Artificial Intelligence and the Consumer Packaged Goods Supply Chain

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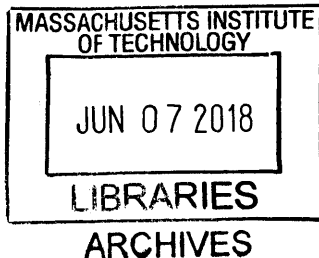MIT Sloan School of Management
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Abstract:

This study explores how Artificial Intelligence (AI) will help the Consumer Packaged Goods (CPG) industry to address the future challenges in its supply chain. It analyses what trends this industry is already exposed to, and the impacts of those trends in its supply chain in the next five years. The work also explores examples of available AI solutions in an attempt to match the demand generated by future trends with the supply of this technology.

The scope is limited to the CPG manufacturers with a bigger focus on planning and distribution rather than manufacturing, since these processes are present in any company with small variances. Other supply chain players such as material suppliers, retailers, distributors, third party logistics (3PL), etc. are covered at a high level since they are part of the network and influence the dynamic of the system.

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To my parents who always supported my learning journey

To Gabi who was by my side during this entire year

To Isa and Cassio who were cheering for my success

"Querer não é poder. Quem pôde, quis antes de poder só depois de poder.

Quem quer nunca há-de poder, porque se perde em querer."

Fernando Pessoa

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Chapter 1 - Introduction

The objective of this study is to explore how Artificial Intelligence (AI) can help the Consumer Packaged Goods (CPG) industry to address the future challenges in its supply chain. It analyzes what trends this industry is already exposed to, the impacts of those trends in CPG supply chain in the next five years, and the challenges supply chain executives will face to adapt to the future trends. The work also explores examples of available AI solutions in an attempt to match the demand generated by future trends with the supply of this technology.

The scope is limited to the CPG manufacturers with a bigger focus on planning and distribution rather than manufacturing, since these processes are present in any company with small variances. Other supply chain players such as material suppliers, retailers, distributors, third party logistics (3PL), etc. are covered at a high level since they are part of the network and influence the dynamic of the system.

The study is structured in five different topics. It starts with a description of what is artificial intelligence (Chapter 2), followed by an explanation of how traditionally the CPG supply chains are organized and what are the future business trends that will affect their structure (Chapter 3). Based on this trends, the work explores the key challenges executives will have to address to adapt to the future (Chapter 4). These challenges are presented in four different dimensions: people, culture, systems and processes, and cost. In Chapter 5, examples of currently available AI solutions applied to CPG supply chains are presented in an attempt to match its applications with the challenges highlighted in

Chapter 4. These examples were divided in four different supply chain areas depending on their application: demand planning, back-office operations, warehouse and fulfillment center operations, and transportation. The study conclusions and final considerations of possible obstacles faced during AI implementation are presented in Chapter 6.

Research Methodology

This research project consisted of three phases:

1. Literature

Literature describing CPG supply chain current design and future trends was analyzed. The focus was to identify common elements that could bring insights on how this supply chain will evolve in the following five years.

AI literature covering its history, current applications and future technology trends was reviewed for a better understanding of its origins and trajectory as well as possible applications for the CPG supply chain.

On top of traditional literature, the research also contemplated companies' web sites.

2. Interviews

Twelve leaders (Appendix – A) were interviewed over the phone. They represent nine companies related to the CPG industry in four different areas:

- Manufacturers: 3 interviews
- Third party logistics (3PLs): 3 interviews
- Consultants: 3 interviews
- Solution providers (software and hardware): 3 interviews

During the interview process three questions were explored with the objective of understanding the future trends of CPG supply chain, its challenges and AI solutions in use today.

Questions for manufacturers and 3PLs:

I.   What are the top three challenges the CPG supply chain faces today?

II.   How are you planning to address the challenges you have listed?

III.   Do you have any experience with AI? How do you see AI helping to address the challenges listed?

Questions for consultants and solution providers:

I.   What are the top three changes the CPG supply chain will see in the future?

II.   How would you advise companies to address the changes you have listed?

III.   Do you have any experience with AI? How do you see AI helping to address the changes listed?

3. Summit participation

The participation in summits and expositions was a complementary way to hear experts talk about AI and CPG industry trends and get insights that could be further explored in this study. I attended the three events listed below:

- AI and the Future of Work – MIT, Cambridge – MA (November 1-2, 2017)

- Beyond the Screen: MIT Sloan Retail & Consumer Goods Conference 2017 – MIT Sloan, Cambridge – MA (December 8-9, 2017)

- 2018 Retail & Luxury Goods Conference: Reinventing the Retail Value Chain – HBS, Boston – MA (February 24, 2018)

Argument

The future of consumer goods supply chain will require a faster, more flexible, more granular, more accurate and more efficient operation. These requirements will be enabled by the digitalization of supply chains, and will demand a well-integrated system, from suppliers to consumers (Alicke, Knut, et al).

In the process of adaptation to this new environment, CPG supply chains will face four challenges:

- People: employees are not prepared to deal with a digital supply network
- Culture: organizations are not used to experimenting
- Systems and Processes: new processes and systems will be required to drive a digital supply network
- Cost: it is difficult to increase flexibility while keeping costs under control

Of the four challenges highlighted, AI tools may help to address only two of them, i.e., better systems and processes capable of driving a digital supply network and a higher flexibility at a competitive cost. The other two challenges, i.e., lack of prepared people and an innovative culture, are not addressed by AI but are mandatory for a successful AI implementation.

AI has a great potential to help CPG companies to reduce cost at the same time as they increase supply chain agility. However, to do it in an effective way, executives in charge

of AI implementation need to guarantee the right skills are present not only in the team that will develop and test such solutions but also in the organization that will use it in the day-to-day. Moreover, it is important to be careful of potential implementation challenges, guaranteeing that the solution is aligned with the company strategy, that people are able to understand what is behind any solution proposed (no black box) and that the organization knows how to deal with coexistent human-machine processes.

Chapter 2 – What is Artificial Intelligence

The definition of Artificial Intelligence (AI) found through a Google search is: "the theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages." Artificial intelligence is a broad field of study, and definitions of the field vary by discipline. For computer scientists, artificial intelligence refers to the development of programs that exhibit intelligent behavior. For engineers, it refers to building machines that perform actions often done by humans. For cognitive scientists, AI refers to building models of human intelligence to better understand human behavior. However, when defining artificial intelligence, it is important to remember that the programs, machines, and models developed by computer scientists, engineers, and cognitive scientists do not actually have human intelligence; they only exhibit intelligent behavior. (Whitson)

Machines are able to process data and follow instructions at a very high speed. The backbone of artificial intelligence development lies in the fact that today computers are much more powerful than they used to be, meaning they can process more data much faster. Moreover, the introduction of the Internet in the 90s and the usage of this technology to connect people and objects enabled the world to generate more data than ever. Data represents to machines what air represents for humans (other authors also refers to data as machines' food). Without data, machines cannot survive. There's no intelligence. In summary, AI is as good as the quality of data it is using.

AI systems learn from the data and feedback that they receive in response to their earlier decisions. In other words, data is a simple piece of information that can be seen as either true or false, although in fuzzy logic, there are levels of truth. When facts are organized, they become information, and when information is well understood, over time, it becomes knowledge (Whitson). A traditional program processes data but does not learn from it. AI enables going from a world where people give computers rules to solve problems, to a world where people give computers problems directly and the machines learn how to solve them on their own, using a set of algorithms (Deng).

The history of AI started in 1959 with Frank Rosemblatt, an American psychologist and computer scientist who created the perceptron algorithm, the first algorithmic model that could learn on its own. A year later, Arthur Samuel would coin the term "machine learning" as well as develop a groundbreaking checkers program seen as an early success in AI. (McKinsey Analytics). The term "artificial intelligence" is attributed to John McCarthy, a Stanford computer science professor. He used the term to describe the ability of certain machines to do things that people are inclined to call intelligent. In 1959, McCarthy and Marvin Minsky created the Artificial Intelligence Group at the Massachusetts Institute of Technology (MIT) (Bernstein)

Initially, to be considered intelligent, a machine needed to pass the Turing Test. This test was developed by Alan Turing in a 1951 paper called "The Imitation Game." The game consisted of a human judge who had to differentiate a human from a machine talking to them through a computer terminal. If the judge was less than 50% accurate in picking the human, the computer was considered intelligent (Department of Psychology University of Toronto). The test has a lot of limitations, since it is based on language processing

capabilities, preventing intelligent machines based on other capabilities from performing well. In spite of its limitations, the Turing Test is still mentioned in many articles about AI.

In a 1970 Life Magazine article, Marvin Minsky from MIT said: "In from three to eight years we will have a machine with the general intelligence of an average human being. I mean, a machine that will be able to read Shakespeare, grease a car, play office politics, tell a joke, have a fight." It took much longer than he originally forecasted but today machines are able to do everything Minsky predicted. (Darrach)

Machine intelligence refers to multiple technologies that can be combined in different ways to enable different "talents." Those technologies can be generally grouped in three categories (Purdy, Mark, and Paul Daugherty):

1. SENSING: how computers perceive the world, for example by acquiring and processing images, sounds, and speech.
2. COMPREHENDING: how computers understand the information collected, for example using probabilistic inferences to extrapolate from similar cases.
3. ACTING: after sensing and/or comprehending, how computers act, for example, deciding to move or stop an autonomous vehicle.

AI can handle both linear problems (essentially generalizations of straight lines) and nonlinear problems (everything else). This twofold ability opens up a multitude of optimization opportunities in fields such as logistics, production, and energy efficiency. However, algorithms are, in part, human opinions embedded in code. They reflect biases and prejudices that may lead machines to learn mistakes and to misinterpret situations. (Schrage). Moreover, machines use past data to predict future outcomes. The reliance

on historical information may reinforce and even amplify past biases if data scientists are not careful when developing and training algorithms. Algorithmic bias is one of the biggest risks in AI adoption.

An important point that commonly drives misunderstanding is the difference between being autonomous versus being automated. A process can be automated without being autonomous. In other words, a system may function with little or no human interference to execute a pre-established task (i.e., automated) and not have the capability to act independently or have the freedom to do so (i.e., autonomous). Most of the automation seen today in supply chains is not based on autonomous systems. Machines can execute a fixed, pre-defined task but cannot comprehend what is happening in their surroundings or take actions when a non-programmed event happens.

An example that illustrates this difference is an Auto-guided vehicle used to transport materials inside a fulfillment or distribution center (DC) versus a smart collaborative robot. While the first follows wires or markers in the floor or uses lasers or magnets for navigation and cannot deviate from a pre-established pathway, the second can sense the environment around it and navigate safely, autonomously deciding which route to follow and even when to ask for human help.

Machine learning provides both predictions and prescriptions. When working on predictions, algorithms use past data to anticipate probable outcomes, which can be used as insights for organizations to take actions. Prescription algorithms provide recommendations on what to do to achieve a pre-established goal. In general, machines learn in three different ways (McKinsey Analytics):

- SUPERVISED LEARNING: An algorithm uses training data and feedback from humans to learn the relationship of a given output (e.g., how the inputs' "price" and "advertisement" predict sales of a given product). This method is applied when users know how to classify the input data and the type of behavior they want to predict, but they need the algorithm to calculate it on new data (i.e., sales).

- UNSUPERVISED LEARNING: An algorithm explores input data without being given an explicit output variable (e.g., explore customer's demographic data to identify patterns). It is used when people do not know how to classify the data, and they want the algorithm to identify patterns and classify the data for them.

- REINFORCEMENT LEARNING: An algorithm learns to perform a task simply by trying to maximize rewards it receives for its actions (e.g., maximizes points it receives for increasing returns of an investment portfolio). It is used when people lack enough training data, when they cannot clearly define the ideal end state, or when the only way to learn about the environment is to interact with it.

AI architecture combines centralization and decentralization. As an example, in an operation automated with a fleet of smart robots, each individual acts autonomously. However, they transmit their data, or learning, to a central data center which aggregates information from everybody else in the fleet. The system then uses aggregated data from each robot to foster central-system learning, and individual robots receive periodic updates based on such learning from the central system. Everything that a single robot learns is shared with the entire group and incorporated into its individual intelligence package. This capability translates into a faster learning process once it happens in a

collective way. On the other hand, humans need to be trained on an individual basis, leading to a much slower dissemination of knowledge.

According Rama Ramakrishnan (Senior Vice President of Data Science and Commerce Cloud at Salesforce), the impact of AI in business results usually comes from small decisions made thousands of times. Even if the percent impact is small, the overall impact is big due to the multiplicative effect of the number of transactions. The higher the uncertainty about the future and the lower the effort to acquire the required data, the bigger the business impact. This concept is reinforced by the Gartner report "Applying Artificial Intelligence to Drive Business Transformation", which states that AI functions best and has its greatest impact when its constituents are narrowly focused on well-defined problems, e.g., image processing to auto-select the proper box size for packing items for shipment. According to this same report, digital business is already disrupting organizations, and AI will add to the disruption. By 2020, AI technologies will be a top-five investment priority for more than 30% of Chief Information Officers (CIOs) (Andrews, Whit).

Chapter 3 – The CPG Supply Chain and its Future Trends

The CPG Supply Chain

Supply chains are traditionally linear and follow a plan-source-produce-deliver path (**Figure 1**). Each participant of the supply chain interacts only with the participants immediately before or after them. Little or no visibility of the entire process is available and intermediate contingencies (usually translated as inventory) are purposely allocated in each step to diminish their risk in the chain. The longer the supply chains are, and the more organizations they involve, the more difficult it is to coordinate the activities.
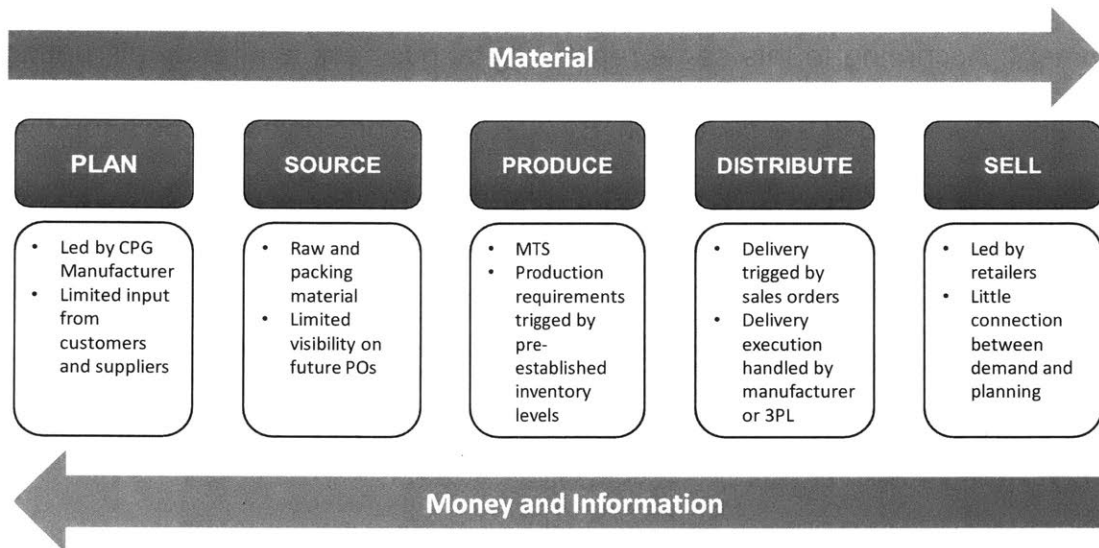

Material

PLAN	SOURCE	PRODUCE	DISTRIBUTE	SELL
• Led by CPG Manufacturer • Limited input from customers and suppliers	• Raw and packing material • Limited visibility on future POs	• MTS • Production requirements trigged by pre-established inventory levels	• Delivery trigged by sales orders • Delivery execution handled by manufacturer or 3PL	• Led by retailers • Little connection between demand and planning

Money and Information

Figure 1: The traditional CPG supply chain

This linear path not only reproduces the way physical movements happen but also describes the data and money exchange flow. What changes is the direction. While

material and products flow from upstream to downstream in the chain, money and information flow in the opposite direction (i.e. from downstream to upstream) but the interactions happen among the same participants. In the traditional supply chain, data tend to be siloed into separate information clusters (Mussomeli, Adam, et al).

CPG companies often operate in a made-to-stock (MTS) model, where inventory is built at both manufacturers' and retailers' distribution centers based on a forecast and demand is met from stock. When a change happens, the system experiences long delays until it fully adjusts. Often, a new change occurs before the complete adjustment of the previous one and introduces extra variability in the system. With time, it's hard to tie what is happening on one end of the chain with what is observed on the other end. This unbalance generates tremendous inefficiencies such as excess inventory, extra costs, lost revenue and poor service levels. This phenomenon is also known as the bullwhip effect (**Figure 2**). The bullwhip effect suggests that the variability of orders increases as they move up the supply chain from retailers to wholesalers to manufacturers to suppliers.
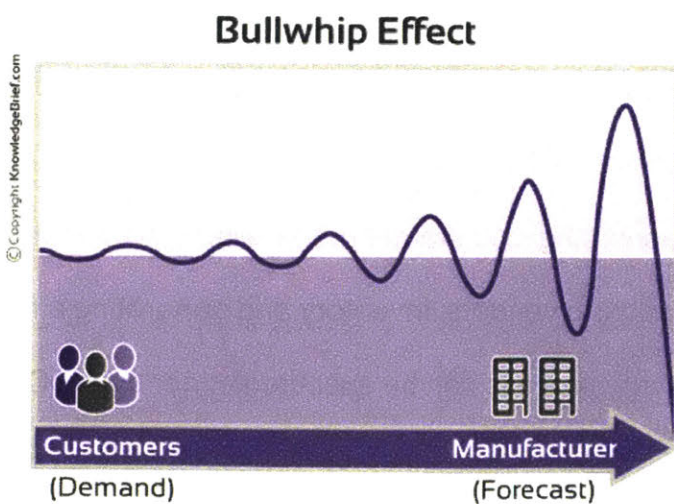

Figure 2: The Bullwhip Effect

Source: https://www.kbmanage.com/concept/bullwhip-effect

The traditional CPG supply chain is reactive to order changes and can be briefly described by the relationship of five elements: plan, source, produce, distribute and sell.

- PLAN: The planning and forecasting role is led by the CPG manufacturing companies which receive order information from the downstream (usually retailers), compare it with pre-established, fixed inventory and service level targets and generate a sales forecast plan that will trigger both production and sourcing activities.

- SOURCE: Raw and packing material suppliers receive purchase orders (PO) from the CPG manufacturer which will trigger their own source, production and delivery plans. Nowadays, most of the big CPG companies provide some visibility of their future purchase orders, sharing their own order forecasting with key suppliers.

- PRODUCE: Once raw and packing material is received in the manufacturers' facility and inventory levels reach the value defined during the planning phase, production is triggered. During this process other resources such as equipment and employee availability, change-over costs and other internal factors are also considered. Traditionally this process is managed with the usage of a company Enterprise Resource Planning System (ERP).

- DISTRIBUTE: Deliveries happen according to customer (i.e. retailers, wholesalers, distributors, etc.) order inflow, consuming vendors' inventory and generating a new production need. The physical delivery process can be executed either by the CPG manufacturer with its own employees or by using a third party logistic (3PL). When a 3PL is present in the process, it typically manages the distribution center

operation and the interaction with the different carriers required to move products from point A to point B.

- SELL: Retailers control sales to end consumers who are the ultimate link in this supply chain and therefore the ones responsible for pulling the demand. They plan their replenishment orders partially based on the demand they are seeing in their stores (physical or online) and partially based on a future demand expectation.

Over the last 30 years, this traditional supply chain evolved. With the advent of the Internet, the increase in data availability and computer power and the decrease of storage and bandwidth costs, this sequential, discrete supply chain became more interconnected and collaborative. Information exchange between the different players happens more frequently, and a stronger link between the ones receiving the delivery (retailers, wholesalers, distributors, etc.) and the ones leading the planning process is established. In some cases, CPG companies have access to demand information that helps to decrease the variability in the system. Demand is less variable than orders, which naturally include other intrinsic information such as inventory adjustments and expectation of future events. Replacing orders by demand in the planning process enables the chain to reduce the noise and therefore be more efficient.

A successful example of how demand sharing can make a difference in service level increase and both cost and inventory decrease is the vendor managed inventory process (VMI). First implemented between Wal-Mart and Procter&Gamble (P&G) in the late 1980s, the delivery (or replenishment) is based on a pre-agreed inventory target that should be kept at the customer site. There's no need of a sales order to trigger the process. The manufacturer (or vendor) receives both inventory and aggregated sales

data (i.e., demand) direct from its customer and defines the right amount of product to be shipped. Potentially, vendors are able to replenish today what was sold yesterday in an almost just-in-time process. The VMI process offers a real possibility to reduce the bullwhip effect. First because there is an elimination of one layer in the replenishment decision making process, and second because the demand information arrives directly to the manufacturer without any adjustment or future expectation incorporated in it. In a numerical study, G.P. Cachon and M. Fisher from Wharton found that a full information sharing policy lower the supply chain costs by 2.2% in average with a maximum difference of 12.1% when compared with a traditional information sharing policy (Cachon).

In spite of being more connected and having access to more data, a lot of companies still rely on their traditional planning processes which are separate from the execution process. Forecasting is largely based on past sales and planning personnel experience. Little information sharing and analytics is present and inventory is the main tool used to cover inefficiencies and guarantee the appropriate service level.

Future Trends

According to McKinsey & Company, the future of consumer goods supply chain will require a faster, more flexible, more granular, more accurate and more efficient operation. These requirements will be enabled by the digitalization of supply chains, also called Supply Chain 4.0, and will demand a well-integrated system, from suppliers to consumers. (Alicke, Knut, et al)

These trends are also aligned with the research project "The Gartner Supply Chain Top 25", where three trends stand out from their interviews: digitalization, adaptive

organizations and capabilities, and health ecosystem. The leading companies in the study are creating digital connections within and across their supply chain operations. Simulation and optimization capabilities have moved to the mainstream, and cognitive computing capabilities, including machine learning, are being tested by most advanced supply chains. At the same time, companies are becoming more adaptive to changes. More specifically, leaders are creating adaptive organizations and capabilities to respond to this dynamic environment. (Aronow, Stan)

A consumer-centric supply chain approach emerges at the same time consumers are changing their purchasing habits. They are abandoning the brick-and-mortar stores as the only source capable to supply their CPG needs. Online purchase with home delivery or self-pick-up is gaining popularity. According to Statista 31% of Americans are very likely to purchase groceries online in 2018 (www.statista.com). The e-commerce of food and personal care generated a total revenue of $46.3 billion in 2017 and the forecast is to reach $78.1 billion by 2022 (**Figure 3**).
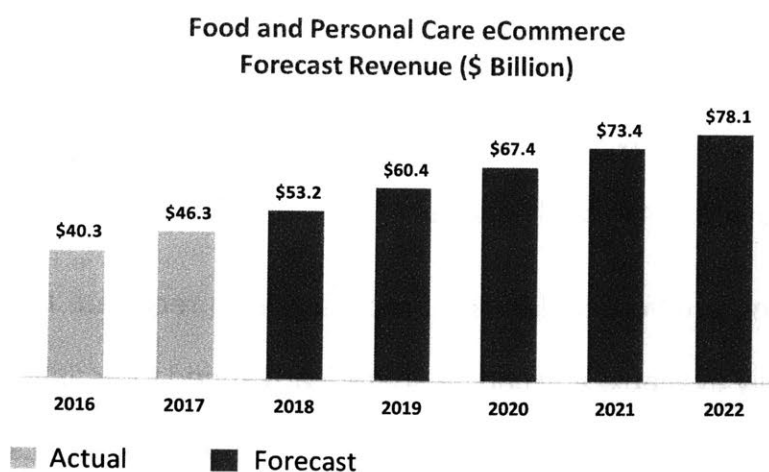

Figure 3 – Food and Personal Care eCommerce Revenue in United States

Source: Graph prepared using data from Statista, January 2018 (www.statista.com)

This change in behavior requires a different supply chain and the CPG industry will need to re-shape its structure to guarantee it will be able to respond to the new consumption habits. With consumers expecting to receive their orders within a 24 hour or less lead-time, the number of fulfilment centers in a country with a continental size like the United States will necessarily increase. In addition, fulfillment centers dedicated to supply on-line purchases have different characteristics than the ones built to supply stores. Their operations are more complex since they need to handle a much broader product portfolio and, instead of moving pallets or full cases of products, must ensure unit picking capability. MWPVL, a global supply chain and logistic consulting firm, reports that Amazon had in February 2018 a total of 121 distribution networks, including fulfillment centers, supplemental centers and return centers and has an expectation to open another 26 in the near future. Wall-Mart opened its first e-commerce fulfillment center in 2013 and today it has 11 of those facilities. (MWPVL)

Moreover, new channels demand different product sizes and packages capable of withstanding shipping methods not used before. To respond to them, a stock keeping unit (SKU) proliferation is inevitable, increasing the planning and operational complexity even further. In addition, with e-commerce, data availability will increase and enterprises able to make good usage of it will have a competitive advantage.

To succeed in this new environment, a different planning process will be required. In a business where information is broadly available and can be shared, advanced forecasting techniques, less dependent on people's experience, more grounded on data analytics, and with shorter planning periods will be demanded.

The traditional monthly sales and operations meeting (S&OP) with one to three months freezing horizon used in the past by several CPG companies will be replaced by a fluid and dynamic process, able to react fast to changes. In its study "The Rise of Supply Network", Deloitte University Press calls this new model the digital supply network (DSN). Being digital enables potential interactions from each node to every other point of the network, and allows greater connectivity among areas where it has previously not existed (**Figure 4**) (Mussomeli, Adam, et al) A similar model is also described by KPMG in its 2016 paper "The Future of Retail Supply Chain."
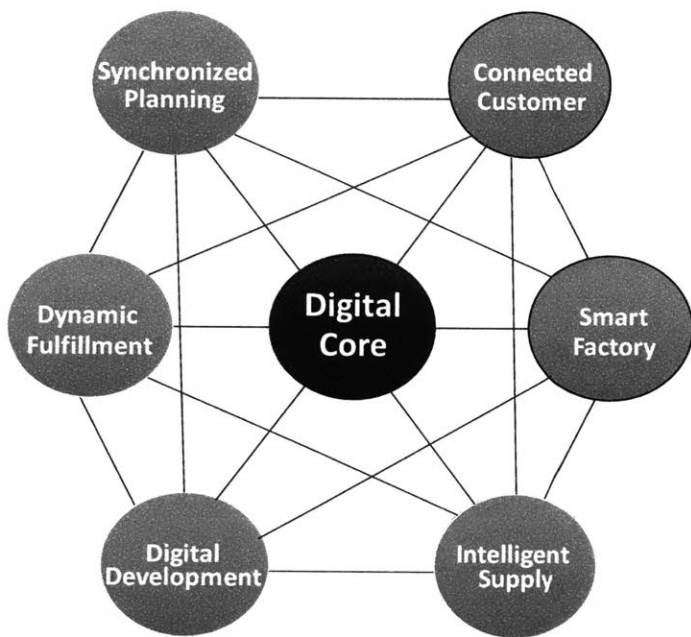

Figure 4: Deloitte DSN model

Source: The rise of digital supply network, Deloitte University Press

In this model, companies need to think beyond the confines of their four walls. Demand for products (or materials) is realized at an individual order line level, meaning that a particular business customer or end consumer requests a certain number of items for a

particular SKU at a particular point in time. Demand is then naturally aggregated by the different participants of the network along three dimensions: locations, products, and time. It is used to inform their decision-making at various organizational and functional levels simultaneously. There is no need to wait for demand information and no filter between one level of the supply chain and the other. Real-time planning allows companies to increase their flexibility to respond to demand variations. At the same time, it diminishes the need of inventory to cover unexpected variations and information delays boosted by the bullwhip effect common in traditional supply chains.

According to the Forbes article "Why Amazon's Anticipatory Shipment is Pure Genius", in the future, we may even see "predictive shipments", a system of delivering products to customers before they place an order. Amazon already has obtained a patent for this system that could potentially place predictive analytics on a different level (Kopalle).

Another trend that will affect the way CPG companies, especially the smaller ones, run their operation is the shared economy concept. The "Uberization" of transport and warehousing operations will enable them to better utilize the available assets and reduce the total operational cost. To enable this new way of collaboration, the traditional role of a 3PL must be expanded from execution to management. There will be room for them to coordinate the supply and demand of logistics services, serving as a platform that optimizes the available resource utilization.

Overall CPG companies are well positioned to react to the challenges described above. According to Gartner, from the Supply Chain Top 25 Companies, 36% are in the CPG industry (Unilever: #1, Nestle: #7, Colgate-Palmolive: #9, Pepsico: #11, Johnson & Johnson: #13, The Coca-Cola Co.: #14, L'Oreal: #20, Kimberly-Clark: #21 and Diageo:

#23). Procter & Gamble was considered in the master category together with Apple and Amazon. P&G continues to innovate through digital automation of workflows and the use of algorithm-driven tools to reduce exceptions and enable end-to-end planning. Investments in digital manufacturing move them closer to the ability to mass-personalize products. They are also automating distribution center operations seeking improvements in efficiency and partnering with other companies in an innovative resource sharing platform for intermodal transportation (Aronow, Stan).

Chapter 4 – The CPG Supply Chain Challenges

Supply chains traditionally have three main challenges and try to balance them in order to add the most value to the companies they represent. The first challenge is how to provide a high service level, being both responsive (i.e. agile, fast) and reliable (i.e. meeting the targets). The second is how to keep costs as low as possible. The third challenge is how to guarantee service and cost goals are met with the least possible cash by either increasing asset utilization or reducing inventory.

During this study, after discussing with CPG industry leaders and analyzing reports produced by global consultant companies, we can conclude that there are four main challenges on how to adapt CPG supply chains to the trends this industry is exposed to. These challenges are:

- People: employees are not prepared to deal with a digital supply network
- Culture: organizations are not used to experimenting
- Systems and Processes: new systems and processes will be required to drive a digital supply network
- Cost: it is difficult to increase flexibility while keeping costs under control

People

Employees are not prepared to deal with a digital supply network

When dealing with a digital supply network, a complete new set of technical and leadership skills will be required from the supply chain personnel. The modern

organization will require, on top of the operational excellence, strong data analytics and influential skills capabilities. These new requirements will affect all levels of the hierarchical pyramid.

On one hand, supply chain leaders will have to undertake a bigger role in their organizations, switching from a supporting executional role to a strategic one. They will be responsible for overcoming the internal functional silos and increasing the collaboration with both suppliers and customers. In some cases, supply chain may become a key company differentiator evolving from a cost center to a revenue engine.

On the other hand, the planning process will have to rely more on data analytics since the flexibility required and the amount of information available will increase exponentially. The "old style" planner, accustomed to using little data and a lot of experience and "gut feeling" to decide supply chain next actions, will not survive in this new environment. Intelligent machines will handle a good part of their current function and only the data-educated professionals with good interpersonal skills will have space in this set-up. Companies will need fewer planners and more data scientists. In addition, the planner role will be elevated and planners will spend more than 60% of their time thinking about how to move the needle to reach company targets instead of spending 80% of their time managing and correlating data and only 20% understanding the problem and thinking about how to solve it. According to Igor Rikalo (COO from o9 solutions), planners will become decision scientists and will play a key role in helping the organizations make better decisions and influencing the execution. The challenge will be how to attract and retain these talents given the high demand for such professionals in e-commerce and tech companies.

At the same time some roles in supply chain will change, AI systems learn from their experience, improving their accuracy and reliability over time. They adapt, and their behavior is expected to change. Organizations will have to be able to manage this dynamism and how it affects their workforce (Whit, Andrews). Companies will also need to think about their current employees and how to enhance the skills in the existing staff. New training programs will be required as well as a cultural shift. Supply chain personnel will need to learn to trust in machines the same way they trust in their own experience. According to Alvaro Cuba (Senior Vice President of Integrated Supply Chain at Mondelez North America), changes are happening very fast and culture change and capability building are critical to stay competitive and take advantage of the opportunities that lay ahead. One of the main challenges today is how to increase organizational agility to make this to happen

Culture

Organizations are not used to experimenting

To build a digital supply network, the supply chain organizations will be required to embrace a culture of innovation and experimentation. The "right first time" mindset will need to adapt to a "test and learn" one, welcoming innovation and experimentation and increasing its tolerance for failure. Finding people who are willing to fail, try new things and think long-term is a challenge in more traditional supply chain organizations. The proverb "No idea is born good; you have to nurture it over time" fully applies in this context. Managers will have to open themselves to more uncertainty and demonstrate this openness in the way they prioritize projects and investments.

Neil Ackerman (Senior Director of Global Supply Chain Innovation at Johnson & Johnson) believes that the challenge is to convince the supply chain team to take chances, to experimenting without knowing the outcomes beforehand. The organization can also be used to run pilots or tests as a mean of validation.

Reshaping culture is not easy and requires time. It may be the most important barrier preventing the traditional CPG from succeeding in a digital environment. Supply chain of companies that were born and raised in the digital era was conceived with a flexible and innovative approach and will see an advantage versus the well-established conglomerates used to the more stable brick-and-mortar set-up.

During MODEX 2018, one of the largest global manufacturing, distribution and supply chain expositions in North America, held in Atlanta, Georgia, Juan Perez (UPS CIO) stated "I would make the argument that if we approached innovation, creativity, disruption the same way we were doing 15 years ago, it's very likely UPS would be out of business." Given that best ideas often do not come from the top, he also highlighted the importance of companies to create mechanisms for employees to share their ideas and thoughts as a way to "free the geniuses" and guarantee a bottom-up innovation approach (Lopez).

Systems and Processes

New systems and processes will be required to drive the digital supply network

The same way people are not ready to deal with a digital supply network, processes and systems are not prepared either. Planning is the area that will demand the biggest renewal. Shifting from a linear, sequential supply chain to an interconnected one will require a complete planning process redesign. Planning activities based on fixed safety

stocks, sometimes performed in Excel spreadsheets will be replaced by advanced planning tools with sophisticated mathematical algorithms able to optimize the manufacturing and logistics activities. Forecasting will also be reinvented. Data coming from different sources will feed the process to potentially contribute to a higher accuracy. An example is the usage of weather forecast data to predict demand of ice-cream.

Companies that have more mature demand-driven supply chains will be better prepared to go through the digital transformation. Having an outside-in focus, starting with customers' experience and working their way back through the internal supply chain design for an appropriate response will become a key business differentiator.

According to the Gartner Institute, there are five stages of supply chain maturity (**Figure 5**) and the path to excellence is partially defined by the organization's current level
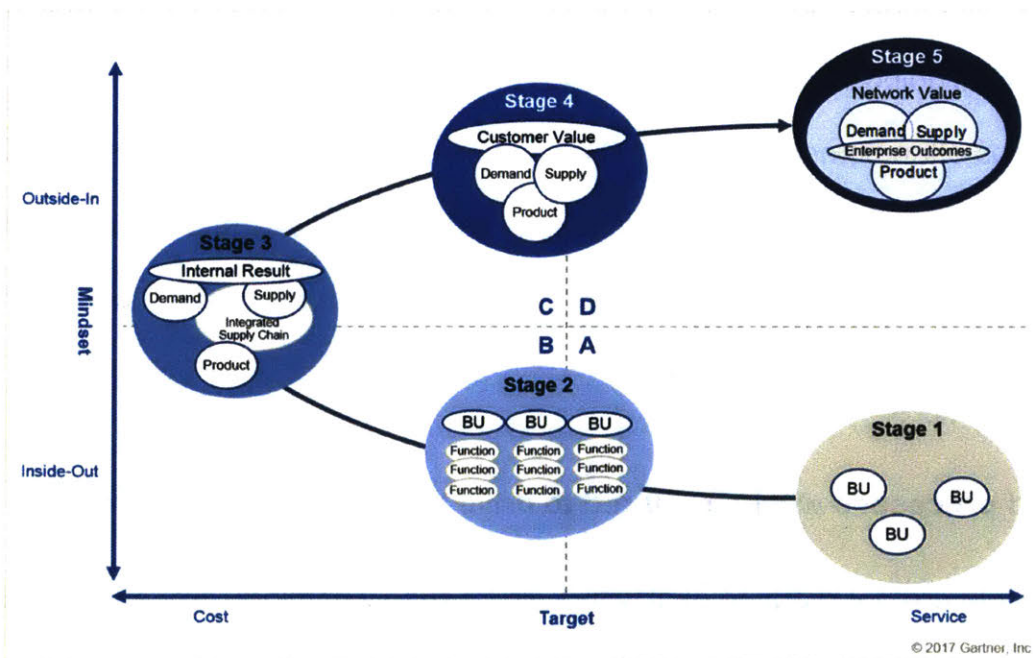

Figure 5: Demand Driven Value Network Maturity Journey
Source: Gartner (May 2017)

The five Gartner maturity levels can be summarized as follow (Van der Meulen, Rob):

- **Stage 1: React** - siloed autonomous operations

- **Stage 2: Anticipate** - internal focus on functional scale and efficiency

- **Stage 3: Integrate** – integration among different supply chain areas and with third party logistic providers

- **Stage 4: Collaborate** – collaboration with suppliers and customers

- **Stage 5: Orchestrate** – network orchestrator across an ecosystem of partners

Another area where disruption is expected is order fulfillment. Orders are coming from different channels with different service level requirements. Two problems arise. First, determining where to get materials from, how to deliver, and when to deliver becomes very ineffective without using intelligent systems capable of optimizing the outputs. Second, one must not only consider current demand but must think ahead to consider what will most probably happen in the future given what is known today. Order management and order fulfillment in an omni-channel environment brings a level of complexity to the decision-making process that is not seen in a single-channel operation. To guarantee speed, automation will be mandatory, and to enable efficacy, AI will be an important tool to be considered.

In this environment another question emerges: how to couple data analytics and technology with human intuition. The answer may lie with the 80:20 rule and applying it to AI. Machines alone may get us to 80% of the way, which in several cases will be good enough for decision making. But there may be a number of occasions when experienced human judgement will be required to get the last 20%.

According to the review "Supply chain forecasting: Theory, practice, their gap and future" published by the European Journal of Operations Research, the comparative performance of judgmental and statistical forecasting also relates to the forecast horizon. Statistical forecasting should usually be preferred for a short-term time horizon. For example, a supermarket that is required to forecast every day in order to replenish stock for say 70,000 SKUs could not rely upon judgmental approaches. At the other extreme, it is clear that the longer the forecast horizon, the greater the probability that the future events will undergo some structural changes and explanatory factors (that not have been considered in the past) will come into play. In contrast with short- term forecasting, it is the nature of the decisions involved in long-term forecasting as well as the likely change in demand dynamics over the forecasting horizon that calls for human input rather than reliance on a statistical model. This same study mentions that judgmental interventions of statistical forecast has shown that large negative adjustments tend to improve forecast accuracy, whereas large positive adjustments results in the opposite effect. (Syntetos)

With so many possibilities, the challenge will lie in how to decide whose partners are the ones able to provide the best set of data, how to guarantee a robust feeding process, and how to aggregate it in a meaningful way to provide signs that trigger actions in the supply chain. Accumulating valuable data without having the right tools and systems to analyze it and transform its insights into actions does not add any value.

Moreover, companies will face a technical challenge on how to integrate the new data analytics and advanced forecasting tools with their legacy system (or systems). To fully capture the benefits of what a digital supply network can provide, system integration, not only internally but also with key customers as well as suppliers, is essential. On top of

technology and the associated costs of building an interconnected platform, this issue also requires a strong cooperation among the different participants of the network.

Different participants may have different IT capabilities and available resources (human and capital) to invest in such integration, which may delay the process significantly. The industry will need to think beyond the four walls of their own organizations to the broader analytics ecosystem. This might entail partnering with technology companies or vendors that have expertise, participating in industry or academic activities in the field, or perhaps teaming with competitors to make the greatest advancements as quickly as possible (Chakraborty, Arnab, and Thomas D. Meyer).

Organizations will also need to decide what to develop internally and what to acquire externally given their own appetite for technology investment and internal capabilities to do so. Even when deciding to largely rely on external partners, they will need to guarantee that internal resources know how to structure the problem, handle the data and stay aware of emerging opportunities. Organizations will become more dependent on technology and IT will play a central role to enable its usage.

Rahquel Purcell (Senior Vice President for Supply Chain Americas at L'Oreal), believes the opportunity is to amplify the partnership between Marketing, Sales, IT and Supply Chain to accelerate the impact and overall results. She also reinforces the importance of a close relationship with key customers and suppliers as a way to better address the challenges of the next five years.

Cost

It is difficult to increase flexibility while keeping costs under control

Achieving a high service level while keeping the costs low is a perpetual challenge. It is a dilemma all CPG supply chains face when adapting to the emerging trend of complexity increase (for example more shipping points, more SKUs, more unit picking, etc.) with a highly competitive retail environment that urges for lower costs. These challenges are mainly driven by alternative channels and online retailer growth and the industry is just seeing the effects of this environment on its customers' expectations. The question is how to reinvent the processes in a way that productivity gains overcomes complexity.

According to 2017 GMA/BCG Supply Chain Benchmarking Study, channel proliferation is a great impediment to on-time delivery performance, and it was ranked as a top-three concern for 33% of its study respondents. When breaking down median case fill rates and on-time delivery rates by channel, they found that CPG companies generally performed best when serving large-format retailers. That is not surprising given that these segments have been CPG companies' traditional target customers, and those with which they have developed joint planning systems. On the other hand, on-time delivery rates when serving smaller-format retailers, especially online retailers, were lower (Von Koelle, Elfrun, et al).

Supply chain leaders do recognize that strengthening collaboration with existent partners as well as developing new alliances will be crucial in the cost reduction process. However, customers from alternative and e-commerce channels may not be accustomed to such relationships with suppliers and developing them will require additional effort. Broadly

making information available to diminish uncertainty and sharing resources to better utilize assets will help both industry and retailers to increase service level and keep costs under control. Their concern stands on the fact they don't see some of their important partners preparing themselves for this change. They also mention the importance machines will have in increasing productivity and flexibility and saving time of current workforce that should be focusing on value added activities.

They all recognize that good forecasting is essential but being agile is equally important especially when operating in a global environment. Getting the data and setting up a flexible and agile supply chain able to adapt to the changes when they occur is crucial nowadays. To increase responsiveness in a cost effective way, the supply chain will need to work with less inventory and more synchronized processes. The collaboration among different departments (or silos) in the company will be essential to increase its ability to move quickly and easily.

A good example on how to build an agile value chain is Luis Vuitton. According to Ana Kelm Arnhold (Demand Planning Director for Americas), their processes and systems enable them to launch a new product on Friday, read demand on the weekend and adjust the production plan in their factories throughout Monday, increasing or decreasing the plan according to the initial consumer reactions to the new product.

Another way to approach the cost and complexity dilemma is to elevate the supply chain to a strategic level where the revenues and profits generated by this unique capability more than pay off the additional costs of complexity. Companies that are able to base their market differentiation on the supply chain will be willing to pay a higher cost in order to guarantee a better responsiveness and a higher reliability.

Chapter 5 – Examples of Artificial Intelligence Applications

When analyzing the key supply challenges CPG companies are facing and searching for available tools that could help to address them, it was clear that manufacturers are in the initial stages of using AI solutions. In some cases, these solutions are being used in a pilot test environment and early results indicate good potential for roll-out with positive impact in three operational dimensions: service (e.g. lead-time decrease and reliability increase), cost (e.g., productivity increase) and cash (e.g., inventory reduction). While it is relatively easy to improve results in one of the dimensions, it is difficult to find solutions that have a broad positive operational impact. AI seems to be an answer to enable balanced solutions that ensure gains in all three areas, maximizing the benefits for the supply chain in which it is implemented.
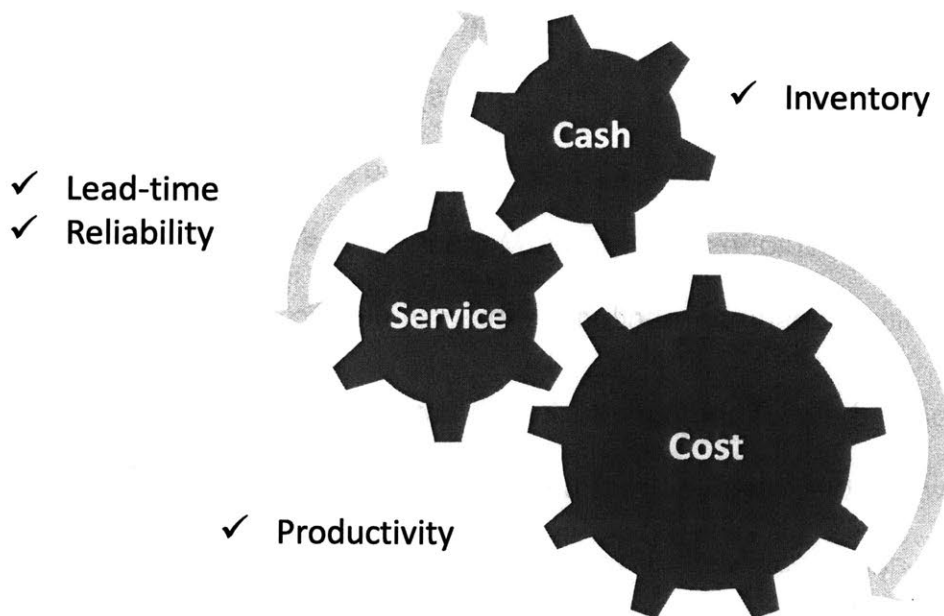
Figure 5: Supply chain dimensions and AI areas of impact

Retailers and some 3PLs are more advanced in the usage of AI and examples of its application can be found in their websites and in the media in general. AI solutions that depend on hardware development such as robots, drones, etc. are shared broadly. Information about applications based purely on algorithms development, e.g. planning and back-office, often is treated as confidential and therefore there are fewer examples available for review.

For practical purposes, in this study the AI tools were divided in four categories depending on the area where they are used in the supply chain:

1. Demand planning

2. Back-office operations

3. Warehouse and distribution center operations

4. Transportation management

All categories presented improvements (or at least potential for improvement) in service, cost and cash but some of them have a higher positive impact than others. **Table-1** summarizes the potential impact in key performance indicators (KPIs) after an AI solution is adopted.

Table-1: Potential impact after AI solution adoption

	IMPROVEMENT		
	LEAD-TIME	**COST**	**INVENTORY**
Demand Planning	High	Low	High
Back-office Operations	Low	High	Low
Warehouse and DC Operations	High	High	Low
Transportation Management	High	High	Medium

Examples of possible AI solutions already available in the market and in usage by either CPG companies or their supply chain partners are described below. The intent is not to provide an exhaustive list, but to give an indication of how and where the technology is being used in this industry.

Demand Planning

With the increase of data availability and a demand for a more agile supply chain, the traditional planning process usually held monthly or, at most, weekly, will be replaced by an integrated, fluid one. Real-time data from different sources will be combined to provide continuous insights on what needs to be adjusted to guarantee a high service level at the lowest possible cost.

The ability to calculate the impact of a disturbance in the network (for example, a supplier's material shortage) all the way through the entire supply chain, from capacity utilization to order fulfilment, and make recommendations to increase its outcomes is only possible with the usage of sophisticated algorithms. These algorithms process an enormous amount of data from different sources and highlight the disturbances that generate a sizable impact in the supply chain suggesting the better course of action to minimize its negative impact or boost its positive potential depending on the case. Gartner estimates that approximately 10% ($400 million in 2016) of the supply chain planning market is covered by technical solutions capable of supporting companies that actively collaborates with suppliers and customers (Stage 4 of maturity) and they forecast a growth between 20% and 40% per year from 2016 to 2021. This potential is huge when compared with the 8% per year growth estimated for the total supply chain planning

market. It reflects the increasing trend of collaboration and usage of more sophisticated planning tools. To be considered ready for the future, Gartner recognizes that any planning functionality should be able to address four elements, also called CORE. They need to help "Configure (C)" the supply chain, "Optimize (O)" through plans that uses constrained resources, "Respond (R) when execution doesn't happen accordingly and help to see what is happening in real time "Execution (E)" (Payne, Tim).

The software company o9 solutions offer an AI tool able to recognize patterns in the supply chain that affect the planning process, and make recommendations for exception-based processes such as moving a material from one site to another, anticipating or delaying an order, etc. For better performance, the system also includes qualitative data generated by humans, merging their insights with structured data. An example of a human insight that may be valuable to the planning process is the market intelligence information that the sales team gets from a customer (e.g., fulfillment center opening or closing in a given area). With a system able to plan demand in an integrated and holistic way, o9 reports their clients are able to increase service level, capacity utilization and forecast accuracy at the same time that they decrease inventory and operational cost. In general, they claim that for each $1 billion in revenue increase, companies using their system are able to increase margin by $15-20 million.

Another good example of advanced planning usage is Kimberly-Clark North America. They capture real-time demand data from more than a dozen retailers to generate their forecast. In response to changes, supply chain makes short-term adjustments in distribution, inventory and factory production. This capability has enabled much higher demand forecast accuracy, allowing the company to support demand with millions of

dollars less finished good inventory. To foster innovation, a few years ago, its digital innovation lab started running the "K-Challenge Program," inviting startups, entrepreneurs and makers to submit ideas in six areas, including supply chain operations solutions (Aronow, Stan). However, the most likely scenario is that large ERP vendors will invest in solutions and integrate or consolidate them with other applications in their portfolio (Payne, Tim).

Back-Office Operations

Back-office operations are not necessarily a core activity in the supply chain but they are necessary to keep the wheel moving smoothly. They are usually compounded by repetitive, high volume transactions, easily a target for AI solutions based on image and language recognition. While machines process the bulk of the transactions, humans can handle the exceptions spending their time in more value added activities.

Some examples of supply chain back-office operations that are already being processed by AI algorithms are: invoice processing using image and language recognition; customs document preparation using data from different sources and translating them to the appropriate customs format depending on the countries' regulatory standards; cash flow prediction based on accounts payable and accounts receivable information as well as purchase orders and sales forecasting. In all these cases, companies that have replaced their personnel with intelligent machines report a higher quality in their process outcome, a lower processing time and, as a consequence, a lower operational cost.

According to industry experts, customer service is another area that in a few years will be completely dominated by intelligent machines. They expect that, in the near future,

customers will never have to talk with a person. Available information will be enough to train machine learning algorithms and the system will be able to understand the customer problem and propose an effective solution without the need of human interference.

Warehouse and Distribution Center Operations

In the recent years, with the growth of e-commerce, an increased service level is being demanded by consumers and is reflected all the way through the supply chain. Unlike five years ago when waiting a couple of days, sometimes even a week to receive an online purchase was acceptable, today's consumers look for a much lower delivery lead-time. This compressed lead-time requires a more flexible supply chain, able to quickly respond to peaks and valleys on demand. In addition, labor regulation imposes limits that make it hard for labor intensive operations to adjust to the new environment. Moreover, the tight margins faced by this sector, especially on the retail side of the supply chain, bring a cost pressure that can't be ignored when trying to increase flexibility.

In order to maintain the service level, companies responsible for consumer goods distribution are being forced to either increase their work force to attend the peak or look for automation alternatives that provide extra peak capacity without infringing labor regulation. In fulfillment centers with an intense manual picking activity, smart robots are being used as a winning solution to this dilemma. These co-bots (or robot co-workers) are equipped with sophisticated navigation systems that enable them to autonomously move around a crowded facility sharing the space with moving obstacles such as pedestrians, lift trucks and other robots. They are able to safely co-exist with humans in the same environment.

In order to increase its fulfilment centers' productivity, in 2012 the giant retailer Amazon acquired Kiva Systems Inc for $775 million in cash. The operation was renamed Amazon Robotics in 2015 and became an exclusive feature of Amazon warehouses.

According to Daniel Theobald (Vecna Robotics co-founder and Chief Innovation Officer), the models commercialized by Vecna are intelligent enough to analyze the environment and make most of the decisions alone, e.g., when to move or stop, which path to follow, what to do when facing an obstacle, when to go to the charging station, etc. They are also able to recognize unknown situations and call for human help. After receiving an instruction, the robot learns what to do and how to act if a similar condition appears in the future. On Vecna platform, as soon as one individual robot learns something, this knowledge can be automatically transferred to other individuals sharing the same environment, leveraging the learning of one for the entire group.

As soon as the knowledge sharing capability is available, it is possible to introduce robots to the operation in an incremental way, adapting it to this new automated environment. It also enables companies with multiple operations to allocate the robot workforce to the places with higher demand, balancing the supply of work without the need of hiring or training new employees, reducing the overall cost required to maintain the desired service level.

While smart robots are usually used for material movement where they are faster than humans, in highly variable tasks such as picking of units, robots can at most perform at human level speed and traditional human labor is still the primary choice. In order to address this opportunity, in 2015 Amazon sponsored the first "Amazon Picking Challenge." The competition took place in Seattle, Washington during the IEEE

International Conference on Robotics and Automation. During two days the 26 international teams who designed robotic systems competed to retrieve items from warehouse shelves. The main objective was to foster the development of a solution capable of automating the picking activity in Amazon's warehouse.

Differently from picking activities where humans still perform better than robots, in inspection and sorting activities, machines are much better than humans in executing the task. Moreover, training an employee to properly perform this task may take years. In this case, experienced employees can spend their time training the system instead of training peers. Automating this task not only brings extra quality and productivity to the operation but also eliminates the risk of losing expertise when an experienced employee leaves the company.

Another area of warehouse automation using AI is the usage of robots to run inventory cycle counts. According to Fetch Robotics, even at companies that have fully embraced radio-frequency identification (RFID) the infrastructure investment required to cover large warehouses with fixed readers is cost-prohibitive. Instead, employees are often tasked with walking the floor with a hand scanner once a week, or less, to complete a cycle count. Their Autonomous Mobile Robots (AMRs) fitted with RFID scanners can perform cycle counts or even full inventories in minutes, multiple times a day, without the need of human intervention (Fetch Robotics). Some DHL operations are using unmanned aerial vehicles (UAVs or "drones") coupled with visual recognition capabilities to perform inventory cycle count in their warehouses.

There is a strong case suggesting that the logistic industry will adopt self-driving vehicles much faster than most other industries. The reason for this is that different rules apply

when a vehicle is moving around in a secure, private zone. Also, liability issues are less pressing when that vehicle is transporting goods instead of people. The robot company Balyo launched MOVEBOX automation kits. This solution converts regular electric forklifts into self-driving vehicles that can position themselves to pick up and deliver pallets as directed, navigating via geo-guidance. These vehicles do not require a new infrastructure and can be easily adapted. (DHL)

The same way it happens with self-driving vehicles, UAVs have a much higher adoption potential in the controlled environment of logistics application inside warehouses, production plants, yards, docks, etc. In spite of having a clear application for last mile delivery in urban areas, especially the ones densely populated where street traffic is high and e-commerce is rapidly growing, the usage of UAVs in this kind of environment is very challenging due to regulatory and infrastructure conditions. (DHL)

With the rapid technology evolution seen in the past decade, it is not difficult to predict that the future warehouses and fulfillment centers will decrease the number of employees to a minimum, dedicating those resources to highly complex tasks and managing most of the activities with the help of intelligent machines.

According to Ben Gesing (Project Manager at DHL) logistic assets will become smart with AI. Machines will have the ability to see, hear and speak. Companies are already testing the replacement of conventional picking and receiving activities based on manual input or barcode scanning by voice command system updates. He sees the possibility of warehouse operations being monitored by 24x7 by cameras enabled with AI capabilities. The system would be able to classify images and understand the relationships among them. For example, if a near miss occurs between a forklift and an employee or a storage

is not properly done, the system highlights the incident and presents it in a dashboard for manager actions. Not only productivity but also quality and safety are improved with the adoption of these kinds of monitoring solutions.

When looking for warehouse flexibility and efficiency, another important element that can be leveraged by AI technology is warehouse management. In the traditional systems, most of which are integrated to an Enterprise Resource Planning System (ERP), a series of tasks to be accomplished and a map of available resources are matched in a planning batch (usually done once a day or before every shift). A list of jobs is created and distributed to the operations personnel in charge of executing them through the planned period. In a system enabled with AI, the system is capable of predicting future patterns (such as a specific employee's productivity on a given day or an SKU demand increase). Both tasks and resources are constantly matched, including their actual and future predicted performance. Decisions on how to best allocate the work are made in real-time in order to maximize the throughput at a minimum cost. The next job is assigned to the first available resource with the required capability to execute it, aiming to eliminate all the possible inefficiencies and minimize the waiting time between tasks, gaining agility and speed. Vecna Robotics already offers a warehouse management solution with all these capabilities.

Transportation Management

Transportation companies are used to dealing with massive data and taking advantage of it to run optimization models in order to increase service level and asset utilization. They are already used to prescriptive analytics and are starting to take advantage of AI

technologies to understand patterns and anticipate actions. An example is the Global Trade Barometer, developed in cooperation between DHL and Accenture. It is an AI tool that monitors exports from seven different countries (China, Germany, Great Britain, India, Japan, South Korea and United States) and maps the movements of containers around the globe. The barometer is able to predict a quarter in advance where the containers will be, enabling DHL to take proactive actions on its supply chain. The same concept is being adopted by carriers that want to anticipate their assets' location to optimize their utilization and maximize revenues and profits out of it.

Routing algorithms that consider real-time information of road congestion, street blockages and social media data to decide the better routes to use to maximize on-time delivery at a minimum cost are also a reality for several carriers in the United States. Technology companies capable of collecting geospatial information and transforming it into insights with the help of AI tools are a key enabler of this development. Digital Globe is a good example of this kind of company. They collect geospatial information from three different sources: i) their own constellation of satellites; ii) their customers who collected in the course of their own business; iii) open sources. Using AI, they create location intelligence from raw data and validate its outputs with a team of experts in a crowdsourced platform.

A good example on how AI is helping a company to reinvent itself is the United States Postal Service (USPS). During the last decade, they saw their pre-defined, fixed mail volume dramatically decline at the same time that the highly variable package delivery demand increased. In this context, the pre-defined routes that their 250,000 carriers had to travel daily had to be replaced by a flexible and dynamic routing system. At USPS,

machines analyze real-time data, identify abnormalities to the process and, using machine learning, provide insights to alert carriers that adjustments need to be made considering the available time. Without this system they would not be able to comply with the increase in service level required by their customers, including Amazon and other big retailers.

Platforms that bring together carriers and shippers optimizing the supply of trucks used to transport less than truckload (LTL) shipments with the demand for this kind of service are already available in several formats. Truckers, like car drivers, often travel from Point A to Point B with spare capacity. The apps let the drivers know if anyone is willing to pay them to occupy the free space. The shipper logs into the apps, enters details about what the shipment is, its destination, and when it needs to get there. Qualified drivers see the job pop up on their app, and the first to click "book it" gets the work. There are several technology startups that match truckers with loads, including Otto, Cargomatic, OMVS, ShipX, Convoy, Transfix, Cargo Chief, Trucker Path and others (Buxbaum). This is a good example of how AI can help the CPG industry to become more flexible and less costly through resources sharing.

Chapter 6 – Conclusions and Final Considerations

Of the four challenges highlighted through the course of this study, AI tools may help to address only two of them, i.e., better systems and processes capable of driving a digital supply network and higher flexibility at a competitive cost. The other two challenges, i.e., lack of prepared people and an innovative culture, are not addressed by AI but are mandatory for a successful AI implementation.

Companies that are adopting AI tools or providing AI solutions report improvements in the processes that are taking advantage of this technology. On one hand, AI is serving as a key enabler for enterprises to gain the required flexibility and agility and become more competitive in cost. On the other hand, companies need to be aware of possible implementation pitfalls in order to minimize the implementation risks. Four potential threats should be on the radar of any executive dealing with AI implementation:

- Lack of understanding from the organization
- Moving from pilot to scale
- Fear of missing out
- AI and human co-existence

Lack of understanding from the organization

From a user standpoint, AI algorithms are usually a black box. They often don't know what was considered when building and training the system and therefore, the lack of knowledge creates a barrier for adoption. To minimize the adoption barrier of AI solutions

in the organizations, it is important to guarantee algorithms are transparent and interpretable. In other words, models need to be understood by the key users and they should be able to explain their outcomes. They need to trust the model. Executives should study the algorithms at their core before deciding to implement. It is important that they understand their outcomes and are able to challenge their assumptions. Developing algorithms that use rules that people are accustomed to also helps to diminish resistance and increase trust in machine's outcomes during the implementation stage.

Ideally a multi-disciplinary team skilled in AI and with good business judgement should be engaged from early stages of algorithm development, and therefore data scientists must be able to manage that type of holistic team. A diverse view of the problem or question to be addressed by the AI solution enables a more complete solution and helps to eliminate possible biases. Having people from different backgrounds participating in any AI development will also help the development team to properly explain to different stakeholders or departments in the enterprise how the algorithm works and get their buy-in during the implementation phase.

It is also important to highlight that AI systems are firstly probabilistic by design, and improve their performance over time with more data. AI systems trained with insufficient or improper data will produce disappointing results at first, but over time can improve and achieve high accuracy. It is essential not to dismiss an AI project too early due to output performance alone, but remain agile and seek to improve system performance with new data or modifications to the core framework (Gesing, Ben, et al).

A common mistake is to think that AI algorithms don't need monitoring or on-going human intervention. However, they are, in fact like kids, requiring constant supervision to capture

changes in the business model and to identify possible biases that could distort their outcomes.

Moving from pilot to scale

Pilots are the means to test and tailor any roll-out process. They are usually built with care and receive a lot of attention from the team in charge of them. These teams tend to be small and people participating on them are usually recognized by their expertise and innovative approach, especially when dealing with new topics like AI. A common focus helps the team to solve any possible conflicts and deliver the expected results. This environment is not necessarily replicable during the roll-out phase.

During roll-out the number of stakeholders involved is much bigger. In several cases, people involved don't have the required technical expertise or are not aligned towards a common goal. Moreover, priorities may vary among different participants of the roll-out. In an AI project there are two other challenges to be taken into consideration.

First, the time spent to clean and prepare data used in the pilot phase may not be replicable in a day-to-day operation. In this case, some of the successes achieved in the pilot test may not be valid and, in the worst case, the entire project may not be replicable at scale. To avoid this threat, it is important that any pilot creates as much as possible the environment that will be faced during roll-out.

Second, the mathematical complexity of some algorithms is not linear. Even today, with a much better computational capability versus five years ago, this issue may be a show stopper for an AI project roll-out. For example, running an AI solution for one fulfillment center in the pilot test may take one hour which could be considered acceptable by the organization. When

trying to reproduce it for a network of one hundred locations in the roll-out phase, this one hour may become one thousand hours due to the mathematical complexity added.

When developing AI solutions data scientists need to evaluate the complexity of data cleaning and preparation, and computational requirements to design a solution that suits both a pilot test and a scalable solution.

Fear of missing out

The concept of "Fear of Missing Out", popularly referred to as FoMO, is defined as a pervasive apprehension that others might be having rewarding experiences from which one is absent. FoMO is characterized by the desire to stay continually connected with what others are doing (Andrew K. Przybylskia).

According to Chris Caplice (Executive Director, MIT Center for Transportation & Logistics) some supply chain executives are suffering from fear of missing out if they don't at least test drive some AI tools in their organizations. This fear is driving some of them to bet on non-strategic AI investments and implementing solutions that do not necessarily help the enterprise to improve its KPIs. Ultimately these investments rarely prove their value and can negatively influence future AI adoption decisions

Choosing the right processes and collecting early wins is the best way to start the journey of an AI implementation in an organization. Any process change that potentially drives a reduction in the work-force or is perceived to do so will face adoption barriers. Affected employees will be distressed with the possibility of losing their jobs and may not see that AI tools can help them eliminate non-value-added tasks to focus on more meaningful

activities. Having an early successful example helps the management to sell the benefits of AI and diminish the adoption barriers.

However, Isaac Cronkhile (Vice President Enterprise Analytics at USPS) believes that, in reality, the pace of adoption of AI solutions is a lot slower than the academic and the start-up feel it should be. With low speed comes the risk of executives not seeing immediate benefits and starting slow down the AI investments.

AI and human coexistence

AI solutions will continue to rely on humans for their initial data sets, but as artificial intelligence applications evolve and become better at gathering and growing their own data, they will become less dependent on humans for ongoing knowledge transfers. But this doesn't mean they will no longer need humans. Instead, what's likely to happen is a more symbiotic form of work, where both machines and humans are dependent on and beneficial to each other to produce the best possible end results (Shani). In order to smooth the human/machine interaction, a group at the MIT Computer Science and Artificial Intelligence Laboratory (MIT CSAIL) designs models and algorithms that enable robots to infer cognitive state and learn preferences of human team members from listening, watching, and practicing with them. Through this process, these robots understand the "unwritten rules of the game" for working with teams of people in complex organizations (Interactive Robotics Group MIT CSAIL).

Moreover, every time that humans are not completely removed from the process, a new problem arises: how to properly coordinate the work and the communication between humans and machines inside the organization. In general, managers are not trained to

deal with the challenge of having co-existent AI and human processes. They have no experience on how to recognize successes or punish failures produced by these interactions. When considering to adopt AI in a process where the machine-human interactions will be frequent (this statement does not apply for AI processes where machines take over all the work), it's important that the reward and recognition system is reviewed and managers are properly trained.

Final Considerations

The CPG industry has a big challenge for the next five years. In order to become more responsive, accurate and efficient, it will need to rethink the way they traditionally operate their supply chains. AI has a great potential to help them to reduce cost at the same time they increase agility. However, to do it in an effective way, executives in charge of AI implementation will need to guarantee the right skills are present not only in the team that will develop and test such solutions but also in the organization that will use them in the day-to-day. Moreover, internal systems and processes will have to be revisited to ensure they are digitally connected internally and with other supply chain players such as suppliers and customers. Different AI applications are already being used in different areas, from more administrative ones (e.g., demand planning and back-office operations), to more executional ones (e.g., distribution center and transportation management operations). Companies interviewed in this study mention improvements in their operations both in cost and inventory reduction, and service level increase. However, no data supporting those improvements was shared during the course of the interviews. This is an area where further investigation should be performed in order to bring more quantitative data to the qualitative analysis of this study

When deciding about implementing an AI application, supply chain executives have to be careful of potential challenges. It is important to guarantee a proper alignment between the proposed AI solution and the company supply chain strategy, to ensure the results obtained will be aligned with the company's priorities. In addition, users need to understand what is behind the solution proposed (no black box). This is the only manner to create trust and enforce adoption. If humans and machines will have to coexist, it is important that roles and responsibilities are re-defined and that a clear system to reward successes and punish failures is in place. In this environment, it is easy for humans to point fingers at machines every time something goes wrong. Leaders and employees will have to be trained on how to properly collaborate with machines to maximize the company's results.

AI investments should be seen as a marathon, not a sprint run. This is a long test and trial process and some benefits may only be perceived after an extensive training of the algorithms and large scale adoption by CPG supply chain organizations. Nevertheless, companies that have fully embraced AI in their supply chain (such as Amazon), have been able to create a market differentiation valued by the consumers and rewarded with market share.

Appendix – List of Interviewees

Name	Company	Position
Alvaro Cuba	Mondelez	Senior Vice-President Integrated Supply Chain North America
Ben Gesing	DHL	Project Manager - Innovation and Trend Research
Chris Caplice	MIT	Executive Director - Center for Transportation & Logistics
Daniel Theobald	Vecna Robotics	Co-founder and Chief Innovation Officer
Igor Rikalo	o9 Solutions	Chief Operating Office
Isaac Cronkhile	United States Postal Service	Vice-President Enterprise Analytics
Jose Chan	Celect	Vice-President Business Development
Luiz Rodrigues	DHL	Head of IT - DHL Supply Chain Brazil
Neil Ackerman	Johnson & Johnson	Senior Director - Global Supply Chain Advanced Planning & Innovation
Rahquel Purcell	L'Oreal	Senior Vice-President Supply Chain Americas
Rohin Wood	Boston Consulting Group	Principal - Technology Advantage Office
Tushar Narsana	Accenture	Managing Director

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