A Study of the Implications of Logistics 4.0 in Future Warehousing: A Sri Lankan Perspective

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Abstract

An effective combination of highly innovative logistics infrastructure plays a vital role in every business activity as a strategy of achieving competitive advantage. Currently, warehousing has been identified as one of the foremost value adding activities in supply chains. In the warehousing industry, automated intralogistics systems would be an ideal solution to eliminate the inefficiencies in conventional practices as well as to overcome the labour shortage issue. With the emergent trend of technology adaptation in industries, it is evident that Sri Lanka has the capability to apply these technologies up to a certain extent. Therefore, discovering the opportunities of logistics 4.0 implementation in Sri Lankan warehousing industry is highly demanding. This scrutiny has been conducted using a comprehensive and systematic review of literature published in relation to the areas of smart warehousing, smart logistics, intralogistics and Sri Lankan Third Party Logistics (3PL) industry. Through the effective categorization and integrative analysis, this paper intends to identify the ways of warehousing process improvements using the logistics 4.0 technologies while achieving the operational excellence. Further, it is expected to suggest the critical success factors affecting the logistics 4.0 implementation from the perspective of Sri Lankan 3PL warehousing Industry.

Keywords: Logistics 4.0, Smart Logistics, Smart Warehouse, Intralogistics, Third Party Logistics (3PL)

1. Introduction

Warehousing has been a foremost element of modern supply chains as a competitive strategy to improve organizational performance. The role of warehouse has been changing over recent years since the prominence has been placed on customer satisfaction and visibility of the supply chain. With the competitive market conditions and the dynamic customer demands, it has been difficult to meet the requirements with the traditional warehouse management approaches, due to their complexity and low efficiency. As a result of the fourth industrial revolution in the context of warehousing, Smart logistics and Smart warehouse concepts have been evolving all over the world in order to eliminate the drawbacks of the conventional warehouse systems. Although these concepts have been widely spread around the world; in the Sri Lankan business context it is still in its infancy. In Sri Lanka, most of the warehousing operations are more labor-intensive, however the labour shortage issue would be a potential challenge in the near future. Therefore, the digitization would be an effective strategy to minimize human intervention in warehousing operations and to enhance the productivity of the available labour force. Hence, exploring the opportunities of logistics 4.0 implementation in Sri Lankan warehousing industry is highly demanding.

With the emerging trend of outsourcing logistics functions, third-party logistics providers play a vital role in the warehousing industry. Most of the Sri Lankan companies also tend to outsource their warehousing functions to third-party logistics providers with the purpose of enhancing their supply chain performance. According to a survey conducted by Hettiarachchi & Ranwala (2015), it has been proved that the warehousing is the most commonly outsourced logistics function in Sri Lanka. Therefore, identifying the role of logistics 4.0 applications in improving warehouse performance and identifying the critical factors affecting the logistics 4.0 implementation are important in the 3PL warehousing industry.

2. Methodology

This systematic review of literature is based on the content analysis as the approach to gather the state of knowledge in the selected areas of Smart Logistics, Logistics 4.0, Smart Warehousing and Sri Lankan Third Party Logistics industry. The initial step of this analysis was to search the articles relevant to the study. Web search allowed accessing many research articles in the said study area from different academic databases, such as IEEE Xplore, Science Direct, and Research Gate etc. At first, fifty articles were retrieved based on their title, abstract and keywords. Each paper was scrutinized in deep to eliminate the duplicate and irrelevant articles to the study, resulting forty-two articles for further screening. The disparities caused in comparing the articles were discussed by the researchers considering appropriateness to the Sri Lankan 3PL Industry. Finally, thirty-five articles were considered for the analysis. Figure 1 shows the selection procedure of the articles based on relevancy. The references section of this paper clearly states the articles reviewed in this analysis. Even though each article was scrutinized in deep, the researchers believed that this analysis would deliver the actual gap of the knowledge areas uncovered by the previous researches related to this study without exhaustion. A comprehensive literature review was conducted related to the study area with the aim of emphasizing the gap of knowledge uncovered. The selected articles of this analysis, belong to the period from 2000 to 2018 considering the knowledge updates and relevancy. The papers cited were retrieved from publications related to Logistics 4.0, Smart Warehouse and Sri Lanka's Third Part Logistics industry.

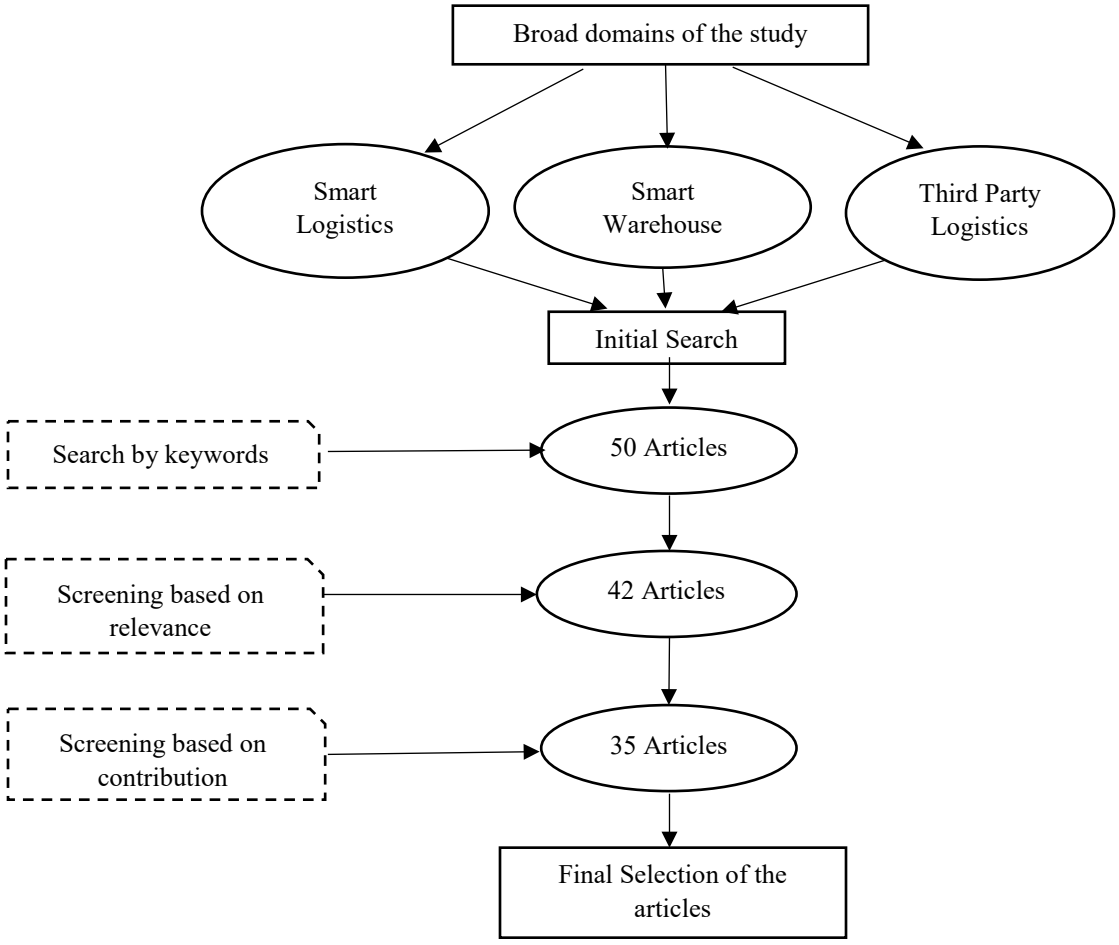

Figure 1: Screening process of systematic review of literature

3. Main Results of the Reviewed Studies

All the articles taken into consideration in the analysis are briefly discussed under the following sections.

3.1 Smart Logistics / Logistics 4.0 Definitions

The definition for the 4th industrial revolution of logistics which is known as logistics 4.0 is also still being evolved. There are diverse definitions available in different literature for the logistics 4.0 or the synonym called as smart logistics. (As cited by Galindo (2016, p.21) in his literature review) "It is needed a more accurate definition than just "Smart Logistics" of what Logistics 4.0 is, since the "Smart Logistics" will change depending on the actual technology driven, so it has a time dependency and it is essential to define the state of the art of the technology in order to know what Logistics 4.0 involves" (Uckelmann, 2008).

Horenberg (2017) highlights that all Industry 4.0 applications within the logistics industry, fall under the denominator Logistics 4.0. He further describes the process efficiency as an important indicator of logistics which can be obtained by realizing Industry 4.0 principles (interoperability, information transparency, technical assistance, and intelligence) on the key logistical services of Warehousing, Transportation, Packaging, Distribution, Loading/Unloading and Information Services. Similarly Maslaric et al. (2016) view logistics 4.0 as the Logistics Response to the Industry 4.0 and the Digitalization of logistics processes lead to "logistics transformation" or to creation of "smart logistics" solutions. Erik Hofmann and Marco Rusch (2017) also state that the logistics-oriented Industry 4.0 application or Industry 4.0 in the context of logistics management, as the logistics 4.0.

Olga Szymańska et al. (2017) indicate two aspects which are combined in the definition of Logistics as: **processual** (supply chain processes are a subject of the Logistics 4.0 actions) and **technical** (tools and technologies that support internal processes in the supply chains). This study further states that Logistics 4.0 is not a new paradigm in management science but a set of known solutions. (As cited by Galindo (2016, p.32) in his literature review) "The state of the art of Logistic 4.0 is the use of Cyber-Physical systems that monitor and control the physical processes, usually with feedback loops where physical processes affect computations and vice versa. This CPS use RFID technology in order to identify, sensing and locate the item, and send the data to a computer which can collect and analyze this relevant information. These systems are able to communicate with other systems or with humans using the internet as a mean of communication, so that it can be shared data in real time and processes can be coordinated" (Herman, Pentek, & Otto, 2015).

Galindo (2016) states that Logistics 4.0 is the progress of "labour saving and standardization by the evolution of IoT". He further describes that the technologies such as warehouse robots and automatic driving are trying to replace processes that do not require operation and determination by human labour with the aim of keeping perfect equilibrium between the automation and the mechanization." Similarly, Gunther Schuh1 et al. (2008) also state that the implementation of the 'Smart Logistics' components and software systems show the savings of individual

transportation tours and in the result savings of staff requirements. Schliemann (2016) also states that within machine-to-machine communication production and logistics could optimize autonomously and in a decentralized way without any human interaction. In 2016, a paper from AXIT GmBH Company defines the logistics 4.0 as a concept of hyper connected processes, data and systems of all the companies along the supply chain, from the manufacturer through 3PLs up to the end customers (Schiemann, 2016).

3.2 Logistics 4.0 Technologies & Applications

The studies done on the Logistics 4.0 applications within the industries are briefly discussed in this section.
Horenberg (2017) describes few logistics 4.0 applications such as Freight brokerage trends enabled by electronic marketplace platforms; Near shoring through 3D Printing applications; Transportation efficiencies due to truck platooning and drones; Warehousing and Distribution operations due to autonomous vehicles and robots; and lastly safe and trustful sharing of information throughout all processes due to Blockchain technology. Galindo (2016) has clealy discussed about the logistics 4.0 technologies such as RFID, RTLS, CPS, IoT, Big Data and Data Mining and IoS with the real world applications in the industries such as B&R companies, Toll Group, South-eastern Container and etc. Further he throughly describes the real implementation of a RFID system based on the case study in Knowledge Discovery Lab. Schuh et al. (2008) also present an application of RFID-supported Kanban boards for a dynamic tour planning of trolley trains for Inbound Logistics stating that "availability of detailed information of actual production status avoids empty runs of the logistic resources" .

Some studies have described the cloud technology applications in the logistics process. Arkadiusz Kawa (2012) proposes a Smart model using agent technology and cloud computing that will allow easier collection and flow of information as well as better and cheaper access to logistics management systems. Schiemann (2016) also highlights cloud platform as a necessary basis for network optimization in logistics. An expert paper of AXIT GmbH company discusses about AX4 cloud platform as a collaboration for quick and easy integration of all participants in supply chains. It also discusses about big data and data variety due to the industry 4.0. In 2015, a report by DHL and Cisco on Internet of Things in Logistics discusses about IoT best practices using real world examples such as Connected Production Floor (Continental Tire Plant), Equipment and Employee Monitoring (Union Pacific - largest railroad in the United States & Dundee Precious Metals (DPM) - Canadian mining company) and IoT-driven smart-inventory Management for damage detection, accurate inventory control, optimal asset utilization (James Macaulay, Lauren Buckalew, & Gina Chung, 2015).

Timm & Lorig (2015) introduce CPS as an integrating concept for improving the bidirectional information flow between execution and decision systems. This paper discusses two integrating approaches to simulate decision makers and logistic processes in the context of Logistics 4.0. Maslaric et al. (2016) also provide a balanced review of professional in the field of CPS to identify the biggest challenges (technological, societal, business paradigm) of proposed new logistics paradigm as a practical solution in supporting Industry 4.0. "Integration of CPS and IoT into

logistics promises to enable a real-time tracking of material flows, improved transport handling as well as an accurate risk management" (Hofmann & Rüsch, 2017, p.3).

Reviewed articles can be categorized according to the logistics 4.0 technologies as shown in Table 1.

Table 1. Literature Classification based on Logistics 4.0 Technologies

Reference	**RFID**	**CPS**	**IoT**	**Big Data**	**RTLS**	**IoS**	**Block chain**	**Cloud Technology**
(Horenberg, 2017)		*	*	*			*	
(Galindo, 2016)	*	*	*	*	*	*		
(Arkadiusz Kawa, 2012)								*
(Schuh et.al., 2008)	*							
(Schiemann, 2016)				*				*
(Maslaric et.al., 2016)		*						
(Macaulay et.al,2015)			*					
(Timm & Lorig, 2015)		*		*				
(Wu et.al 2016)			*	*				
(Hofmann & Rüsch, 2017)		*	*				*	
(Natalia Szozda, 2017)			*					*
(Bottani et.al., 2009)	*							
(Bernd Scholz-Reiter et al, 2010)	*							
(Liu, et al. 2018)	*	*			*			
(Lee, et al. 2011)	*							
(Juntao and Yinbo 2016)	*		*		*			
(Ding 2013)	*		*					
(Wang, McIntosh and Brain 2009)	*							

3.3 Smart Warehouse

"A smart warehouse is an automated, unmanned, and paperless warehouse when conducting the operations of pickup, delivery, and bookkeeping" (Liu et al., 2018,p.1). Liu et al. (2018) discuss how the state-of-the-art techniques in cyber-physical systems facilitate building smart warehouses to achieve the promising vision of industry 4.0. They focus on four significant issues when applying CPS techniques in smart warehouses such as efficient CPS data collection, accurate and robust localization, human activity recognition and multi-robot collaboration. That study further discusses some challenging issues in the future CPS-based smart warehouses. Lee, et al. (2011) suggest a smart storage system that passive tag recording methodology on sensor tags is used in. It desribes the application of RFID

and Sensor tags as a solution to store the senstive goods (Food Preservation) based on a case study conducted in a Agricultural Products Processing Center. That system has solved the problems of the RFID storage where the existing sensor node is used with sensor-sensitive products, i.e. real-time object information identification/verification, and the detailed sensor information obtaining problem in the storage sector. (Lee et al., 2011).

Juntao and Yinbo (2016) introduce the internet of things technology concrete applications in the warehouse operations such as RFID technology, management and control technology, sensor technology. Then, this study discusses about the internet of things technology development trend in warehouse operations under the themes such as "the application of RFID technology in warehousing will be rapid development", "the integrated application of sensing technology", " the AGV will be integrated into the warehouse the Internet of things", "the storage and the Internet of things will be the trend of the each other". Zhu, Qi and Huang (2016) aim at the practical problems of warehouse in an enterprise, constructing the intelligent storage system, through the use of RFID technology, sensor technology, ZigBee technology to improve information transmission efficiency of the system, shortening the system response time.

Wang, McIntosh and Brain (2009) presents a novel conceptual design for a modular automated warehouse system which is based on a series of simple modules with their inherent feature of scalability and reconfigurability. Throughout the simulation results, it demonstrates that this type of automated warehousing system can simultaneously deliver large numbers of items from storage modules to assigned collection locations with minimal delay. It suggests that performance of such system can be enhanced by deploying an integrated warehouse control and management mechanism using automatic identification, data capture techniques and wireless communication networks. This study proposes a framework on application of these emerging technologies in order to achieve the desired & coordinated functionality of automated warehouse operations. "The new design has shown advantages by being more compact, requiring greatly reduced numbers of staff and yet outperforming the design of the existing warehouse at the company."(Wang, McIntosh and Brain, 2009, p.13).

Ding (2013) presents a new type of intelligent warehouse management system based on the IOT, and explains the principles and structure of it. It represents the great advantages of this suggested system by comparing with the traditional mode. An article from the company of Basler Vision Technologies (2016) discusses about the Warehouse Logistics in the age of Industry 4.0 focusing on the smart vehicles in order to eliminate the inefficiencies of traditional forklifts and existing generation of driverless vehicles which are limited to following predefined routes and cannot react flexibly to change. This study introduces the new intelligent and drivless reach trucks that survey their own environment so as to orient themselves in unfamiliar warehouse and factory halls. "Humans can interact intuitively with the vehicles, and they are capable of understanding voice and gesture commands. Industry 4.0 promises new approaches for providing machines with the innate human ability to orient themselves without expensive aids"(Basler Vision Technologies, 2016).

Vijayaraman (2006) has done an empirical study of RFID implementation in the warehousing industry. A survey was sent to Warehousing Education and Research Council (WERC) members at manufacturing firms, third party warehousing/logistics providers, wholesaler/distributors, and retail firms to determine whether they are implementing RFID technology and what challenges they are facing. The result of this survey reveals that "a high percentage of respondents are not currently considering RFID technology. Companies implementing or considering RFID plan to invest a significant amount of money into this technology over the next three years. But a number of concerns still exist and skepticism remains about the potential for RFID to deliver cost savings or a positive ROI in the near future" (Vijayaraman 2006).

Barretoa et al. (2017) states that "the introduction of 'smart' management throughout the proper adoption and implementation of Warehouse Management Systems (WMS) which will transform the warehouse activities into the future requirements of the inbound logistics according to the Industry 4.0 paradigm". This article describes the new functionalities resulting from the RFID integrated intelligent WMS such as select and prepare docking slots, optimize just-in-time and just-in-sequence delivery, send the track-and-trace data to the entire supply chain, automatically attribute storage space according to the delivery specifics, request the appropriate equipment to move the goods to the right location autonomously, provide real-time visibility into inventory levels, prevent costly out-of-stock situations and enhance the management decision capabilities (Barretoa, Amarala, & Pereiraa, 2017).

In 2016, a report from ZebraTechnologies states that "the retail, wholesale, transportation and logistics sectors are transitioning to "best-of-breed" warehouse management systems that take automization to new heights — from equipping workers with mobile devices that increase the speed and accuracy of order picking to the roll out of radio frequency identification technology (RFID) for real-time inventory visibility.".This reports presents the survey details of the state of the warehousing marketplace as well as the future technology investments in the warehousing industry such as Equipping staff with technology, Barcode scanning, Tablet computers, Warehouse/truck loading automation, Internet of Things (IoT), Big data analytics, RFID and etc.This report further describes about the modern trends affect on the warehosuing industry including the benefits gained from emerging technologies. (ZebraTechnologies, 2016).

Ballabio and Maria (2017) illustrates the project conducted for the design of a new automated warehouse with the industry 4.0 paradigm and it represents the implementation of the Smart Factory concept, adapted to the warehousing operations. The main characteristics of the Fourth Industrial revolution are illustrated, as well as the main components that give rise to it. This study puts particular emphasis in the iterative process enabled by the cornerstone of the Industry 4.0 paradigm: the strong connection and integration between the physical and digital world. Moreover, it investigates the main implications that can be triggered by this paradigm, as well. It dicusses about many tough challenges which are expected to arise in the future, with disrupting impacts on the traditional systems and it focuses on the next steps the company is intended to take in order to progress along the Industry 4.0 direction (Ballabio and Maria 2017). Lerher (2018) states that "Warehousing 4.0 represents a new area of storing and retrieving goods by using shuttle-based storage and retrieval systems instead of fixed crane automated warehouses." This study has dicussed about the functioning of shuttle-based storage and retrieval systems as a new approach for warehouse 4.0.

Table 2 illustrates how the logistics 4.0 technologies positively influence the performance of intralogistics process of warehousing to achieve the operational excellence.

Table 2. Ways of Warehousing Process Improvements using logistics 4.0 Technologies

Study	**Smart Technologies**	**Ways of Warehousing Process Improvements**
(Liu, et al. 2018)	CPS	-Monitor and create a virtual copy of the real-world industry processes -Make proper decisions in a real-time manner
	RFID	-Inventory Management
	Smart Robots	-Carry and arrange goods in the warehouse.
(Lee, et al. 2011)	RFID	-Storage technology for fast checking goods in-and-out
	Sensor Tags & RFID	-Sensisitive Goods persevation inside a warehouse
(Juntao and Yinbo 2016)	RFID	-Accurate warehouse location management
	Intelligent management technology	-Automatic recognition, automatic perception, automatic positioning, process tracing, online tracking, online scheduling
	IoT – Sensing Technology	-Monitoring of environmental and items, and security monitoring
	Automated Guided Vehicle	- Ensure that items emissions more reasonable, scientific and security
(Liu, et al. 2018)	RFID, Sensor & ZigBee technologies	-Improve information transmission efficiency of the system, shortening the system response time
	Intelligent goods shelf system based on RFID technology,	-Shows the raw material storage information, production date and other information. - Real-time display of a related inventory information -Generate goods inventory of single check
	Intelligent storage monitoring system with Sensor & Zigbee	-Obtains the environmentel and inventory information by -Realize the comprehensive monitoring of the warehouse
(Wang, McIntosh and Brain 2009)	Modular automated warehouse with RFID and Wireless Network	-Simultaneously deliver large numbers of items from storage modules to assigned collection locations with minimal delay. - Permits large numbers of parallel events to occur at any given time throughout the warehouse. - Increase the capability, flexibility and responsiveness for the warehousing
(Ding 2013)	IoT, RFID	-Smart Warehouse Management System based on the IOT which has great advantages compared with the traditional mode
(Basler Vision Technologies 2016)	Smart Vehicle-intelligent, driverless reach trucks	- Permit transportable goods to be reliably identified, picked, transported and deposited at their destination . - Single worker can control multiple vehicles at once.
(ZebraTechnologies 2016)	RFID enabled Warehouse Management	-Offers the promise of heightened inventory visibility : the ability to know precisely where any pallet, case or SKU is in the warehouse at any given moment. - Boost efficiencies in put-away and picking -Verify shipments received from the manufacturer and those shipped to stores with greater precision

		-Increase everything from inventory accuracy to merchandise replenishment speed while reducing opportunities for human error
(Lerher 2018)	Shuttlebased storage and retrieval systems	-Moves goods through each tier and colums of storage racks efficiently.

3.4 Third Party Logistics Industry in Sri Lanka

Limited number of research articles found under this category are reviewed as below.

Malkanthie and Jayamanna (2016) states that "While today world logistic industry is practicing up to 7PL, within a short span of time, Sri Lanka is still grappling with 3PL activities." So this study identifies the challenges, barriers / factors hindering the growth of 3PL market in Sri Lanka to facilitate the growth of the industry to meet the world competition. It also identifies the main issues respectively that affect the growth of 3PL market in Sri Lanka such as costs, lack of control, lack of coordination, inadequate capabilities and etc. This study further specifies the future challenges in 3PL market in Sri Lanka such as minimizing lead time between deliveries, adoption of new technology, handling no of order channels multiplied by the number of delivery options and handling overstocks due to online sales, and etc. Alwis (2016) states that the Sri Lankan 3PL market is yet to achieve maturity. "There are few major players who have developed specialized service offerings over the years and have achieved market leadership" This survey also reveals the challenges faced by users and 3PL providers such as cost focus, low margins, lack of professionalism, skill gaps, fear of collaboration, lack of clear industry standards and legislation, high attrition rate, unorganized transport sector, suboptimal cold chain logistics, readiness to adopt technology and innovation. And this study further reveals the emerging opportunities in Sri Lankan 3PL company such as Integrated supply chain service offerings, R&D and Technology as a differentiator, Collaborative transport, Multi user facilities, Green logistics, Micro logistics, E-logistics, Omni Channel evolution.

Hettiarachchi & Ranwala (2015) have found the factors affecting the customer satisfaction of third-party logistics outsourcing relationships in Sri Lanka. The result of this study states that warehouse operation is the most commonly used 3PL service in Sri Lanka. According to this study most preferred reasons for logistics services outsourcing are cost reduction, focus on core business and reduction in capital investment. Customer satisfaction in third party logistics relationship in Sri Lanka have been mainly categorized into four factors; "Tangible, image and trust", "Empathy and relationship", "Reliability and responsiveness", and "Assurance" (Hettiarachchi & Ranwala, 2015). Sugathadasa and Rajapaksha (2011) investigates how information technology, supply chain security and green supply chain practices are affecting to the level of relationship between third party logistics service user and provider. The result of this study shows that 3PL users are satisfied with the above three factors provided by the 3PL providers in Sri Lanka. It provides the useful information especially for 3PL provider to improve their service.

Identified challenges & opportunities in the 3PL industry can be summarized as follows.

Table 3. Challenges & Opportunities in Sri Lankan 3PL industry

Challenges	Opportunities
Minimizing lead time between deliveries	Integrated supply chain service offerings
Readiness to adopt technology and innovation	R&D and Technology as a differentiator
Handling overstocks due to online sales	Multi user facilities
Cost focus	Green logistics
Lack of professionalism	Micro logistics
Lack of control	E-logistics
Lack of coordination	Omni Channel evolution

Inadequate capabilities	Collaborative transport
Lack of clear industry standards and legislation	
High attrition rate	
Unorganized transport sector	
Suboptimal cold chain logistics	

4. Discussion

The reviewed studies on smart logistics & smart warehouse have significantly deliberated the sophisticated logistics 4.0 technologies with the industrial applications highlighting their influences in process improvements. Most of the high end countries have successfully implemented these smart systems and these technology adoptions have drastically renovated their industrial environment providing massive benefits to the all stakeholders. According to the reviewed studies, most of intralogistics functions in warehousing such as unloading, put away, storing, picking, sorting, packing and loading have been automated through the integration of information and material handling technologies enabled with logistics 4.0.

In the modern business domain, Outsourcing the selected logistics functions to a third party has become a common practice. The major benefit among this strategic decision includes, the ability of a company to focus on its core competencies concentrating its resources on them, while expert care is given to the non-core activities. Most of the Sri Lankan companies also tend to outsource their warehousing functions to the third party logistics providers with the purpose of enhancing their supply chain performance. Therefore, the 3PL providers play a vital role in the current context of warehousing industry. When literature is reviewed, a limited number of studies were found on Sri Lanka's 3PL industry. Those studies have mainly discussed on the challenges and drawbacks in the traditional practices and stressed the importance of exploring the opportunities of technology adoption. It is stated that the Sri Lankan 3PL market is yet to achieve maturity. As a developing country, the major challenge that has been faced in implementing the digital technologies is whether the country has enough resources and competencies to adopt them successfully. Therefore, these studies have emphasized the importance of future research in this area.

5. Conclusion

There is no hesitation that the logistics performance adds value to the entire supply chain in the organization. Companies have identified logistics as one of key success factors in obtaining competitive advantage. Outsourcing the logistics functions to a third party has become a common practice in the corporate world. Therefore, the 3PL service providers perform a vital role in the current context of Sri Lankan Logistics sector and they have become the experts in providing a wide range of services such as warehousing services, transportation services, inventory management, shipping etc. Hence, the 3PL service providers make a significant contribution to the country's economy, because they allow most of the organizations to achieve their goals through enhancing the performance of their supply chains. Nonetheless, these 3PL firms have been encountering some major challenges due to the lack of some capabilities. One such critical challenge is the labour shortage.

The digitization will be an effective strategy to overcome above challenge to minimize human intervention and enhance the output of the available labour force. In this study, the attention has been mainly focused on the intralogistics processes of warehousing. Optimization of the warehousing operations is becoming challenging for the 3PL firms to cope up with the dynamic customer demand and market features. The application of logistics 4.0 concepts in to the intra-logistics processes would be an ideal solution to overcome these issues. It is evident that there is a possibility to foster digitization in Sri Lanka by promoting digital infrastructure, investing and stimulating professional training and promoting the creation of specific funding lines and etc. "Industry 4.0-related opportunities and challenges have a significant influence on its tendency towards implementation" (Müller, Kiel and Voigt 2018). Based on the content analysis of the above reviewed studies, technology related opportunities and challenges can be

identified in the context of Sri Lankan 3PL industry. According to analysis, few critical success factors affecting the logistics 4.0 implementation have been identified, such as Aligning with competitive strategies, Top Management Commitment, Comprehensive Change Management Process, Strategic Workforce Planning, Synchronization and Coordination with existing business processes and Effective Financial Investments.

There is a high necessity of conducting research on these areas to explore the opportunities of adopting the evolving advanced technologies. As the future work, it is expected to conduct an empirical study on 3PL warehousing for assessing Industry 4.0 readiness based on a capability maturity model. The result of this study would provide useful information for Sri Lankan 3PL providers to develop their capabilities to cope with the dynamic requirements in the feature.

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