Digital Distilleries: Navigating Industry 4.0 Trends in Sri Lanka's Beverage Industry

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Abstract - *Industry 4.0 is a rapidly evolving paradigm allowing industries to explore digital transformation opportunities to provide services and products to both existing and new markets at competitive prices. Developed nations have largely capitalized on Industry 4.0, creating fresh market opportunities by embedding advanced technologies in industrial processes. This research assesses the readiness for implementing Industry 4.0 in Sri Lanka's beverage sector through primary data. Using focus group interviews with managerial-level employees in large-scale beverage firms, this study identifies technical, operational, and market/environmental factors as key influences in adopting Industry 4.0 in this sector. The findings contribute actionable insights into strategic pathways for digital transformation.*

Keywords: Beverage Industry, Digitization, Industry 4.0, Manufacturing Industry, Technology

I. INTRODUCTION

In early 2010, the Fourth Industrial Revolution, sometimes known as Industry 4.0, began. The term describes the current automation and data-sharing developments in industrial technology. Although the word "Industry 4.0" was coined by the German government's high-tech planning committee in 2011, the concept has been evolving for some years. Industry 4.0 is one of the sophisticated technologies employed by many industrialized countries throughout the world, and it is presently creating new market opportunities. Countries such as the United States, Germany, Canada, Japan, and China are already using industry 4.0 technology in the industrial sector (Yüksel, 2022). Modern technology has been implemented into manufacturing and other industrial operations as part of the 4th Industrial Revolution. The goal of Industry 4.0 is to create "smart factories" that are more productive, adaptive, and efficient. It digitizes whole supply chains and makes better supply and production decisions using real-time data. This notion can help businesses reduce waste, increase productivity, and enhance quality control (Veile et al., 2019).

Nowadays, manufacturing industries are highly intended to fulfill individualized consumer preferences, and they generate efforts to change market dynamics (Yin & Stecke, 2018). This has amplified the need for profitable mass customization and today the increasing demand and changing needs of both customers and suppliers have become a challenge to all manufacturing companies (Yin and Stecke, 2018). Therefore, various initiatives have been taken by manufacturing companies to improve collaboration, better analytics, productivity, machinery utilization, supply chain management and financial management of organizations to create a point of difference among competitors via numerous ways.

Generally, the food markets are financially pressured with very slim margins and require high vertical integration. Vertical integration focuses much value from the value chain, hence, it's a must for all food and beverage companies to be ready and compete in the marketing environment with the production along with required quality standards and legislation. Thereby, it's vital to perform research and development for all new products

and value addition of existing products in the food industry is essential as this all processes play an important role in determining the economy of the nation according to the 30% of the total global energy consumption was contributed by food production and supply chain (UN-Water, 2021). Also, the research studies highlight that, nearly 1.7mt of food waste arose in 2016 in the United Kingdom in the manufacturing phase; thus, estimated as a cost of £1.2 billion per annum (Jagtap & Rahimifard, 2019). Waste reduces the return of industries in investment. Hence, it's clear that a well- designed supply chain along with agility, adoption, and alignment of supply networks to overcome the challenges is a timely need of all food industries.

Transformation to I4.0 requires adequate strategies and organizational models that lead to radical changes in the organization in terms of physical infrastructure, manufacturing operations, technology, human resources, and process management, etc. The entire implementation process of the I4.0 model shows a radical digital transformation. The complete implementation process of I4.0 model signifies a radical digital transformation. For the largest firm's even, this transformation will be a significant challenge (Akyazi et al., 2020). To resolve this, the factors that influence the digital transformation need to be understood by the implementing bodies and it will be useful for them while implementing I4.0 within their organizations. There for proper smart industry readiness assessment should be required and it will provide a faster learning cycle and give an edge to Sri Lankan food and beverage companies that are competing with the export market. Developing the capabilities of I4.0 and implementing with fast-changing cross company processes in Sri Lankan food and beverage manufacturers are a great challenge. Nowadays, the role of I4 on behalf of business world is increasing drastically and therefore it should be effectively governed to positively impact both business and society (Sony, 2020). However, building them with innovation generates a good market demand and increases the economic status of the countries like Sri Lanka that consists of a huge number of food and beverage sectors.

Consumer tastes have shifted as technology has advanced, and they are no longer the same as in the past. As a result, the goal of this research is to learn how industry 4.0 operates in the beverage business. In this context, industry 4.0 refers to the fourth industrial revolution. This includes modern technologies such as AI, automation, the Internet of things, and data analysis. These technologies are altering how businesses function and engage with their employees, partners, suppliers, and consumers. Industry 4.0 implementation in the beverage industry can increase efficiency, reduce costs, improve product quality, and create sustainability, and by using new technologies such as automation, the accuracy and speed of bottling and packaging can be improved, and errors or contaminations can be reduced (Demir & Dincer, 2020). As a result, this study is critical for everyone who wants to effectively compete and discover answers to changing customer expectations by comprehending developments in the beverage business as well as the implementation of industry 4.0.

Despite the various benefits of industry 4.0 to the beverage industry, there is a lack of research to implement them and in Sri Lanka. But few researchers have conducted the use of such technologies in Sri Lanka, and researchers have conducted more extensive research on the readiness and barriers of adopting Industry 4.0 for the beverage industry. For that, this study mainly focusses on the large-scale beverage industry of Sri Lanka, which is one of the key exporters (Export Development Board, 2022). According to the Sri Lankan Export Development Board, this industry will earn 275.64 million US dollars in the year 2022 (Export Development Board, 2022). However, the EDB has clearly

explained that even in these large-scale industries there is a lack of technology transfer system which has become the major weakness of these industries. Research is motivated by the desire to get satisfaction through giving meaningful things to society while acquiring new knowledge.

Also, this study has many benefits for all the beverage industries as well as for the researchers studying this. Through this study, the impact of industry 4.0 is shown not only on the beverage industry but also on many industries that are ready to change with this new era. This shows us the improvement of the factors of an industry through the implementation of industry 4.0. The intention of this study is to aid the beverage industries to get involved in the digitalization process to improve all the production sectors while having a focus on design and manufacturing phases.

As a rapidly developing country, Sri Lanka's food and beverage sector contributes to the country's economic well-being. Since it has the potential to provide a slew of economic advantages, Sri Lanka should focus on competing with the global market by using cutting-edge technology. (Export Development Board, 2022). When considering the fulfillment of the emerging market requirement of the beverage sector, Fourth industrial revolution where the industry 4.0 (I4.0) revolution significantly effects on the food and beverage industry which can be considered as backbone of this and it is moving to a technological advancement process with smart factory concept (Demir & Dincer, 2020). Global food manufacturers direct their attention and resources towards I4.0 through rapid and constant changes (Akyazi et al., 2020). Industry 4.0 technologies are presented as an essential factor to reduce the obstacles faced by food and beverage manufacturers. Sri Lanka also should consider adopting this concept even though this concept has evolved from technologically advanced countries. Therefore, it is necessary to conduct research to identify these challenges and opportunities and propose strategies to implement them. There has been limited research on adopting sector 4.0 for the beverage sector in Sri Lanka, and there is little evaluated information on the use of I4.0 technologies in the country. As a result, the findings of this study will aid businesses, scientific communities, and governmental institutions in developing the appropriate strategies and policies to address such difficulties.

There is a lack of published literature on Industry 4.0 technology usage adaptation of beverage industry. Few studies conducted in Europe countries, USA, and Singapore regarding the beverage industry I4.0 however, there is no or less published similar data available in Sri Lankan context.

The primary goal of this research is to uncover the elements that influence the beverage industry's adoption of Industry 4.0 in Sri Lanka.

This research was carried out in selected leading large scale Sri Lankan beverage industries with the presence of significant relationships between company size and implementation of I4.0. Compared to medium and small-sized companies, large-sized companies have made significant progress in integrating their manufacturing plants with high-end IT systems (Schwab, 2016). The food and beverage industry importance are increasing day to day, but product life cycle of beverages is becoming shorter and shorter because of the human happiness and sensory experience is continuously changing with innovative, healthy, and standard. It will change industry to responding quickly to request but this bit risker than other sectors (Sima et al., 2020).

II. LITERATURE REVIEW

A. Overview of Industry 4.0.

New digital industrial technology, dubbed "I4.0," was first discussed at the 2011 Hannover trade fair in Germany. There has been a global race among developed nations to produce intelligently since that time. The United States, Germany, Japan, and China are currently in first through third places, respectively. The term "I4.0," which refers to technological advancements toward greater degrees of automation and data exchange, has been defined in several different ways (Hasnan & Yusoff, 2018). The United States calls it the "Industrial Internet," while the European Commission calls them "Factories of the Future" and the United Kingdom calls them the "Future of Manufacturing" (Büchi et al., 2020). I4.0, as defined by Köbnick et al. (2020), is all about capitalizing on the widespread interoperability of the supply chain from raw materials to finished products. Therefore, the objective is to convert digital data into measurable strategies for long-term success in the marketplace. Smart factories are made possible by I4.0, which bridges the gap between digital and physical manufacturing. So, more products tailored to individual consumers that offer real value should be prioritized (Schwab, 2016). The model, known as Industry 4.0 (I4.0), relies solely on AI and does away with any need for human intervention. Increasing output and enhancing product quality aids in satisfying consumer needs. The smart factory system makes it easy to collect, monitor, and analyze data thanks to modern automation systems, data exchanges, and manufacturing technologies. Thus, beyond the boundaries of a single company, the integration of sensors, production tools, and information technologies via industrial chains will improve business model efficiency (Köbnick et al., 2020).

Schwab (2016) argues that widespread adoption of mobile networks, intelligent machines, and new technologies are made possible by fully embracing digitalization in the production phase. Third industrial revolution has already increased computer usage and brought attention to technology (Büchi et al., 2020). With the help of ICT, the fourth industrial revolution is affecting all industries simultaneously (Schwab, 2016). Conversion, sensors, machines, work pieces, and IT systems can connect beyond a single business with the help of a common internet protocol (Pirola et al., 2019). Therefore, the I4.0 requires cutting-edge internet technologies that permit integrating smart products with digital and physical processes that are inextricably linked (Büchi et al., 2020). Manufacturing systems that are both highly flexible and adaptive are made possible by I4.0, which also facilitates the realization of the Internet of Things (Schwab, 2016).

While most people associate the term "Industry 4.0" with applications in manufacturing, some definitions broaden that to include other economic sectors because many of these tools also have applications in the "services domain" (Castelo-Branco et al., 2022).

B. Factors in Adopting Industry 4.0 Technologies

Here, the factors shown in chapter 2 are extracts from the studies done by the authors through various research, and the correct data and analysis that affect the implementation of industry 4.0 in Sri Lanka's beverage industry are shown in chapter 4, i.e., in the result and discussion. Some of the factors that have been shown in this section have changed in that section and detailed data based on the information taken from the latest research in Sri Lanka has been shown in that section.

The emphasis of I4.0 is on technical products such as collaborative robots, while additive products are considered more agile procedures and processes that operate in complex environments and are subject to interruptions and deviations (Wang et al., 2017). Agility and adoptability of smart machines with vertical integration will result in reduction in resource wastage thereby supporting to improve organizational efficiency (Sony & Naik, 2020). Organizational horizontal integration and end-to-end integration result organization for better using supply chain leads to improve output and realize the organizational goal (Sony, 2020). It interconnects humans with machines and equipment in a wide communication network, aiming for mobility, flexibility, and the construction of intelligent networks that improve vertical and horizontal integration (Belinski et al., 2020). I4.0 technologies aid the manufacturers to increase their proficiency while causing a reduction in downtime and costs and distinguish themselves in the market and improve their services, deliveries, and quality (Narula et al., 2020; Veile et al., 2019). These technologies speed up the taking of decisions based on real-time data, increased transparency, and reduced complexity costs (Müller & Däschle, 2018).

The Internet of Things (IoT), artificial intelligence (AI), robotics, and big data analytics are among the industry 4.0 technologies that are rapidly revolutionizing the industry. Companies are progressively implementing these technologies to increase efficiency, reduce costs, and improve product quality. However, several commercial and environmental factors influence the adoption of Industry 4.0 technology. Industry 4.0 facilitates an improvement in an organization by aiding the implementation of vertical integration, horizontal integration, and end-to-end integration; to produce a competitive advantage for the company with comparison to its competitors, as the high degree of automation for high quality, competitively priced and the high degree of customization (Sony, 2020). End-to-end data connection increases the possibility for interaction with the product beyond its point-of-sale and breaks high market entry barriers through digitalization and online sales (Yunus, 2020).

Industry 4.0 technologies affect the technology sector as well as human factors. In a study done by Gallo and Santolamazza (2021), it has been shown that it is very important to consider human factors when adopting new technologies. And he has shown that if this new technology is going to be implemented in an organization, there should be a change in the behaviour and culture of the employees. With the advent of these new technologies, it has been pointed out that the security of people's jobs and that they can engage in jobs in various sectors (Gallo & Santolamazza, 2021).

The implementation of industry 4.0 requires a lot of capital for base location, infrastructure development, software development and training, but the benefits after this implementation are huge. Once I4.0 group of technology has been adopting and built, cost of products and processes will be dropped because of less quality problem, low wastage and low manpower usage but cost of maintenance might increase (Sony, 2020). Accordingly, many researchers' options are to implement I4.0 to be profitable in the long run thereby organizations should convince the stakeholders regarding the validity of an investment data available in relation to the return of investment (ROI) of I4.0 implementation (Herceg et al., 2020). Long-term focus on investment returns is a key factor that helps organizations succeed (Habib & Chimsom, 2019).

C. Food and Beverage Industry

The beverage sector is wide and diverse, producing soft drinks, alcoholic beverages, coffee, tea, and bottled water, among other things. The market is quickly expanding

because of rising demand for healthy and functional beverages, rising disposable incomes, and shifting customer preferences (Haakon, 2020). Beverage is known to be a type of portable liquid drink which is consumed to fulfill the requirements of cravings, hydration and for the purpose of nourishment and refreshment. Furthermore, it acts as food supplements as well. The natural characteristics of beverages aid them to act as thirst quench, social drinks, and drinks with medicinal and nutritional properties. Beverage is generally separated into two categories such as alcoholic and non-alcoholic (Arora, 2020).

III. DATA AND METHODOLOGY

SLIIT Business School has accepted this study after reviewing it. The objective of this research is to "identify the driving forces behind Sri Lanka's beverage industry's adoption of industry 4.0." To achieve this goal, data was gathered using the qualitative technique via interviews from 16 managerial level employees in large scale beverage companies in Sri Lanka.

After the interviews were finished, the researcher initially translated and transcribed the interviews. Secondly, for the simplicity of data analysis, the researcher carefully translated and accurately transcribed the audio recording made during the interviews with the interviewer after listening to it numerous times. The researcher accurately translated every interview into English. The creation of all interview transcripts will be based on major topics. The MAXQDA software was used to code all the transcripts.

IV. DATA ANALYSIS AND DISCUSSION

According to the results of the data taken from interviews, the factors affecting the implementation of Industry 4.0 in beverage industry can be pointed out as technology factors, operational factors, and market and environmental factors.

A. *Technology Factors*

For this study, technology factors were identified as a new influencing factor when implementing industry 4.0 in the beverage industry after data collection and data analysis. The technology factor can be pointed out as one of the factors affecting the implementation of industry 4.0 in an organization. The idea is to produce high-quality products more efficiently and to respond quickly to customer changes. Some of the technological factors that can be pointed out as IoT, AI, Cloud Computing, and Additive Manufacturing.

The industrial revolution was the supply chain that connects systems through digitization based on data exchange (Obermayer et al., 2022). As a result, AI, robotics, and machines can be seen. The industrial revolution had three main effects on the business world as digitization, integration and vertical and horizontal value chains. These techniques have also been used in industry 4.0. Cloud computing, IoT, big data analysis, smart sensors, 3D printing, fraud detection, enhanced human machine interfaces and location detection technologies were already used in European countries (Obermayer et al., 2022). Industry 4.0 technologies have already been applied in some countries, automotive and electronics companies in Hungary are already using smart technologies to expand their products. It is important to create these technologies based on IT development and also it is possible to use those technologies in the country and know the future benefits of using those technologies (Obermayer et al., 2022).

"Sometimes they are going to be digitized, sometimes there is a plan. If we take HR, we can use artificial intelligence to recruit people in HR. After telling what qualifications are required before taking it, the experience is also added to it and it's over. After advertising it, we can select the things that come up if we want. We can use AI for such things. Then if we go to the production now, the work done by 10 to 12 people in the layout of the production can be done by using a single machine. But if we take such testing methods, people are doing some testing methods. Now they are doing online monitoring, there is space problem when storing in water systems and other raking system warehouses. We have a trade sale tracking system, which means everything is called power BI. Then another thing is security, there are some places where you must put fingerprints on them to get access control areas, and then you can go in and all those areas are recorded. Then we can get records from CCTV cameras, we can see who had access to it, who went, who went and what was stolen, then another order tracking system, whether delivery is delayed, where the goods are now, monitor the sales of the day". (IDI 1)

"We are using IOT and cloud computing. To some extent, cloud computing is used for sales. From the company's point of view, industry 4.0 has things like robotics and machines. That is, from the place where bottles are made to the place where soft drinks are filled with labels, there is a lot of automation. That means, after we feed the materials, the robot machinery auto identifies them, wash the bottles, heat them to the relevant temperature, fill the soft drinks, hit the labs, and all come back together. Automation is currently only used for that side. But if we can use things like automation and robotics machines, we can reduce errors from employees. If we can use this like industry 4.0, we can go to a higher production from our production side". (IDI 2)

"Artificial intelligence and robotics are used a little. Cyber physical systems can do many things. We have not yet gone to robotics. Robotics side is very less. There is a bit of big data and cloud computing". (IDI 3)

"Robotics automation systems we use automated systems for various manufacturing processes such as filling, packaging, and labelling. We hope to increase the number of products produced per day. Mainly, we are looking to see if our employees can work with new technologies. Also, we have already trained a small group of employees to use and maintain the machines with the technology we want to use. Also, we have already implemented a smart manufacturing platform that uses data analytics and machine learning to keep our manufacturing process optimized". (IDI 4)

B. *Operational Factors*

This I4.0 provides operational advantages that will improve organizational efficiency, and effectiveness leads to overall success and maintain their point of difference. Some of the factors included in operational factors are: I4.0 technologies aid the manufacturers to increase their proficiency while causing a reduction in downtime and costs and distinguish themselves in the market and improve their services, deliveries, and quality. Also, these technologies operational process speed up the making of decisions based on real-time data, increased transparency, and reduced complexity costs, the adopting of Industry 4.0 can facilitate and enable product innovation to be more easily achieved within the organization.

"Then if we go to the production now, the work done by 10 to 12 people in the layout of the production can be done by using a single machine. Unloading loading polarize, depolarizer. One person works for both. We can use technologies like that. There are chlorine dosing pumps in water purification, they are monitored online, if it is low, they are used to maintain the same condition, then when maintaining the gas level in drinks, you can monitor online how the sugar percentage is going. There are all such things in this computer. There is another machine that scans bottles, it is sixteen angles, to see if there is any waste in the bottles, they are looked at from every angle, before people looked with their eyes, now people have been replaced by machines. Everything in Sri Lanka we can monitor the sales, monitor the order, machines have been installed". (IDI 1)

"We are using IOT and cloud computing. To some extent, cloud computing is used for sales. From the company's point of view, industry 4.0 has things like robotics and machines. But if we can use things like automation and robotics machines, we can reduce errors from employees. If we can use this like industry 4.0, we can go to a higher production from our production side". (IDI 2)

"We are focusing on increasing the efficiency of our production operation with Industry 4.0. Industry 4.0 helps reduce environmental issues and the impact of our organization's production processes. Industry 4.0 technology can also improve the quality of our company's products or services, the implementation of Industry 4.0 can lead to a higher level of safety in our organization's operational processes". (IDI 3)

"We hope to increase the number of products produced per day. Mainly, we are looking to see if our employees can work with new technologies. Also, we have already trained a small group of employees to use and maintain the machines with the technology we want to use. Also, we have already implemented a smart manufacturing platform that uses data analytics and machine learning to keep our manufacturing process optimized". (IDI 4)

The majority of firms are utilizing technical implementations like IoT and cloud computing, as shown by the codes produced by MAXQDA. Organizations in Sri Lanka use technology like robots and machine learning aside from these. According to the comments, employing these I4.0 technologies has helped firms boost productivity and efficiency.

C. Market and Environmental Factors
The market and environmental factors are the third factor, and by using industry 4.0 technologies, researchers discuss the price of products, what are the demands of customers in the market, and how to monitor sales.

"We have a trade sale tracking system, which means everything is called power BI and it is software like Excel. What are the new types of drinks among the customers, and what are the favourite types of drinks among the available drinks? We also have an annual growth of about 10%. The annual sales here are around 2.1 million. Digitization also affects the scale of the business". (IDI 1)

"To some extent, cloud computing is used for sales". (IDI 2)

"Industry 4.0 helps our organization expand its market size and better navigate market volatility, uncertainty and complexity in the market and environment. Industry 4.0 technology can also improve the quality of our company's products or services, the implementation of Industry 4.0 can lead to a higher level of safety in our organization's operational processes". (IDI 3)

"We are currently looking into the benefits that our organization can get from industry 4.0 in relation to our needs. If they are in our organization, we can increase efficiency. Then we can provide our products to our customers according to their needs. Through these, we will be able to compete well with our competitors. Give it a go. We look forward to working closely with this technology. We are always looking at where we are competitive and how we can improve our operations". (IDI 4)

According to the responses, it can be seen that businesses are now investigating the advantages of Industry 4.0 for businesses in connection with their requirements. Organizations are thinking of methods to boost productivity. Then, they want to provide clients with items based on their demands. They will be able to effectively compete with the rivals due to these. Additionally, most businesses are eager to collaborate closely with this technology.

To determine the elements that will influence Sri Lanka's beverage industry's adoption of Industry 4.0 based on the results received. After the data from the in-depth interview with the beverage firm was collected, the researchers were able to pinpoint the instances in which the terms "technology," "operations," "market," and "environment" are employed as research factors. The MAXQDA detected this. As a result, the authors discovered the influencing elements that were applied to the beverage firm in Sri Lanka, which are shown in a word cloud in Figure 1.

**Figure 1. Word Cloud Output generated through MAXQDA**

Source: Authors' compilation.

The word cloud output obtained from the interview transcripts shows that operational, environmental, and technological elements have been identified as having a higher status in the debate they generated.

Based on the analysis conducted, the researchers have built the conceptual framework as shown in Figure 2. The conceptual framework consists of three independent variables such as technological factors, operational factors and market and environmental factors.

Figure 2. Conceptual Framework
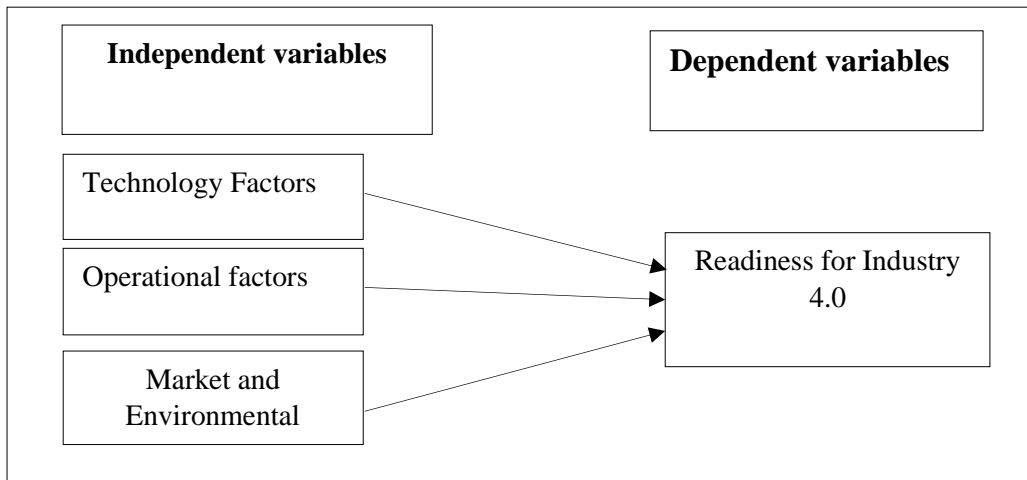
Source: Authors compilation.

V. CONCLUSION AND RECOMMENDATIONS

The present consumers have changed their preferences along with the trends and it is fully different from the past. They are looking forward to a wide variety of stuff with superior quality within a short period of time. This is true in case of beverages. Hence, it is a need for the food and beverage companies to be ready and competitive in the marketing environment with quality products. This automatically generates the position in a market while others will leave from the competitive environment (Demir & Dincer, 2020). This study mainly focuses on Sri Lankan large-scale beverage industries which are one of the key exporters. According to the Export Development Board of Sri Lanka, these industries generate high revenue to the country (more than $ 300 million annually) thus they are the key players in the marketing environment. However, the Export Development Board (EDB) (2022) clearly elaborated that these particular industries have a lack of technology transfer programmers which becomes the major weakness of these industries. Therefore, adopting these industries with technological innovation paves way to generate superior quality along with good market value. This study is focused significant impact on human capital factor, economic factor, operational factor, organizational factor, and market and environment factor on the large-scale beverage industry of Sri Lanka with the readiness of Industry 4.0. Research is motivated by the desire to get satisfaction through giving meaningful things to the society while acquiring new knowledge. The intention of this study is to aid the beverage industries to get involved in the digitization process to improve all the production sectors while having a focus on design and manufacturing phases.

The qualitative technique is the primary emphasis of this investigation. Future researchers can carry out the same investigation to evaluate the model outlined in the report. This report focused on the beverage business in Sri Lanka. Researchers can investigate the same hypothetical model developed by researchers examining a distinct industry in the same aspect.

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