MITIGATING SUPPLY CHAIN RISKS WITH INDUSTRY 4.0 TECHNOLOGIES

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Abstract -
Supply chain of a company is impacted with multiple risks such as supply risks, demand risk, technological risk, transportation risk and safety and security risk etc. Industry 4.0 technologies can be employed in mitigating such risks and improving supply chain key performance objectives. In this study, impact of Industry 4.0 on controlling various supply chain risks is studied. Experts evaluate how a particular industry 4.0 technology can help in mitigating a particular supply chain risk. The inputs are taken in linguistic terms and converted into their numerical equivalent using fuzzy set theory. The importance of a technology in controlling risks can be quantified using this approach. This can be useful in prioritizing company's efforts in incorporating Industry 4.0 technologies in their workflow.

Keywords - Industry 4.0, Supply Chain Risks, Risk Mitigation Strategies, Linguistic Inputs

I. INTRODUCTION

The concept of Industry 4.0 has been firstly published by Kagermann in 2011, which is an initiative by the German Government (Kagermann et al., 2011). Considering its implications and importance, Industry 4.0 has gained huge attraction after that. Yin et al. (2018) have discussed the need of manufacturing industry as it is changing from Industry 2.0 to Industry 4.0 by focusing on different production systems. Moeuf, Alexandre et al. (2018) has developed a framework for understanding the implementation of Industry 4.0 in MSMEs by studying the performance objectives, understanding the available managerial capacities and possibilities of implementation of the selected group of technologies. Tortorella and Fettermann (2018) have explored Industry 4.0 as a strategy for improving performances of manufacturing in Brazilian manufacturing companies.

Emerging technologies like Artificial Intelligence (AI), Machine Learning (ML), and Internet of things (IoT) are transforming the future of businesses. There has been a huge emphasis on how these technologies are impacting the strategic functions and enterprise business functions. Beyond just looking for cost savings, Internet of things (IoT) is being used along with other technologies like Big Data, Artificial Intelligence to achieve objectives like speed, agility, security and traceability in Supply chain. This strengthens the supply chain management and credibility of services provided by the organizations. IoT facilitates machine-enabled decision making by constantly monitoring the parameters of production process and through the use of technologies like wireless sensors, RFID tags, mobile apps etc. (Zhou et al, 2015; Yuvaraj et al., 2016). It can accelerate the flow of information throughout the supply chain, and the material flow can be tracked and traced over the IoT.

Pharmaceutical, food processing, dairy companies operate in complex supply chains comprising of vast numbers of natural ingredients' suppliers and processors for finished goods' production (Li, 2011; Pachayappan et al, 2016). The regulations necessitate inventory of these companies to be auditable throughout each stage of supply chain. They require continuous monitoring of live temperature, humidity, physical position of their raw materials and final product to ensure traceability of their products. The traditional ERP system though provided some functionalities it does not have big data analytics and Industry 4.0 features built into it. Therefore, the companies are exploring application of Industry 4.0 to increase visibility of their supply chain (Sun et al., 2011). In this study, we will explore how Industry 4.0 applications can help in controlling multiple supply chain risks.The insights generated by this study can be utilized by practicing managers to prioritize the implementation of Industry 4.0technologies in their systems and processes. In our work, we have used fuzzy linguistic approach to assess the impact of a technology in mitigating a supply chain risk.

II. SUPPLY CHAIN RISK AND INDUSTRY 4.0 TECHNOLOGIES

Supply Chain of an organization operate under multiple risks. These risks are generally categorized as supply risk, demand risk, technological risk, safety security risk etc. These risks have varying characteristics related to likelihood, visibility and impact on the organization's key performance indicators. The companies adapt various strategies to control these risks and mitigate them. Industry 4.0 term is conceptualized as an accumulation of technologies and its implementation by considering the concepts of the value chain in an organization. From various research papers, as of now, key technologies applicable in supply chain are:

Cyber Physical System: Cyber physical systems integrate physical systems with computing / virtual world. They help in sharing real time information with all stakeholders leading to faster decision making.

Big Data Analytics: Big Data analytics involve collection and comprehensive evaluation of data using computerised algorithms in large databases. The trends, insights drawn help in improving accuracy of forecasting, traceability, visibility, efficiency and forecasting risks.

Internet of Things: IoT connects all entities using embedded software, sensors, electronic and network devices, through Internet technology. It helps in integrating information from all entities, locations, assets of supply chain leading to enhanced information sharing and integration.

Cloud Computing: Cloud computing store information on a common shared platform which enable all stakeholders access the same information. This reduces information asymmetry and pays way for shared digital resources.

Augmented Reality: Augmented reality helps in better visualization of systems using virtual mode and thus helps in better planning, assessment of physical infrastructure.

System Integration: System integration connects all entities of supply chain including supplier, buyers, manufacturers etc. This leads to collaborative supply chain planning thereby reducing bullwhip effect and information asymmetry.

Autonomous Robots: Autonomous robots are smart robots that are able to work on their own without human assistance. They enable smart manufacturing and smart warehouses. The operations productivity of tasks is increased using autonomous robots.

III. EVALUATING IMPACT OF INDUSTRY 4.0 TECHNOLOGIES

The experts provide inputs on how an industry 4.0 technology can impact the supply chain risk. The inputs are given on the linguistic term scale (VL, L, M, H, VH). The semantics of the linguistic terms are given using the fuzzy sets given in Fig. 1 below.

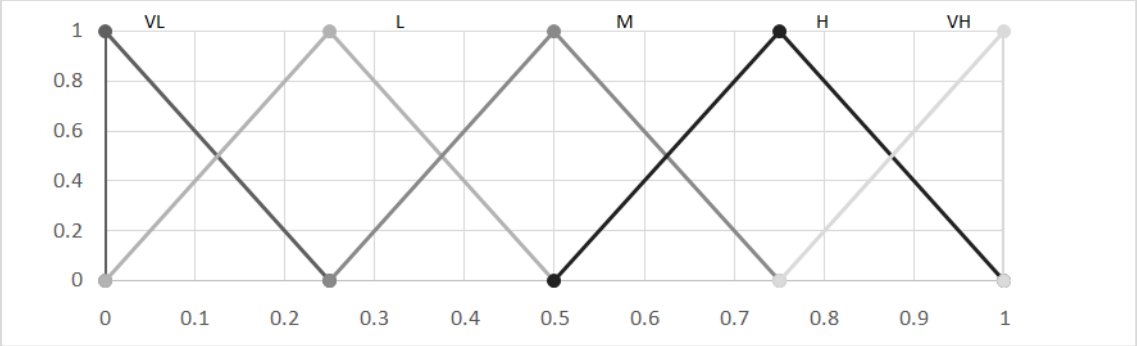


Fig. 1 Linguistic termset

The fuzzy sets defining the following linguistic terms are as follows:
VL (0,0,0.25); L(0,0.25, 0.5); M(0.25,0.5,0.75); H(0.5,0.75,1); VH(0.75,1,1)
Experts assess how well an industry 4.0 technology curb a particular risk using the linguistic term sets given above. For instance, if experts believe that IoT can curb the transportation risk immensely they can use linguistic term "VH". These linguistic terms are converted to their numerical equivalents. The potential impact of an industry 4.0 technology is risk mitigation is calculated by aggregating their numerical equivalents across multiple supply chain risks.

	Supply Risk	Demand Risk	Transportation Risk	Global Supply Chain Risk/Coordination Risk	Safety and Security Risk	Storage Risk
Cyber Physical System	M	VL	L	M	L	H
Big Data Analytics	H	L	VH	VH	VL	L
Internet of Things	H	H	VH	H	L	M
Cloud Computing	L	H	VL	H	VL	VH

Augmented Reality	VL	H	VL	M	L	VL
System Integration	VL	VH	L	H	M	M
Autonomous Robots	H	M	M	VH	VH	H

After aggregating the impact of a technologyacross multiple risks, the potential impact of a technology on a supply chain is obtained as follows:

Cyber Physical System	Big Data Analytics	Internet of Things	Cloud Computing	Augmented Reality	System Integration	Autonomous Robots
0.42	0.58	0.71	0.50	0.29	0.54	0.79

IV. CONCLUSION

In this study, we have exploredhow Industry 4.0 technologiescan be used to mitigate supply chains risks. The insights generated by this study can be utilized by practicing managers to plan the implementation of Industry 4.0 technologies. This study can be further enhanced by studying the interrelationship between these risks and interdependence between Industry 4.0 technologies. This can be further enhanced by incorporating the inputs from multiple stakeholders.

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