



The role of green supply chain practices in competitive advantage in the automotive industry

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Abstract

The research examines how the application of GSCP can support competitive advantage in the automotive industry by exposing concerns and pressures in the field and showing the necessity of improving sustainable management. Extensive Supply Chain Management, green purchasing, sustainable transport and closed-loop systems that comprise of GSCP, enhances both environmental conservation and firm operations, under emissions standards and EPR polices. The study also looks at aspects on how sustainable innovation impacts competitive capabilities, problems accruing, and how best to integrate sustainability with successful green practices with reference to Tesla, Toyota, and BMW among the leading firms. Through filling the theoretical-practical gap in sustainable supply chain management, the results can provide important knowledge for academics, practitioners, and policymakers, for proving that sustainability can as a strategic resource in the automotive industry. This paper provides guidance on how green supply chain practices contribute to the competitiveness of some of the prominent automobile companies. As the following analyses indicate, all three companies show that sustainability within supply chains creates strategic worth and enhanced performance. Implementing principles such as green purchasing, energy management and waste minimization, they cut operating costs and align to a more planet sensitive market environment. Further research should be conducted to investigate the sustainability effects of green supply chain and the effects of the regulatory norms regarding their implementation across all industries.

Keywords: Green Supply Chain Practices; Automotive Industry; Sustainability-Driven Innovation; Competitive Advantage; Regulatory Pressures; Consumer Demand; Closed-Loop Supply Chains

1. Introduction

1.1. Background and Context

This concept of sustainability has emerged as a vital feature in the current world economy whereby business companies are struggling to achieve sustainable development. This is especially so in the automotive industry, which is increasingly under pressure to decrease its impact on the environment thereby decreasing the competitive edge that it holds (Lukin et al., 2022). The automotive industry is one of the major emitters of gases that cause greenhouse impacts, from production processes and raw material acquisition to product disposal. Instead, sustainability-driven innovation especially in the operations of supply chain has become important strategic drivers that would determine the next generation competitiveness of automotive firms.

The green supply chain practices, which include green purchasing, green transportation and the use of circular supply chain techniques are central to this change. These practices include; procuring materials sustainably, reducing waste, achieving sustainable transportation of supplies, and prolonging product life by recycling and remanufacturing (Mugoni et al., 2024). In addition to cutting costs, green supply chains present the essential industry imperative to play the

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strategic marketing card and appeal to concerned environmental-conscious consumers, and meet continually tightening legislation requirements.

More so, sustainability does not only become a best practice for the automotive companies to embrace when implementing supply chain management but is a strategic imperative. Consumers are becoming more environmentally conscious, and this puts pressure on manufactures to supply cars that are environmentally friendly from point of production to use all the way to how they are disposed (Masoumi et al., 2019). Moreover, international factors and antecedents like the European emission standards and carbon reduction target compel original companies to redesign supply chains. These shifts are not only changing the competitive environment but are also exerting pressures on organizations to not only get better at sustainability but also use it as a platform to gain a competitive advantage.

1.2. Problem Statement

Automotive companies face a complex challenge: managing the pursuit of a firm's competitive advantage while meeting sustainability goals in the contexts of emerging regulation and consumers. It is argued that green supply chain practices are critical to decreasing the environmental cost even though their relationship with competitive advantage lacks sufficient research within the automotive industry (Yang et al., 2023). Although, supply chain sustainability has been recognized as an important area for companies to address, they remain unresolved with the ways and means of realizing the linkages between sustainable supply chain management activities and correlated organizational performance improvements and sustainable competitive advantages and consumer goodwill.

That is why this task is rather challenging, especially given the current rates of change in the regulatory environment and evolving consumer preferences. Most countries today are introducing low emission reduction goals and using carbon taxes which puts pressure on automotive industries to adapt to these policies while still making profits. Consumers at the same time are expecting the products to be more aligned with their personal beliefs and one such belief is that the product should be environment friendly. These pressures create a paradox: automotive firms are under pressure to respond to these demands through green supply chain management innovation but often unclear on the conceptualization of how sustainability led ideas translate into sustained competitive advantage.

1.3. Research Aims and Objectives

This study aims to examine the role of sustainability-driven innovation in the supply chains of automotive companies and explore how green supply chain practices influence their competitive advantage. To determine the role of green supply chain management practices like environmentally responsible procurement, sustainable transportation and closed-loop supply chains on automotive firms' competitive capabilities.

To examine the drivers and their relationship in determining the direction of green supply chain implementation and supply chain management strategies in the automotive industry. To explore the problem areas that car manufacturers and their suppliers experience when implementing sustainability solutions in their networks and the ways for addressing these issues. Through achieving the stated objectives, the study aims to contribute to the understanding of how sustainability-based innovation can advance the competitive advantages that the automotive firms can accrue under conditions of dynamic market and policy environments.

1.4. Research Questions

- This study is guided by the following research questions
- In what ways, do, green supply chain practices enhance automotive companies' competitive capability?
- What are the main challenges automotive companies face when integrating sustainability practices into their supply chains?
- How do regulatory pressures and consumer demand for sustainability influence supply chain decisions in the automotive sector?
- What strategies can automotive companies adopt to integrate green supply chain practices effectively?

These questions aim to explore the multifaceted relationship between sustainability, innovation, and competitive advantage, providing a comprehensive understanding of how green supply chains can be leveraged as a source of strategic advantage in the automotive industry.

1.5. Significance of the Study

It could be confidently stated that the present research will be of particular relevance for academic and industrial fields. For academics it adds to the existing literature on sustainability driven innovation and its effect on organizational

performance in the automotive industry. More specifically, the research provided a deeper insight into the fact than how specific GSCM practices can affect the competitive advantage, a theme which have not been given much attention in prior literature. The results could assist in closing the theoretical-practical gap of sustainability models and integrated solutions within the automotive sector.

For the industry professional's meaningful data and best practices based on the implementation of sustainability into supply chain are offering a better perspective on how the issue of sustainability can actually be beneficial for the organization when implemented properly. The research will act as a reference to automotive companies since it provides an understanding of a number of issues connected with sustainable supply chain management, how the companies need to react to the emerging legislations, and consumer preferences. Moreover, the results of this research will be useful to policymakers and stakeholder interested in developing enabling environment conducive to the implementation of sustainable supply chain in the automobile industry.

2. Literature Review

2.1. Sustainability-Driven Innovation

Sustainability-oriented innovation is defined as the introduction of new or altered goods, services, processes or technologies that create value by solving society's environmental and social problems. This form of innovation aligns such concepts as acting in a business's ecological and social impact, and the use and management of resources in total organizational strategy (Adams et al., 2016). This form of innovation integrates sustainability principles, such as reducing environmental impact, conserving resources and ensuring social responsibility, into business strategy. With a move towards the green economy as global economy carries on progress to be achieved in terms of sustainable development strategies, it also puts pressure on organizations to develop new competitive business models so as to satisfy this social need. The exact role of innovation as a driver for the formulation of competitive advantage within a sustainability economy cannot be overlooked. Sustainability involves the consideration of broader social, economic, and environmental impacts and can be used by organisations and firms as a strategy to create competitive advantage, reduce costs, provide value and satisfying a legal imperative (Maier et al., 2020).

Sustainability-driven innovation is also discovered to have new market opportunities for innovation, consumer loyalty as well as appeals to the increasing sustainability market consumers. However, in such industries as automotive, with sustainability now being a critical success factor is not simply an efficiency play but more importantly a factor of sustainable competitive advantage such as automotive, where environmental impact is a major concern, sustainability-driven innovation is not just about compliance but also about long-term profitability. In the automotive industry for instance Innovation in sustainability has resulted to formation of products like EVs, technological advancement in autonomous driving, more efficient engines and among others (Molina & Rajagopal, 2023). These innovations are not only good for a company's environmental profile but excellent for positioning a business to take full advantage of public demand for eco-friendly products. In sectors such as automotive, where environmental impact is a major concern, sustainability-driven innovation is not just about compliance but also about long-term profitability. In the automotive sector, sustainability-driven innovation has led to developments such as electric vehicles (EVs), autonomous driving technology, and more fuel-efficient engines. These innovations not only contribute to environmental goals, but also enhance a company's competitive position by meeting the growing demand for greener products. For instance, Tesla company has shifted the market dynamism by introducing cars that are both durable and highly efficient hence competing fiercely within the market. Likewise, sustainable solutions have recently been set in BMW concerning design and manufacturing, as well as the utilization of renewable resources in those areas (Dangelico & Pujari, 2010).

2.2. Green Supply Chain Management (GSCM)

Green supply chain management (GSCM) therefore stands for the management and operation of the supply chain with environmental considerations incorporated into supply chain management processes, green purchasing, reduction of wastes, energy efficiency and green supply chain. Known as life cycle management, it is a supply chain procedure that covers the procurement of materials and components and production of goods, as well as product delivery, usage and end-of-life disposal with the objectives of eliminating or reducing the detrimental effects of each phase on the environment (Srivastava, 2007). Green supply chain management (GSCM) is effects or impacts of environmental consideration on supply chain management practices involving green sourcing, waste minimization, energy conservation, and green logistics. It covers also acquisition of raw materials, production process, delivery of the finished product right up to disposal with the general goal of reducing the ecological retrograde effect.

In particular, GSCM has a big role in minimizing the effects of industries to the environment, particularly the automobile industry. Due to the application of sustainable principles in the management of the supply chain, the automotive industry can be able to derive two benefits: benefits arising from environmental sustainability as well as benefits arising from operational efficiency. As an instance practical measures such as switching to efficient means of transportation, and using environmentally friendly products are less costly in the long run. Furthermore, GSCM practices assist corporate organizations to implement environmental policies and satisfy the market need for eco-products (Tseng et al., 2019). The major theoretical tools adopted in automotive industry for the application of GSCM include the Triple Bottom Line (TBL) which encompasses the financial, environmental and social impacts of business as well as the Circular Economy (CE) model which focuses on the closed-loop reuse of materials.

2.3. Green Supply Chain Practices in the Automotive Industry

More automobile manufacturers are adopting sustainable supply chain management strategies through green initiatives. Such practices include use of sustainably sourced raw materials, low carbon emission activity in production and distribution channels, as well as adoption of product recovery management systems that entail the design of products with end of use intentions of reuse, recycling or remanufacturing. Sourcing sustainable raw materials: Manufacturers are gradually embracing the adoption of environmentally friendly materials such as pre-production recycled minds, bio polymers, and eco-friendly fiber composites. For instance, when BMW integrates reprocessed materials into its automobile manufacturing then not only does it save on costs but it also contributes to the prevention of the cost to environment sourcing sustainable raw materials, reducing carbon emissions during production and logistics, and implementing closed-loop supply chains where products are designed to be reused, recycled, or remanufactured sourcing sustainable raw materials (Mugoni et al., 2021). Automakers are increasingly prioritizing the use of sustainable materials such as recycled aluminum, plant-based plastics, and natural fibers. For example, BMW's use of recycled materials in its production not only reduces material costs but also minimizes its environmental impact. Reducing carbon emissions: Manufacturers are paying attention to minimizing carbon emission across the lifecycle of products with particular emphasis on production and distribution. Energy efficient manufacturing technologies have been adopted at Toyota and carbon neutral vehicle production lines have been introduced at Volkswagen.

Closed-loop supply chains: CLOS supply chains refer to the systems whereby products and/ or materials are reclaimed, recycled or repurposed to minimize waste and increase the useful life of the product. For instance, Tesla has a mission to recycle batteries with the goal of creating a closed loop supply chain which will go a long way in minimizing on wastage and identifying for reuse in the future value raw materials (Masomi et al., 2019). For example, Tesla's commitment to recycling batteries contributes to a circular supply chain that reduces waste and recovers valuable raw materials for future use. The opportunity to see how companies operating in the automotive industry apply these practices in their activities is illustrated by the provided examples. Toyota is one of the pioneers of the company to incorporate environmental issues across its supply chain with its strategies on minimized emissions and wastes, and the introduction of hybrid and electric vehicles. Tesla has integrated green supply chain in two ways apart from manufacturing electric car; it has manufactured battery energy systems that are generated from renewable resource commitment to recycling batteries contributes to a circular supply chain that reduces waste and recovers valuable raw materials for future use (Yang et al., 2023).

Case studies of automotive companies demonstrate the successful integration of these practices. Toyota has been a leader in implementing sustainable practices in its supply chain, including initiatives to reduce emissions and waste and the development of hybrid and electric vehicles. Tesla has incorporated green supply chain practices not only by manufacturing electric vehicles, but also by manufacturing energy storage systems that rely on renewable energy sources. Types of SCM adopted by BMW include green supply chain management whereby the company has developed sustainable automobile design as well as the use of renewable resources in production.

2.4. Regulatory Pressures on the Automotive Industry

2.4.1. Consumer Demand for Sustainability

The two main outside forces that have influenced the greening of the automotive industry are regulatory pressures inside the supply chains. Because of government regulations on emissions, efficiency and waste management originating from the international and local scene automakers have been challenged and forced to develop (Adams et al., 2016). As an example, emissions standards in the European Union, the carbon pricing system compelled auto makers to develop innovations such as electric cars and hybrid drives. Another regulation known as Extended Producer Responsibility (EPR) is the one forcing business towards becoming sustainable. EPR policies demand that manufacturers accept liability for their products through their end-life; the disposal as well as the recycle part. Such regulations help organizations to implement green supply chain management practices including designing products

for recycled purposes and minimizing material use in production. Enthusiastically, the difficulty in meeting these rules is massive, mostly in areas that have strict set of regulations (Luk et al., 2022). However, if a company overcomes these pressures, it has an opportunity to strengthen its competitive advantage and adjust the consumers preferences for purchasing more environmentally friendly good.

Several studies have proved that such consumers are likely to make a purchase from a brand that relates to their sustainability beliefs. That has shifted the trend in the automotive market where manufacturers began to tout sustainability efforts as part of their marketing strategy. For instance, by perfecting the electric cars market, Tesla has targeting people with conscious by offering them quality cars.

2.5. Competitive Advantage through Green Supply Chains

The value chain of Porter, the resource-based view (RBV) and the concept of dynamic capability give theoretical background for elucidation how such a green supply chain can enhance the competitiveness of a firm. Porter's value chain: Supply chain for environmental purposes introduces benefits to each of the stages of the green supply chain by attempting to develop mechanisms that would transform social cost into economic value (Pusparini & Kusumastuti, 2019). Through the cuts of the costs and its optimization the firms and companies can decrease the costs of their operations and increase the quality of the final product. Those supplying green also acquire other resources that are valuable for long term strategic advantage such as sustainable technologies, green materials, and good sustainable brand names contribute to a firm's competitiveness.

Dynamic Capabilities: One of the dynamic sources is competence in modifying environmental regulations and consumer preferences by innovatively adopting GSCP practices that allow the firm to be a strategic competitor in a very dynamic market environment (Beske, 2012). Auto manufacturers adopting green supply chains for competitive advantage, include utilization of hybrid vehicles by Toyota which enhanced its leading status in fuel efficient vehicles, utilizing electric vehicles by Tesla which challenged traditional auto manufacturers and has attracted large, devoted, environmentally conscious consumers

2.6. Gaps in Literature

Despite the vast availability of literature discussing sustainability and green supply chains, there is limited literature on the link between green supply chain practices, and competitive advantage in the automotive industry. However, most prior studies merely touch on the larger sustainability consumption frameworks without elaborating on how these programmes improve competitive advantage of auto businesses and their supply chains (Hammou, 2022). Further studies must be invested in understanding the bilateral relationship between the pressures arising from regulation and the demand from the customers on the management of green supply chains. The regulatory environment is intensifying and customers' demands remain dynamic implicating that automotive firms require more profound understanding of the ways that measure compliance with customers' demands.

3. Methodology

3.1. Research Design

This research employs a qualitative research method, and case studies to examine the effect of GSCM on competitive advantage in the automotive industry. This study is well positioned to adopt a qualitative research design because it gives the researcher a chance to identify the finer details involved in the incorporation of sustainability into supply chains. It also provides opportunities to look at certain contextual factors, left undiscoverable by quantitative approaches, including culture, choice making, and strategy. The rationale for adopting the qualitative approach in this regard is that it is more effective in capturing the complex nature of how green working practices enhance competitive advantage, and how the interrelated pressures become more responsive to regulatory change, customer requirements, and internal business processes. The fact makes the case studies more realistic by giving the reader first-hand information and experiences on the execution of GSCM practices when adopted in the automotive industry by different firms and with also a comparative lens for examining the existing differences in practice.

3.2. Case Study Approach

This research employs a qualitative research technique to examine case studies that captures the effectiveness of the GSCM on the competitive advantage of automakers. Qualitative research design is appropriate for this research because it affords an understanding of the processes in which firms implement sustainability within their supply chains. It also permits close identification of features that quantitative methods can only approximate, characteristics such as

organisational politics, decision making, and strategy. The rationale for using the qualitative approach in this context is that the reality of how green practices can directly enhance competitive advantage, as well as how the regulatory pressure concerns, customer expectations, and firm strategies are interrelated, is relatively complex. First, the case studies offer detailed, realistic views of how GSCM can be implemented, so as to facilitate the comparison of various automotive firms and their GSCM strategies. The companies for case studies have been chosen to portray large international automotive giants who are contributing to green supply chain practices. This case work will complement the previous research on institutional pressures focusing on the companies with the peculiar strategic and regional circumstance and thus, offer the broad vision of the ways these practices contribute to the competitive advantage in the various markets.

3.3. Data Collection Methods

The main data gathering technique will be interviews with supply chain, sustainability and senior management within the sample of automotive firms. Semi-structured interviews provide the option of both following the respondents' thoughts or asking specific questions related to themes of GSCM and competitive advantage of automotive companies. Semi-structured interviews allow for flexible and in-depth exploration of interviewees' perspectives while ensuring that key themes related to GSCM and competitive advantage are covered. These interviews will seek to establish the extent to which companies have incorporated sustainable practices in their supply chains besides the various difficulties and advantages accruing from it. Secondary data will be in form of survey of existing sustainability reports, CSR reports, supply chain management strategies, and products available on the market automotive companies. Semi-structured interviews allow for flexible and in-depth exploration of interviewees' perspectives while ensuring that key themes related to GSCM and competitive advantage are covered.

These interviews will aim to understand how companies approach sustainability in their supply chains, the challenges they face and the benefits they derive from integrating green practices. Document analysis: Secondary data will be collected through analysis of publicly available sustainability reports, corporate social responsibility (CSR) reports, supply chain strategies and product offerings. This will in turn give a clearer understanding of how firms explain their sustainability plans and where these plans fit into their strategic management frameworks. Similarly, analysis of extant literature will also offer understanding about formal and intermediate factors of GSCM and strategic significance of GSCM. Secondary data: Secondary data which would be used in addition to the primary data will include the industrial reports, white papers and the articles found in the academic journals. The above secondary data will complement the results interpreted from the case study by offering further, industry-level insight into the trends, stringent guidelines and market forces that affect GSCM.

3.4. Sampling and Selection Criteria

Supply chain initiatives in sustainability: Companies that could provide strong manifestations of the distinct attempts in making green supply chains, which include sustainability in the procurement of raw materials, reduction of carbon footprints in production, among others or who have designed closed-loop supply chains will qualify. Also, reducing carbon emissions in manufacturing, or adopting closed-loop supply chains, will be given priority. The strategies to being adopted GSCM by these companies should have documented in public report or case study. The selected companies will be core automotive players key in the global automotive industry varying from the conventional automobile firms to lean sustainable automotive firms. Durable efforts to integrate sustainability practices into their supply chains, such as sustainably sourcing raw materials, reducing carbon emissions in manufacturing, or adopting closed-loop supply chains, will be given priority. These companies should have public reports or documented case studies detailing their GSCM strategies. Market positioning: The selected companies will be significant players in the global automotive industry, representing a wide range of market positions, from traditional automakers to new sustainability-focused companies. Market position means that we can generalize the study results to all this industry player, from the traditional players to new entrants. Regulatory compliance: This state will only include companies that meet regional and international environmental standards – from emissions control to a carbon price. This criterion guarantees that case studies depict the pressure and opportunities relating to the regulations that take vital roles in encouraging the green supply chain.

Companies that demonstrated clear and measurable efforts to integrate sustainability practices into their supply chains, such as sustainably sourcing raw materials, reducing carbon emissions in manufacturing, or adopting closed-loop supply chains, will be given priority. These companies should have public reports or documented case studies detailing their GSCM strategies. Market positioning: The selected companies will be significant players in the global automotive industry, representing a wide range of market positions, from traditional automakers to new sustainability-focused companies. Market position ensures that the findings are applicable to a wide range of industry players, from traditional players to disruptive companies. Regulatory compliance: Companies that comply with regional and international

environmental regulations, such as emissions standards and carbon pricing, will be considered. This criterion ensures that case studies reflect the pressures and opportunities arising from regulatory frameworks that play a key role in promoting green supply chain practices. The choice of companies will cover firms from North America, Europe and Asia in order to ensure comparative understanding of the automotive GSCM trends.

4. Data Analysis, Presentation and Interpretation

4.1. Overview of Case Study Companies

For purposes of this analysis, three big car manufacturers have been depicted as embracing different strategies to adopt GSCM. To improve the validity of the research, the selected key actors to analyze include Toyota a Japanese company, Tesla an American company, and BMW a German company. The selected firms are industry leaders with unique market positions, geographic presence and are adopting different sustainability strategies. BMW (Germany) – are industry leaders, each with distinct market positions and geographic presences, and represent a variety of sustainability strategies.

Hence green supply chain management strategies have been adopted by such companies for multiple purposes such as to meet the requirements of the law, to fulfill the expectations of consumers as well as to achieve long term goals of cost efficiency. Each company has also had to adopt innovation and technology to enhance sustainability in its business.

4.2. Green Supply Chain Practices Adopted

This green supply chain deals with Toyota practices based on the Toyota Production System (TPS), which focuses on wastage minimization, and energy use. The company has implemented a number of green practices: Environmental friendly purchasing: Toyota ensures that it sources its inputs from the environment friendly sources and they are all reliable. For instance, the company applies bioplastics and recycled materials in vehicle interior parts.

Reducing waste: This research establishes that Toyota has succeeded in implementing lean manufacturing in order to minimize waste in its production line. For green logistics, Toyota has budgeted for cutting emissions in its supply chain. This includes using Low-emission vehicles as well as achieving the best possible Supply-chain routes that cut down fuel emissions. (TPS), which emphasizes waste reduction and energy conservation.

The company has implemented a number of green practices: Eco-friendly sourcing: Toyota focuses on using renewable materials and sustainably sourced components in vehicle manufacturing. Toyota has reduced waste in its manufacturing process through lean manufacturing techniques, which focus on minimizing material waste, reducing energy consumption, and optimizing production line efficiency. Toyota has invested in reducing emissions in its supply chain. This includes using low-emission vehicles and optimizing routes in the supply chain to reduce fuel consumption.

Tesla has a low carbon supply chain by default because the company and its products are centered on EVs and renewable energy products. The company's green supply chain practices include: Circular economy: Tesla has implemented the best circular economy measures, especially in the battery production where old batteries are reclaimed and manufactured into new ones. Tesla's Gigafactories adopt sources of electricity such as solar and wind in order to minimize on carbon footprint during product manufacturing. Raw materials used in battery making such as lithium and cobalt are sourced responsibly at Tesla. products. The company's green supply chain practices include: Circular economy initiatives: Tesla has integrated a closed-loop recycling system, particularly in battery production, where used batteries are recycled to create new ones, thereby reducing waste. Green manufacturing: Tesla's Gigafactories are powered by renewable energy sources, such as solar and wind, to reduce carbon emissions during manufacturing. Sustainable sourcing: Tesla ensures that raw materials for its batteries, such as lithium and cobalt, come from responsible sources. Another form of sustainability the company maintains is the sustainable supplies where it has close relationship with suppliers.

BMW has adopted a number of green supply chain practices to emphasize sustainability and environmental stewardship: They have focused on using green materials in production and sustainable acquisition of materials to meet their demand. The products offered by the company are prepared through sustainable practices where aluminum and plastics used are derived from natural resources. Energy efficiency in production: It lacks specific examples tied with the company but it is a fact that BMW has been paying much attention to the optimization of energy use in production sites. It has used renewable electricity such as wind and solar energy, and also improved usage of electricity through efficient equipment. BMW continues to employ vehicles that emit little to no carbon to ensure the logistics of their

products and services and improving its supply chain turn around. The company also encourages the adoption of electric vehicles in logistics.

The role of digital tools and technologies: In these companies, the application of digital tools and technologies has been found to have supported green supply chain practices. **Supply chain management:** All three companies are utilizing digital and data analytics to enhance supply chain inventory management, cut out unnecessary expenses and enhance logistics. Both BMW and Toyota are piloting block chain in their supply chains with special focus on sourcing of raw materials to promote ethical / sustainable operations.in its vehicles. The company uses materials such as aluminum and plastics from sustainable sources, ensuring minimal environmental impact. **Energy efficiency in production:** BMW has focused on reducing energy consumption at its production facilities.

It has invested in renewable energy, such as wind and solar power, and has optimized energy use through more efficient machinery. BMW uses low-emission vehicles for its logistics operations and has streamlined its distribution processes to reduce its carbon footprint. The company also promotes the use of electric vehicles in its logistics operations. **The role of digital tools and technologies:** Digital tools and technologies have played a key role in supporting green supply chain practices in these companies.

When it comes to Supply chain optimization all three companies use advanced digital and data analytics platforms to optimize inventory management, reduce waste, and improve logistics efficiency. BMW and Toyota are experimenting with block chain technology to improve the transparency of their supply chains, especially when it comes to sourcing raw materials to ensure ethical and sustainable practices. Digital tools and technologies have played a key role in supporting green supply chain practices in these companies. BMW and Toyota are experimenting with block chain technology to improve the transparency of their supply chains, especially when it comes to sourcing raw materials to ensure ethical and sustainable practices.

4.3. Impact of Green Practices on Competitive Advantage

The part of sustainable sourcing and energy conservation in their supply chain management has added more credibility to BMW's luxury brand image of sustainability. Firstly, BMW has ensured it has embraced circular economy principles including recycling of cars to meet clients' increasing desire for environmentally friendly luxury automobiles that are manufactured using renewable materials economy principles, such as vehicle recycling and the use of renewable materials, has given it an advantage in meeting growing consumer demand for environmentally friendly luxury vehicles (Blunk, 2016).

The environmental projects have also been magnificent in ensuring BMW meets strict regulation laws in Europe thereby reducing potential losses arising from altering standards. In each case, green supply chain practices were not only cost effective but also built brand image among green consumers. green supply chain practices have not only helped companies reduce costs but also differentiated their brands in the eyes of environmentally conscious consumers (Ghosh et al., 2020). This has also gone a long way in helping them to retain their customer base and in the process stand better in the market.

4.4. Challenges Faced by Automotive Companies

BMW has adopted a number of green supply chain practices to emphasize sustainability and environmental stewardship: They have emphasized the use of green materials in production and the procurement of sustainable materials to meet their needs. The food products supplied by the company are processed using sustainable practices where the aluminum and plastics used are sourced from natural resources (Okogwu, 2023). For energy efficiency in production specific examples related to the company are lacking, but it is a fact that BMW has placed great emphasis on optimizing energy use at its production sites. It uses renewable electricity such as wind and solar power, and improves electricity use through efficient equipment.

BMW continues to use vehicles with low or no carbon emissions to ensure the logistics of its products and services and improve supply chain profitability. The company is also promoting the adoption of electric vehicles in the logistics sector. **The role of digital tools and technologies:** In these companies, the adoption of digital tools and technologies is said to support green supply chain operations (Franke et al., 2023). All three companies are using data analytics and digital to improve supply chain inventory management, reduce unnecessary spending, and improve logistics operations. Both BMW and Toyota are piloting block chain in their supply chains, focusing on sourcing raw materials to promote sustainable/ethical practices in their vehicles. The company uses materials such as aluminum and plastics from sustainable sources, ensuring minimal environmental impact. Energy efficiency in production shows BMW has focused

on reducing energy consumption at its production facilities. The company has invested in renewable energy such as wind and solar power, and has optimized energy use through more efficient machinery.

5. Summary and Conclusion

5.1. Interpretation of Findings

This study therefore provides a clear understanding of how different green supply chain practices improve the competitiveness of automotive companies, including Toyota, Tesla, and BMW. These companies have implemented green strategies in different ways depending on their specific strategies, regulatory pressures, and consumers (Ghadge et al., 2022). But despite these differences, what remains consistent across all three cases is the idea that sustainability in the supply chain can create strategic value and positive performance for companies competing in an increasingly sustainability-conscious market environment. In this context, it is argued that sustainable supply chain issues such as green procurement, green manufacturing, waste reduction and circular economy are related to both tangible and intangible total operating costs.

For example, Toyota has implemented lean manufacturing focusing on waste elimination and energy use, which not only reduces costs but also makes Toyota a better industry environmental advocate. Similarly, the use of vertical integration and the integration of renewable energy into Gigafactory concepts aligns with Tesla's mission and vision of commercial and social responsibility versus the traditional challenge to electric vehicles (Ohno, 2019). BMW's strategy of elevating luxury and sustainability in the future aligns with an increasingly environmentally conscious customer base, which also gives the company a competitive advantage.

In this context, it is argued that sustainable supply chain issues such as green procurement, green manufacturing, waste reduction and circular economy are related to both tangible and intangible total operating costs. For example, Toyota has implemented lean manufacturing focusing on waste elimination and energy use, which not only reduces costs but also makes Toyota a better industry environmental advocate (Duarte & Cruz-Machado, 2014). Similarly, the use of vertical integration and the integration of renewable energy into Gigafactory concepts aligns with Tesla's mission and vision of commercial and social responsibility versus the traditional challenge to electric vehicles. BMW's strategy of elevating luxury and sustainability in the future aligns with an increasingly environmentally conscious customer base, which also gives the company a competitive advantage.

5.2. Limitations and Future Research

First, the sample size of companies, while including some of the most notable leaders in the automotive industry, does not include all global companies nor is it representative of all industry segments. The regional focus on companies based in Japan, the United States, and Germany means that the results may not fully reflect the challenges and opportunities faced by companies in emerging markets. Furthermore, the scope of green supply chain practices analyzed in this study is limited, focusing primarily on sustainable sourcing, energy efficiency, and waste reduction, rather than other green practices such as product design and end-of-life vehicle recycling. Future research could address these limitations by conducting longitudinal studies on the long-term impacts of green supply chains in the automotive industry. Such studies would provide valuable insights into how green supply chains evolve over time and their long-term impact on competitive advantage. Comparing the green supply chain practices of the automotive industry with those of other industries would also shed light on the challenges and opportunities of each specific industry. Additionally, further research into the impact of regulatory policies on green supply chain adoption in different regions would provide a better understanding of how government actions influence business strategy.

Compliance with ethical standards

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

- [1] Adams, R., Jeanrenaud, S., Bessant, J., Denyer, D., & Overy, P. (2016). Sustainability-oriented innovation: A systematic review. *International Journal of Management Reviews*, 18(2), 180-205.

- [2] Dangelico, R. M., & Pujari, D. (2010). Mainstreaming green product innovation: Why and how companies integrate environmental sustainability. *Journal of business ethics*, 95, 471-486.
- [3] Duarte, S., & Cruz-Machado, V. A. (2014). Lean and green supply chain performance: A balanced scorecard perspective. In *Proceedings of the Eighth International Conference on Management Science and Engineering Management: Focused on Intelligent System and Management Science* (pp. 645-654). Springer Berlin Heidelberg.
- [4] Franke, J., Wasserscheid, P., Ihne, T., Lamp, P., Guldner, J., & Zipse, O. (2023). The Power of Technological Innovation: Driving Sustainable Mobility. In *Road to Net Zero: Strategic Pathways for Sustainability-Driven Business Transformation* (pp. 215-264). Cham: Springer International Publishing.
- [5] Ghadge, A., Mogale, D. G., Bourlakis, M., Maiyar, L. M., & Moradlou, H. (2022). Link between Industry 4.0 and green supply chain management: Evidence from the automotive industry. *Computers & Industrial Engineering*, 169, 108303.
- [6] Ghosh, M., Ghosh, A., & Roy, A. (2020). Renewable and sustainable materials in automotive industry. *Encyclopedia of Renewable and Sustainable Materials 2020*, 162-179.
- [7] Hammou, I. A., Salah, O., & Hebaz, A. (2022). The impact of lean & green supply chain practices on sustainability: literature review and conceptual framework. *LogForum*, 18(1).
- [8] Lukin, E., Krajnović, A., & Bosna, J. (2022). Sustainability strategies and achieving SDGs: A comparative analysis of leading companies in the automotive industry. *Sustainability*, 14(7), 4000.
- [9] Maier, D., Maier, A., Aşchilean, I., Anastasiu, L., & Gavriş, O. (2020). The relationship between innovation and sustainability: A bibliometric review of the literature. *Sustainability*, 12(10), 4083.
- [10] Masoumi, S. M., Kazemi, N., & Abdul-Rashid, S. H. (2019). Sustainable supply chain management in the automotive industry: A process-oriented review. *Sustainability*, 11(14), 3945.
- [11] Molina, A., & Rajagopal. (2023). Based innovation: economics, transferability, and consumerism. In *Challenge-based learning, research, and innovation: leveraging industry, government, and society* (pp. 143-168). Cham: Springer International Publishing.
- [12] Mugoni, E., Kanyepe, J., & Tukuta, M. (2024). Sustainable Supply Chain Management Practices (SSCMPS) and environmental performance: a systematic review. *Sustainable Technology and Entrepreneurship*, 3(1), 100050.
- [13] Okogwu, C., Agho, M. O., Adeyinka, M. A., Odulaja, B. A., Eyo-Udo, N. L., Daraojimba, C., & Banso, A. A. (2023). Exploring the integration of sustainable materials in supply chain management for environmental impact. *Engineering Science & Technology Journal*, 4(3), 49-65.
- [14] Pusparini, E., & Kusumastuti, R. (2019, August). Sustainable Supply Chain Management: Exploring the Role of Supply Chain Dynamic Capabilities in Determining Firm Performance. In *Proceedings of the 1st Sampoerna University-AFBE International Conference, SU-AFBE 2018, 6-7 December 2018, Jakarta Indonesia*.
- [15] Srivastava, S. K. (2007). Green supply-chain management: a state-of-the-art literature review. *International journal of management reviews*, 9(1), 53-80.
- [16] Tseng, M. L., Islam, M. S., Karia, N., Fauzi, F. A., & Afrin, S. (2019). A literature review on green supply chain management: Trends and future challenges. *Resources, Conservation and Recycling*, 141, 145-162.
- [17] Tseng, M. L., Islam, M. S., Karia, N., Fauzi, F. A., & Afrin, S. (2019). A literature review on green supply chain management: Trends and future challenges. *Resources, Conservation and Recycling*, 141, 145-162.
- [18] Yang, Y., Chen, J., Lee, P. K., & Cheng, T. C. E. (2023). How to enhance the effects of the green supply chain management strategy in the organization: A diffusion process perspective. *Transportation Research Part E: Logistics and Transportation Review*, 175, 103148.