AUTORIZACIÓN PARA LA DIGITALIZACIÓN, DEPÓSITO Y DIVULGACIÓN EN RED DE PROYECTOS FIN DE GRADO, FIN DE MÁSTER, TESINAS O MEMORIAS DE BACHILLERATO

1º. Declaración de la autoría y acreditación de la misma.

El autor D. JUAN VERGARA MUÑOZ

DECLARA ser el titular de los derechos de propiedad intelectual de la obra: TECHNOLOGIES IMPACTING SUPPLY CHAIN IN THE FUTURE, que ésta es una obra original, y que ostenta la condición de autor en el sentido que otorga la Ley de Propiedad Intelectual.

2º. Objeto y fines de la cesión.

Con el fin de dar la máxima difusión a la obra citada a través del Repositorio institucional de la Universidad, el autor **CEDE** a la Universidad Pontificia Comillas, de forma gratuita y no exclusiva, por el máximo plazo legal y con ámbito universal, los derechos de digitalización, de archivo, de reproducción, de distribución y de comunicación pública, incluido el derecho de puesta a disposición electrónica, tal y como se describen en la Ley de Propiedad Intelectual. El derecho de transformación se cede a los únicos efectos de lo dispuesto en la letra a) del apartado siguiente.

3º. Condiciones de la cesión y acceso

Sin perjuicio de la titularidad de la obra, que sigue correspondiendo a su autor, la cesión de derechos contemplada en esta licencia habilita para:

a) Transformarla con el fin de adaptarla a cualquier tecnología que permita incorporarla a internet y hacerla accesible; incorporar metadatos para realizar el registro de la obra e incorporar "marcas de agua" o cualquier otro sistema de seguridad o de protección.
b) Reproducirla en un soporte digital para su incorporación a una base de datos electrónica, incluyendo el derecho de reproducir y almacenar la obra en servidores, a los efectos de garantizar su seguridad, conservación y preservar el formato.
c) Comunicarla, por defecto, a través de un archivo institucional abierto, accesible de modo libre y gratuito a través de internet.
d) Cualquier otra forma de acceso (restringido, embargado, cerrado) deberá solicitarse expresamente y obedecer a causas justificadas.
e) Asignar por defecto a estos trabajos una licencia Creative Commons.
f) Asignar por defecto a estos trabajos un HANDLE (URL *persistente)*.

4º. Derechos del autor.

El autor, en tanto que titular de una obra tiene derecho a:

a) Que la Universidad identifique claramente su nombre como autor de la misma
b) Comunicar y dar publicidad a la obra en la versión que ceda y en otras posteriores a través de cualquier medio.
c) Solicitar la retirada de la obra del repositorio por causa justificada.
d) Recibir notificación fehaciente de cualquier reclamación que puedan formular terceras personas en relación con la obra y, en particular, de reclamaciones relativas a los derechos de propiedad intelectual sobre ella.

5º. Deberes del autor.

El autor se compromete a:

a) Garantizar que el compromiso que adquiere mediante el presente escrito no infringe ningún derecho de terceros, ya sean de propiedad industrial, intelectual o cualquier otro.
b) Garantizar que el contenido de las obras no atenta contra los derechos al honor, a la intimidad y a la imagen de terceros.
c) Asumir toda reclamación o responsabilidad, incluyendo las indemnizaciones por daños, que pudieran ejercitarse contra la Universidad por terceros que vieran infringidos sus derechos e intereses a causa de la cesión.

d) Asumir la responsabilidad en el caso de que las instituciones fueran condenadas por infracción de derechos derivada de las obras objeto de la cesión.

6º. Fines y funcionamiento del Repositorio Institucional.

La obra se pondrá a disposición de los usuarios para que hagan de ella un uso justo y respetuoso con los derechos del autor, según lo permitido por la legislación aplicable, y con fines de estudio, investigación, o cualquier otro fin lícito. Con dicha finalidad, la Universidad asume los siguientes deberes y se reserva las siguientes facultades:

- La Universidad informará a los usuarios del archivo sobre los usos permitidos, y no garantiza ni asume responsabilidad alguna por otras formas en que los usuarios hagan un uso posterior de las obras no conforme con la legislación vigente. El uso posterior, más allá de la copia privada, requerirá que se cite la fuente y se reconozca la autoría, que no se obtenga beneficio comercial, y que no se realicen obras derivadas.
- La Universidad no revisará el contenido de las obras, que en todo caso permanecerá bajo la responsabilidad exclusive del autor y no estará obligada a ejercitar acciones legales en nombre del autor en el supuesto de infracciones a derechos de propiedad intelectual derivados del depósito y archivo de las obras. El autor renuncia a cualquier reclamación frente a la Universidad por las formas no ajustadas a la legislación vigente en que los usuarios hagan uso de las obras.
- La Universidad adoptará las medidas necesarias para la preservación de la obra en un futuro.
- La Universidad se reserva la facultad de retirar la obra, previa notificación al autor, en supuestos suficientemente justificados, o en caso de reclamaciones de terceros.

Madrid, a 31 de Agosto de 2018

ACEPTA

Fdo JUAN VERGARA MUÑOZ

Motivos para solicitar el acceso restringido, cerrado o embargado del trabajo en el Repositorio Institucional:

Declaro, bajo mi responsabilidad, que el Proyecto presentado con el título

TECHNOLOGIES IMPACTING SUPPLY CHAIN IN THE FUTURE

en la ETS de Ingeniería - ICAI de la Universidad Pontificia Comillas en el curso académico 2017/2018 es de mi autoría, original e inédito y no ha sido presentado con anterioridad a otros efectos. El Proyecto no es plagio de otro, ni total ni parcialmente y la información que ha sido tomada de otros documentos está debidamente referenciada.

Fdo.: Juan Vergara Muñoz Fecha: 31/08/2018

Autorizada la entrega del proyecto

EL DIRECTOR DEL PROYECTO: Prof. Mazin Safar

Fdo.: Mazin Safar Fecha: 31/8/18

I declare, under my responsibility, that the Project presented under the title

TECHNOLOGIES IMPACTING SUPPLY CHAIN IN THE FUTURE

in the "ETS de Ingeniería - ICAI de la Universidad Pontificia Comillas"

in the academic year 2017/2018 is of my authorship, original and unpublished and has not previously been presented for other purposes. The Project is not plagiarism of another, either totally or partially, and the information that has been taken from other documents is duly referenced.

Issued by: Juan Vergara Muñoz Date: 31/08/2018

Authorized the delivery of the project

THE DIRECTOR: Prof. Mazin Safar

Sign: Mazin Safar Date: 31/8/18

ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA (ICAI)

MÁSTER EN INGENIERÍA ELECTROMECÁNICA (MII)

TECHNOLOGIES IMPACTING SUPPLY CHAIN IN THE FUTURE

Autor: Juan Vergara Muñoz
Director: Professor Mazin Safar

Chicago, IL (EEUU)

Agosto 2018

TECHNOLOGIES IMPACTING SUPPLY CHAIN IN THE FUTURE

Vergara Muñoz, Juan.

Director: Safar, Mazin.

Entidad Colaboradora: Illinois Institute Of Technology

RESUMEN DEL PROYECTO

INTRODUCCIÓN

En este proyecto se analizarán las principales tecnologías actuales y futuras que afectan a la cadena de suministro: fabricación, diseño, transporte, almacenamiento, logística, y servicio al consumidor. Entre estas tecnologías se encuentran: los clasificadores lineales para paquetes, los clasificadores omnidireccionales, la impresión 3D, el IIoT (del inglés "Industrial Internet of Things"), los drones y montacargas autónomos, la realidad aumentada y virtual, los camiones autónomos, los robots colaborativos, el blockchain, la distribución usando infraestructura pública (bajo el título en inglés "Subway Transportation"), la inteligencia artificial (machine learning y big data), el SaaS (por sus siglas en inglés: "Software as a Service"), los AGVs (por sus siglas en inglés "Automated Guided Vehicles"), y los sistemas de transporte mixtos.

El objetivo de esta tesis es analizar las tecnologías con mayor potencial en un plazo de 8 años, para que las empresas puedan enfocar sus esfuerzos económicos presentes en tecnologías que vayan a seguir siendo relevantes entonces. Dicho de otra forma, para poder obtener ventajas competitivas sobre los competidores. Para evitar conclusiones superficiales, se realizan cuatro casos estudios en el penúltimo capítulo de este proyecto. En dichos casos estudio, se analiza el

impacto concreto de cada una de las tecnologías descritas previamente en cuatro sectores diferentes: compra al por menor (en el caso de Amazon), servicios (en el caso de Microsoft), fabricación (en el caso de Apple) y distribución (en el caso de UPS). El documento consta de seis capítulos y un apéndice.

En definitiva, muchas tecnologías se están desarrollando al mismo tiempo, pero no todas las posibles tecnologías tienen la oportunidad de recibir la inversión necesaria para alcanzar su pleno potencial. Las empresas necesitan tecnologías para adelantarse a sus competidores, pero sólo cuando la rentabilidad del proyecto está garantizada de alguna manera. Es por ello que este proyecto pretende alumbrar las tecnologías más relevantes a futuro, para evitar que las empresas inviertan tiempo y dinero en tecnologías cuya relevancia a futuro no está asegurada.

Estado del arte

Como ya se ha dicho, la rentabilidad es un aspecto necesario para dedicar tiempo al desarrollo de cualquier tecnología. La verdad es, sin embargo, que las tecnologías también pueden desarrollarse por necesidad. Como ejemplo, la tecnología RFID fue desarrollada durante la Segunda Guerra Mundial, donde los tanques y los aviones aliados requerían ser capaces de identificarse entre sí (para evitar fuego amigo). Pero la necesidad empuja a las tecnologías sólo hasta el momento en que son necesarias. Después de la Segunda Guerra Mundial, la tecnología RFID continuó utilizándose gracias a su probada capacidad para identificar elementos. Esta capacidad no pasó desapercibida y fue la que mantuvo el desarrollo del RFID en las aplicaciones de almacenamiento.

Motivación

La intención de este proyecto es ayudar a las empresas a comprender mejor cómo será el mundo en el futuro. Las tecnologías se desarrollan siempre que sean rentables. Y la rentabilidad proviene de su capacidad para resolver un problema, haciendo que los procesos sean más eficientes. Por lo tanto, saber qué tecnologías resuelven más problemas puede indicar en que tecnologías merece la pena invertir y en cuáles no.

METODOLOGÍA

El primer capítulo presenta la introducción principal de todo el documento. Se presenta la estructura del documento y las ideas generales sobre el tema.

El segundo capítulo se centra en el estado del arte. La idea es presentar el concepto de desarrollo tecnológico, y también mostrar ejemplos de cómo se desarrolló la tecnología en el pasado. De esta manera se asegura que todos los lectores tengan la misma idea sobre lo que hace que las tecnologías sean relevantes.

El tercer capítulo se centra en los retos actuales y futuros de la cadena de suministro en su conjunto. Los desafíos se dividen en diferentes categorías, para asegurar la coherencia y el orden. Esta parte de la investigación es clave, ya que las tecnologías sólo se desarrollan si se traducen en rentabilidad económica.

El cuarto capítulo se centra directamente en el análisis de cada tecnología y su relación. Se presentan tecnologías muy diferentes, y su impacto se muestra en función de los retos que cada

una de ellas resuelve. El alumno presenta una tecnología propia: un sistema de distribución basado en la infraestructura del transporte público.

El quinto capítulo presenta las entrevistas realizadas y los casos estudio. La primera parte explica cómo se realizaron las entrevistas y quiénes participaron en ellas. En segundo lugar, se presentan los comentarios de los entrevistados sobre cada una de las tecnologías más "relevantes". Luego, se realizan más investigaciones sobre un par de tecnologías que fueron mencionadas por los entrevistados. Por último, se presentan cuatro casos estudio sobre el comercio minorista (Amazon), la prestación de servicios (Microsoft), la fabricación (Apple) y la distribución (UPS).

CONCLUSIONES

La aplicación del IIoT y el desarrollo de la inteligencia artificial son dos de los primeros elementos clave a ocho años vista. La plataforma que permitirá a las empresas acceder a estas tecnologías será la SAAS.

Los AGVs tendrán un gran impacto en el almacenaje por la implementación vertical del sistema “OSP” de la empresa Ocado. Esta tecnología es otra de las ideas desarrolladas por el estudiante.

Además, la realidad aumentada y la impresión 3D se presentan como factores decisivos para la personalización a largo plazo y la visualización de datos.

El uso del transporte público (como el metro) para entregar paquetes dentro de una ciudad se presenta como una idea que comenzará a implementarse ampliamente dentro de 8 años.

Por último, se utilizarán coches autónomos, pero es probable que no se apliquen plenamente en un plazo de ocho años. Aunque su impacto final estará restringido por las leyes reguladoras que puedan surgir, los coches autónomos tendrán un gran impacto en la distribución de paquetes.

TECHNOLOGIES IMPACTING SUPPLY CHAIN IN THE FUTURE

Vergara Muñoz, Juan.

Director: Safar, Mazin.

Collaborating Entity: Illinois Institute Of Technology

MAIN ABSTRACT

INTRODUCTION

This project will analyze the top current and future technologies affecting supply chain: manufacturing, design, transportation, warehousing, logistics, and customer service. These technologies include: slat sorters, omnidirectional sorters, 3D printing, IIoT (Industrial Internet of Things), autonomous drones and forklifts, augmented and virtual reality, autonomous trucks, collaborative robots, blockchain, 'subway transportation', artificial intelligence (machine learning and big data), SaaS (Software as a Service), AGVs (Automated Guided Vehicles), and mixed transport systems.

The aim of this thesis is to analyze the technologies with the greatest potential within 8 years, so that companies can focus their current economic efforts on technologies that will continue to be relevant then. In other words, in order to obtain competitive advantages over competitors. In order to avoid superficial conclusions, four case studies are carried out in the penultimate chapter of this project. In these case studies, the specific impact of each of the technologies described above is analyzed in four different sectors: retail (in the case of Amazon), services

(in the case of Microsoft), manufacturing (in the case of Apple) and distribution (in the case of UPS). The document consists of six chapters and one appendix.

Ultimately, many technologies are being developed at the same time, but not all possible technologies have the opportunity to receive the investment required to reach their full potential. Companies need technologies to stay ahead of their competitors, but only when the profitability of the project is somehow guaranteed. This is why this project aims to state the most relevant technologies in the future, to prevent companies from investing time and money in technologies whose future relevance is not assured.

State of the Art

As stated before, profitability is one aspect that is required for dedicating time to developing any technology. Truth is, though, that technologies can also be developed from necessity. As an example, RFIDs were developed during WWII, where ally tanks and airplanes required to be able to identify each other (to avoid friendly fire). But, necessity pushes technologies only up to the moment they are required. After WWII, RFIDs continued to be used thanks to its proven ability to identify elements. This ability did not pass unobserved, and was the one to maintain RFIDs' development on warehousing applications.

Motivation

This project's intention is to help companies have a better understanding on how the world is going to look like in the future. Technologies are developed as long as they are profitable. And profitability comes from its ability to solve a problem, making processes more efficient.

Therefore, knowing which technologies solve more problems can outline which technologies are worth to be invested, and which are not.

METHODOLOGY

The first chapter presents the main introduction for the whole document. The structure of the document and general ideas on the topic are presented.

The second chapter focuses on the state of the art. The idea is to present the concept of technology development, and also to show examples of how technology was developed in the past, to ensure that all readers have the same idea about what makes technologies relevant.

The third chapter focuses on current and future challenges in the supply chain as a whole. The challenges are divided into different categories, to ensure coherence and order. This part of the research is key, as technologies are only developed if they translate into economic profitability.

The fourth chapter focus directly on the analysis of each technology and its relationship. Very different technologies are presented, and their impact is shown according to the challenges that each one of them solves. The student presents a personal idea: using public transport's infrastructure to deliver packages.

The fifth chapter presents the research carried out. The first part explains how interviews were conducted and who participated in them. Secondly, the interviewees' comments on each of the most 'relevant' technologies are presented. Then, further research is done on a couple of

technologies that were mentioned by interviewees. Finally, four case studies are presented on retail (Amazon), service delivery (Microsoft), manufacturing (Apple) and distribution (UPS).

CONCLUSIONS

The application of IIoT and the development of artificial intelligence are two of the first key elements in an eight-year period. The platform that will allow companies to access these technologies will be SAAS.

AGVs will have a great impact on warehousing by the vertical implementation of Ocado's OSP. This technology is an idea developed by the student.

Additionally, augmented reality and 3D printing are presented as decisive factors for long-term personalization and data visualization.

The use of public transport (such as the subway) to deliver parcels within a city is presented as an idea that will begin to be widely implemented in 8 years' time.

Finally, autonomous cars will be used, but they will probably not yet be fully implemented within 8 years. Although their final impact will be restricted by the regulatory laws that may arise, autonomous cars will be of great help in the distribution of parcels.

TECHNOLOGIES IMPACTING SUPPLY CHAIN IN THE FUTURE

BY

JUAN VERGARA

INTM

Submitted in partial fulfillment of the
requirements for the degree of
MITO in INTM
in the Graduate College of the
Illinois Institute of Technology

Supervised by Prof. Mazin Safar
Adviser

Chicago, Illinois
08 2018

ACKNOWLEDGEMENT

First of all, deep thanks to Professor Mazin Safar. Thanks for redirect my initial idea. This research has proven to be very interesting, and also valuable in terms of real application. Second, thanks for pushing me forward and giving me the opportunity to come up with my own ideas as well. Third, thanks for reminding me about deadlines from time to time. It was the push that I needed to finish it on time.

Secondly, I would like to thank my family. In the end, it is because of you that I have been able to be here in Chicago. It has been a deeply rewarding experience. One that has given me time to learn about myself and others.

Thirdly, I want to thank the five people that agreed to have a personal interview with me: Jaime Boal Martín-Larrauri, Juan Luis Zamora Macho, Romano Gianetti, José Antonio Rodríguez Mondéjar, and Bernardo Villazán Gil. Each of you took the time to explain your personal and professional view on the topic, and for that I am really grateful.

Fourthly, I want to thank my new family in Chicago. It would have never been the same without you. Thanks for your support for both good and bad. Hopefully, we will keep in touch no matter where each of us ends. Anyhow, I wish you all the best.

Lastly, I want to thank my university back from Spain. This is supposed to be the last piece of work that we are submitting, and, now that it is all over in a little while, I do not want to pass up the opportunity to say thank you. As a suggestion, it would be best to ensure that future students have a more comprehensive and practical experience than the current one. Anyhow, thanks to all the great teachers that have been there to help me whenever I have needed them. Thanks for being so passionate, and caring so much about the student. Special thanks to all teachers in the Electronics Department. Thanks to you, I never doubted if I had chosen the right specialization.

I very much hope that this project will push more people into the field of research. The more people involved in the analysis of new technologies and their impact, the better. Finally, I am sure that this research will be useful for those companies that are willing to invest the money needed to become leading companies. If they follow the line of thought defined throughout the document, they will agree on the conclusions. Best,

Juan Vergara Munoz

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

LIST OF SYMBOLS / ACRONYMS

Symbol	*Definition*
AGV	Automated Guided Vehicle
AI	Artificial Intelligence
ERP	Enterprise Resource Planning
ETA	Estimated Time of Arrival
GBs	Gigabits
GDP	Gross Domestic Product
HR	Human Resources
IIoT	Industrial Internet of Things
OSP	Ocado Smart Platform
PLM	Product Lifecycle Management
RFID	Radio-Frequency Identification
R&D	Research and Development
SAAS	Software as a Service
TMS	Transporting Management System
US	United States
WWII	World War II

ABSTRACT

In this research, top current and upcoming technologies are going to be analyzed. The aim of this thesis is to analyze the technologies with the greatest potential within 8 years. The document consists of six chapters and one appendix.

The first chapter is the main introduction to the document. All initial assumptions and thoughts are presented in this section. General information on the structure of the document is provided as context.

The second chapter focuses on the state of the art. The idea is to present the concept of technology development, and also to show examples of how technology was developed in the past. This section is important to ensure that all readers have exactly the same idea about what makes technologies relevant.

The third chapter focuses on current and future challenges in the supply chain as a whole. The challenges are divided into different categories, to ensure coherence and order. This part of the research is key, as technologies are only developed if they translate into economic success or cost reduction.

The fourth chapter focus directly on the analysis of each technology and its relationship. Very different technologies are presented, and their impact is presented according to the challenges that each one of them solves. At the end of some technologies there are additional capabilities that do not specifically solve any of the main challenges posed.

The fifth chapter presents the research carried out. The first part explains how interviews were conducted and who participated in them. Secondly, the interviewees' comments on each of the most 'relevant' technologies are presented. Then, further research is done on a couple of technologies that were mentioned by interviewees after the first research was done. Finally, four case studies are presented on retail (Amazon), service delivery (Microsoft), manufacturing

(Apple) and distribution (UPS). For each company, the current implementation is presented in contrast to future innovations.

The sixth chapter presents the conclusions of this research. The application of IIoT and the development of artificial intelligence are two of the first key elements in an eight-year period. The platform that will allow companies to access these technologies will be the SAAS. AGVs will have a great impact by the vertical implementation of Ocado's OSP. Additionally, augmented reality and 3D printing are presented as decisive factors for long-term personalization and data visualization. The use of public transport (such as the subway) to deliver parcels within a city is presented as an idea that will begin to be widely implemented in 8 years' time. Finally, autonomous cars will be used, but they will probably not yet be fully implemented within 8 years. Although their final impact will be restricted by the regulatory laws that may arise, autonomous cars will be of great help in the distribution of parcels.

CHAPTER 1

INTRODUCTION

This research project will present how upcoming technologies are going to radically change the way we understand supply chain on any industry under the title *"Technologies Impacting Supply Chain in the Future"*.

As society evolves, new problems arise. The objective of this paper is to identify the problems that supply chain will face in the future, and the technologies that will solve those problems. There are many new technologies that are only used by few companies today. This paper will first cover an in-depth analysis of the main technologies that can undergo dramatic change in the short term. Again, keeping in mind that technology is used as long as it solves a problem.

To support the conclusions, research is conducted to include the views of those working in the industry. It is these people who can best understand the impact of each technology. Then, a more in-depth analysis is made over the main technologies that interviewees indicated as relevant. From there, four case studies are developed to see how it all comes together. Lastly, final general conclusions are summarized in the last chapter.

There are four goals for this paper:

1. Prior analysis of current and upcoming technology that dramatically affected and can affect the supply chain as a whole.
2. Developing a survey, presenting it to people involved in supply chain, and extracting all relevant conclusions from this research.
3. In-depth analysis of other major technologies that people from the industry think could have a dramatic impact on the supply chain as a whole.
4. Making a future projection of what four different industries will be like in the future based on all the research and data analyzed.

The industry is constantly evolving. Companies need to be competitive, and therefore they continuously make improvements by updating hardware or software. One of their options is to integrate new technologies into their processes to achieve better results.

But, knowing what changes are best is not an easy decision. Some technologies could be very profitable in the short term, but not so profitable in the long term. Current technologies are improving day by day, but new technologies are also being developed. Technologies that make prior ones obsolete. It is therefore important to analyze how technologies have impacted supply chain in the past, in order to anticipate which technologies may actually have a major impact in the future. Those who can efficiently solve the problems ahead.

For that reason, and in order to avoid spending time and money on technologies that could become obsolete in a couple of years, it is crucial to anticipate any upcoming technology. Thus, a company can accommodate any foreseeable changes more efficiently, by choosing the one that can present the best solutions to supply chain problems. By doing this, a company can be competitive in the long term.

CHAPTER 2

STATE OF THE TECHNOLOGY

There are a lot of technologies that have already changed the way the supply chain is understood and implemented. For instance, in 1848 Chicago (IL, US) became a great trading city when the Illinois & Michigan Canal was finally built (Chicago History, n.d.). At that time, the telegraph had only recently demonstrated its functionality in the US, with the message sent in 1844 from Washington, D.C. to Baltimore, Maryland (Morse Code & the Telegraph, 2009). Since the Pantelegraph was not introduced until 1865 in France, and the telephone patent was not expedited until 1876, the main way of communication in the US was the postal service (The History of Fax (1843 to Present), 2018). For this reason, for several decades, customers had to go to their suppliers' large warehouses to see what they had, what their stock was or even to check their availability to produce a certain amount of a product given a certain date.

Everything is different in that respect now. First, customers can check the availability of products from their computers (or even from their tablets or smartphones). This great transformation was due to the development of one of the main technologies that changed everything since 1844: the Internet. Internet was the one to completely ease the communication between customers and suppliers by allowing fast connectivity and communication (What are the Advantages of the Internet?, 2017).

Second, Internet has not only improved the ease of communication between the company and its customers, but also enhanced it inside the company. Instant communication and exchange of information have made from the Internet one of the greatest creations (What are the Advantages of the Internet?, 2017). On the one hand, Internet improved the coordination between different departments of the company, and, therefore, improved the overall efficiency of the company. On the other hand, Internet made it easier to gather data of how much products a company has in each warehouse or store. This monitoring made it possible to move products

from one warehouse to another depending on demand. For instance, Zara Store, the clothing retailer, has a 62h response in Spain (Zara's SC Keys, 2017). This means that if a product sells faster than expected, they have the ability to re-produce it in several new colors and distribute it in all Spanish stores in less than three days.

Internet has also been key for the development of other remarkable improvements indirectly, such as advances in forecasting. The increased ease of communication thanks to the Internet helped to augment the gathering of recent data that can be useful for a given company. Since the introduction of Enterprise Resource Planning (ERP) in the 1990s (which mainly improved data availability and accuracy), logistics has been considered a key factor in the supply chain to increase profits (History of Supply Chain Management, 2015). ERP is a system that today has expanded its potential to centrally manage all daily activities of companies, such as project management, industrial management and accounting (What Is ERP?, n.d.). In the beginning, though, ERP mainly allowed the interconnection of companies' databases, isolated before ERP (History of Supply Chain Management, 2015). Since then, its capabilities have been greatly enhanced. Nowadays, companies can somehow predict how much demand a specific product might have, and where that demand will take place.

Another example of technologies that have changed and improved supply chain is RFID (radio frequency identification), as well as its current cheaper competitor: barcodes. The latter provides companies with a simple way to identify a product. RFIDs, on the other hand, can contain much more information, such as the type of product or the number of products in a ballet. In fact, the latest RFIDs are even capable of transmitting information about vibration or temperature (Saunders, 2015). As an example, this is currently being used in transport of drugs that require strict temperature conditions to be maintained (Saunders, 2015).

The main problem in researching any kind of new technology is that technologies usually need to have proof or at least an in-depth study of their usefulness before any money is invested

in their development. RFID is no different. This technology was first developed for WWII, and implemented to help identify allied tanks and airplanes (Saunders, 2015). After that, its usefulness was obvious in identifying products or containers more efficiently.

That said, both positions will be considered in this study. First, explaining the actual impact of technologies that have already been tested. Second, making reasonable assumptions about the possible future impact that technologies may have on the supply chain.

2.1 INTERNET & MOBILE DEVICES

Internet has dramatically changed supply chain. On the one hand, it has simplified communication between customers and companies. On the other hand, it has also simplified communication within the company. Lastly, it has similarly eased the one between companies and suppliers. All this, by permitting instantly great connectivity and communication (What are the Advantages of the Internet?, 2017).

This has great repercussions on supply chain. For example, the faster the communication inside a company, the quicker information will be gathered on how, when and where products are sold. And, the faster you access that information, the faster solutions can be implemented.

In terms of figures, Internet was responsible for 21% growth in the GDP of a selection of 13 countries (GBs countries, China, India, Brazil, Sweden and South Korea) in the 5 years leading up to 2011 (Manyika & Roxburgh, 2011). In 2009, Internet accounted for 3.4% of the total GDP in average. Given this, Internet would have entailed a greater contribution to the GDP that year than agriculture or utilities, if Internet were consider a sector by itself (Manyika & Roxburgh, 2011).

Moreover, Internet has offered companies a tool that supports many other new upcoming technologies. An example of this would be IIoT (Industrial Internet of Things), a technology that fosters the connection of any device (such as manufacturing machines or trucks) to the Internet in order to receive (and send) information from (and to) them (What is IIoT?, n.d.).

Right now, the IIoT (Industrial Internet of Things) is starting to be noticed as a key factor that could have several applications on different aspects of supply chain, manufacturing and warehousing mainly. For instance, what if a machine can automatically detect anomalies in the time it takes to produce a certain component, and so alert a technician to evaluate that immediately. That could save the company hundreds of thousands of dollars by repairing the machine before it breaks down. And all this advances are possible mainly thanks to the Internet.

Also, Internet has enabled Computerized Shipping and Tracking which has recently impacted the way products are provided to the customer. The enterprise can now receive real-time information on where each of its products is at any time. This simplifies the way to track packages and reduces the number of shipping errors. It also helps to organize inventory, and provides the company with the option to create electronic invoices when products are already delivered.

Additionally, mobile devices are an important factor that has been developed in parallel with the Internet. Internet provides the ease of communication, but mobile devices are the ones that allow everyone to access any necessary online resources at any given time. First of all, smartphones allow national and international calls, while provide users with easy access to applications and websites for quick communication and interaction with mobile tools (reading the news, watching real time data, accessing learning modules…). And, beyond that 24/7 quick access to information, laptops provided everyone with the accessibility to more complex tasks. Even though this device is clearly bigger, a laptop adds the capability of doing work of any kind (programming, analyzing data, preparing presentations…), and still allows the user to take it with him and work on a train, an airplane, or even before a business meeting. Everything for less than 5lbs weight.

Lastly, and after recognizing the importance of mobile devices, this section could not end without the mention of Social Media. Giving companies the chance to communicate with

customers about shipping delays due to weather, or having the chance to gather information about customers' interests to provide a better service (respecting their privacy, of course) are two key factors that should not be underestimated (History of Supply Chain Management, 2015). Mobiles devices and Internet gives 24/7 connectivity to any individual, and Social Media is the one to provide the platform for worldwide open communications. In 2015, 70% of all companies in the Fortune 500 relied on Social Media as part of their supply chain and marketing strategy (History of Supply Chain Management, 2015).

These examples provide relevant data on how a specific technology can create a first impact, and then affect (after further development) on areas that could not even be thought of. Analyzing that interaction between technologies is one of the aims of this paper as well.

2.2 BIG DATA (PAST)

This element is important as key part of new technologies too. Being able to handle all the data that is produced every single second on the Internet is key to gaining an advantage over your competitors. Human beings are animals that have habits and needs, and that could be the reason that explains how massive data could give information on specific behavior patterns.

Getting to numbers, a McKinsey's report stated that US health care could have saved more than $300 billion per year by using big data creatively and effectively, boosting efficiency and quality (Manyika & Roxburgh, 2011). From all that money, 66% would account specifically to reducing expenditures. Given that the health expenditure per capita was $8,161 in 2011 (US Health Expenditure, n.d.), that makes a total cost of $2,546 billion, as the population of US on 2011 was 312 million people (Population US, 2017). That means that, only by using Big Data wisely, a minimum of 11.78% of the whole health care expenditures could have been saved in US on 2011.

Right now, the tendency has evolved. As the number of connected devices increases, and people use internet more and more (even for shopping food), more data is available. Nowadays,

it is estimated that only 33.5% of the data within a company is actually used (Barrett, 2018). The other 66.5% remains unused, whether it is due to lack of ideas on how to use that data, or due to impossibility to process more data for computational reasons.

Taking apart the computational aspect, and assuming companies take the most relevant data as possible, the key factor would be how to apply and use at least some of that 66.5% currently unused. A key element on this aspect is Artificial Intelligence. This technology has its importance on the analysis of any technology, and with Big Data is no different.

Artificial Intelligence (AI) would be the pillar that could sustain the comprehension of all these big pieces of data in the future. AI basically consists of algorithms that can learn by themselves, and take decisions over non-programmed environments (Marr, The Key Definitions of Artificial Intelligence, 2018). And, even though it is already in use, there are many things that still we do not understand about it. Not even its full potential. Can we develop a technology that is as smart as us? We do not know that yet. What we do know is that we need to keep on with it, because it has various ways to be implemented and almost not an area that could not profit from it (from arts to medicine). At least, its effects with Big Data are already taking place:

Artificial Intelligence is the one that, by interacting with the data generated by computers all around the globe, could provide companies with the power to generate better services, predict better product demands, and formulate better customer needs to provide more satisfying products. Machine Learning, ML, (an implementation of AI) is already being used, and it permits to train algorithms to differentiate, or categorize inputs. Not really understood yet, ML can easily differentiate with up to 90% accuracy whether a photo contains a cat or not.

2.3 RFID & BARCODES

As it has already been mentioned, RFID started on WWII (Saunders, 2015). They wanted that technology to assure no airplane would hit an ally tank nor plane, and vice versa. It is

currently used to identify products, but also to provide information about temperature or vibration.

Barcodes were the first solution to the inventory system. They were one of the greatest solutions to assure that same products were identified as so (Barcodes - Past & Present, 2016). No more paperwork needed in order to check in and check out products from a warehouse or a store. Barcodes were very beneficial to supply chain by easing the management of inventory of products, speeding up the whole process, and by making it more accurate in terms of recording the exact number of products on a warehouse, truck, or store.

Later, RFID appeared, and its potential did not go unobserved. This technology not only had the chance to store more data than standard barcodes, but, additionally, its reading time is ten times faster (Saunders, 2015). Mainly, the reader does not need to be placed exactly on top of the RFID.-Their signal can trespass the product on most cases (as it can depend on size and material of the product).

One of the main benefits of RFID, apart from its advantages over barcodes, is that they can firstly detect anomalies (on temperatures, for instance) (Saunders, 2015). In addition, it reduces operating costs by simplifying product management and being able to identify errors faster on a given order. Lastly, it offers consistent tracking and can provide faster warehousing management.

All benefits mentioned helped companies on the managing and tracking process. Its importance relies on the company's increase on efficiency. Given the company more time to dedicate on investigating and focusing on customer service, by reducing the time invested on putting orders together and tracking products location on the warehouse. Having a standardized and simple way of identification clearly enhanced overall companies' performance.

2.4 LIST OF MOST IMPACTFUL TECHNOLOGIES OF THE 20TH CENTURY

It is important to signal first which technologies impacted supply chain, and our way of living in general, in the past. It is the only way to agree on the definition of words such as relevance and impactful. The technologies that revolutionized the world on the 20th Century have been taken from two different sources. On the first source: historians, scientists, and technologists were consulted (Fallows, 2013). The second source was developed by one of the contributors from the company (History of Supply Chain Management, 2015).

We want to denote technologies such as the steam engine, which revolutionized the speed of travelling, and, more importantly, the massive move of goods (such as carbon, wood or food) on trains that could travel without stopping. As the electricity, which provided the opportunity to use energy stored anywhere, even far away in the distance. It impacted both homes and industry, deeply and equally. Lastly, as the shipping container, which permitted massive shipping, helping to make shipping cheaper and therefore incrementing the trade among countries separated by water such as China and US.

OVERALL LIST OF IMPACTFUL TECHNOLOGIES:

1. Pallets – Allowing vertical stacking (1925)
2. Forklifts (1926)
3. Barcoding patent (1952)
4. Semiconductor electronics (mid-20th century)
5. Standard steel shipping container is invented (1956)
6. The Internet (1960s)
7. Enterprise Resource Planning (ERP) systems (1960s) – Databases at first
    a. Improved data availability and accuracy
8. First computerized inventory system, IBM (1967)

9. Personal computer (1970s)
10. First real-time warehouse management system (1975)
11. RFID – Electronic Product Code [Auto-ID Labs, MIT] (1999)
12. Baxter – Industrial Robot able to learn any automated task (2012)

CHAPTER 3

ANALYSIS OF INDUSTRY TOP CHALLENGES TODAY AND TOMORROW

3.1 TRANSPORTATION

One of today's problems in supply chain is the **cost of transporting** items. On the one hand, there is fear that fuel might get more expensive (Top 8 Logistics Challenges Facing the Industry, 2017). This would directly impact the cost of transportation no matter if it is by train, truck, airplane or ship. On the other hand, having enough drivers for truck transportation is a problem as less and less young people want to accept the conditions given. Forbes states, though, that it is mainly related to salary, not to scarce of interest (Banker, The Biggest Supply Chain Fallacies, 2018). They claim that if salaries were to increase from $45.000 to $60.000 annually, there would definitely not be scarcity of drivers.

Speed of delivery is another problem many companies worry about. New levels of predictability and responsiveness are demanded from retailers to suppliers (Kuntze, Martin, Regnier, & Silva, 2018). Amazon, for instance, provides all its Prime members with a two-day delivery for most of its products at no additional cost. It has made the changes needed in order to provide this service, like implanting a two hours policy for picking, packing, and having orders ready to ship. Suppliers on the other hand (as well as other retailers, of course), are not quite at that high level of performance. Companies that can reach those levels of efficiency and speed are going to be able to capture a greater market share in the future (Kuntze, Martin, Regnier, & Silva, 2018).

Selecting the correct **transportation channel**, says Dan Clark, is as important as well (Clark, 2017). Many companies spend millions of dollars in freight, and, due to inefficiencies and non-optimal channel selection, they are losing hundreds of thousands of dollars. In his opinion, Transporting Management Systems (TMS) are going to be key in the near future. He believes that TMS might even become free in the future, as purchasing airplane tickets has.

And, whenever that point is reached, many companies might stop considering continue making orders prediction and freight decisions based only on spreadsheets. To reach the performance needed in the future, companies must start to use new available technologies. Relying on third-party services that are given by companies specialized on items tracking and transportation can leave companies without the current logistics problem, as well as provide it with extra money expendable elsewhere.

3.2 INVENTORIES

Another great problem supply chain is facing today is the **difficulty to control and track inventory** over multiple warehouses and stores. By augmenting the operating size, companies might end up not being sure on the amount of each product that is in transit between warehouses (Hidjaja, 2018). Totally disrupting the ease of distribution and inventory management. Additionally, it is equally important to assure that there is a common system shared among all warehouses and stores. Doing otherwise might led to risk of losing control over the amount of each product that each warehouse or store is going to have at different specific times. This lack of visibility could mean selling products that are unavailable or asking for resupply on products that the company already have.

Another key point apart from controlling and tracking inventory, is **reducing inventory**. Many companies are putting efforts on this, as the value of the inventory in stock is money that the company cannot spent until sold (Moses, 2018). Having more visibility can allow to go from a lower-speed system based on full trucks, to a system with quicker-response rates due to smaller shipments. With the whole-truckload system, problems in shipping made the company more vulnerable. By partnering with other companies into the same truck, or choosing lower-size shipments, companies can acquire better response to contingencies and therefore need less back-up inventories.

3.3 DEMAND

As a third factor, **anticipating demand and production needs** is key for any company (Hidjaja, 2018). Right now, many manufacturers have little information about demand on a given product. Therefore, companies have to estimate what are they going to produce with the amount of requested supplies using previous years' demand only. This makes companies to normally overestimate inventories in order to be able to respond upon changes in demand. Since every dollar in inventory is money that cannot make profit to the company until sold (Moses, 2018), ability to forecast demand more accurately is critical.

Moreover, forecasting demand efficiently would not only be helpful to reduce inventories, but also to center efforts on producing products with the highest demand. The Pareto principle states that many times 80% of the effects derive from the 20% of the causes (Pareto Principle, n.d.). Following that, by focusing on the products that are better sold you assure to focus on the 20% top-sold products that account for 80% of the final benefits of a company (roughly speaking).

3.4 TRACKING PRODUCTION & QUALITY ASSURANCE

As a forth factor, **product traceability** is key for a company too (Hidjaja, 2018). Not only tracking products when they are being distributed to customers, but also tracking their position on the production cycle. Many companies lack the ability to estimate accurately the exact position each of their products is at. For instance, an automotive company would benefit of knowing if they have fifty cars at the middle of their manufacturing process, and twenty at the very first step, and so on. Again, this is key to assure that efforts put on forecasting demand are not lost due to surplus inventory generated without notice. Producing the exact amount desired is as important as knowing how many of the total needed products are going to be ready at each given time.

3.5 PERSONALIZATION

The fifth factor is **product personalization**. Society is starting to value the fact of being given the chance to have a product that is different somehow to the ones other people have. Right now, companies are offering standardize products with small variations one from the other. But they are basically giving the minimum variation that keeps customers happy. Now that new technologies are arriving and being implemented, personalizing products is becoming more and more viable. People would be willing to pay extra money to be given the chance to add a sign, name, logo or symbol to their laptop. But companies need to incorporate new technologies in order to be able to provide this kind of services.

Additionally, in order to be able to provide personalized products, companies would need to **move their manufacturing operations** nearer to the customer. Now, that most companies produce overseas (in China, India…), providing personalization on products looks almost impossible. People may be willing to wait weeks (the actual 'boat' shipping time) for a personalized laptop, but probably not for most other products. Nevertheless, there are other products that could be personalized from abroad. An iPhone, for instance, takes in average only three days to reach a store in San Francisco from the factory floor in China (Barboza, 2016). This is due to the fact that iPhone's are transported by airplane (due to their compact size), which makes the delivery much faster.

3.6 PRODUCTION METHODS

The sixth factor is the production methods in which a company operates such as flexibility, speed and coordination. As companies grow around the globe, they have to face managing an increasing amount of factories as well as warehouses. **Integrating all levels of information,** from manufacturing to demand deadlines and supplies in transit, is key for any company's success (Ostdick, 2017). In order to be able to produce more efficiently, and not waste valuable time, information must be shared throughout the company: among all states of production flow,

demand and supply. Nowadays, whenever a contingency appears, many efforts have to be put from both management and plant-workers in order to follow an order and assure that it is delivered on time. Lots of communications have to be set one-on-one in order to gather all the details of both the contingency and each of the possible solutions. Integrating all the information, in order to gather all the data in an instant and make decisions quickly, is one of the huge challenges of both today and tomorrow.

The exchange of information is also key in the long-term, when talking about **Product Lifecycle Management (PLM)**. PLM is the integrated system that basically allows managing and automating all processes from the moment a product is conceptualize up to its retirement (Unraveling the complexities and nuances of modern Product Lifecycle Management (PLM) solutions, 2017). Companies keep trying to achieve faster time-to-market at lower cost, while adapting more complex designs that provide greater flexibility. But this is an issue when coordinating all prototypes throughout the lifecycle of each product. The procedure to solve this problem is given by technology and software that helps to keep track of all that, even between teams of a company that are miles away from each other. Here is where PLM has its greater challenge: to provide the ability to keep track of all the procedures needed on one single product. An automation and exchange of information that gets even more challenging when, for instance, the designing team is on a different country than the testing team. Hence, using all the technologies that the digital era provides supposes a great challenge that companies need to overcome.

Additionally, it is key to acquire the **flexibility and adaptability** that today is demanded (Demaitre, 2017). With all the new changes, advances, and customer demands, the more manually-operated a company remains, the less prepared to deal with contingencies. Matthias Heutger (senior vice president of strategy, marketing, and innovation at DHL) recognizes that DHL has automated only 20% of its operations in warehouses (Demaitre, 2017). While it has

a high degree of automation in the mailing part, it lacks all those advances in the delivery of bigger packages. The challenge in the warehouse is mostly the fact of automating the management of completely different package sizes, weights, and fragility. The challenge in manufacturing is being able to integrate the communication among machines and robots, so they can collaborate and send orders' information to each other. The less human-intervention in manufacturing, warehousing, and also the relation between both: the quicker, more flexible, and more reliable the whole manufacturing process can become.

3.7 CUSTOMER SERVICE

As a seventh problem companies are facing today arises the implementation of a great, quick, and **user-friendly customer service** (Top 8 Logistics Challenges Facing the Industry, 2017). Customers want their products to work properly. When they do not, they expect to get an easy way to reach the company for help. Companies need to handle a lot of requests, and personalize the service as much as possible. Right now, this is done well to some extent by some companies, and not good at all by most of them. The problem even increases when dealing with clients that want to change a recent order (Kuntze, Martin, Regnier, & Silva, 2018), or customers that want to return a given package (Top 5 Omni Channel Logistics Challenges Businesses Face, 2018).

Additionally, as another very important part of providing a good customer service is the fact of giving customers a good combination of both **online and physical purchasing** options. "Brick and mortar" was the term used to describe a physical retail store (Hudson, 2018). Nowadays, the term has attached a bad connotation: "old-fashioned" retailing style. Nevertheless, truth is that many customers still prefer to buy in physical stores. A research carried out on Fall of 2016 showed that 62% of Millennial shoppers still had preference for physical stores, rather than online retailing (Hudson, 2018). There is a clear debate (at both company and customer level) whether the benefits of online retailing will outstand the ones

that brick-and-mortar stores provide. Customers still value touching and seeing the product in person, but purchasing items online is normally quicker and can be done from anywhere (no buses, cars, parking, nor walking). On the other hand, companies would definitely prefer to sell online, as physical stores requires renting or buying an extra asset: a building. Knowing how to place the key minimum physical stores, and at the same time improve the online experience for customers, is key for any company that wants to stay in the retail business.

Lastly, providing customers with a satisfying and diverse set of **purchasing and delivery channels** is one of the great challenges of customer service today, and potentially greater in the future. This challenge belongs to the so-called "**Omni-Channel Logistics**" (Top 5 Omni Channel Logistics Challenges Businesses Face, 2018). It takes into account the processing of both orders made online and in-person; as well as both the package delivery to a physical store or directly to the costumer's doorstep. The customer is happier the more options are given. The company, on the other hand, has to be careful to manage all this channels efficiently. There are a handful of ways to deliver products to the customer's doorstep, the difficulty resides in selecting the correct transportation in terms of both efficiency and effectiveness.

3.8 Environmental Concerns & Sustainable Operations

The great effect that a company has in the environment that surrounds its activity is clear. And no matter if they do want to change to the better or they do not, there is always a possibility of **new more restrictive environmental laws** arising (Top 8 Logistics Challenges Facing the Industry, 2017). So, no matter if they are planning to change or not, companies are aware of the huge problem that could derive from reaching an operation cost greater than the current benefit. If companies should or should not look for the environment themselves could be argued. Anyhow, if there is no benefit, there is no company. Then, as long as laws are enforced to assure sustainability, companies must analyze how sustainable they are in order to assure profitability in the long term (avoiding being caught off-guard). Truth is that many times fines

are cheaper than changing the whole producing system. But that would be the topic of a different research.

Fortunately for the environmentalists, there are new currents of thought that encourage customers to be concerned about the way in which companies operate (Lopez, 2017). Companies are starting to increasingly care about environmental issues in order to maintain a **good public reputation**, and sometimes this can be an operational challenge. Truth is that companies can also benefit from being sustainable. Karin L. Bursa (Executive Vice President of Marketing at Logility) states that a good design that reduces the amount of waste, or increases the durability of products, can actually save money to the company (Lopez, 2017). In that same report, Cathy Morrow Roberson (Founder and Head Analyst at Logistics Trends & Insights LLC) indicates UPS' efforts to reduce polluting as a good sign. In 2016, UPS reduced its CO2 emissions by 100,000 metric tons after adding 440 much less-polluting vehicles based on compressed natural gas (CNG) and liquefied natural gas (LNG). Not trying to fool anyone, she states that companies are also driven by personal motives. Many companies share their willing to reduce its CO2 footprint by transporting more efficiently, which in the end also means less fuel spent by the company.

CHAPTER 4

UPCOMING TECHNOLOGIES AND IMPLEMENTATIONS

4.1 SLAT SORTERS

Figure 1. Slat Sorters Illustration (Sliding Shoe Sorter, 2017)

Slat sorters are a not-so-recent kind of sorters that are better known by the name "sliding shoe sorters" (Shoe Sorters, 2018). They have existed for decades, but they still are not massively used. The greatness of this technology is that it provides the company with an easy and careful way to divert products on different conveyor belts. Generally used to separate products that are arriving into different parts of a warehouse, or to separate products from the warehouse into trucks with different destination.

The greatness of this type of sorters is the quick way in which they can sort products. It can take up to 225 cartons per minute, which means (assuming 20'' as the average length of a package) an speed of 6.25 feet/s (Shoe Sorters, 2018). Anyhow, speed is as important as effectiveness, and that is why this technology can be very useful. They provide 100% accuracy at greatly high speeds. And they can also provide up to two different directions to divert each product.

Even though this technology looks simple, it can solve several of the challenges companies have to face today. First, slat sorters can help to *speed-up deliveries*. By assuring quicker times with 100% accuracy, companies can be less worried about not reaching customers' deadlines.

Basically, less time is needed for the order to be at the sending point of the industrial plant (or warehouse), and no orders are lost or misplaced in its transit.

Secondly, by allowing faster accurate speeds inside manufacturing plants and warehouses, this technology can help to facilitate *inventory reduction*. Slat Sorters shrink the time from the moment an order is placed to the moment the requested package is in front of the corresponding truck. Similarly, a package that arrives to a warehouse needs less time to be processed and sent to any part of the warehouse or to another truck. This improvement in speed implies no need to prepare or send orders with much time in advance due to delays in processing or trucks' loading. This more reliable system allows companies to stop using full-loaded trucks. Opposite, companies can rely on smaller trucks or vans that additionally provide greater flexibility in case of contingencies. Moreover, when using full-loaded trucks, half or more of the packages are sent with unneeded extra time, as the time limit is set by the order with nearest deadline. Relying on less and smaller dispatches would additionally help companies to send packages closer to its deadline, and therefore having them less unnecessary extra time in the warehouse without motive.

Lastly, the more automated the process, the more *flexible and adaptable* the whole system becomes. Again, faster speeds and perfect accuracy provides the company with a contingency-proof infrastructure.

4.2 OMNIDIRECTIONAL SORTERS

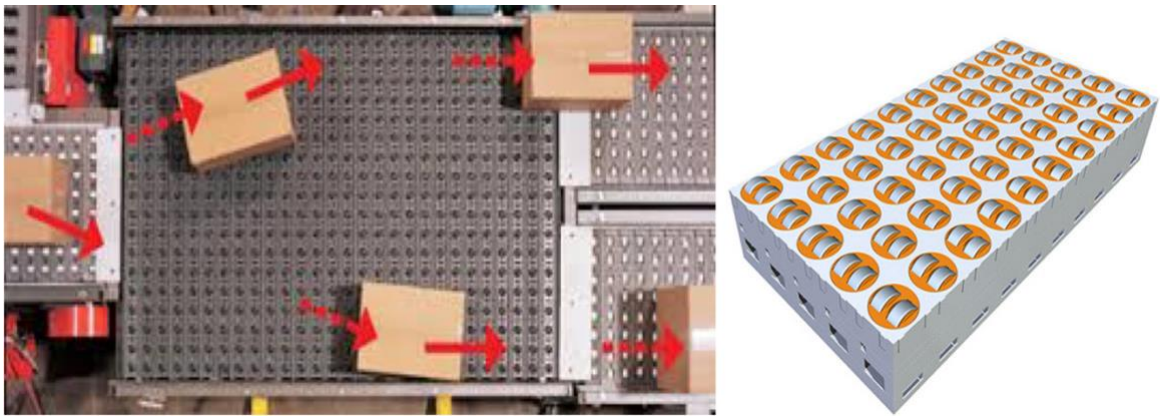

Figure 2. Omnidirectional Sorters Explanation. Figure in the left presents the packages sorting system (Gavin Materials Handling Ltd., 2018). Figure in the right shows the rotatory-system (Omni-directional Transfer Tables for Roller Conveyors, for Crossings, Diverters and Sorters, 2018)

Even better than the one above, omnidirectional conveyors have the capability to differ the product on any direction (Conveyor Switches and Crossings with Avancon OTU, 2018). This provides the company with the chance to diversify products in lines on the very same conveyor. Avancon's sorters can get to speeds up to 5 feet/s (Conveyor Switches and Crossings with Avancon OTU, 2018). Even though it is much more expensive, this technology can be used to receive packages from several different conveyors and distribute them as needed. It could theoretically be used as a sequential conveyor that connects trucks and parts from a warehouse, and have packages going and coming both ways. Truth is that having an all-omnidirectional conveyor belt would be currently too much expensive. Its current uses, as stated already, are diversifying and receiving packages to and from different conveyor belts. Additionally, this technology can be used to add an extra conveyor belt for return, in case any package needs to be sent back to the beginning without having to wait until it reaches the end instead.

The benefits of this technology mount over the ones stated for slat sorters. Firstly, it can equally help to *speed-up deliveries*. Secondly, *inventory reduction* can also be satisfied with this technology, with the added value of being able to create much more complex infrastructures with less conveyors required. As stated before, this technology could be used to

separate packages in one direction, but also packages in both directions. Thirdly, omnidirectional sorters surpass the ability of slat sorters to give a more *flexible and adaptable* system. They can permit, for instance, to stop and send back a delivery that was incorrect, preventing it to go any further in the conveyor belt.

4.3 3D PRINTING

This technology, also called additive manufacturing, is only used at small scale nowadays (Banker, 3D Printing of Spare Parts, 2017). The type of material and size of the machines needed to provide highly bulky products makes them clearly expensive, and so not affordable nor profitable for most companies today.

Nevertheless, the way it is used right now could give us hope after all. Some companies are starting to rely on other specific companies to produce smaller components. By outsourcing the manufacturing of those small components, the company benefits from cheaper components, while the specialized company does have profit.

Personalization using 3D printers would be easily applicable to fully 3D-printed products. When thinking about personalizing only some parts of a product (such as the home button of a phone, or the borders of a TV), it seems as if the final assembly (where all elements are put together) would have to be wherever 3D printers are placed. Nothing further from reality. Products could be design to have a base element with exterior attachments wherever the personalized part is supposed to be placed. Products could then be assembled and sent without the personalized parts. In the 3D printing location, parts are attached to the product. The idea would be to use non-screw attachments, such as the ones you find in the back of most android phones.

Also, additive manufacturing can provide instant production of small items close to the customer (maybe even at home-level). Whether if a user wants to get a toy for his kids or a new

vase (or piece of cutlery) that just got broken. The possibilities are endless, and the cost of an individual and small 3D printer will go down as this technology is more used and developed.

This closer-to-the-customer manufacturing could even take place at home level, where customers would have a 3D printer in their homes (such as people have regular printers at home today), or maybe one per building. Another possible options is for 3D printing to be offered as a service provided at physical stores. Fully 3D-printed products would then become patents over virtual designs. On the one hand, it could happen that companies decided to have their own physical stores to print final products and show physical models to customers. More likely, though, this companies would only have the virtual design available online, as it would mean saving on renting or purchasing a physical store. Products would then be available to be printed at any physical store that provides 3D printing services. Securing each design would then be crucial to avoid easy-copying of products' designs.

Focusing first on **3D printing in general**, this technology would firstly solve the *personalization* that customers are so willing to receive. On the one hand, 3D printing would allow to provide customers with different variations on a product, like a laptop cover. Among the options given users could for instance add logos or drawings to their product. Secondly, Artificial Intelligence (AI) could enable users to incorporate their own more complex designs. Basically, AI would tell the user what the 3D printer can or cannot do.

Nevertheless, this implementation would then force companies to *move their manufacturing process* closer to the customer. People would wait up to one week to receive their personalized product. But now that most products are massively produced in Asia, people would not wait for weeks for their personalized laptop cover to arrive. As long as the manufacturing is done in the same state (in US instead of China, for example), the delivery would be done quickly.

Secondly, companies could easily *reduce inventories*. Assuming that the manufacturing is closer to the customer, there is less need to have a lot of extra products going from the manufacturing plant (in Asia) to each of the warehouses. Truth is that this only fully applies for products that are fully created by 3D printers, as they do not need any further processing (such as laptop covers, decorative elements or canteen bottles). In case of personalization of only some parts of a product (such as the handles of a suitcase), it would require to have all other pieces in inventory (assembled or not) prepared for the final assembly. Therefore, inventories would remain somehow similar.

Thirdly, companies could definitely benefit from much greater *flexibility and adaptability*. Companies could make changes to any product design that is showing any kind of weakness in an instant, without needing to readjust any machine. This would be a great upgrade in customer service, and an increment in customer satisfaction. Also, for fully 3D-created products, in case suddenly an order gains preference over the rest, it can easily be included on top of the queue. On current manufacturing process there would be a lot of pieces in the middle of the chain, making the problem much more complex. On the other hand, for personalization of only some parts of a product, 3D printers could compromise the companies' flexibility if it is not carefully implanted. This is due to the fact of final assembly-to-order for very customized orders, which gives no much time for delays.

Lastly, 3D printers would provide companies with the *good public reputation* that they want to show. Usually, 3D printing uses much less material, and therefore saves a lot of material that is sometimes directly thrown away. And even in the case of recycling that material, 3D printers do not even waste resources on making that product reusable again: no need to transport the material to the recycling center, nor to spent energy in, for instance, melting the metals again for producing new metal sheets.

Continuing from the benefits explained above, the potential even increases when considering **3D printing really near to the customer**. Firstly, for fully 3D printed elements, this technology would almost definitely erase the *cost of transporting items*, augment the *speed of delivery*, and solve the problem of *reducing inventory* up to almost no inventory at all. All this would be achieved by taking the whole manufacturing process directly to customers' hands. It also would solve the problem of moving the *manufacturing process closer to the customer*, as it would be on his home, or at a mile distance maximum in case of a physical store. Again, for not fully 3D-printed products, all this benefits are not applicable.

Nevertheless, for products that have only part of the elements personalized, it would clearly help providing much more *flexibility and adaptability* whenever any of those parts needs to be replaced. The customer could quickly print any of the needed parts on its nearest physical 3D printing store.

Additionally, for the fully 3D-printed products, as well as for the parts personalized on a product, *Product Lifecycle Management* gets much more manageable. Companies would not have to carefully deal with the initial nor last states of a product, as it could be all managed online.

Moreover, the company could decide whether to have or not a physical store in order to provide both *online and physical purchasing*. This would make sense whenever a company is willing to also attract buyers that need to see the product. Additionally, by having the whole design of a product (or a part of a product) available online the company would be further improving its *Omni-Channel Logistics*. Any customer would have the chance to get the product from any 3D printing store, or from home.

4.4 IIoT (Industrial Internet of Things)

As it has already been commented the Industrial Internet of Things (IIoT) has a great potential. The principle behind IIoT is to provide an infrastructure where machines are all

connected through the internet. It takes into account all types of machinery and elements that take part of the supply chain such as manufacturing machines, conveyor belts, RFID scanners, and even delivery trucks. For instance, this technology would let machines to communicate with the central station to alert of a possible problem on its working process, which can save a lot of money to the company. The sooner and more accurately an error is reported, the sooner and better it can be addressed.

Firstly, IIoT could address the nowadays requested *faster speed of delivery*, as well as the difficulty of *controlling and tracking inventory*. All information could be shared across warehouses, manufacturing plants, and deliveries in process (received from truck information)~~,~~. This would provide exact accuracy of the products available at each location at each given time. That information would then help to make better and more informed decisions. Ultimately, access to better decisions provides greater chances of meeting deadlines as contingencies appear.

Secondly, having more accurate information can also help to *reduce inventory*. The more exact data available, the less extra amount for each product is requested due to products in transit that are not taken into account. Also, by having information spreading faster among the system, the less extra inventory is needed in general. Responding to contingencies would be quicker, and therefore requires less safety inventory.

The third great challenge that IIoT would be solving is *product traceability*. As manufacturing machines are connected to the central system, they can directly provide accurate information on how many parts are being processed at each time. In the end, companies would know exactly how much pieces are at each step of the manufacturing process at any given moment. This provides companies with even more accurate information about product inventory, by taking into account the future final products or orders.

Product personalization could also be empowered by IIoT. It could, for instance, connect 3D printers to the central system. This would allow companies to send and manage orders directly online. Additionally, management could change orders' information and importance, in order to meet customers last-minute changes and deadlines, respectively.

In fifth position, IIoT could help to *integrate all levels of information*. As said before, this technology can gather information from manufacturing, warehousing and transporting. This would help to face any contingency that might appear by giving priority to a special order or component required, due to an urgent order that might arrive at any certain point. Additionally, IIoT can also provide really high levels of *flexibility and adaptability*. It certainly gives the chance to change orders and production of each machine on the go. But is can also communicate multi-purpose machines to change their current state in order to produce a very different component needed, without any human intervention.

In sixth position, as the information gathered is more accurate, companies can provide customers with more accurate information about the state in which their order is. Giving a better and personalized *customer service*.

As an additional benefit, if a producing machine is able to communicate with its surroundings, it could *prevent safety hazards* whenever it detects that a certain element is not positioned where expected for a specific module that is going to be produced. For instance, when a machine massively produces equal items, and it is commanded to change to a different producing mode.

Lastly, machines could have inner sensors that could, for instance, detect abnormal vibrations. This would be very useful for *preventive maintenance*, by letting management know when a machine has detected anything abnormal that could suggest an eminent failure. This report would allow management to check the machine status, assuring it does not break sooner than expected. For instance, a machine might need lubricant oil. If nothing is done, the machine

breaks, and a repair must be done. But if abnormal vibrations were detected: an analysis would be done, and the oil problem would arise before it finally breaks.

ALL BENEFITS:

- DESIGN
  - ✓ New designs could be directly sent to each producing machine without any human interaction needed
- MANUFACTURING
  - ✓ Errors could be communicated more accurately to management
  - ✓ Hazards prevented from possible misconnected elements on a machine that produces huge lots of equal items
  - ✓ Quicker, more efficient and less time-consuming communications where actions can be taken automatically
  - ✓ Preventive Maintenance that allows a machine to auto check its general status
- TRANSPORTATION
  - ✓ Trucks letting management know their position and time expected for arrival to destination
- WAREHOUSING
  - ✓ Automatic control of inventory, and request of any product needed directly to factory
- CUSTOMER SERVICE
  - ✓ Products could collect data (whenever the user agrees) to make future improvements

4.5 AUTONOMOUS DRONES AND FORKLIFTS

This technology has already been implemented somehow up to a point on several companies, but has a clear greater potential to be expanded. Autonomous forklifts are the ones that have more popularity, normally following a line to omit any unexpected intersections, they are given the order to go from one point to another. Normally to move large packages from a

specific conveyor, to the specific truck's conveyor specified. No intelligent decisions to be taken, only repetitive tasks. But it is difficult to rely on a product with no eyes.

On the other hand, autonomous drones are rarely used. Only a couple of companies have taken the risk to implement this technology, and only a few are investigating using this. But this technology could definitely impact warehousing, as well as the last mile delivery too. Firstly, if a drone is provided with RFID technology, it could check that all products are positioned on the specific place where they are supposed to be. Secondly, drones could also be very helpful on the last mile, as they could deliver packages in areas where such technology could be adopted. For instance, drones could deliver packages in the garden of condos that are located far from each other and far from the main route; making the delivery fast and easy. Also, it could help to deliver products to the terraces of different houses in the same block, saving a lot of time as well.

Lastly, the combination of both autonomous drones and forklifts can seem promising. While the drone can assure each product is positioned on the exact spot where it is supposed to be, the forklift can now go to any needed spot in order to pick it up and then go and put it wherever is needed. To avoid security concerns of forklifts moving autonomously among workers walking on the warehouse, it could all be combined with IIoT. If every worker was provided with a transmitter on its helmet, the forklift could know when a worker is nearby and stop or reduce its movement whenever needed.

4.5.1 Autonomous Forklifts

The main benefit of autonomous forklifts is that it helps to *automate repetitive tasks*: carrying heavy valuable orders from one specific point to another. Its mayor benefit is the fact that it can work at highest performance all day long without getting tired due to the repetitive task.

4.5.2 Autonomous Drones

Autonomous drones have greater benefits in the supply chain. In the first place, it can help to *integrate warehousing information*. Its ability to move faster throughout the warehouse provides the infrastructure needed to check items availability in the warehouse at any given time. Additionally, they could be used to provide more *flexibility and adaptability*. Due to its high speed, providing drones with cameras to check manufacturing plants' or warehouses' status can be helpful as well.

Additionally, by using drones to deliver packages into condos or houses far from the main delivering route can help to increase *speed of delivery*. At the same time, it provides a new *channel of transportation* that can be cheaper when saving time and fuel, as drones can deliver in straight line but trucks or vans cannot.

4.5.2 Autonomous Drones and Forklifts

Putting those two technologies does not only imply the sum of the individual benefits. Drones can provide the opportunity for forklifts to pick up deliveries from wherever in the plant or warehouse. As long as the drone can tell where the order is placed, the forklift can follow an automated path in order to pick it up. This gives additional *flexibility and adaptability* to move packages throughout the warehouse.

ALL BENEFITS:

- MANUFACTURING
  - ✓ Repetitive move of packages could be totally automatized
  - ✓ Packages would be moved quicker throughout the warehouse and pack
- LOGISTICS
  - ✓ Packages would be moved quicker on the warehouse, trucks loaded faster, and therefore the customer could receive packages earlier
- WAREHOUSING
  - ✓ Packages could be managed quicker and more accurately

4.6 AUGMENTED REALITY IN SUPPLY CHAIN

Augmented reality consists of overlapping virtual images over reality. The user has to put on a pair of glasses that allows light to go through, and, over that, show the user virtual images. By doing this, the user can see any virtual image over the environment that surrounds him. This could be very helpful in various ways. From helping workers to prepare orders by showing them each order details on top of the order box; to letting machines to directly show workers a 3D path to reach the place where a problem has occur.

Augmented reality can firstly increase the *speed of delivery*, mainly on the warehousing side. In order to meet deadlines effectively is key to assure that deliveries are not delay due to contingencies in warehouses or producing plants. By providing workers with instant information of errors in the plant, delays are shortened. Workers waste no time in detecting where an error has taken place, they are provided with a direct path to the problem. Also, by having 3D visualization of the problem, they can more easily detect where the failure has taken in any machine.

Secondly, augmented reality could help with the *difficulty to control and track inventory*. They can be shown the details of every order that is moving throughout the warehouse. If glasses are provided with QR and/or RFID scanners, workers can even get accurate information showed in real time on each package with no wasted time in entering any kind of code.

Augmented reality could also help in *product personalization*. If customers where provided with the glasses, they could see the final result of the products they are ordering, with all the personalized features. This would assure customer satisfaction on personalized products.

Also, Product Lifecycle Management (PLM) can be empowered by augmented reality. The part where this technology would be the most useful would be in design. Product designers could see the product in 3D, and easily make corrections on the go. Cooperating and commenting designs with other designers would be a much rich experience as well, both in

person and in online cooperation. Additionally, being able to compare products one to another in 3D can help to ease the improvement of past products.

The fifth challenge that would solve augmented reality would be *flexibility and adaptability*. Again, by tracking the products (and incidents occurred) in real time with 3D information showed without any code scanner, workers time can be spent in more valuable tasks such as solving any problems in production or machinery. Additionally, it can empower workers to prepare each customer's order. As said at the beginning, it can help workers to identify each product that is on the list of an order, and assure that those are the ones that are put into shipping. It would diminish the number of order errors.

The last two factors that augmented reality (AR) can solve are providing a *user-friendly customer service*, while improving the *online purchasing* experience. With a pair of AR glasses, customers could take advantage of seeing the final product in 3D even from the comfort of their houses. This feature would create a new user-friendly manner for the customer to evaluate the product from anywhere. This service would increase customers satisfaction with online products purchases, thereby increasing the amount of people that are comfortable shopping online. AR could even make online shopping an even more satisfying experience than in-person purchase for some items. For instance, it can let customers see how a table really fits in the living room, or how a lamp would light the dining room. And on a physical store this would be impossible.

Companies would also benefit from this, as they would need less stores from the moment more customers are comfortable buying online. Also, they would need less room on each store. Big items could be stored somewhere else, but still be shown to the customer virtually whenever they went to the store for something else.

This new experience would form part of the *Omni-Channel Logistics*. Efforts would have to be put in order to assure that customers are happy with this new experience. Truth is that, as

it is mainly all software, its integration is somehow easier, shorter, and less expensive (once developed of course).

Lastly, empowering augmented reality could be seen as good thing in relation to environmental issues. Companies can get a *good public reputation* when investing money in AR features, in order to diminish the quantity of non-selling models they produce.

Additionally, it would help to ease the interaction among humans and machines. If a forklift is moving autonomously throughout the factory, it could signal its path and make sure that workers are aware of it. This would diminish almost completely the possible accidents from the implementation of any new upcoming technology. Also, it could help workers to set up machines that need a configuration before it is set up. The worker could see which the new configuration for the machine is, and what steps to follow in order to prepare the machine correctly (such as setting the cutter to a certain height, or two pieces forming a certain angle). This would firstly reduce the number of accidents, as well as it would ease the time spent on worker's training.

ALL BENEFITS:

- DESIGN
  - ✓ Let designers show the product to the customer, and receive feedback from them before even investing money on the manufacture of a new product
  - ✓ Designers could put their designs in their hands, and see the appearance on a given set if necessary
- MANUFACTURING
  - ✓ See any package or machine problems
  - ✓ Help workers to set machines to next operation mode (when changes are needed)
- TRANSPORTATION

- ✓ Help drivers know which items must be given at each place with ease (by pointing signaling it with another color)

➢ WAREHOUSING

- ✓ Follow up orders and items with ease
- ✓ Assure if a specific item is requested for different orders at the same time
- ✓ Help workers to move throughout the plant avoiding incidents with autonomous machinery

➢ CUSTOMER SERVICE

- ✓ Get products accessible to the customer from their homes
- ✓ Less and smaller stores
- ✓ Less time spent on explaining customers how to mount or set a product (virtual and interactive explanations)

4.7 VIRTUAL REALITY IN SUPPLY CHAIN

Virtual Reality's (VR), unlike Augmented Reality, fosters to put the user in a completely different environment. The user has to put a pair of glasses that have an inner display. In order to give a 3D feel, they normally have two separate displays (screens). Basically, each of the two displays shows the environment from a different perspective, exactly, at eye separation length. This is why it actually creates the 3D feel of really being on any given environment. Right now virtual reality is mostly used at gaming level, where VR is sold as an extra feature to gamers.

The first challenge that VR could solve is the *transportation of products by trucks*. As stated when commenting the challenges to face in supply chain (Chapter 3), if new generations are willing or not to keep on being truck drivers is not clear yet. Anyhow, to help and improve drivers conditions, VR could allow truck drivers to drive from a specific transportation spot remotely. This would ease truck drivers to have a permanent home, as it would also reduce company's costs due to actual continuous relocation of drivers. It would also help, if not to

drive, to supervise trucks paths and patterns from the same transportation spot whenever autonomous cars are introduced.

Secondly, this technology can help to really increase the *speed of delivery*. Right now, for safety reasons, truck drivers are forced to rest every certain amount of hours. If trucks were controlled remotely, different driving turns could be stablished from the same central station. By stablishing this infrastructure, delivering times would be shortened, and meeting deadlines while dealing with contingencies would be easier.

Virtual reality could also indirectly help with *inventory reduction*. If delivery times are shortened, less inventory is needed at each warehouse as inventory backup could be quickly sent from elsewhere.

Fourthly, VR can also help with *product personalization*. Similar to what was said on augmented reality, customers could see their final products in 3D. In this case, of course, customers cannot possibly see their products on top of the reality though, but only on the virtual environment.

Next, *flexibility and adaptability* can also be empowered by VR, by letting managers and supervisors to check the plant remotely. Giving them the chance to supervise even when the circumstances do not allow them to be there personally. No matter if it is due to an overnight problem; a business travel to see suppliers and clients; or a trip to attend a company's meeting.

Similar to what was said in augmented reality, VR can also generate a new *user-friendly customer service* that would enrich the *online experience*. Virtual reality would allow customers, not only to check one item at a time, but to check the whole store from home. The service could even go beyond, by providing customers with personalized stores depending on interests and previous purchases.

Companies would benefit from this even more than with augmented reality. They would need almost no stores in order to show their products to clients in a store-like environment.

Additionally, rearrangements on stores would be carried out instantly (not weeks, nor months) and more than 99% cheaper as it would be only software programmed (no material investments).

Again, similar to AR, this new experience would start to form part of the *Omni-Channel Logistics*. Efforts would have to be put in order to enrich the user experience.

Virtual reality could also be very useful at *robots' safe-integration* in supply chain. VR provides the precision of a robot, with the know-how and more intelligent decision-making process of human. And all, without the necessity of having the human exposed to the thread of a dangerous task, like cutting himself by mistake with an industrial cutter. Additionally, the worker would neither be exposed to a robot's failure. To understand the potential of machines empowering humans, we could mention the Da Vinci medical robot. It enables doctors with a much more precise way of accessing and operating on difficult areas. And in this case, there are not even task-related hazards to be avoided.

ALL BENEFITS:

- DESIGN
  - ✓ Designers could see their products virtually, and set them on the environment they are supposed to be (as seats on an airplane, or a wardrobe on a house)
- MANUFACTURING
  - ✓ Supervise the plant from anywhere
- TRANSPORTATION
  - ✓ Trucks could be driven remotely
  - ✓ Supervise trucks paths and patterns
- CUSTOMER SERVICE
  - ✓ Get personalized stores accessible to the customer from their homes
  - ✓ No physical stores needed

4.8 AUTONOMOUS TRUCKS

This technology is the one that society is most aware of. If not from trucks themselves, from its almost identical implementation on cars. Tesla is well-known from its efforts in developing a completely hands-free car. There are different levels related to a car's automation. From cars that alert the user whenever they might be out of the lane; to cars that autonomously redirect the car into the center of the lane, or cars that drive without human interaction up to a point where the car alerts the user that in a certain amount of time (maybe 1 minute) it might need the user to take control of the car. The ultimate goal, of course, is to create a car that would be able to drive even in non-familiar nor programmed situations without any human intervention at any time.

Nevertheless, we are still far away from that point. The first fatal accident due to an autonomous car has already taken place. There is much to be developed from now until cars can ultimately take decisions and drive completely autonomously. Additionally, it is going to take time before human beings start to trust this technology. People want 100% accuracy, not just very good ratios avoiding accidents. Yet, there is no doubt that whenever implemented, this technology will be very useful.

As stated on virtual reality, autonomous cars could help to reduce the *cost of transporting items*. No more truck drivers that have to be away from home for long periods of time, as trucks could be supervised remotely by drivers, if necessary.

Again, the *speed of delivery* can highly increase as there is no time spent on driver's rest defined by law. Supervisors rotating-turns over a series of truck (if even needed), could be established and implemented from the controlling location. This shrinking on time to deliver would definitely help companies to meet deadlines, and provide greater customer service. Moreover, autonomous cars would be providing better times at cheaper rates.

As delivery times are improved, *reducing inventory* becomes a reality. As it has already been suggested with other technologies, by reducing response times to unforeseen events, less inventory would have to be stored as backup. If any contingency were to take place, needed products could be provided from somewhere else in much less time. In accordance to the latter, *flexibility and adaptability* are also highly achievable for the same reason. A quicker system is always better contingency-proof.

Lastly, autonomous vehicles in general could become part of the *Omni-Channel Logistics*. Packages could be deliver to customers during the night with no extra cost and at a quicker rate, due to no traffic jam at night time

Lastly, Artificial Intelligence is the one that can ultimately empower autonomous vehicles. AI is the one that can give trucks the possibility to take decisions on non-trained environments, like traffic accidents. Also, AI would be the one that could greatly enhance the routes trucks follow. Quicker and more efficient deliveries could be established based on traffic, number of orders, or real-time change of deliveries' location (made by package receivers).

ALL BENEFITS:

- LOGISTICS
  - ✓ Real-time control and monitoring of trucks for better and quicker deliveries
- TRANSPORTATION
  - ✓ Lower transportation times
  - ✓ Better quality of life for truck drivers (after being changed into remote drivers)
- CUSTOMER SERVICE
  - ✓ Quicker deliveries
  - ✓ 24/7 pick up spots

4.9 COLLABORATIVE ROBOTS

Robots have been developed and improved for a long time now. Collaborative robots are a new step in the robotics industry that tries not only to develop capable robots, but robots that operate with other robots and/or humans. Truth being said, since a few decades ago, many efforts have been directed into how to humanize them correctly. The main objective behind all this is to make robots more attractive to human eye. To make people trust this technology. Nowadays, there are robots that can express their "feelings" on a digital screen that shows a pair of eyes, a nose, lips, …; an equivalent to a facial expression.

Anyhow, there are clearly some tasks that people would happily let robots do without doubt. For instance, in the case of any repetitive task where the work must be done the same, such as building electronic boards. This task requires each piece to be located in the same specific spot, over and over again. Similarly, robots could be very helpful in any dangerous environment. A human could be supervising, commanding, or even collaborating with the robot. When talking about supervising and commanding, no artificial intelligence is needed. The robot would be doing the task without any added hazards due to possible programming errors; while the human would be safe working from outside the working environment. On the case of human-robot collaborative robots, Artificial Intelligence (AI) is key. AI would be the one providing robots with the ability to react until unexpected situations where a human life is at stake.

Lastly, when collaborating with human beings, robots would need to be always aware of the whole environment. And take into account any human that might be near them. But, if achieved correctly, Collaborative Robots would be the key for personalization, quick response to customers, and integrated and autonomous production based on customer requests and forecasting. Robots would be able to work quicker while producing better quality products as well.

ALL BENEFITS:

- MANUFACTURING
  - ✓ Automating repetitive tasks (robots do not get bored)
  - ✓ Doing any dangerous tasks for humans (like cutting metal or wood plates)
  - ✓ Being able to receive in real time customer orders
  - ✓ Adapting orders and responding consequently by defining the work process based on customer needs and producing capabilities
- CUSTOMER SERVICE
  - ✓ Quicker deliveries
  - ✓ Provide the infrastructure for easing the personalization of products

4.10 BLOCKCHAIN

This technology could be very beneficial for companies as well. For those who are not familiar with blockchain, it is mainly a huge database that is shared by many computers on the network and stores records of any kind, all of them secured using cryptography. As it is shared globally by many computers on the network, it cannot be changed by a single computer (there relies the security of the whole system). Sharing data among many computers in the network provides more reliability, but at the same times it may seem that the information can get compromised. Nothing could be further from the truth. Firstly, as there are many computers in the blockchain network, each computer does not have all the information, but only a small piece. Secondly, even if they were to extract that information, the information is highly encrypted.

Many projects are being developed using this technology. From Bitcoin, that simply uses blockchain to assure each transaction and each user's balance is correct and valid, to Ethereum, another cryptocurrency that has also attached the capacity to create Smart Contracts. The mainly benefit for this last cryptocurrency (apart from the value of the coin itself) is the ability to buy and sell things safely from the real owner in milliseconds, without any paperwork needed and through an automated order if desired.

Other project that could be mentioned is the one that attempts to use the globally shared tool to store data. By buying that cryptocurrency you have the chance to use certain GBs of the total blockchain. Instead of paying for the storage service to an online server, the user has access to the given GBs while investing on that cryptocurrency at the same time.

The main benefit that blockchain could add to the industry would be to track the veracity of a product's origin or a company's operating processes. This would help people to get informed in order to divulgate a *good or bad public reputation* of each company. For instance, if a company wants to assure to their clients that their products are produced inside the US, or that they have been developed by fair-workers-wages. Nevertheless, Forbes claims that those kinds of affirmations cannot be assured as long as the person in charge of inserting the data in the first place is allowed to lie (Banker, The Biggest Supply Chain Fallacies, 2018). A beef distributor might assure that their beef is grass fed, but the farmer supplying them could have lied about their origin in the first place. Steve Banker (Forbes Contributor) states the importance, and still needed figure, of certification companies.

Truth is, though, that there are other ways to bypass the exhaust examination of every single product for same companies and retailers. For instance, users and companies on the blockchain could be rated. Whenever a farmer is inspected, their report goes online. This way, if a farmer has several consecutive reports that assure their beef is grass fed, anyone in the network can trust that they are saying the truth, and the veracity of the distributors statement is therefore based on real data. This would extend to any kind of affirmation such as fair-workers-wages, secure working zones, environmental concern and commitment, lowest prices policies…

ALL BENEFITS:

- DESIGN
  - ✓ Store and secure design patents
- LOGISTICS

- ✓ Assure the veracity of products' origin and track suppliers
- ➢ CUSTOMER SERVICE
  - ✓ Quicker deliveries

4.11 SUBWAY TRANSPORTATION (PERSONAL IDEA)

Surface transportation is the most common inside a city, mainly for its home delivery option. Nevertheless, there is a pattern that starts to appear. As many people are not at home when receiving a package, delivery companies are starting to locate lockers on certain spots such as subway stations to provide the client with 24/7 pick-up spots.

Water delivering-system first approach was the same as packages are now, over the surface. Nevertheless, someone came up with a better idea, creating an underground connection to provide everyone with water. The same happened with sewage water. Maybe packages should be delivered the same way. It is clearly not the exact thing, given that packages are not a continuous viscous element that could be transported by pipes, as water is. But, it is clear though that traffic intensity and estimated times of arrival would clearly diminish if a similar solution could be somehow developed.

One option would be to create tunnels for individual-home distribution, but it would be hardly implementable in already existing cities. It would not make any sense to implement it in the country side either, as it would be highly expensive and would have a very low expectancy return. Changing the idea somehow, there is a much cheaper option that could actually be implemented: using already existing underground transportation could be useful for metropolitan areas on any city. Subway stations are normally well distributed around the city for anyone to access.

This infrastructure could be used to reduce transportation times and delays. Packages would arrive quickly to its destination, traffic would be less dense, and pick-up points would be accessible 24/7. Also, this version would be much cheaper than creating a new tunnel

infrastructure all over the city. Although, additional spots would have to be located near to each subway station in order to receive the delivery carriage and collect the packages that are to be delivered to that station.

At the beginning of its implementation, packages could be manually located at delivery lockers. The final goal, though, would be to have an inner warehouse on each station where all packages are waiting to be picked up. Whenever a user wants to pick up its package, the system would autonomously take their package from the warehouse and put it into one of the lockers at request.

Nevertheless, it is also important to notice that on new cities or new urban areas, individual tunnels for each house would be implementable, and provide the customer with a better experience. Its final financial return should be analyzed though. For instance, on new urban areas, customers might not mind to pick up packages from a central common spot (which would resemble the subway access).

The first challenge that subway transportation would be solving is the reduction on the *cost of delivering* products. Having trucks and vans moving throughout the city can be very expensive for the company, even more at rush hour due to traffic jam. If packages were automatically attach from train to train until it reaches destination, the service could be provided at a much cheaper rate.

Secondly, the *speed of delivery* can also be addressed by using public transportation infrastructure. Meeting deadlines would be easier, not only in terms of greater speeds of transportation (that really only works on rush hour), but mainly in terms of reliability. As long as the subway is well managed, using it avoids extra variables that can end in a contingency problem as traffic jams and traffic accidents. Moreover, this system allows packages to be delivered over night. This would even avoid any delivery problems derived from trains intensive operation during the day.

Thirdly, this service includes the addition of *another delivery channel*, which will be included into the Omni-Channel Logistics. This channel would provide customers with new 24/7 picking points close to their homes.

Lastly, companies that bet on this type of ideas are certainly going to gain a *good public reputation* in terms of environmentalism. Reducing CO2 emissions is clearly one of the major benefits of this technology.

ALL BENEFITS:

- LOGISTICS
  - ✓ Packages would not have to be delivered to each individual house inside cities
- TRANSPORT
  - ✓ Quickly delivered packages
  - ✓ Less traffic, delays and unexpected events

4.12 ARTIFICIAL INTELLIGENCE – MACHINE LEARNING – BIG DATA

The difference between artificial intelligence (AI) and machine learning (ML) is still not perfectly defined. Many people use this words indistinctly, while others believe there is a clear difference between them. Bernard Marr (Marr, What Is The Difference Between Artificial Intelligence And Machine Learning?, 2016) defines AI to be a broader term that englobes ML, and this is the most common way to understand it. Artificial intelligence reference to the idea of machines carrying out tasks in a manner that resemblances the human behavior. Machine learning relates to an specific application of AI where tons of past data are given to a machine, so it can extract the relations needed to make correct predictions on future data.

As it has already been mentioned, Artificial Intelligence is the future on many aspects. Not only on engineering, but also on medicine and arts. Having the chance to develop more intelligent programs, that can detect problems on coding, or develop new routes for products

through the conveyor belts with omnidirectional sorters, could really impact how efficient supply chain is.

On the one hand, Artificial Intelligence really benefits from Big Data. By gathering more and more data, and being able to handle it better, decisions in a company can be taken more quickly, easily, and with greater accuracy on its result. But data without understanding means nothing. That is why the relation between AI and Big Data goes in both directions. For instance, extracting information on the top patterns requested on a specific area, or different color tendencies that arise on different areas inside the same country, are examples of the potential that AI and Big Data have together.

Also, tracking products in order to analyze distribution patterns for better estimations of ETA (Estimated Time of Arrival). Checking products' transportation regularly for indicating whenever a package has been taken out of route (possible robbery involved).

Moreover, Artificial Intelligence would be very important on the implementation of autonomous forklifts and drones. The software that would allow forklifts to respond to non-programmed environments and situations would have to be based on Artificial Intelligence. It is essential as these elements will be moving around human beings, and not all situations can be assumed to be considered.

Additionally, in smart and personalized 3D printing, Artificial Intelligence would add an important key. For instance, it could allow a 3D machine to detect if a product can be executed (considered the size and shape of the object). Given that, the machine could decide how to change a product in order to make it executable. Users could send their designs directly from their phones or laptops to the company.

Also, personalized items through laser (as phone covers) could be requested by the user instantly. As in the example before, the machine could analyze how to proceed with the laser on each users' request.

ALL BENEFITS:

- DESIGN
  - ✓ Auto proposals on new products specifications
  - ✓ Extraction of specifications and customers' desires from Big Data plus surveys
- MANUFACTURING
  - ✓ Smart 3D printing with variations
- LOGISTICS
  - ✓ Big Data gathering and treatment
  - ✓ Security obstructions or problems
  - ✓ Products' demand estimations
- TRANSPORTATION
  - ✓ Auto tracking of products
  - ✓ Autonomous plus secure movement of trucks
- WAREHOUSING
  - ✓ Autonomous plus secure movement of forklifts & drones (being aware of workers)
- CUSTOMER SERVICE
  - ✓ Automatic responses and help support for customers' questions/problems

It could be said that Artificial Intelligence is the basis for many of the other technologies. But at the same time, each one must put its part in order to make it all work. To get more and more efficient each part is required, but clearly this part is more essential, as it participates on most of the processes and technologies development.

CHAPTER 5

FUTURE PROJECTION – RESEARCH

5.1 RESEARCH – INTERVIEWS' PROCEDURE

In order to gather professional feedback on the matter, 5 different people were interviewed. Each with different background, and with expertise on different areas, had a different overall perspective for each of the technologies. People interviewed were:

- Jaime Boal Martín-Larrauri

  University professor from Universidad Pontificia Comillas (Madrid) specialized in home and mobile robots automation, analog and digital electronics, artificial intelligence and wireless communications.

- Juan Luis Zamora Macho

  University professor from Universidad Pontificia Comillas (Madrid) specialized in control of drones, identification of systems and signal processing.

- Romano Gianetti

  University professor from Universidad Pontificia Comillas (Madrid) specialized in biomedical engineering, electronic instrumentation and analog electronics.

- José Antonio Rodríguez Mondéjar

  University professor from Universidad Pontificia Comillas (Madrid) specialized in automation and communication in the electrical power and railway systems.

- Bernardo Villazán Gil

  University professor from Universidad Pontificia Comillas (Madrid) and director from the Master in Connected Industry. Industry experience in the Board of Directors at several companies, and specialized in fostering technology advances.

Before starting the interview, interviewees were provided with a copy of the questionnaire that can be found on Appendix A. The first questions posed on the questionnaire were regarding

the professional career of the interviewee. Their background was important to understand the context of each of the answers they were going to give later on. After knowing their background, questions turned into the interviewee's vision of each of the technologies analyzed. Other technologies that they might have had in mind were also included. At the end, additional comments were recorded as well.

5.2 CONCLUSIONS FROM THE INTERVIEWS

One of the key elements that most interviewees talked about was on the importance of differentiating between supporting technologies and intrinsic technologies. Industrial internet of things (IIoT), artificial intelligence (AI), software-as-a-service (SAAS), and even blockchain, were commonly described as being part of the former (supporting techs). The vision shared was that those technologies were relevant as long as they were applied to some of the other technologies. Like IIoT connected to a SAAS, in order to provide information needed for manufacturing management. Opposite, intrinsic technologies were those that, needing or not from others, had an objective by themselves. An example of this could be Virtual Reality, which has the objective of immersing the user into a visual experience of other environment.

Nevertheless, interviewees made clear that this differentiation did not intend to indicate different categories of technologies, in terms of importance. For instance, they stated the clear importance of AI and IIoT in the development of future supply chain strategies. The former due to data analysis and automation of many of today's manual processes and analysis. The latter in terms of manufacturing and warehousing integration for better coordination, as well as for effective automation.

Security in the implementation of all these technologies was another factor that a few of the interviewees were concerned about. Implanting technology that is ahead of its security

measures is daring. Human lives are at risk, as well as both intellectual and physical property. Security measures, in their opinion, have to be assured before any technology is publicly sold.

Lastly, resilience and interoperability were also commented as features that would really enable the development of these technologies.

One of the questions that interviewees were asked was to order each of the technologies in order of importance in 8 years' time. Following the order that each of them gave, we can proceed to show the following table with the results ordered from most to least important from their point of view:

Table 1. Top Most Relevant Technologies in 8 Years' time (retrieved from thesis' survey)

TECHNOLOGY	I1	I2	I3	I4	I5	TOTAL
Artificial Intelligence - Machine Learning (Big Data)	10	10	10	10	6	9
Augmented Reality	7	6	9		9	6
Autonomous Cars	4	8		7	10	6
3D Printing	5	7		9	2	5
IIoT: Idustrial Internet of Things	9	9			7	5
Autonomous Drones & Forklifts	2		7	8	1	4
SAAS: Software-As-A-Service	12			6	3	4
Blockchain	8		6		5	4
Servo Robots with Vision System	3		8			2
Other: AGVs					8	2
Virtual Reality	6					1
Collaborative Robots	1				4	1
Slat Sorters						0
Omnidirectional Sorters						0
Subway Transportation						0

*This table will be used to order the different interviewees' opinions. Results on top results, and its order, are not conclusive due to the small amount of people interviewed.

Artificial intelligence was highly depicted as one of the key technologies in 8 years' time. They all shared the idea of AI providing the environment for data comprehension. Mr. Boal signaled the importance of developing artificial intelligence with less parameters, and more capacity to learn by itself. In his opinion this procedure could give surprising results. Mr.

Villazán indicated the importance of knowing the boundaries that we are willing to trespass, and the ones that we should not. After all, if we all have ethics that guide our decisions and actions, why should not we think about it when developing technology. Anyhow, the importance of this technology to automate process was shared among interviewees.

Augmented reality was commonly seen as a technology with a great future impact in the industry. Helping to repair machinery, and also prevent from hazards in the operation of new technologies that might work autonomously around workers (such as collaborative robots or autonomous forklifts). A couple of interviewees shared the idea of augmented reality getting to customer levels. Portable AR glasses that people would be wearing all the day long, and that companies would even use to set advertisements on streets. On the other hand, Mr. Rodríguez was reluctant to embrace this idea so easily based on the fact that Google, as an example, has already stopped the development of its well-known Google Glasses.

Autonomous cars were commented to be a revolutionary technology that would change the way in which we operate in a daily basis. Nevertheless, they mostly thought that still more time was required for this technology to really unravel its potential. Opposite, Mr. Villazán commented that autonomous trucks had already been tested at industry level (inside and outside the safe environment of a warehousing complex). Therefore, he did not expected that much time as the other interviewees for this technology to start being implemented.

Additionally, Mr. Villazán signaled the impact that autonomous electric vehicles could have. In his opinion, autonomous electric vehicles could derive into having different channels of transportation that could work together. He gave the example of electric motorcycles that could be inside trucks. This bikes could be detached at some given point for specific deliveries. This idea is somehow similar to the case described of drones that get off the truck for delivery to far locations. In the end its all related to new Omni-Channels that will allow better customer service, and adjustment to deliveries' specifications.

3D printing was also indicated as disruptive, but also complex to be implanted in the short-term. Mr. Villazán further explained that right now the only two applications, where 3D printing is already a success, are first at prototyping level (where sizes are much smaller) and also at modeling level (as producing one unique piece is much cheaper through this technology). Further development of materials (allowing metal alloys) and cost reduction on massive production are two key challenges to face right now.

IIoT was certainly mentioned by all the interviewees. It was declared to be one of the technologies that will further help to make great advances in AI,. More specific, Mr. Boal specified that the main improvement will be that IIoT will provide AI with huge amounts of real and more complex data. AI would benefit from this, as having more inputs would derive on the ability to have a more comprehensive control of the plant. Nevertheless, most mentioned the importance of security in the development of this technology. Mr. Gianetti mentioned that, right now, systems are tested and implemented without inserting strict security measures.

Autonomous Drones and Forklifts were also mentioned. Mainly autonomous drones were the ones that captured more attention of the interviewees. Mr. Zamora even indicated its utility in case of natural catastrophes, where no other channel could provide assist to the human-beings involved. Similarly, he mentioned that the same could be said of supply chain. Drones could reach areas that maybe in winter are impossible to reach, and provide them with products and services such as the postal service.

Lastly, SAAS was also mentioned to be a key element in all technologies development. They thought of SAAS as the element that would put complex technologies as AI and IIoT, in the hands of non-technical profiles. Additionally, a few commented that SAAS was the only way that all companies could get access to these technologies. Programming and implanting the software infrastructure that these technologies require would be very expensive for small and medium companies. By getting the software developed by a third party, the company can

use the features it needs while the provider can make profit from the huge amounts of money that have to be put in R&D.

Additionally, Mr. Villazán stated the importance of AGVs (Automated Guided Vehicles). This system has been recently implanted in a few plants. Amazon is one of the few that has already bet on this technology. Mr. Villazán explained the importance of this technology, as it can now complete full orders by picking up the items one by one, and all done autonomously. The systems consists of boxes with the items one next to each other, and automated robots that go above this boxes picking up the needed items for each order. It is intended for small items, though. For huge packages there is still not such a solution.

5.3 RESEARCH ON OTHER TECHNOLOGIES MENTIONED BY INTERVIEWEES

5.3.1 Software-As-A-Service (SAAS)

As Nick from Flexis.com states: when talking about the challenges of supply chain, SAAS will permit the implementation of a fully-integrated supply chain system (Ostdick, 2017). In his opinion, this is the only way a company can receive and interpret data to address contingencies, as well as plan production, inventory and transportation (Ostdick, 2017).

This technology is not going to solve any challenge on its own, opposite it is a supporting technology. On its own it has no value, but as the facilitator that grants user-friendly access for anyone of a company, it is highly required, and will be deeply part of society. Additionally, not every company can afford to pay for research into every possible technology. Few companies will actually invest, and SAAS will be the technology that will permit that those companies (big providers) and their customers (small and medium companies) profit from establishing the service. SAAS will be crucial for those challenges that are solved by applying a technology that needs to be managed. Examples of this are: AI selecting the cheapest combination of transportation channels based on input, or IIoT helping to reduce inventories by providing

graphs and/or taking decisions. This technology is therefore crucial in almost all technologies such as augmented reality, 3D printing, IIoT, autonomous cars and AI.

5.3.2 Automated Guided Vehicles (AGVs)

Although Mr. Villazán was the only one to comment about AGVs, this technology is relevant enough to be considered separately. There is still debate on what this term means, and what it does not mean (Bond, 2018). On the one hand, some people use Automated Guided Vehicles (AGVs) and Autonomous Mobile Robots (AMRs) indistinctly. John Clark (Mobile Automation Marketing Manager for Dematic) believes that the lines are very complex to define (Bond, 2018). He states that AVGs are incorporating features from AMRs, and vice versa. On the other hand, for example, Melonee Wise (Chief Executive Officer of Fetch Robotics) deeply signals AMRs as vehicles that do not follow a guide path, and therefore discards it as a generic term (Bond, 2018).

There are other terms that make definitions even more complex such as Vision-Guided Vehicles (VGV) and Self-Driving Vehicles (SDVs). Anyhow, AGVs is usually consider to be the general term to describe autonomous vehicles with or without depicted paths (Bond, 2018). Therefore, in order to ease the analysis of this technology as a whole, AGV is going to be the general term used in this section. For instance, with this description, an autonomous forklift could be depicted as an AGV.

5.3.2.1 Kiva System - AGVs

Figure 3. Amazon's AGVs - Kiva System (Murphy, 2017)

This are the type of AGVs that Amazon incorporated in 2012, when it bought Kiva (a well-known company in the AGVs business). This **Kiva robots** are the ones that place themselves behind shelves in order to move them throughout the warehouse (Murphy, 2017). This can be used to get shelves to workers so they can pick up items or arrange orders. Opposite, this system normally is set with a person following the AGV in order to put items on or take items from the shelf (Murphy, 2017). It is and interesting solution as it saves a lot of time on moving orders and products. Additionally, it decreases the space needed for shelves, as they can be grouped together in a cluster. Whenever a certain shelf needs to be extracted, the shelves that surround it can be moved in order to let it pass.

5.3.2.2 Ocado Smart Platform - AGVs

Figure 4. Ocado Smart Platform (OSP) Infrastructure (Ocado Smart Platform: Transforming Warehouse Automation with another World-First in Radio Design, 2018)

Another really interesting system, whose implementation in Paris was recently signed last November, is the **Ocado Smart Platform** (OSP) (Frangoul, 2017). This agreement in implementation was signed between U.K.'s Ocado (online grocer and system's owner) and French Groupe Casino (giant supermarket in France). As Jean-Charles Naouri (Groupe

Casino's CEO) explained, they were expecting to open a quick and precise home-delivery service on up to 50,000 food items for shoppers in the Greater Paris area.

This technology was previously developed and implanted by Ocado in their own plant in Andover, England (UK) (Welcome to the Automated Warehouse of the Future, 2018). This system can help to pick a typical 50-item order in a matter of a couple of minutes. The robots grab the needed crate from above, and get it to the person who is making the order. They are AGVs that move over the crates, instead of next to or underneath them. Robots are controlled from a central system, and are coordinated among different orders (Welcome to the Automated Warehouse of the Future, 2018). Moreover, as each column can hold up to 17 crates one on top of another, and all crates are right next to each other, it uses space in a very efficient manner.

5.3.2.3 Ocado Smart Platform: Vertical Implementation – AGVs (Personal Idea)

The previous concept is very powerful, as it saves a lot of space: the OSP system allows having all crates one on top of another, as well as having all piles of crates one next to each other. They are firstly helping to *reduce inventories*. Additionally, the autonomous movement of robots provides more *flexibility and adaptability*, in terms of quick response time to customers, retailers (in the case of suppliers), and contingencies.

Another new implementation suggested here is to extract the same concept and apply it to the vertical movement of robots. Compared to the horizontal stack of crates, this system could be used to allow vertical stacking of orders on shelves, without no height limit. As houses changed a long time ago into high-rise buildings, the same could happen with warehouses.

Today's AGVs (autonomous forklifts, for example) can reach objects that are up to 30 feet above the floor (Bond, 2018). This technology would allow stacking vertically without limit (apart from constructing limits, of course).This vertical implementation could somehow resemble the one used on fully automated parking systems (Gupta, 2017), shown on Figure 5.

As it can be seen, there are specific spots for each car, and a central system that moves cars from the garage entrance to each of the spots.

Figure 5. Vertical Stacking of Cars - Fully Automated Parking Systems (Gupta, 2017)

Keeping in mind the automated parking shown above as a mere concept, the warehousing system would be different in its implementation. Moving packages and orders requires faster times and more pallets moving per second. Therefore, as said at the beginning, the implementation would be more similar to the OSP system: several robots moving packages, orders, or pallets from one shelve to another. Robots would be installed on one side of the rack (or even between racks), and would move from side to side, and up and down, depending on the movement required.

This technology could even be further empowered by omnidirectional sorters. Pallets would no need direct access to the pick-up side of the rack where the robots are moving. Pallets and orders would be rearranged in each level of the rack. The order to be taken next is positioned close to the side where robots are picking up items, and the rest are placed anywhere else.

5.3.2.5 Challenges that AGVs Will Solve

AGVs in general can be very beneficial in various aspects. Firstly, they can help to improve *flexibility and adaptability*. AGVs make movement of inventory within a warehouse more

efficient, more automated, and therefore more contingency-proof. This features indirectly derive into improvement on *speed of delivery* and *shrinkage of inventories* as well. Greater flexibility gives the company less need for inventory backups in each warehouse. In the end, companies can take advantage of shorter-in-time and smaller deliveries to warehouses and customers. Which makes the system even more reliable if any problem happens.

Secondly, AGVs help in *inventory tracking* is also one of the obvious results. Since everything is automated, it would be easy to efficiently track where each item is, and where it is coming from. This system could therefore avoid any human errors in the process of moving items.

Additionally, it would also help to improve the *online shopping* experience by starting to place orders in a matter of minutes from the order is put by the customer. Shorter lead times would always satisfy the client. Moreover, the customer would have more time to change any order placed. As changing the order would be a much faster process, customers would be allowed to make changes until shortly before shipping.

Lastly, a *good public reputation* could be shown by companies that use these technologies (specifically the last one), because they save warehousing space required. Truth is that also many bad opinion could be derived, as it actually erase some specific working positions. In order to avoid this perspective, research on how in the end there are more works being created than being erased should be presented. Also, interest for those who cannot accommodate to new jobs created by these technologies (such as elder people) should be shown as well. Anyhow, this analysis is not part of this research; and, therefore, it is not going to be further developed.

5.3.3 Mixed Transport Channels

Another element that was only commented by Mr. Villazán was the implementation of vehicles transported by other vehicles. In other words, vehicles that provide a function up to a

point, and from there, other vehicles detach from the first vehicle in order to access points the first one could not. Drones that detach from a truck in order to deliver packages on each terrace of a building could be one example of this.

This section could be endless, therefore, only two really interesting examples are going to be provided.

5.3.3.1 'Flying Warehouse' & Drones – AGVs

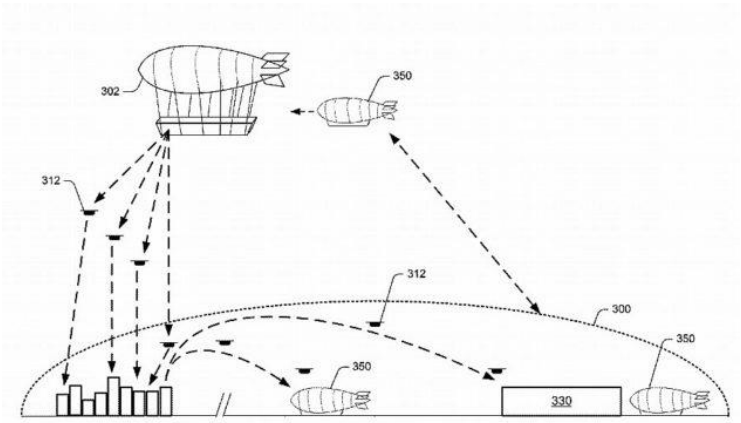

Figure 6. Amazon's 'Flying Warehouse' (Boyle, Drone delivery from flying blimp 'fulfillment centers'? Are you kidding, Amazon?, 2016)

On April of 2016, Amazon patented their next revolutionary idea: a 'Flying Warehouse' (Boyle, Drone delivery from flying blimp 'fulfillment centers'? Are you kidding, Amazon?, 2016). Based on Boyle's description, their idea was to have a main airship at a high altitude (45,000 feet) that would work as the 'warehouse'. Drones provided with wings would pick the package from the airship, and descend to deliver the package with almost no usage of energy. Drones would then move to a another airship at floor-level that would collect them and transport them to the main take-off hub. From there, drones, fuel and products to be transported to the 'warehouse' are sent up to the main airship ('warehouse').

This idea sounds far beyond our current possibilities, and indeed has a lot of troubles (Boyle, Drone delivery from flying blimp 'fulfillment centers'? Are you kidding, Amazon?, 2016). Difficulties go from the actual cost of having the drone constantly so high in the air, to

the arduous procedure of reacting to changes in weather. For instance, what would be done when rains or storms would not allow to have the airship or the drones in the air.

Nevertheless, someone else has got into the 'flying warehousing' business: Walmart has made its own patent (Boyle, Battle of the retail blimps: Amazon and Walmart propose airship drone stations, 2017). Their idea is slightly different though. Walmart plans to use a gas-filled warehouse aircraft to transport packages between cities at between 500 and 1,000 feet altitude. Drones would be used to get orders down to the customer or warehouse as programmed or needed.

This last version is somehow similar to the idea presented before of drones delivering packages to inaccessible zones. For instance, this applies to delivery where the snow (or floods) close the main roads. Additionally, it can also be transferred into leaving packages directly into customers' terraces on a skyscraper.

5.3.3.2 Amazon's 'Postmen' – AGVs

Figure 7. Amazon 'Postman' Possible Design (Borkhataria, 2018)

Lastly, another element that is worth to be mention is the new Amazon's patent: a robot called 'Postmen' (Borkhataria, 2018). This robot is supposed to ease the delivery of packages to customers' houses directly. This robot can use Amazon's smart locks in order to enter the house and leave or pick up a 'small' product. This product mainly belongs to the AGVs section;

nevertheless it was worthwhile to be commented here. The main reason for that is that this vehicle could, for instance, cooperate with trucks. They would be attached to the truck, and make the delivery to customer's doors without making the truck to stop.

The main problem with this idea of autonomously delivering packages to customers' homes, is that still many people do not trust Amazon's smart locks (Schlosser, 2017). Only 33% of people between 18 and 29 years old are comfortable with this idea (Schlosser, 2017). For people older than 55 years, the numbers get down to less than 16% of them. Even though smart locks' kit comes with a security camera, there is still time for people to totally trust them. Until then, this AGVs could start to be implemented for those who trust it, still a lot of people to work with.

5.3.3.3 Challenges that Mixed Transport Channels Can Solve

Amazon's 'flying warehouse' is supposed to help reducing *cost of transportation*, incrementing the *speed of delivery*, and adding a new *transportation channel*. The first one is only supposed, because further studies should be provided in order to assure that this is true. Secondly, incrementing the speed of delivery would definitely take place, as drones would descend with products at high speeds, no matter of traffic nor other products to be delivered first. More information in case of bad weather conditions should be gathered, though. Thirdly, it would add a transportation channel, that could be very useful in some cases. On the other hand, it could consume time and resources in case logistics get too complicated.

This new transportation channel would definitely not help with the *difficulty to control and track inventory*. More complex systems on gathering information would be needed, in order to assure that this technology can actually help to improve today's delivery system. If wrongly implemented, it would only be a chaos. As stated before, this technology could end up being very resource-intensive in terms of coordination (as well as cost, of course).

As a fifth factor, this technology's impact on *reducing inventories* is not clear. Having all those packages up in the air in advance could imply needing a lot of inventory. On the other hand, sending to the main airship only the packages to be delivered the next day could maybe save costs on transportation, as well as help to reduce inventories stored in the air.

Putting the profitability aside, giving customers the chance to receive packages in no-time would definitely help the *relation between company and customers*, as well as improve the *online experience*. Nevertheless, this new last mile channel of transportation would only help to provide a better service to certain customers. If no extra infrastructure is added, only customers with sufficiently big terraces or gardens could benefit from this service. The space required mainly correlates with the one needed for the safe landing of the drone.

Walmart's airship has, on the other hand, an added value to the Amazon's 'flying warehouse': it surely helps with the *difficulty to control and track inventory*. Walmart's airship has almost all the benefits from Amazon's warehousing system: reducing *cost of transportation*, incrementing the *speed of delivery*, and adding a new *transportation channel*. But, on top of that, this system operates somehow similar to something in between delivery trucks and airplanes. Therefore, it would not need extra complex systems to be taken into account. Implementation changes, but complexity of the distribution channel remains the same.

Lastly, **Amazon's 'Postmen'** could mainly help with the *cost of transporting items*: less fuel costs could be reached by this vehicles that consume very low amounts of energy. Also, they would help providing higher *speeds of delivery* by reducing the time spent in the last mile. For instance, as explained before, several of these AGVs could take off a truck to deliver a package, and return to the truck whenever successfully delivered. This technology would make meeting deadlines an easier task, although it would only work for small packages mainly. Going back to the challenges, it would essentially help to provide another *transportation channel* that companies could profit from.

5.4 CASE STUDIES

5.4.1 Amazon – Retail Company

Amazon's system is thought as one of the most innovative supply chain retailers from the industry, but that might not be completely true (Banker, Cunnane, & Reiser, The Amazon Supply Chain: The Most Innovative in the World?, 2018). This article mainly comments three main parts on Amazon: its grocery business (Whole Foods), its carrier service (air cargo hub to be built at Cincinnati/Northern Kentucky Airport), and its warehousing business (the retailing part itself).

Amazon long wanted to get into the **grocery business**, but it was not until last year's June that they finally got in by purchasing Whole Foods (Banker, Cunnane, & Reiser, The Amazon Supply Chain: The Most Innovative in the World?, 2018). Walmart has much more experience and expertise in the topic, but Amazon plans to use its technology to really make a difference. For instance, one of the main technological developments was its Dash Button, which allows any customer to automatically purchase any programmed items with the push of a button. In the store management, they have also been able to reduce grocery inventories to near zero, while still providing shelves as full or more than before. Beyond that, another additional benefit they are looking for is to use Whole Foods as additional warehouses where clients can pick up their online orders when they go shopping.

On the **carrier part of the business**, Amazon is planning to spend $1.5 billion in a highly automated facility (Banker, Cunnane, & Reiser, The Amazon Supply Chain: The Most Innovative in the World?, 2018). Amazon plans to start small (2,000 initial workers) and expand whenever more people are needed to satisfy demand. Whereas same-level competitors are probably not going to be willing to use this facility, this could be a great chance for small retailers. In fact, many small retailers already sell through Amazon's marketplace. At the same

time, Amazon benefits by diminishing their cost of transportation in compare to the cost of using UPS or FedEx.

Thirdly, as an entity that highly depends on **warehousing**, amazon has completely bet for robots (Banker, Cunnane, & Reiser, The Amazon Supply Chain: The Most Innovative in the World?, 2018). Since Amazon acquired Kiva Robots in 2012 (for $775 million), Amazon has grown up to the point where it has 100,000 robots in use across 493 warehouses world-wide. Nevertheless, their profit is not the highest, due to highly expensive last mile deliveries. Its growth rate is really high, but its profitability could be much better.

Lastly, it is true that Amazon is first in providing cloud services (Novet, 2018). Nevertheless, we will not analyze this part of the company, as Microsoft cloud services are going to be analyzed specifically in the next section.

5.4.1.1 The Retailing Part of Amazon

It is difficult to know the real future of companies such as Google and Amazon. Companies that are continuously expanding the sector and activities in which they operate. Maybe such companies have found the way to do it successfully, or maybe they are destined to disappear sooner or later. The same way that people work better in specialized jobs, makes sense that companies should specialize in a ‘small’ set of activities. The only current fact that might be making of Google and Amazon successful companies is their inner cooperation. But, the more efficient and coordinated the communication between retailers, suppliers, distributors and customers becomes, the more it makes sense to have specialized companies.

Anyhow, Amazon’s purchase of Whole Foods has probably been a good move. Maybe a partnership would have worked as well, who knows. Anyway, there are two clear benefits. First, Amazon puts at customers’ hands another channel for the customer to receive (and potentially return) packages near their homes. Smart move to improve customers’ experience of the Omni-Channel logistics. Second, they are attracting new customers for both groceries

and non-groceries. A regular shopper of Whole Foods might decide to buy on Amazon, as they can pick the deliver while shopping. On the other hand, a regular Amazon shopper might decide to go shopping to Whole Foods, as they have to pick up their package somewhere in any case.

Secondly, their involvement into the carrier service is not going to be analyzed in this section. Analysis of pick-up, transportation, and delivery will be done directly on a carrier company: UPS (see other cases).

Getting into the retailing part, Amazon deals mainly with a warehousing challenge. Even though it already sells its own products, it mainly receives and sends all types of products from suppliers and to customers, respectively. For the analysis, their current technology on a generic **Amazon fulfillment center** in California is going to be presented (Inside An Amazon Warehouse On Cyber Monday, 2016). This center had 1.1million square feet in 2016. On Cyber Monday from 2015, Amazon shipped around 51 million items from this center (Inside An Amazon Warehouse On Cyber Monday, 2016). That amount equals to 629 items sold every single second, and this was almost 3 years ago. Today, given that they were expecting more sells each year to pass, must be even more.

Getting into the center, packaging and order preparation are done manually (Inside An Amazon Warehouse On Cyber Monday, 2016). Nevertheless, there is a high level of automation as well. Even though the items picking is done by hand, Kiva robots are implanted in order to help workers. These AGVs go throughout the plant moving entire shelves, moving them from the storage place to wherever the worker who is putting the items on a bin is. This saves a lot of time, as workers do not have to walk any distance (given that items are coming to them). Bins with orders are then send through conveyor belts to the packaging zone. This conveyor belts sort products using slat sorters. After being packed, boxes are then sorted into lanes for each truck.

Another interesting warehousing element is the **Amazon's Prime Now service**. For instance, last year, prime members from several cities around the US had a free 2-hour delivery on up to 938,764 products (Number of Products on Sale at Amazon Prime Now, 2017). But 2 hours is really few time to correctly prepare and deliver orders. Their success relies on a randomly way of putting orders into shelves called 'random stow' (How does Amazon Prime Now deliver packages in under two hours?, 2016). By doing this, workers might find in one single aisle products as different as apple snacks, tennis balls and toilet paper. This saves a lot of time as workers do not have to move great distances to prepare each order. One program decides where each element should be put (somehow randomly). Another program tells the worker which is the most efficient route to follow for picking orders, knowing where the same products are located throughout the warehouse.

5.4.1.2 Amazon's Future Projection

In 8 years' time, **retail companies** will highly rely in robots. Companies will need to introduce autonomous tracking and movement of orders in order to adjust to the high *flexibility* and *speed of delivery* that will be required, at an economical cost. Amazon has already automated most of its warehousing, and it is further planning to automate them more. Other companies will need to get to Amazon's level to be competitive. Amazon has already proven the effectiveness of the Kiva robot, and Ocado has proven the profitability of its OSP. From there, **AGVs** of different kinds will be highly introduced. From AGVs transporting big packages from shelves to delivery points; to OSP-like infrastructures (robots moving on an horizontal plane above crates with products and orders). Additionally, in 8 years' time, pioneering companies will have started to implement vertical OSP. The reduction of horizontal space will derive in cheaper warehouses, as less square feet will be needed. This will permit as well the construction of warehouses in the middle of cities. Additionally, as elements are closer to each other (in vertical direction), warehouses could acquire quicker rates of receiving and

sending products. Anyhow, it will take more than 8 years for regular companies to decide to take advantage of this complex but cost-effective system.

On the conveying system part, **slat sorters** have already proven really valuable. In 8 years' time, they will be fully-used on every company to sort small and medium packages on different lanes. On the other hand, **omnidirectional sorters** will be fully implanted in warehousing for small and medium packages' routing throughout the warehouse. Mainly, due to the power it gives of deriving products into several different conveyors. Moreover, they will probably also be used on vertical OSPs. It can deeply help to move and track products, as well as diminish warehouses' size by reducing the amount of needed access points for vertical AGVs. Basically, not all items will have to be at AGVs reach, as they could be reorganized from front (vertical AGVs' access point) to back whenever needed.

In 8 years' time, **IIoT** will be totally implanted at warehousing level. In Amazon, all the control of slat sorters, RFID readers, and Kiva robots is possible thanks to IIoT one way or another. In the future, each product, machine and industrial element (such as AGVs) will be tracked and control at every moment. By doing that, IIoT will be the one that will allow the interconnectivity required among technologies. IIoT will conform an infrastructure of elements that talk to each other, and deal with contingencies autonomously. Additionally, security in 8 years' time will be a real concern for all companies and implementations of IIoT and others. If companies do not start taking care of security by themselves, they will start taking care whenever a massive cyber-attack takes place and money is lost.

Artificial intelligence will be the one permitting the autonomous human-like decision-making at many levels of the enterprise: from helping an employee with a technical problem, to providing customers with purchasing options based on customer preferences. The latter already exists in fact, but at a much lower level than in the future. For instance, AI has already proven successful at solving complex tasks such as choosing a selection of different

transportation channels for different orders. In that case, the parameters given to the program to operate are to save the highest possible transportation cost. In the future, AI will be the one behind the scenes, that will allow everything else to take decisions based on all the information provided: from customers' orders to supplies and products in transit. Some few examples of AI's applications on Amazon as a retail company are: help to control and automate an efficient movement of AGVs and packages throughout the warehouse; make autonomous decisions on order preference and movement of parcels between warehouses when contingencies occur; and greatly improve demand forecasting based on past customer purchases, internet customer searches, and social trends.

Augmented reality will also be highly introduced at warehousing level in the future. This technology will help to repair the different equipment, to manage and control orders, and to safely integrate all other technologies such as AGVs (in terms of workers' safety). Also, augmented reality will surely be at customers' reach. Many products will have a 3D design encrypted online, and available to be printed at physical 3D printing stores. Also, companies will provide customers with special pieces that will be possible to personalize. This parts will be 3D printed and easy to attach (and detach) to the product. This will solve people's willing to have personalized things whenever they want them, and at the same time solve part of the companies challenges on logistics. Further explanations on manufacturing are given on the manufacturing case.

SAAS will be the framework to put all these technologies together. As interviewees stated, it will be the one to allow any company to access and implement technologies that would be very expensive otherwise. SAAS will empower companies with a tool to manage and make use of other services such as IIoT, augmented reality, and AI through an online software. An app will allow anyone from a company to see real-time data and analysis on technologies, logistics… For implementation, specialized engineers would be required of course.

Amazon's idea of having a fixed-in-the-air airship working as a warehouse does not seem to be possible in the short term. On the other hand, Walmart's idea of using an **airship to move packages between cities** seems more achievable. More information about transport will be provided on the carrier example: UPS (see other cases).

5.4.2 Microsoft – Service Companies

Microsoft is a really well-known company, that is currently highly getting into the service business (Hall, 2018). It all started with their operating system: Windows. After its complete success, they developed Windows NT for communication among computers, and later on Internet Explorer, the search engine (Hall, 2018). In 2001, Microsoft entered the gaming market with the release of the Xbox, and one year later they provided it with Xbox Live: the internet network for online gaming. It tried to improve its operating system Windows XP with the release of Windows Vista (2007), but it was a complete failure. Microsoft's reputation on operating systems was not completely rebuild until later versions release such as Windows 7 (2009), Windows 8 (2012), and the recent Windows 10 (2015). Additionally, Windows 10 was included with additional products/tools such as Cortana (the personal assistant that responds to voice commands) and Microsoft Edge (the new Internet Explorer).

Additionally, in 2008, Microsoft announced its first move into **cloud computing**: Azure (Hall, 2018). Azure was to be a centralized service accessible through the internet. In 2011, Microsoft released Office 365, the same idea behind Azure but for its business software: Word, Excel, PowerPoint... Lastly, in 2011, Microsoft went further buying Skype for $8.5 billion. Lastly, in 2012, Microsoft's Surface was successfully introduced.

It is undoubtable that Microsoft offers many different products, even physical ones. Nevertheless, Microsoft's importance as a service provider is clear (Novet, 2018). It is currently even more relevant thanks to the huge development of its cloud computing services (Novet, 2018). In fact, Microsoft is planning to push further their cloud services. One of the

main changes, for instance, has been the introduction of Azure's head of department as a new executive vice president (one of the top leadership positions at Microsoft).

5.4.2.1 The Service Part of Microsoft

As stated before, Microsoft's relevancy in the cloud computing market is clear. In fact, Azure's service is second in the market, after Amazon's AWS (Amazon Web Services) (Novet, 2018). In order to provide all the services in the cloud, Microsoft has an infrastructure of over 150 datacenters connected to the internet (Russinovich, 2018). On each region, they provide several datacenters with same data from one to another. In fact, the minimum number of independent servers per region is 3. This way, they still have 2 usable datacenters with identical data prepared to be used if something where to happen to any of them. Apart from the physical infrastructure, they obviously have main operating buildings from where IT workers, consultants, and salespersons help clients to decide what they need, and how to implement it inside their system.

Opposite to other services such as banking, Microsoft does not directly offer the service to each client. They heavily rely on online marketing and support for most small companies and individuals. Obviously, for big companies and/or implementations directly related to hardware (such as IIoT), visiting the client's infrastructure is required.

Interestingly, in order to provide their services and products, Microsoft uses its own software (Bringing digital transformation to the supply chain with Azure IoT Suite, 2017). One of the main things key in their adoption of the system was the implementation of an online fully-connected infrastructure. Having everything online permits to efficiently share real-time information from different sources. For instance, Microsoft's Azure Connected Factory allows them (and clients) to monitor the plant, receive real-time data from sensors, read data analytics, and improve operational efficiency. The second mayor element is their improvement on predictability. Thanks to Machine Learning, they can get all the input data (no matter the size)

and check if everything looks normal or not in general terms. Detecting errors and solving them becomes much quicker.

5.4.2.2 Microsoft's Future Projection

In 8 years' time, **service providers** such as banks and insurers will have almost completely gone online. The more comfortable people start to be doing everything online, the less sense is going to have to provide so many physical places. Right now, for instance, there are lots of banking services being offered online as **software-as-a-service**. You can change money from one currency to another, and even invest it, all without needing to see any particular agent. And all thanks to the development of apps that allow any user to be informed and make decisions. In the future, most services will be automated, and services will be provided to customers through SAAS. Microsoft already has this feature on Azure. A customer can create an account, buy the products it needs, and be ready to use them in a matter of an hour (depending of the service).

As almost every service will be provided online, development better customer service will be needed. **Artificial intelligence** development is the key to enabling customers to successfully access the required information in order to decide what to buy and how to set it up effectively. In fact, customers will be dealing with AIs for most of the interaction required when, for instance, creating and closing contracts, receiving technical support, and be provided with options depending on current situation.

Additionally, **virtual and augmented reality** are two important technologies that will be implanted. Virtual reality is currently being developed, mainly aiming at customer level. The target is to immerse users into films, gaming, and other environments such as visiting a city. But, virtual reality will also expand into the industry as well. Service companies will use VR to present their products on a personalized environment that surrounds the user, making the service more appealing. On the other hand, augmented reality will have further impact. First,

AR will be used to provide customers with more interactive services. For instance, Amazon will get rid of its Dash Button. Virtual buttons will appear close to the product that is about to finish. A client will be able to order toilet paper, Tide detergent, or mineral water just by seeing the product and pushing its specific button. Also, AR will provide further improvement of users' experience of the service such as permitting the interaction with a product or prototype. Specifically in the industry, AR will allow management to see a 3D map of any warehouse, with elements moving in real time.

Again AI will be key, as said on the retail case. AI will be the one providing customers with a really high-standard and personalized customer service. In order to deal with the customer effectively, AI will be further improved.

5.4.3 Apple – Manufacturing Companies

Apple is one of the main companies that is mainly focused on retailing its own products. It all started in 1976 with the first built model of the Apple 1 (Glazer, 2018). After that, the Macintosh was introduced in 1984, a product that revolutionized the market (Huguet, 2018). After several other products and improvements, the new family of iMac computers was presented in 1999 (Glazer, 2018). Then, the iPod music player is presented in 2001, and in 2005 a special model even incorporates video capabilities. From there, the first MacBook Pro is presented in 2006, and the ever first iPhone in 2007. Apple TV is introduced that same year. Later on, the first iPad and Apple Watch are presented in 2010 and 2015, respectively. Lastly, the HomePod is introduced in 2017, as well as the iPhone 8 and iPhone X special anniversary models.

Clearly Apple has a large expertise on manufacturing. Right now, most of its manufacturing process is done overseas by a third-party to which Apple sells the supplies needed (such as components), and buys the final product (iPhone, iPad or MacBook) (Barboza, 2016). For

instance, one of its iPhone's plants is located in ZhengZhou, and its managed by Foxconn, a Taiwanese company. One iPhone can take up to 400 steps to be finally assembled.

5.4.3.1 The Manufacturing Part of Apple

As described above, Apple is mainly a manufacturer. Even though, for instance, Apple does manage inventories, this section focuses on its manufacturing part only. And not even on its own manufacturing part, as the assembling process and production of required pieces is done by the third-party enterprise. No matter, the focus is to understand how the production of Apple's products will change from today to the future.

The first time an external person was allowed to visit the part of a factory where Apple's products are being assembled was in 2012 (Apple's Chinese Factories: Exclusive, 2012). Bill Weir was allowed to get into one of Foxconn's facilities, to surprisingly find out that the process was almost completely manual. Each worker had to assemble one or two of the elements, over and over again. Back then, one iPad took 5 days to be assembled, and 325 pair of hands. Interestingly, it does not seem that the process might have change a lot. No much recent information is really available on current workers' conditions nor about the manufacturing process on Apple's products. Nonetheless, a recently-opened Xiaomi's plant in India opened its doors to an Indian newspaper last year (A look inside Xiaomi's manufacturing plant in Noida, 2017). From what it seems on this video, not much autonomous equipment is yet introduced. Indeed, the few equipment showed in the video seemed to require an individual to operate it. As Xiaomi is also a well-known brand, we can assume that it is not far in the producing process from its competitors. Therefore, companies that produce electronic products still have a lot of room for improvement.

5.4.3.2 Volvo – A Different Way of Manufacturing

As electronic devices might be a really specific example where there is no automation at all, another brief counterexample is going to be presented. Volvo, for instance, has more

autonomous robots in the manufacturing process (Volvo XC40 Factory in Ghent, Belgium, 2018). Volvo is a well-known automotive company. Opposite to Amazon and Microsoft, that have expanded its activities, Volvo is only in the car manufacturing industry (Our Company at a Glance, 2017). That simple. Volvo has its origin in Scandinavia, and its first model was created in 1927 (Our Company at a Glance, 2017). Since it was created, Volvo expanded its operations internationally. Its manufacturing, though, expanded only to China, Sweden, Belgium and United States.

As it can be seen in the video, there is still much more room for automating the plant (Volvo XC40 Factory in Ghent, Belgium, 2018). There is certain autonomous robots, such as the robot that places the rear window, and mostly collaborative robots/tools that help workers do it 'manually'. For instance, the moment when an operator appears moving a hook that has the front seat of the car on it. However, most of the assembly is done manually: from the assembly of the doors to the placement of the mudguards. Truth is that in this case, there is still work to be done in order to assure robots are able to deal with objects of different size and fragility. Until then, only specialized features can be automated on a manufacturing plant.

5.4.3.3 Apple's Future Projection

In 8 years' time, manufacturers will have already highly **automate the producing process**. As Apple's products are assembled of small rigid plastic parts, it will surely have automate most of the assembly process. First, as the pieces are small, the machines, that are needed to implement certain consecutive assembling parts of an iPhone, are cheaper (than the machines to put a car's roof). Additionally, as most pieces are rigid plastic, there is no need to have special complex hooks that are able to precisely take a variety of elements made of different materials. Other companies that might not have the evolution so easy, will certainly find the way to automate most part of their processes anyway. Not specific information can be made on each of the possibilities, as for each product the solution will be different.

Personalization of products or parts of a product will be a reality thanks to **3D printing**. 3D printers will be available at store level, like printing services provided today at different places. In 8 years' time, still not many people will have their own printer. More time will be needed for this technology to become totally integrated and cheap enough at a family level. Even though it will be reasonably cheap, families at the beginning will not see a clear benefit on owning one. **Virtual reality and augmented reality** will be implanted and will help previous manufacturers to address the design and the marketing in a completely different manner. Additionally, VR and AR will be very beneficial for the designing team, as well as for the workers on the industrial plant. Mainly, AR will help to provide workers with useful real-time information about an order or a problem.

Additionally, **collaborative robots** will be highly implanted in manufacturing. First, on complex assembly of small or fragile products, where a human is needed. The human could use the VR to control the robot. Second, on producing products in a way in which the worker can get hurt. Introducing a machine, we assure that whatever happens, the worker is safe and sound. Lastly, it has a great potential to allow automating processes, that the machine alone could not do.

All the transporting management will be accessible online through a **SAAS**. This SAAS will be free or very cheap, and it will basically use AI to suggest optimal channels of transportation depending on quantity and size of each order. The SAAS will be the one to share information from the distributors to the manufacturers. Again, more information on transporting channels is given on the next section.

5.4.4 UPS – Carrier Companies

UPS is a company that mainly offers carrier services today. It manages all types of orders from individual customers to other companies' orders. It started by specializing in delivering packages from stores, until 1953, when they decided to go back online (Lewis, 2018).

It was created in 1907 by two teenagers James E. Cassey and Claude Ryan (Lewis, 2018). They tried freight service once, but it was a complete failure. Later, in 1953, they successfully relaunched it, and it has been offered since then. Not until 2001, they started to have a physical store. There, they mainly offered mailbox, shipping, and special services for small business and individuals.

5.4.4.1 The Carrier Part of UPS

As a carrier, UPS currently offers air, ocean, rail, and road transportation channels (Transportation & Freight, 2017). They provide with the service, but also with the framework needed to make the best choice. Also, order tracking can be included in all shipments if desired. Operating in 200 countries (Haseeb, 2015), UPS offers customers the chance of delivering an international package in less than 24h (HOW UPS DELIVER PACKAGES AROUND THE WORLD - INSIDE OF UPS COMPANY, 2017). Its great and vast network, as well as its advanced supply chain is clear (Haseeb, 2015). The trip of an international package starts with its pickup in a UPS van (HOW UPS DELIVER PACKAGES AROUND THE WORLD - INSIDE OF UPS COMPANY, 2017). From there, items are transported to the airport. If the airport is near, the same van would be the one in charge of making this transport. From there, pickups are received manually, and inserted into the corresponding lanes. The first reason is to account for the order reception, the second to assure no package is lost due to ticket unreadability. In UPS airport's hubs, there is a lot of automation. Orders are moved from their pickup spot, directly to the airplane that the order belongs to. From there, the process is followed the other way around.

It is interesting to know that something similar to omnidirectional sorters are used on planes' inside floor (HOW UPS DELIVER PACKAGES AROUND THE WORLD - INSIDE OF UPS COMPANY, 2017). The main difference is that the ones used are not controllable, they are rollers that help workers to pull and push packages inside the plane. This suggests in

fact the future potential of omnidirectional sorters. They will work as elements that will permit the transition into a fully-automated process.

Lastly, it is important to note that UPS has already developed and tested its first prototype of drones' delivering system from a truck (Brownfield, 2017). Earlier last year, UPS was provided with a final model of the operating drone, which successfully delivered the package.

5.4.4.2 UPS's Future Projection

In 8 years' time, the automating process will be much further developed. In order to continue reducing international delivery times, much more work is going to be put in order to be able to better respond to contingencies. **Omnidirectional sorters** will be used to sort products inside the airplane, and to get products in and out of it. Techniques are going to start being developed on how to effectively load and unload vans, and trucks. This still is not a problem, as there are other easier things that could be addressed.

Vertical OSP will already be implanted by some companies: maybe FedEx, UPS or another. The need for much smaller facilities will be key to save companies cost on terrain, and also reduce the amount of time from storage to delivery (as products will be much next to each other).

IIoT will be very important in the autonomous management of orders, solutions, and transportation channels. The only way to be able to automate the service is by interconnecting all parts of the business, from orders and deadlines, to cost of channels available and weather conditions. Again, security is crucial in order to avoid workers' danger and companies' loses. At some point all providers, not only top providers such as Microsoft that are already taking this seriously, will start to assure the security measures required on each part of the company.

Autonomous trucks will almost surely be implanted to some extent, like autonomous driving allowed for trucks and cars on special lanes of a highway. This will really help to diminish the operating times, giving more flexibility and helping to reduce backup inventories.

Distributors will be using **augmented reality** to analyze the whole logistics operation in detail in a virtual in-the-air map, and **virtual reality** to supervise each of the trucks and provide backup whenever needed. Additionally, VR could also help if remote partial control is needed. This can be due to states' regulation such as remote control when moving around the city, or due to unexpected trouble on a route that needs human intervention to be resolved.

As a sixth technology, some cities will have already implemented the **subway transportation system**. Erasing the need to getting inside the cities and get delays due to traffic accidents or rush hours. Trucks will be leaving packages in one of the cities' borders, and the public transportation will do the rest. More time will be needed for further extension into all main cities. The same vertical OSP that has been commented above could be applied to managing subway packages, as well as when placing each of the corresponding orders in lockers.

As a service provider, UPS will have highly improved their **SAAS** services, support, and user experience. On the one hand, for instance, for the specific case of subway transportation. Letting the user be aware of where their package is at every single moment. On the other hand, it will be key on their service dedicated to small and medium enterprises. Providing them with an easy to use and quick app to select the best transportation channels.

Artificial intelligence will also be key in the previous aspect. In the end, once more, is the one that will empower transportation channels' selection. It is a very hard task to do, that in the end has really high cost repercussions. The challenge is that, nowadays, many companies do not have the time nor resources to make better informed decisions. AI will be the one to solve this problems where computing processing and intelligent agents can deeply help.

Blockchain will also be used for tracking systems. This way, the information is stored, and companies will not have to store all the information themselves. Regulatory organisms will be needed to assure that throughout the distribution items have not been changed nor damaged.

Walmart's idea of using an **airship to move packages between cities** seems very viable in 8 years' time. It is much more doable than Amazon's warehouse, as it is not a total disruption from today's transportation channels. In the end, it would be a mix between the current trucks (in terms of moving between cities) and ships (in terms of size of the channel). Additionally, at warehousing, it could be really interesting to see how to move packages and orders between the airship and each warehouse. Focusing on the non-direct delivery of products to customer, this channel could be very useful to reduce the time of loading urgent items. This items could be loaded into the moving airship using drones, no wasted time.

Drones coworking with trucks is also a reality that is going to take place in 8 years' time. Helping to delivery several packages to the same building at the same time, but also deliver packages while the truck is on the move. Lastly, Walmart's idea of using airship between cities for direct and non-direct reach of customers will probably be in terms of being tested. Much more time will be needed for this technology to be fully implemented.

CHAPTER 6

CONCLUSION

Technology is being developed at very high rates, making predictions about how technology will be in 8 years' time is very a complex process. After all the research carried out, conclusions are now going to be presented as a summary of the key points that have already been stated. Elements and context is going to be provided to ensure ideas are not put one after another without connection.

The first thing that must be clearly stated is that **automation** is no-doubt the future of supply chain. Having people coordinating contingencies by making calls, and sending emails, is a complete waste of time. In this aspect, **artificial intelligence** (AI) is going to be the most important technology. Making sense of the data that is gathered, as well as automating as much processes as needed (like contingencies approach), is going to depend on the development of AI and ML, nothing more.

Secondly, in order to provide AI with full control of the plant, implementing the **industrial internet of things (**IIoT) at all levels is required. AI will need IIoT, in order to receive all the precise information needed to make assumptions and choose solving actions. Additionally, **SAAS** will be implemented as the fully-integrator upon the whole information system. If we want to really automate decision-making into the controlling system, we need that companies have access to these resources without any technical knowledge required on its use. For its implementation, deeper programming skills might be necessary, and that makes sense of course.

The tendency seems to be looking at **AGVs** as well. On the one hand, vertical OSPs will be starting to revolutionize the way warehousing is thought of. Allowing vertical stacking with almost no limits will save costs of terrain, permit the fully automation of warehouses, and shrink the times for items delivery from inventory. **Omnidirectional sorters** can really help in

the manufacturing process: first by allowing more complex sorting frameworks, and second by allowing vertical AGVs to directly pick orders from the shelves. Development of AGVs would be quickly developed in the short term, and more innovative solutions that allow to pick packages from very different sizes and shapes will be implemented. Kiva's robot is another example of a technology that will start to be used in managing inventories, and rapidly spread.

The fifth key technology would be **augmented reality** as it gives a bunch of different and interesting possibilities. It firstly provides customers with a great powerful tool that allows them to make better and more informed purchases online. Secondly, companies also benefit by needing less physical stores after promoting online purchases. Also, at the industry level it can help to manage plants and warehouses more efficiently by allowing workers to receive real-time interactive information from all the plant. Additionally, it can help workers to repair machines and to solve any issue or contingency that might take place at any given time. Lastly, it will help in the designing process, by providing real-time interactive in-the-air models. Improvement on latency is currently one of the mayor problems.

3D printing offers also a series of solutions to challenges that no other technology can overcome. Giving customers the chance to get products with the ease of printing a document today makes of this technology a very powerful tool. Also, the saving in transportation, and the incorporation of digital companies into the market are very interesting aspects as well. Obviously, improvements on materials and overall cost are highly required. Also, it will permit highly personalization, as well as provide new channels among the omni-channel logistics.

Subway transportation will probably be implanted, but in a few cities only. Taking advantage of an infrastructure that is already placed, and that is almost not used during the nights, is what makes sense in the end. Nevertheless, 8 years' are too few years for it to be fully implanted worldwide.

Collaborative robots are going to be introduced exponentially into the manufacturing plants. Having machines producing one next to another, helping one another is going to become a very powerful technology in the future. Probably 8 years is not enough time for this technology to be fully implemented on all producing methods of manufacturing. Nevertheless, some parts of manufacturing, such as welding, might have started to benefit from this technology. An additional benefit that will enhance this technology is that collaborative machines provide a less rigid infrastructure. Collaborative robots can provide a production package more open to changes in design and production method.

Lastly, **autonomous cars** are probably going to reshape the future, but possibly not at complete level in 8 years' time. People's fear of crashing is inevitable. Even if an autonomous has less accidents than a human, it still is not a human, and therefore fails are not equally measured by the general public. Apart from the obvious problem of responsibility in case of accident. Anyhow, this does not mean that it would not be used at all. In 8 years' autonomous cars are not going to be driving next to the few people who still go for regular human-driven cars. But, what might be implantable, would be autonomous driving of trucks in highways, but remote control inside cities or on smaller roads. Or, for instance, there might be special lanes for autonomous cars, and others for human-driven cars.

APPENDIX A

RESEARCH QUESTIONNAIRE

On this appendix, the questionnaire that was given to interviewees is presented. The first questions were related to the professional career of the interviewee. This questions were necessary as the background of a person tells a lot about his/her answers. Then, questions about the interviewee vision of each of the technologies analyzed were posed. Additionally, any other comments, or additional technologies that they might believe interesting, were recorded as well.

AP-A.1 RESEARCH QUESTIONNAIRE

The aim of this survey is to analyze the impact that upcoming technologies would have on supply chain. Feel free to add any notes where necessary. The impact of the survey is supposed to be general. Therefore, please try to not be biased by your scope of work. The intention is to gather data about arriving technologies, and the impact of them on the whole supply chain. The word “impactful” is used in that same way, in the sense of revolutionary in all parts and the relation among them.

Thanks for taking the survey!

➢ *First it is important to know a little about yourself to understand the personal circumstances under each answer. Thanks for your understanding. First, what sector are you working at?*

- ☐ Aerospace
- ☐ Agriculture
- ☐ Chemical
- ☐ Computer
- ☐ Construction
- ☐ Real Estate
- ☐ Public Utilities
- ☐ Defense
- ☐ Education
- ☐ Energy
- ☐ Entertainment
- ☐ Financial Services
- ☐ Food
- ☐ Health Care
- ☐ Information
- ☐ Manufacturing
- ☐ Mass Media
- ☐ Mining
- ☐ Telecommunications
- ☐ Transport
- ☐ Water
- ☐ *Other:* _____

➢ *What department are you working at?*

- ☐ Production
- ☐ R&D
- ☐ Purchasing
- ☐ Marketing
- ☐ HR
- ☐ Accounting/Finance
- ☐ *Other:* _____

➢ *Are you currently participating in the specific development of any of the following technologies?*

- ☐ Slat Sorters
- ☐ Omnidirectional Sorters
- ☐ Servo Robots with Vision System
- ☐ 3-D Printing
- ☐ IIoT: Industrial Internet of Things
- ☐ Autonomous Drones & Forklifts
- ☐ Artificial Intelligence (Machine Learning) – Big Data
- ☐ SAAS (Software-as-a-service)
- ☐ Augmented Reality
- ☐ Virtual Reality
- ☐ Autonomous Cars
- ☐ Collaborative Robots
- ☐ Blockchain
- ☐ Subway Transportation
- ☐ *Other:* _____

➢ *What impact do you believe that technology (those technologies) is going to have on people's lives, and more importantly on supply chain? Explain briefly.*

➢ *Could you order from the following technologies the 10 first which will have the highest impact in 5 years' time? Why do you those technologies are going to be more impactful?*

- ☐ Slat Sorters
- ☐ Omnidirectional Sorters
- ☐ Servo Robots with Vision System
- ☐ 3-D Printing
- ☐ IIoT: Industrial Internet of Things
- ☐ Autonomous Drones & Forklifts
- ☐ Artificial Intelligence (Machine Learning) – Big Data
- ☐ SAAS (Software-as-a-service)
- ☐ Augmented Reality
- ☐ Virtual Reality
- ☐ Autonomous Cars
- ☐ Collaborative Robots
- ☐ Blockchain
- ☐ Subway Transportation
- ☐ *Other:* _____

➢ *Which 10 technologies, and in which order, will have a greater impact in 8 years' time?*

- ☐ Slat Sorters
- ☐ Omnidirectional Sorters
- ☐ Servo Robots with Vision System
- ☐ 3-D Printing
- ☐ IIoT: Industrial Internet of Things
- ☐ Autonomous Drones & Forklifts
- ☐ Artificial Intelligence (Machine Learning) – Big Data
- ☐ SAAS (Software-as-a-service)
- ☐ Augmented Reality
- ☐ Virtual Reality
- ☐ Autonomous Cars
- ☐ Collaborative Robots
- ☐ Blockchain
- ☐ Subway Transportation
- ☐ *Other:* _____

➢ *Could you explain why?*

➢ *Could you mention and order on importance 3 groups of technologies that bundled together will be more impactful in 8 years' time? (For example: "Artificial Intelligence + Big Data") Explain the bundle.*

- ☐ Slat Sorters
- ☐ Omnidirectional Sorters
- ☐ Servo Robots with Vision System
- ☐ 3-D Printing
- ☐ IIoT: Industrial Internet of Things
- ☐ Autonomous Drones & Forklifts
- ☐ Artificial Intelligence (Machine Learning) – Big Data
- ☐ SAAS (Software-as-a-service)
- ☐ Augmented Reality
- ☐ Virtual Reality
- ☐ Autonomous Cars
- ☐ Collaborative Robots
- ☐ Blockchain
- ☐ Subway Transportation
- ☐ *Other:* _____

➢ *Any other point that this questionnaire is missing?*

REFERENCES

A look inside Xiaomi's manufacturing plant in Noida. (2017, November 21). Retrieved from YouTube - The Times of India: https://www.youtube.com/watch?v=D1TwE8BjBms

Apple's Chinese Factories: Exclusive. (2012, February 21). Retrieved from YouTube - ABC News: https://www.youtube.com/watch?v=TmLsV9cSk0o

Banker, S. (2017). *3D Printing of Spare Parts*. Retrieved from Logisticsviewpoints.com: https://logisticsviewpoints.com/2017/09/11/3d-printing-spare-parts-challenges/

Banker, S. (2018). *The Biggest Supply Chain Fallacies*. Retrieved from Forbes: https://www.forbes.com/sites/stevebanker/2018/04/09/the-biggest-supply-chain-fallacies/2/#1614a9922b05

Banker, S., Cunnane, C., & Reiser, C. (2018). *The Amazon Supply Chain: The Most Innovative in the World?* Retrieved from Logistics View Points: https://logisticsviewpoints.com/2018/01/08/amazon-supply-chain-innovative-world/

Barboza, D. (2016). *An iPhone's Journey, from the Factory Floor to the Retail Store*. Retrieved from New York Times: https://www.nytimes.com/2016/12/29/technology/iphone-china-apple-stores.html

Barcodes - Past & Present. (2016). Retrieved from Barcoding.com: https://www.barcoding.com/blog/barcodes-past-present/

Barrett, J. (2018). *Misusing Data Could Be Costing Your Business*. Retrieved from Inc.com: https://www.inc.com/jeff-barrett/misusing-data-could-be-costing-your-business-heres-how.html

Bond, J. (2018). *AGVs: Predictably Flexible*. Retrieved from SupplyChain 24/7: https://www.supplychain247.com/article/agvs_predictably_flexible/agv

Borkhataria, C. (2018). *Amazon patents robot 'postmen' that can unlock doors to deliver and pick up packages at any time of the day*. Retrieved from Daily Mail:

http://www.dailymail.co.uk/sciencetech/article-5354457/Amazon-launch-robots-unlock-doors-deliver-items.html

Boyle, A. (2016). *Drone delivery from flying blimp 'fulfillment centers'? Are you kidding, Amazon?* Retrieved from Geek Wire: https://www.geekwire.com/2016/drone-delivery-flying-blimp-amazon/

Boyle, A. (2017). *Battle of the retail blimps: Amazon and Walmart propose airship drone stations*. Retrieved from Geek Wire: https://www.geekwire.com/2017/battle-retail-blimps-amazon-walmart-propose-airship-drone-stations/

Bringing digital transformation to the supply chain with Azure IoT Suite. (2017). Retrieved from Microsoft: https://www.microsoft.com/itshowcase/Article/Content/969/Bringing-digital-transformation-to-the-supply-chain-with-Azure-IoT-Suite

Brownfield, A. (2017). *UPS delivers first package with Cincinnati company's drone*. Retrieved from The Business Journals: https://www.bizjournals.com/cincinnati/news/2017/09/14/ups-delivers-first-package-with-cincinnati.html

Chicago History. (n.d.). Retrieved from Cityofchicago.org: https://www.cityofchicago.org/city/en/about/history.html

Clark, D. (2017). *How the Evolution of Transportation Management Systems is Changing the Future Freight*. Retrieved from SDCExec.com: https://www.sdcexec.com/transportation/article/12381589/how-the-evolution-of-transportation-management-systems-is-changing-the-future-of-freight

Conveyor Switches and Crossings with Avancon OTU. (2018). Retrieved from Avancon: https://www.avancon.com/otu-examples.html

Current Health Expenditure per Capita, PPP (Current international $). (n.d.). Retrieved from Data.worldbank.org: https://data.worldbank.org/indicator/SH.XPD.CHEX.PP.CD?locations=US

Demaitre, E. (2017). *Supply Chain Robots Must Earn their Place at DHL*. Retrieved from RoboticsBusinessReview.com: https://www.roboticsbusinessreview.com/supply-chain/supply-chain-robots-earn-place-dhl/

El Exito de la Cadena de Suministro de Zara. (2017). Retrieved from Retos-operaciones-logistica.eae.es: https://retos-operaciones-logistica.eae.es/el-exito-de-la-cadena-de-suministro-de-zara/

Fallows, J. (2013). *The 50 Greatest Breakthroughs Since the Wheel*. Retrieved from Theatlantic.com: https://www.theatlantic.com/magazine/archive/2013/11/innovations-list/309536/#list

Frangoul, A. (2017). *Ocado and supermarket giant sign deal to develop smart platform*. Retrieved from CNBC: https://www.cnbc.com/2017/11/28/ocado-and-supermarket-giant-sign-deal-to-develop-smart-platform.html

Gavin Materials Handling Ltd. (2018). Retrieved from Intralox Activated Roller Belt: https://www.gmhgb.com/product/intralox-activated-roller-belt/

Glazer, J. (2018). *40 Years of Apple: A Look Back at Apple Product Evolution*. Retrieved from NBC New York: https://www.nbcnewyork.com/news/tech/Apple-Products-Through-the-Years-374175161.html

Gupta, K. (2017). *An Overview of Automated Parking System and its Types*. Retrieved from Get My Parking: Blog: http://blog.getmyparking.com/index.php/2017/08/30/an-overview-of-automated-parking-system-and-its-types/

Hall, M. (2018). *Microsoft Corporation*. Retrieved from Britannica: https://www.britannica.com/topic/Microsoft-Corporation/

Haseeb. (2015). *SWOT Analysis of UPS*. Retrieved from Maketing Dawn: http://marketingdawn.com/swot-analysis-of-ups/

Hidjaja, C. (2018). *Top Supply Chain Management Challenges*. Retrieved from Vision33.com: https://blog.vision33.com/top-supply-chain-management-challenges-and-how-to-overcome-them

History of Supply Chain Management. (2015). Retrieved from Cerasis.com: http://cerasis.com/2015/01/23/history-of-supply-chain-management/

How does Amazon Prime Now deliver packages in under two hours? (2016, December 22). Retrieved from YouTube - GeekWire: https://www.youtube.com/watch?v=AEKMgCmLcRc

HOW UPS DELIVER PACKAGES AROUND THE WORLD - INSIDE OF UPS COMPANY. (2017, October 29). Retrieved from YouTube - Learn PLUS: https://www.youtube.com/watch?v=49H7rTjHBJE/

Hudson, M. (2018). *Learn About Brick and Mortar Stores*. Retrieved from The Balance Small Business: https://www.thebalancesmb.com/what-are-brick-and-mortar-stores-2890173

Huguet, K. (2018). *Apple Reports First Quarter Results*. Retrieved from Apple: https://www.apple.com/newsroom/2018/02/apple-reports-first-quarter-results/

Inside An Amazon Warehouse On Cyber Monday. (2016, November 28). Retrieved from YouTube - Tech Insider: https://www.youtube.com/watch?v=qRQwkJLRfWw

Kuntze, C., Martin, A., Regnier, C., & Silva, I. (2018). *Deliver on Time or Pay the Fine: Speed and Precision*. Retrieved from McKinsey: https://www.mckinsey.com/business-functions/operations/our-insights/deliver-on-time-or-pay-the-fine-speed-and-precision-as-the-new-supply-chain-drivers

Lewis, R. (2018). *United Parcel Service*. Retrieved from Britannica: https://www.britannica.com/topic/United-Parcel-Service

Lopez, E. (2017). *What is the future of sustainability in the supply chain?* Retrieved from Supply Chain Dive: https://www.supplychaindive.com/news/what-is-the-future-of-sustainability-in-the-supply-chain/510756/

Manyika, J., & Roxburgh, C. (2011). *The great transformer: The impact of the Internet on economic growth and prosperity.* McKinsey Global Institute.

Marr, B. (2016). *What Is The Difference Between Artificial Intelligence And Machine Learning?* Retrieved from Forbes: https://www.forbes.com/sites/bernardmarr/2016/12/06/what-is-the-difference-between-artificial-intelligence-and-machine-learning/#7d15af382742

Marr, B. (2018). *The Key Definitions of Artificial Intelligence*. Retrieved from Forbes: https://www.forbes.com/sites/bernardmarr/2018/02/14/the-key-definitions-of-artificial-intelligence-ai-that-explain-its-importance/#74e0c8ff4f5d

Morse Code & the Telegraph. (2009). Retrieved from History.com: https://www.history.com/topics/inventions/telegraph

Moses, A. (2018). *Reliable Supply Chains Help Keep Inventories Low*. Retrieved from PenskeLogistics.com: https://www.penskelogistics.com/solutions/supply-chain-management/lead-logistics-provider/reliable-supply-chains/

Murphy, A. (2017). *AGV Deep Dive: How Amazon's 2012 Acquisition Sparked a $10B Market*. Retrieved from Loup Ventures: https://loupventures.com/agv-deep-dive-how-amazons-2012-acquisition-sparked-a-10b-market/

Novet, J. (2018). *Microsoft has now rebuilt the company around the cloud instead of Windows, and employees approve*. Retrieved from CNBC:

https://www.cnbc.com/2018/03/29/microsoft-cloud-reorg-what-insiders-are-saying.html

Number of Products on Sale at Amazon Prime Now. (2017). Retrieved from ScrapeHero: https://www.scrapehero.com/number-of-products-on-sale-at-amazon-prime-now/

Ocado Smart Platform: Transforming Warehouse Automation with another World-First in Radio Design. (2018). Retrieved from Cambridge Consultants: https://www.cambridgeconsultants.com/case-studies/ocado-smart-platform

Omni-directional Transfer Tables for Roller Conveyors, for Crossings, Diverters and Sorters. (2018). Retrieved from Avancon: https://www.avancon.com/otu-tables.html

Ostdick, N. (2017). *The Challenges of Supply Chain Integration*. Retrieved from Flexis.com: https://blog.flexis.com/the-challenges-of-supply-chain-integration

Our Company at a Glance. (2017). Retrieved from Volvo Cars: https://group.volvocars.com/company

Pareto Principle. (n.d.). Retrieved from Investopedia: https://www.investopedia.com/terms/p/paretoprinciple.asp

Russinovich, M. (2018). *Inside Azure Datacenter Architecture*. Retrieved from Microsoft: https://azure.microsoft.com/en-us/resources/videos/inside-azure-datacenter-architecture-with-mark-russinovich/

Saunders, K. (2015). *9 Facts About Rfid Technology in Logistics*. Retrieved from Morailogistics.com: http://morailogistics.com/9-facts-about-rfid-technology-in-logistics/

Schlosser, K. (2017). *Give Amazon a Key to your home? Poll finds majority of Americans uncomfortable with idea*. Retrieved from Geek Wire: https://www.geekwire.com/2017/give-amazon-key-home-poll-finds-majority-americans-uncomfortable-idea/

Shoe Sorters. (2018). Retrieved from Bastian Solutions: https://www.bastiansolutions.com/solutions/technology/conveyor-systems/sortation/conveyor/shoe-sorter

Sliding Shoe Sorter. (2017). Retrieved from Precision Warehouse Design: http://precisionwarehousedesign.com/products/conveyors/sortation-conveyor/sliding-shoe-sorter.html

The History of Fax (1843 to Present). (2018). Retrieved from Faxauthority.com: https://faxauthority.com/fax-history/

Top 5 Omni Channel Logistics Challenges Businesses Face. (2018). Retrieved from Legacy Supply Chain Services: https://legacyscs.com/5-omni-channel-logistics-challenges/

Top 8 Logistics Challenges Facing the Industry. (2017). Retrieved from Logisticsmgmt.com: https://www.logisticsmgmt.com/article/top_8_logistics_challenges_facing_the_industry

Total Population in the US. (2017). Retrieved from Data.worldbank.org: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=US

Transportation & Freight. (2017). Retrieved from UPS: http://www.ups-scs.com/transportation/

Unraveling the complexities and nuances of modern Product Lifecycle Management (PLM) solutions. (2017). Retrieved from Capgemini: https://www.capgemini.com/wp-content/uploads/2017/07/unraveling_the_complexities_and_nuances_of_modern_product_lifecycle_management_plm_solutions.pdf

Volvo XC40 Factory in Ghent, Belgium. (2018, March 26). Retrieved from YouTube - DPCcars: https://www.youtube.com/watch?v=j6qVP--W4Ho

Welcome to the Automated Warehouse of the Future. (2018). Retrieved from The Verge: https://www.theverge.com/2018/5/8/17331250/automated-warehouses-jobs-ocado-andover-amazon

What are the Advantages of the Internet? (2017). Retrieved from Computerhope.com: https://www.computerhope.com/issues/ch001808.htm

What Is ERP? (n.d.). Retrieved from Oracle: https://www.oracle.com/applications/erp/what-is-erp.html

What is IIoT? (n.d.). Retrieved from Inductiveautomation.com: https://inductiveautomation.com/what-is-iiot/