A study of the effects of Sustainable Supply Chain Management in the Automotive Industry

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Imperial College Business School

Executive Summary:

The automotive industry has been source of many innovations in the manufacturing industry. Their experience with supply chain enabled the automotive industry to create efficient tools to better manage their supply chain. The current base for all of these technique is Sustainable Supply Chain Management (SuSCM). Because of competitiveness and companies' desire to keep their competitive advantage, I was able to find summarized data from previous studies but no very detailed information. This paper has found that the basis for sustainable supply chain management is the triple bottom line which highlights the importance of economic, environmental and social dimension of sustainable development. Based on this concept, firms generally use one of the many tools to address SuSCM such as lean management, six sigma or product lifecycle management. A framework is also given in order to evaluate performance of SuSCM practices and displays the key solutions measures for the automotive industry.

1. Sustainable development

Sustainable Development (SD) was first mentioned in 1980 in a program called “World Conservation Strategy: Living Resource for Sustainable Development”. It is one of the first written agreement on resource conservation from governments, non-governmental organizations and other experts. The document requires to think on the long term (more than 25 years) to address the three dimensions of the triple bottom line (TBL): economic, environmental and social. The TBL is an accounting framework that includes three measures of performance. The economic dimension puts forward the creation of wealth through the reasoned use of natural resources, the evolution of international economic relations and the integration of social and environmental costs in the cost of the product. The environmental dimension argues for a preserved, improved and valued natural environment by the sustainable management of natural resources, the maintaining of natural balance and the reduction of environmental risks. Lastly, the social dimension aims at fulfilling human needs with the objective of social equity when satisfying essentials needs, fighting against poorness and segregation, reducing inequalities and respecting cultures (Depoers, 2005).

To help companies take into account the 3Ps of the TBL, some norms have been instituted such as: the SA8000, a social certification, or the ISO 14000, an environmental norm. In this perspective, for example in France, the French Standardization Association (AFNOR) created the SD 21000 guide to help companies set a sustainable development strategy. In his 2005 essay, Dontenwill uses stakeholder’s theory as a parallel with SD. In this paper, he compares the economic dimension to clients and shareholders, the environmental dimension to NGOs or government policies and the social dimension to employees or worker unions. In his analysis, stakeholder theory is closely linked to SD and both can be addressed in similar ways.

The strong links between all three dimensions, push us to think about the links between supply chain management and sustainable development. SuSCM requires a good understanding of the three dimensions.

2. Supply Chain Management and inter-organisational competitive advantage

Supply Chain Management (SCM) is described by Chen and Paulraj as “the challenge of designing and managing a network of interdependent relationships developed and fostered through strategic collaboration”. The shift from inter-firm competition to inter-supply-chain level competition has made the gain of competitive advantage through supply chain management even more important. As Fynes points out in his paper, “by engaging in deep partnership types

of supply chain relationships, suppliers can improve supply chain performance". There is an incentive for both parties to engage in tighter relationships to improve their operations. They can both benefit from increased communication and cooperation. Chen and Paulraj also argue that firms are links in a networked supply chain. From that point of view, the performance of a firm is tightly connected to the performance of the suppliers and therefore, of their supply-chain. Inter-organizational cooperation comes from two-way communication. Trust, commitment, shared-values and a common vision for the future are needed for the cooperation to be successful while they are also the results of a tight cooperation. The objective is the gain of inter-organizational competitive advantage. This comes from the possession of heterogeneous resources and capabilities being shared with suppliers.

Supply Chain Management (SCM) is a key tool in order to establish a sustainable future for the whole supply chain. The incentive of gaining competitive advantage made SCM evolve to a core competency.

3. Sustainable Supply Chain Management and the triple bottom line

When considering Sustainable Supply Chain Management as a consequence of the spread of Sustainable Development in every sector, the triple bottom line appears as the most adequate tool in order to set up the foundation of SuSCM. The Triple Bottom Line (TBL) also called 3Ps, which stand for People, Planet and Profit, puts an importance on the economic, environmental and social dimensions of sustainable development. While most models forget the social dimension of SD, the TBL highlights the necessity to take this dimension into account in order for a supply chain to be sustainable.

3.1. The economic dimension of sustainable development:

Adding on to the inter-organisational competitive advantage gained by SCM and strong supplier relationships, the economic dimension of SD also brings a lot to the table. The Council of Supply Chain Management Professionals (CSCMP) defines SCM as: "an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model". Their definition of Supply Chain Management encompasses two pillars of the economic dimension of Sustainable Development. The execution of SCM in its economic dimension rests on inter and intra-organisational cooperation, and the management of systems and technologies of information and communication.

As a part of a large network, a firm needs to establish strong relationships with its partners and suppliers. Transparency and information sharing is key in both pillars of the economic dimension of sustainable development. By tightening their relation with suppliers, firms are able to express their needs more precisely and cooperate together. Even more than the pure benefits of cutting better deals, a close relationship leads to information sharing, shared experience and reduced redundancies. For as long as the relation is sustainable, the economic returns will be beneficial for both parties. The network of companies is the basis of the flows of merchandises, information and cash. Each department has its own tools in order to manage these flows. Just-in-time manufacturing is one management strategy to organise the flows of merchandises on a tight-flow. Furthermore, the numerous communication technologies available nowadays, such as Block chain and Big Data, facilitate decisions for company managers. While they could enable large information sharing and cooperation, companies are faced with "the collaborative paradigm" (Van Tulder, 2011). A change in behaviour towards trusting and sharing is therefore necessary in order to benefit from the economic dimension of SD.

3.2. The environmental dimension of sustainable development:

With the acceleration of climate change, environmental policies are more and more numerous and reaching the Paris agreements' objectives is becoming even more difficult. The environmental dimension of SD is taking a more important place than ever. The environmental dimension of SD, also called Green Supply Chain Management can be enforced or voluntary. Waste treatment, reverse logistics and green production/re-production are part of "Green Operations" and risk management, resources preservation and conservation are part of "Green Conception" (Svrivastava 2007). In his paper, Svrivastava highlights the need for the implication of top management in order to have conclusive results. While many efforts are made on Green Operations, the issue of waste management remains one of the most problematic. Selling waste to African and Asian developing countries is no solution. A real effort has to be made in order to limit waste. Reverse logistics can play a major role in reducing waste. Governments are widely intervening and encouraging reverse logistics for environmental, economical and ethical reasons. An article published in the European Journal of Operational Research (Fleischmann et al, 1997) points out that some traditional methods can already be applied in the context of reverse logistics. On the other hand, they add that even though logistics is achievable, new technologies can greatly help in more complex implementations. The success of Green Operations is tightly linked to well-designed "Green Conception" processes. In order to reuse, repair or recycle, the conception team need to have these factors in mind when designing the product. Eco-design also takes into account

resources management when purchasing the needed material to build the product. Regarding this, the concept of “tracking” and “tracing” is becoming more and more important. Study shows that traceability of products plays a key role in protecting brand image and retaining customers (Chhikara et al, 2018).

Green transport also adds on to the environmental dimension of SD. Because, freight transport is one of the biggest source of CO2 emissions, finding ways to reduce its pollutions is essential. Using less polluting means of transport, maximising the load and avoiding empty trips are solutions participating to Green transport.

3.3. The social dimension of sustainable development:

Even though, all three dimension of the TBL work in balance, the social dimension of SD is often forgotten and social supply chain management is often left behind. In an article linking SCM and human resources, Emeric Levy points out that if the human factor is ignored, firms’ evolution is blocked because of inadequate organisation, failing processes, unidentified malfunctions and demotivated teams (Logistiques magazine 2007). Motivating and engaging employees is key for a company to evolve. In order to manage the social dimension of SD, some company use Corporate Social Responsibility (CSR) initiatives. According to Ciliberti et al, two factors are required: “compliance with requirements and capacity building” (Ciliberti et al 2008). “Compliance with requirements” deals with finding and keeping suppliers that satisfy their criteria. “Capacity building” is the philosophy of promoting and expanding their socially responsible culture among suppliers.

Social supply chain management can be implemented using Gond’s model (Gond 2006). His model is based on three pillars:

- transformational leadership and sense-making
- HR performance from an internal point of view
- HR performance from an external point of view

More precisely, Gond adds that HR performance from an internal point of view can be assessed on four parameters: justice seen by employees, organisational involvement, work satisfaction and organisational identification. Regarding HR performance from an external point of view, Gond puts forward firm attractiveness, brand image and union support during social crisis. Frequently assessing these parameters to improve employee satisfaction is a key way of participating to social supply chain management.

4. SuSCM practices in the automotive industry

4.1. Lean Management: Toyota and Japanese car manufacturing companies

Lean Management first appeared in 1990 with *The Machine that Changed the World,* a five-year study about the world's automobile manufacturing industry. Lean management is defined in the book as (Roos, Womack and Jones, 2014): "The lean producer, by contrast, combines the advantages of craft and mass production, while avoiding the high cost of the former and their rigidity of the latter. Toward this end, lean producers employ teams of multi-skilled workers at all levels of the organisation and use highly flexible, increasingly automated machines to produce volumes of products in enormous variety (…). Lean producers (…) set their sights explicitly on perfection: continually declining costs, zero defects, zero inventories, and endless product variety."

As one of the most used management technique in SCM, lean management emphasizes the importance of flexibility. Machines, models, employees, chains and timetables have to be flexible so that they can be improved each step of the way.

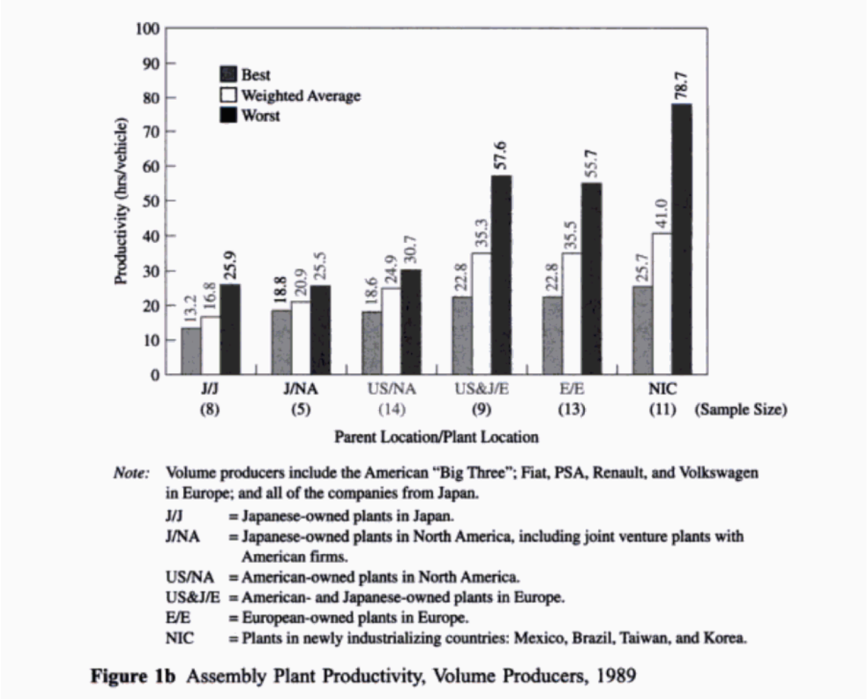

Figure 1: Assembly plant productivity: comparison between regions: (Taylor and Brunt, 2010)

When considering this method in automotive industry, the results are phenomenal. The above table (Taylor and Brunt, 2010) also shows to what extent productivity is improved by using lean management. Japanese-owned plants in Japan had an average productivity (hours per

vehicle) of 16,8 when American-owned plants in North America had a productivity of 24,9 and European-owned plants in Europe, 35,5. This proves that lean management has a tremendous impact on productivity, therefore on financial results and employee satisfaction. Furthermore, the same study shows that there are much less defects on products leading to less waste and therefore great environmental results.

4.2. Six Sigma strategy: a Kumar et al study

Six Sigma is a management technique created by Bill Smith during his time at Motorola. In his article in IEEE Spectrum in September 1993, Smith insists on customer satisfaction (Smith, 1993): “if you take care of the customer better than your competition, the business will take care of itself.”. He adds on that customer satisfaction comes from the quality of the product, technical support, billing, salesperson competence, product availability, and countless other interactions with the customer. The goal of Six Sigma is to reach “defect-free” performance. His tool is based on standard deviation. With a sigma quality level equalling six, the chances for a product to be defective is equal to 3,4 ppm (3.4 parts per million).

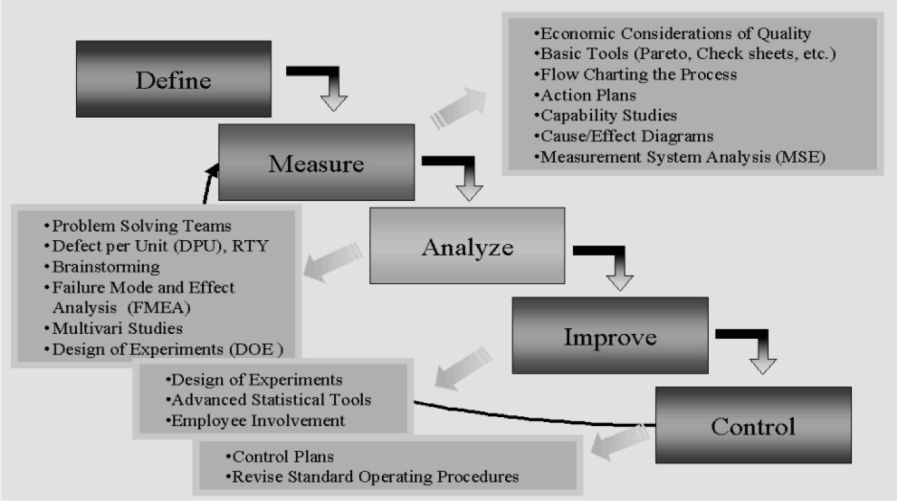

Figure 2: DMAIC methodology for running Six Sigma projects, (Sokovic et al, 2006)

Among other methodologies required to set up a Six Sigma management technique in a team, the DMAIC methodology (Sokovic et al, 2006) is one of the most commonly used and most effective. It consists of five phases: Define, Measure, Analyse, Improve, and Control detailed in Figure 2.

In their article (Kumar et al, 2013), Kumar et al. tackle the “reduction of casting defects in an automotive engine” using the six sigma DMAIC methodology. They explain that as a product evolves through the processing stages four costs are incurred: labour cost, raw material cost,

operating expenses and other overheads. Furthermore, the more it is processed the more values it gains and the more a defect has a financial impact.

$$\text{DPU} = \text{number of defects found/number of units processed}$$

$$\text{throughput yield} = e^{-\text{DPU}}$$

	Depth of the porous core	
Key metrics used	Before improvement	After improvement
Defect rate	0.194 DPU	0.029 DPU
Throughput yield	82%	97.14%
Capability indices	0.49	1.28
Process mean	1.202 mm	0.843 mm
Process standard deviation	0.277 mm	0.137

Figure 3 : Comparison between before and after improvement, (Kumar et al, 2013)

Thanks to the Six Sigma strategy, the firm was able to save $110,000. The results are shown in the above table. Not only were the financial results of Six Sigma impressive, the implementation also had an impact on customer and employee satisfaction. Top management at the firm was even seduced by the technique and adopted it on other projects. One year after the project savings had reached more than $250,000.

4.3. Product Lifecycle Management:

Product Lifecycle Management (PLM) focuses on supplier integration and cooperation (Morris, 2004). There are two types of supplier integration: quasi-supplier integration and full-supplier integration. The first means that joint efforts are made in order to develop collaboration while processes and information are kept within each party's field of action. With full-supplier integration, the automotive firm and the supplier share resources and knowledge when building their supply chain. The development of the product lifecycle is done jointly by both entities and boundaries tend to diminish (Tang et al, 2008). PLM creates links between information management and system integration with the business strategy. Product information is shared, used and created more efficiently. PLM is also sources of innovation for companies as they perceive production processes in a dynamic way.

Nanjing-Fiat, an automotive joint venture company in China studied the implementation of a PLM system. This PLM system was designed to tackle a set of issues that Nanjing-Fiat were not satisfied with:

- not giving enough importance to Chinese suppliers as well as Chinese customers' views
- new suppliers must join the supply chain to keep up with high rhythms

- the LPM system must preserve links between design and production even though they are located in different countries.

With PLM, Nanjing-Fiat came up with a tool to solve these problems: the Nanjing-Fiat Solution Kit (NSK). NSK can handle communications of change and facilitate work across functional and geographical boundaries. The implementation of such a tool requires multiple steps; preparation, definition and execution; that reach across different levels of the firm. From use of the NSK system, Nanjing-Fiat were able to draw conclusive results:

- Collaboration and integration must not only come from the supplier
- PLM requires good communication across departments and countries

The example of Nanjing-Fiat is very interesting as it differs from the first two automobile examples. The NSK system was able to put forward serious issues in the firm. Even though PLM is a powerful tool, it cannot evolve if some actors don't put in the efforts. Because communications between Italy and China were poor, the system wasn't successful. Indeed, when looking at the above figure, the three phases required collaborative actions from strategy teams, technique teams and operation teams.

5. A Sustainable Supply Chain Management Framework to improve performance of SuSCM practices in a company

I decided to choose this framework for the clarity of the results which are based on options comparison and mathematical computation. This framework is based on an automotive study (Yadav et al, 2020) which identified 28 SSCM common challenges and 22 solution measures (appendix 2). Each of the 28 SSCM challenges is evaluated using the Best Worst Method (BWM). The BMW gives tools to weight the importance and the alternatives to certain problems. Adding on to that, the 22 solutions measures are evaluated using the Elimination and Choice Translating Reality (ELECTRE) method. In their article, Yadav et al built a framework based on Multiple-Criteria Decision-making (MCDM) methods which you can see in figure 4. The first step is to assess each problem using the BWM. In BWM, first, we need to identify the best and worst criterion from each group, then two comparisons are made. Such comparison ensures the least possibility of judgements to be inconsistent. In the end, the best and worst challenges are ranked in order of importance. The second step is to assess the solution measures using ELECTRE. After a few steps, each solution measure is given a superiority ratio indicating the most preferred solution.

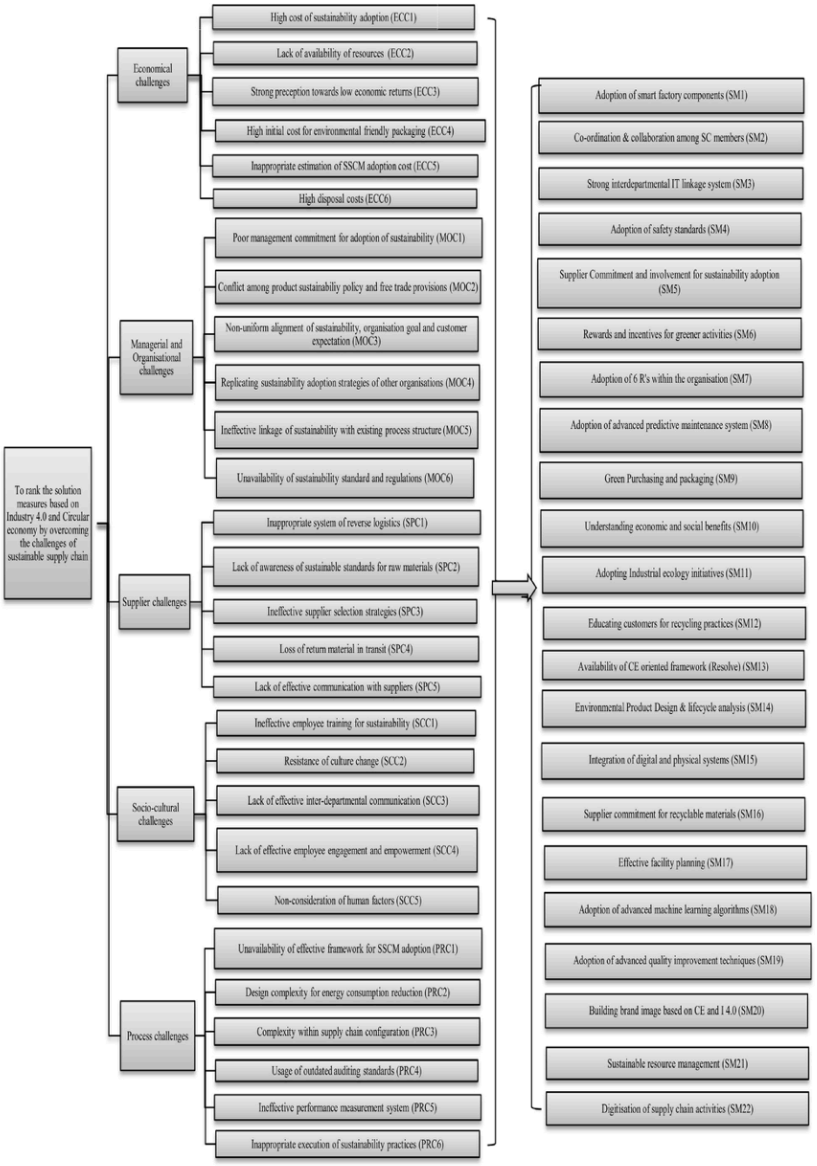

Figure 4: Framework based on Multiple-Criteria Decision-making methods, *(Yadav et al, 2020)*

In this article, the framework is tested on an automotive company leading to conclusive results on their practices. Among others, they highlight the importance of “the adoption of 6R’s”, “environmental product design and life-cycle analysis” and “digitisation” as the most important solutions measures.

6. Conclusion: the great benefits of SuSCM

SuSCM was first implemented in the automotive industry. It can be used and implemented by using the triple bottom line as the base structure. As the figure bellow illustrates, SuSCM benefits stakeholders in a lot of ways.

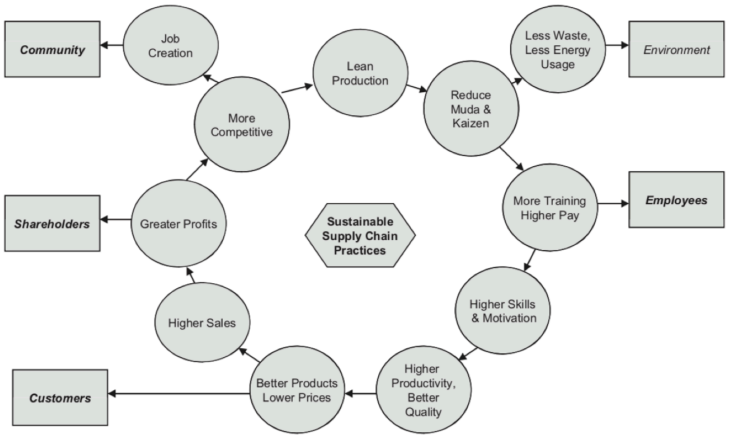

Figure 5: Stakeholder benefits from a Sustainable Supply Chain, (Mefford, 2011)

There are many ways of implementing SuSCM such as lean management, the six-sigma method or product lifecycle. In order to review the challenges to target first, the above SuSCM framework gives a clear and precise structure to tackle these issues. SuSCM is essential nowadays as a lot of brand image is based on their supply chain practices. SuSCM is also a great tool to fight social and environmental issues. Some brands have recently been targeted for hiring Uighur workers (Xiaomi, Nike or Toyota) or North Korean workers. On the other hand, other firms such as Tiffany and Co. insist on showing the traceability of their products to build their brand image.

The automotive can fully benefit from SuSCM also with the rise of new technologies such as Block-Chain (Saberi et al, 2018). This study shows how block-chain can favour information sharing and revolutionize the automotive supply chain.

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Appendix:

Table 1 Three eras of motor car production

	Craft	*Mass*	*Lean*
● Workforce	Highly skilled in design, machine operations and fitting. Apprenticeship for workers.	Interchangeable workers (division of labour). Improvement responsibility – Industrial engineer and foreman	Flexible teams work the process. Little management layers. Improvement responsibility throughout the organization
● Organization	Extremely decentralized but concentrated in one city. Most parts and design from small machine shops. Coordination by owner/ entrepreneur.	Vertical integration. Central organization – design, engineering and production in one place.	Network of suppliers with design and engineering capability. Improvement along supply chain.
● Tools	General-purpose machine tools.	Dedicated machines.	General purpose.
● Product	Very low production volume – 1000 or fewer per year. No two exactly alike.	High volume. Long product life cycle.	Ever-decreasing model life cycles. Niche models possible.

Appendix 1 : Lean production as a derivate of Craft and Mass production (Taylor and Brunt, 2010)

SSCM adoption challenges identified through literature.

S. No.	SSCM adoption challenges	Description
1	High initial cost for environmental friendly packaging	The high cost for packaging of products restricts its adoption among the organisation
2	Poor management commitment for adoption of sustainability	The minimal involvement of top management authorities towards sustainability adoption leads to SSCM implementation failures
3	Ineffective linkage of sustainability with existing process structure	In many cases, the management is unable to link sustainability within the existing supply chain process structure
4	Conflict among product sustainability policy and free trade provisions	There exists conflict of interest between the product sustainability policy and free trade provisions which influences sustainability adoption
5	Unavailability of effective framework for SSCM adoption	Lack of availability of appropriate SSCM framework deviates the organisation from achieving sustainability in supply chain
6	Lack of awareness of sustainable standards for raw materials	It is extremely critical to be aware of existing sustainable standards of raw material in context to the suppliers
7	Strong perception towards low economic returns	The decision making authorities have perception of low economic returns through adoption of SSCM
8	High cost of sustainability adoption	The adoption of SSCM requires high initial investment and this again acts as a drawback that resists the management through adoption process
9	Ineffective employee training for sustainability	The employees need to be trained regarding adoption strategies for sustainability in order to enhance supply chain performance
10	Non-consideration of human factors	Many organisations ignore the human factors that eventually affects the organisational performance and misaligns the supply chain activities
11	Non-uniform alignment of sustainability, organisation goal and customer expectation	It is significant to make a perfect mix of sustainability, organisation goals and customer expectations to sustain in the global competition
12	High disposal costs	The high disposal costs restricts the organisation from adopting sustainability in supply chain
13	Lack of effective communication with suppliers	It is important to have strong and real time communication with the supplier by tracking organisational activities to eliminate the production delay
14	Replicating sustainability adoption strategies of other organisations	To gain quick success in SSCM adoption, many organisation attempts to replicate other organisations' strategies that often lead to adoption failures
15	Design complexity for energy consumption reduction	To produce sustainable products and reducing energy consumption several organisations switches to alters design procedures which leads to complexity
16	Inappropriate execution of sustainability practices	Ineffective utilisation of sustainability practices makes it difficult to adopt SSCM
17	Lack of effective employee engagement and empowerment	Defined involvement of employee in managerial activities and offering empowerment improves their efficiency and supports SSCM adoption
18	Inappropriate estimation of SSCM adoption cost	Lack of effective estimation of SSCM adoption is extremely necessary for its successful execution
19	Lack of availability of resources (financial, technical, human, etc.)	Unavailability of financial, technical and human resources makes it critical for the organisation to adopt sustainability
20	Ineffective supplier selection strategies	Selection of appropriate supplier is necessary to produce desired sustainable products
21	Ineffective performance measurement system	Lack of appropriate performance measurement system results in ineffective mapping of performance and tracking of supply chain activities
22	Inappropriate system of reverse logistics	Lack of effective reverse logistics system makes it difficult to recycle the products and the path towards sustainability achievement gets deviated
23	Unavailability of sustainability standard and regulations	It is essential to have exposure towards sustainability standards and regulations because it ensures the benchmarking of the produced products
24	Lack of effective inter-departmental communication	Poor communication within the departments delays the monitoring of activities and though the adoption process
25	Loss of return material in transit	Return material loss in transit strongly affects the reverse logistics activities
26	Resistance of culture change	During sustainability adoption, the employees portrays resistance to culture change which makes SSCM adoption difficult
27	Usage of outdated auditing standards	Unavailability of advanced data auditing standards affects SSCM adoption
28	Complexity within supply chain configuration	Existence of complexity within the supply chain restricts in adopting sustainability among traditional SC

Appendix 2: SSCM adopted challenges, (Yadav et al, 2020)

Industry 4.0 and CE based solution measures identified through literature.

S. No.	Solution measures	Description
1	Supplier commitment for recyclable materials	Assurance of supply of recyclable raw materials uplifts the probability sustainability adoption in existing supply chain
2	Adoption of 6 R's within the organisation	By adopting 6 R's in the organisation, the sustainability level can be enhanced
3	Green Purchasing and packaging	Green purchasing and packaging ensures minimal harm to the environment and society
4	Rewards and incentives for greener activities	Planned rewards for execution of greener activities promotes sustainability
5	Co-ordination and collaboration among SC members	Effective co-ordination among supply chain members leads to develop smart information and communication system
6	Supplier Commitment and involvement for sustainability adoption	Suppliers need to be educated for sustainability benefits to strengthen their commitment
7	Adoption of advanced machine learning algorithms	Usage of advanced machine learning algorithms will develop flexibility among the existing supply chain
8	Adoption of smart factory components	Employing smart factory components will boosts the success possibility of SSCM
9	Availability of CE oriented framework (Resolve)	Adopting CE specific framework will help in enhancing reverse logistics activities
10	Strong interdepartmental IT linkage system	Effective interdepartmental IT linkage system results in uninterrupted monitoring of SSCM activities
11	Environmental Product Design and life cycle analysis	Designing of product considering environmental aspects and effective life cycle analysis smoothens SSCM adoption
12	Adoption of advanced quality improvement techniques	Practicing advanced quality improvement techniques will assist in removing non-value added activities in existing SC results continuous improvement
13	Digitisation of supply chain activities	Digitising supply chain activities will help in optimising the entire supply chain
14	Sustainable resource management	Sustainable resource management will help in reducing the energy consumption leading sustainability achievement
15	Adopting Industrial ecology initiatives	Industrial ecology initiatives helps in implementing circular economy practices for better sustainability
16	Adoption of advanced predictive maintenance system	Execution of advanced predictive maintenance helps to prevent system shutdown and break in supply chain
17	Effective facility planning	Better facility planning helps in executing supply chain practices optimally
18	Adoption of safety standards	Existence of safety standards in the system ensures employee safety from accidents during supply chain
19	Understanding economic and social benefits	Realising economic and social benefits of sustainability enhances its adoption possibilities
20	Building brand image based on CE and I 4.0	Developing a brand image on CE and I 4.0 helps in global acceptability of produced product
21	Educating customers for recycling practices	Regular education for customers to execute recycling practices assist in improving sustainability adoption
22	Integration of digital and physical systems	Linking digital and physical systems facilitates the supply chain tracking system for quick responses

Appendix 3: Solution measures identified in the literature, (Yadav et al, 2020)