**ISBN:** 978-623-92201-0-5

# THE USE OF INTERNET OF THINGS (IOT) IN IMPROVING SUPPLY CHAIN EFFICIENCY OF THE EUROPEAN AUTOMOTIVE INDUSTRY - A CONCEPTUAL FRAMEWORK

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*Abstract. The world has entered a brand new industrial revolution so-called the Industry 4.0 where new technology such as Internet of Things starts to play a crucial role in many business activities. However, the possibility to utilize the Internet of Things have not been fully investigated, especially in the European automotive industry where they have the most complex supply chains compared to other industries. This research paper aims to study the impact of IoT in improving the supply chain efficiency of the European automotive industry. Additionally, the implementation and the possible challenges of IoT within the industry are also being analyzed.*

*Keywords: Internet of Things; Supply Chain; Automotive; European*

## INTRODUCTION

The Internet of Things (IoT) is believed to be the next big thing in many industries. Much research has predicted that the number of IoT devices will increase steeply in the upcoming years and many businesses will immensely invest in this very technology. Continuously of 2020, there will be a roughly 20.4 billion IoT devices, an extremely steep increment contrasted with couple of years back (Gartner, 2017). Other statistics have also estimated that by the year of 2017 to 2025, companies in different industries will invest for approximately $15 trillion in the Internet of Things (Gyarmathy, 2018). The IoT has given significant benefits in this modern industry, however, the possibility to utilize these devices in the supply chain, specifically in the European automotive industry has not been fully investigated. The automotive industry, with its extremely complex supply chains, has the opportunity to benefit from the innovation. Therefore, this research paper will focus on the impact of the Internet of Things in improving the supply chain efficiency and how it can be integrated within the European automotive industry.

The analysis of the automotive supply chain shows that communication between manufacturers or the OEMs and different level suppliers is still a major issue (Ma, 2018). As a result of this, the amount of data they collect and process is low. This occurring problem may lead to disruptions along the supply chains which may affect a company's product, thus it is a huge threat to its profitability. Furthermore, the lacking of transparency between OEMs and multi-level suppliers make it difficult for automakers to achieve a leaner supply chain.

Additionally, the analysis shows that the Internet of Things has a great opportunity in overcoming the current issue. With the help of sensors, data collecting devices, network, and user friendly software, car manufacturers as well as its different level suppliers can share the same information on a centralized system and done automatically by the IoT technology. As a result, automakers will have better communication and relationship with its suppliers. Thus, efficiency will be improved and leaner supply chain can be achieved. The Internet of Things has great potential in improving the European automotive supply chain and provide a better transparency, flexibility and speed in the supply chain.

## LITERATURE REVIEW

*Internet of Things*

The Internet of Things (IoT) is the latest innovation of the Internet. Internet of Things is a more advanced concept of the Internet that connects almost everything, starting from electronic devices to people, products and machineries together (Ramakrishnan, 2018). IoT refers to a world where objects are connected, monitored, and optimized through wired, wireless, or hybrid systems (Zhou, 2015). Kevin Ashton and different specialists from the Auto-ID focus at Massachusetts Institute of Technology (MIT) were the ones who right off the bat presented the term Internet of Things in the late 1990s (Ashton, 1999). These individuals had this splendid vision of making a brilliant world in which physical items and web are altogether associated. They defined IoT as "an intelligent infrastructure linking objects, information and people through the computer networks, and where the RFID technology found the basis for its realization". Gartner Research suggested a definition of IoT as the network of physical objects

**ISBN:** 978-623-92201-0-5

accessed through the Internet that contain embedded technology to sense or interact with their internal states or the external environment (Gartner, 2014). The Internet of Things enables devices to be embedded with sensors that are linked to an information sharing system to facilitate communication and collaboration through data analysis and decision-making tools. The IoT have improved humans life significantly and it is believed that it will also improve business in many industries, including the automotive industry.

The analysis shows that with Internet of Things technology, devices and systems are now more connected which provide real time data and help managers in making critical decisions. IoT incorporated systems are being used to achieve better visibility and responsiveness for the supply chain management (Wagenaar, 2012). The Internet of Things demonstrated a huge impact on supply chain activities including improving transit visibility, improving operational efficiency, promoting information sharing, improving customer services and improving inventory management (Ramakrishnan & Ma, 2018).The integration of IoT devices in supply chain enhance the coordination of logistic services. It enables faster inspection of in-transit items during delivery from the warehouse to the customers. It is more accurate to predict the location of an item during tracking, therefore reducing instances such as theft of goods in transits (Pandikumar & Vetrivel, 2014). With the help of data collecting devices such as the RFID scanners, QR code readers, Barcode readers and the networks, large volume of information will undergo through in-depth analytics. This information include location of products, traffic congestion, routes selections, and performance statistics which can help managers to predict when a delivery will arrive. The IoT devices will send an alert if the shipment is not according to schedule, therefore managers will be able to take immediate action to reschedule workers, order replacement shipments, or make other arrangements to avoid wasting time and resources at their facility in where it can save a lot of cost (Dukach, 2018).

Other impact of the Internet of Things in supply chain is enhancing information sharing between suppliers and manufactures. The exchange of information is very crucial to increase operational efficiency. Exchange of information between the different supply chain entities brought by the modern technology such as IoT increases productivity, reducing the rate of error and promotes improved billing, all which contribute to an efficient and effective supply chain (Madakam et al., 2015). Information sharing is critical for both manufactures and suppliers as it minimizes what is called the Bullwhip effect where it affects the amount of suppliers' safety stocks. The implementation of IoT also replaces the traditional paper based data exchange where data are now in digital form and stored on a cloud based system.

One other successful impact of the Internet of Things is increasing the efficiency in inventory management. IoT innovation has significantly improved how companies handle their inventory by providing real time information on restocking and reordering inventories (Yasumoto et al., 2016). The Internet of Things help manufacturers to have a more effective and cost efficient operations. IoT enables companies to update their inventories on real time according to their replenishment orders, promoting efficient inventory management practices (Rose et al., 2015). Delays is never again a test for manufacturers and suppliers who have coordinated IoT innovation and development in their production network frameworks.

*Automotive Industry*

The automotive industry has undergone different phases throughout the centuries. The first phase of the industry or craftsmanship generally started at the end of the 19th century. In this era, all workers should have excellent skills and productions were done in a long period of time. Mass production was then introduced in the early of 20th century by Henry Ford (Braese, 2003). This was the time where assembly line started to be implemented by car manufacturers. New concept so-called Lean Production was introduced in the mid of the 20th century. The lean philosophy is quality rather than cost oriented which mainly focus on three aspects which are eliminating waste, involving everyone along the supply chain, and continuous improvement. The latest slight shift of trend in the automotive supply chain is the change to modular production. This concept enable manufactures to not only focus on quality, but also customization. The basic idea behind the modular production is to have a more focused and consolidated supply chain.

Generally, the automotive industry is composed of Original Equipment Manufacturer (OEM) and different suppliers at different levels. The number of 2nd and 3rd tier suppliers is often in the thousands, while a manufacturer might only have tens to hundreds of 1st tier suppliers (Standard & Poor's, 2004). These different suppliers are carefully selected by the Original Equipment Manufacturer. The intermediate supplier to the OEMs is called the Tier 1 and the supplier to Tier 1 is called the Tier 2 and it goes the same down the chain (Tier 1, 2,3, etc.). The OEMs basically assembles and produce a vehicle. The 1st tier suppliers produce large sections or modules before being delivered to the OEMs. They usually produce large parts such as the body (seats and consoles), power (engine and transmissions), and chassis (steering, brakes, and suspensions). The 2nd tier suppliers produce smaller components such as air bags, pistons, gauges and valves and supply to the 1st tier. The 3rd tier suppliers usually build piece parts such as stamps, castings and moldings to the 2nd tier suppliers. Finally, the 3rd tier receives raw materials from the 4th tier.

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## METHODOLOGY

The empirical research in this dissertation paper is based on qualitative meta-analysis where secondary data of primary findings are collected and illuminated by qualitative approach. By using meta-analysis, a wide variety of questions can be investigated, as long as a reasonable body of primary research studies exist (Neil, 2006). Literature study is obtained as data collection techniques where data are derived from different scholarly sources namely journals, articles, books, lectures, and posts that delve in the subjects being researched. The authors are either practitioners and/or experts in the study area unless stated otherwise. This research paper aims to investigate the impact of emerging technology in the Industry 4.0, specifically the Internet of Things, on the European automotive industry. In respect to this, the main points that will be discussed in this paper are firstly the overview of the European automotive industry, the big players in the European automotive industry, and the current structure of the automotive supply chain. Additionally, the literature review will provide information and understanding of the Internet of Things framework: how it is done and how can it be implemented. Finally, an analysis on the implementation of the Internet of Things within the Industry will be obtained as well as the future and possible challenges of the technology.

## FINDINGS AND ARGUMENT

In regards to the European automotive industry, an IoT framework shows that the IoT can be integrated in the supply chain very well. The framework consists of 4 basic layers consisting object/sensing layer, network layer, data layer, and application layer (user friendly software) (Ramakrishnan & Ma, 2018). The object layer is where information are being collected from data collecting devices such as RFID scanners, QR code readers and Barcode readers. This layer also involve the use of sensors as the supporting tool. The network layer is responsible for the transmission of data to the data center through wireless connection such as the Internet, Bluetooth and Wifi. The next layer is data layer. This layer acts as data storage which will then be processed for the requested purposes. Lastly, the application layer is where human comes into contact with the IoT. The application layer is the software which is used to store and present the gathered data in user friendly form (Ramakrishnan & Ma, 2018). The framework enables OEMs and different level suppliers share information in a centralized cloud based system and done automatically using the Internet of Things technology (Figure 1). The OEM and the end consumer can log in the system and access real time product information such as the location, cost, quality, lead time and manufacturer details along the supply with the help of relevant network and information gathering technologies (Ramakrishnan & Ma, 2018). The information collected will be analyzed using big data analytics before being stored in the cloud based system. The data is then being grouped according to the needs of the manufacturers and the suppliers. In this way, the the OEMs are able to follow information along the supply chain from suppliers in different tiers on a real time basis.

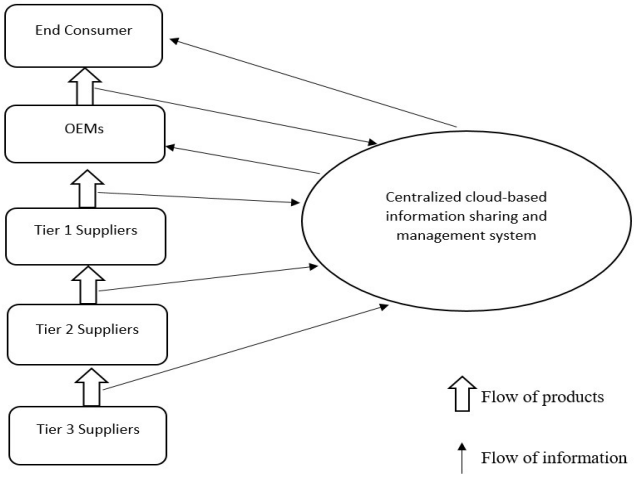


Figure 1. General Model of IoT Framework in Automotive Industry

Another possible IoT framework which can be applied to improve the supply chain efficiency of the European automotive industry. A slight difference from the previous framework is that this framework focuses more on how the Internet of Things

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technology help manufacturers to collect information directly from the products and share it among distributors and different level of suppliers. In the framework, suppliers, manufacturers, distributors, retailers as well as customers are connected in one cloud based system (Figure 2). This is a pull model and information is gathered directly from the end item. The data may include customer behaviors and preferences. These data are valuable for the research and development department, which is capable of improving future product models on the basis of the collected information about the product (Szozda, 2017). The information is stored in one centralized cloud based system and shared among different level of suppliers, distributors and retailers. With this design, OEMs have the ability to understand their customer better. Knowing exactly what the customer needs means that OEMs are able provide more customized automobiles, thus improving customer service and customer satisfaction. The sharing of information is very crucial for the both OEMs and suppliers as it also enables them to have a more accurate demand forecast. Demand forecasts are determined on the basis of customer behaviors (Szozda, 2017). The OEMs then can apply the build-to-order system better and have an even leaner supply chain than ever before.

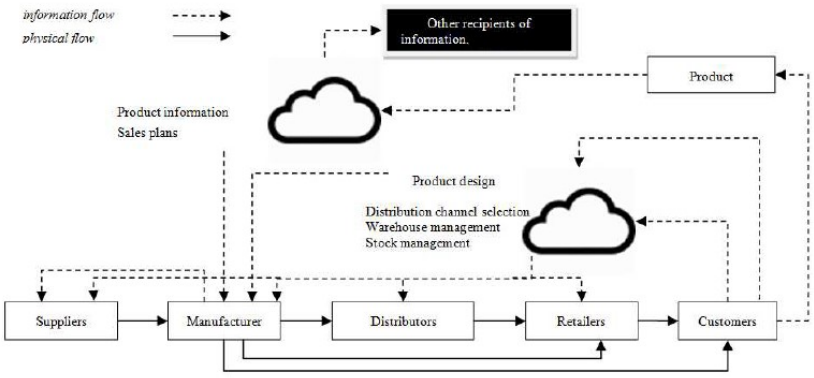


Figure 2. Cloud based IoT application in supply chain.

## CONCLUSIONS

Until today, it is still undeniable that the automotive industry has the most interesting supply chains contrasted with the other industry, especially in Europe, where the automotive industry is a standout amongst the most critical supporters of the economy of the European Union. The automotive supply chains are extremely complicated and designed to adjust to constant changes in manufacturing schedules, production quantities, delivery requirements, etc. It becomes more complex as one car manufacturer has to deal with hundreds or even thousands different level suppliers. Enhancing communication and relationship between manufacturers and suppliers is what the automotive industry is trying to accomplish. Today, achieving lean supply chain goes beyond than only minimizing wastes, having accurate forecasts and implementing pull systems. However, integrating communication between manufacturers and suppliers becomes a key aspect of today's supply chain.

The automotive industry has undergone several phases throughout the centuries. Starting from mechanization, mass production, automation and finally, new industrial revolution so-called the Industry 4.0 allows new technology such as the Internet of Things to finally come into reality. The Internet of Things provides a great solution to the automotive industry especially the OEMs. With the help of data collecting devices, networks, data analytics and software, manufacturers and suppliers can now be integrated in one centralized cloud based system and done automatically by the Internet of Things technology. In other words, data is shared along the supply chain where suppliers as well as manufactures can access the same information in real time. Manufactures and suppliers will be able to track products from raw materials until it reaches to the customers. Additionally, automakers can take advantage of understanding their customers better from this system. Therefore, efficiency and transparency in the supply chain can be achieved. However, both manufacturers and suppliers have to be careful in sharing their information. Knowing that data shared through a network can be easily stolen, companies need to have high level data security. To conclude, aside from its challenges, the Internet of Things is an extraordinary potential for the automotive industry to achieve an even leaner supply chain than ever before. It is unarguable that this technology will help car manufacturers in creating a transparent, flexible and efficient supply chain.

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