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# Vendor Partnerships in Sustainable Supply Chains in the Indian Electric Two-Wheeler Industry—A Systematic Review of the Literature

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**Abstract:** The United Nations Convention on Climate Change 2015 mandates reducing the carbon footprint to reduce global warming. Considering environmental concerns, electric vehicles (EVs) spearhead the move towards green mobility. Niti Aayog (Indian Government) has envisaged an "EV only" scenario by 2030. Two wheelers, with almost 80% of the market share of the Indian automobile industry, will provide the primary thrust for EVs. The holistic sustainability of the Indian EV two-wheeler industry will depend upon its vendor partnerships and processes, which are examined in this paper through a systematic review of the literature available from all known sources. This study, after reviewing over 165 papers apart from government and independent reports, also explores how sustainability and allied topics like green supply chain management in business decision making promotes efficiency, controls expenditure, enhances customer delight, increases sales and market share, optimizes risk management strategies and promotes profitability. Considering the restricted availability of the literature on the Indian automobile industry in general, and specifically on the Indian EV or EV two-wheeler industry, this work will help in bringing focus on this area of fast-burgeoning importance and will pave the way for the establishment of a conceptual framework for research.

**Keywords:** sustainability; electric vehicles (EV); vendor partnerships; vendor management; electric two wheelers (E2W); supply chain management (SCM); sustainable supply chain management (SSCM)



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## 1. Introduction

The quest for clean energy aided by government regulations and a proactive world-wide zeitgeist have hastened the move towards electric vehicles (EVs). The United Nations (UN) Convention on Climate Change 2015 [1] aims at reduction in the carbon footprint globally. Citing proactive responses, the "Fit for 55" program of the European Union (EU) seeks a 55% reduction in greenhouse emissions through policies and measures with a target of 2030; and the US government set a 50 percent target for EVs by 2030 [2].

A total of 20% of global $CO_2$ emissions emanate from transport use, rising to 24% for emissions from energy [3], which is particularly significant for India, where 30% of urban particulate emissions are due to two-wheelers [4]. India imports 85% of its oil needs [5], with impacts on geopolitical resilience. The Indian auto industry follows that of China and USA, being the 3rd largest [6]. Two-wheelers (2W) constitute almost 80% (numbers; not value) of the automobile sector in India [4,7,8].

India has a clear preference for 2W and three-wheelers (3W) [9]. Electric bikes and scooters (E2W) hence have ample scope [10], with the electric two-wheeler (E2W) market expected to have a compounded annual growth rate (CAGR) growth of 29.07% to reach USD 1.3 billion by 2028 [11]. Ironically, in spite of the potential, E2Ws in India have not

really been well researched. The need for EV research (in a broader sense) as well as opportunities and challenges for this industry has been spoken about, but most studies do not directly address the E2W supply chain [12].

EVs, which cut fossil fuel use, paradoxically increase power requirement manifold, but disrupt the entire automotive supply chain [13]. This disruption has implications on the sustainability of the supply chain which is impacted by vendor partnerships.

The significance of this study stems from the increasing importance of EVs in addressing environmental concerns, the importance of E2Ws in the EV industry, the importance of India as a rising economic and manufacturing power, and the importance of vendor partnerships in ensuring the sustainability of the EV industry. This work is expected to attract more research in vendor management and partnerships, especially in the Indian automobile industry context, thereby bringing focus on this fast-growing area, and will pave the way for the establishment of a conceptual framework for future research. This paper will explore existing research in the past decade in sustainable supply chain management (SSCM) and vendor partnership, as related to EVs especially; and in the process, examine what research gaps exist that need to be addressed.

This paper will scrutinize the literature available on barriers to the adoption of EV, government policy, sustainability, SSCM, green supply chain management (GSCM), economic perspectives, profitability, environmental aspects of manufacturing and social aspects, all of it in an Indian context.

## 2. Sources and Classification of the Literature

For an extensive review of the literature to identify research gaps, over 165 research articles published in 79 different journals and 15 reports pertaining to sustainability, SSCM, GSCM, vendor collaborations or strategic partnerships, automobiles, automobile engineering and EVs were perused. Effective references to reputed publishers like Emerald Insight, Springer, Wiley, Elsevier, SAGE, MDPI, and Taylor & Francis have been made. Articles published in Government websites and widely circulated national newspapers have been studied. String searches with requisite filters and keywords as well as backward and forward searches as required were explored to identify the relevant literature pertaining to sustainability, EVs, vendor partnerships, vendor management, E2Ws, supply chain management (SCM), SSCM, etc.

The outcome is explained in the ensuing paragraphs, which go on to explore the need for this study; barriers to EV penetration; policy and its role in EV manufacturing; environmental aspects including sustainability, sustainable supply chain management, green supply chain management and manufacturing; the economic, social and profitability perspectives; supply chain practices and vendor partnerships.

### *2.1. Need and Scope*

The need for this study and any connected research is directly related to EV proliferation across the world and especially in developing countries like India. To this end, examination of smart mobility solutions found significant potential for EVs to address global concerns [14]. Similarly, the outlooks of various EV technologies and areas for further growth have been explored [15,16], while tailor-made lessons for India on EV adoption have been drawn [17]. Recommendations on how EVs can help India keep the five pledges: to achieve net-zero emission (2050); generate 500 Giga Watts (GW) non-fossil energy (2030); achieve half the energy generated to from renewable sources; reduce greenhouse gases by 1000 million tons; and reduce the intensity of the economy's carbon emissions to less than 45% have been given [18].

The process to follow a 7-C attempt to gain insights into the future of Indian mobility, a mobility paradigm with dependence on connectivity, commonality, convenience, and state-of-the-art infrastructure for reducing congestion has been laid out [19]. A multi-level perspective (MLP) in studying how the E2W socio-technical system evolved has been developed, has also been set [20].

### 2.2. Barriers to EV Adoption

Global EV proliferation, a desirable outcome as highlighted in Section 2.1, has been partly impeded by apprehensions on higher initial and lifetime costs, charging concerns with the lack of suitable points, and a lack of overall awareness of the technology. A machine learning model has been used to predict EV purchase in India, arriving at the conclusion that while buyer age, gender, salary, environment issues, performance and lifetime cost, range anxiety and market forces are significant predictors, some other expected parameters like education level and government subsidies do not play a significant part [21–23]. 13 barriers using ISM (Interpretive Structure Modelling) and MICMAC (Matriced' Impacts Croisés Appliquéeá un Classement) to help policy makers and EV manufacturers to overcome design constraints have been identified [24].

The fuzzy-SWARA (Stepwise Weight Assessment Ratio Analysis) method and the fuzzy-WASPAS (Weighted Aggregated Sum Product Assessment) to attribute weight to each of the EV barriers, with the main barriers being higher vehicle prices and a lack of adequate charging stations; to be overcome through government policy, support and strategic planning, has been used [25].

Investigation of factors affecting EV adoption, and expectedly find higher penetration in countries where the levels of sustainable development are higher has been carried out [26]. With regard to sales promotions, the exploration and ranking of a dozen significant manufacturer challenges, using the triangular fuzzy number (TFN) method has been done [27], finding limitations in charging infrastructure to be a big challenge towards penetration [28].

A case study in Delhi, UP, Gujarat and Karnataka found that in order to achieve a penetration of 30% EVs, these states would need to register 0.31, 1.51, 0.88 & 0.79 million EVs by 2030 [29]. There is demonstrated reluctance for EV adoption amongst those who place a premium on the vehicle performance [30]. Factor analysis has been used to determine what exactly influences buyers' behavior towards EVs touching upon parameters like loyalty, range and motor efficiency, and charging efficacy [31]. It has been explored how a shared economy in conjunction with public transport affect EV adoption, keeping the affordability of the Indian consumer in mind [32].

### 2.3. Policy

The FAME (Faster Adoption and Manufacture of Hybrid and Electric Vehicles) scheme was adopted in 2015, which enabled the Indian EV market to grow in leaps and bounds, displaying the importance of government policy. Notwithstanding this, it was found that India has been falling behind other countries in EVs due to the lack of an explicit policy or strategy [33]. The government's role in facilitating EV proliferation has been brought out [34].

The Indian EV market valuation in 2020 was USD 5.47 billion, projected to reach USD 17.01 billion by 2026 (CAGR 23.47% over 2021–2026) [35]. By 2030, the Indian Government rooted for 'E-Vehicles Only' [36,37], in a way showing the government commitment for proliferating EVs.

A strengths, weaknesses, opportunities, and challenges (SWOC) analysis to encourage policy makers, governments, and businesses to incentivize EVs in India, with the Centre coordinating state activities has been done [33]. EV policies and environmental and socio-economic impacts in India have been explored, with the focus on battery wastes and advocate a safe working environment for workers and communities [38]. Parliament questions on EV policy to prevent air pollution have been intricately examined for insights [39].

The methodology for design and selection of governmental policies, challenges and mitigation, to boost Indian EV adoption vis à vis a global perspective has been discussed [40,41]. While most government policies focus on subsidies, it was found that only personal cars and long-haul trucks need subsidies, and that upfront subsidies are the

most effective [42]. Sometimes policies can also impede growth through policy, supply chain and finance challenges [43].

### *2.4. Environmental Aspects*

India's declared intent is carbon neutrality by 2070. There is a need to green our transport system towards achieving this in keeping with the Paris Agreement [44,45]. Clean air, aided majorly by EVs, is one of the foundation blocks. Research indicates cutting 80% pollution from road transport by 2070 in India [46,47].

There are challenges in dealing with the challenges in lithium-ion battery (LIB) disposal focusing on the availability, storage, and transportation of LIB [48]. EVs can lead to reduction in pollution only if maximum electricity used for charging, emanates from renewable sources [49,50]. The environmental issues of the Indian automobile industry, using SWOT analysis, and allocating scores to each environmental factor have been addressed [51]. The health impact of the transition to EVs has been examined by looking at emissions, air quality and effect on individual health in China [52].

#### 2.4.1. Sustainability

Sustainability has been described in management parlance and in operations to encompass societal, environmental and economic concerns [53], which was also found to be lacking [54]. The balance in the three aforesaid concerns was found to be elusive and complex [55,56]. Brundtland World Commission on Environment and Development defined sustainability as "a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [57].

Its criticality in supply chain and operations management was put forth [58]. Organizations considering environment and society in their efforts, prove competitive in the long run [53]. Sustainable practices can impact performance and supply chain visibility can act as a moderator [59]. Empirical analysis of strategic sustainability and operational initiatives in medium and small manufacturers has been carried out [60].

#### 2.4.2. Sustainable SCM (SSCM) & Green SCM (GSCM)

The evolution of supply chain management (SCM) into SSCM in industry is natural in a world fast moving towards green practices. SSCM ensures that supply chains (SC) are run such that it integrates the objectives of the exercise as articulated by the firm as well as other stakeholders [61]. By integrating environment and social factors to the conventional supply chain, operational competitiveness is achieved [62].

Based on 3BL approach, SSCM can be defined as "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains" [53].

Another definition of SSCM: "The management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements" [63].

While empirical investigations in SSCM in recent years is growing in developing countries [64,65], the inadequacy of SSCM research in developing countries is observed [62,65]. Further, most empirical studies on SSCM deal with environmental and economic dimensions, without attempting to identify and address social or environmental aspects of the supply chain [66,67].

That SSCM can boost competitiveness (contrary to popular belief) has been established [68,69]. Counter-intuitively, empirical investigations in Chinese firms revealed that while SSCM had positive impact on firm's environment and social performance, its impact on the monetary performance was not seen [70].

Internal conflicts may warrant an uneven balance in the three concerns for supply chain sustainability [71]. Taking ethical concerns in SSCM, a link has been drawn between SSCM

and sustainable development goals (SDGs) [61]. Additional dimensions of performance and governance have been introduced, bringing out the existence of research gap in collaboration between suppliers and customers to enhance SSCM [54]. The inadequacy of SSCM research to cover societal issues and the interplay of the above sustainability dimensions has been studied [65].

Environmental aspects of sustainable supply chain can be clubbed under GSCM, which is loosely considered to be part of SSCM, although no consensus exists. The difference between GSCM and SSCM has been brought out with the opinion that GSCM covers only environmental performance, whereas SSCM covers social, environmental and economic performance [61].

An exhaustive literature review on GSCM, observed significant increase in its study in the past decade, albeit qualitatively [72], with the perception that there was ample scope for further quantitative and empirical analysis. The concept of green supply chain integration (GSCI) in organizations encompasses internal GSCM, supplier GSCI, customer GSCI and community GSCI [73]. With regard to supplier GSCI, in order to achieve environmental enhancements, a healthy collaborative structure with suppliers is mandated, involving support and sharing of resources with suppliers.

Green manufacturing practices fully support all three dimensions, with scope for further research on integration into other parameters of sustainability [56]. Perusal of research articles published from 1996 to 2015 related to emerging economies in Asia, found that GSCM led to improved performance economically, environmentally and operationally but not socially [74].

A single-vendor single-buyer (SV-SB) framework can promote carbon emission costs saving [75], and further, a green supply chain can be promoted in light of the government's carbon policies [76].

#### 2.4.3. SSCM & GSCM in the Indian Automobile Industry

Barriers and hurdles for setting up an effective SSCM for the Indian automobile industry have been studied [77,78]. 7 factors have been validated with 67 variables that affect the sustainable manufacturing of EVs in India, to benefit original equipment manufacturers (OEMs) and service providers [77,79]. The impact of six critical success factors (CSFs) on GSCM have been studied towards sustainable supply chain in automobile industries in India, viz, internal management, customer management, regulatory, supplier management (strong partnership with suppliers), social and competitiveness [80].

SSCM practices in the Indian automotive industry, taking a multi-stakeholder view, by examining vendors, suppliers, OEMs, MSMEs, distributors, transporters, franchisees and exporters have been studied [81], while CSFs of GSCM for achieving sustainability and profitability in the Indian automobile industry were looked into [78,82].

The sustainable supply chain practices in the competitive Indian automobile industry have been empirically looked into [69] with an assessment of sustainable supply chain initiatives in the Indian automobile industry using the PPS method also being done [22]. The SSCM of the automotive sector in context to the circular economy laying out a strategic framework in the process has been studied [83].

A resilience strategy in the supply chain can be a primary factor in ensuring sustainability in the automobile sector, offering good inputs on how to optimize vendor management while simultaneously ensuring sustainability [84]. Research has thrown insights into the development of environmental collaboration among supply chain partners for sustainable consumption & production [85].

The environmentally conscious SCM process benefits the industry as a whole and the Indian EV sector by association [86]. This is referred to as environmental management in the role of supply chain capabilities in the auto sector [87]. Taking another angle, the correlation of sustainable manufacturing and green human resources for success in the automotive sector, has been studied [88]. Green manufacturing and eco-innovation on sustainability performance has been explored [55]. An empirical analysis of green SCM

practices in the Indian automobile industry, is also relevant to the EV industry since the complete process of production, distribution, warehousing, franchising, transportation, exports, sales and after sales support, are common to both [89]. An optimal strategic sourcing model for green SCM in the Indian automobile industry has been taken up by researchers [90].

### *2.5. Green Energy and Manufacturing*

A comprehensive green process will encompass generation of power, charging, and its ultimate disposal of storage devices. There exists a paradox that energy to run EVs are not produced in a green manner [91]. The extensive proliferation of EVs will necessitate higher energy production with corresponding impact on the electric grid [92,93].

A heavy dependence on imported oil (90%) and industrial coking coal (80%) exposes us to volatility in global energy markets [94]. They focus on the three major consumers—power, transport and industry. India's new and renewable energy market policies and implications for foreign cooperation have been assessed [95].

The feasibility of solar cell integrated energy storage devices for EVs has been examined [96]. Evaluation of the efficacy and adequacy of green charging attempted by centralized EV stations, finds that greater effort is needed [97]. A young consumer EV rental behavioral model to analyze all these issues has also been developed [98].

Battery swapping [99], and recycling batteries through new techniques like pyrometallurgy, hydrometallurgy and green technologies have been studied [100]. Similarly new battery technologies with new cathode and anode materials such as silicon, lithium-sulfur, and lithium-air have also been explored [101]. While solid-state electrolytes have also been explored to improve safety and longevity, it has been found that sodium ion battery (NIB) can supplement but not replace the lithium-ion battery (LIB) [102]. The wireless power transfer (WPT) system [103], and variable renewables for flexible EV charging for decarbonization of the rapidly growing power sector [104] have been studied. The relevance of the battery raw material supply chain, material processing, and commodity price appreciation [105] has been established while the battery and power related aspects of Indian EV sector have been evaluated [106].

Energy eventually is but a geopolitical play of nations, and lithium is the new gold [107]. Geopolitical risks and strategic uncertainty after the Ukraine war, analyzing how the circular economy can decrease market power of lithium and resources dependency on critical minerals is insightful [108], and the economic feasibility of green hydrogen and fuel cell electric vehicles for transportation in China [109] gives a timely insight into the future of alternate propulsion.

Green manufacturing norms help in meeting governmental regulations and establish processes compatible with modern world environmental concerns, and it is pertinent to analyze the CSF of green manufacturing towards sustainability, specifically in the automotive sector [110]. Internet of Things (IoT) is increasingly facilitating how machinery and products talk to each other, with immense application in the automobile industry. Assessing the relevance of green manufacturing and IoT in industrial transformation, marketing management, and computational intelligence techniques for green smart cities is timely [111]. Reviewing green manufacturing, it has been described to usher in a modern era for Indian manufacturing industries [112].

An analysis of the developed versus developing world vis à vis utilizing emerging technologies in implementation of green practices has been done [113]. Using a unique technique, barriers to green manufacturing using the hybrid approach focused on the automobile industry, have been evaluated [114].

### *2.6. Economic Perspective and Profitability*

Sustainability should lead to profitability (the prime objective of any business), while simultaneously balancing environmental and social responsibilities [54]. An analysis of operational and economic performance shows that economic performance is macro in

nature and includes dimensions like decrease in cost of production and energy cost [66]. Some other economic dimensions considered in the literature are financial outcomes, cost reductions, competitiveness and profits [71]; operating cost, total sales, employees' wages & benefits [69]; market share and returns on the investment made along with profitability [70]; and, productivity, firm's edge and customer satisfaction [82]. The economic dimensions also consider competitive priorities like cost, delivery, quality, flexibility [115]. Financial performance and inventory management which deal with many aspects of vendor management as well as the supply chain specifically in the Indian automobile industry, have been interrelated, [116].

### *2.7. Social Perspective*

The GSCM literature indicates a vacuum with regard to social performance in research [56]. Societal sustainability in small and medium manufacturing enterprises (SME's) and its impact on performance of a firm analyzing six social factors which included parity, security, charity, healthiness and welfare, integrities and basic rights have been studied [117].

Social aspects of supply chains using best-worst method in manufacturing industries of Iran, predominantly considering the health and safety issues at work were studied [118]. A qualitative case study in pharmaceutical industries located in USA, China, Europe, Japan and South Asia, discovered that collaborative training can enhance social aspects of sustainability by considering supplier development aspects [119].

### *2.8. Supply Chain Practices*

The concept of 'supply chain' has been adequately defined [120]. Bibliometric and systematic reviews have been used to achieve state-of-the-art in EV supply chains, employing quantitative and qualitative indicators to identify supply chain risks [121]. Outlook for EV demand juxtaposed with supply chain demand trends has been examined [122].

After systematic ROL on SSCM in the global supply chains, research articles of 15 years have been classified into two categories: configurations and governance mechanisms related to suppliers [123]. Review of supply chain integration, found that there is not much significance of practices on performance parameters, which may be due to selection of heterogeneous sectors and biased responses [67]. They recommended future study to be limited to a particular industry for consistent results. The importance of having a strategic supplier partnership and good customer relations empowered with optimal and quality information sharing has been studied [124]. Strategic collaboration and the modalities of external and internal sharing of knowledge [125]; information sharing [126,127]; sustainable procurement practices, which focus on in-house and outsourcing modes [128]; green and ethical supply management [129]; and, supplier innovativeness, information sharing and strategic sourcing [130] have also been studied.

A significant relationship between SCM practices and organizational performance including innovation has been established [131]. A need to undertake further research on practices in collaboration between suppliers and vendors has been felt [129]. A study on Taiwan's optoelectronics industry revealed that such a collaboration can actually positively impact innovation further improving competitiveness of the firm [127].

#### 2.8.1. SCM in the Automobile Industry

The complexities and challenges of SCM in the Indian automotive industry, have implications for the EV industry too [132]. SSCM practices of Indian automobile industries like lean practices, eco-design practices, continuous improvement, risk management practices, customer cooperation ethical behavior, investment recovery and technological innovation have been studied [69], finding that SSCM can positively impact supply chain performance, thereby recommending that automobile companies in India should encourage vendors towards sustainability, perhaps by sharing initial costs as a motivational tool.

CSFs have been identified to achieve optimal level of green SCM performances and profitability in the Indian automobile industry [133]. Resilience has been correlated with the sustainability of the supply chain in the Indian automobile industry [134]. It has been relevant to study lean practices in the automobile sector, which faces numerous challenges like regulation, labor, and high initial costs [135], well-documented with overcoming strategies [136].

Critical components in the EV industry like batteries and electric drives and for autonomous driving like light detection and ranging (LiDAR) sensors and radar sensors are likely to reach 52% of total market size by 2030. Components only used in ICE vehicles such as conventional transmissions, engines, and fuel injection systems would reduce to approximately 11% by 2030 (approximately 50% of 2019 levels), forcing traditional component players to adapt quickly to offset decreasing revenue streams [2]. The EV industry has attracted more than USD 400 billion in investments over the last decade, with approximately USD 100 billion of that coming since the beginning of 2020 [2]. All this will significantly impact the supply chain in the Indian automobile industry.

#### 2.8.2. Logistics/Industry 4.0 Concepts

Logistics 4.0 is a new science to enhance the efficiencies of logistic support and SCM. Studies show the link between Industry 4.0 and GSCM in the automotive industry, and revealing their compatibility, thereby alleviating concerns that green practices adversely impact profitability or commercial performance [110,137]. A MICMAC analysis of Industry 4.0 in the Indian automotive industry has been carried out [138]. The process of correlating the techniques of green smart manufacturing in the Indian automotive industry, analyzing and prioritizing the barriers to the same; and examining how it can be used to implement Industry 4.0 using the AHP technique, has been addressed [139].

### *2.9. Vendor Management*

Vendor collaboration is a partnership which works towards mutual benefit of the parties involved [54,61,70,140,141]. Competitiveness of firms can be boosted by focusing on core business and outsourcing non-core activities [142,143], which logically highlights importance of vendor partnerships. A direct correlation between levels of partnership and performance has been established [144].

A strong relationship between innovation (including in vendor collaboration) and sustainability performances has been established [145]. Partnership management and supplier collaboration on innovation performance of Chinese manufacturing companies have been empirically studied, finding its direct effect on innovation performance, transfer of wide information, knowledge and technology [146]. ROL found inadequacy of study on supply chain collaboration in Indian context [147]. Most research failed to draw a connection between vendor collaboration and impact on lengthy partnerships [148].

The literature shows that vendor managed inventory (VMI) is a competitive and flexible business model SCM tool for reducing the inventory management cost [149]. A study of Malaysian manufacturing industries and also found that VMI reduces operational cost and improves customer satisfaction [150,151]. Future research on the impact of collaboration on resiliency of supply chain has been suggested [152].

#### Vendor Partnerships in the Indian Automobile Industry

Supplier selection has been studied using a decision-making model, which employs an integrated MCDM approach with evidence from the Indian automotive sector [153]. Vendor selection in the Indian automotive industry has been studied through a case study with the creation of a Two-Stage Multi-Criteria Supplier Selection Model for sustainability in supply chains in the automobile industry [67,154]. The practices for the selection of suppliers to ensure lasting global supply chain networks have been explored [155]. VMI factors in automotive industries from buyer and vendor perspectives have been analysed [156].

Some term lean and agile practices as 'leagile' and the leagile enablers of the SCM Indian automobile sector have been modelled [157], with the measurement of supplier performance and selection [158]. Improving supplier capability through training could be very effective for the overall performance of companies, obtaining research evidence from the Chinese Automobile Industry [159].

At present, challenges in the Indian automobile sector include inventory optimization, warehousing, transport, distribution, damages during transit and delivery, and the lack of real-time visibility and information sharing across stakeholders. Vendor management practices may ameliorate this. Various technologies and models on SCM performance in India's automobile industry to address these challenges have been assessed [160].

## 3. The Conceptual Framework

The literature review brings out that researchers identified various research gaps and scope for future research in SSCM practices. A look at the literature demographics indicates that most research on SSCM has been carried out in China, SE Asian countries like Taiwan, South Korea, Malaysia, and some Middle Eastern/African countries like Jordan, Kenya and Iran. Limited studies exist in India on GSCM pertaining to automotive and other manufacturing industries. Another common trend seen through literature reviews is that studies take into account a number of different types of industries and generalize findings which may not hold good for a specific industry, since operations in different industries vary in nature and are not comparable. Resultantly, studies have not supported many important hypotheses. Researchers themselves have recommended that research be carried out for a specific industry for consistent results and extend further longitudinal research for future.

Some research gaps identified based on research in the past decade are:

- Need for study specific to EVs in India rather than generic to the automobile sector or industry.
- Need for India-specific study on E2Ws.
- Need for specific topics of research to consider developing country like India.
- Need to incorporate and integrate social issues in SSCM performance.
- Need to further research on vendors/suppliers' partnership or collaboration on sustainable supply chain performance.
- Need to focus investigation of SSCM performance to a particular type of industry to have consistency in results, which in this case would be the EV sector in India and specifically E2W sector.

A tentative conceptual framework is given in Figure 1. This framework shows how vendor collaboration and partnerships can impact industries positively with regard to economic, environment and social aspects.

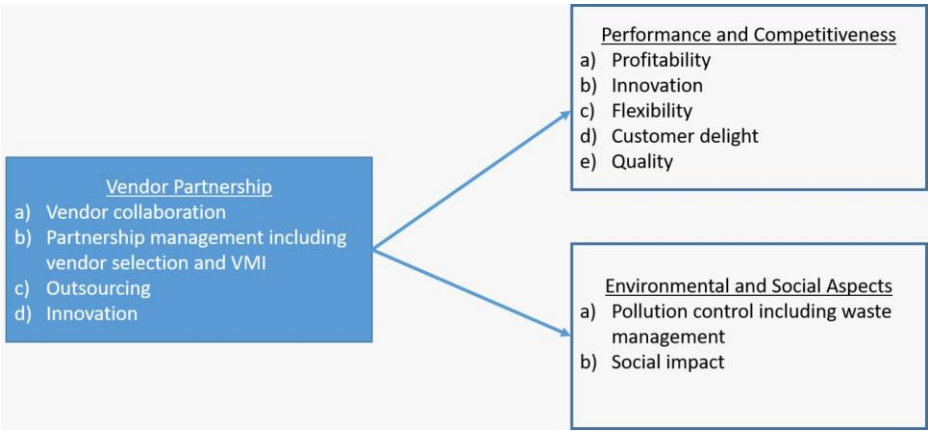


**Figure 1.** The Conceptual Framework.

Under Vendor Partnerships, the aspects of vendor collaboration, vendor selection, partnership management, VMI, outsourcing, innovation, etc., can be studied using various independent variables like top management commitment, quality of vendor, and information sharing between the company and its vendors.

On the dependent variables' perspective, performance and competitiveness (profitability, innovation, flexibility, customer delight, quality) and environmental/social aspects (pollution control including waste management and social impact) can be studied.

Research on the above lines will have the following outcome:

- Assessment of critical factors of suppliers' partnership influencing industry's performance.
- Evolve suitable sustainable supply chain practices to tap significant opportunities expected in the EV/E2W industry in future.
- Assessment of GoI support for the E2W industry, and influence of State Government's policies on the development of ecosystem, especially for undertaking E2W manufacture.
- A framework for further research on investigation of other variables like technology, human resources, investment, operations, vis à vis industries' performance.
- Creating awareness among the E2W industry on the opportunities existing and also solutions for the supply chain challenges related to E2W work packages.
- Academic institutions collaboration for E2W research and development activities.
- The current study is expected to help practitioners of not only the E2W industry but also other manufacturing industries for overcoming supply chain challenges.

The various application fields are foreseen to include the E2W and EV industry; industries embracing green energy norms and sustainability; industries involved in the production of green energy and alternate energy sources; and, vendor management and sustainable supply chains.

## 4. Future Research and Conclusions

### *4.1. Limitations*

The limitations of this review include restricted material including empirical data availability in the Indian context with regard to the automobile as well as the EV industry. Some of the dynamics of the automobile industry relied upon for the literature, may not be true for the EV industry. The reliance on imports for EV manufacture may impact the vendor management principles followed for the automobile industry in general. The net impact of the energy saved through non-use of fossil fuels vis à vis the additional power requirements for charging of batteries in EVs have not been taken into account.

### *4.2. Discussion*

#### 4.2.1. Theoretical

We have built upon the need and scope for EV technology and how it can address global climate concerns [14,18]. For EVs to proliferate, barriers will need to be understood [23,161]. The importance of government policy in helping this industry cannot be undermined [34].

Building upon sustainability [53] and its evolution into SSCM and GSCM [64] and specifically in the Indian automobile industry [81,136], we have seen its interplay with profitability [54] even as Indian attempts to implement green manufacturing norms [110] and logistics/industry 4.0 concepts [137]. How vendor management and collaboration impact these factors [54,61,70,140,141] has been examined with a tentative conceptual framework.

#### 4.2.2. Managerial

Taking the theoretical aspects forward, we have outlined steps that can be taken by managers to adopt 'leagile' practices [157] and supplier selection [153,158]. This work seeks to encourage managers to link sustainability and vendor management to profitability and that addressing environmental concerns need not affect economic perspectives [66]. Managers in the Indian EV industry need to adopt best practices of the global automobile industry while adapting to specific dynamics of EVs and EV supply chains [77,79]. Our

work thereby highlights the significance of vendor partnerships in promoting sustainability in the Indian E2W industry.

#### 4.2.3. Areas for Future Research

Some topics for further analysis, study and future development are:

- Research on E2W penetration, proliferation in India and globally, including studying its role in expediting the shift from ICE. Further analysis on buyer behavior towards EV purchase and barriers.
- Research on alternate elements for future batteries with corresponding impact on geopolitics, including geopolitical aspects of dependence on lithium., e.g., research on materials like sodium for batteries. Research will also focus on other propulsion technologies like hydrogen and solar driven.
- For balance, future research can also explore the negative impact of EVs on society, environment, industry, supply chain, etc. Examples include disposal of existing ICE vehicles, and EV batteries, which will be a logistics and environmental nightmare.
- More in-depth analysis of the social impacts of EV industries.
- Research on supply chain of automobile ICE industries vis à vis the EV industry, and changes necessitated. Supply chain involved in the eventual and perhaps inevitable re-purposing of ICE automobile factories into EV production lines, and the consequent evolving of vendors for this change, could be studied.
- The supply chain and logistics aspects that determine the choice of location for setting up an EV plant.

### *4.3. Summary*

The literature review has made evident the gaps in research with regard to the Indian E2W industry, which is fast gaining in stature in its attempts towards assuming humanity scale in terms of numbers, profitability and technology, not to forget adherence to global norms for sustainability. We have seen how green and sustainable practices in the automobile industry in India in general and the Indian EV/E2W industry in particular, could benefit through better vendor management practices and appropriate partnerships. Indian Government policy too would have a significant role in encouraging and incentivizing the industries dealing with the manufacture of EVs. The success of Indian manufacturing will largely depend on the potential of the E2W industry to exploit state-of-the-art in sustainability and green manufacturing.

In this context, far greater research than exists at the moment, is required to study this subject holistically, especially from an Indian viewpoint, since EVs will be the go-to technology in the fight to battle climate change for the upcoming decades at least until newer propulsion systems, like hydrogen, fuel cells, and solar, take over [162,163].

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