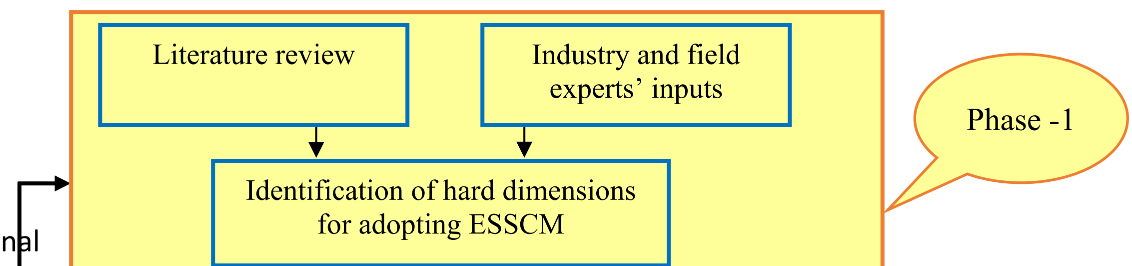

Figure 1: Methodology framework of the study

3.1 BWM

While several dimensions are involved in the evaluation, certain problems can occur during data collection including a reliable and consistent comparison of pair, respondent fatigue and lack of knowledge. Multi-Criteria Decision Making (MCDM) methods are able to handle these problems. Jafar Rezaei (2015) developed BWM, which is quite capable of computing the weight of each dimension in a multi-dimension problem without putting consistency of results at risk (Rezaei et al., 2016). The proposed method gives flexibility to the decision-maker to select the best and worst dimensions among all. Table 1 shows applications of BWM reported in the recent literature.

Table 1: Applications of BWM reported in the recent literature

Author	**Application area**
Rezaei (2015)	Description of Best Worst Method
Gupta and Barua (2016)	Technological innovation for Indian MSMEs
Rezaei et al (2016)	Description of the property of BWM

Ahmad et al. (2017)	Evaluating external forces affecting the sustainability
Ahmadi et al. (2017)	Assessing the social sustainability in supply chain
Rezaei et al. (2018)	Measuring the logistics performance index indicators
Shojaei et al. (2018)	Airports evaluation
Yadav et al. (2018)	Offshore outsourcing adoption
Kusi-Sarpong et al. (2018)	Supply chain sustainability
Kumar et al. (2019)	Evaluating soft dimensions of green SCM
Mosayebi et al. (2020)	Evaluating university-industry collaboration

Stages involved in BWM calculation process (Rezaei, 2015; Rezaei, 2016a) are provided in Appendix A.

3.2 DEMATEL

The calculation of selected dimensions weights is not the only objective of the current study as we also want to measure the interrelationship among these dimensions. For analysing the complex causal relationships among various dimensions, DEMATEL is the finest technique and was proposed by Fontela and Gabus in 1972. DEMATE helps in understanding the cause-effect interrelationship among dimensions and in creating a structural model for dimensions (Wu et al., 2018). Therefore, DEMATEL is used heavily in the literature (as shown in Table 2).

Table 2: Application of DEMATEL reported in the recent literature

Author	**Application area**
Bai and Sarkis (2013)	Evaluating business process management CSFs
Büyüközkan and Güleryüz (2016)	Energy resources selection
Bai et al. (2017)	Low-carbon practices in SC
Kumar and Dash (2017)	Evaluation of online reputation management
Bhatia and Srivastava (2018)	Examine of external barriers to remanufacturing
Tseng et al. (2018)	Determine corporate sustainability performance
Wu et al. (2018)	Marketing audit implementation
Kumar et al. (2019)	Evaluating soft dimensions of green SCM
Ahuja et al. (2019)	Evaluating human critical success factors of sustainable manufacturing
Feng and Ma (2020)	Examine service innovation
Song et al. (2020)	Adopting sustainable online consumption

For applying DEMATEL, the mathematical calculations steps are presented in Appendix B.

4. Case Example

In this section, a numerical illustration of the proposed framework is presented by using the case of real-world automotive manufacturer from an emerging economy i.e. India. The data collection, analysis and related results are presented in the following subsections.

4.1 Industrial Background of the Case Company

The case company is a pioneer automotive manufacturer in India. The company holds 108th spot rank in the Forbes list which has helped it to earn a venerable position worldwide. It is assiduous regarding its market share and holds a market share of 46 per cent of the Indian market, making it the most reliable automobile selling brand of the country. With its copious and high-powered network of distributors and service outlets disseminated across the nation, it shares the vision of delivering the best in class automobiles to the society and offering engineering advanced and best-fitted products to customer needs. The vision is translated into reality through its four leading manufacturing plants with a possessing capacity of deploying two-wheelers in numbers more than 7.2 million annually. The company rolls out 17 products to its customers that are scattered across geographic limits. The case company is dedicatedly involved into manufacturing of four-stroke, electric motorcycle and scooters of eclectic engine specifications. Proving to be a paragon in the conventional automobile segment within and outside the country, the case company now endeavours to branch out its portfolio. In an agile fashion, it is now moving ahead in the electric vehicle segment.

The company is actively putting innovative, environment-friendly and connected activities in motion. The company has taken various green initiatives. The company's focus is on upgrading itself via its ESSCM initiatives. The case company's management is determined to single out and analyse the hard dimensions concerning green supply chain. Selected employees from supply chain planning, supply chain innovation, operation, logistics, supplier selection and procurement-related departments of the case company were contacted. These experts were required to fulfil the minimum criteria of holding an experience of more than ten years in respective and related departments, and they should be engineering graduate with a management degree.

Current study focuses upon automobile industry in India. Currently, this industry is contributing 50% towards Indian manufacturing GDP (Khan, 2019). This industry is characterised by strong backward and forward ties with various other key sectors of the economy. Indian automobile exports increased by 14.50% during FY19 and likely to expand at a CAGR of 3.05% through 2016-2026; this industry received Foreign Direct Investment of US$ 22.35 billion during April 2000 to June 2019 (IBEF, 2020). Moreover, this industry is expected to become the leading driver of Make in India campaign (Make in India, 2020) As a result, issue of sustainable operations carries a key importance for automobile industry in India. Consequently, this sector is amongst the early adopters of various green practices to embrace sustainable operations (Khan, 2019). However, it is observed that supply chain operations contribute maximum towards the environmental hazardous caused during the production process (Centre for Science and Environment, 2020). Therefore, the current study is likely to provide important insights to the industry players that are making efforts to minimise their environmental footprints by implementing the system of ESSCM.

4.2 Validation of Dimensions

The dimensions (strategy, technology and policy) that influence ESSCM have been identified earlier thorough literature. However, the practical application of these dimensions may vary from one organisation to the other. Therefore, experts who meet the set criteria of expert selection were contacted separately to check the practical applicability of the identified dimensions in the automobile sector. In order to collect expert opinion and feedback on hard dimensions in the given setting, a survey questionnaire was designed (as shown in Appendix C).

The experts were required to specify whether a dimension is relevant in adopting ESSCM. The flexibility of adding new dimensions was given to the experts. Since experts strongly believe that dimension 'green manufacturing' is part of other dimensions namely 'technologies for cleaner production'. Therefore, these two dimensions were clubbed together into one for further analysis. Moreover, experts found all the eight identified hard dimensions relevant in the given context. In this way, we checked the conceptual and practical applicability of all selected eight hard namely, Lean manufacturing (D1); Total quality management (D2); Supplier relationship management (D3); Technologies for cleaner production (D4); Institutional pressures (D5); Green logistics (D6); Green purchasing (D7); and Innovation (D8).

4.3 Evaluating Dimensions using BWM-DEMATEL

4.3.1 Priority rank of the hard dimensions

After finalisation of the dimensions, another questionnaire was designed (see phase 2 of the questionnaire provided in Appendix C) to collect expert opinions. The experts were asked to select the best (the most desirable) and the worst (less desirable) dimensions among all according to their expertise and experience. Considering these two, they were asked to do a pair-wise comparison with rest other dimensions on a 1-9 scale. The final inputs given by the experts are given in Appendix D (Table D1). Table D2, which is given in Appendix D shows the best dimension selected by the experts and their pair-wise comparison with other dimensions by using a nine-point scale. The experts' preferences others-to-worst dimensions in ESSCM adoption are provided in Appendix D (Table D3).

After collecting data from experts, the Consistency Ratio (CR) is calculated by using Eq. (5). CR values of each expert's matrix are shown in Table D4 (Appendix D). Since all the values are close to zero, it indicates that comparisons are consistent (Rezaei, 2015; Rezaei et al., 2016). Final optimal weights were calculated for all nine experts by using Eq. (1) to Eq. (4). Mean value of respective weights by each expert was calculated for every dimension to ascertain the final weight for all the eight dimensions (as given in Table 3).

Table 3: Final weights for each hard dimension

Dimensions	Weight	Ranking
Lean Manufacturing (D1)	0.161	3
Total Quality Management (D2)	0.250	1
Supplier Relationship Management (D3)	0.125	4
Technologies for Cleaner Production (D4)	0.166	2
Institutional Pressures (D5)	0.063	8
Green Logistics (D6)	0.089	5
Green Purchasing (D7)	0.065	7
Innovation (D8)	0.082	6

'Total Quality Management (D2)' with highest relative weight takes the topmost rank and emerges as the most important dimension. However, Abbas (2020) also indicated that TQM has a remarkably positive impact on corporate's green performance. While, 'Technologies for Cleaner Production (D4)' score 16.6% and 'Lean Manufacturing (D1)' with 16.1% relative weights occupy second and third place, respectively. These results are consistent with the findings of Silva et al. (2019). They have also acknowledged the crucial significance of technologies for cleaner production and lean manufacturing towards attaining higher operational, environmental, financial, and social performance via implementing ESSCM. The priority rank of all the eight dimensions taken in the study are given above in Table 3. ‘Institutional Pressure (D5)’ has attained the last rank in the current analysis indicating the weak significance of this dimension. In an empirical analysis Dubey et al. (2015) also found similar results.

4.3.2 *Causal interrelationships among hard dimensions*

The average matrix of hard dimensions is given in Appendix D (Table D5) that are critical for ESSCM implementation is obtained from expert’s inputs thru Eq. (6). After that, the average direct matrix is converted into a normalised matrix (U) using Eqs (8-9), given in Appendix D (Table D6). Next, the total relation matrix (*T*) is computed through Eqs. (8) and (9), as shown in Appendix D (Table D7). Table 4 shows the impact result by using Eqs. (10) and (11).

Table 4: Impact results of hard dimensions in ESSCM adoption

Dimensions	**R+C**	**R-C**	**Impact**
Lean Manufacturing (D1)	16.269	-1.131	Effect
Total Quality Management (D2)	15.755	0.731	Cause
Supplier Relationship Management (D3)	15.782	-0.075	Effect
Technologies for Cleaner Production (D4)	16.496	0.514	Cause
Institutional Pressures (D5)	16.845	-0.707	Effect
Green Logistics (D6)	15.707	-0.491	Effect
Green Purchasing (D7)	14.341	0.294	Cause
Innovation (D8)	14.984	0.864	Cause

To avoid minor impact, the threshold value (α) is computed by using Eq. (12).

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left[t_{ij}\right]}{N} = 0.986 .$$

To create an interrelationship map among dimensions, all values greater than the threshold are used. Figure 2 demonstrates the graphical cause-effect representation of dimensions and the corresponding digraph.

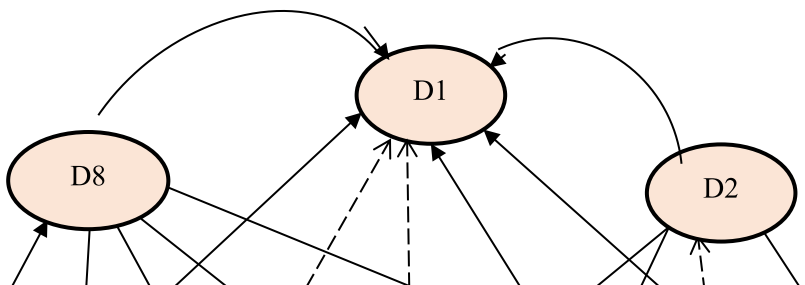

Figure 2: Causal map of the ESSCM oriented hard dimensions

The interrelationship map as pictured in Figure 2 considered only those values that are > the threshold of 0.986. For instance, the total relation matrix (T) i.e. $t_{41}(1.116) > \alpha$ (0.986); this relationship in the digraph is presented using a solid arrow from D4 to D1 indicates that D4 is capable of exerting an impact on D1 whereas, dotted line in the digraph represents the two-way relationship between dimensions. DEMATEL classifies the selected dimensions into two groups: 1) cause and 2) effect. Cause group dimensions have positive (r-c) value and directly impact the other dimensions, therefore decision-makers need to address the variables the join this group. Four out of total eight hard dimensions under consideration for the current study fall in cause group for the set context namely, 'Total Quality Management (D2)'; 'Technologies for Cleaner Production (D4)'; 'Green Purchasing (D7)'; and 'Innovation (D8)' with values of 0.731, 0.514, 0.294 and 0.864, respectively. Whereas, 'Lean Manufacturing (D1)'; 'Supplier Relationship Management (D3)'; 'Institutional Pressures (D5)'; and 'Green Logistics (D6)' belongs to effect group with values -1.131, -0.075, -0.707 and -0.491 in the same order. Feng et al. (2018) have acknowledged green purchasing as important variable which lead to drive other variables such as supplier relationship management. Dahlmann and Roehrich (2019) indicated that supplier relationship management can trigger innovation. However, current analysis identifies innovation as cause group variable and supplier relationship management as effect group variable. Similarly, contrary to current findings, Dey et al. (2019) found lean practices as more important than innovation. Regarding green logistics, our results converge with the findings of Dubey et al (2017). They also observed that green logistics is characterised by lower driving power and higher dependence. DEMATEL results put institutional pressure into effect group. This finding is contradictory to the results of study conducted by Feng et al (2018). They conducted this study in Chinese setting and found institutional pressure (from government) of key significance. However, in India government control is quite less.

5. Discussion and Implications to Business Practice

BWM analysis indicates the first priority rank to the dimension 'Total Quality Management (D2)' and DEMATEL analysis also put it into the cause group. These results fairly indicate the crucial significance of total quality management system for organisations that aspire to adopt ESSCM. Our results regarding this variable fall in line with the existing the literature which indicates that for ESSCM adoption, the total quality management system of an organisation is not only significant in itself but it also influences the other important dimensions that play a key role in ESSCM implementation. Moreover, Figure 2 clearly indicates that total quality management directly influences Lean manufacturing (D1), Supplier relationship management (D3), Technologies for cleaner production (D4), Institutional pressures (D5), and Green logistics (D6) during ESSCM adoption process. Hence, in order to adopt ESSCM to fulfil the commitment towards protecting the environment, managers of the case company need to put in efforts to have a robust and flexible total quality management system in place that complements ESSCM adoption.

With the weight score of 16.6, the dimension 'Technologies for Cleaner Production (D4)' has obtained second priority rank and is also a cause group dimension. ESSCM adoption is required to be embedded in organisational processes; therefore, in order to have a process that is environment friendly, implementation of advance technologies is highly required (Luthra et al., 2016). In addition, Figure 2 demonstrates that D4 impacts D1, D2, D3, D5, and D6. Figure 2 also shows that total quality management and technologies for cleaner production are critical hard dimensions for ESSCM adoption. Moreover, total quality management and technologies for cleaner production together influence other dimensions and exert influence on each other as well.

The hard dimension 'Innovation (D8)' is positioned in a cause group and holds the sixth rank with a weighted score of 8.2. It can be observed from Figure 2 that D8 is a fundamentally significant dimension as it has a spill-over impact on other five hard dimensions (Lean manufacturing (D1), Supplier relationship management (D3), Technologies for cleaner production (D4), Institutional pressures (D5), and Green logistics (D6)) that are critical for ESSCM implementation.

Another cause group dimension is 'Green Purchasing (D8)' and it has obtained the seventh rank among all hard dimensions. Green purchasing is a vital part of ESSCM process and play a decisive role in obtaining superior performance of GSC (Zhu et al., 2017). The interrelationship graph also reveals that this dimension impacts other dimensions also and hence, is an important hard dimension from ESSCM implementation standpoint.

The effect dimensions are 'Lean Manufacturing (D1)', 'Supplier Relationship Management (D3)', 'Institutional Pressures (D5)' and 'Green Logistics (D6)'; and secure third, fourth, eighth and fifth ranks, respectively. A change in these dimensions can be triggered by cause group dimensions. It is clear from Figure 2 that 'Lean Manufacturing (D1)' and 'Institutional Pressures (D5)' get influenced directly by four causal dimensions. Hence, these are quite sensitive dimensions. It can be observed from Figure 2 that 'Supplier Relationship Management (D3)' and 'Green Logistics (D6)' have comparatively smaller distance from the causal group and therefore, these variables are less sensitive towards changes in the cause group dimensions.

Decision-maker is required to have an inclusive understanding of the priority ranks of variables under considerations and cause-effect relationships between them for planning and execution to implement ESSCM in a most appropriate manner. Current work offers support to decision-makers by providing priority ranks and cause-effect relationships between the eight crucial hard dimensions which are expected to play a decisive role in ESSCM adoption by the case company.

5.1 Implications to Practice

The current research provides several insights which can help decision-makers to formulate robust business strategies to facilitate environmentally SSCM adoption. Awareness about supply chain efficiency has grown remarkably over the last two decades due to pressure from stakeholders and government and more importantly because organisations have realised the significance of sustainable and eco-friendly supply chain structures in the wake of growing environment concerns (Zhu et al., 2017). Findings of the current study are likely to help decision-makers in a variety of ways. There are numerous hard dimensions relating to strategy, technology and policy that contribute towards the adoption of ESSCM practices successfully (Su et al., 2016). However, the present research has identified the most significant hard dimensions applicable in ESSCM implementation framework through literature review and experts' inputs. Hence, it is recommended that decision-makers should focus upon these dimensions to achieve the stated objective.

By applying the hybrid approach, current work provides precise information about the relative importance of each hard dimension through their respective priority ranks and their cause-effect interrelationship. All identified dimensions are categorized into two groups i.e. cause and effect. The effect group variables can be modified to the desired state by making changes in the cause group variables. Therefore, managers can optimise their efforts by putting more emphasis on cause dimensions while keeping a tab on the ranking of dimensions in the process of ESSCM implementation in their organisation. For instance, 'Total Quality Management (TQM)' takes first and 'Technologies for cleaner production' holds second priority ranks and both are in cause group which make both the variables very crucial for the purpose of planning. Therefore, managers must remain diligent and careful about strategizing to put a robust and flexible TQM along with most appropriate technologies for cleaner production in place. Therefore, organisations that are thriving to implement ESSCM should remove barriers related to the adoption of technologies for cleaner production and optimise their TQM system.

'Green Purchasing' is also a cause group dimension. Supplier selection is significant for green purchasing. Moreover, organisations should conduct training programs to impart desired knowledge and skills to their employees and trade partners to facilitate the translation of the green concept into practice. For instance, The Coca-Cola Company has established a robust supplier development program to facilitate their supplier to build capabilities and capacity by augmenting their awareness about its environmental commitments. The case company can also plan training programs on similar lines.

The case company also needs to focus upon building a culture that promotes innovative approach at all levels. Although, the dimension 'Innovation (D8)' stands 6th on the priority ranking it is a cause group variable. Moreover, Figure 2 indicates that it influences five other variables (D1, D3, D4, D5 and D6). And this list of variable contains technologies for cleaner production which is a notable cause group variable. And this is to be pointed out here that innovation is the only dimension that has a unidirectional influencing relationship with technologies for cleaner production. This finding has an implication for the government and policymakers also as it's important to find out new ways to look at and address the environmental issues at the topmost level to be able to deal with it effectively and efficiently. 'Green Logistics' and 'Lean Manufacturing' have occupied 5th and 3rd spot in priority ranking and both are falling in effect group. Interestingly, both the dimensions are not influencing rest others but are influenced by the majority of them. Therefore, decision-makers may not focus on working upon these two dimensions but must plan to bring in the other variables in place which will lead to not only cost-effectiveness but also streamlining of these two dimensions.

The current study discovers that institutional pressure is appearing at the bottom in priority ranking table and it is an effect group variable also. The study findings offer an interesting implication for policymakers. As the results indicate that 'Institutional pressure' is not driving this organisation to make effort to move towards environmentally sustainable operations, therefore, government and policymakers should focus on spreading awareness that degrading environment is a cause of concern for everyone and playing a supporting role in helping individual and organisations to transit towards sustainable operations.

Broadly, the current work offers insights for decision-makers at different levels concerning optimised planning around hard dimensions and implementation of these plans to ensure ESSCM adoption in a unique setting of the Indian economy.

6. Impact and Concluding Remarks

Organisations that are intended to put in efforts towards attaining sustainability at a global level are increasingly focusing on ESSCM practices. Such practices are the initiatives taken by firms to minimise the harmful impact of the supply chain activities on the environment. In the current research, a hybrid BWM-DEMATEL approach is used to prioritise ESSCM oriented hard dimensions, and to extract interrelationships among them. At first, key hard dimensions are extracted from literature and subsequently, these dimensions are finalised through expert validation. Data for the current analysis is collected from an Indian automotive company (case company). Current work finds that 'Total Quality Management', 'Technologies for Cleaner Production', 'Green Purchasing' and 'Innovation' are the most critical dimensions; hence, these dimensions must be prioritised over others for efficient ESSCM implementation. In a similar manner, outcomes of the current research provide substantial information to decision-makers to efficiently channelize their effort in order to accomplish ESSCM implementation thru hard dimensions.

The current study carries relevance for all the stakeholders of a business. As business operations impact a variety of entities such as owners, employees, trade partners, government, society, environment etc. The interest of each stakeholder is mutually connected. Results of the current research are likely to help decision-makers to efficiently run a business while working towards enhancing its own sustainability along with minimising the negative effect of supply chain operations on the environment. The current study also provides insights to employees at different levels to understand how they can contribute toward optimising hard dimensions in access to boost organisational sustainability. A sustainable business will generate greater business opportunities for its trade partners; and a stream of consistent profits for investors and owners for the long term. Hence, owners and investors must extend flexibility to managers to formulate strategies to implement ESSCM and suppliers should also join and support organisations to move to green supply chain operations. In a nutshell, the outcome of the current study will enable each stakeholder to comprehensively understand their respective role in driving the identified hard dimensions into the required state and to contribute accordingly towards taking leaps towards sustainability via ESSCM implementation.

The study has few limitations also that can be addressed by researchers in future studies. The current work is based on an Indian automotive company. For generalizability, future studies can take into account multiple companies and also conduct a comparative analysis. In the same context a multi-countries perspectives studies can be conducted in the future. The weights of the dimensions are calculated by BWM but other MCDM methods can be employed for the same and weights comparison can also be performed in future research. Based on the cause-effect model further research can be conducted for the development of the hypothesised model.

References

Abbas, J. (2020). Impact of total quality management on corporate green performance through the mediating role of corporate social responsibility. *Journal of Cleaner Production*, *242*, 118458.

Abdul-Rashid, S. H., Sakundarini, N., Raja Ghazilla, R. A., & Thurasamy, R. (2017). The impact of sustainable manufacturing practices on sustainability performance: Empirical evidence from Malaysia. *International Journal of Operations & Production Management*, *37*(2), 182-204.

Agi, M. A., & Nishant, R. (2017). Understanding influential factors on implementing green supply chain management practices: An interpretive structural modelling analysis. *Journal of Environmental Management, 188*, 351-363.

Ahmad, W. N. K. W., Rezaei, J., Sadaghiani, S., & Tavasszy, L. A. (2017). Evaluation of the external forces affecting the sustainability of oil and gas supply chain using Best Worst Method. *Journal of Cleaner Production, 153*, 242-252.

Ahmadi, H. B., Kusi-Sarpong, S., & Rezaei, J. (2017). Assessing the social sustainability of supply chains using Best Worst Method. *Resources, Conservation and Recycling, 126*, 99-106.

Ahuja, J., Panda, T. K., Luthra, S., Kumar, A., Choudhary, S., & Garza-Reyes, J. A. (2019). Do human critical success factors matter in adoption of sustainable manufacturing practices? An influential mapping analysis of multi-company perspective. *Journal of Cleaner Production*, *239*, 117981.

Alonso, L., Rubio, E. M., de Agustina, B., & Domingo, R. (2017). Latest clean manufacturing trends applied to a world class manufacturing management for improving logistics and environmental performance. *Procedia Manufacturing*, *13*, 1151-1158.

Altuntas, S., & Dereli, T. (2015). A novel approach based on DEMATEL method and patent citation analysis for prioritising a portfolio of investment projects. *Expert Systems with Applications, 42*(3), 1003-1012.

Andersén, J., Jansson, C., & Ljungkvist, T. (2019). Can environmentally oriented CEOs and environmentally friendly suppliers boost the growth of small firms?. *Business Strategy and the Environment, 29*(2), 325-334.

Bag, S., Gupta, S., & Telukdarie, A. (2018). Importance of innovation and flexibility in configuring supply network sustainability. *Benchmarking: An International Journal*, *25*(9), 3951-3985.

Bai, C., Sarkis, J., & Dou, Y. (2017). Constructing a process model for low-carbon supply chain cooperation practices based on the DEMATEL and the NK model. *Supply Chain Management: An International Journal, 22*(3), 237-257.

Bai, C., Satir, A., & Sarkis, J. (2019). Investing in lean manufacturing practices: an environmental and operational perspective. *International Journal of Production Research*, *57*(4), 1037-1051.

Bhandari, D., Singh, R. K., & Garg, S. K. (2019). Prioritisation and evaluation of barriers intensity for implementation of cleaner technologies: Framework for sustainable production. *Resources, Conservation and Recycling*, *146*, 156-167.

Bhatia, M. S., & Srivastava, R. K. (2018). Analysis of external barriers to remanufacturing using grey-DEMATEL approach: An Indian perspective. *Resources, Conservation and Recycling*, *136*, 79-87.

Büyüközkan, G., & Güleryüz, S. (2016). An integrated DEMATEL-ANP approach for renewable energy resources selection in Turkey. *International Journal of Production Economics, 182*, 435-448.

Centre for Science and Environment (2020): https://www.cseindia.org/is-the-indian-automobile-sector-as-environmentally-conscious-as-best-in-the-world-287) (Assessed on 7-05-2020)

Chen, D., Demirbag, M., Ignatius, J., Marra, M., Sun, D., Zhan, S., & Zhou, C. (2018). Reverse logistics pricing strategy for a green supply chain: A view of customers' environmental awareness. *International Journal of Production Economics, 217*, 197-210.

Cousins, P. D., Lawson, B., Petersen, K. J., & Fugate, B. (2019). Investigating green supply chain management practices and performance. *International Journal of Operations & Production Management, 39*(5), 767-786.

Cseindia (2018), *"India at the bottom of 2018 Global Environmental Performance Index (EPI) rankings"* https://www.cseindia.org/india-at-the-bottom-of-2018-global-environmental-performance-indeax-epi-rankings-says-yale-university-study-analysed-by-cse-8780 (accessed at 22-07-2019).

Dahlmann, F., & Roehrich, J. K. (2019). Sustainable supply chain management and partner engagement to manage climate change information. *Business Strategy and the Environment*, *28*(8), 1632-1647.

Dallasega, P., & Sarkis, J. (2018). Understanding greening supply chains: Proximity analysis can help. *Resources, Conservation and Recycling, 139*, 76-77.

de Sousa Jabbour, A. B. L., Jabbour, C. J. C., Foropon, C., & Godinho Filho, M. (2018). When titans meet–Can industry 4.0 revolutionise the environmentally-sustainable manufacturing wave? The role of critical success factors. *Technological Forecasting and Social Change, 132*, 18-25.

Delhi, S. I. N. (2015). Automotive mission plan 2016–2026—a curtain raiser. *Auto Tech Review*, *4*(10), 18-21.

Dey, P. K., Malesios, C., De, D., Chowdhury, S., & Abdelaziz, F. B. (2019). Could lean practices and process innovation enhance supply chain sustainability of small and medium-sized enterprises?. *Business Strategy and the Environment*, *28*(4), 582-598.

Dubey, R., Gunasekaran, A., & Ali, S. S. (2015). Exploring the relationship between leadership, operational practices, institutional pressures and environmental performance: A framework for green supply chain. *International Journal of Production Economics*, *160*, 120-132.

Dubey, R., Gunasekaran, A., & Papadopoulos, T. (2017). Green supply chain management: theoretical framework and further research directions. *Benchmarking: An International Journal, 24*(1), 184-218.

Dubey, R., Gunasekaran, A., Papadopoulos, T., Childe, S. J., Shibin, K. T., & Wamba, S. F. (2017). Sustainable supply chain management: framework and further research directions. *Journal of Cleaner Production*, *142*, 1119-1130.

Feng, G. C., & Ma, R. (2020). Identification of the factors that influence service innovation in manufacturing enterprises by using the fuzzy DEMATEL method. *Journal of Cleaner Production*, 120002.

Feng, M., Yu, W., Wang, X., Wong, C. Y., Xu, M., & Xiao, Z. (2018). Green supply chain management and financial performance: The mediating roles of operational and environmental performance. *Business Strategy and the Environment*, *27*(7), 811-824.

Gandhi, N. S., Thanki, S. J., & Thakkar, J. J. (2018). Ranking of drivers for integrated lean-green manufacturing for Indian manufacturing SMEs. *Journal of Cleaner Production*, *171*, 675-689.

Golicic, S. L., & Smith, C. D. (2013). A meta-analysis of environmentally sustainable supply chain management practices and firm performance. *Journal of Supply Chain Management*, *49*(2), 78-95.

Govindan, K., Shankar, K. M., & Kannan, D. (2020). Achieving sustainable development goals through identifying and analyzing barriers to industrial sharing economy: A framework development. *International Journal of Production Economics, 227,* 107575.

Gupta, H., & Barua, M. K. (2016). Identifying enablers of technological innovation for Indian MSMEs using best–worst multi criteria decision making method. Technological Forecasting and Social Change, 107, 69-79.

IBEF (2019), "*About Indian Economy Growth Rate & Statistics*" https://www.ibef.org/economy/indian-economy-overview (accessed at 26-07-2019).

IBEF (2020), Automobile Industry in India: https://www.ibef.org/industry/india-automobiles.aspx. (Assessed on 7-05-2020)

ICAT (2019). ICAT - A World Class Automotive Testing Centre http://pib.nic.in/newsite/PrintRelease.aspx?relid=189887 (accessed at 22-07-2019).

Kauppi, K., & Hannibal, C. (2017). Institutional pressures and sustainability assessment in supply chains. *Supply Chain Management: An International Journal, 22*(5), 458-472

Khan, S. (2019), Reinventing the wheel: The constant transformation of India's auto sector: https://economictimes.indiatimes.com/small-biz/sme-sector/reinventing-the-wheel-the-constant-transformation-of-indias-auto-sector/articleshow/71916541.cms (Assessed on 7-05-2020)

Kumar, A., & Dash, M. K. (2017). Causal modelling and analysis evaluation of online reputation management using fuzzy Delphi and DEMATEL. *International Journal of Strategic Decision Sciences, 8*(1), 27-45.

Kumar, A., Mangla, S. K., Luthra, S., & Ishizaka, A. (2019). Evaluating the human resource related soft dimensions in green supply chain management implementation. *Production Planning & Control*, *30*(9), 699-715.

Kumar, A., Moktadir, A., Liman, Z. R., Gunasekaran, A., Hegemann, K., & Khan, S. A. R. (2020). Evaluating sustainable drivers for social responsibility in the context of ready-made garments supply chain. *Journal of Cleaner Production*, 119231.

Livemint (2019), "The growing threat of climate change in India" https://www.livemint.com/news/india/the-growing-threat-of-climate-change-in-india-1563716968468.html (accessed at 26-07-2019).

Luthra, S., Garg, D., & Haleem, A. (2016). The impacts of critical success factors for implementing green supply chain management towards sustainability: an empirical investigation of Indian automobile industry. *Journal of Cleaner Production, 121*, 142-158.

MacKay & Company (2018), "The future of mobility in India's passenger-vehicle market" https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-future-of-mobility-in-indias-passenger-vehicle-market (accessed at 22-07-2019).

Make in India (2020) https://www.makeinindia.com/sector/automobiles. (Assessed on 7-05-2020) (Assessed on 7-05-2020)

Malviya, R. K., Kant, R., & Gupta, A. D. (2018). Evaluation and selection of sustainable strategy for green supply chain management implementation. *Business Strategy and the Environment*, *27*(4), 475-502.

Mani, M., Bandyopadhyay, S., Chonabayashi, S., Markandya, A., & Mosier, T. (2018). *South Asia's Hotspots: The Impact of Temperature and Precipitation Changes on Living Standards*. The World Bank (accessed at 22-07-2019).

Meera, B. L. L., & Chitramani, P. (2016). Casual Effect of Between Lean and Green Supply Chain Management Practices on Environmental Performance of Manufacturing Firms. *International Journal of Management & Business Studies, 6*(2), 270-276.

Mishra, R., & Mishra, O. N. (2019). Prioritising dimensions of entrepreneurial orientation for supply chain flexibility development in an uncertain environment. *Journal of Manufacturing Technology Management, 30*(2), 483-505.

Mosayebi, A., Ghorbani, S., & Masoomi, B. (2020). Applying fuzzy delphi and best-worst method for identifying and prioritizing key factors affecting on university-industry collaboration. *Decision Science Letters*, *9*(1), 107-118.

Muduli, K. K., Luthra, S., Kumar Mangla, S., Jabbour, C. J. C., Aich, S., & de Guimarães, J. C. F. (2020). Environmental management and the "soft side" of organisations: Discovering the most relevant behavioural factors in green supply chains. *Business Strategy and the* Environment, 29(4), 1647-1665

Neutzling, D. M., Land, A., Seuring, S., & do Nascimento, L. F. M. (2018). Linking sustainability-oriented innovation to supply chain relationship integration. *Journal of Cleaner Production*, *172*, 3448-3458.

Online available at: *Dramatic growth in-laws to protect environment, but widespread failure to enforce, finds report"* https://www.unenvironment.org/news-and-stories/press-release/dramatic-growth-laws-protect-environment-widespread-failure-enforce.

Orji, I. J., & Wei, S. (2015). Dynamic modeling of sustainable operation in green manufacturing environment. *Journal of Manufacturing Technology Management*, *26*(8), 1201-1217.

Pandey , K. (2019) report:https://www.downtoearth.org.in/news/mining/this-un-report-shows-green-laws-remain-in-books-63039). (Assessed on 7-05-2020)

Parveen, C. M., Kumar, A. P., & Rao, T. N. (2011, December). *Integration of lean and green supply chain-Impact on manufacturing firms in improving environmental efficiencies*. In Green Technology and Environmental Conservation (GTEC 2011), 2011 International Conference on (pp. 143-147). IEEE.

Petljak, K., Zulauf, K., Štulec, I., Seuring, S., & Wagner, R. (2018). Green supply chain management in food retailing: survey-based evidence in Croatia. *Supply Chain Management: An International Journal*, *23*(1), 1-15.

Piercy, N., & Rich, N. (2015). The relationship between lean operations and sustainable operations. *International Journal of Operations & Production Management*, *35*(2), 282-315.

Rezaei, J. (2015). Best-worst multi-criteria decision-making method. *Omega*, *53*, 49-57.

Rezaei, J. (2016). Best-worst multi-criteria decision-making method: Some properties and a linear model. *Omega*, *64*, 126-130.

Seth, D., Shrivastava, R. L., & Shrivastava, S. (2016). An empirical investigation of critical success factors and performance measures for green manufacturing in cement industry. *Journal of Manufacturing Technology Management*, *27*(8), 1076-1101.

Sharma, V., Garg, S. K., & Sharma, P. B. (2016). Identification of major drivers and roadblocks for remanufacturing in India. *Journal of cleaner production*, *112*, 1882-1892.

Shojaei, P., Haeri, S. A. S., & Mohammadi, S. (2018). Airports evaluation and ranking model using Taguchi loss function, best-worst method and VIKOR technique. *Journal of Air Transport Management*, *68*, 4-13.

Silva, G. M., Gomes, P. J., & Sarkis, J. (2019). The role of innovation in the implementation of green supply chain management practices. *Business Strategy and the Environment*, *28*(5), 819-832.

Singh, M., Brueckner, M., & Padhy, P. K. (2015). Environmental management system ISO 14001: effective waste minimisation in small and medium enterprises in India. *Journal of Cleaner Production*, *102*, 285-301.

Singla, A., Ahuja, I. S., & Sethi, A. S. (2018). An examination of effectiveness of technology push strategies for achieving sustainable development in manufacturing industries. *Journal of Science and Technology Policy Management, 10*(1), 73-101.

Tseng, M. L., Islam, M. S., Karia, N., Fauzi, F. A., & Afrin, S. (2019). A literature review on green supply chain management: Trends and future challenges. *Resources, Conservation and Recycling, 141*, 145-162.

Tseng, M. L., Lim, M. K., & Wu, K. J. (2018). Corporate sustainability performance improvement using an interrelationship hierarchical model approach. *Business Strategy and the Environment*, 27(8), 1334-1346.

Varela, L., Araújo, A., Ávila, P., Castro, H., & Putnik, G. (2019). Evaluation of the relation between lean manufacturing, Industry 4.0, and sustainability. *Sustainability*, *11*(5), 1439.

Vargas, J. R. C., Mantilla, C. E. M., & de Sousa Jabbour, A. B. L. (2018). Enablers of sustainable supply chain management and its effect on competitive advantage in the Colombian context. *Resources, Conservation and Recycling*, *139*, 237-250.

Vijayvargy, L., Thakkar, J., & Agarwal, G. (2017). Green supply chain management practices and performance: the role of firm-size for emerging economies. *Journal of Manufacturing Technology Management*, 28(3), 299-323.

Wicki, S., & Hansen, E. G. (2019). Green technology innovation: Anatomy of exploration processes from a learning perspective. *Business Strategy and the Environment*, 28(6), 970-988.

Yadav, G., Mangla, S. K., Luthra, S., & Jakhar, S. (2018). Hybrid BWM-ELECTRE-based decision framework for effective offshore outsourcing adoption: a case study. *International Journal of Production Research*, 56(18), 6259-6278.

Yang, D., Jiang, W., & Zhao, W. (2019). Proactive environmental strategy, innovation capability, and stakeholder integration capability: A mediation analysis. *Business Strategy and the Environment*, 28(8), 1534-1547.

Yu, Y., Zhang, M., & Huo, B. (2017). The impact of supply chain quality integration on green supply chain management and environmental performance. *Total Quality Management & Business Excellence*, 1-16 (in press).

Yun, G., Yalcin, M. G., Hales, D. N., & Kwon, H. Y. (2019). Interactions in sustainable supply chain management: a framework review. *The International Journal of Logistics Management, 30*(1), 140-173

Zhu, Q., Qu, Y., Geng, Y., & Fujita, T. (2017). A comparison of regulatory awareness and green supply chain management practices among Chinese and Japanese manufacturers. *Business Strategy and the Environment*, 26(1), 18-30.

Appendix A

BWM calculation process:

Step 1. Identify the set of decision dimensions$(D_1, D_2, \ldots\ldots, D_n)$.

Step 2. Identify the most and least preferred dimensions among all.

Step 3. Identify the best dimension over others based on 1-9 scale, the resultant of best-to-others would be:

$$A_B = (a_{B1}, a_{B1}, \ldots\ldots, a_{Bn)}, \quad (1)$$

Where, a_{Bj} indicates the best dimension *B* over dimension j.

Step 4. Identify the worst dimension, where, 1 for the worst dimension and 9 for the most important, the others-to-worst would be:

$$A_w = (a_{1w}, a_{1w}, \ldots\ldots, a_{nw)}T, \quad (2)$$

Where, a_{jw} indicates the dimension *j* over the worst dimension *W*.

Step 5. Calculate the weight of each dimension. The problem statement is written as:

$$\min \max_j \{|w_B - a_{Bj}w_j|, \ |w_j - a_{jw}w_w|\}$$

subject to

$$\sum_j \mathrm{w}_j = 1, \quad (3)$$

$$w_j \ \geq 0 \ for \ all \ j$$

We can solve this by converting its linear programming formulation as under:

Min ξ^*

Subjected to

$$|w_B - a_{Bj}w_j| \leq \xi, for \ all \ j$$

$$|w_j - a_{jw}w_w| \leq \xi, for \ all \ j$$

$$\sum_j \mathrm{w}_j = 1$$

$$w_j \ \geq 0 \ for \ all \ j \quad (4)$$

The model (4) is a linear programming problem and must have a unique solution.

By carrying out the above-mentioned steps, the optimal weights $(w_1^*, w_2^*, \ldots, w_n^*)$ are obtained. Taking help from Consistency Index (*CI*) as shown in Appendix A.2, we can estimate the consistency ratio (CR), using ξ^* and the corresponding consistency index, as below:

$$\mathrm{CR} = \frac{\xi^*}{CI} \tag{5}$$

A value of *CR* which is closer to zero indicates higher consistency.

Appendix B

DEMATEL calculation process:

Step 1. Recognize the dimensions for the research.

Step 2. Frame the direct relation matrix. The decision makers are requested to evaluate the influence among the n dimension ($i, j = 1, \ldots n$) on a scale from 0 to 4 (0 = no influence and 4 = very high influence). Next, the average direct relation matrix (a_{ij}) is formed using Eq.(6):

$$a_{ij} = \frac{1}{H}\sum_{k=1}^{H} x_{ij}^{k} \text{ where } H \text{ is number of experts with } 1 \leq k \leq H \tag{6}$$

Step 3. Prepare a normalized matrix by using Eqs.(5-6):

$$U = k \times A, \tag{7}$$

$$k = \min\left(\frac{1}{\max_i\left(\sum_{i=1}^{n} a_{ij}\right)}, \frac{1}{\max_j\left(\sum_{j=1}^{n} a_{ij}\right)}\right), i, j = 1, 2, \ldots\ldots n. \tag{8}$$

Step 4. Compute the total relation matrix (*T*) using Eq.(9).

$$T = U(I - U)^{-1} \tag{9}$$

Total sum of rows and columns of the *T* matrix, are obtained by Eqs.(8-9) as below:

$$r = [r_i]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} \tag{10}$$

$$c = [c_i]_{1\times n} = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} \quad (11)$$

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 by Eq.(12).

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}[t_{ij}]}{N} \quad (12)$$

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

Appendix C

Phase 1 - Validation of hard dimensions questionnaire

Greetings!!!!

Dear respondent, present research aims to evaluate the significance of dimensions (strategy, technology and policy - related) on the subject of Environmentally Sustainable Supply Chain Management (ESSCM) implementation. We have identified the below mentioned dimensions through current literature. Please provide your response (0 signifies irrelevance and 1 signifies relevance) regarding the applicability of these dimensions concerning ESSCM implementation. Kindly add/delete/rephrase/merge the dimensions.

Hard dimensions to ESSCM adoption	**Response**
Lean Manufacturing	
Total Quality Management	
Supplier Relationship Management	
Technologies for Cleaner Production	
Institutional Pressures	
Green Logistics	
Green Purchasing	
Innovation	
If you want to mention any other specific dimension	
If you want to mention any other specific dimension	

Phase 2 - Evaluating the hard dimensions

Dear respondent, present study seeks to explore the significance of dimensions (strategy, technology and policy) regarding ESSCM implementation. Please select and place the most important dimension from the given list of eight hard dimensions in the first column and compare the most important dimension with the rest others on a scale of 1-9.

The most important dimension	
Lean Manufacturing	
Total Quality Management	
Supplier Relationship Management	
Technologies for Cleaner Production	
Institutional Pressures	
Green Logistics	
Green Purchasing	
Innovation	

Subsequently, please select the least important dimension and compare it with the remaining dimensions on a scale of 1-9.

The least important dimension	
Lean Manufacturing	
Total Quality Management	
Supplier Relationship Management	
Technologies for Cleaner Production	
Institutional Pressures	
Green Logistics	
Green Purchasing	
Innovation	

Causal interrelationships among hard dimensions using DEMATEL

Dear respondent, we also seek to determine the interrelationships among the stated dimensions ((strategy, technology and policy) regarding ESSCM implementation. For this purpose, the following questionnaire is prepared to measure the interrelationship among these dimensions on a 0-4 scale. Please tick (√) in the appropriate box. ("4 = Very high influence" to "0 = No influence")

With respect to: *The Overall Goal*	**Compare the influence of one dimension over another**																																							
Main dimensions → *Main dimensions* ↓	Lean Manufacturing					Total Quality Management					Supplier Relationship Management					Technologies for Cleaner Production					Institutional Pressures					Green Logistics					Green Purchasing					Innovation				
	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0
Lean Manufacturing	0																																							
Total Quality Management						0																																		
Supplier Relationship Management											0																													
Technologies for Cleaner Production																0																								
Institutional Pressures																					0																			
Green Logistics																										0														
Green Purchasing																															0									
Innovation																																				0				

Appendix D

Table D1: Identified best/worst dimensions in ESSCM adoption

Dimensions	Identified as 'Best' by the experts	Identified as 'Worst' by the experts
D1	2, 5	8, 9
D2	3, 4, 7, 8	
D3	1	
D4	6, 8	
D5		1, 2, 3, 4, 5, 6, 7
D6		
D7		
D8		

Table D2: Best to other dimensions in ESSCM adoption

Experts	Best	D1	D2	D3	D4	D5	D6	D7	D8
1	D3	3	2	1	5	6	3	4	4
2	D1	1	2	7	3	8	6	5	4
3	D2	2	1	3	4	9	6	5	3
4	D2	3	1	3	5	6	5	5	5
5	D1	1	2	5	3	8	4	6	7
6	D4	7	5	3	1	6	4	8	2
7	D2	2	1	7	8	4	3	6	5
8	D2	8	1	4	2	5	6	7	3
9	D4	9	2	3	1	6	4	5	2

Table D3: Others-to-worst dimensions in ESSCM adoption

Experts	1	2	3	4	5	6	7	8	9
Worst	D5	D8	D8	D8	D8	D8	D8	D1	D1
D1	3	5	5	5	8	6	6	1	1
D2	5	5	6	5	7	7	7	7	8
D3	5	4	4	4	4	4	4	6	7
D4	4	3	4	4	6	5	5	4	9
D5	1	1	1	1	1	1	1	5	4
D6	3	2	3	2	5	3	3	2	5
D7	3	2	2	2	3	2	2	3	6
D8	4	3	4	3	2	8	8	8	8

Table D4: Consistency analysis

Experts	A_{BW}	ξ*	CR
1	6	0.222	0.060
2	8	0.125	0.042
3	9	0.319	0.071
4	6	0.338	0.076
5	8	0.330	0.074
6	8	0.315	0.071
7	8	0.189	0.042
8	8	0.301	0.067
9	9	0.331	0.062

Table D5: Average matrix of hard dimensions in ESSCM adoption

Dimensions	D1	D2	D3	D4	D5	D6	D7	D8
D1	0.111	2.889	2.889	2.444	3.111	3.111	2.778	2.000
D2	2.556	0.222	2.889	3.111	3.333	3.333	3.000	2.778
D3	3.000	3.222	0.000	3.222	3.222	3.222	1.444	2.667
D4	2.889	2.889	3.222	0.000	3.667	3.333	2.889	3.111
D5	3.000	2.667	3.222	3.556	0.000	2.667	2.333	3.222
D6	2.889	3.000	3.000	2.889	3.444	0.000	1.889	2.222
D7	5.556	1.444	2.222	2.556	2.444	2.111	0.000	1.778
D8	2.778	2.667	2.778	2.667	3.556	3.000	2.889	0.000

Table D6: Normalized initial direct-relation matrix

Dimensions	D1	D2	D3	D4	D5	D6	D7	D8
D1	.005	.127	.127	.107	.137	.137	.122	.088
D2	.112	.010	.127	.137	.146	.146	.132	.122
D3	.132	.141	.000	.141	.141	.141	.063	.117
D4	.127	.127	.141	.000	.161	.146	.127	.137
D5	.132	.117	.141	.156	.000	.117	.102	.141
D6	.127	.132	.132	.127	.151	.000	.083	.098
D7	.244	.063	.098	.112	.107	.093	.000	.078
D8	.122	.117	.122	.117	.156	.132	.127	.000

Table D7: Total relation matrix (*T*)

Dimensions	D1	D2	D3	D4	D5	D6	D7	D8
D1	0.944	0.924	0.969	0.961	1.067	0.995	0.866	0.844
D2	1.124	0.891	1.045	1.061	1.160	1.080	0.942	0.940
D3	1.086	0.969	0.890	1.021	1.109	1.034	0.847	0.898
D4	1.167	1.024	1.087	0.970	1.204	1.111	0.964	0.978
D5	1.116	0.971	1.038	1.056	1.011	1.038	0.901	0.938
D6	1.054	0.934	0.978	0.981	1.085	0.880	0.838	0.857
D7	1.118	0.845	0.916	0.932	1.011	0.930	0.758	0.807
D8	1.092	0.954	1.005	1.009	1.127	1.031	0.906	0.799

Appendix E

Table E1: Consistency index

a_{BW}	1	2	3	4	5	6	7	8	9
CI (max ξ)	0	0.44	1	1.63	2.3	3	3.73	4.47	5.32