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GOING GREEN - INDUSTRY 5.0, SUPPLY CHAIN AND DEMANDING CUSTOMER

(Sayfa 21-30)

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Abstract

Industry 5.0 differs from the former industrial revolutions with a high propensity to human orientation. Sustainability and resilience are the key salient instruments of this emergent process. Besides, there is a growing interest in sustainable and green products. The main purpose of this study is to provide a common green ground for supply chains and consumption within the scope of Industry 5.0. Besides, another aim is to present an integrated theoretical framework of Industry 5.0, green supply chain, and green consumption to guide future studies. Advancements in technologies of manufacturing systems can support greening actions regarding supply chains and, in turn, customer satisfaction. This study contributes to the existing literature by examining the connections among Industry 5.0 specific technologies and its philosophy, greening supply chains, and consumption. Results reveal that new Industrial revolution dynamics benefit green implications of supply chains and lead to increased customer satisfaction. The findings of the paper are presented as a conceptual model to guide future research.

Keywords: Green Supply Chain, Green Consumption, Sustainability, Resilience, Industry 5.0.

Jel Code: E21, M31, O14, O33, Q01, Q56

1 Introduction

The COVID-19 pandemic has triggered ecologically friendly thinking in many perspectives as everyday lives, working conditions, and business cycles. For example, many people run for living in nature. In England, city residents wanting to move to a village increased by 126% due to the pandemic (Country Living, 2020). A similar trend has also been determined In Turkey. After the COVID-19 pandemic, 68% of those who started working remotely wanted to move away from their metropolitan areas. Survey respondents point out lack of green space, overpopulation, and traffic as the top three reasons for moving out of the city. This is followed by noise pollution and the fact that small settlements are more financially attractive for employees (Pazarlamasyon, 2020). In other words, COVID-19 made the low quality of life in big cities more apparent and made small green residential areas more attractive. However, the exemplified facts seem like a new social sustainability norm (to avoid virus infection); it has actually interconnected to economic and ecological sustainability. Thus, the pandemic has evoked not only people but also businesses so as to consider the protection of the earth for environmental sustainability because the disruptions highly impact consumer behavior and preferences. One of the possible impacts is green consumption representing the demand for green market offerings, which has surged lately.

In January 2021, the European Commission officially called for the Fifth Industrial Revolution (Industry 5.0) with the document entitled "Industry 5.0: Towards a Sustainable, People-Centered and Resilient European Industry". Since the title emphasizes Industry 5.0 does not follow the exact footprints of the previous industrial revolutions. Rather this new era focus on sustainability, human, and resilience. Furthermore, the COVID-19 crisis has highlighted the need to rethink current working methods and approaches, including the fragility of global supply chains, to make industries more future-proof, sustainable and people-centered (Xu et al., 2021). In particular, research on sustainable supply chains with a green focus has gained a permanent place in the supply chain discipline (Sarkis, 2021).

The motivation of this study stems from the mentioned recent developments and events relying on going green. The study aims to present a viewpoint based on environmental sustainability. The paper setting is as follows; first, sustainability and resilience elements of Industry 5.0 will be discussed. In the second stage, green supply chain literature will be examined. After that, within the scope of Industry 5.0, green supply chains and green consumption perspectives will be investigated. Finally, inferences will be presented in the conclusion.

2 Industry 5.0, Sustainability, and Resilience

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Industry 5.0 is one step further from Industry 4.0 and represents a human-centric approach rather than a techno-centric one. On the other hand, Industry 4.0 is technocentric and does not consider the social system (Margherita and Braccini, 2021). Though it is an enhanced version of Industry 4.0 (Maddikunta et al. 2021), it still adopts some base technologies of the former (e.g., Big data and AI). However, due to a response to recent worldwide disruptions as the COVID-19 pandemic and climate change related disasters, Industry 5.0 presents more improved social, healthier, environmentalist cornerstones.

Enabling technologies of Industry 5.0 are stated in some studies. For example, Xu et al. (2021: 533) listed six enabling technologies depending on the European Commission declarations: Individualized human-machine interaction technologies that interconnect and combine the strengths of humans and machines. Bio-inspired technologies and innovative materials that allow materials with embedded sensors and enhanced features while being recyclable. Digital twins and simulation to model entire systems. Data transmission, storage, and analysis technologies that are able to handle data and system interoperability. Artificial Intelligence to detect, for example, causalities in complex, dynamic systems, leading to actionable intelligence. Technologies for energy efficiency, renewables, storage, and autonomy. Maddikunta et al. (2021: 8-11) enlist seven enabling technologies in Industry 5.0 as Edge computing, Digital twins, Cobots, Internet of Every Things (IoE), Artificial Intelligence (AI), Big data, Blockchain, 6G, and beyond. Besides, some other technologies such as Network Slicing (NS), eXtended Reality (XR), and Private Mobile Network (PMN) are added as other enabling technologies.

The circular economy concept and its relation to Industry 4.0 have been discussed within the sustainability in production and consumption philosophy. There are three elements of circular economy. The first one is the conservation of natural capital, which means creating a balance of consumption between renewable and non-renewable resources. The second element is increasing the lifetime of resources through both biological and technical cycles, i.e., increasing the circularity of resources and energy. The last one is reducing the adverse effects of the production system. In this context, de Souza et al. (2018) suggested a framework for cirricular economy in Industry 4.0.

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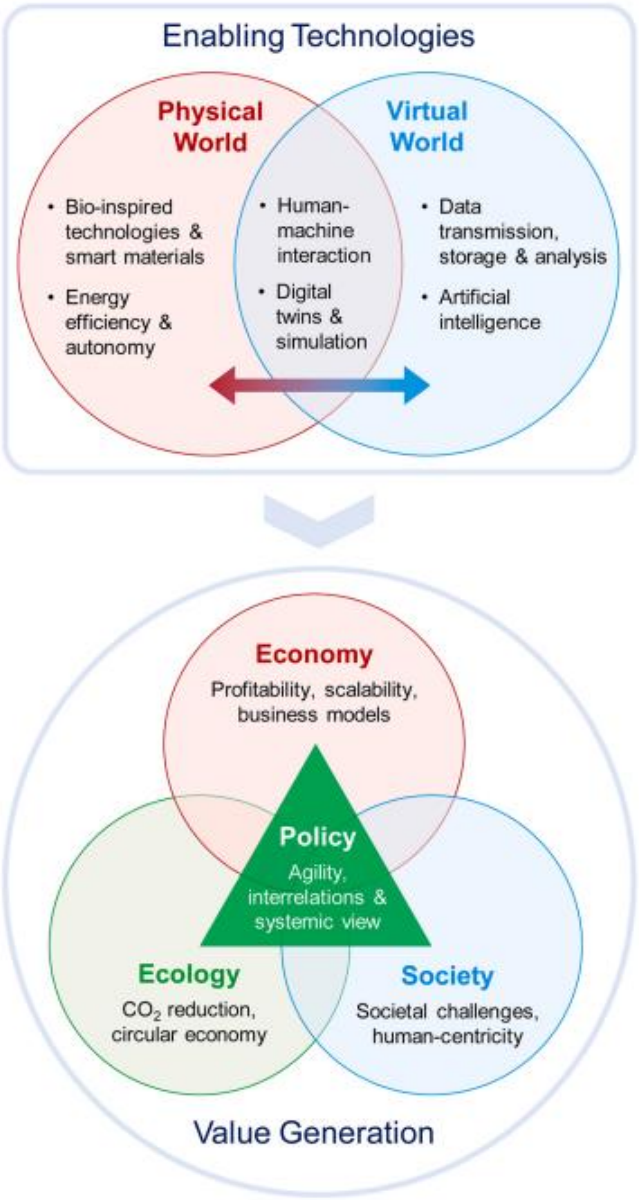

Fig.1 Goals and the technological enablers of Industry 5.0 (Xu et al., 2021: 534)

Prihatna and Hereyah (2021) explain human-centric and sustainability as follows: “The people-centered approach places basic human needs and interests at the heart of the production process, moving from technology-driven progress to a fully people-centered and community-centered approach. Technology serves people and communities, meaning that the technology used in manufacturing can be adapted to the needs and diversity of industry workers. For the industry to respect planetary boundaries, it needs to be sustainable. It needs to develop circular processes that reuse, reuse and recycle natural resources, reduce waste and environmental impact, and ultimately lead to a circular economy with better resource efficiency and effectiveness.” Resilience refers to “the need to better arm industrial production against disruptions and ensure that it can provide and support critical infrastructure in times of crisis” (Xu et al., 2021: 533).

Demir et al. (2019) argued that two visions have emerged for Industry 5.0. The first is “human-robot collaboration.” In this vision, robots and humans will work together wherever possible. Humans will focus on creative tasks, and robots will do the rest. Another vision for Industry 5.0 is “bioeconomy." The wise use of biological resources for industrial purposes will help strike a balance between ecology, industry, and economy. According to the European Commission, bioeconomy is defined as "the production of renewable biological resources and the conversion of these resources and waste streams into value-added products such as food, feed,

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bio-based products, and bioenergy." In the context of this definition, the bioeconomy includes parts of the chemical, biotechnological, and energy industries as well as agriculture, forestry, fisheries, food, pulp, and paper production. In addition, many branches of science (life sciences, agricultural sciences, ecology, food sciences, and social sciences) and facilitating and industrial technologies (biotechnology, nanotechnology, information, and communication technologies (ICT), engineering) are also within the scope of bioeconomics (Demir et al. 2019; Yücebalkan, 2020).

With the help of smart machines, the fifth industrial revolution increases safety, improves quality, and also reduces waste while enhancing creativity and innovation in production. Humans play a lesser role in this revolution, and artificial intelligence plays an important role. The advantage of the robots in the system is that the material and information flow are easy, and the environmental conditions affect the processes less.

3 Green Supply Chain

There is a tripartite approach in sustainable supply chain research in which economic and environmental factors play dominant roles, and social concerns increasingly draw attention (Sarkis, 2021). However, this study mainly focuses on environmental sustainability. Hence, here presented a brief discussion on green supply chains.

There is a great body of literature on green supply chains (e.g., Zhang et al., 1997; Sarkis, 1998; Guide et al., 2000; Bey, 2001; Srivastava, 2007; de Oliveria, 2018; Bhatia, 2021). Green supply chain management occurred with the idea of incorporating environmental thinking into supply chain management. It includes product design, material sourcing and selection, manufacturing processes, product delivery, and end-of-life management of the product (Srivastava, 2007).

Recently, business life has witnessed a remarkable paradigm shift in supply chain management due to the ongoing pandemic conditions and the changing climatic conditions. According to a report of Climate Action entitled “An Eco-awakening: Measuring global awareness, participation, and action for nature" indicates an increase in consumer clicks for sustainable products in high-income countries such as the United States, United Kingdom, Germany, Australia, and Canada. However, the green trend has gone beyond these countries and has risen rapidly in emerging and developing countries such as Ecuador -120%- and Indonesia -24% (Climate Action, 2021). Hence, this trend makes businesses worldwide rethink green supply chain management operations to supply green products for customer satisfaction. In line with the rates mentioned above, studies on green supply chains are focusing on emerging markets have been increasing in literature after the year 2018 (e.g., Suryanto et al., 2018; Yıldız Çankaya and Sezen, 2019; Tumpa et al., 2019; Jemai et al., 2020).

Fasan et al. (2021) stressed whether green supply chain management mitigates the effects of COVID-19. They suggest that both green and non-green industries will benefit from greater supply chain resilience and fewer supply chain disruptions in the short term. However, provided that environmental sustainability plays a more prominent role in the post-COVID era, the long-term benefit of green supply chain management can be expected to be more pronounced for environmentally sensitive industries. Some studies claim that businesses with green supply chains will benefit in terms of economic performance (Yıldız Çankaya and Sezen, 2019). For example, Ahi and Searcy (2013) stated that implementing sustainable or "green" supply chain management is the primary goal of increasing the company's ability to maintain profitability during disruptions. In this sense, a business with a supply chain based on non-toxic chemicals (environmental sustainability) will have less profit lost due to a chemical leak (Marchese et al., 2018). Similarly, Yıldız Çankaya and Sezen (2019) found that green production, green distribution and packaging, and environmental education dimensions of the green supply chain are positively related to economic performance. Nevertheless, the idea of a greener supply chain is one of the main drivers where sustainable processes still need to be improved. Adidas is an example of eliminating virgin plastics in its supply chain. It seems likely that more potential will emerge in this area in the future than ever before (Purwanti et al., 2019; Rupp and Hillekamp, 2021).

Although global supply chains are becoming increasingly important for value creation, which is the primary purpose of any business organization, the academic literature has not reached a consensus on the effectiveness of green supply chain management (Fasan et al., 2021). However, this study will contribute the existing literature by providing a first attempt to integrate Industry 5.0 with green supply chains and gren consumption.

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4 Green Supply Chains for Green Consumption in Industry 5.0 Era

4.1. Supply Chains in Industry 5.0

Industry 5.0 is based on the concept and practices of Industry 4.0. The first focus of Industry 4.0 applications has been supply chain management, manufacturing, and production (Özdemir and Hekim, 2018). It is claimed that the visions developed for Industry 5.0 are faster, more scaled, and more relevant to more people than previous industrial paradigms due to the type of technology in use. In the literature, this will happen with the push of more advanced human-machine interfaces with improved integration better automation of robots paired with the power and creativity of the human brain; productivity will increase; It is also stated that the economy, ecology, and social world will be affected by the efficient synergy in question. In addition, these effects are accompanied by a waste prevention perspective applied in industrial recycling (Paschek et al., 2019; Yücebalkan, 2020).

	Enabling technologies											
Industry 5.0 Applications	Edge computing	Digital twins	Cobots	IoE	AI	Big data	Blockchain	6G and beyond	Swam networking	Network slicing	Extended reality	Private mobile networks
Intelligent healthcare	H	M	L	H	H	H	H	H	L	H	H	M
Cloud manufacturing	H	H	H	H	H	H	H	H	H	H	H	M
Supply chain management	M	L	L	H	H	H	H	H	H	L	L	L
Manufacturing/Production	H	H	H	H	H	H	H	H	H	H	H	H
Education	H	M	L	M	M	M	M	H	L	H	H	M
Human–cyber–physical systems	H	H	H	H	H	H	H	H	H	H	H	H
Disaster management	H	M	M	H	H	H	M	H	H	M	H	M

H High Utilization M Medium Utilization L Low Utilization

Fig. 2 The role of enabling technologies on applications of Industry 5.0 (Maddikunta et al., 2021: 9).

Maddikunta et al. (2021) suggested supply chain management as one of the Industry 5.0 applications. In this context, authors claim that IoE, AI, big data, blockchain, 6G and beyond, and swan networking are highly utilized in supply chain management. On the other hand, digital twins, cobots, network slicing, extended reality, and private mobile networks technologies are pointed out as low utilized technologies in supply chain management. Only edge computing technology is classified as a medium used enabling technology.

To get all the benefits of Industry 5.0, SAM is combined with integrated automation capability to streamline processes involved in supply chain management and reduce lead time for products. The first step in hyper-customization is the transition to the agile manufacturing process and supply chain. This requires human intervention, production staff, and customer preferences. Moreover, the feasibility of hyper-customization is highly dependent on the cost-effectiveness of the developed products (Maddikunta et al.,2021).

In Industry 5.0, devices and equipment are automatically upgraded to upgrade the production system. In this revolution, with the help of smart systems, vehicles are selected correctly, and overproduction is prevented. The data in this system is analyzed intelligently, improving research and development possibilities. On the other hand, the smart and automated internal systems of the factories are connected to the systems of other factories, creating a smart factory set, improving production support, and providing the desired services to the customer. This system makes the supply chain smarter and increases its competitiveness and efficiency. Intelligent systems in Industry 5.0 can be used in supply chain operations such as transportation and logistics. Internet of Things (IoT) is one of the components of Industry 5.0. In this sense, connected things/machines via Internet have changed the activities of the production and supply chains (Yavari and Pilevari, 2020).

4.2. Green Product and Consumption in Industry 5.0

With the environmental movement that started in the 1960s, concerns about environmental pollution and deterioration of the environment gradually increased (Choice, 2010). In support of this orientation, the United Nations' Sustainable Development Goals in 2017 included the goal of "providing sustainable consumption and production patterns." As Hart (1997: 3) stated, "the environmental revolution has changed forever how companies do business." Rising ecological awareness and clicks on sustainable products create new market opportunities, especially for businesses in the cosmetics, pharmaceuticals, fashion, and food industries. While sustainable and eco-friendly products used to be a niche market, this is no longer the case today (Climate Action, 2021).

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Most consumers consider environmental issues while shopping and prefer green products. For example, consumers demand products that are compatible with nature by paying attention to whether the product packaging is recyclable, whether it is a product containing biodegradable dyes, or whether it is a hair spray containing gases that do not harm the ozone layer. In this context, according to 2013 data, environmental effects are expressed as the third most important factor for European Union consumers after quality and price (European Commission, Final Data, 2021). Due to rapidly changing market conditions and customer awareness of health issues and environmental and social issues concerns, the production of final goods and services without supply chain sustainability is not applicable (Bag et al., 2020). In this sense, green supply chains can enable businesses to become more conscious of identifying and responding to environmental demands from consumers and other stakeholders (Danso et al., 2019).

Green demanding consumer behavior leads to the occurrence of the terms as green marketing, green product, and green consumer. According to the American Marketing Association (AMA) definition, green marketing refers to the development and marketing of products that are deemed environmentally safe (i.e., designed to minimize adverse effects on the physical environment or improve its quality). The term can also be used to describe efforts to manufacture, promote, package, and recycle products in a way that is sensitive to ecological concerns (AMA, Marketing Dictionary, 2021).

Industry 5.0 includes elements that emphasize the environment-oriented approach. Draganov et al. (2018) draw attention to the fact that green marketing activities can be successfully implemented by businesses, given the changing environmental processes led by Industry 5.0 and the associated movement towards environmental and global welfare. In the concept of Industry 5.0, one of the essential elements in value production is shown as ecology. At this point, value for the environment can be created by reducing the use of carbon dioxide and creating a cyclical sustainable economy (Xu et al., 2021).

According to Demir et al. (2019), the Industry 5.0 approach establishes a balance between the environment, industry, and economy and acts on the idea of sustainability. Accordingly, it is stated that another approach of Industry 5.0 is the bio-economy, which deals with the correct and trouble-free use of biological resources. According to Margherita and Braccini (2021), in Industry 5.0, sustainability describes a production system that reduces the environmental impact of producers and encourages energy saving, cleaner production, and circular economy practices.

Although there is a high level of development focus in digitalization and technology, it can be said that the green product is promoted in Industry 5.0. At this point, the European Commission includes the use of recyclable smart materials among the six effective technologies of Industry 5.0. Furthermore, other technologies point to energy efficiency and renewable energy (Xu et al., 2021). Therefore, in fact, the use of sustainable energy sources, environmentally friendly production, and recyclable green products inspired by biology are some of the main lines that should be underlined in Industry 5.0.

The Industry 5.0 vision is socio-technical in nature. Herein, it includes the necessity of following the sustainability results (economic-environmental and social) rather than the traditional results of a working system (Margherita and Braccini, 2021). Businesses can successfully implement green Marketing in terms of changing environmental processes led by Industry 5.0 and the associated movement towards environmental and global well-being. Green marketing and Industry 5.0, which contribute to successful implementation to achieve global prosperity, are interconnected (Draganov et al. 2018). In summary, one of the essential elements of Industry 5.0 is to emphasize and support green consumption and green marketing activities (Zengin and Zengin, 2021).

Conclusion

Organizations, governments, and consumers are taking steps to make their lives “green” (Prothero et al., 2010). To satisfy the end customer of the green supply chain, business processes (such as purchasing, manufacturing, marketing, and logistics) throughout the supply chain must be integrated, coordinated, and strategically aligned (Fasan et al., 2021). Regarding the existing literature discussion outlined above, a conceptualized model is developed (Fig 3).

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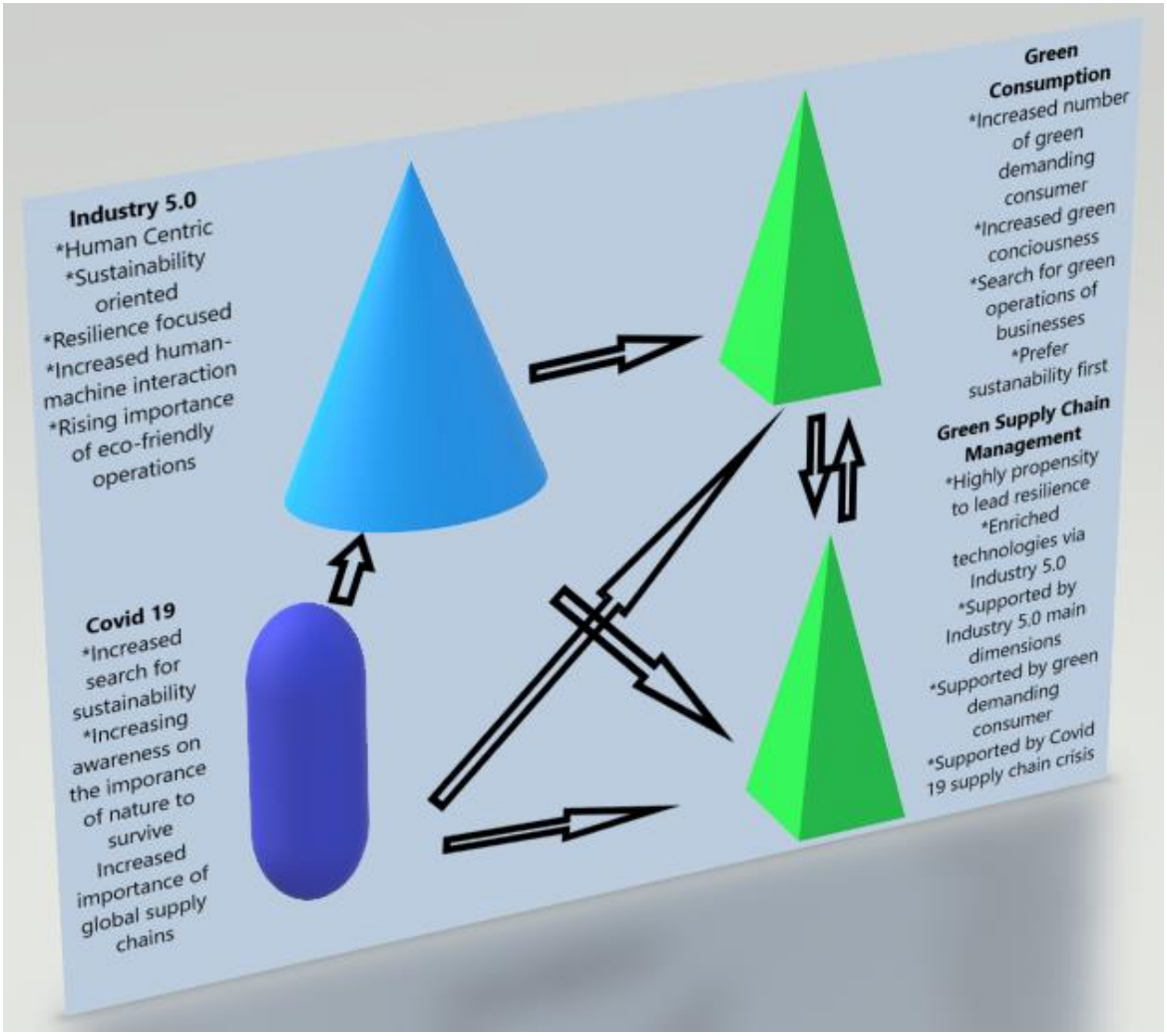

Fig. 3 Proposed Conceptual Model- Going Green: Connections in Industry 5.0, COVID-19, Green Supply Chain, Green Consumption

As proposed by the model regarding the connections among Industry 5.0, COVID-19, green supply chain management, and green consumption, these concepts are interrelated. COVID-19 pandemic leads an understanding on an increasing need for sustainability, human and social-oriented approach in Industry applications. Hence, World has met with the concept of Industry 5.0. This 5th industrial revolution is human-centric, sustainability-oriented, and resilience-focused. Advancements in technology and digital development enable increased human-machine interaction. For example, AI and robots interact more with consumers and workers. Industry 5.0 perspective emphasizes using technology for human welfare and, thus, the rising importance of eco-friendly operations. At the same time, COVID-19, Industry 5.0 approach, and green supply chain practices surge Green Consumption. COVID-19make people rethink the importance of nature for the survival of human being. Many people may treat nature - earth now as God-given escape land for survival. Sustainability and resilience in global supply chains come forth because of the COVID-19 crisis. The increasing repetition and emphasis on sustainability by COVID-19 caused issues, Industry 5.0 implications, climate change problems lead consumers more tend to buy green products. Today number of demanding green consumers has been growing. As presented above, literature statistics indicate that green consciousness is improving. Conscious green consumers today search for green operations of businesses. Also, an increasing number of consumers have started to prefer sustainability first in their purchase decisions. Ongoing events and developments take green supply chain management a step further and underline its importance. As evidenced by some studies, green supply chain management implications have a high propensity to lead to resilience in crisis, as COVID-19. Industry 5.0 main features support the underlying idea of green supply chain management. Enabling technologies of Industry 5.0 may provide significant benefits for businesses to adopt and develop green supply chain practices. For example, the Industry 5.0 era put great importance on AI. In Finland, high-tech AI-powered robots are used in recycling plants, and this technology

boosted recycling rates by %40 (News24, 2021). Besides, as discussed above green supply chain management will be more supported by demanding green consumers in the near future.

Accordingly, all these components may increase the ecological activities of the businesses. Under the flagship of Industry 5.0, green manufacturing, green operations, green supply chain management, green marketing activities can be successfully implemented by businesses in terms of changing environmental processes and the associated movement towards environmental and global welfare. Depending on the model proposed here, quantitative, qualitative, or mixed-method can be used to provide empirical evidence on going green processes of businesses. Hence, the correlations among the elements of the model and the impacts of COVID-19, Climate Change and Industry 5.0, and green consumption on green supply chain management adoption and implication may be examined.

Further research may benefit the possible growth in literature on Industry 5.0 applications and technologies. Since the concept was first mentioned literally in 2021 by the European Commission, there has been scarce research. Although limited in background literature, this study may provide a baseline for later academic papers. Future studies should also use qualitative and/or quantitative methods to examine the practical response to industrial operation changes, track green consumer behavior, and the role of green supply chains. Besides, cross-cultural approaches may enhance the understanding of differences in adopting and implementing greening in supply chain management.

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