Risk and Resilience Analysis for Industry 4.0 in Achieving the Goals of Smart Logistics: An Overview

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Abstract

Purpose: An increase in demand for customized products and services has led to the rise in current globalization and resulted in global industrial landscape change deeply in recent years. With the help of successive technological innovations and developments in the supply chain process. The concept of "Industry 4.0" is the modern way of leading the value chain of an industry. However, there are various risks involved in the process of its implementation. The research paper is intended to highlight the major risks and its resilience action to achieve Smart Logistics in Indian Context.
Methodology: Decision Framework is developed to identify possible risks that affect the adoption of these technologies and achieving Smart logistics based on literature review and in-depth expert.
Practical implication: This work is intended to develop a Smart Logistics strategy and prioritized plan for logistics providers and organization to mitigate the effects of risk and uncertainty with the help of Risk Management.

Keywords

Industry 4.0, Smart Logistics, Decision Framework, Risk Management.

1. INTRODUCTION

From the history it is evident that the technological advancements has prevailed a prominent factor in expanding modern efficiency, which was exhibited by the past three Industrial Revolutions, i.e., mechanization (fueled by steam engines during the 1800s), large scale manufacturing (controlled by power and the assembly line in the mid1900s), and computerization (fueled by cyber systems in the late 1900s) (Kagermann et al. 2013). In recent years, computer and internet integration innovation—specifically, the information and communication technology advances—is experiencing fast improvement, which has led to the rise of various novel technologies, for example, Cyber-Physical Systems (CPS), the Internet of Things (IoT), Cloud Computing, and Big Data Analytics. With the implementation of these new advances empowers the production of a smart and connected products and services, in which "things" are invested with a specific level of knowledge, and also, being progressively associated with one another. This technological transformation has given rise to the concept of fourth generation Industrial Revolution-Industry 4.0, which composed of human and computer integrated system. In an Internet of Things (IoT) term, the logistics challenges may require something like high requirement for transparency (supply chain visibility); integrity

control (right product, at the right time, place, amount, condition and the correct expense) in the supply chain (Barreto et al. 2007); dynamic 'reconfigurability' of supply systems, specially by reconsidering service level agreement with upstream and contracted vendors; supply system structure, towards accomplishing agile, lean, flexible and green supply chains (Carvalho and Cruz-Machado 2011).
In this context, logistics are addressed under the term of "Smart Logistics." About Smart Logistics, the main implication is the right product, right time, right place, and right quantity. In fact, with the help of Industry 4.0 in logistics, the integration of CPS and IoT into logistics referred as Smart Logistics which constitutes to ensure a real-time movement in materials flow, improved material handling and, precise risk management helps in better implementation of these technologies. Below is the figure representing the logistics and its sub-activity taken for the empirical study in the automobile domain.

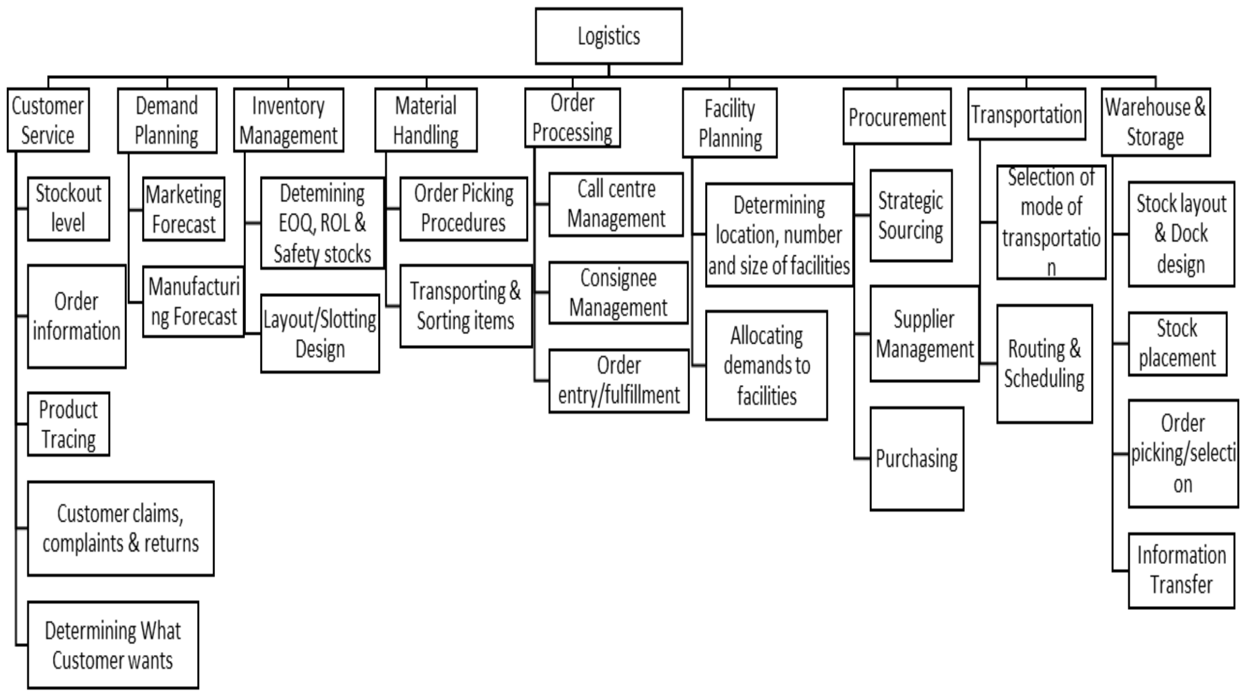

Fig. 1. Logistics Activity and Sub-activity

2. LITERATURE REVIEW

With an increase in research on Industry 4.0 and its implication in Logistics 4.0, is evidence that it is the subject of interest and need for growing industry. Industries of many Country and its Government have accepted the approach which will enhance the acceptance "Industry 4.0" concept. As an example, Czech Government has agreed to "Initiative Industry 4.0" document and assigned help related to such projects of research. On the other note, the experimental problems are how to devise the Industry 4.0 concept. This 4th revolution word is nowadays frequently applied in International Conferences and Articles Journals. This literature study has the main objective to show conditions which highlight the combined effect of Industry 4.0 in logistics and its risk analysis to achieve resilience action based on the formulated questionnaire (Kagermann et al. 2011).

Industry 4.0 concept was published firstly by Kagermann in 2011 and that have structured the Industry 4.0 pillars declaration which was published by the German National Academy of Science and Engineering in 2013. Industry 4.0 concept is specified as the amalgamation across three dimensions: Horizontal Integration along with utility matrix, Vertical Integration combined with connected supply chain networks and End-to-end Digital Integration for product's life cycle engineering along the supply stream. Industry 4.0 term also conceptualized like "a cumulative of concepts and technologies of the supply network with digital integration in an organization. From various research papers, as of now, nine Industry 4.0 pillars are defined out of which eight pillars are applicable in the Logistics sector, which are described as follows:

1) *Cyber-Physical System*: Cyber-Physical System (CPS) concept is explained as the technique where artificial and biological systems are together integrated into physical and cyberspace for processing, information exchange, and feedback process (Bagheri et al. 2015). The amalgamation of tightly consolidated physical processes, networking, and processing are called as Cyber-Physical system (CPS). Network systems control and monitor the physical process with the help of embedded (cyber) subsystems through networked systems. Feedback loops are in aid to change the behavior of the physical process when required. Different devices like, sensing, computing, and communication (often wireless) capabilities are used to create a physical system. Identification of these physical devices can be performed with the help of physical attributes or data sensing systems, for example, Radio Frequency Identification (RFID) or (infrared sensors), and then it can be combined with a networking system, mostly the Internet, for transmitting the collected information to the processing subsystem.
2) *Big Data Analytics*: The extensive collation and assessment of unstructured or structured data across several distinct data generated from different systems and functions like enterprise customer management, sales management and production system to make it standard for supporting decision making in real time (Rüßmann et al. 2015). As per Forrester's explanation, Big Data comprises of four dimensions: Volume, Variety, Velocity, Value of Data. Big data is processed across all these four dimensions for effective decision making (Witkowski 2017). The analysis of data for already stored data is utilized for finding the security issues and decision making in functions of the supply chain or operations in the organization and predicting the future threats and risks, also providing the possible solution to overcome from that issue happening in the organization (Bagheri et al. 2015).
3) *Internet of Things*: Internet of Things (IoT) an emerging Internet-based technology that is widespread in an integrated connection of smart artificial devices, targeted for enhancing the output, efficiency, and finance with the help of prognostic approach and big data innovation. The IoT conceptualizes a wider channel where the network has originated to a physical scenario to connect with machines, equipment, and physical devices and are connected. A cyber system is used to control and monitor these devices. Hence all the Things connected using a cyber-physical interface called the IoT system architecture. IoT architectures contain scalability and interoperability function for smoother network connection throughout the supply chain.
4) *Cloud Computing*: Cloud-based Information Technology, which uses application of communication for the technical backbone as well as for the prudent connections (Landherr et al. 2016). Using this technology, the organization can enhance data sharing within milliseconds or even faster. (Rüßmann et al. 2015) The term "Digital production" is a concept where all devices are connected to a single cloud and share information from one device to other (Marilungo et al. 2017).
5) *System Integration*: System Integration is the system software which helps in integrating all the business functions to bring them at the common platform (Stock and Seliger 2016). The complete System Integration in computerized and robotization for assembling forms in the vertical and even measurement suggests computerization of correspondence and participation, particularly along with standardized procedures also (Erol et al. 2016).
6) *Autonomous Robot*: This era of bringing advancement in the systems which made Robot automatic, reliable and user-friendly for common day challenges so that they can communicate to each-other safely for incompetence part of human beings to learn from them (Bagheri et al. 2015). The function of an autonomous robot is to perform production method autonomously, which will be precise and to work in the prohibited human environment. Autonomous robots finish their task with greater accuracy and intelligence for a given timeframe keeping their aim on safety, reliability, maintainability, and user-friendly (Bahrin et al. 2016).
7) *Simulation*: Simulation leverages the real-time data for virtualizing the real scenario in a virtual model, plants and organizations use simulation, which may contain location, layouts, and machine, thereby reducing machine downtime and enhance the quality (Bagheri et al. 2015). Simulation techniques such as two-dimensional and three-dimensional simulations can be formed for virtual processing and cycle times simulation, energy consumption, or ergonomic aspects of a production facility. Simulations in an industrial application reduce the machine driving time and chances of failures at the start (Simons et al. 2017). Simulation can improve Decision-making quality with an easy and fast way (Stock and Seliger 2016).

Smart Logistics: As the requirement of customized items are expanding increasingly so inbound/outbound processes in logistics must adapt to this evolving condition. Because of its expanding intricacy, it can't be taken care of with regular planning and control processes. We conceptualize the term Smart Logistics, which is defined as the combination of Logistics activities with the application of cyber systems, robots, and the internet of things. Smart Logistics concept is identical with the smart factory, smart product, and smart services. We considered the technology-driven method for defining smart logistics with the help of smart product and smart services. Smart Logistics is a center idea segment just as a key component of Industry 4.0, which is the place the vertical mix happens. The core concept of Smart Logistics is the three-dimensional integration: Vertical integration happens across all the functions in the logistics; Horizontal integration among all the stakeholders in logistics process starting from supplier to end user of product; End to end integration with digital systems across all the value chain (DeLoach 2000).

Risk Management: A growing management strategy needs some risk management techniques to deal with challenges where effective risk management is a key factor that plays the role. Risk as "the level of exposure to uncertainties that the enterprise must understand and effectively manage as it executes its strategies to achieve its business objectives and create value" (Sodhi et al. 2012). Risk management is a systematic process that aware an organization about all ways the risk can be managed. In the absence of adequacy, certain actions are needed to level down the risk to an acceptable and reasonable level. Its amplification is done through computerized developments, for example, Cyber-Physical System, Internet of Things, Big Data Analytics and Autonomous Robots, which are incorporated under the term Industry 4.0 or IoT. Distinguishing potential risks, investigating them, and building up the resilience actions for effective risk management (Sodhi et al. 2012).

3. METHODOLOGY

The study is subjected to highlight the risks and resilience action for Smart Logistics in logistics in Indian context and design for its implementation. Hence an empirical qualitative study is developed with the help of multiple responses from expert opinion from Automobile domain and literature review for each logistics sub activity and required Industry 4.0 tools applicable. The Questionnaire contains information about all the activities comes in logistics and help explore facts in depth and risk involved in implementing Industry 4.0 tools in different logistics activities. This approach will provide solutions to the risks during Industry 4.0 implementation.
The output of sample data for the study will consist of a survey conducted with five logistics managers with experience five to fourteen years each from automobile companies in India. All experts are from the logistics domain not necessarily from information technology (IT) related sectors. Therefore, the research attempts to formulate a wider perspective of the risks and resilience action that are related to Smart Logistics implementation relevant to the automobile sector in the Indian context.
The Questionnaire contains comprehensive the list of logistics and sub logistics activities followed by the applicable Industry 4.0 Pillar and then the risk associated with the implementation and its resilience action. In the second part, a risk assessment of Industry 4.0 and the proposed solution for the same will be carried out. Thereby, respondents have to specifically answer the risk encountered while practicing Industry 4.0, rather than sharing knowledge acquired from an external agency. Also, the possible solutions companies are looking to mitigate the risks.
Data Collection and Analysis
The following questions were asked:

1. List the different Industry 4.0 tools used in mentioned Logistics Sub-activities?
2. Which are the Industry 4.0 pillars used in mentioned logistics activities?
3. What is the Implementation Stage for mentioned each Industry 4.0 pillar?
4. What is the Industry 4.0 implementation Risks in mentioned logistics activities?
5. What is Risk and Impact Probability for each risk mentioned?
6. What solutions does the company incorporate for the Risks mentioned (for Resilient Logistics)?
7. Who will implement these recover actions?

A. Figures and Tables

From the above Questionnaire, for each logistics sub-activity, different risk and its resilient actions were identified in implementing Industry 4.0 in Automobile domain.
The graph between Implementation stage and Industry 4.0 Pillars was obtained based in data collection, and we can see that most of the Automobile companies have already implemented Cyber-Physical System, System Integration and Autonomous Robots for some logistics activity and still lags the due to implementation risk involved.
Table 1 gives the major risks arising during Industry 4.0 implementation in every logistics activity and possible resilient actions to mitigate these risks based on data collection. This major and critical risk is identified through Risk Heatmap plotted (Fig 3) between risk probability and impact probability. Risk heatmap is developed by calculation risk score, which is multiplication of risk probability and impact probability.

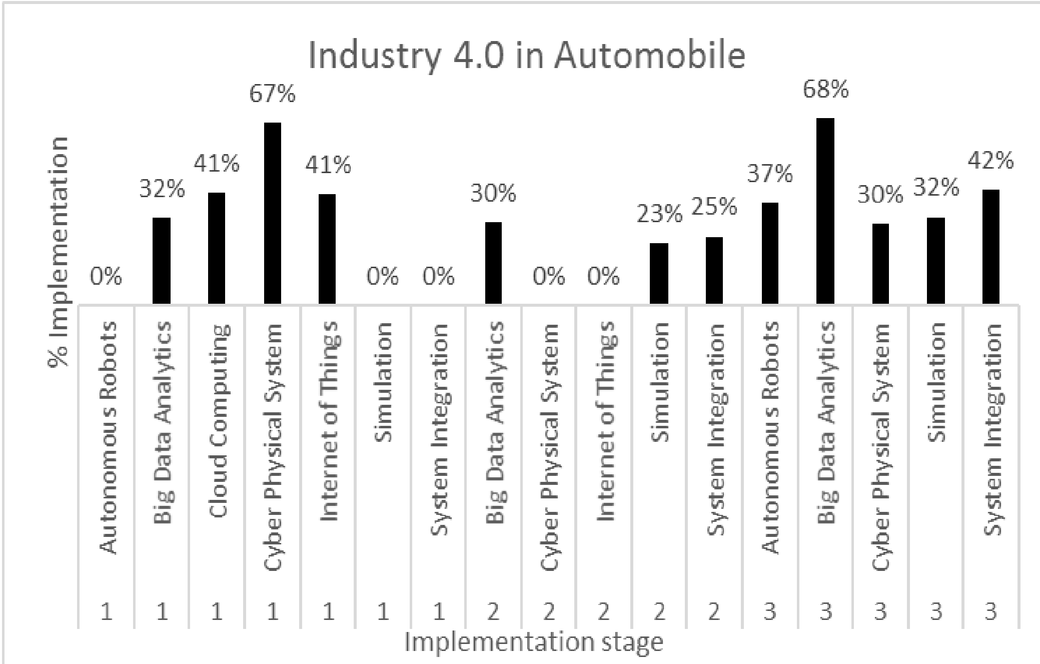

Fig. 2. Implementation stage for Industry 4.0 Pillars in Automobile Industry
1. Initial implementation, 2. In process implementation, 3. Already applied and use.

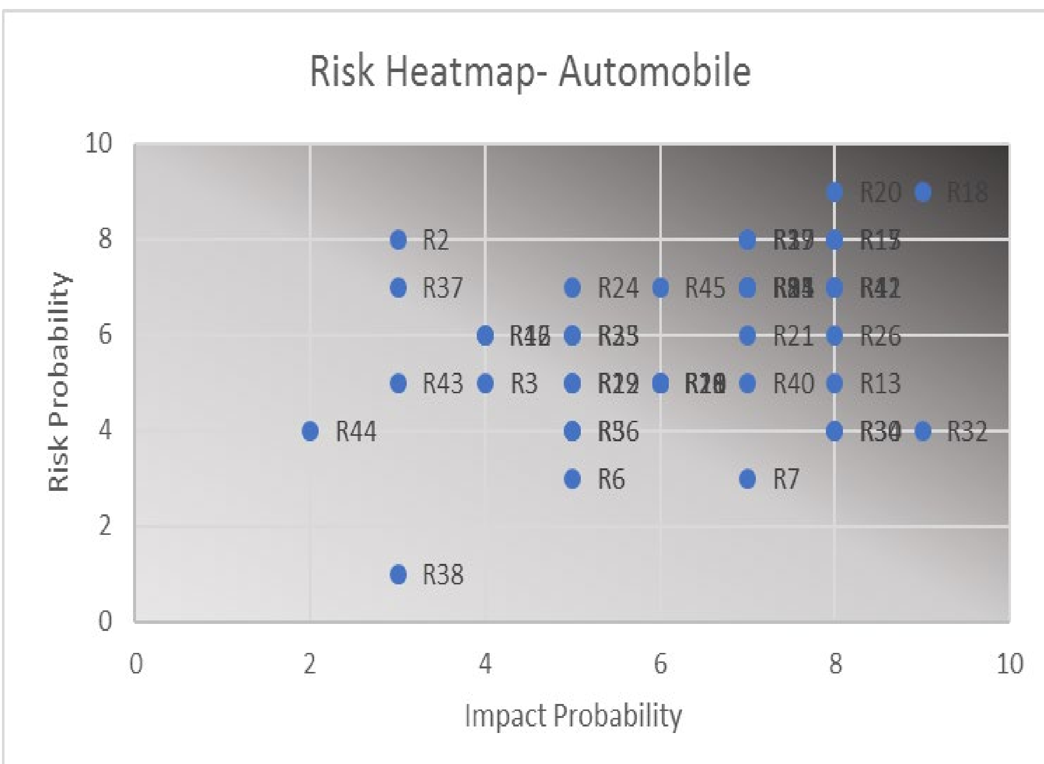

Fig. 3. Risk Heatmap matrix for Risk probability and Impact probability

Table 1. Risk and resilience action for industry 4.0 implementation in logistics for automobile domain

What is the Industry 4.0 implementation Risks in mentioned logistics activities	Risks	What solutions does the company incorporated for the Risks mentioned (for Resilient Logistics)
Security, Trust and Privacy	R1	Policy-driven approaches to security and provisioning and New compliance frameworks to address Trust and Privacy issues
Shortage required skill in data analyst team and lack of sophisticated developers	R4	Providing trainingl materials or hiring of personnel with required skill
Keeping that vast lake of data secure	R8	User authentication and use encrypted data while data transfer
Risk associated with Scalability	R9	A cloud solution which can scale up or down as per requirement and faster during operation
Lack of clear business objective and reliable data sources	R12	Ensuring collaboration among different business functions
High cost of a big data project	R14	Cost benefit analysis before implementing big data projects
Complexity, confusion and integration issues	R15	Implementation of Change management concept and training
Lack of Internet Infrastructure Cyber-Physical System	R17	Ensuring electricity and internet connectivity
Lack of system which assures that all implementation fulfills the required system needs	R18	Develop appropriate metrics which can assess threats, internal issues and system reliability during implementation
High Skillset required	R25	User manual and training materials
Lack of clear use cases or strong ROI examples	R26	Well-grounded, customer-oriented communications and Detailed explanations of technical details and explain the key benefits of their services or face the proverbial
Safety in premise	R27	Smart sensors can be installed to detect the catastrophic failures and suitable measures can be taken to ensure safety
Constant changes of the integration landscape	R31	Flexible system which can be easily scaled up and down
Lack of human skill availability	R33	Training on IoT usage and implementation
Lack of simulation model acceptance in the industry	R39	Simulation system can be designed in user friendly manner and can be potential for improvements in the industry
Simulation takes too long to collect, design and process data for effective decision making	R41	Analyzing data proactively by installing latest software to maintain current system and reduce the experimental time using reduced complex models which can provide high-fidelity results

Above matrix is obtained by plotting each risk probability with its impact probability based on the collected data. Here darker region denoted the critical and major risks, and lighter region denotes the less risk. From the above figure following major risks keywords are highlighted:

1. Security Privacy and Trust
2. High Investment and setup cost
3. Lack of technical skill and standardization
4. Lack of infrastructure
5. Digital transformation from the legacy system and resistance to change

4. CONCLUSION

Today Industry 4.0 represents setting control on the new way of technological developments and innovations in the automobile domain rather than focusing only on increasing the efficiency to develop the business model. Hence, automobile logistics requires intricate new skills, both at the individual level and within the organization as a whole, to become Smarter.

The digital integration and transformation in logistics will create a single database, making logistics smarter, more transparent, and more efficient at every stage, from customer need to delivery. Production, procurement, purchasing, and sales & marketing functions are becoming more closely aligned as digitization advances.

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BIOGRAPHIES

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