Analysing the Inhibitors of Complexity for Achieving Sustainability and Improving Sustainable Performance of Petroleum Supply Chain

Pradeep Kumar Tarei, Pushpendu Chand, Rajan Kumar Gangadhari, Anil Kumar

Abstract

In the era of business sustainability, the modern supply chain is becoming complex due to several inhibitors such as uncertainty in the market, technological innovation, environmental protocols, cross-border trade regulations, and the involvement of many stakeholders. In the existing literature, very limited discussion to study the inhibitors of supply chain complexity (SCC) for achieving sustainability. Therefore, the purpose of the study is to analyse the inhibitors to SCC and supply chain sustainability (SCS) jointly and examine the underlying relationship for improving sustainable performance in the context of the Petroleum Supply Chain (PSC) which is arguably one of the complex sectors with significant impact on environment and sustainability. The inhibitors to SCC and SCS are identified through extensive literature review and experts' opinions. Through a structured questionnaire, data was collected from PSC experts. An integrated approach of analytic hierarchy process (AHP) and interpretive structural modelling (ISM) is proposed to prioritize and examine the underlying relationship between inhibitors. This study explores the driving and dependence power of the inhibitors. The results indicate that most of the SCS inhibitors, such as institutional pressures (laws and regulations), strategic lack of strategic supplier alliance, market threat, act as drivers of SCC inhibitors, such as technological complexity, horizontal complexity, and complexity of customers. The findings of the study would help the supply chain managers and the policymakers of the petroleum sector to take better decision to overcome the challenges for achieving sustainability in PSC.

Keywords: Petroleum Supply Chain; Environment and sustainability; Complexity, Business Strategy; Interpretive structural modelling, performance

1. Introduction

In the present era of highly competitive global markets, supply chain (SC) is experiencing various risks related to sustainability. Hence prioritising risks and barriers for attaining supply chain sustainability (SCS) is gaining interest from both scholars and practitioners in the last decade (Moktadir et al., 2020). Maintaining financial profits along with sustainability goals while fulfilling the desired level of customer service is becoming difficult. (Lis et al., 2020; Dubey et al., 2020; Majumdar and Sinha, 2019; Ahmad et al., 2017; Oelze, 2017). Sustainability as a research discipline has been gaining attention in supply chain literature due to the evolving paradigms like circular economy, environmental sustainability, social responsibility, and reduction in carbon footprints (Hussain and Malik, 2020; Bier et al., 2020). Further, to cope up with the global competition, modern supply chains have expanded their levels of participation from the focal company, to their suppliers, customers, and primary and secondary customers of those suppliers (Dubey et al., 2020).

Complexity can be defined as overwhelming interactions and interdependencies among various entities of SC participating in SC processes (Surana et al., 2005). The increasing supply chain complexity (SCC) results in SC disruption (Bode and Wagner, 2015), rising SC cost (De Leeuw et al., 2013), inferior customer service (Manuj and Sahin, 2011) and reduced capital utilization, etc. (Xiaoxiao and Zikui, 2019). Many corporate reports revealed that "Complexity is the new challenge that companies must face to maintain the supply chain flow" (Gonclaves, 2020; Alicke and Strigel, 2020). A recent Gartner's survey suggests that 89% of companies have experienced supplier risk event in the last five years. It highlighted that SC disruption is one of the leading drivers causing the transformation in the supply chain balancing the costs and efficiencies. The survey found that 30% of supply chain leaders have no or low maturity for sustainability initiatives whereas 36% per cent of the respondents consider the tremendous increase of SCC as the most critical risk to operational planning (Gartner, 2020).

In the era of sustainability, complexity in SC has also been increasing due to several reasons. External forces such as market uncertainty, cross-country trade commitments, and geography-specific legal restrictions have led global SC into complex situations. On the customer side, desire for personalized (customized) product and service, ever-changing customer demand and the consumer's preference towards sustainability have increased the competition among the SCs on a global scale (Kavilal et al., 2017, 2018; Bode and Wagner, 2015;

Gunasekaran et al., 2014; Gerschberger and Hohensinn, 2013). Hence, SC practitioners and academicians have examined the SCC and expressed it as crucial inhibitors in attaining business objectives (Bozarth et al., 2009; Choi and Krause, 2006; Mariotti, 2007). Serdarasan (2013) mentions that a firm can increase its performance and customer satisfaction with effective management of SCC.

Researchers have identified the inhibitors of supply chain sustainability (SCS), their mutual interaction, and overall impact on SC performance (Dubey et al., 2016; Ahi et al., 2018; Shareef et al., 2019; Centobelli et al., 2020). Depending on their origin and overall impact on the organization, SCS inhibitors are mainly categorized into external and internal categories (Varsei, 2016). Strategic supplier inclusion (Kumar and Rahman, 2016), SC cooperation (Chen et al., 2017), government and statuary institutions, international guidelines, consumer preference, top-level corporate policy (Saeed and Kersten, 2019) and pressure from stakeholders (Meixell and Luoma, 2015) are a few frequently discussed SCS inhibitors in the literature.

The increasing importance of sustainability and complexity inhibitors in the overall SC performance context has been highlighted by a few recent studies. For instance, Zayed and Yaseen (2020) explored the barriers and analysed the interrelationship to sustainable SC management execution in Egyptian firms. Chirra et al. (2020) examined the obstacles to flexibility in the supply chains of Indian automobiles from a sustainability perspective. Kumar et al. (2021) analysed nine inhibitors of sustainability in conjunction with fifteen criteria of Industry 4.0 in the context of small and medium scale auto ancillaries situated in northern India. Narwane et al. (2020) analyzed thirty-eight barriers to sustainable development in biofuel SC in India. Soni et al. (2020) identified the sustainable barriers to the Indian marble and stone industry. Like sustainability, complexity has also achieved significant research attention in recent years. Schneider et al. (2016) used social system theory to manage environmental complexity in an organization. Birkie and Trucco (2020) examined the impact of supply chain complexity on disruption and a firm's resilience capability. Ates et al. (2020) performed a meta-analysis to assess the impact of SCC on firm performance. Piya et al. (2020) identified twenty-three drivers of SCC and obtained the interrelationship between them.

However, to the best of our knowledge, there are very few studies that have simultaneously considered SCC and SCS. Firstly, Macchion et al. (2020) investigated the sustainable alternatives of an SC by considering the static complexity. Secondly, Chand et al.

(2020) considered the impact of the drivers of both SCC and SCS on the firm performance for mining and earthmoving equipment manufacturers. The combined study of SCC and SCS inhibitors seems to be very recent, and still in a nascent stage with no meaningful mention of SC of the process industry. Keeping the aforementioned research limitations in high regard, this research attempts to derive a mutual relationship between the inhibitors of SCC and SCS in the case of a petroleum SC. The importance of the considered case industry is discussed in the following section.

Unlike other industries, the petroleum supply chain (PSC) is a long network comprises of multiple processes like exploration, refining, transportation, processing and marketing, the hazardous nature of chemicals associated with PSC makes it much complex and sensitive to risk (Fernandes et al., 2011). Petroleum products are the backbone of the transportation industry for many countries (Gangadhari et al., 2020). The following section highlights a few critical issues in the context of PSC.

1. Due to the nature of business operations, PSC is inherently complex. For instance, huge capital investment for exploration, the establishment of offshore plants, exposure to harsh weather conditions, a huge cost for maintenance and monitoring, makes the PSC is very complex and vulnerable to risks. (Alfaqiri et al., 2019; Stewart, 2016).
2. Involvement of nonlinear relationship between factors in the PSC: managing relationships with international clients, production management according to the demand from global markets, political and financial risks, fluctuations in exchange rates are unpredictable and result in SC complexity and uncertainty (Tarei et al., 2018; Varma et al., 2007).
3. Various trade-off issues such as issues in regional cooperation bodies (eg. OPEC), uncertainty in the crude oil prices, limited supply vs high demand, and also transportation constraints etc. (Sinha et al, 2011).
4. The recent global move towards green -fuels to reduce the carbon emissions towards achieving the goals of sustainability have also provoked petroleum companies to develop environment-friendly fuels thus creating enormous pressures on the existing infrastructure and operations etc. (Abubakar, 2014).

The emerging interest in the sustainability of the Petroleum industry has attracted global research interest (Tarei et al., 2020a; Tarei et al., 2020b; Zhang and Yousaf, 2020; Sheel et al., 2020). However, a few of the existing literature have discussed the barriers and inhibitors of sustainability in the context of the oil and gas sectors. For instance, Gardas et al., (2019) mentioned regulatory pressure from central /state government and/or regulatory body creates inter-business competition, shareholders, and investors pressure. Regulatory pressure is the principal determinant that induces the firm to adhere to eco-friendly design norms such as a reduction in hazardous emissions, recycling and reusing of materials and products. Raut et al. (2018) reported the following four driving forces for implementing sustainable practices in petroleum industries, 1) Statutory regulations, 2) lack of knowledge and training to adapt sustainability norms, 3) financial constraints for adopting modern technology, development of IT infrastructure and high initial investments with slow ROI; and 4) Management commitment and leadership capability by employee empowerment, teamwork, incentives and reward systems. Maleki and Rosiello (2019) empirically evaluated the effect of knowledge base complexity on spatial innovation of upstream petroleum industries. Since there is a lot of scopes to reduce operational cost by managing the complexity Bimha et al., (2020) and Wilding et al., (2012) indicated complexity as one of five major challenges for the petroleum industries.

This study aims to provide a decision-making framework to determine the dynamic relationship between the SCC and SCS inhibitors in response to all the research issues and constraints mentioned above. In addition, to address the following research questions, an Indian PSC case was considered a viable case study.

RQ1: What are the critical inhibitors to SCC and SCS, and what are their importance (priority values)?

RQ2: What is the mutual inter-relationship between inhibitors of SCC and SCS and how does that affect the overall SC performance?

RQ3: What is the driving-dependent relationship structure of the SCC and SCS inhibitors?

The following research objectives are formulated to answers the above-mentioned research questions:

- To identify the critical inhibitors to SCC and SCS, and their importance (priority values)
- To understand the mutual inter-relationship between inhibitors of SCC and SCS and how does that affect the overall SC performance
- To derive the driving-dependent relationship structure of the SCC and SCS inhibitors

To fulfil the research objectives, the current research works starts with the exploration of a wide variety of SCS and SCC inhibitors from the existing literature. Furthermore, the identified inhibitors are validated by PSC practitioners. The study uses an integrated AHP-ISM decision-making framework to accomplish the research objectives. AHP is used to calculate and rank the importance (priority) of each SCS and SCC inhibitors, and only the critical inhibitors are considered for further analysis. ISM is used to capture the inter-relationship between the critical SCS and SCC inhibitors, represented by a network structure. Additionally, driving and dependent analysis are performed to derive further insights. Finally, theoretical and managerial implications are derived to assist the various stakeholders (Indian petroleum industries, research practitioners, and government officials) to effectively manage the organizational complexity, and improve sustainable performance simultaneously.

The balance of the article is structured as follows. Section 2 presents a literature review to explore various SCS and SCC inhibitors from the existing literature. The proposed integrated framework discussed in Section 3. Section 4 presents a brief of the case industry. The results derived from the analysis are tabulated in Section 5 and presented. Section 6 lists the contributions of the study and recommended managerial implications. Lastly, the research papers conclude with summary, limitations and future directions in section 7.

2. Literature review

A literature review is conducted to explore different SCS and SCC inhibitors and the different methodologies used by previous studies to achieve the research objectives.

2.1 *Supply Chain Sustainability (SCS)*

The practice of SCC enhances long-term economic performance. Carter and Rogers (2008) described “sustainability as a critical factor for an organization to achieve its social, environmental and economic objectives”. Asefeso (2015) defined sustainability in the context of

SC as “a holistic view of SC procedures and technologies that go beyond the focus of delivery, inventory and traditional cost views." A recent HSBC (2019) survey shows that 26 percent of respondents considered "improving SC sustainability" as one of the 5 major challenges in SC for the forthcoming 3 years, including 350 business units in India. The Confederation of Indian Industry (CII, 2020) also highlighted the need for incorporating supply chain practices in Indian industries particularly in Automobile, Petroleum, Agriculture, Forestry and other domains.

The growing emphasis of both the academic and practitioner community on SCS, increasing compliance with legal regulations and protocols imposed by authorized agencies and the inclination of consumers for sustainable products have driven organizations to implement sustainable SC practices (Diabat et al., 2014; Jia et al., 2015; Li and Mathiyazhagan, 2018; Kumar et al., 2020). Few research works have been conducted towards exploring the motivating factors/drivers/enablers which encourage the execution of sustainable SC operations (Caniato et al., 2012; Hsu et al., 2013; Köksal et al., 2017; Saeed and Kersten, 2019; Shaw et al., 2020). In the recent time, SC sustainability has also been studied in conjunction with the enablers of Industry 4.0 (Luthra et al., 2019) such as IoT (de Vass et al., 2020; Mastos et al, 2020), blockchain (Bai et al., 2019; Venkatesh et al., 2020; Yadav & Singh, 2020), big data (Papadopoulos et al, 2017), and social media analysis (Orji et al., 2019; Kong et al, 2020).

2.2 Inhibitors to Supply chain complexity (SCC):

Bode and Wagner (2015) and Bozarth et al. (2009) mentioned that SCC is one of the most difficult problems that organizations deal with in modern SC. Business Continuity Institute (2018) reported 73% of the manufacturing firms acknowledged the booming SCC as a threat in their survey. The business impact of SCC can be a reduction in customer satisfaction and market share (BCI, 2018). Hence, the effective management of SCC not only improves SC performance but also enhances customer satisfaction (Serdarasan, 2013).

Inhibitors, defined as "any property of a supply chain that increases complexity" are classified as static, dynamic, and decision-making based on how it is generated (Serdarasan, 2013). Kavilal et al. (2017) used an integrated fuzzy approach to identify and prioritize 14 SCC drivers and assessed the mutual relationship between them for the Indian mining equipment manufacturing firm. In another study, Kavilal et al. (2018) identified 18 SCC drivers and further clustered them considering the Indian automotive industry's significant dimensions of complexity.

To capture a wide range of SCS and SCC inhibitors from multiple heterogeneous industries, a literature review approach was adopted. A four-level search structure is proposed with the keywords as shown in Table 1. Web of Science, Google Scholar, Scopus, Taylor and Francis, Springer and Emerald, are the bibliographic databases used for conducting this literature review. To narrow down the scope, some additional filters such as 'book chapter',' short communications', 'note', and commercial publications such as 'magazine articles' are included. Only the articles written in English are considered in the analysis.

Table 1**:** The proposed four-level keyword structure for literature search

Level	Keyword(s)
First level	Supply chain
	AND
Second level	TBL OR Sustainable OR sustainability OR Triple bottom Line OR
	AND
Third level	Complexity OR complicacy OR volatility or fragile
	AND
Fourth level	factor OR sub-factor OR driver OR sub driver OR indicator OR source OR criteria

The results of the extensive literature review (four-level search structure) are summarized in a tabular format which represents the taxonomy of various inhibitors to SCS and SCC.

Table 2: List of SCC and SCS inhibitors

Inhibitors of Supply chain sustainability		Inhibitors of Supply chain complexity			
External to SC	Internal to SC	Supplier	Operational	Customer	External

Author (Year)	Institutional pressure	Environmental pressure	Market threat	Corporate policy	Organizational ethos	Firm characteristics	Lack of strategic supplier a	Organizational resource capab	Horizontal Complexity	Geographical distribution of suppliers	Supplier's local strategies	Product Life Cycle	Product Complexity	Process complexity	Technological complexity	Customer Complexity	Desire for servitization	Larger scale customization	Geographical distribution of	Legal obligations	Competitors challenge	Market uncertainty	Modern Technology

Chen et al. (2019)			✓	✓					✓					✓				
Chhetri et al. (2021)									✓	✓		✓						
Chowdhury & Quaddus (2021)	✓	✓	✓	✓														
Piya et al (2020)			✓		✓		✓			✓		✓		✓				✓
Keivanpour et al (2020)											✓	✓	✓					
Lis et al (2020)		✓										✓						✓
Saeed and Kersten (2019)	✓	✓	✓	✓	✓	✓		✓										
Chand et al (2018)																✓		
Sousa & da Silveira (2018)															✓			
Ahmad et al (2017)		✓		✓														
Saeed et al (2011)		✓															✓	
Schlie and Yip (2000)										✓								
Mccarthy and Golicic (2002)														✓				

Vachon & Klassen (2002)						✓				
Blackhurst et al. (2005)										
Choi and Krause (2006)					✓					
Zhu & Sarkis (2007)	✓									✓
Rugman and Verbeke (2008)							✓			
Walker et al. (2008)		✓	✓							
Bozarth et al. (2009)					✓			✓	✓	
Freeman (2010)				✓						
Huang and Kung (2010)		✓								
Chaturvedi and Martínez-de-Albéniz (2011)					✓					
Gunasekaran and Spalanzani (2012)		✓								

Giunipero et al (2012)						✓	✓							
Gerschberger and Hohensinn (2013)								✓	✓	✓			✓	
Hashemi et al.(2013)								✓				✓		✓
Hsu et al. (2013)	✓				✓									
Serdarasan (2013)	✓									✓	✓			✓
Alblas et al (2014)		✓												
Alzawawi (2014)					✓									
Gualandris and Kalchschmidt (2014)			✓											
Schrettle et al. (2014)				✓			✓							
Bode and Wagner (2015)													✓	
Meixell and Luoma (2015)												✓		
Paulraj et al (2015)					✓									

Dubey et al. (2016)					✓							
Govindan (2016)		✓	✓									
Kumar et al (2016)				✓								
Kavilal et al. (2017)	✓					✓	✓	✓	✓	✓	✓	✓

2.3 Research gaps

Sustainable supply chain management helps companies for synergistic and effective management of economic, social, environmental performance (Ahmad et al., 2017; Carter and Rogers, 2008). Recognizing the criticality of SCS and SCC, current literature has attracted considerable attention. Researchers and industry professionals have explored SCS and SCC in the context of various industry perspectives and enriched literature. The petroleum supply chain (PSC) is highly asset-intensive. Especially, India is the third-largest consumer and importer of petroleum products and the operations depend heavily on crude oil imports (Workman, 2019). The fragmented and non-linear PSC cause issues in the end-to-end visibility in operations. The involvement of multiple stakeholders causes complexity and uncertainty in the petroleum SCs (Hussain et al., 2006; Shah et al., 2011). The aim of addressing SCS and SCC management combined is to find significant similar motivation in the performance of the SC, corporate business strategy, risk management of companies, long-term supply chain resilience, organizational cost-effectiveness. Most previous researchers tend to take a distinctive approach to the subject of SCS and SCC to suggest a managerial framework (Turner et al., 2018; Govindan, 2018; Dubey et al., 2017; Chen et al., 2017; Bode and Wagner, 2015; Hashemi et al., 2013; Manuj and Sahin, 2011). The problem of SCS and SCC is often addressed independently by industry practitioners and important strategies are developed to guide and regulate the respective inhibitors. The relative scarcity of current literature incorporating SCS inhibitors and SCC inhibitors leaves considerable scope for further research jointly addressing SCS and SCC inhibitors holistically in view of the petroleum industry. This study addresses the combination of the respective inhibitors, their interrelationship, driving and dependence power between the inhibitors of SCS and SCC. The findings of the study will help the industry personnel in managerial decision-making to maintain the perspective of general firms to balance SCS and SCC. The research findings will also examine the need for a new approach by companies and jointly adopt the strategy for SCS and SCC.

3. Proposed Methodology

The research methodological process framework is provided in Figure 1. An AHP-ISM integrated multi-criteria decision-making (MCDM) framework is used to assess the criticality of the SCS and SCC inhibitors. These inhibitors are often qualitative, which needs the cognitive knowledge of the SC executives and other stakeholders.

Figure 1: Research methodological process framework

The following section briefly depicts the steps of the methodologies used for the current research.

3.1 AHP method

Saaty originally proposed the Analytical Hierarchy Process (AHP) in 1980 (Saaty, 1980, 1990). In this study, one of the most popular MCDM tool AHP is used to examine the significance of various inhibitors to sustainability and complexity. The benefit of AHP over other MCDM methods is its ability to integrate the decision-makers subjective judgment and ease the computational burden over broad disciplines (Harputlugil et al., 2011). AHP is used in this research to identify the priority values (weights) of different SCS and SCC inhibitors. Based on the priority values, a ranking of critical inhibitors is obtained. AHP's steps are summarized as follows (Lee and Geum, 2017).

Step 1: Structure of the problem:

The decision-making problem is defined and subdivided into a multi-level hierarchical structure of different levels, such as objectives, criteria and sub-criteria, in the initial phase. The overall objective is stated in the top-level (apex) of the hierarchy and the corresponding decision criteria and sub-criteria are represented as the branches subsequently. Figure 2 shows the hierarchical structure.

Step 2: Construct pairwise comparison matrices:

The subjective and/or objective opinion of various field experts is collected and represented by a pairwise comparison matrix among the decision criteria, by following Saaty’s nine-point scale (mentioned in the appendices).

Step 3: Calculation of Eigen Vectors:

The obtained pairwise comparison matrices are subjected to row and column operations to estimate the eigenvalues and eigenvectors, to finally calculate the relative importance of each decision criteria.

Step 4: Consistency Ratio (CR) Evaluation:

The CR is calculated to ensure the informational bias obtained from the experts is within a considerable range. The mathematical formula for estimating CR is given as, CR=CI/RI, where

CI denotes the consistency index.   (is the maximum average value) and the RI denotes the random consistency index whose value upon the value of (). The acceptable value of CR is less than 10%.

Step 5: Calculation of final relative weights

Relative priority values for each element at each level are calculated in this step. The final decision (ranking) is made based on these relative priority values.

The final refinement of the critical inhibitors to SCS and SCC of Indian petroleum SC is done by obtaining the global ranks of each inhibitor. Only the refined (critical) inhibitors are further considered for the ISM analysis. The mathematical calculations associated with AHP are mentioned in the appendix section.

3.2 ISM method

John N. Warfield in 1982 developed the Interpretive Structural Modelling (ISM at the Battelle Memorial Institute (Warfield, 1982). ISM is used to represent the mutual relationships among various criteria (Attri et al., 2013). The relationship between the variables of the system depends on the organized, experienced, and constructive thinking of industry experts (Warfield, 1982). The advantage of ISM over any other MCDM tool is its ability to construct a system-level structure by segregating the decision criteria into different levels based upon their driving and dependence power. In the current research, ISM is employed to examine the mutual interrelationships between the critical SCC and SCC inhibitors. Concerning the SCS, the relative importance of SCS and SCC inhibitors is estimated based on their corresponding driving and dependency power. ISM method is summarized in the following steps (Tarei et al., 2021):

i. The critical SCC and SCS inhibitors, found from the AHP analysis, are identified and listed.

ii. Examining the dyadic relationship between identified inhibitors and establish the relationship between the inhibitors considering a pair of inhibitors at a time.

iii. Step 3: Preparing a Structural Self–Interaction Matrix (SSIM) based on pairwise comparison of inhibitors of the complex system being examined.

iv. Step 4: Developing an initial reachability matrix from the SSIM to check the transitivity of the contextual relationship matrix.

v. Step 5: Splitting the obtained reachability matrix and positioning the inhibitors into their distinct levels.

vi. Step 6: Drawing a directed graph (digraph) based on the relationships of the reachability matrix after removing the transitive links;

vii. Step 7: Checking the model for conceptual inconsistency and incorporating the required changes.

viii. Step 8: Conducting MICMAC analysis to examine the driving-dependent power of the inhibitors.

4. Brief overview of the case industry

India is the third-largest consumer of petroleum products with an annual consumption of 214 million metric tons (MMT) in the year 2020 (IBEF, 2021). The petroleum sector is one of the eight core industries in India with a 15 percent contribution to the country's overall GDP (Ministry of Petroleum and Natural Gas, 2020). Despite having proven reserves of 635 MMT, India imported USD 101.4 billion worth of crude oil in the year 2020 (Ministry of Petroleum and Natural Gas, 2021). Hence, to reduce the country's import dependency on Oil, the current government in India has taken the following policy initiatives. To increase the country's crude oil production, Hydrocarbon Exploration Licensing Policy (HELP, 2016) has been set up recently, helping companies to invest in the sector. India has emerged as a favourite destination for companies to invest in exploration & production businesses due to the newly explored oil reserves. Two national oil companies and more than twenty-four foreign companies work in upstream activities. ONGC is a leading firm that accounts for 60% of India's total output of crude oil. Indian Oil Corporation is India's largest crude oil 61.7 MMTPA capacity, operating 10,541 km of petroleum and gas pipelines and holding a retail network of 18,643 outlets nationwide. Some private industries like Cairn India, Reliance Industries, Essar oil etc have also appeared as significant players in recent times (IBEF, 2021).

One of the major challenges in India is to ensure the distribution of petroleum products to a huge population almost uninterruptedly. To cater to the needs of different segments of the country the Government has predetermined (subsidized) prices. In this regard, the Government of India (GOI) introduced NELP in 1999 to balance the gap between oil demand and the supply of the country. To make the sector further conducive, GOI has allowed 100 % FDI in exploration, natural gas, and petroleum products and refineries business (HELP, 2016; NELP, 1997). Keeping the significance of this industry, the PSC is considered as a sector for national importance and case industry for this research work.

The followed methodology is mentioned in section.3. The initial list of SCC and SCS inhibitors is obtained by systematic literature analysis, as shown in Figure 1, and provided in Table 2. The next stage involves the data collection process. This study considered a panel consisting of eight respondents (D_1, D_2, D_3, D_4, D_5, D_6, D_7 and D_8) which is acceptable in the literature for a consensus-based approaches such as AHP (Bardhan et al, 2021; Tarei et al., 2020b). The panel consists of six mid-level and senior-level executives of the leading petroleum manufacturing companies and two academic researchers based on their job experiences and practical knowledge of SC. The profile (designation, work experience and nature of the industry) of the experts is summarized in Table 3. A convenience sampling approach was used to choose the panel of respondents based on the personal and professional contacts of the authors. The job experience of each respondent/expert was ensured to be more than fifteen years to strengthen the quality of input data.

Table 3: Profile of experts

Decision Maker	***Designation***	***Experience (in years)***	***Industry type***
	Deputy General Manager, Supply chain	22	Petroleum refinery
	Senior Manager, Marketing	17	Petroleum refinery
	Senior Executive, Research and Development	15	Petroleum exploration
	Regional Manager, Promotion and Sales	21	Petroleum refinery
	Deputy General Manager, Sourcing and Planning	18	Petroleum refinery
	Senior Manager, Production	16	Petroleum exploration
	Supply Chain Researcher	18	Academician
	Supply Chain Professor	20	Academician

The data was collected in three stages. The experts were contacted by email and telephone in the preliminary stage, where they were asked to select (and confirm) the relevant SCC and SCS inhibitors to the Indian PSC (explored from literature). In the second stage, the respondents were approached for one-to-one interviews. The interview output is used for constructing the pairwise comparison matrices (PCM) of the AHP. During the interviews, real-time data and industry-relevant examples were also shared with the experts for understanding the inhibitors of PSC. The duration of each interview was ranging from sixty to a hundred minutes. The experts were asked to share the feedback on the relative importance of each inhibitor over the other inhibitor following Saaty's nine-point scale. The individual responses were aggregated, representing the average PCM of various inhibitors. The average PCMs were further used as an input for the AHP. In the third stage, the same respondents were approached for a brain-storming technique to voice their opinion about the inter-relationship between the critical inhibitors. The mutual relationship among any pair inhibitors is examined with "Yes" and "No" questions (Dubey et al, 2016). For n identified SCS and SCC inhibitors, the total number of paired comparisons will be ${}^{n}C_{2}$. The significant inter-relationship between the inhibitors is rated by a score following the VAXO scale (mentioned in section 4.2.1). Finally, the score collected from individual respondents was aggregated and an average input matrix was constructed, which is used as input for the ISM analysis.

5. Results and findings

The steps mentioned in section 3.1 are performed to calculate the priority values (PVs) of each inhibitor. As shown in Figure 2, the goal is classified into supply chain sustainability (SCS), and supply chain complexity (SCC) measures. In the subsequent layer, the measures are classified into SCS and SCC inhibitors. The AHP is employed to calculate the local PV (weight of inhibitors within the group) and local ranking (LR: the rank of inhibitors within the group in decreasing order). Local PVs with four SCC measures, i.e., upstream, operational, downstream, and external are shown in Table 4. Based on the PVs of SCC measures at the individual level, they are ranked as external (0.440), the customer (0.264), operational (0.180) and upstream (0.117) from 1 to 4. With a CR (Consistency ratio) value of 0.0341 (within the acceptable range i.e., 10%), the consistency of opinion between the decision criteria is ensured.

Figure 1: Decision hierarchy for SCC & SCS inhibitor analysis

	Supplier	Operational	Customer	External	**PV**	**Rank**
Supplier	1.000	0.535	0.469	0.316	**0.117**	**4**
Operational	1.870	1.000	0.463	0.465	**0.180**	**3**
Customer	2.130	2.160	1.000	0.422	**0.264**	**2**
External	3.167	2.150	2.370	1.000	**0.440**	**1**
CR=0.0341						

Table 4: PCM, PV and rank of SCC factors

Local PV and ranking of supplier SCC inhibitors along with the pair-wise comparison matrix are shown in Table 5. Supplier SCC inhibitors are ranked based on AHP weights a horizontal complexity (0.573), the geographical distribution of suppliers (0.244), the number of echelons of the supplier (0.100), Supplier's local strategies (0.083) from 1 to 4. Based on the results of AHP, it can be inferred that horizontal complexity, which indicates the total no. of suppliers and the position (location) of suppliers, are the two topmost (significant) inhibitors within the supplier complexity measure.

Table 5: PCM, PV and rank of supplier measure

	HC	GDS	SCS	NE	**PV**	**Rank**
Horizontal Complexity	1.000	4.049	4.575	5.848	**0.573**	**1**
Geographical distribution of suppliers	0.247	1.000	3.636	3.378	**0.244**	**2**
Supplier's local strategies	0.219	0.275	1.000	0.617	**0.083**	**4**

Numbers of echelons	0.171	0.296	1.621	1.000	**0.100**	**3**
CR = 0.0664						

Table 6: PCM, PV and rank of operational measure

	PLC	PdC	PcC	TC	**PV**	**Rank**
Product Life Cycle	1.000	3.704	4.184	0.875	**0.396**	**1**
Product complexity	0.270	1.000	1.179	0.308	**0.116**	**3**
Processes complexity	0.239	0.848	1.000	0.311	**0.104**	**4**
Technological complexity	1.143	3.246	3.216	1.000	**0.384**	**2**
CR = 0.0060						

The PCM, local PV, and ranking of SCC inhibitors within the operational measure are mentioned in Table 6. The PVs for operational SCC inhibitors are used to rank in the following order, product life cycle (0.396), technological complexity (0.384) followed by product and process complexity with a PV of 0.116 and 0. 104 respectively. Similarly, the PCM, local PV, and rank of SCC inhibitors within the customer measure are shown in Table 7. Local PVs of customer SCC inhibitors are customers' complexity (0.380), customers desire for servitization (0.123), large scale customization (0.115), and geographical distribution of customers (0.381). Customer complexity represents the number of variety of customers and geographical position of customers location seems to be the two most critical inhibitors of the SCC measure. In the case of PSC, there are two primary varieties of customers, an industrial customer which includes the conventional power generating companies, hospitals, logistic service providers, etc. who buy petroleum products in bulk for their business purpose. The second type of customer of PSC is the domestic customers, who primarily buy and use various petroleum products for cooking and personal transportation purpose

Table 7: PCM, PV and rank of Customer measure

	CC	DS	LSC	GDC	**PV**	**Rank**
Customer complexity	1.000	3.226	3.571	0.886	**0.380**	**2**
Desire for servitization	0.310	1.000	1.149	0.315	**0.123**	**3**
Large scale customization	0.280	0.870	1.000	0.350	**0.115**	**4**
Geographical distribution of customers	1.129	3.176	2.861	1.000	**0.381**	**1**
CR = 0.0046						

The PCM, local PV, and ranking of the SCC inhibitors of external measure are shown in Table 8. Local PVs of the external SCC inhibitor indicates that market uncertainty plays the most critical role with a score of 0.473, followed by competitors challenge (0.233), modern technology (0.167) and legal obligations (0.127). The uncertainty in the petroleum market is often caused by several factors such as crude price volatility, cross country diplomatic relations between crude exporting and importing countries, etc. The PSC is often challenged by its direct and indirect competitors with the increasing customers' awareness towards clean and alternative fuels.

Table 8: PCM, PV and rank of External measure

	CC	DS	LSC	GDC	**PV**	**Rank**
Legal obligations	1.000	0.422	0.315	0.808	**0.127**	**4**
Competitors challenge	2.371	1.000	0.348	1.490	**0.233**	**2**
Market uncertainty	3.170	2.870	1.000	2.427	**0.473**	**1**
Modern Technology	1.237	0.671	0.412	1.000	**0.167**	**3**
CR = 0.0227						

As shown in Figure 2, The SCS inhibitors are categorized into two measures viz. inhibitors within SC and inhibitors outside the scope of SC. The AHP is used distinctively to analyse and prioritize the inhibitors. Table 9 shows the PCM, local PV, and rank of the SCS inhibitors which are prominent within the SC network. It shows an organizational strategy with a PV of 0.586, followed by a lack of strategic supplier alliance and firm characteristics with a PV of 0.296 and 0.118, respectively.

Table 9: PCM, PV and rank of within SCS factor

	OS	FC	SA	**PV**	**Rank**
Organizational strategy	1.000	3.780	2.780	**0.586**	**1**
Firm characteristics	0.265	1.000	0.287	**0.118**	**3**
Lack of strategic supplier alliance	0.360	3.480	1.000	**0.296**	**2**
CR= 0.007					

Similarly, the PCM, local PV, and rank of the SCS inhibitors outside the SC network are shown in Table 10. The inhibitors are ranked in the decreasing order as following, institutional pressure, market threat and environmental pressure with a PV score of 0.536, 0.310 and 0.155 respectively.

Table 10: PCM, PV and rank of the outside SCS factor

	IP	EP	MT	**PV**	**Rank**
Institutional pressure	1.000	3.215	1.870	0.536	1
Environmental pressure	0.311	1.000	0.463	0.155	3
Market threat	0.535	2.160	1.000	0.310	2
CR= 0.067					

The final step of AHP is to obtain the global PVs of each SCS and SCC inhibitor. For this purpose, the local PVs obtained for each inhibitor is multiplied with the corresponding local PV of the factor. After consulting with the experts, the SCS and complexity are given the weights of 0.4 and 0.6, respectively. Based on the global PV, the global ranks of the inhibitors are calculated (Table 11).

Factor

Measures

Local PV

Inhibitors

Local PV

Global PV

Rank

Sustainability

0.4

Within SC

0.5

Organizational policy

0.5856

0.1171

2

Firm characteristics

0.1182

0.0236

15

Lack of strategic supplier alliance

0.2962

0.0592

8

Outside SC

0.5

Institutional pressure

0.5357

0.1071

3

Environmental pressure

0.1548

0.0310

14

Market threat

0.3095

0.0619

4

Complexity

0.6

Supplier

0.1166

Horizontal complexity

0.5733

0.0401

12

Geographical distribution of suppliers

0.244

0.0171

18

Supplier's local strategies

0.0829

0.0058

22

Numbers of echelons

0.0998

0.0070

21

Operational

0.1798

Product life cycle

0.3964

0.0428

10

Product complexity

0.1155

0.0125

19

Processes complexity

0.1039

0.0112

20

Technological complexity

0.3842

0.0414

11

Customer

0.2636

Customer complexity

0.3803

0.0601

7

Desire for servitization

0.1231

0.0195

16

Large scale customization

0.1154

0.0183

17

Geographical distribution of Customers

0.3812

0.0603

6

External

0.44

Legal obligations

0.1267

0.0334

13

Competitors challenge	0.2336	0.0617	5
Market uncertainty	0.4729	0.1248	1
Modern technology	0.1668	0.0440	9

Table 11: Local PV, Global PV and ranking of SCC and SCS inhibitors

Figure 3: SCC and SCS inhibitors with AHP global PV and the cumulative score

Figure 3 shows the SCC and SCS inhibitors with AHP global PV & cumulative score in increasing order. From the corresponding ranking and the global PV, the results found that the top five inhibitors are market uncertainty, organizational policy, institutional pressure, market threat, and competitors' challenge. The cumulative AHP PV score of the inhibitors in increasing order suggests that the topmost thirteen inhibitors stand for around 85% overall accountability, which is further considered for the ISM analysis.

5.2 Research finding from the ISM

Structural modelling helps to convert indistinct and poorly elaborated tacit models into easily interpretable and well-defined structural models that demonstrate the interrelationships between the decision criteria (Dubey et al., 2015; Diabat et al., 2014; Attri et al., 2013). For ISM, the same expert panel (mentioned in Table 3) is approached with the final list of SCS and SCC inhibitors, as obtained after the analysis of AHP. Thirteen SCS and SCC inhibitors have been finalized, represented by I1, I2, ., I13 which is shown in Table 12. By estimating the dyadic relationship among any couple of inhibitors with 'Yes' and No' questions, the inter-relationship between the 13 finalized SCS and SCC inhibitors is established. The total number of paired comparisons will be 78 for 13 finalized SCS and SCC inhibitors ($={}^{13}C_2$).

The stepwise calculation of ISM analysis is shown in the following.

5.2.1 Developing SSIM:

The presence of a significant inter-relationship among two inhibitors and the corresponding direction of the influence is assessed to capture the strength of the contextual relationship. The impact of each SCS and SCC inhibitor on the other is also assessed. The response is gathered to construct a VAXO table in the following format. To develop SSIM (Table 12), the below symbols explain the relationship between the inhibitors (i and j):

V: inhibitor i will lead to the accomplishment of inhibitor j but not the other way around

A: inhibitor j will lead to the accomplishment of inhibitor i but not the other way around

X: inhibitor i and inhibitor j are correlated, and hence help to the accomplishment of each other

O: inhibitor i and inhibitor j are uncorrelated and independent of each other.

Finally, eight individual SSIMs were collected from each expert. They are combined by the simple averaging process to reach the final SSIM as shown below.

Inhibitors	**Symbol**	**I13**	**I12**	**I11**	**I10**	**I9**	**I8**	**I7**	**I6**	**I5**	**I4**	**I3**	**I2**	**I1**
Market uncertainty	**I1**	V	V	V	O	O	O	O	O	V	V	V	V	-
Organizational policy	**I2**	A	V	V	O	O	O	O	O	O	A	A	-	
Institutional pressure	**I3**	A	V	V	O	V	O	O	V	V	O	-		
Market threat	**I4**	O	V	V	O	X	A	O	V	O	-			
Competitors challenge	**I5**	A	O	O	O	O	O	V	V	-				
Geographical distribution of customers	**I6**	O	V	X	O	A	A	V	-					
Customer complexity	**I7**	O	V	A	O	A	O	-						
Lack of strategic supplier alliance	**I8**	O	V	V	O	V	-							
Modern technology	**I9**	O	V	V	O	-								
Product life cycle	**I10**	A	V	V	-									
Technological complexity	**I11**	O	V	-										
Horizontal complexity	**I12**	O	-											
Legal obligations	**I13**	-												

Table 12: Structural self-interaction matrix (SSIM)

5.2.2 Developing the reachability matrix:

To proceed with the further calculations of the ISM, the SSIM has to be converted into a numerical form, i.e., the initial reachability matrix (IRM) as shown in Table 13. The IRM contains binary values in the form of '0' or '1'. The following rules are followed for transforming the SSIM to an IRM:

1. If the inhibitor corresponding to (i, j) cell in the SSIM is V then in the IRM, the inhibitor corresponding to (i, j) cell it becomes '1' and the inhibitor corresponding to (j, i) cell becomes '0'.
2. If the inhibitor corresponding to (i, j) cell in the SSIM is A then in the IRM, the inhibitor corresponding to (i, j) cell becomes '0' and the inhibitor corresponding to (j, i) cell becomes '1'.
3. If the inhibitor corresponding to (i, j) cell in the SSIM is X then in the IRM, the inhibitor corresponding to (i, j) cell becomes '1' and the inhibitor corresponding to (j, i) cell becomes '1'.
4. If the inhibitor corresponding to (i, j) cell in the SSIM is O then in the IRM, the inhibitor corresponding to (i, j) cell becomes '0' and the inhibitor corresponding to (j, i) cell becomes '0'.

Table 13: Initial Reachability Matrix (IRM)

I1

I2

I3

I4

I5

I6

I7

I8

I9

I10

I11

I12

I13

I1
1
1
1
1
1
0
0
0
0
0
1
1
1
I2
0
1
0
0
0
0
0
0
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0
1
1
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I3
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I4
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I12
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I13
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1

5.2.3 Transitivity check:

The concept of transitivity can be explained as follows: if inhibitor ‘A’ has a significant influence on inhibitor ‘B’ and inhibitor ‘B’ has a significant influence on inhibitor ‘C’, then as per the rule of transitivity, inhibitor ‘A’ will have a significant influence on inhibitor ‘C’ (Sage, 1977). Transitivity helps to reinforce ISM's conceptual coherence and fills the gaps between inhibitors. The concept of transitivity is applied to modify certain elements of the IRM. Due to the effect of transitivity some cells with ‘‘0’’ values in Table 13 are replaced with ‘‘1’’ (represented by ‘‘1*’’) in Table 14. After incorporating the transitivity concept, the Final Reachability Matrix (FRM) is obtained in Table 14.

Table 14: Final Reachability Matrix (FRM) with transitivity*

	I1	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**I9**	**I10**	**I11**	**I12**	**I13**	**Driving Power**
I1	1	1	1	1	1	1*	1*	0	1*	1*	1	1	1	12
I2	0	1	0	0	0	1*	1*	0	0	0	1	1	0	5
I3	0	1	1	1*	1	1	1*	0	1	1*	1	1	0	10
I4	0	1	0	1	0	1	1*	0	1	0	1	1	0	7
I5	0	0	0	0	1	1	1	0	0	0	1*	1*	0	5
I6	0	0	0	0	0	1	1	0	0	0	1	1	0	4
I7	0	0	0	0	0	0	1	0	0	0	0	1	0	2
I8	0	1*	0	1	0	1	1*	1	1	0	1	1	0	8
I9	0	1*	0	1	0	1	1	0	1	0	1	1	0	7
I10	0	0	0	0	0	1*	1*	0	0	1	1	1	0	5
I11	0	0	0	0	0	1	1	0	0	0	1	1	0	4
I12	0	0	0	0	0	0	0	0	0	0	0	1	0	1
I13	0	1	1	0	1	1*	1*	0	1*	1	1*	1*	1	10
Dependence power	1	7	3	5	4	11	12	1	6	4	11	13	2	

5.2.4 Level partitioning:

The multi-layered hierarchical structure is obtained by finding the belongingness of each inhibitor to the corresponding level. The levels are partitioned by considering the reachability set and intersection set (Ruiz-Benitez et al., 2018). The reachability set of i elements, denoted as Ri, consists of all those elements that can be accessed from element i for each level k, while the antecedent set of elements i denoted as Ai, consists of all those elements from which element I can be accessed. If the intersection of the two sets is the same as Ri, then the element can be denoted as the kth-level element and its corresponding row and column are deleted from the matrix for the next level. This process is repeated until the allocation of each inhibitor is completed. The level partitioning process resulted in 7 levels for the considered inhibitors (shown in Table 15). The detailed level partitioning procedure is illustrated in Appendix A1 (Table A1 to Table A7).

Table 15: Level partitions in the ISM model

	Reachability set	Antecedent set	Intersection set	Level
I1	1,2,3,4,5,6,7,9,10,11,12,13	1	1	7
I2	2,6,7,11,12	1,2,3,4,8,9,13	2	4
I3	2,3,4,5,6,7,9,10,11,12	1,3,13	3	6
I4	2,4,6,7,9,11,12	1,3,4,8,9	4,9	5
I5	5,6,7,11,12	1,3,5,13	5	4
I6	6,7,11,12	1,2,3,4,5,6,8,9,10,11,13	6,11	3
I7	7,12	1,2,3,4,5,6,7,8,9,10,11,13	7	2
I8	2,4,6,7,8,9,11,12	8	8	6
I9	2,4,6,7,9,11,12	1,3,4,8,9,13	4,9	5
I10	6,7,10,11,12	1,3,10,13	10	4
I11	6,7,11,12	1,2,3,4,5,6,8,9,10,11,13	6,11	3
I12	12	1,2,3,4,5,6,7,8,9,10,11,12,13	12	1
I13	2,3,5,6,7,9,10,11,12,13	1,13	13	6

5.2.5. Formation of ISM-based framework

An initial digraph is prepared based on the conical shape of each inhibitor's reachability matrix and level partition values. The conical shape of the reachability matrix is calculated by rearranging the elements of the final reachability matrix according to the decreasing order of the partitioning level. To denote the structural model, a guided graph with hierarchical level inhibitors linked to lines is created based on the final accessibility matrix (Table 14) and level partitioning (Table 15). Successively, in the model, transitivity is removed. Lastly, for any conceptual inconsistency, the model is checked. The final digraph is seen in Figure 4. Oval circles represent pairwise relationships between elements and arcs. Figure 4 shows a complete view of the flow of the influences of the problem under study.

Figure *2***:** Final ISM digraph

5.2.6 MICMAC analysis

MICMAC analysis is performed to calculate the dependency and driving power of SCS and SCC inhibitors. The dependence power is plotted on X-axis and driving power is plotted on Y-axis. Based on the driving power and dependence power the inhibitors are classified into four categories, they are autonomous, driving, linkage and dependent, as shown in Table 14, Figure.5.

Cluster 1: This cluster represents inhibitors with weak dependence and driving power, we termed these inhibitors as autonomous SCS and SCC inhibitors. Product Life Cycle (I10) and competitors challenge (I5) are in this cluster.

Cluster 2: Dependence SCS and SCC inhibitors- These inhibitors have strong dependence power but a weak drive power. This cluster consists of five inhibitors, Organizational policy (I2), Geographical distribution of customers (I6), Technological complexity (I11), Customer complexity (I7), and Horizontal complexity (I12).

Cluster 3: Linkage SCS and SCC inhibitors- No inhibitor was found for this cluster in this research problem.

Cluster 4: Driving SCS and SCC inhibitors- These inhibitors have a weak dependence power but strong drive power. In this cluster, the following inhibitors are found: Market uncertainty (I1), Institutional pressures (I3), Legal obligation (I13), Lack of strategic supplier alliance (I8), Market threat (I4), and Modern technology (I9).

Figure 3**:** MICMAC analysis

6. Research implications

The study, conducted for the petrochemical companies operating in India, provides a deeper insight into the joint exploration of SCS and SCC inhibitors. The interrelationship between SCS and SCC inhibitors provides ground for a unified approach in complex decision-making. This study, supported by feedback from industry experts, enriches the current literature with its critical contribution to identifying the inhibitors of sustainability achievement and managing the complexity of the SC. The research offers several crucial scholarly and managerial implications, which scarcely addressed in empirical research.

6.1 Theoretical implications

While academicians tend to explore the SCS and SCC inhibitors independently, the investigation of their mutual relation largely remains unanswered in the empirical study. This research attempts to overcome the limitation by analysing the interactions among SCC and SCS inhibitors with the corresponding impact on overall SC performance. It examines SCS and SCC inhibitors autonomously and establishes a transitive seven-levelled model involving 13 finalised critical inhibitors combining SCS and SCC based on relative importance.

The outcome of this study has made numerous decisive contributions. First, a wide variety of SCS and SCC inhibitors are explored from the existing literature and they are further validated by the PSC practitioners. Second, the importance (priority) of each SCS and SCC inhibitors are calculated and only the critical inhibitors are considered for further analysis. Third, the inter-relationship between the critical SCS and SCC inhibitors is established and represented by a network structure. Fourth, driving and dependent analysis are also performed to derive further insights.

The study, to the best of our knowledge, stands as one of few works on SCC and SCS, conducted in the context of India, which is one of the fastest-growing economies in the world. To that end, the study might offer applicability for similar developing and emerging economies with comparable market conditions, such as Mexico, Brazil, South Africa (Yasmin et al., 2020). In addition, the research outcome can be generalized by practitioners to the industries sharing similar industry dynamics with the Petroleum industry. Notably, the results provide comprehensiveness for the sector as it covers the end-to-end processes of the petroleum industry.

6.2 Managerial implications

Knowing the interrelationship between inhibitors of SCS and SCC will empower SC managers in informed decision-making aligned with organizational goal. The present study supports practitioners with following contributions.

a) First, from a practitioner perspective, market uncertainty (I1), institutional pressures (I3), legal obligations (I13), lack of strategic supplier alliance (I8), organization’s resistance to modern technologies (I9) and market threat (I4) are key the critical causal inhibitors which require urgent attention and focus from the SC managers (Figure 5). From Figure 4, it is evident that SCS inhibitors such as institutional pressure (I3), market threat (I4), and legal obligations (I13) are influentially driven by market uncertainty. Market uncertainty in the petroleum industry is mainly caused by multiple factors, such as fluctuations in crude prices, natural and manmade disasters, unfavourable taxation or government policies, and countries' geopolitical relations.

b) SCS inhibitors with relatively higher driving power such as institutional pressures (I3) and lack of strategic supplier alliance (I8) have a significant impact in structuring the overall ISM digraph. The research outcome is in alignment with Kessler et al. (2019) in highlighting the importance of institutional stakeholder engagement in organizational sustainability management. The findings of the study are consistent with stakeholder theory (Mitchell et al., 2016). Petroleum companies can integrate vertically with exploration and production companies to enhance the key performance parameters. However, it has often been noted that each alliance/merger is not always successful because of the misalignment between the value and culture of the organization. According to research conducted by Alliance Best Practice Limited, a UK based research and consultancy firm, more than 40% of supplier alliances fail to achieve the desired strategic objective (Deloitte, 2019). Hence, due attention should be given in developing meaningful strategic supplier alliance to attain the benefit of integration.

c) The outcome of this study suggests that the Organization’s resistance to modern technologies (I9) can lead a firm to a disadvantageous position in a technologically competitive environment. In the era of digitalization and industry 4.0, the failure to exploit the smart and intelligent features of the technology causes the opportunity to be taken away by the competitors. The implementation of digital technologies such as blockchain plays a crucial role in reducing transaction costs between the players and improving the transparency and efficiency of the petroleum SC (Lu et al, 2019).

7. Conclusion and future research

While the study offers novelty by examining the inhibitors of SCS and SCC combinedly, certain limitations are inherent in it. First, the study is conducted with participants in the context of a single developing economy. Therefore, country-specific factors should be considered before the generalization of the research outcome. Second, this study can be considered as exploratory as it analyses inhibitors in the limited number of Indian petroleum companies. A larger sample size involving multiple geographies can ensure the robustness of results before further extension.

In this research, a hybrid two-phased research methodology is developed for enhancing the decision-making process. The AHP is employed to identify and assess critical SCS and SCC inhibitors. The mutual relationship between the critical inhibitors is established by ISM. However, with soft computing techniques such as fuzzy or grey relational analysis, the capacity of the proposed framework can be improved to capture the uncertainty and subjectivity bias of decision-makers. Besides, future research can be directed including a larger sample size of participants applying structural equation modelling.

The framework developed in this paper can be extended to sectors such as the chemical and pharmaceutical industries sharing similar sectoral dynamics. This study can be extended for a large number of firms with a significant operating presence in multiple geographies to provide robustness in generalizing the outcome for the industry. Following this detailed research framework, a similar study can also be explored for other sectors/industries/geographies with sector-specific SCS and SCC inhibitors.

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