Review

Vendor Partnerships in Sustainable Supply Chain in Indian Electric Two-Wheeler Industry – A Systematic Review of Literature

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Review

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

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Abstract: UN Convention on Climate Change 2015 mandates reducing 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 dominate the Indian automobile industry with almost 80% market share. With the transportation sector accounting for 70% of world's fossil fuels use, the need for a sustainable supply chain which addresses environment, economy and societal issues, has, of late, aroused interest in the business academic community and industries. Sustainability in business decision-making promotes efficiency, controls expenditure, enhances customer delight, increases sales and market share, optimises risk management strategy, and promotes profitability. This study intends to develop a conceptual framework after examining research gaps in sustainable supply chain management (SSCM) and allied topics like sustainability, green supply chain management, and vendor partnerships through collaborative efforts. Even the UN vide Goal 9 of sustainable goals pertaining to industry, highlights the importance of this framework.

Keywords: supply chain management; SSCM; sustainability; environmental concerns; electric vehicles (EV); ICE vehicles; Li-ion batteries; vendor partnerships; vendor management strategy (VMS); electric two wheelers (E2W)

Introduction

The quest for clean energy aided by government regulations, and a proactively pro-planet zeitgeist, have hastened the move towards electric vehicles (EVs). The United Nations (UN) Convention on Climate Change 2015 (S. Seethalakshmi & K. Shyamala, 2019) aims at reduction of the carbon footprint. Regions and countries followed suit in adoption of their own regulations. The "Fit for 55" program of the European Union (EU) seeks 55% reduction in greenhouse emissions through a combination of policies and measures with a target of 2030; and the US government set a 50 percent target for EVs by 2030 (Cornet et al., 2021).

20% of global CO_2 emissions emanate from transport use [it rises to 24% for emissions from energy] (Ritchie, 2020), which is true for 2Ws in India too where the urban particulate emissions owe 30% to 2Ws (PM2.5) (Paladugula et al., 2018). India imports 85% of its oil needs (Anand et al., 2023), with impact on geopolitical resilience. Simultaneously, while EVs will lead to increased efficacy of energy consumption, the demand for power would go up, apart from the cascading disruptions in the entire automotive supply chain (Gandhi & Sheorey, 2019).

The Indian auto industry follows China and USA, being the 3rd largest (ANI, 2023). Two-wheelers (2W) constitute almost 80% (numbers; not value) of the automobile sector in India (Paladugula et al., 2018; SIAM, 2022; Sripad et al., 2019):

India has a clear preference for 2W and 3W (Jacob, 2023), and hence, electric bikes and scooters (E2W) have ample scope (Khande et al., 2020), with the E2W market expected to have a CAGR growth

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of 29.07% to reach $ 1.3 billion by 2028 (Dhaked & Birla, 2021). With comparatively smaller batteries E2W do not unduly strain the limited charging infrastructure (public) (Sripad et al., 2019), rendering it more environmentally friendly.

The nascent E2W industry continues to need government policy support to push sales (Phadke & Nalam, 2021). The first phase of FAME (FY 2015-2016 to FY 2018-2019) supported slow- and high-speed E2W. FAME II (FY 2019-2020 to FY 2021-2022), seeks to add incentives to lead to sales of a million high-speed E2W that use batteries with advanced chemistry, implying efficiency in the manufacturing processes, an effective supply chain, and effective vendor management.

Ironically, in spite of its potential, E2W in India has not really been well researched. K. Indu & M. Aswatha Kumar (2022), speak on need for EV research (in a broader sense) and opportunities as also challenges for this industry. Some works like Nayak et al., (2023), cover E2W-related subjects like state-of-the-art energy systems, new materials and approaches, hybrid motor and engine setups, clever braking technologies with regenerative techniques etc; Ramji et al. (2023), analyse the potential EV sales required in major 2W export markets for India, like Nepal and Chile, based on their stated EV targets and pledges for year 2030; but, the topics do not directly address the E2W supply chain.

This paper investigates impact of vendor/ supplier partnerships on sustainable supply chain performance and competitiveness of Indian E2W industry, which would further lead to the formulation of a research (conceptual) framework based on research gaps identified through literature review.

This review seeks answers to the below given research questions:

RQ1: Existing research in the past decade in SSCM and vendor partnership, especially and if possible, as related to EVs.

RQ2: What research gaps emerge from the above analysis?

RQ3: Development of a conceptual framework connecting strategic partnerships with SSCM in the EV industry in India.

The paper is being covered in the succeeding heads: **Introduction** giving a background of the Indian EV industry and especially E2W; **Literature Review** on sustainability, SSCM, vendor partnership and collaboration; **Conceptual Framework** as these relate to the Indian E2W industry; and finally, **Areas for Future Research and Conclusions**.

Literature Review

For a comprehensive review of the research gaps, over **157** research articles published in **79** different journals, and **15** Reports were perused. The selected research articles pertain to sustainability, SSCM, green supply chain management, vendor or supplier collaborations or strategic partnerships, automobiles, automobile engineering and EVs. Effective references of 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 were referred.

The outcomes of literature review against respective subjects are explained in the following paragraphs.

Need and Scope

The need for EVs to proliferate across the world and primarily in developing countries like India cannot be overstated. Satya Sai Surya Varun et al. (2023) examine smart mobility solutions, finding significant potential for EVs to address global concerns. Similarly, Hema & Venkatarangan (2022); Sreeram et al. (2019), explore outlooks of various EV technologies and areas for further growth. Kesari et al. (2019), adopt a global case-study approach on adopting EVs, to draw lessons tailor-made for India. K & P (2023) analyse how EVs can help India keep the 5 pledges: to achieve net-zero emission (2050); generate 500 GW non-fossil energy (2030); half the energy generated to be from renewable sources; reduce 1000 million tonnes of greenhouse gases; and, reduce intensity of economy's carbon emissions to less than 45%.

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Prajeesh & Pillai (2022) 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. Dutt (2023) employs multi-level perspective (MLP) in studying how the E2W socio-technical system evolved.

Barriers and Adoption of EVs

Over the years EVs and their proliferation was impeded by apprehensions on higher initial costs, lifetime costs, charging concerns with lack of suitable points, and of course, a lack of overall awareness on the technology, as discovered by Tarei et al. (2021); R. Kumar et al., 2020. It is logical that an understanding of barriers would assist in policy and decision making. Dixit & Singh (2022) used a machine learning model to predict EV purchase in India, arriving at the conclusion that while buyer-age, gender, salaries, environment issues, performance and lifetime cost, range-anxiety and market forces are significant predictors, some other expected parameters like education levels and government subsidies do not play a significant part. Patyal et al. (2021) studied 13 barriers using ISM (Interpretive Structure Modelling) and MICMAC (Matriced' Impacts Croisés Appliquéeá un Classement), to help policymakers, and EV manufacturers to overcome design constraints.

Virmani et al. (2023) use fuzzy-SWARA (Stepwise Weight Assessment Ratio Analysis) method and fuzzy-WASPAS (Weighted Aggregated Sum Product Assessment) to attribute weight to each of the EV barriers, with the main barriers being higher vehicle price and lack of adequate charging stations; to be overcome through government policy, support and strategic planning.

Javanmardi et al. (2023) investigate factors affecting EV adoption, and expectedly find higher penetration in countries where the levels of sustainable development are higher. With regard to sales promotions, Bhattacharyya et al. (2023) explore and rank a dozen significant manufacturer challenges, using the triangular fuzzy number (TFN) method. They too find limitations in charging infrastructure to be a big challenge towards penetration, as do S. Mishra et al. (2021).

Saw & Kedia (2023) carried out a case study in Delhi, UP, Gujarat and Karnataka and found that in order to achieve a penetration of 30% EVs, by 2030 these states would need to register 0.31, 1.51, 0.88 & 0.79 million EVs. Digalwar & Rastogi (2023) demonstrate reluctance for EV adoption amongst those who place a premium on the vehicle performance. The study by Chawla et al. (2023) uses factor analysis to determine what exactly influences buyers' behaviour towards EVs touching upon parameters like loyalty, range and motor efficiency, charging efficacy etc. R. Kumar et al. (2020) explore how a shared economy in conjunction with public transport affect EV adoption, keeping the affordability of the Indian consumer in mind.

Policy

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, V. Singh et al. (2021) found that India has been falling behind other countries in EVs due to lack of an explicit policy or strategy. P. K. Das & Bhat (2022) bring out the role of government in facilitating EV proliferation.

The Indian EV market valuation in 2020 was $5.47 billion, projected to reach $17.01 billion by 2026 (CAGR 23.47% over 2021-2026) (Mordor Intelligence, 2023). By 2030, GoI rooted for 'E-Vehicles Only' (Dhawan et al., 2017; Khurana et al., 2020), in a way showing the government commitment for proliferating EVs.

V. Singh et al. (2021) carry out a SWOC analysis to encourage policy makers, governments, businesses to incentivise EVs in India, with the Centre coordinating state activities. Asokan et al. (2023) explore EV policies and environmental and socio-economic impacts in India, with focus on battery wastes and advocate a safe working environment for workers and communities. Mahajan et al. (2023) carryout an insightful analysis on parliament questions on EV policy to prevent air pollution.

Srivastava et al. (2022); B M Honna Prabhu Lingegowda & Dr. A N Santosh Kumar (2022), discuss methodology for design and selection of governmental policies, challenges & mitigation, to

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boost Indian EV adoption vis-à-vis a global perspective. While most government policies focus on subsidies, Shrimali (2021) found that only 4W personal cars and long-haul trucks need subsidy, and that upfront subsidy was most effective. Sometimes policies can also impede growth as found by Soman et al. (2019) through policy, supply chain and finance challenges.

Sustainability

Carter & Rogers, 2008 describe sustainability in management parlance and in operations to encompass societal, environment and economy concerns, which is lacking as discovered by Panigrahi et al., 2019. The balance in the three aforesaid concerns was found to be elusive and complex by (Sezen & Çankaya, 2013; Yildiz Çankaya & Sezen, 2019). Brundtland World Commission on Environment and Development (Holden et al., 2014) defined sustainability as "*a development that meets the needs of the present without compromising the ability of future generations to meet their own needs*."

Its criticality in supply chain and operations management was put forth by De Brito & Van der Laan, 2010. Per Carter and Rogers (2008), organisations considering environment and society in their efforts, prove competitive in the long run.

Sustainable SCM (SSCM) & Green SCM (GSCM)

The evolution of SCM into SSCM is natural in a world fast moving towards green practices. Industries need to be sustainable in production and supply chains. Sustainable supply chain management (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 (Fritz, 2019). By integrating environment and social factors to the conventional supply chain, operational competitiveness is achieved (Hong et al., 2018).

Based on 3BL approach, Carter and Rogers (2008) defines SSCM 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."

Seuring & Müller (2008) defined SSCM as: "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."

Empirical investigations in SSCM in recent years is growing in developing countries (Najjar et al., 2020; Sánchez-Flores et al., 2020). Hong, et al. (2018) observe the inadequacy of SSCM research in developing countries (Sánchez-Flores et al., 2020). 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 (D. Das, 2018; D. Das, 2017).

SSCM can boost competitiveness contrary to popular belief. Chikán et al. (2022); Gopal & Thakkar (2016), analyse competitiveness as a business performance in strategic management by examining functional strategies like production and operations management. Counter-intuitively, empirical investigations in Chinese firms (Wang & Dai, 2018) revealed that while SSCM had positive impact on firm's environment and social performance, its impact on the monetary performance was not seen.

Winter & Knemeyer (2013) reiterated that internal conflicts may warrant an uneven balance in the three concerns for supply chain sustainability. Fritz (2019) took on ethical concerns in SSCM, and drawing the link between SSCM and sustainable development goals (SDGs). Panigrahi et al. (2019) introduced additional dimensions of performance and governance, bringing out the existence of research gap in collaboration between suppliers and customers to enhance SSCM. The authors have recommended industry specific research on SSCM.

Overall, SSCM research appears predominantly on green or environmental issues, with inadequate coverage of societal issues and the interplay of the above sustainability dimensions (Sánchez-Flores et al., 2020).

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Environmental aspects of sustainable supply chain can be clubbed under GSCM. Fritz (2019) brings out the difference between GSCM and SSCM, saying that GSCM covers only environmental performance, whereas SSCM covers social, environmental and economic performance. He is of the opinion that GSCM is part of SSCM, although no consensus exists. He derived GSCM concepts which encompassed all supply chain stages which include design, purchase, supply, manufacturing, packaging, warehousing, transport and customers.

Gong et al. (2019) conducted exhaustive literature review on GSCM and observed significant increase in studies on this subject in the past decade, albeit with focus on qualitative analysis, with ample scope for quantitative and empirical analysis. Wong et al. (2015) threw light on the concept of green supply chain integration (GSCI) in organisations which encompasses internal GSCM, supplier GSCI, customer GSCI and community GSCI. With regard to supplier GSCI, in order to achieve environmental enhancements, a healthy collaborative structure with the suppliers is mandated. This may involve support and sharing of resources with suppliers.

Yildiz Çankaya & Sezen (2019) find that green manufacturing practices fully supported all three dimensions, with scope for further research on integration into other parameters of sustainability. Geng et al. (2017) perused research articles published during the period 1996 to 2015 related to emerging economies in Asia and found that GSCM led to improved performance economically, environmentally and operationally but not socially.

Luthra et al. (2016) studied impact of six CSFs on GSCM towards sustainable supply chain in automobile industries in India, viz, internal management, customer management, regulatory, supplier management (strong partnership with suppliers), social and competitiveness. The study brought out that all these CSFs significantly impact GSCM. Their recommendations for future study include exploring other parameters like flexibility, delivery, quality and technology advancements in performance. They want the study to be extended to other geographically diversified industries, and the social parameters too.

SSCM & GSCM in Indian Automobile Industry

Barriers and hurdles for setting up an effective SSCM for Indian automobile industry, have been studied (Jamwal et al., 2022; Luthra, Luthra, et al., 2015) Jamwal et al., (2022). Digalwar et al. (2021) validates seven factors with 67 variables, that affect the sustainable manufacturing of EVs in India, to benefit original equipment manufacturers (OEMs) and service providers in the EV industry.

Mathivathanan et al. (2018) have studied SSCM practices in Indian automotive industry, taking a multi-stakeholder view, by examining vendors, suppliers, OEMs, MSMEs, distributors, transporters, franchisees and exporters. Critical success factors (CSFs) of GSCM for achieving sustainability and profitability in Indian automobile industry have been studied (Luthra et al., 2016; Luthra, Garg, et al., 2015).

Gopal & Thakkar (2016) empirically look at the sustainable supply chain practices in the competitive Indian automobile industry. R. Kumar & Bangwal (2022) carry out an assessment of sustainable supply chain initiatives in Indian automobile industry using the PPS method, whereas Sonar et al. (2022) study SSCM of the automotive sector in context to the circular economy laying out a strategic framework in the process.

J. Singh et al. (2023) understand that resilience and a resilience strategy in the supply chain can be a primary factor in ensuring sustainability in automobile sector. They offer good inputs on how to optimise vendor management while simultaneously ensuring sustainability. R. Mishra et al. (2022) offer insight on development of environmental collaboration among supply chain partners for sustainable consumption & production.

Environmentally conscious SCM process benefits the industry as a whole and the Indian EV sector by association, as found by Balakrishnan & Suresh (2018). Liu et al. (2016) call it environmental management in the role of supply chain capabilities in the auto sector. Taking another angle, Gedam et al. (2021) study the correlation of sustainable manufacturing and green human resources, for success in the automotive sector. Sezen & Çankaya (2013) examine green manufacturing and eco-innovation on sustainability performance. Luthra, Garg, et al. (2014) carry out an empirical analysis

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of green SCM practices in Indian automobile industry, which is relevant to the EV industry also since the complete process of production, distribution, warehousing, franchising, transportation, exports, sales and after sales support, are common to both. Ghosh et al. (2022) take up the automobile manufacturing units in India, and study an optimal strategic sourcing model for green SCM.

Economic Perspective & Profitability

The primary objective of any business unit is profitability. As per Panigrahi et al. (2019), sustainability should lead to profitability, judiciously balancing profits, protecting the environment and upholding social responsibilities. D. Das (2017) considers operational performance instead of economic performance, explaining that economic performance is macro in nature and includes dimensions like decrease in cost of production and energy cost. Some other economic dimensions considered in literature are financial outcomes, cost reductions, competitiveness and profits (Winter & Knemeyer, 2013); operating cost, total sales, employees' wages & benefits (Gopal & Thakkar, 2016); market share and returns on the investment made along with profitability (Wang & Dai, 2018); and, productivity, firm's edge and customer satisfaction (Luthra et al., 2016). The economic dimensions also consider competitive priorities like cost, delivery, quality, flexibility (Sopadang et al., 2017), innovation and customer focus. S. Kumar & Dutt (2022) have interrelated Financial Performance and Inventory Management, which deals with many aspects of vendor management as well as the supply chain, in specific, with the Indian automobile industry.

Environmental Aspects

While India's declared intent is carbon neutrality and the target year is 2070, the role of EVs in promoting clean air has been addressed by Hossain, Fang, Ma, Huang, & Dai, 2023; and Hossain, Fang, Ma, Huang, Peng, et al., 2023. Research indicated cutting 80% pollution from road transport by 2070 in India. They cite fuel cell vehicles as a viable alternative to EVs. Gupta & Garg (2020) drive home the need to green our transport system to achieve carbon-neutrality in keeping with the Paris Agreement (IPCC, 2018).

Shyam et al. (2023) deal with the challenges in Lithium-Ion Batteries (LIB) disposal focusing on the availability, storage, and transportation of LIB. Vidhi & Shrivastava (2018); Bhosale & Mastud (2023) opine that EVs can lead to reduction in pollution only majority of the electricity used for charging, emanates from renewable sources. Gautam et al. (2023) address environmental issues of the Indian automobile industry, using SWOT analysis, and allocating scores to each environmental factor. The health impact of the transition to EVs has been examined by Hsieh et al. (2022), by looking at emissions, air quality and effect on individual health through the transition to EVs in China.

Green Energy

EVs often face criticism that energy being used to power or charge EVs is not fully green as yet, since a significant proportion of energy produced is from coal and other polluting sources. This paradox is adequately covered in research (Dixon et al., 2020). The extensive proliferation of EVs will necessitate higher energy production with corresponding impact on the electric grid (Kapustin & Grushevenko, 2020; Desai et al., 2023).

Abhyankar et al. (2023) explore the heavy dependence on imported oil (90%) and industrial coking coal (80%), which exposes us to volatility in global energy markets. They focus on the 3 major consumers – power, transport and industry. Han (2023) analyse India's new and renewable energy market policies and implications for foreign cooperation.

A comprehensive green ***process*** will encompass generation of power, charging, and its ultimate disposal of storage devices. In this context, A.V. et al. (2022) study the feasibility of solar cell integrated energy storage devices for EVs. Makeen et al. (2022) evaluate efficacy and adequacy of green charging attempted by centralized EV stations, and find greater effort is needed. Gulzari et al. (2022) have worked on a young consumer EV rental behavioural model to analyse all these issues.

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Yang et al. (2023) look into battery swapping in 3 scenarios: no subsidy, consumer subsidisation and provider subsidisation, finding that it is more effective to subsidise service providers rather than the end consumers. Varshney et al. (2020) covers recycling LIBs, and new recycling techniques like pyrometallurgy, hydrometallurgy and green technologies. Ourici (2023) explores new battery technologies with new cathode and anode materials such as silicon, lithium-sulphur, and lithium-air. Solid-state electrolytes have also been explored to improve safety and longevity. Eftekhari & Kim (2018) find that sodium ion battery (NIB) can supplement but not replace the LIB. Manivannan et al. (2023) review the wireless power transfer (WPT) system. Shu et al. (2023) explore variable renewables for flexible EV charging for decarbonisation of the rapidly growing power sector. Barman et al. (2023) use a systematic literature survey to explore the battery raw material supply chain, material processing, and commodity price appreciation. Areas of concern include resource reserves, supply, demand, geographical distribution, battery reuse, and recycling industries. Shaikh et al. (2023) review the battery and power related aspects of Indian EV sector.

Energy eventually is but a geopolitical play of nations, and lithium is the new gold (Penn & Lipton, 2021) which will make nations plan accordingly. Nygaard (2022) discusses the geopolitical risks and strategic uncertainty after the Ukraine war, analysing how the circular economy can decrease market power of and resources dependency on critical minerals. Li & Taghizadeh-Hesary (2022) explore the economic feasibility of green hydrogen and fuel cell electric vehicles for transportation in China.

Green Manufacturing

Industries follow green manufacturing norms to meet governmental regulations and establish processes compatible with modern world environmental concerns. P. L. Singh et al. (2022) analyse the CSF of green manufacturing towards sustainability, specifically in the automotive sector, also studying recent trends in industrial and production engineering. Internet of Things (IoT) is increasingly facilitating how machinery and products talk to each other, with immense application in the automobile industry. Naim et al. (2022) seek to find the relevance of green manufacturing and IoT in industrial transformation, marketing management, and computational intelligence techniques for green smart cities.

J. Singh, Singh, & Deepak (2022) review green manufacturing, calling it a modern era for Indian manufacturing industries. Umar et al. (2022) analyse developed versus developing world vis-à-vis utilising emerging technologies in implementation of green practices. Using a unique technique, Pathak et al. (2021) analysed the barriers to green manufacturing using the hybrid approach, focusing on the automobile industry.

Social Perspective

It is noted from the literatures on GSCM that there is a vacuum with regard to social performance in research, while the environmental and economic factors have been exhaustively covered (Yildiz Çankaya & Sezen, 2019). Mani et al. (2020) studied societal sustainability in small and medium manufacturing enterprises (SME's) and its impact on performance of a firm analysing six social factors which included parity, security, charity, healthiness and welfare, integrities and basic rights.

Ahmadi et al. (2017) studied social aspects of supply chains using best-worst method in manufacturing industries of Iran, considering predominantly the health and safety issues at work. Zhang et al. (2017) carried out a qualitative case study in pharmaceutical industries located in USA, China, Europe, Japan and South Asia on social aspects of sustainability supply chain by considering supplier development aspects, finding that social responsibility of the supply chain can be enhanced through collaborative training after assessment is carried out of gaps that may exist in the suppliers' capabilities, and they come out with recommendations to link development of suppliers with other SCM practices.

Overall, the lack of substantial studies on social perspectives for sustainability in the supply chain, was apparent.

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Supply Chain Practices

A 'supply chain' has been adequately defined by Chopra & Meindl, 2016. Soares et al. (2023) use bibliometric and systematic reviews to achieve state-of-the-art in EV supply chains. They employ quantitative and qualitative indicators to identify supply chain risks. Jones et al. (2023) examine outlook for EV demand juxtaposed with supply chain demand trends.

Koberg & Longoni (2019) after systematic ROL on SSCM in the global supply chains, classified research articles of 15 years into two categories: configurations and governance mechanisms related to suppliers. D. Das (2018) reviewed supply chain integration, finding that there is not much significance of practices on performance parameters, which may be due to selection of heterogeneous sectors and biased responses. They recommended future study to be limited to a particular industry for consistent results. The importance of having in place a supplier partnership at a strategic level coupled with good customer relations empowered with optimal and quality info-sharing, has been studied by Gamini & Rajapaksa, 2020; strategic collaboration and the modalities of external and internal sharing of knowledge (Mehdikhani & Valmohammadi, 2019); information sharing (Khan et al., 2016; Liao et al., 2021); sustainable procurement practices which focuses on in-house and outsourcing modes (Sayed et al., 2021); green & ethical supply management (Kähkönen et al., 2017); and, supplier innovativeness, information sharing and strategic sourcing (Jermsittiparsert & Rungsrisawa, 2019).

Lee (2021) conducted empirical study on SCM strategies and their effects on operations and competencies of SMEs in Korea. Overall, significant relationship between SCM practices and organizational performances including innovation has been established. Kähkönen et al. (2017) drew upon the need to undertake further research on practices in collaboration between suppliers and vendors. Liao et al. (2021) studied Taiwan's optoelectronics industry and found that such a collaboration can actually positively impact innovation further improving competitiveness of the firm.

SCM in the Automobile Industry

Bhattacharya (2014) studied the complexities and challenges of SCM in Indian automotive industry, and how they may be addressed with implications for the EV industry too. The study by Gopal & Thakkar (2016), focuses on SSCM practices of Indian automobile industries like lean practices, eco-design practices, continuous improvement, risk management practices, customer cooperation ethical behaviour, investment recovery and technological innovation. These are considered for assessing supply chain performance including social dimensions like child labour, disclosure of environmental initiatives to the public, employee wellbeing, training and education operating cost. The study finds that SSCM positively impact supply chain performance. They recommend that automobile companies in India can encourage vendors towards sustainability, perhaps by sharing initial costs as a motivational tool.

Luthra, Qadri, et al. (2014) identify CSFs to achieve optimal level of green SCM performances and profitability in Indian automobile industry. Khot & Thiagarajan (2019) study resilience, correlating it with sustainability of the supply chain in the Indian automobile industry. Kumar Singh & Modgil (2023) study lean practices in automobile sector, which faces numerous challenges like regulation, labour, high initial costs etc, which are well-documented by Mathivathanan et al. (2022), with overcoming strategies.

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 around 11% by 2030 (about 50% of 2019 levels), forcing traditional component players to adapt quickly to offset decreasing revenue streams (Cornet et al., 2021). The EV industry has attracted more than $400 billion in investments over the last decade—with about $100 billion of that coming since the beginning of 2020 (Cornet et al., 2021). All this will significantly impact the supply chain in the Indian automobile industry.

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Logistics/ Industry 4.0 Concepts

Logistics 4.0 is a new science to enhance efficiencies of logistic support and SCM. Ghadge et al. (2022); P. L. Singh et al. (2022), study the link between Industry 4.0 and green SCM in the automotive industry, and show their compatibility, thereby alleviating concerns that green practices adversely impact profitability or commercial performance. Fauzdar et al. (2022) carry out a MICMAC analysis of Industry 4.0 in the Indian automotive industry. The process of correlating the techniques of green smart manufacturing in the Indian automotive industry, analysing 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 done in the study by Agarwal et al. (2022).

Vendor Collaboration or Strategic Vendor Partnership

Vendor Collaboration has been brought out as a partnership which works towards mutual benefit of the parties involved (Cao & Zhang, 2011; Spekman & Davis, 2016; Fritz, 2019; Panigrahi et al., 2019; Wang & Dai, 2018). Researchers highlight that competitiveness of firms can be boosted by focusing on core business and outsourcing noncore activities (Soosay et al., 2008; Soosay & Hyland, 2015).

Kuzma et al. (2020) established a strong relationship between innovation (including in vendor collaboration) and sustainability performances. Hui et al. (2015) empirically studied partnership management and supplier collaboration on innovation performance of Chinese manufacturing companies, finding its direct effect on innovation performance, transfer of wide information, knowledge and technology. Hudnurkar et al. (2014) through ROL found inadequacy of study on supply chain collaboration in Indian context. Most research failed to draw a connection between vendor collaboration and impact on lengthy partnerships (Ramanathan & Gunasekaran, 2014).

Literature shows that VMI is a competitive and flexible business model SCM tool for reducing the inventory management cost (Beheshti et al., 2020), for which Enterprise Resource Planning (ERP) and info-sharing is critical. Similarly, Owusu Kwateng et al. (2022); Radzuan et al. (2018), studied Malaysian manufacturing industries and found that VMI reduces operational cost and improves customer satisfaction. Shin et al. (2019) established a direct correlation between levels of partnership and performance. Future research on impact of collaboration on resiliency of supply chain has been suggested (Chen et al., 2017; Mehdikhani & Valmohammadi, 2019).

Vendor Partnerships in Indian Automobile Industry

Sahu et al. (2022) study supplier selection using a decision making model, which employs an integrated MCDM approach with evidence from the Indian automotive sector. Vendor selection in the Indian automotive industry has been studied through a case study by Jain et al. (2018); Dang et al. (2022), who have created a Two-Stage Multi-Criteria Supplier Selection Model for sustainability in supply chains in automobile industry; and Sytch et al. (2022) who have studied the practices for the selection of suppliers to ensure lasting global supply chain networks. Juned & Farooquie (2022) study VMI factors in automotive industries from two different perspectives (from buyers & vendors), comparing the perceptions of professionals and academia.

Some term lean and agile practices as 'leagile' and Sharma & Sohani (2022) models the leagile enablers of SCM Indian automobile sector, although they believe that this alone is insufficient. Meena et al. (2022) measure supplier performance and selection. Yu et al. (2022) attempt to establish that improving supplier capability through training, could be very effective for the overall performance of the company, obtaining research evidence from the Chinese Automobile Industry.

At present, challenges in the Indian automobile sector include inventory optimisation, warehousing, transport and distribution; reduce damages during transit and delivery, and achieve real-time visibility and information sharing across stakeholders. Logistics management practices may ameliorate this. J. Singh, Singh, & Kumari (2022) assess various technologies and models on SCM performance in India's automobile industry.

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Conceptual Framework

The literature review brings out that researchers identified various research gaps and scope for future research in SSCM practices. Mostly, the 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 green SCM 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 study specific to E2W in India.
- 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.

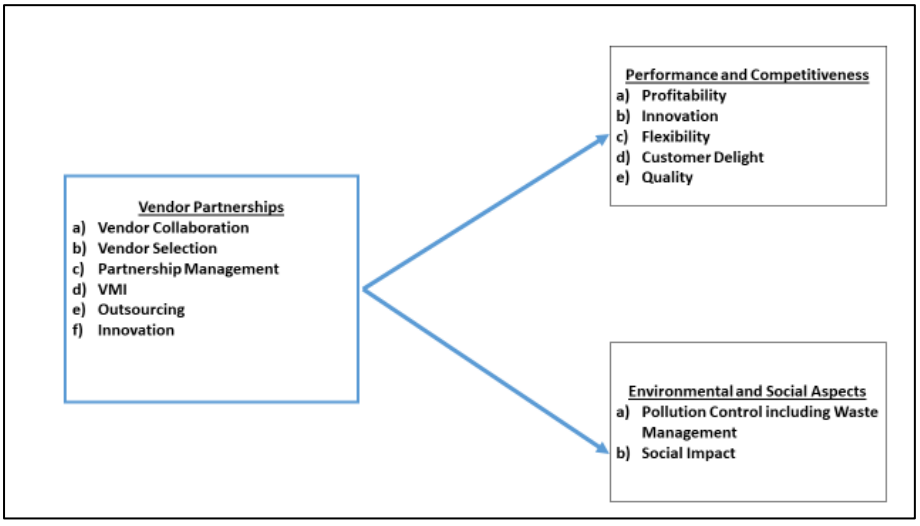

Figure 1. Conceptual Framework.

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, information-sharing between the company and its vendors etc.

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.

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- Evolve suitable sustainable supply chain practices to tap significant opportunities expected in the EV/ E2W industry in future.
- Assessment of GoI support for E2W industry. Influence of State Government's policies on 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 E2W industry but also other manufacturing industries for overcoming supply chain challenges.

Future Research and Conclusions

Some of the topics for further analysis and study are:

- For a balanced view, rather than take only a positive view of EVs, future research can also explore negative impact of EVs on society, environment, industry, supply chain etc. One example is on how the existing ICE vehicles would be disposed, creating a logistics nightmare.
- EV industries taking on less ambitious ventures initially and moving up the value ladder when they gain experience and market share, could be the topic of research.
- Explore geopolitical aspects of EV proliferation and connected challenges, especially with regard to lithium, a basic raw material for EV batteries, will have an important bearing on logistics and supply chain.
- Research could also explore alternate elements which may power future batteries where countries like India could be more self-sufficient in. E.g., research is in progress to identify materials like sodium, which may mitigate geopolitical issues.
- Research could deal with the disposal of batteries which is a sustainability nightmare.
- More in-depth analysis of the social impacts of EV industries could be studied.
- The difference between the supply chain of automobile ICE industries and EV industry could be a rich field for study.
- 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, can be studied. This has relevance even as states have become competitive in attracting industries for job creation.
- Research could question whether EVs are the final frontier in propulsion or other technologies like hydrogen or solar powered vehicles could rule in the future. This has an important bearing on the supply chain and vendor base.

Summary

Environmental concerns have led to the flurry of manufacturing activity pertaining to EVs and India is at the forefront of an EV revolution, of which E2W is a major component. In India, in the foreseeable future 2W and hence E2W will not fall in popularity or sales. GoI has a significant role in encouraging and incentivizing the industries dealing with the manufacture of EVs. The manufacturers also need to take steps to increase efficiency and profitability through the adoption of proper SCM and SSCM measures, without compromising upon the social aspects. 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.

EV technology in itself may not be the final frontier in mankind's search for newer propulsion systems. The world is already looking at hydrogen powered vehicles, vehicles running on fuel cells, solar power etc. However, all of these technologies have their own set of problems which will undoubtedly be solved in the future. Hydrogen production as yet is also not green, and it is understood that green hydrogen requires focus (Venkatasatish & Dhanamjayulu, 2022). Also, storage

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and transport of hydrogen is a big problem due to its low density, and flammability (Guo et al., 2022). While these issues are being resolved, EVs will be the go-to technology for automobiles till 2040-50 at least.

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