

## **Industry 5.0 Technologies for Supply Chain Management through Triple Bottom Line Approach in Companies of Sri Lanka for Economic Growth and Socio-Environmental Protection**

Doluweera L.K.

The American College of Higher Education Sri Lanka, The International Center of Broward College, USA,  
*Doluweera.lalkumarasiri@gmail.com*

### **ABSTRACT**

In the midst of blazing Global environmental concerns- climate changes, global warming risking the planet, Industry 5.0 generates hyper-personalized, human centric solutions resulting resilient, sustainable, regenerative circular economic businesses protecting the people-planet-prosperity by moving away from neo-liberal capitalism of maximizing profit realizing the Transformative Vision for Europe -climate neutral world emphasizing the European Commission Green Deal. In Industry 5.0, embedded supply 5.0, Collaborative Robots (Cobots), Artificial Intelligence (AI), Blockchain, and Digital Twins offer data-driven predictive analytical decisions for hybridized human centric industrial archetypes and societal infrastructure ensuring environmental protection. Industry 5.0 embedded human centric Supply Chain 5.0 caters to the hyper-personalized customer needs, with the right amalgamation of human creativity and machine efficiency. Digitization and human collaboration and the hybrid human-machine model of Supply Chain 5.0 create resilient green supply chains uncompromising competitiveness and profitability. How can Supply Chain 5.0 interplay with society, in order to create a super-smart society achieving climatic goals resulting more sustainable environment are unexplored sporadic research territory yet.

The main objective of this research is to utilize Triple Bottom Line-People Planet and Profit to investigate the implementation issues of industry 5.0 in Sri Lankan companies through deductive thematic top- down qualitative analysis of case studies of 12 giant companies with robust supply Chains representing the registered in the National Chamber of Commerce (2019) ensuring no greater biases of the researcher's preconceived notions of inquiry. Findings revealed that Companies maintain status quo due to complexities of paradigmatic transition of supply chains into supply chain 5.0, lack of industry 5.0 maturity models, and inadequately upskilled IT professionals and IT productivity paradox. Therefore, state visionary policy for the human centric resilient sustainable green supply chains and upskilling professionals to embrace supply chain 5.0 are a sine qua non for inculcating the triple bottom line concept in supply chains -people planet profit. The insight shed by the conceptual framework to uncover the ways that Industry 5.0 technologies be interoperable across the supply chains fostering society 5.0 -Super Smart Society are the future research avenues with dearth of global investigations. Finally, the Industry 5.0 conceptual framework designed, interoperable across the supply chain to create a super smart society -society 5.0 will minimize Greenhouse Gas Emissions and Adverse Climatic Changes emphasized by United Nations -Transforming our world- 2030.

**Keywords: Industry 5.0, Supply Chain 5.0, Human Centric Sustainable Supply Chains, Triple Bottom Line, Super Smart Society**

## INTRODUCTION

### **Global environmental concerns and the Sri Lankan supply chain environmental initiatives**

Being a well-developed continent- United States of America the Total U.S. Emissions in 2021 is approximately 6,340 Million Metric Tons of CO<sub>2</sub> equivalent and greenhouse gases make the planet warmer and "thickening the Earth's atmospheric blanket (Transforming our world - the 2030 Agenda for Sustainable Development- global warming potentials (GWPs) and Fluorinated gases emitted even in smaller quantities, which are referred as high-GWP gases because, for a given amount of mass, they trap substantially more heat than CO<sub>2</sub>.and other greenhouse gases typically in thousands <https://www.epa.gov/ghgemissions/overview-greenhouse-gases>. Moreover, in Industrial processes, the fossil fuel combustion component of various industrial processes accounted for 15% of total U.S. CO<sub>2</sub> emissions and 12% of total U.S. greenhouse gas emissions in 2021. Therefore, United Nations Environmental Protection Agency (2023) is constantly experimenting the prevention of Greenhouse Gas Emissions – Fluorinated Gases, N<sub>2</sub>O emitted from Transportation, fossil fuel combustion which can remain in the Air for thousands of years (Global Warming Potential- GWP). If these harmful effects are ignored by the globe there would be no mankind on earth in future.

Consequently, European Commission Green Deal 2030 has announced Industry 5.0-an effective solution to prevent earth from environmental hazards by introducing humanistic industrial practices protecting the people planet prosperity and then the profit. Sri Lanka In this regard has no exception and can blaze the trail to implement industry 5.0 embedded supply chain 5.0 for societal friendly humanistic supply chains. Priyashani L. N and Gunarathne G.C.I. (2021) have shown that there is a significant positive relationship between Green Supply Chain Management (GSCM) practices and organizational performance. Enhanced GSCM practices will result in greater environmental, operational and financial performance through minimization of harmful air emission, solid and water wastage and decreasing the hazardous materials consumption, environmental accidents.

### **Criticality of Supply Chain Management for the companies to achieve integration of supply and demand**

Aabid M, Majeed A, Thashika D (2017) stated that Council of supply chain management professionals (CSCMP)\_defined supply chain as “Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion,

and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers.. Supply Chain Management is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high performing business matching the supply and demand.

However, whether industry 5.0 embedded supply Chain 5.0 can reduce the environmental pollutions and can provide humanistic supply chain solutions have rarely been investigated.

### **Industry 5.0 and the sociotechnical transformation through Human Centric sustainability solutions**

According to João Barataa, \*, Ina Kayserb (2023) Industry 5.0 is the phenomenon of sociotechnical transformation of industries defined as a humanized vision of technological transformations in industry, balancing the needs of the global society with the sustainable optimization of energy consumption, materials processing, and products which has been prominently experimented by top three continents India, China, and the USA.

### **Industry 5.0 empowers people to generate green productions**

Saeid Nahavandi (2019) in Industry 5.0—A Human-Centric Solution Sustainability have stated that, during the 2<sup>nd</sup> industrial revolution world has faced a massive increase in environmental pollution. The manufacturing industry should focus on controlling different aspects of waste generation and management eliminating adverse impacts on the environment from its operation. The international organizations like the UN, WHO urge to create and environmentally friendly organizations. Unfortunately, Industry 4.0 neither have a strong focus on environmental protection, nor has it focused technologies to improve the global environmental sustainability, even though many different AI algorithms have been used to investigate the sustainability during the last decade. Laura Lachvajderová et. al. (2022) has justified that through European Commission's invention of Industry 5.0- the Fifth Industrial Revolution, better meet the economic and the special environmental requirements of "green production" for carbon neutral, energy-efficient industry (European Commission, 2021).

### **Futuristic trends of Industry 5.0 embedded Supply Chain 5.0**

In the examination of The Reconciliation between Humans and Machines, Guilherme F. Frederico (2020) has shown that Supply Chain 5.0 phenomenon emerges as an important concept in the futuristic view of supply chains, reconfigured and managed from futuristic

trends, since there is not only a dearth of investigations both academic and practitioners' sides, but also even Industry 4.0 is still on middle stage of emergence.

### **The criticality of Industry 5.0 in creating personalized human centric products with human engagement**

In contrast, industry 5.0 (Banu OZKESER,2018) products/services, which join forces man and machine, empower people to realize the basic human prefer human touch in personalized products since the customers mostly demand for unique products with distinctive human craftsmanship which can only be made through human involvement – human engagement. - personal imprint of human designers and craft created by digital transformation of Industry 5.0 over industry 4.0 sophisticated technologies.

### **The profit driven approach of Industry 4.0 technologies is not sustainable for long term**

In contrast, Naseem, M.H.; Yang, J.(2021) have shown that through diverse disruptive technologies, Industry 4.0 has a vital impact on the sustainability of the logistics as well as the supply chain network in enterprises in establishing the concept of future-oriented intelligent factory -the smart factory-the digital factory that consists of a completely integrated automated manufacturing system without human interventions. Moreover, Banu OZKESER (2018) stated that Industry 4.0 embedded supply offers timely delivery trucks arrivals and the forklifts deliver the parts straight to the assembly line station because of the due determination of creating inexpensive, high-quality products that provide appearance of uniqueness, today's mass customized unequal products.

As stated by Marina Crnjac Zizic et. al. (2022) Industry 4.0 is based on the concept of smart factories. The smart factory initiative consists of disruptive technologies such as internet of things(IOT), cloud computing, Cyber Physical Systems, Artificial intelligence, Augmented reality simulation, Autonomous Robots -Human Robot interactions. Even though, these state of art technologies enable the connectivity of the virtual and real world in order to achieve better results in production with maximum profit, this completely profit-driven approach is not sustainable for the long term. Finally as shown by Saeid Nahavandi (2019), While the researchers of industry 4.0 struggle to link AI algorithms with environmental management, the lack of strong focus and action leads to the need for a better technological solution to save the environmental sustainability of the globe through Industry 5.0.

## THEORETICAL LENS

### Triple Bottom line

Timothy F. Slaper & Tanya J. Hall (2011) have stated that According to Elkington, J. (1994) the Triple Bottom Line ( TBL) is defined as an accounting principle that integrates three magnitudes of - social, environmental and financial performance which diverges from traditional reporting systems as it includes ecological and social measures that enhanced the standard of measurement accuracy. The TBL dimensions of three Ps: people, planet and profits which captures the heart of sustainability by measuring the impact of an organization's activities in the globe including both its profitability and shareholder values and especially the social, human and environmental capital.”

### **Industry 5.0 typically fulfills the concept of triple bottom line -Human-centric approach in Industry 5.0**

Marina Crnjac Zizic et. al. (2022) has shown Instead of taking technology as a crucial element, the document of European Commission has identified three key drivers as the center of new industrial paradigm- Industry 5.0 differentiating from industry 4.0

Human-centric approach, which places human needs at the heart of the production process, asking what technology can do for workers and how can it be useful, Sustainability, which emphasizes on reuse, repurpose, and recycle of natural resources resulting reduction of waste and environmental pollution Resilience, which assures robustness in industrial production which offers support through adaptable production capacities and flexible processes, especially during crisis. Finally, TBL framework enables firms to assess the consequences of their decisions in long-run perspective.

Moreover, as stated by Dmitry Ivanov (2023) Industry 5.0 covers four areas-organization, management, technology, and performance assessment. Industry 5.0 spans three levels: society level, network level, and plant level establishing a new triple bottom line resulting, human well-being, sustainable society and resilient value creations.

Moreover, Vincenzo Varriale et. al. (2023) has utilized the triple bottom line (3BL) perspective to justify the application of Industry 5.0 digital technologies for sustainable Supply Chain Management (SCM) practices.

Therefore, the present researcher utilizes Triple Bottom Line concept as the theoretical lens to investigate the robustness Industry 5.0 -Technologies for sustainable Supply Chain Management Practices in Sri Lankan Companies ensuring Economic Growth and Scio Environmental Protection

## **Research Gap**

### **The evolution of industry 4.0 to industry 5.0 and the interplay among Industry 4.0, Industry 5.0 and Society 5.0.**

Guilherme F. Frederico(2021) has shown, In parallel with the industry 5.0 concept, an approach proposed by Japan called Society 5.0 has also attracted attention from the scientific and practical audience. The terminology Society 5.0, also known as Super Smart Society, has been initially presented in the Fifth Science and Technology Basic Plan, which has been elaborated by the Japanese Council of Science, Technology and Innovation in 2016

Guilherme F. Frederico(2021) has further shown the interplay among Industry 4.0, Industry 5.0 and Society 5.0. Industry 5.0 is focused on allowing a Society 5.0 to create a sustainable human-centered society by utilizing the technologies from Industry 4.0, while Industry 4.0 is more concerned with the application of disruptive technologies. Consequently, it is challenging to create a Society 5.0 only by incorporating the disruptive technologies from Industry 4.0 since Society 5.0 goes beyond the boundaries of technological and organizational transformation of the industrial system blazing its trail more towards social and human aspects to achieve a sustainable environment in this technological context.

Hence, Society 5.0 uses advanced technologies to connect people and things, share knowledge and information, thereby create new social business chains contributing more values to the society Finally, Society 5.0 frees humans from exhausting routine work by exploring the advantages of technologies of Industry 4.0

### **Industry 5.0 embedded supply chain 5.0 can create the digital replica of SCM**

Praveen Kumar Reddy Maddikunta (2021) have shown that the state of art technologies in Industry 5.0 like Digital Twins(DT), Cobots, 5G, Machine Learning , IoT, Edge Computing , etc. amalgamated with the smart human innovations, can assist the industries in matching demand and supplies by faster delivering the personalized and customized products enabling the supply chain management to integrate mass customizations, into their production systems

emphasizing the key concept in Industry 5.0. Finally, DT can create a digital replica of the SCM that consists of assets, warehouses, inventory positions, and logistics

Through the lens of the viable supply chain model, the reconfigurable supply chain, and human-centric ecosystems, Dmitry Ivanov (2023) has conceived model of Industry 5.0 uncovering the major dimensions that characterize Industry 5.0 as a technological-organizational framework primarily the major technological principles of Industry 5.0 such as collaboration, coordination, communication, automation, data analytics processing, and identification.

According to Supply Chain brain (2023) digitization and human collaboration are key to build resilience into supply chain. The hybrid human-machine model of Supply Chain 5.0 helps companies withstand disruption without compromising competitiveness or profitability practices.

Furthermore, in global context, Vincenzo Varriale et. al (2023) have shown that when considering the potential of digital technologies in SCM operations, digital transformation in SCM has mainly focused on the design of technology infrastructures and their integration according to Industry 4.0 principles paying lesser attention to sustainability aspects of SCM. Impact of disruptive technologies of Industry 5.0, in the supply chain management encourage the researchers in further conceptual and empirical works.

### **Industry 5.0 and the “Green Deal” fulfill human and planetary needs**

Sandrine Dixson-Declève et al. (2021) have shown that An EU-wide industrial strategy focused on the constituent elements of Industry 5.0, would unleash Europe’s industrial potential and reward resilient, sustainable, regenerative and circular economic business conduct fulfilling the human and planetary needs -Green Deal being the core of Industry 5.0 rather than just innovation for profit through short term overproduction and consumption models determined by the current growth paradigm

Amr Adel (2022) has stated that Industry 5.0 is changing the business paradigm since it will decrease emphasis on the technology and assume that the progress is based on collaboration among the humans and machines. In modern business with the paid technological developments, industry 5.0 is required for gaining competitive advantages as well as economic growth for the factory.

## **Cobots -Collaborative Robots A companion for the human to share the brain in Industry**

### **5.0**

Furthermore, Praveen Kumar Reddy Maddikunta et. al. (2021) has stated that Cobots (Collaborative Robots) can collaboratively share human brain and play a critical role in SCM which are routine/dangerous such as packaging, routine quality checks, carrying of heavy goods, etc. streamlining routinized inventory management, that humans hesitate to do & reducing costs, whereas the expertise of the humans can be used in more complex jobs in the SCM life cycle.

When considering this transformation Güğərçin, S. & Güğərçin, U. (2021). Examining how Employees Survive In the era of Industry 5.0 by 2025, a new business with the hybridization of automation systems with humans, robots, and algorithms will emerge. Consequently, the skills required to work will change, which will result in skills gaps. In order to prevent the skills gaps to occur, the in-demand skills should be identified.

### **Supply Chain 4.0 is still in embryonic**

Despite the above technological advancements, Frederico, G.F et. al(2019) stated that Supply Chain 4.0 approach is still embryony ( Xue-Ming Yuan and Anrong Xue, 2023) in academia being more extensively explored. As Supply Chain 4.0 has the potential to disruptively transform traditional supply chains and how they are developed and managed, there are opportunities for significant academic research contributions (Doluweera L.K, 2022)

They further stated that the role of human in digitalized SCM applications and practices rest on on humancentric problems, especially in the exploration of the level of transformation of power and the decision rights of SCM to machine learning and AI (prescriptive vs predictive) and the excessive trust on big data and machine learning insights that could suffocate innovation and collaboration efforts in the supply chains.

Moreover, Frederico, G.F (2021) in assessing the transformation from supply chain 4.0 to supply chain 5.0 has stated that, even though industry 4.0 in production planning and control, strategic management, organizational structure, sustainability and lean manufacturing, in supply chain context, have been investigated, there is a dearth of research to investigate the impact of Industry 4.0 and its disruptive technologies on the supply chains.

Finally, Frederico, G.F (2021) have shown that industry5.0 related literature is scarce and discoveries are being emerged since Industry 5.0 is still in an embryonic and ideal stage.



**Sri Lanka has only embarked in to industry 4.0 necessitating for simultaneous integration of economical, ecological, and social measures of operations for a sustainable supply chain.**

Lakmali G.D.E. et. al. (2020) has stated that examining the applications of industry 4.0 in apparel industry and analysis of existing Industry 4.0 readiness assessment models Industry 4.0 enhances process functions by providing real-time visibility for smooth production flow. Before aligning with Industry 4.0, there is an urgent need for assisting companies to improve their capabilities

When implementing Industry 4.0 in real-world enterprise environments, the problems such as lack of strategic guidance, perception about highly complex Industry 4.0 concepts, uncertainty about outcomes of Industry 4.0 applications in the matter of benefits and costs, failure to assess Industry 4.0 capability and readiness of the company are major issues.

Lakmali G.D.E. et. al. (2020) further stated that in formulating Industry 4.0 readiness assessment model can help organizations to determine their state of readiness in the adoption of Industry 4.0 technologies, identify the gaps and opportunities for productivity improvement and development of feasible strategies such as readiness and maturity assessment models-IMPULS—Industrie 4.0 Readiness (2015) (Lichtblau et al., 2015), Industry 4.0/Digital Operations Self-Assessment (2016) (PricewaterhouseCoopers, 2016), The Connected Enterprise Maturity Model (2014) (Rockwell Automation, 2014). However, the properties of each model are different and also there is no standard and well-accepted Industry 4.0 readiness assessment model (Akdil et al., 2018, Gokalp et al., 2017, Schumacher et al., 2016).

Jayatilake, H.S.B. Withanaarachchi, A.(2016) stated that some companies have a positive attitude towards industry 4.0 because of the workshops conducted for their employees found that the highly skilled and the knowledgeable workforce in the IT sector would be a key opportunity to adopt the concepts like Industry 4.0 in Sri Lanka as they take up any challenge to develop innovative solutions to the apparel industry.

Malsinghe M.T.D. et al (2022) have investigated on operational excellence (OpX) models of sustainable supply chains (SSCs) in Sri Lankan manufacturing organizations have shown that the simultaneous integration of economical, ecological, and social measures of operations in a supply chain as the basic concept in a sustainable supply chain (SSC) of organizations By amalgamating the TBL concept that aims on sustainable consumption, effective management

of natural resources optimization, organizations strive to straightly integrate the sustainability paradigm in order to design their supply chains.

Even though, in the midst of the positive developments in supply chains through industry 4.0 and industry 5.0 technologies, and Industry 5.0, unleashes Europe's industrial potential through resilient, sustainable, regenerative and circular economic business conduct fulfilling the human and planetary needs –“Green Deal” being the core of Industry 5.0 rather than just innovation for profit through short term (Sandrine Dixson-Declève et al., 2021), industry 5.0 embedded supply chain 5.0 is still a visionary concept and embedding industry 5.0 in supply chains is being experimented (Guilherme F. Frederico 2021) and even Supply Chain 4.0 is still in embryony( Xue-Ming Yuan and Anrong Xue, 2023)

Moreover, there is a paucity of theoretical and empirical studies identifying the broad capabilities that affect the supply chain management firm's ability to simultaneously pursue economic, environmental and social success and worldwide research in this direction are sporadic.

## **PROBLEM STATEMENT**

By considering above information the present researcher justified that researches related to embedding state of art technologies of Industry 5.0 to generate human centric reliant sustainable supply chains satisfying Global Environmental Concerns and the challenges faced by the Sri Lankan Companies in implementing human centric sustainable supply chains are in lacuna.

### **Research Questions.**

*RQ1—What are the constructs which form the concept of Industry 5.0? RQ2—How can Industry 5.0 s constructs be aligned with the supply chain context? RQ3-To what extent Industry 5.0 technology-centric advancements are of human-centric and resulting sustainability and resilience in supply chains? RQ4-What are the barriers existing on the way to implement supply chain 5.0 in Sri Lankan companies?*

## **LITERATURE REVIEW**

In a 2021 policy brief, the European Commission describes Industry 5.0 as “more futureproof, resilient, sustainable, and people-centric” phenomenon. According, to EU AI regulations, and crises such as disrupted supply chains, climate change and shortage of skilled workers, broaden

the focus and question the effects and opportunities of digitalization with a view to the next evolutionary step in the development of Industry 4.0, namely Industry 5.0

*RQ1-What are the constructs which form the concept of Industry 5.0? and RQ3-To what extent Industry 5.0 technology-centric advancements are of human-centric and resulting sustainability and resilience in supply chains?*

### **Criticality of emerging Industry 5.0 for social environmental and economic sustainability**

Regina Lenart-Gansiniec (2019), stated that companies in the midst of strong competitive pressure and challenge of struggle to improve efficiency struggle to meet the constantly growing market demand for personalized and innovative products. Therefore, the organization should advance the level of integration, communication, and cooperation between business processes, which is, associated with the adoption of incremental and radical innovations and implementation of cutting-edge business models which requires new key professional skills competencies from the workforce for an effective digital transformation by the present and future (Borowski, P.F,2021).

In examining the State-of-the-Art technologies, in Industry 5.0 and Triple Bottom Line Approach in Supply Chain Management: Vincenzo Varriale et. al (2023) stated that the concept of Industry 5.0 has been theorized by advancing the existing Industry 4.0 approach by embedding the Immersive environments, classification of digital transition towards a sustainable, human-centric and resilient approach through the recognition of the state of art technologies such as Geospatial technology, 3D printing and blockchain which are more promising for environmental sustainability, while blockchain, geospatial technologies and the IoT which assures the social sustainability and gaining economic sustainability.

The goals of United Nations 2030 Agenda have emphasized that sustainable development is no longer a choice, but rather obligatory for the existence of firms, societies and communities through digital transformation to improve the sustainable development strategies since, sustainability has become a fundamental necessity in business strategy, products and processes. All organizations adopt digital technologies to strengthen their sustainability performance on operations. Sustainability issues associated with Industry 4.0 have encouraged SCM scholars to develop a more sustainable theorization and approach to operations management bearing supply chain 5.0.

### **Industry 4.0 lacks sustainability measures and human centricity**

According to the European Commission since Industry 4.0 lacks specific characteristics such as promoting social welfare, improving the circular economy and preventing environmental disasters, the Industry 4.0 paradigm cannot be practical solutions for a sustainable industrial transformation and to address the current social, economic and environmental issues.

Therefore, this new perspective created the industry 5.0 agenda that integrates the technological rewards of Industry 4.0 with the objectives of environmental protection, social welfare and economic growth.

Vincenzo Varriale (2023) has stated that researchers have investigated how the industry 4.0 paradigm is mainly driven by the rapid technological advancement and productivity improvement have theorized to make production systems hyper-connected by sharing devices and machines resulting automate production processes.

Industry 4.0 has adopted various technologies in manufacturing systems and SCM such as AI, cloud computing, robotics, big data, blockchain, virtual reality, 3D printing, blockchain and RFID to focus on the theme of Smart Manufacturing enabling the minimization of logistics and production costs and improved quality management leading to increased efficiency and productivity.

Although Industry 4.0 experts can support sustainable development at the micro-organization level through optimal energy utilization, transportation and consumed resources, they have disregarded many sustainability issues such as the digital gap, autonomy in the workplace and overconsumption of resources creating the necessity of a human centric sustainable resilient industry 5.0 phenomenon.

In respect to the construct Innovation and Technologies, according to Guilherme F. Frederico (2021) IoT, big data analytics, 3D printing, cloud computing, robotics, blockchain, augmented reality, and artificial intelligence are the dominant technologies existing in industry 4.0. These Industry 4.0 technologies are the scaffolding for the implementation of Supply Chain 5.0 since industry 4.0 technologies persist in Supply Chain 5.0, and artificial intelligence is enhanced.

However, Surajit Bag et.al. (2018) stated that there have been limited research in the area of managing supply chain network sustainability through Industry 4.0 technologies. Industry 5.0 is a solution to the problems that have been caused by Industry 4.0. Difficulties associated with Industry 4.0, are effectively addressed by Industry 5.0. (Mona Mohamed et al.2023)

**Industry 5.0 technology has and interplay and coexistence with Industry 4.0**

As shown by Xun Xu et. al(2021), the introduction of Industry 5.0 is based on the observation or assumption that Industry 4.0 focuses less on the original principles of social fairness and sustainability. Instead it focuses more on digitalization and AI-driven technologies for increasing the efficiency and flexibility of production. On the contrary Industry 5.0 emphasizes, the criticality of research and innovation to support the industry to ensure humanity within planetary boundaries in its longevity.

However, Vincenzo Varriale et al (2023) have stated that Industry 4.0s technologies are the scaffolding for implementing the industry 5.0 approach remedying the sustainability issues of SCM, which defines the digital technologies that are more promising according to the 3BL index. Furthermore, blockchain, Internet of Things (IoT), additive manufacturing and artificial intelligence (AI), can radically change traditional manufacturing processes and SCM ensuring the accelerated digital transformation to improve the sustainability of companies which has become a fundamental prerogative business strategy.

Marina Crnjac Zizic et. al. (2022) stated that smart factory which governs the industry 4.0 are the key drivers of industry 5.0 such as IOT, Cloud computing, Artificial intelligence augmented reality and cyber physical Systems.

Cyber-physical system (CPS) is defined as a system that can interact with people through new modalities through an integrated computational and physical capabilities. Augmented reality (AR) is the real-time use of information in the virtual form of text, graphics, audio and other virtual enhancements amalgamated with real-world objects. AR is combined with human abilities to provide complementary tools efficiently to promote the manufacturing tasks. Abderahman Rejeb et.al (2021) have shown AR can add value in five main areas, namely warehousing, manufacturing, sales and outdoor logistics, planning and design and human resource management

Simulation- which is a powerful tool in the field of digitalization lead to more comprehensive, efficient, embedded, and cost-effective modeling of existing or proposed manufacturing systems, in order to identify potential problems or conflicts, and to identify opportunities and solve current problems, by providing a virtual sandbox environment that gives a deeper understanding of complex operations and relationships enabling risk-free exploration of ideas and alternatives for robust decision making.

## **Technologies in industry 5.0 for sustainable emerging practices in supply chain Management considering the triple bottom line (3BL) perspective by utilizing the 3BL index**

Vincenzo Varriale et al (2023) has shown that 3D printing, artificial intelligence, blockchain, computing, digital applications, geospatial technologies, Internet are the most prominently SCM oriented technologies that enables sustainable supply chain management

3D printing -Environmental benefits of 3D printing is Reducing carbon emissions, Reuse of waste material, Material savings & Reduction in energy consumption, Economic advantages are Reducing product and energy costs [Reducing product development time, while Improved product satisfaction is the social benefit.

Artificial intelligence – AI offers the data-driven predictive analytics to assist decision making in highly complex, nonlinear, and multistage production. the multitude data incoming from different sensors in a production system is filtered and analyzes them in order to support the cyber-physical system. (Marina Crnjac Zizic et. al. 2022)

Environmental -sustainability of AI -Optimizing resource consumption Reduction of environmental pollution through optimized routing Reducing waste of perishable products, Economic sustainability of AI- Improved collaboration with supply chain partners better planning and control of demand forecasting. Social sustainability- Better planning and increased safety for the worker

Blockchain -Due to its sophisticated security systems, blockchain technology, can ensure compliance with environmental standards and responsible sourcing by increasing traceability and transparency in supply chains by creating a collaborative peer-to-peer marketplace, while avoiding fraud or opportunistic behavior, in complex trading mechanisms enabling the selection of green suppliers. Furthermore, distributed ledger can be adopted in a perishable supply chain to match supply and demand, leading to less product loss assuring consumer trust and more sustainable higher quality products.

When considering the Sustainable aspects of implementing blockchain in SCM Environmental benefits are -Tracking resource consumption, minimizing perishable product waste Recycling programs. Economic -Improved collaboration with supply chain partners Automation of operations management Reducing time and costs for specific activities Social -benefits are Tracking fair workplace practices and Reducing fraud and opportunistic behavior.

Cloud computing - supports the Internet of Things, enabling the access to large datasets and its processing to generate new useful information through different types of reports. Even though the cybersecurity is critical issue, it consists of security mechanisms, policies guidelines, best practices, risk approaches, and crucial technologies to protect the cyber environment, organization, and user's assets. Marina Crnjac Zizic et. al. (2022). From an economic and social perspective, cloud technology creates sustainable emerging business models which use mobile applications based on cloud and edge computing technology ensuring enhanced supply chains connection efficiency among the multiple parties.

Sustainable aspects of implementing cloud computing in SCM-Environmental -Tracking the carbon footprint and Improved reuse and recycling programs Economic- Improved collaboration with SCM partners Production monitoring Inventory monitoring, Improved machine maintenance & performance and social benefits are Tracking product origins.

Digital applications-Variou emerging sustainable practices can be achieved through digital applications such as mobile and web applications and social media. The use of social media platforms can connect buyers and suppliers ensuring the social sustainability, since digital applications can easily detect information on safety risks and child labor in the SCM

Sustainable aspects of implementing digital applications in SCM- Environmental- Reducing food waste Energy reduction programs Economic- Improved efficiency in logistics management Faster new product development **Social** -Monitoring child labor and workplace risks Transparency and traceability of purchased products Improved customer satisfaction

### **Geospatial technologies**

Geospatial technologies-can be employed for several aspects of environmental, social and economic sustainability. For instance, satellite remote sensing mechanisms combined with georeferenced data can assist production systems to understand how soil quality and fertilizer affect productivity resulting effective agricultural policy.

Considering the social perspective, the deforestation risks can be traced by remote. For economic sustainability, GPS can track transport vehicles in transit through the entire supply chain for route optimization by determining the quickest routes for the deliveries to prevent perishability, reduce transport costs, minimizing the carbon footprint and fuel use, CO<sub>2</sub> emissions resulting the green supply chain models. GIS with spatial data shows the cartographic information of natural resources, logistical networks of industrial sites. When

Sustainable aspects of implementing geospatial technologies in SCM. Environmental benefits -improved soil protection and monitoring Reducing CO2 emissions, Economic- Optimization of routing for vehicles and fleet Optimal identification of production sites. Social benefits - Tracking and monitoring illegal activities.

Immersive Environments- is a spectrum of novel technologies used to create sustainable supply chains. For instance, not only the digital twins can simulate and anticipate the replacement of batteries in electric vehicles and analyze traffic congestion, carbon emission and logistics information but also it can be used to monitor the engines of a machines in order to control its performance and avoid higher fuel consumption, increase in greenhouse gas emissions.

For social sustainability, based on the response of the physical, biochemical and physiological states digital twins can forecast the expiries of perishable products. consumers' attention can be attracted to sustainable products by using Augmented Reality inside the shops. Sustainable aspects of implementing immersive environments in SCM. While the environmental concerns – are reducing CO2 emissions and consumption of polluting materials for production, and reducing energy consumption, Economic concerns are the production efficiency, Cost reduction and Product life cycle monitoring. Finally the Social benefits are the enhanced customer satisfaction and carrying out awareness of acquired products

### **Internet of Things (IOT)**

IOT, encompasses services and data that enable the communication between objects by embedding the intelligence into objects thereby, turning into smart objects that collect information from the environment enabling interaction or the control the physical world through interconnected networks to exchange data and information Marina Crnjac Zizic et. al. (2022)

Considering the SCM, sustainable aspects, IoT-based architecture, collects and processes mass data volumes to improve the working conditions, safety, health and welfare of people. Through IOT, supply chain actors and retailers, can excavate information about the sustainability of supply chains, such as acceptable working practices, occupational health, and circumvent the issues of machinery breakdowns and prevent using defective raw materials for logistics and manufacturing operations.

In Economic point of view, IOT sensory mechanisms can automate the replenishment of products. They can capture stocking units on the wholesalers' shelves and utilize automated



reordering to reduce delivery times. Complex sensory mechanisms can detect and monitor objects in real time- its location, departure, arrival time and adverse circumstances that harm the quality of the product. Ensuring product traceability, safety and transparency as well

Open and Crowd-Based Platforms -Recently, there are several applications based on open, collaborative and crowd-based platforms that promote sustainable practices in SCM. For example, open-source technologies enable specific solutions for agriculture to provide goods and services to small farms for free. Sustainable aspects of implementing open and crowd-based platform in SCM. Environmental-Reducing CO2 emissions Pollution monitoring  
Economic- Optimising resource consumption Social benefits are Increasing quality of life

**Proximity Technologies-** Extensive utilization of Proximity technologies embeds SCM with sustainable practices. In both economic and social perspectives, information and evidences about products features can be detected by RFID sensors. QR codes on the product label empowers consumers to see data on origin, manufacture and processes. RFID can effectively be used to resolve conflicts raised between suppliers and retailers, especially due to inaccurate inventory information. Pallets with RFID permit real-time information gathering to ensure product transparency traceability, and security ensuring the RFID enables the circular economy by reducing waste satisfying environmental concerns Optimising inventory management Tracking products conditions ensure the Economic concerns and finally generating the social benefits- of transparency on product origin.

Robotics-Robotics is increasingly being used in manufacturing processes to improve the efficiency of operations, but also to favor sustainable emerging practices -self-directed freight trucks can enhance delivery reliability, transparency in transportation resulting increased customer satisfaction. Robotic drones can be managed by a script that allows the user to monitor and plan the route guaranteeing last-mile delivery reducing labor costs. Additionally, they could refuel trucks along the optimal routes Considering the Economic concerns, improved delivery reliability, reducing labor costs improved delivery planning, reduced transport costs are the crucial advantages Sustainable delivery choices, increased customer satisfaction. Reducing CO2 emissions is one of the major Environmental concerns. Finally European Commission (2021) Industry 5.0: Towards more sustainable, resilient and human-centric industry emphasized that Digitalization provides industry unprecedented opportunities. Digital technologies such as artificial intelligence (AI) or robotics allow radical workplace

innovation, optimizing human-machine interactions will capitalize on the added value human workers bring to the factory floor.

***RQ2—How can Industry 5.0 s constructs be aligned with the supply chain context?***

Formulation of interrelated constructs for industry 5.0- when moving from supply chain 4.0 to supply chain 5.0 -criticality of Industry strategy, innovation and technology, society and sustainability and transition issues

Frederico, G.F. (2021) has proposed an alignment industry 5.0 with the supply chain context being the basis for the incipient Supply Chain 5.0 framework, even though Industry 5.0 is still in an embryonic and ideal stage and literature is scarce.

**Industry Strategy** - Industry 5.0 concept will redefine and reengineer the efficient utilization of skilled people in the manufacturing scenario. There is a relevant consensus that the era of robotics and automation in previous industrial revolutions brought about paradigm shifts in the manufacturing industry worldwide. According to futurists, Industry 5.0, amalgamate human touch or personalization through co-working between humans and robots.

**Innovation and technologies** - Industry 5.0 moving from technologies as the scaffolding for creating an Industry 5.0 environment, although they belong to the current age of Industry 4.0. New technology approaches integrated with those already applied in Industry 4.0 are required, since innovations human centrality of technologies and intelligent autonomous systems for brain -machine interface plays a crucial role in Industry 5.0.

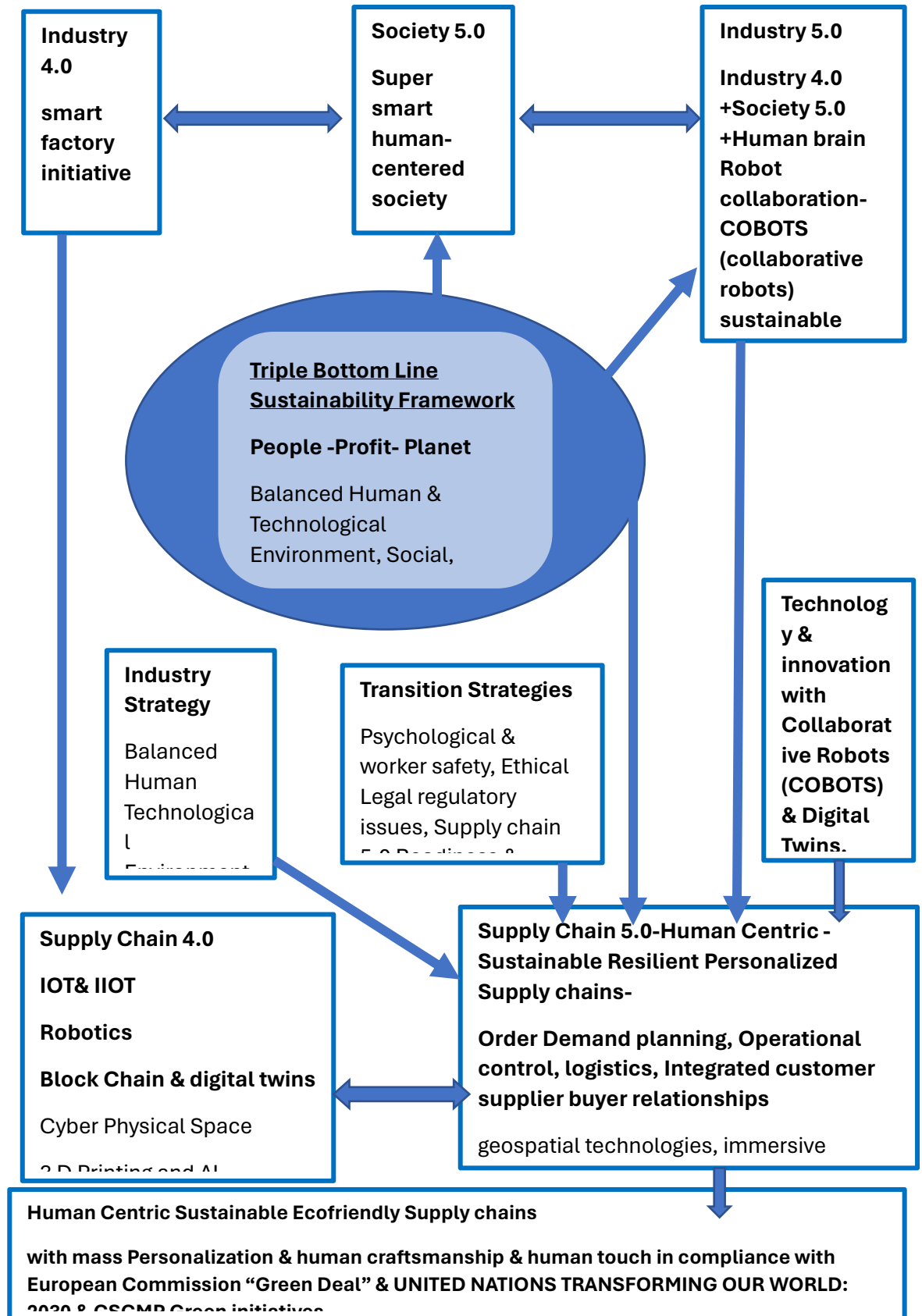
**Society and Sustainability**-Industry 5.0 includes two visions: one is the interaction between humans and robots and the other is approaching issues related to the bioeconomy, which is more related to the sustainability issue achieving the vision of society 5.0 transforming from digital manufacturing to digital society- Society 5.0. Industry 5.0, concentrates on more sustainable development.

**Transition Issues**-The transition from a fully technological to a balanced human-centric perspective is being considered as one of the main challenges and the industry 4.0 paradigm to be overcome. One prominent emerging issue is human–robot co-working (COBOTS) and its implications from the organizational and human relations side-psychological, social, ethical, learning, legal, and regulatory issues.

Moreover, Supply Chain 4.0 enables a mass customization advantage and also enable greater performance in supply chain's processes through enhanced transparency, responsiveness, flexibility, waste reductions, and efficiency. Considering industry strategy- Supply Chain 5.0 (Guilherme F. Frederico ,2020) while possessing these technological aspects for performance improvements, it successfully achieves the balanced human–technological environment, mainly allowed by Cobots (collaborative robots). In addition to innovation and technology in industry 4.0 technologies, in Supply Chain 5.0 new technological advancements have emerged, such as collaborative robots (cobots), multi-agent systems and technologies, digital ecosystems, complex adaptative systems, 4D printing, 5D printing, 3D scanning, holography, intelligent autonomous systems, energetics and particularly the Enhanced AI

**Finally, Regarding the society and sustainability** – “creating a super digital smart society” being the core of supply chain 5.0 The interaction between Supply Chain 5.0 s technologies and approach and smart society must be designed to create a most advanced sustainable environment in both organizations and societies. When considering the Transition issues in relation to Supply Chain 5.0- leadership support, digital infrastructure, strategic alignment, and people skills and training are ever essential. these issues become more complex and comprehensive in supply chain 5.0,by psychological issues, workers' safety, social, ethical, learning, and legal and regulatory issues. Lastly, the main challenge is the change from a fully technological to a balanced human-centric perspective.

**Conceptual framework for effective implementation of supply chain 5.0 based on literature review for designing the in-depth structured interviews**



## RESEARCH METHODOLOGY

The research methodology is based on qualitative theoretical deductive thematic top- down analysis of case studies of 12 giant companies with well-established supply Chain Management Practices registered in the National Chamber of Commerce (2019) which represent the spectrum of industry in Sri Lanka ensuring no greater bias toward verification of the researcher's preconceived notions than other methods of inquiry.

In-depth interviews were followed by a structured questionnaire-based survey developed for the CEOs and senior chief information technology officers the company directors of supply chain management and company executives who make strategic decisions. Rhetorical prevalence of quotes said by the prospects were annualized for the objective judgments of subjective quotes given in in-depth interviews minimizing interview biases.

Structured questionnaire focused on the company's readiness for embracing the industry 5.0 embedded supply chain 5.0. The ethical considerations was assured by confidentiality, anonymity of the prospects.

These prospects were provided with concise idea and definitions of key terms of industry 4.0, industry 5.0, supply chain 5.0 and Supply Chain sustainability and the dynamics of the Triple Bottom Line concept (3BL) in order to enable them to better comprehend the interview questions of Industry 5.0.

## FINDINGS AND THE DISCUSSION

The investigation of the CASE study with face-to-face in-depth interviews with company CEOs and executives followed by a structured questionnaire revealed many surprising findings

*RQ4-What are the barriers existing on the way to implement supply chain 5.0 in Sri Lankan companies?*

Thematic analysis revealed that all companies are reluctant to invest huge cost in attracting retaining and compensating ICT savvy talented professionals which is indispensable in adoption of Industry 5.0 embedded supply chains.

Among the -Industry strategy, innovation technologies, Society and sustainability and transition issues, the least concern has been given to the Society and sustainability by the companies except company A & G.

Even though they have a positive attitude about supply chain 5.0 neither they are well informed about industry 5.0 nor about supply chain 5.0 or super smart concept. Together with Transition issues and fear of technology issues especially the unforeseen security threats of data transmission encourage ½ the companies to maintain status quo. However, Company I, has advanced towards SCADA (SIEMENS SIMATIC *WinCC*, Automated system for Supervisory Control and Data Acquisition) together with SAP ERP solutions fulfil their manufacturing and distribution process

Moreover, many companies have their own philosophies of up to which degree they should embark in to industry 4.0 and industry 5.0 for sustainable resilient supply chains which has become a great hindrance to develop integrated supply chains.

Company H ERP solutions – Jinasena Infotech Locally designed and tailor made to them. Covers manufacturing order management and distribution and Dialog Vehicle Monitoring system - A Real-Time GPS driven Smart vehicle tracking system- monitoring Speed mobility Fuel efficiency and breakdown and unaware of industry 5.0 embedded supply chain management

Company J- Bulldozer Power generators exporters distributors and maintenance utilizes Computer governed AI embedded engine control systems for excavators and generators located in 5star hotels with engine control units for remote monitoring systems together with battery level observation sensors for monitoring customer machines.

Company best utilizes Internet of things, Cloud Computing applications Big Data technologies AI embedded supply chain management and Cyber Physical systems to detect battery levels of bulldozer machines and electrical generators located in 5star hotels. Virtual reality glasses are used for repairs- The VR glasses use a technology called head-tracking, which changes the field of vision as a person turns their head

Even the Most prominent companies with well-established supply chain management practices are in infancy in establishing human centric hyper customized supply chain 5.0. However Company A, Company C Company G Company and company I have only concentrated in embracing supply chain 4.0.

Company B has implemented IIOT & Cloud based Warehouse management systems –Energy Services -the Best Exporter – Marine and Offshore Engineering Services Sector

Company C successfully runs Major Digitalization -SAP solutions -Warehouse Management Systems -public Cloud based operation work load planning and forecasting and GPS sensing

systems and IOT applications Data warehousing data cleaning, data integration, and data consolidations Dashboard -SPU - Snippet Processing Unit (SPU) and Transportation Management Systems

### **Strategy to align Industry 5.0 s constructs with the supply chain context**

Supply Chain 4.0 has its own strategy, consisting of a vast spectrum of disruptive technologies embedded with AI, and essential competencies to face the challenges in implementing these disruptive technologies, and implications in terms of the performance of the supply chain processes. In contrast

On the contrary, Supply Chain 5.0 while possessing this technological aspect, it gives its prominence to produce a balanced human–technological environment, mainly through Cobots (collaborative robots). While Supply Chain 4.0 achieves a mass customization advantage through a greater supply chain performance initiatives in terms of transparency, responsiveness, flexibility, waste reductions, and efficiency in all processes, in addition to these performance improvements Supply Chain 5.0 add more value to supply chains by a mass personalization of products and services

In depth interviews with sample prospects revealed that companies have not thought adequately of amalgamation of industry 5.0 in their supply chains such as Drone deliveries for warehouse management which will minimize environmental pollution and fossil fuel consumption, digital twins and augmented realities in Manufacturing processes Cyber physical Space together with IIOT for machine to machine communication for monitoring production processes and they are in infancy

However, Only Company A has advanced towards the triple bottom line concept People profit and Planet.

Company G (Sri Lankan subsidiary of a global supply chain) has successfully implemented Net Zero Eco delivery & many supply chain 4.0 technologies and gradually migrating to supply Chain 5.0

At present it utilizes GT NEXUS - Unified global platform for supply chain management - Gain greater visibility, agility, and control of supply to meet today's dynamic demand. Assure supply, improve on-time delivery, and boost service levels, while simultaneously reducing lead times, costs, and inventory throughout the supply chain, block chain technologies for high securities and drone deliveries

Purchase Order visibility embedded with AI, RFID identification are the major areas of digitalization of supply chain

Company L -A company which has fully implemented Industry 3.0- a huge trend the era of robotics in which human tasks are highly performed by robotics but with the human touch

Big data, Microsoft Data Visualization and business intelligence for Trend analysis, IIOT is effectively utilized for dashboard concepts and strategic management and monitoring of global supply chains, RFID technology is not compatible with metallic spare parts storing inventorying spares since RFID magnetized fields react with the spares

Innovation of Connected Autonomous Shared Electric (CASE)- cars, made it a reality in company L has embarked ERP systems that provides tailor made solutions –(developed by IFS -Swedish) consists of server management ,distribution Human resource management finance Customer Relationship Management of single platform, Micro 365 -cloud-powered productivity platform for communication is implemented. Block chain has not been utilized since transactions are not complex

### **The degree of human centricity in Industry 5.0 technology-centric advancements resulting in sustainability and resilience in supply chains**

Company A with the greatest achievement of “Green certification for AI “ utilizes IOT and AI embedded (ORELGO) – vehicle selection -point of routes analysis consists of vehicle rating systems, ORELBUY Point of Sales digital valets for distributors, Manufacturing plants with Machine Learning Autonomous Automobiles, Default detection robots, Autonomous Mobile Robots and Optimization of business output through office automation. Success behind the company is shared vision higher employee contribution through employee upskilling and reskilling in AI machine learning and augmented reality and 3D printing

Company I, H and J have optimized its environmental pollution through the implementation of AI embedded systems for minimum vehicle emission of transportation

Company I -has successfully implemented SCADA– SIEMENS SIMATIC *WinCC*, Automated system for Supervisory Control and Data Acquisition for plan factory automation. SCADA is a computer-based system for gathering and analyzing real-time data to monitor and control equipment that deals with critical and time-sensitive materials or events together with ERP solutions company maintains the Status quo sans embarking in to new technologies since escalating profit gains through existing automation



### **The barriers existing on the way to implement supply chain 5.0 in Sri Lankan companies,**

The thematic analysis of the in-depth interviews revealed that unawareness about rewards of Industry 5.0 embedded supply chain is the greatest barrier to embrace industry 5.0 resulted in companies remain in status quo.

Company D & E is purely relying on ( Locally developed widely accepted by many logistics firms ) -Gensoft Software –Gensoft Logistics ERP is a comprehensive, Modular enterprise level application that combines all the operations and functions of Logistics service provider into integrated system- The software provides Freight Forwarding, Documentation, consolidation, Track and Trace container management NVOCC Shipping line and Feeder Vessel operations Customer Relationship Management Billing & finance accounts, customs clearing, Alerts & notifications and Tracking cargo via destination ports updates through GPS trackers for container tracking systems and are ever ready to maintain status quo without running the risk of innovating supply chain 5.0 with opaque returns on investment

Company F & K are giant well established manufacturing plants with a global supply chain has limited its attention to SAP ERP solutions and Tally ERP 9 software –more concentration in Cost efficiency and inventory optimization, IOT Business Model connecting the whole sellers and the Customer Relationship Management, Cloud computing, AI based applications in manufacturing process, Augmented Reality in design and optimization in manufacturing and the secret behind this limitation is the unaware of the benefits gained by the supply chain 5.0 for a sustainable resilient human centric supply chains

Even though the company has embarked into Lean inventorying Sri Lankan subsidiary has neither concentrated in industry 5.0 nor Supply chain 5.0 since they are amazingly unaware of such sophisticated state-of-the-art technologies. Maintaining status quo, opaque return on investment in Industry 5.0 leading to ICT Paradox, unawareness of the benefits of embracing Industry 5.0, huge investment in acquisition retention compensation and development of IT savvy talent pool are the major themes discovered through rhetorical prevalences in the thematic analysis.

### **CONCLUSION**

According to Maija Breque et. al.(2021) in Industry 5.0 Towards a sustainable, human-centric and resilient European Industry , Policy brief European one of the most crucial paradigmatic transitions characterizing Industry 5.0 is the shift of focus from technology-driven progress to

a thorough human-centric approach by going beyond for profit. This wider purpose constitutes three core elements: human-centricity, sustainability and resilience. In a globalized world, a narrow focus on profit fails to account for environmental and societal costs and benefits. For industry to become the provider of true prosperity, its true purpose must include social, environmental and societal considerations. This includes responsible innovation, not only aimed at increasing cost-efficiency and maximizing profit, but also increasing prosperity for all involved: investors, workers, consumers, society, and the environment.

*ICT paradox is the second most crucial barrier quoted by the company owners and CEOs for implementation of industry 5.0 embedded supply chains*

When considering the companies examined by the present Reacher, Fear of Quantum Leap needed, Low realization of long-term futuristic success and the misconception of Superiors of the organizations that Industry 5.0 embedded supply chains are not the best solution earned for massive dollar investment when compared with other investment decisions are in line with the IT Productivity Paradox "There is no relation between spending for computers, profits and productivity." Macdonald Stuart (2001)

Furthermore, business owners feel they should not even embrace Industry 4.0 since the awareness of benefits of such implementation is unclear to them, it is similar to findings of Rahamaddulla, S.R.B et. al. (2021) who stated that, some business owners are confused on the current trend of industrial digitalization, and are clueless on how to implement due to lack of tailored models that suit their companies. Since Supply chain 4.0 technologies are prominent in supply chain 5.0, researchers should firstly eliminate issues and challenges in supply chain 4.0.- 20 technical, sociocultural, technological and financial, environmental, and legal challenges that require further studies to eliminate them to achieve supply chain efficiency (Felipe de Campos Martins et. al., 2020).

*Supply chain 5.0 maturity models should be derived from Industry 5.0 Maturity models*

Supply chain 5.0 Readiness and Maturity Models are rare since Supply chain 5.0 and the standards is an evolutionary. Formulation and development in speculation, of industry 5.0 embedded Supply chain 5.0 maturity models by modifying a well-defined maturity model (Çınar, Z.M.; Zeeshan, Q.; Korhan, O.,2021) is a sine qua non.

As shown by Franziska Hein-Pensel et. al.(2023) maturity models (MMs) a valuable tool for shaping the strategically aligned digitalization transition of companies to see whether the

existing MMs for Industry 4.0 address the specific requirements of Industry 5.0. MMs sufficiently assesses the human-centered approach along with the assessment of readiness for disruptive technologies in SMEs. Hence industry 5.0 maturity models should be speculated in the near future. Studies show that a poor innovation culture, lack of financial and human resources and to drive the process of digital transformation., Employee's new skill acquisition is central to the overall transformation success of the companies.

Vipin Kumar Bagria (2022) stated that Readiness and implementation monitoring models of Industry 5.0 enable the quantification and qualification of its readiness level, based on variety of parameters. The ease and speed with which these emerging technologies can be used vary greatly. incorporating Industry 5.0 into the business models, is essential for accurate self-assessment of the level of preparedness. To accomplish this goal, companies should address the challenges of digital transformation, assess the enabling technologies for Industry 5.0, identify the barriers to adoption.

### **Talent Acquisition and development of professionals**

Therefore, state statutory body for ICT policy design - Sri Lanka Information Communication Technology Agency (ICTA) and other State Policy initiatives for implementation of the human centric resilient sustainable green friendly supply chain Management practices and a building shared vision through learning organization concept (Senge P.M 1990) and upskilling and reskilling professions to harness supply chain 5.0 are a sine qua non for achieving the triple bottom line in supply chains -people, planet and the profit

### **IMPLICATIONS**

Since Supply chain 5.0 -supply chain with a green friendly (European Commission Green Deal) in compliance with blazing Global environment concerns- climate changes, global warming risking biological support systems, societies and the planet (united nations transforming our world: the 2030 agenda) are embryony the companies visited by the present researcher and the in depth interview findings were inadequate for hypothesis development and a statistical analysis and limited the present researcher's investigation to a case study analysis.

### **FUTURE RESEARCH AVENUES**

New developments of research are crucial to a deeper understanding of the industry 5.0 phenomenon in supply chains.

As shown by Vincenzo Varriale et al. (2023), by utilizing 3PL index, proper Identification of Digital Technologies mostly contributed to sustainable practices in SCM, in their prominence such as Block Chain Geospatial, IOT, 3D printing, open crowded based platforms appropriate to Sri Lankan companies with supply chains is an unexperimented arena.

The techniques to make Industry 5.0 technologies interoperable across the supply chains, the means to Supply Chain 5.0 interplay with society, to a super-smart society. The new initiatives to develop innovation ecosystems that foster the amalgamation of Industry 5.0 programs in supply chains and, the innovative experiments in enhancing the achievement of climate goals through Supply Chain 5.0, resulting a more sustainable environment, are less well investigated arenas and further research is ever essential

Finally, redesigning the supply chain's members roles, proper skill development of professionals needed to make the Society 5.0 reality for supply chain sustainability create future research avenues which are indispensable to establish worldwide humancentric sustainable supply chains encouraging people-plant and then the profit

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