Manufacturing Digital Transformation Strategy for FMCG

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ABSTRACT

Manufacturing companies are facing serious challenges to survive and succeed in the market in this ever-changing economy. The FMCG industry is not unaware of these challenges, and therefore, many leading manufacturing companies are creating initiatives of Smart Manufacturing or Industry 4.0. However, the literature on Digital Manufacturing mainly addresses technical aspects of the implementation and not the design of a complete strategy, which involves not only technologies but also the organization and external components like customers or suppliers.

Our project aimed to close the gap between the technological components of a Digital Transformation and the human factor. Therefore, this project could be considered a multiple methodological approach. On one side, the study is based on the collection and analysis of data obtained from the ERP System of the company. On the other hand, the project relies on a survey to discover the digital maturity of the bottling plants to include the human factor. Thus, the sponsor company will have the base information to implement a Digital Manufacturing strategy.

With the information captured from the ERP System, we performed a cluster analysis to group the bottling plants into smaller groups that have similar performance characteristics. Moreover, with the results of the surveys, we examined the perspectives of the operational team from all bottling plants. Consequently, plants can be group depending on their operational performance and digital maturity of their organizations.

Finally, managerial recommendations for all clusters were provided. In some cases, where digital technologies are more advanced, the goal is to exploit this competitive advantage and introduce more sophisticated methodologies to analyze the data and create value-driven decisions. In other cases, before starting with the implementation of new digital technologies, employees must be prepared to receive new technologies and learn how to work in a digital world.

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Sara: I will like to thank Anais for her wonderful collaboration. Without you this couldn’t be possible!

Anais: Thank you Sara. I was lucky to have you a partner; but I now I am even luckier to have you as a friend. And last, but not least, my deepest appreciation goes to Daniel and my family. Thank you for challenging me to go a step further and for believing in me, even in the moments when I do not. Without your caring support none of this could have happened.

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1 INTRODUCTION

Manufacturing companies across all major industries are facing serious challenges trying to survive and succeed in the market in this ever-changing economy. Even established corporations with long traditions and successful pasts have been losing value because of their inability to change (Henderson & Clark, 1990). In fact, many companies have started a major transformational change trying to integrate digital technologies into their businesses (Tekic & Koroteev, 2019).

Therefore, leading manufacturing companies are starting to implement initiatives in their plants such as Smart Manufacturing, Industry 4.0 and the factory of the future in order to create new opportunities to transform, differentiate and compete (Poliakine, 2019). Through these initiatives, manufacturers can connect people, equipment and systems, making relevant information available in real time to facilitate agile decision-making and elevating the role of manufacturing (Jacobson, 2018).

However, manufacturing companies still lack a strategy that allows them to achieve a successful Digital Transformation in their operations. Although a wide range of models are presented in the literature regarding Digital Manufacturing, they mainly address technological aspects of the implementation of smart systems without taking into account organizational aspects like training of the employees or change management, that are also essential for this type of transformation (Carolis et al., 2017).

A Digital Transformation strategy for manufacturing is not just about introducing digital technologies such as Additive Manufacturing, Augmented Reality or Big Data to the factories. It should consider different dimensions such as maturity levels of the plants, people (organization and talent), processes & methodologies, technology, networks, data and information, and financial aspects. Digital technologies can provide possibilities to increase efficiency. However, if people lack the right mindset to change and the current processes are not prepared, Digital Transformation will not succeed (Savastano et al., 2019).

This is the problem that the sponsor company, BeverageCo, is currently facing. BeverageCo is a multi-category beverage leader of the Fast-Moving Consumer Goods (FMCG) sector that is under pressure to transform their manufacturing strategy due to changes in consumers' needs and preferences as well as low profit margins. Therefore, the company's primary objective is to explore new opportunities: finding and connecting new and enriching existing resources such as people, products and platforms in their productive plants.

Although BeverageCo had an initial strategy to transform its manufacturing facilities, the level of implementation significantly varies from plant to plant. One of the reasons for the different levels of implementation of digital technologies is that all plants have been treated in the same way, without taking into consideration their particularities.

To develop the most effective strategy for the plants, it is fundamental to understand the current situation and readiness of each bottling plant as well as their main characteristics from both operational and organizational perspectives. This information will enable BeverageCo to apply the technological change that the digital technologies envision (Carolis et al., 2017). For this reason, the aim of this project is to develop a Digital Transformation strategy for BeverageCo's manufacturing plants that considers all these aspects to attain their competitive advantage.

To understand the situation of each plant and its readiness to implement a Manufacturing Digital Transformation, it was necessary to use a multiple research methodology approach. The proposed multiple research methodology considers data gathered from BeverageCo's ERP system and data from surveys.

The data from the ERP System was used to standardize and compare the technical information about the performance of the plants. According to several indicators, plants are divided into smaller groups, viz.

clusters. Each cluster includes plants with similar characteristics, where it is expected that their response to Manufacturing Digital Transformation is similar.

The data from the surveys was used to incorporate the human factor and the knowledge of operational administration. The goal is to measure the adoption level of digital technologies and the digital culture of the plants. Both data, permit to incorporate technological aspects as well as the cultural characteristics of the plants.

The research questions of this projects are:

- **RQ1.** What are the most relevant indicators that have an impact in the performance of the plants?
- **RQ2.** Are there any external factors that also impact the performance of the plants?
- **RQ3.** How can plants be grouped according to similar characteristics?
- **RQ4.** What is the current digital culture of the plants?
- **RQ5.** What are the recommendations to implement Manufacturing Digital Transformation?

Therefore, the overall hypothesis of this capstone project is that the development of clusters of plants that considers technical, cultural and organizational similarities will allow the company to create a more successful Manufacturing Digital Transformation strategy.

This document is structured as follows: Chapter 2 explains the current situation in the FMCG industry and BeverageCo. Chapter 3 provides a review of previous works in Digital Transformation strategies, their key drivers and technologies to be implemented in manufacturing. It also describes the methodologies considered to obtain and analyze the data provided by the plants. Chapter 4 explains the methodology chosen and the process of data gathering and explores the resulting data of the validation steps and clustering of the plants. Chapter 5 presents and validates the results from both methodologies. Next, chapter 6 the discusses the results and proposes managerial recommendations for the Manufacturing Digital Transformation strategy. Finally, Chapter 7 concludes the documents with a summary of the findings and the recommendations for next steps for the sponsor company.

2 BACKGROUND

This chapter presents a brief description of the fast-moving consumer goods industry and the challenges that this industry as a whole and BeverageCo are currently facing.

2.1 Fast-Moving Consumer Goods Industry

Fast-moving consumer goods (FMCG) such as food, beverages and personal care goods are defined as “nondurable retail products” that typically have three characteristics: 1) They are cheap, 2) They are bought frequently, and 3) They have a short service life (Kuzmina et al., 2019).

Taking into account that these products are quickly substituted, FMCG corporations are trying to meet the changing taste and demand from customers who are expecting healthier options (products that contain fewer additives and preservatives), low-calorie products and more sustainable packaging.

The key brands of top FMCGs hardly make the list of the top ten most valuable global brands because people no longer consider valuable what is not healthy. According to the market trends, healthy food items will drive sales of products for the next five years, therefore, FMCG companies need to transform their current business model in order to satisfy the new consumers’ needs (Lorange & Rembiszewski, 2014).

During past decades, FMCG manufacturers were focused on achieving economies of scale to be more competitive. This trend led to centralized productions systems where one single facility served a large area making possible to reduce costs. However, by doing this, FMCG companies could not adapt to local preferences/demands and lost local communication between customer and producer (Angeles-Martinez et al., 2018). For this reason, FMCG companies did not expect such radical consumer changes and they were not prepared for faster innovation cycles. This led to an innovation gap that generates pricing pressure and low margins (Lorange & Rembiszewski, 2014).

In order to be competitive, the FMCG industry is moving towards Industry 4.0, which involves fast and disruptive changes that will allow improvements in efficiency and productivity (Pereira & Romero, 2017). The implementation of Industry 4.0 could also increase revenues and provide the flexibility, adaptability and agility that manufacturing companies currently need because of the changes in the market that will lead to a new source of value creation (Mohamed, 2018).

2.2 BeverageCo

In the last decades, BeverageCo has grown from a Mexico-based bottler to a multinational multi-category beverage leader, serving 290 million people across 10 countries, through 52 plants and 263 production lines (see Figure 1). They produce a diversified portfolio: low- or no-sugar sparkling beverages, refreshing juices, hydrating purified water and energy drinks; that can satisfy its consumers' and clients' evolving preferences.

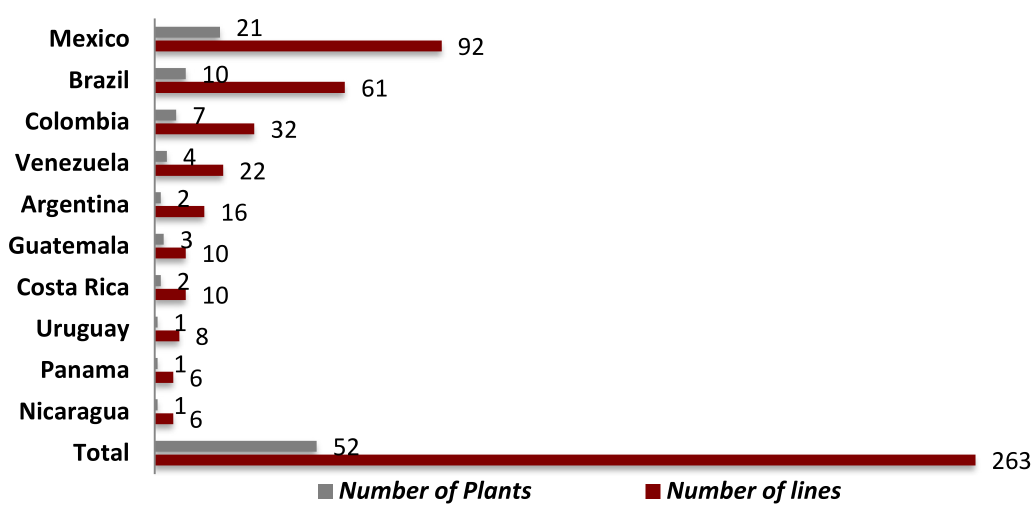

Figure 1. *BeverageCo - Plants and lines per Country*

BeverageCo is aware of the need to move the FMCG towards Industry 4.0, but most of the efforts at supply chain digitalization were located in logistics (planning) and distribution, not in manufacturing. For example, in logistics, JDA software was implemented in all BeverageCo's operations to create a unique Supply Chain Planning model that enhances their customer service while optimizing costs and capital allocation. In distribution, a Digital Distribution platform was implemented to improve customer satisfaction, deliver increased resource optimization and enhance driver safety.

However, for manufacturing, the resources were mainly focused on how the plants should be operated and maintained. The priority was the standardization of the operating models and the centralized maintenance planning model. The aim was to consolidate the maintenance planning and budgeting of the manufacturing plants at country level. Although some attempts were made to apply digital systems like Manufacturing Execution System (MES) or Statistical Process Control (SPC), the effort to implement digitalization in manufacturing was still lower than the one executed in logistics and distribution. Moreover, these first digital implementations in manufacturing did not have the results that the company was expecting.

Therefore, before making any further investments in digitalization, the company is currently re-evaluating its approach to the Digital Transformation. However, the creation of a new strategy is not simple.

According to Cimini et al. (2017) there is a lack of knowledge about the practices required in an Industry 4.0 implementation. There are no clear guidelines, much less a path that explains how to transition from a traditional factory to a smart factory. Although in the literature are plenty of models about Industry 4.0, researchers have been focused on the technical aspects of the technologies to be implemented (Carolis et al., 2017). They have not considered elements such as the organization and the people that are key players for this type of transformation.

For this reason, BeverageCo aims to create a centrally, standard and global digital strategy to transform its bottling plants that considers not only technological features but also aspects of the bottling plants such as the economy of the region where the plant is located, country's market, people's capabilities, cultural behaviors, operating models, supplier's technology, SKUs produced and product life cycle in order to increment the probability of having a successful Digital Transformation.

3 LITERATURE REVIEW

This chapter reviews the existing literature on Manufacturing Digital Transformation. This study will introduce the terminologies that will be used throughout the project to create a common framework and discuss the gaps identified in previous researches.

3.1 Manufacturing Digital Transformation

The world is going through a Digital Transformation and manufacturing companies are aware of this. Digital Transformation has become a high priority for manufacturing leaders around the globe that desire to increase their companies' chances for survival and success in today's market. For this reason, many manufacturing enterprises have been trying to integrate digital technologies into their processes and use it as a competitive advantage (Hess et al., 2016).

However, to remain competitive, manufacturing leaders must create and execute strategies that embrace the implications of Digital Transformation. Strategy, not technology, is the key for driving a Digital Transformation (Kane et al., 2015).

According to the literature, the definition of Digital Transformation is "the use of new digital technologies to enable major business improvements" (Fitzgerald et al., 2013). For manufacturing, the Digital Transformation is known with the terms of Industry 4.0 in Germany or *Smart Manufacturing* in the United States (Osterrieder et al., 2019). The term Industry 4.0*,* also known as the *Fourth Industrial Revolution,* was presented by the German Government as a strategic initiative for the development of advanced production systems that integrate a set of emergent and convergent technologies in order to increase efficiency and productivity in the industrial sector (Frank et al., 2019a).

One of the key concepts in Industry 4.0 is the term *Smart Factory*. A traditional factory is responsible for converting raw materials into finished products through the interaction between physical flow and information flow. In contrast, a smart factory is a fully connected manufacturing system that embraces a set of industrial developments such as Internet of Things (IoT), Big Data, robotics, Cloud Manufacturing, Artificial Intelligence (AI), Augmented Reality (AR) and advanced analytics, that will bind the digital and physical worlds through technology (Pereira & Romero, 2017).

Despite its benefits, the Digital Transformation will bring new challenges to the organizations since they will need to overcome some obstacles to implement Industry 4.0 successfully. Some of these obstacles are the lack of digital skills in workforce, high investment requirements, uncertainty of the economic benefits in investing in technology, data security (more connectivity, more security risks for sharing information) (Kiel et al., 2017), low maturity level of technology, lack of standards and regulations, lack of digital infrastructure, ensuring data quality, lack of internal digital capabilities and culture, resistance of change, ineffective change management and inadequate top management level (Raj et al., 2019).

According to Raj et al. (2019), the lack of a digital strategy and the shortage of financial resources are the most prominent barriers to the adoption of Industry 4.0. Therefore, it is clear that the management level needs to create a strategy that contemplates not only the technology but also the people's involvement and organizational aspects (Savastano et al., 2019).

3.1.1 Manufacturing Digital Transformation Technologies

Technological advances have driven major transformations in the manufacturing sector since the industrial revolution. In the nineteenth century, in the first industrial revolution, steam engines powered factories. In the twentieth century, during the second industrial revolution, electrification led to mass production, and in the 1970's, in the third industrial revolution, industry became automated. Now, in the rise of the fourth industrial revolution, new digital technologies are changing the traditional relationships among suppliers, producers, and customers, as well as between humans and machines (Gerbert et al., 2015).

According to Büchi et al. (2020), there are ten foundational technologies transforming manufacturing. These technologies embrace the integration of all elements such as data, human and machine agents, materials, products, production systems and processes in a value adding system, by eliminating the boundaries between the digital and the physical world. The nine pillars come from a study done by Boston Consulting Group (Gerbert et al., 2015). The technologies in the nine pillars are:

- **Additive Manufacturing:** Also known as 3D-Printing. The technology allows to create parts from diverse materials and with complicated structures better than traditional technologies. Additive Manufacturing provides the capability to customize products in an affordable and faster way (D'Aveni, 2018).
- **Augmented Reality:** This relates to the devices that enriches human sensory perception by accessing to virtual environments through sensory elements that can be added to smart devices or other sensors that can augment vision (augmented-reality glasses), sound (earphones) or touch (globes), providing multimedia information (Büchi et al., 2020).
- **Autonomous robots:** The concept behind robotics is to design machines that move autonomously and assist humans in some of the most monotonous or dangerous activities or even perform these tasks (Davenport & Kirby, 2015). This pillar is also related to automation that consists on delegating tasks to machines that were previously made by humans. Depending on the level of automation machines first take away the heavy or dangerous tasks; next, they take control of the monotonous activities and finally, in the third step, machines are also able to take decisions by themselves (Davenport & Kirby, 2015).

- **Cloud Computing:** The technology is based on the power of computing without having the information and the software "on premise". This way the information is available at anytime and anywhere. It is proved to be a tool that increases the efficiency and the collaboration between the employees (McAfee, 2011).
- **Data Analytics:** Usually also known as Big Data Analytics. It bundles a bunch of techniques for collecting, transforming and combining data (coming multiple sources) to support a data driven decision making process. The main goal is to extract insights value and information from raw data and identify or predict patterns (LaValle et al., 2011).
- **Digital Twin (Simulation):** A Digital Twin is a virtual representation of a product or a model that behaves like the original model. The virtual model can be updated also with information from the real world and it is usually used to simulate different scenarios to predict the response of the real model (Purdy et al., 2020).
- **Industrial Internet of Things**: The term Industrial Internet of Things refers to the ability of products and equipment to communicate with each other and be "smart". The idea is to have products and equipment connected to the network through high-quality microprocessors to keep track of equipment status on a real-time basis (Porter & Heppelmann, 2015).
- **Cybersecurity**: When the processes more automatized than ever and all the data generated, every company must focus on potential threats and their impact on the business activities. The goal is to protect all systems and to reduce the risks of both intentional and unintentional breaks (Parenty & Domet, 2019).
- **Horizontal and Vertical System Integration:** This concept relates to the integration of companies, suppliers and customers, using data-integration networks that will enable truly automated value chains.

Also, various techniques can be used for Manufacturing Digital Transformation. The most significant techniques are:

- **Artificial Intelligence:** Under the term Artificial Intelligence there are several techniques involved. All these techniques are characterized by the fact that can perform tasks efficiently and intelligently without being explicitly instructed (Cagle, 2019).
- **Machine Learning:** It is a technique included in the Artificial Intelligence practices. Machine Learning algorithms learn from past data and improve themselves recursively to better identify data (Cagle, 2019).
- **Blockchain:** It is a technique that allows transactions between two parties efficiently. The information is not centralized, but all parties have access to the data and can verify it. Once a transaction is recorded in the database, it cannot be altered; making the information almost incorruptible (Iansiti & Lakhani, 2017).

3.2 Manufacturing Digital Transformation Strategy

Digital Transformation strategies have certain elements in common that can be attributed to four dimensions: the use of technologies, changes in value creation, structural changes and financial aspects. These elements must be aligned with each other, to have a successful Digital Transformation that fully exploits its expected benefits (Matt et al., 2015).

A winning Digital Transformation strategy must provide direction to the manufacturing leaders, take into account the existing capabilities and competitive advantage of the plant (Ross et al., 2017). A successful Digital Transformation strategy should consider the current state of the plants ("where they are"), the future state ("where they need to be") and how to get there (Ustundag & Cevikcan, 2018).

Even though manufacturing is on its way to being digital, it is important to know that changes are not confined to the production floor (White et al., 2019). It requires a strong support from the upper management that convince people about the advantages that this transformation can bring (Cimini et al., 2017).

Without a clear digital strategy, it will be very difficult that the factories can achieve all the benefits that this type of transformation involves.

Following the best practices for Digital Transformation strategies found in the literature, the goal of this project is to recommend a certain roadmap for the BeverageCo plants attending similar idiosyncrasies. To discover the similitudes and differences between plants, in Chapter 4, we analyzed the data from the Scorecard data and the surveys.

4 DATA AND METHODOLOGY

This chapter presents the multiple research methodology approach used in this project. It includes the methods for data gathering and data analyzing (Exploratory Factor Analysis and clustering) for both Scorecard data (ERP Data) and surveys. This approach that will help to underpin the creation of the Digital Transformation strategy for BeverageCo manufacturing plants.

4.1 Methodological Approach

This capstone project uses a multimethodological approach to analyze quantitative and qualitative data that came from two different sources: BeverageCo's ERP system and a survey carried out all the plants.

The methodology used is visualized in Figure 2. The first step was an extensive literature review and a series of interviews with BeverageCo's executives. In the second step, once the basic concepts about Digital Manufacturing were established, two methodologies were developed; one for the Scorecard data and other one for the survey. In the first methodology, data was gathered from the ERP system, was analyzed through Exploratory Factor Analysis and then was clustered. In the second methodology, data was gathered from a survey, designed by the authors and performed by BeverageCo's plant managers. The data from the survey was analyzed with Exploratory Factor and Cronbach Alpha analyses.

Finally, managerial recommendations for the next steps in BeverageCo's Manufacturing Digital Transformation were suggested considering the results from the cluster analysis and the survey. Each cluster had a distinct set of recommendations that will be the basis for the roadmap of the Manufacturing Digital Transformation strategy for BeverageCo's plants.

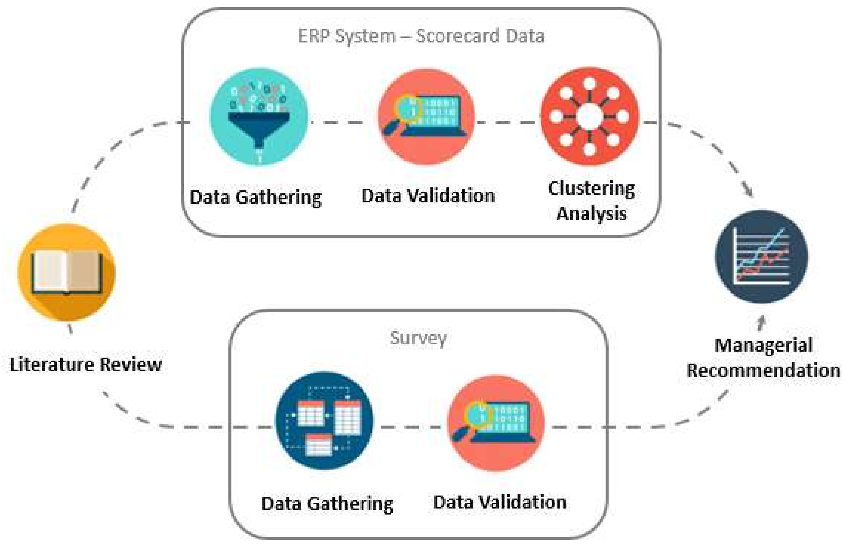

Figure 2. *Diagram of methodology steps.*

4.1.1 Interviews

To understand the current situation of the sponsor company, the authors conducted semi structured interviews with BeverageCo corporate executives, with more than 20 years of experience in manufacturing and supply chain. The questions asked about the company's manufacturing situation and considerations for a Manufacturing Digital Transformation. The structure of the interview can be found in Appendix A.

According to the interview responses, the main aspects to be considered for Manufacturing Digital Transformation strategy are:

1. According to the executives, the level of automation of the plants will differentiate the approach to the implementation of Digital Transformation. For example, some plants are 30 years old and equipped with basic technology while other plants are 3 years old and have cutting-edge equipment. Therefore, the technologies to be implemented (and the velocity of these implementations) cannot be the same.

2. Aspects such as economy of the region, the situation of the market in the country, people's capabilities (some operators are engineers while others only attended high school), cultural behaviors, operating models, supplier's technology, SKUs produced and product life cycle will also play a key role in the performance and therefore they must be considered when creating the Digital Transformation strategy.

4.2 Scorecard Data

4.2.1 Data Collection

Considering that data from the majority of the plants is available for the last three years, data from 2017 to 2019 was collected from the sponsor's ERP system. The gathered data provided quantitative information of the performance on the manufacturing plants. The collected data covered 45 plants of the 52 plants because 3 plants are new acquisitions and they do not have information in the ERP system yet; and 4 plants have an unusual operation because of the current situation in the country where they are located.

For BeverageCo, the most relevant manufacturing Key Performance Indicators (KPIs) are shown in Table 1. The indicators cover the 8 areas related to manufacturing. The idea is to create a holistic view, so not only were pure manufacturing indicators analyzed but also indicators from departments that contribute to the good performance of production, such as Quality, Maintenance, and Human Resources.

Table 1. *Manufacturing KPIs*

Area	*Indicators*
Sustainability	Water Use Ratio
	Energy Use Ratio
Quality	CpK Compliance
	Microbiology Index
	Sensory Index
Assets Management	Maintenance Cost
	Loss points of efficiency
Safety	Lost Time Incident Rate
	Work Fatalities
Manufacturing	Cost to make
	Utilization
	Productivity
	Volume (Liters/Unit cases)
	Efficiency
	Losses
	SKUs
Human Resources	Headcount
Infrastructure	Number of lines
Digital Manufacturing	Digitalization

However, not all of the indicators were directly in the BeverageCo's ERP System. Some of them are still measured in Excel spreadsheets and they do not have the granularity needed (for example, safety indicators are only available at country level). Consequently, these indicators were not considered for further analysis.

During the interviews, BeverageCo executives mentioned that external factors such as economy of the region and cultural behavior could affect the performance of the plants. Therefore, data from the statistical entities of each country was gathered to determine the effect of these variables (see Table 2).

Depending on the countries and their national statistical entities, some indicators can be calculated by region (for example, unemployment) while other indicators are reported only at the country level (like GDP per person or rural population). Although regional indicators were desirable to compare the impact of external factors within plants of the same country, most indicators are provided only at a country level. However, this information is also useful, since it provides at least the possibility to compare the plants from different nations.

Table 2. *External factors*

External Factors
Unemployment rate [%]
Employed labor/Total population [%]
GDP per Person [USD/year]
Minimum Wage [USD/month]
Literacy Rate [%]
Location of the plant [rural or metropolitan]
Rural population [%]

4.2.2 Variable Selection

As shown in Table 1, BeverageCo uses several manufacturing variables (or KPIs) to control and monitor the performance of the plants. However, some of these variables were not available for analysis or they were not valid descriptors, so it was necessary to determine which ones were going to be used for subsequent analyses.

The original dataset had 30 variables but some of these were highly correlated so they were discarded. There were also variables that measure the same business feature but with different units, for example, volume is measured in liters of beverage but also in unit cases (measurement unit created by BeverageCo), so only one of these variables was chosen. The eight selected variables are shown in Figure 3.

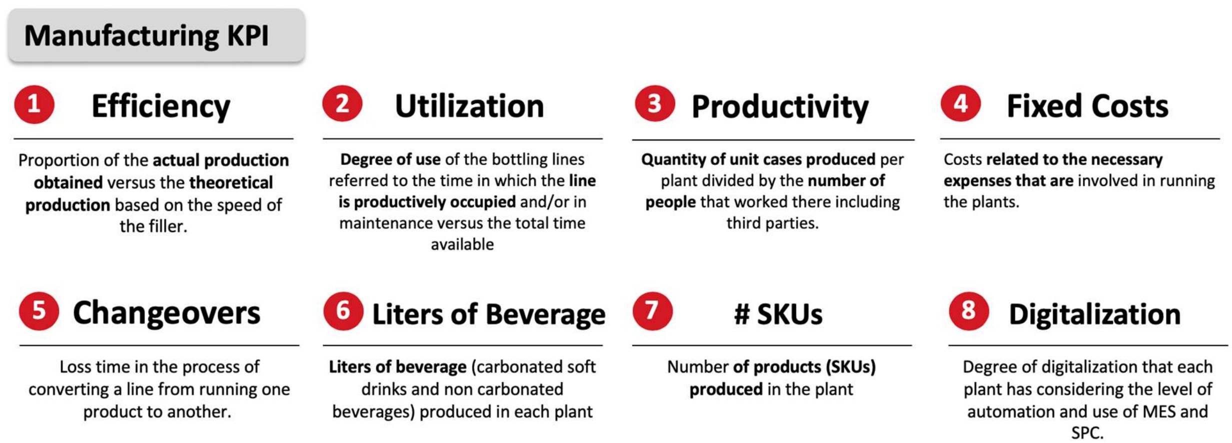

Figure 3. *Manufacturing final variables*

Before Exploratory Factor Analysis was performed, the data was cleaned and standardize to scale variables to have values between -1 and 1. During the cleaning process, it was noticed that data from 2017 and 2019 was incomplete, so only data from 2018 was considered for further analyses.

The KPI Efficiency was not included in the performance of the Exploratory Factor Analysis because it was set as a target metric to validate clusters after the model outcome.

For the external factors, only two variables (out of the initial seven) were chosen: GDP per Person and Literacy Rate (see Figure 4). Some variables were rejected since the calculation was not standardized between countries and therefore not comparable. For example, Unemployment or the Employed Labor/Total Population. In some countries, like Mexico, unemployment is not calculated with only the official jobs, but also the informal works which are neither taxed nor monitored.

Figure 4. *External factors*

4.2.3 Research Methodology

Data analysis consisted of two main steps. In the first step, an Exploratory Factor Analysis (EFA) was conducted to reduce the number of variables and linear combinations of the original set. In the second step, a cluster analysis was performed to i) Define the number of possible groups of plants with similar characteristics according to their performance (Manufacturing KPIs), using hierarchical clustering, and ii) Refine the clusters solution through K-means cluster algorithm (Marodin et al., 2016).

According to Frank et al., (2019b), the final clusters should present high homogeneity within the cluster and high heterogeneity between different clusters so descriptive analyses were performed also in order to validate the final clusters.

All data analyses were performed with SPSS Statistics 26 Software.

4.3 Survey

4.3.1 Survey Design

Many robust frameworks to assess the diffusion of any innovation can be found in the literature, such as the Technology Acceptance Model (TAM) (Davis et al., 1989), the Innovation Diffusion Theory (IDT) (Rogers, 2003) or Technology – Organization – Environment (TOE) (Tornatzky & Fleischer, 1990).

Although all of these models could be suitable to assess the adoption of Digital Manufacturing within BeverageCo, a deeper analysis reveals that TAM is primarily focused on technological aspects. It does not consider the impact of organizations and neglects the human components in every implementation (Agarwal & Prasad, 1998); (Venkatesh & Bala, 2008). Since one of the hypotheses of this capstone project is that the organizational aspect must be always considered in the adoption of innovative technologies, the TAM model is rejected.

Despite the fact that the IDT methodology already includes the organizational and technological frameworks simultaneously, it does not include the external factors (Rogers, 2003). The company cannot change these external factors, but it could be strongly affected by them. Since the plants of BeverageCo are scattered across South America the external factors will vary extremely from plant to plant and could also affect the adoption of Digital Manufacturing and therefore, the ID methodology is also rejected.

Alternatively, TOE includes all aspects mentioned above and it also has robust empirical support in technologies included in the Digital Manufacturing context like Augmented Reality (Masood & Egger, 2019), 3D-printing (Yeh & Chen, 2018) and even Industry 4.0 (Arnold et al., 2018). Therefore, the TOE methodology is used in this capstone project.

The TOE methodology is composed of 3 different constructs: technologies, organization and external factors.

- The technological construct describes the current technologies implemented in the company as well as the technologies not yet in place, but still considered important for the business and under consideration (Baker, 2012).
- The organizational construct relates the structures, relations and boundaries of employees and groups within the company. It could also contain the perception of the leadership and the communication methodologies (Baker, 2012).
- The third construct is named "environment," however this term could be easily misinterpreted. To avoid confusion, this term was renamed "external factors". It represents the external setting of the company (Lippert & Govindarajulu, 2006). It usually refers to the external operational moderators and inhibitors for the adoption of the technologies (Awa, 2016), the support infrastructure for the technologies and the interactions with extern partners, like suppliers or even governments (Baker, 2012).

4.3.2 Data Collection

The survey was developed in English and then translated into Spanish (by the authors) because the native language of most respondents is Spanish. There were two preliminary assessments. First, the survey was pre-tested with students in MIT Supply Chain Management Master's program and BeverageCo employees. Based on their feedback, the wording of some questions was modified and some questions were deleted to ensure that the survey was understandable. After the changes, the survey was tested again and approved by the sponsors.

The survey consists of 3 parts. The first seeks information about the location and some personal data about the respondent (e.g. position in the company and number of years working for BeverageCo). The second gives a brief explanation of Digital Manufacturing and asks the respondents about their knowledge and opinion about different technologies commonly associated with Digital Manufacturing. The third part contains questions regarding Digital Manufacturing and it is designed to assess the current level of diffusion that these technologies already have. These questions are Likert-scale reaching from 1 (strongly disagree) to 5 (strongly agree).

The survey was sent to the 52 bottling plants as well as the responsible executives in the regional divisions. At each plant, five managers of diverse departments (manufacturing, maintenance, quality and human resources) received the survey, generating a total of 250 possible respondents.

The survey provides an excellent opportunity to assess the opinion of the bottling plants on the benefits and challenges associated with the implementation of Digital Manufacturing. Consequently, in addition to the 3 constructs proposed in the TOE Framework (Technologies, Organization & External Factors), a fourth construct named "Acceptance of technologies" was added to the survey (Figure 5).

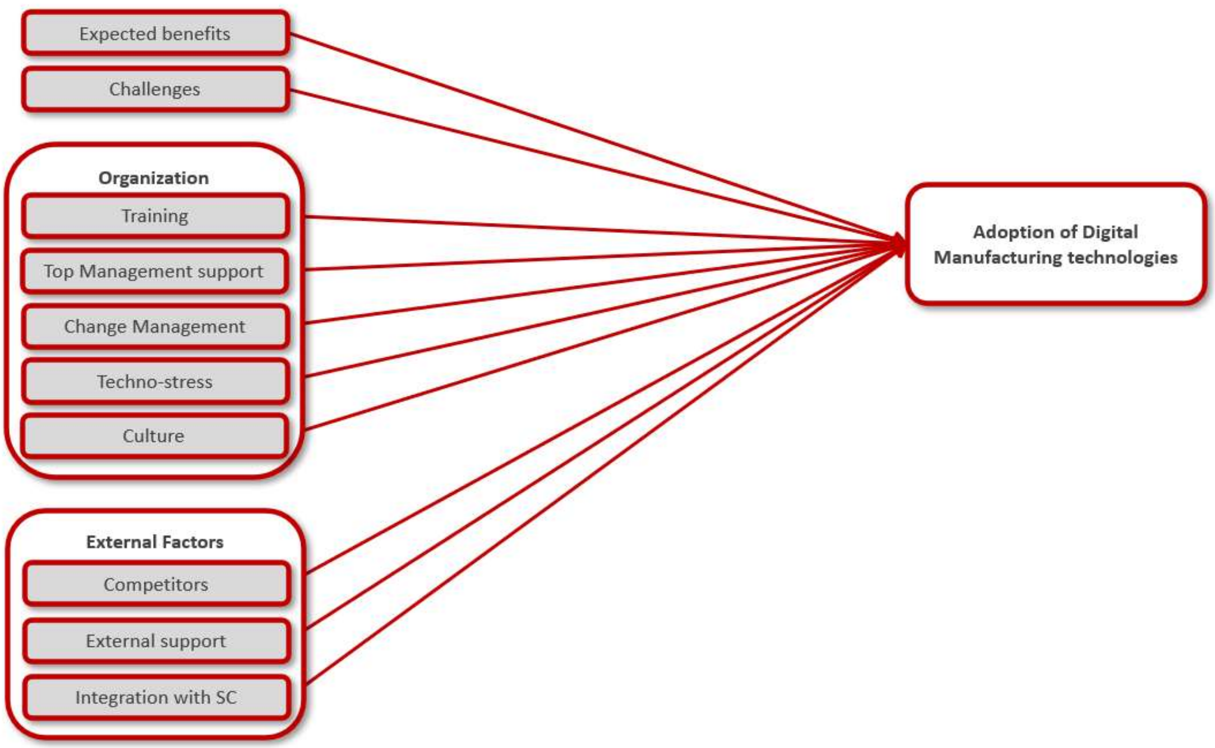

Figure 5. TOE *Framework.*

More details about the definition of the constructs employed and the previous scholars works that we used as a foundation to create the questions are summarized in

Table 3.

Table 3. *Constructs for TOE framework*

Construct	Description	Based on
Expected benefits (EBen)	There is an expected benefit if the advantages of Digital Manufacturing surpass the negative effects of its implementation.	(Arnold et al., 2018)
Challenges (Cha)	The challenges associated with the implementation of Digital Manufacturing should be also considered.	(Arnold et al., 2018)
Compatibility (Compa)	Digital Manufacturing is considered a compatible methodology if it fits the processes and values of the company.	(Masood & Egger, 2019)
Ambidextery (Amb)	For a company to be ambidextrous requires to use both exploration and exploitation techniques.	(Yeow et al., 2017) (Hess et al., 2016)
Cyber Security (CS)	The capacity to protect the data and make the processes robust once the new technologies are implemented.	(Ichsan et al., 2017)
Training (Tra)	During and after the implementation of Digital Manufacturing employees must be educated in the use of the technologies associated with it.	(Gangwar et al., 2015)
Top Management Support (TMS)	The role of Top Management could play and key role during the implementation and sustainability of Digital Manufacturing.	(Yeh & Chen, 2018)
Change Management (CM)	The change management construct measures the help of the organization while transitioning to the new processes and technologies.	(Pejic et al., 2017)
Techno-stress (TS)	Employees can experience stress influenced by new technologies and affect their job satisfaction and commitment to the organization.	(Ragu-Nathan et al., 2008)
Culture (Cul)	The culture and the values of the organization may contribute to adapt faster and easier the new methodologies and/ or technologies.	(Gangwar et al., 2015)
Competitors (Compe)	The adoption of Digital Manufacturing could be also affected if the competitors are more willing to invest in such technologies.	(Jia et al., 2017)
External support (ESup)	If there is a perceived outside support (from headquarter & governments), Digital Manufacturing is more likely to be implemented.	(Arnold et al., 2018)
Integration with SC (ISC)	The goal is to measure the degree of collaboration All stakeholders along the supply chain.	(Flynn et al., 2010)

4.3.3 Research Methodology

In order to validate the model, the methodology used was the one recommended in Arnold et al. (2018):

1. Validation of the applied constructs with the Exploratory Factor Analysis (EFA).
2. Validation of the reliability of constructs calculating the Cronbach's alpha.
3. Assessment of multicollinearity between the dependent constructs.
4. Multiple linear regression to assess the impact of the independent factors on "Adoption of technologies", measuring the willingness of employees of BeverageCo to adopt the technologies of Digital Manufacturing.

Also, as in Section 4.2.3, all data analyses were performed with SPSS Statistics 26 Software.

Considering the methodology described before, the following Chapter 5 presents in detail the results obtained from the analysis of the Scorecard data and the survey in order to support the digital manufacturing strategy for BeverageCo.

5 RESULTS AND ANALYSIS

This chapter presents the results and analysis of the Scorecard data and survey.

5.1 Scorecard Data

5.1.1 Exploratory Factor Analysis Results

Exploratory factor analysis (EFA) was performed using varimax rotation to extract the orthogonal components. This method was used both for Scorecard data and external factors.

For Scorecard data, the variables were loaded into different factors but only two had eigenvalues greater than 1 (2.920 for factor 1 and 2.223 for factor 2), representing approximately 73.48% of variation. The scree plot of the eigenvalues of the factors is shown in Figure 6.

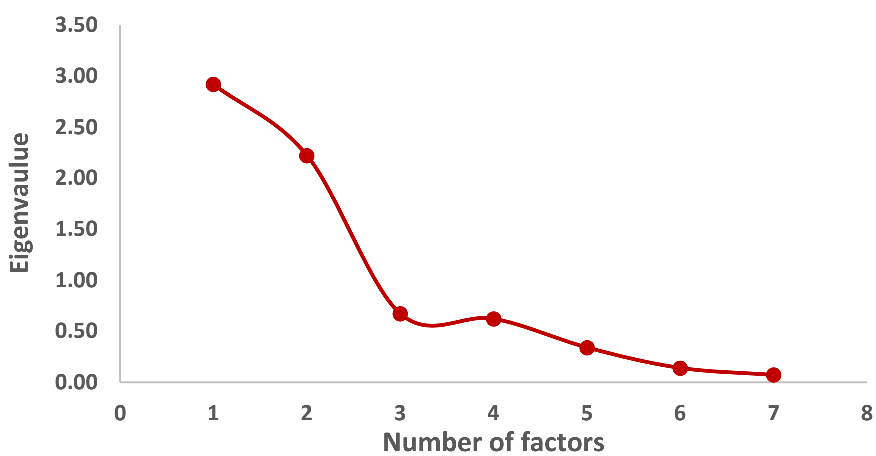

Figure 6. *Scree plot of eigenvalues and factors*

In order to understand the suitability of the data for structure detection (underlying or latent relationships between the variables), two tests were performed: Kaiser-Meyer-Olkin (KMO) measure of sampling and Bartlett's test of sphericity. KMO was 0.635, showing that the factor analysis is useful for the data (the variance in the variables is not caused by underlying factors); Bartlett's level of significance was 0.000, demonstrating that the variables are related and therefore suitable for structure detection.

According to these results, factor 1 includes liters of beverage, changeovers, utilization and SKUs, while factor 2 is composed by SKUs, productivity and fixed costs. Because of this composition, factor 1 was renamed Complexity and factor 2 Expenses. The loading factors of each variable in both of factors are shown in Table 4.

The finding that SKUs was in both factors, although with different loading factors (0.7 for Complexity Factor and 0.6 for Expenses factor), was expected because one of the major drivers for complexity is the number of SKUs that a plant has. At the same time, it is a significant driver for expenses because with more SKUs, it will require more storage space, suppliers and labor cost. Moreover, it could increase excess and obsolescence inventory provisioning.

Also, it is important to mention that in the Expenses factor, productivity has a loading factor of -0.923. This negative sign was also expected because productivity and expenses have a negative correlation (if one variable increases, the other decreases). For example, if productivity is low, the expenses will be higher.

Table 4. *Factor matrix for Scorecard data*

Scorecard Data		
Variables	***Factors***	
	1 - Complexity	***2 - Expenses***
Liters of Beverage	0.938	
Changeovers	0.674	
Utilization	0.717	
Digitalization	0.690	
SKUs	0.700	0.614
Productivity		-0.923
Fixed Costs		0.929

Analogously, for external factors, the analysis resulted in one single factor with an eigenvalue of 1.852 and a percent of variance explained of 92.624%. KMO was 0.500 and Bartlett's level of significance was 0.000, showing that the data is suitable for structure detection. The results are shown in Table 5.

Considering that there was only one factor and it evaluated the external factors of each plant, this factor was renamed External Factor.

Table 5. *Component matrix for external factors*

External Factors	
Variables	***Factor 1 – External***
GDP per person	0.962
Literacy Rate	0.962

5.1.2 Clustering Analysis Results

Clustering methodologies are used to discover similarities between data items and grouping them according common characteristics into several categories, known as clusters (Milligan & Cooper, 1985).

The clustering analysis was used to divide the total amount of 45 bottling plants into smaller groups with similar characteristics. As done by Frank et al., (2019) the first step in the cluster analysis was using hierarchical cluster analysis (HCA) to determine the adequate number of clusters for the data followed by the use of K-means cluster algorithm for the refinement of the cluster solution.

The main advantage of hierarchical clustering is that is not necessary to assume the number of clusters. Hierarchical cluster analysis was performed using Ward's method with the Euclidean distance as the measure of similarity. To perform it, the three factors found in the Exploratory Factor Analysis (Complexity, Expenses and External) were used.

To visualize the analysis a dendrogram was created (see Figure 7). The dendrogram represents the similarities between plants based on the factors previously mentioned.

Figure 7. *Dendrogram for number of clusters selection*

As it shows, the plants can be grouped into three to six main clusters. Considering that the number of groups of plants should be sufficient to be differentiated but also not too numerous, so the groups can still count with representativeness, the number of clusters that seemed appropriate was five. With 3 and 4 clusters, the dendrogram does not show a significant difference, while with more than 5 clusters, the differences between groups would be significantly reduced and would provide less insights to BeverageCo.

To confirm that the classification using the five clusters represented the best solution, k-means analysis was performed for k ranging from 3 to 6. K-means clustering is one of the most used algorithms in research and together with the hierarchical clustering can overcome one of its major disadvantages, the necessity to define the appropriate number of clusters.

The results of performing k-means with the three factors Complexity, Expenses and External for different numbers cluster are shown in Table 6.

Table 6. *K-means with k=3 to k=6*

k	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
3	24 plants	19 plants	2 plants			
4	19 plants	8 plants	2 plants	16 plants		
5	14 plants	2 plants	10 plants	11 plants	8 plants	
6	12 plants	3 plants	2 plants	12 plants	8 plants	8 plants

Performing a composition analysis of the clusters for k=3 to k=6, confirmed that the ideal number of clusters for BeverageCo plants was five because with k=5, dissimilarities between plants can be captured and also the clusters formed were the ones that made good business sense due to business usability and actionability. For example, cluster 5 is composed of 8 plants that produce only drinking water and have only 1 or 2 SKUs. Before doing clustering analysis, these plants were identified as "bottled water plants" so it was expected that these plants would be grouped together during clustering. However, this cluster is only formed when k is equal to 5. This is explained with more details in Section 5.1.3.

After determining the appropriate number of clusters, it was necessary to evaluate if the final clusters presented high heterogeneity between the different clusters and high homogeneity within the cluster. In order to accomplish this, the graphical representations of the clusters were analyzed.

The first step was to graph the possible combinations of factors (Complexity-External, Expenses-External and Complexity-Expenses) for all clusters (see Figure 8). As it shows, all clusters except for Cluster 2, are centered at 0 on the x-axis.

Also, in the graphs External vs. Expenses and External vs. Complexity, Cluster 2 is away from the others, indicating that this cluster is an outlier. This cluster is composed by two plants that do not belong to none of the other clusters because of their correlation with the external factor.

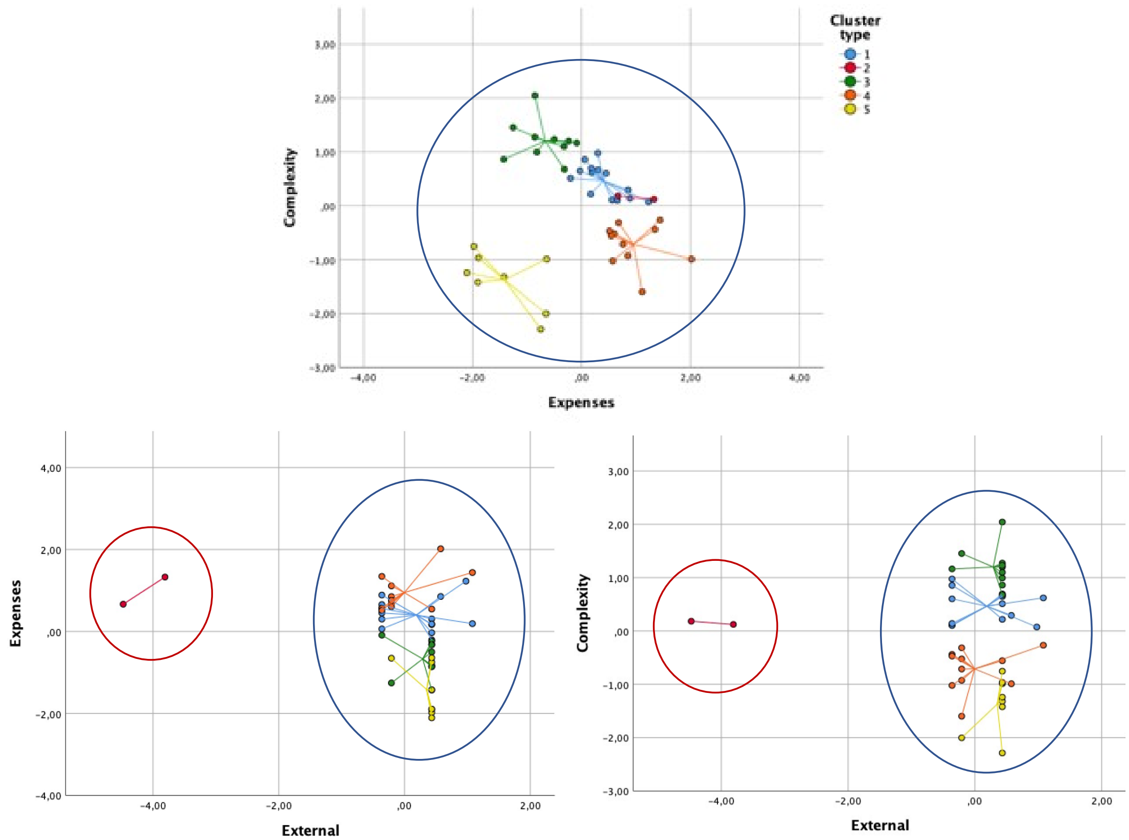

Figure 8. *Representation of clusters within the 3 factors in 2D*

Figure 9 shows the graphical representation (3D) of the five clusters for the three factors. It clearly shows that the clusters are separated and they are not overlapping with each other (they are heterogeneous). Also, it can be identified that cluster 2 lies significantly outside the other clusters, confirming that this cluster is an outlier as it was mentioned before.

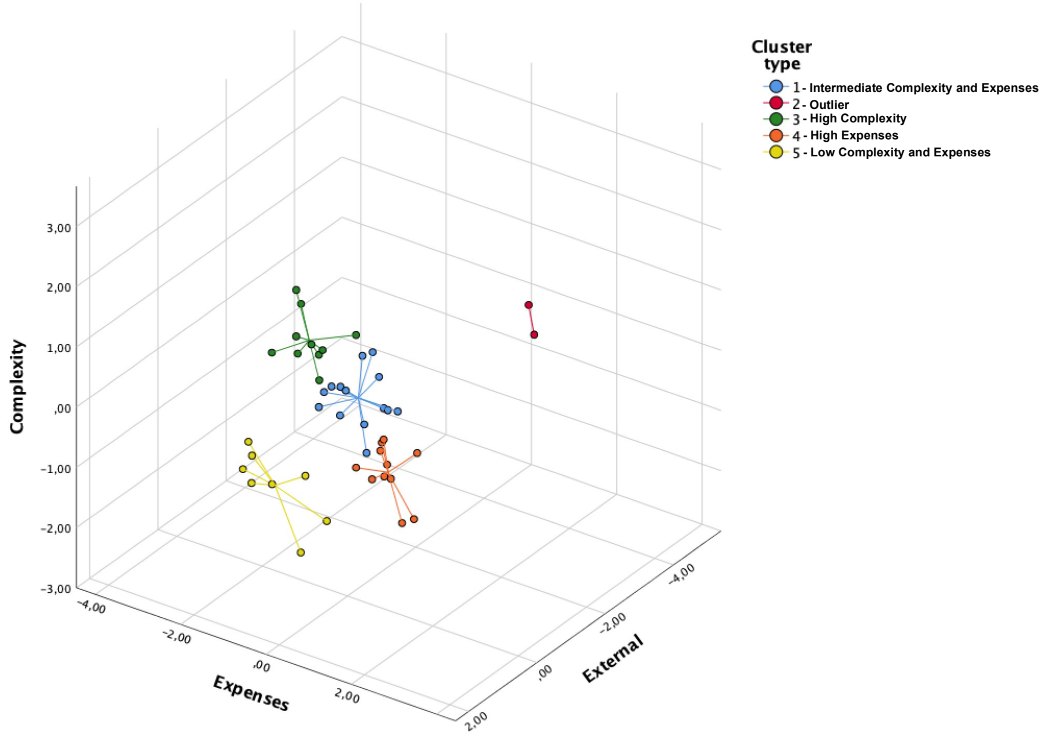

Figure 9. *Representation of clusters within the 3 factors in 3D*

The second step was to characterize the clusters based on the final centers. We used ANOVA comparison test in order to identify significant differences among clusters. Table 7 shows descriptive statistics (mean and standard deviation values) and ANOVA results for each factor (Complexity, Expenses and External) for the clusters. For example, while Cluster 3 is characterized by the highest level of complexity, Cluster 5 is characterized by the lowest level of complexity. This is explained with more details in Section 5.1.3.

Table 7. *Descriptive analysis of the clusters*

	Mean (SD) of cluster group					
	CLUSTER 1	**CLUSTER 2**	**CLUSTER 3**	**CLUSTER 4**	**CLUSTER 5**	**F (ANOVA)**
Complexity	0.465 (0.302)	0.153 (0.042)	1.199 (0.369)	-0.711 (0.394)	-1.372 (0.528)	64.351*
Expenses	0.401 (0.397)	0.997 (0.469)	-0.669 (0.448)	0.949 (0.48)	-1.419 (0.642)	37.477*
External	0.187 (0.531)	-4.142 (0.47)	0.289 (0.304)	-0.004 (0.478)	0.352 (0.227)	49.689*

Significant at p < 0.001

Also, a comparison of performance outcomes among the clusters was done. In order to do this, ANOVA comparison test was performed again. Table 8 shows descriptive statistics and ANOVA test results for the performance outcome chosen (efficiency).

Table 8. *ANOVA*

	Cluster 1	***Cluster 2***	***Cluster 3***	***Cluster 4***	***Cluster 5***	***F (ANOVA)***
Efficiency	*-0.69* *(0.44)*	-1.24 (0.11)	-0.16 (0.6)	0.06 (0.69)	1.62 (0.6)	1.809*

***** Significant at p < 0.1***

5.1.3 Clusters Composition Analysis

With the clustering results in hand, it became clear that even though each plant has certain particularities, they could be classified in groups that can be used in the industry and are statistically valid. Based on the results, BeverageCo plants can be grouped in 5 clusters. However, one of these clusters (Cluster 2) is an outlier so this cluster was not considered for further analyses.

Cluster 1, which comprises 14 plants, is characterized by intermediate levels of complexity and expenses. The plants included in Cluster 1 do not have the highest values in neither of the factors but they do not have the lowest values either. From the industry point of view, these plants have a good overall performance but they do not possess high levels of automation, although; some of them are working on this.

Cluster 2, the outliers, is composed of only 2 plants that have in common a strong negative correlation with the External Factor (composed by GDP per Capita and Literacy Rate variables). This result, although unexpected, is logical because these plants are located in less developed countries (comparing to the other ones where BeverageCo has a presence), proving the high impact that the external factors has.

Cluster 3, with 10 plants, is characterized by the highest levels of complexity. This group is consistent with the industry perspective because these plants have several production lines and the highest production volumes of the system. Because of this, most of the plants in this cluster are highly automated (specially the new ones) and have adopted, or at least implemented, some technologies of Industry 4.0.

Cluster 4, composed of 11 plants, is characterized by the highest levels of expenses. From an industry point of view, this cluster has medium-size plants, with SKUs that are not very profitable and require special lines to produce them. This cluster has basic level of automation and a moderate overall performance.

Finally, **Cluster 5**, which comprises 8 plants, is characterized by the lowest levels both in complexity and expenses. This group is composed of plants that only produce drinking water in a specific package called a jug (only two plants produce also in PET plastic bottles) and have fewer complex operations. In fact, the majority of these plants have only 1 SKU, need less people to operate and their volumes are low. Since bottled water is less profitable than other BeverageCo products, the company is more concerned about investment and the plants are still not automated. However, and since these plants do not have changeovers, these bottling plants are very efficient.

5.2 Survey

5.2.1 Survey Results

We obtained 149 complete responses from a total of 245 surveys sent to the 52 bottling plants, representing a response rate of 61%. The survey was created and tested in an open platform and sent to all respondents by an executive of the corporate team. The initial email included a description of this project, the purpose of the survey and a claim to their participation, explaining that the understanding of the organization is essential for this project and for the development of the Digital Manufacturing strategies for the bottling plants.

The first part of the survey asked the participants about their personal information and their location. Table 9 shows the composition of the surveys regarding country, position of the respondents and years that they have been working for BeverageCo.

Table 9. *Demographic composition of the survey results*

Country	*Number*	*Response rate*	*Position*	*Number*	*%*	*Years in the company*	*Number*	*%*
Argentina	6	55%	*Director*	6	4%	1 – 3	16	11%
Brazil	9	36%	*Manager*	56	38%	3 – 5	8	5%
Colombia	28	48%	*Leader*	58	40%	5 – 10	26	18%
Costa Rica	5	56%	*Other*	26	18%	10 – 15	24	16%
Guatemala	19	90%				15 – 20	32	22%
Mexico	58	71%				20 – 25	25	17%
Nicaragua	3	38%				25 – 30	11	8%
Panamá	6	75%				more 30	4	3%
Uruguay	3	43%						
Venezuela	9	56%						
Total	**146**	**60%**						

The second part of the survey asked the respondents about their knowledge of Digital Manufacturing technologies and their opinion about the benefits of implementing these technologies. Results are summarized in Table 10.

Table 10. *Analysis of technologies*

	Number	*Media*	*Std Dev*	*Number*	*% Do not know the technology*
Additive Manufacturing	109	3.98	0.948	37	25%
Artificial Intelligence	116	4.20	0.949	30	21%
Augmented Reality	100	4.11	0.871	43	30%
Automation	141	4.67	0.846	5	3%
Blockchain	49	3.98	0.958	97	66%
Cloud Computing	131	4.49	0.868	15	10%
Data Analytics	135	4.64	0.837	11	8%
Digital twin	52	4.25	0.998	94	64%
Internet of Things	109	4.29	0.912	37	25%
Machine Learning	102	4.51	0.789	40	28%
Robotics	124	4.51	0.884	22	15%
Cybersecurity	129	4.52	0.855	16	11%

Before analyzing more deeply the results of the survey, two general tests were performed to assess two possible biases: late potential bias and position potential bias.

The survey was sent to BeverageCo employees on March 11, 2020. Due to the evolution of the Covid-19 pandemic, on March 14, 2020, BeverageCo decided that all employees whose tasks could be done from home, will continue their work from their houses and not from the BeverageCo facilities. This unexpected situation and their uncertain consequences could lead to biased answers to the survey and therefore; we wanted to test if the bias could be confirmed.

We split the answers into two groups: the early respondents (from March 11 to March 13) and late respondents (from March 14 to March 31). The results in Table 11 show p-values bigger than 0.05 for the four constructs; consequently, we cannot reject the hypothesis that the means were the same.

Table 11. *Survey results for early and late respondents*

Construct	*Group*	*Number*	*Mean*	*Standard Deviation*	*t*	*p-value*
Expected Benefits	Early	46	4.420	0.523	1.363	0.176
	Late	103	4.288	0.598		
Challenges	Early	46	4.327	0.446	0.389	0.698
	Late	103	4.286	0.594		
Adoption of technologies	Early	46	3.422	0.640	-0.129	0.898
	Late	103	3.437	0.626		
Organization	Early	44	3.457	0.593	-0.630	0.531
	Late	99	3.521	0.485		
External factors	Early	46	3.457	0.615	-0.286	0.776
	Late	101	3.488	0.594		

The survey was answered by people working at the bottling plants as well as people in corporate departments. We defined that a respondent belongs to the corporate group if the person works in the headquarter; either the headquarter of the company in Mexico or the country group leading the operations in some of the regions where BeverageCo has presence. We wanted to identify if the answers from corporate are statistically different from the answers coming directly from the bottling plants. The results of the tests are shown in Table 12.

All constructs (except Organization) have a p-value below 0.05; therefore, the null hypothesis can be rejected and we can conclude that the assessment of corporate and bottling plants employees is statistically different for these four constructs. This means that the perception of Digital Manufacturing for people working at a more operative level is different than the perception of people working in the central departments of the country or even region.

Table 12. *Results survey for corporate and non-corporate respondents*

Construct	*Group*	*Number*	*Mean*	*Standard Deviation*	*t*	*p-value*
Expected Benefits	Corporate	25	4.040	0.778	-2.143	0.041
	Bottling plant	105	4.391	0.518		
Challenges	Corporate	25	4.020	0.696	-2.275	0.030
	Bottling plant	105	4.355	0.491		
Adoption of technologies	Corporate	25	3.1429	0.498	-2.892	0.006
	Bottling plant	105	3.484	0.649		
Organization	Corporate	25	3.441	0.473	-.702	0.487
	Bottling plant	105	3.518	0.556		
External factors	Corporate	25	3.229	0.594	-2.335	0.026
	Bottling plant	105	3.543	0.595		

5.2.2 Exploratory Factor Analysis Results

With the data from the survey also an EFA analysis was performed. The initial run of EFA consisted on loading all the variables of the model. However, the results were not as consistent with the model that we have planned and so much noise was introduced in the methodology. Consequently, we performed several smaller EFAs including only the questions from the related constructs.

We performed the first EFA with the construct “Expected benefits”. The validation of the construct is carried out with the Cronbach’s alpha. It is commonly considered that the good reliability of a construct is validated it alpha is equal or bigger than 0.7 (Nunnally & Bernstein, 1994). In this case, although the value is at the limit, but we could consider that the alpha is big enough and therefore, the construct "Expected benefit" is considered valid.

Table 13. *EFA results for construct "Expected Benefits"*

Questions	*Expected Benefits*
Cronbach's α	0.699
Expected Benefit 1	0.840
Expected Benefit 2	0.768
Expected Benefit 3	0.762

Analogously, an EFA was performed for the construct "Challenges". In this case the Cronbach's alpha is bigger than 0.7; and therefore, the reliability of the construct is also valid.

Table 14. *EFA results for construct "Challenges"*

Questions	*Challenges*
Cronbach's α	0.794
Challenges 1	0.714
Challenges 2	0.791
Challenges 3	0.838
Challenges 4	0.827

Next, the initial constructs "Compatibility", "Ambidexterity" and "Cyber Security" are grouped in a common construct named "Adoption of technologies". Since the three initial constructs are related, we decided to perform the EFA with a single construct. The Cronbach's alpha is also greater than 0.7, validating the reliability of the construct.

Table 15. *EFA results for constructs in "Adoption of technologies"*

Questions	Adoption of technologies
Cronbach's α	0.822
Compatibility 1	0.609
Compatibility 2	0.514
Compatibility 3	0.540
Ambidexterity 1	0.759
Ambidexterity 2	0.837
Cyber Security 1	0.486
Cyber Security 2	0.610

For the constructs included in the category "Organization", we decided to organize the constructs according to their conceptual meaning. "Training" and "Culture" (see Table 16) were considered together as they aimed to measure the willingness of both employees and the whole organization to adopt Digital Manufacturing. Separately, the role of change and evolution and its relation with the management level are considered in another group (

Table 17). The first question in the construct "Techno stress" has a loading factor below 0.4 and therefore, it was eliminated for the following analysis. However, all Cronbach's alphas are greater than 0.7 and the reliability of the constructs is valid.

Table 16. *EFA results for constructs in "Organization I"*

Questions	Training	Culture
Cronbach's α	0.796	0.816
Training 1	0.410	
Training 2	0.987	
Training 3	0.650	
Culture 1		0.746

Culture 2	0.728
Culture 3	0.823

Table 17. *EFA results for constructs in "Organization II"*

Questions	***Top Management Support***	***Change Management***	***Techno stress***
Cronbach's α	0.885	0.776	0.744
Top Management Support1	0.809		
Top Management Support 2	0.818		
Top Management Support 3	0.834		
Top Management Support 4	0.768		
Change Management 1		0.793	
Change Management 2		0.860	
Change Management 3		0.541	
Techno Stress 1			
Techno Stress 2			0.650
Techno Stress 3			0.704
Techno Stress 4			0.782

Finally, all constructs related with the "External Factors" were considered to perform the last EFA. For this analysis the question 3 of the construct "External Support" had a loading factor smaller than 0.4 and therefore this question was eliminated for further analysis. Moreover, the remaining 2 questions of "External Support" (see Table 18) were loaded together with the questions from "Integration of Supply Chain". Accordingly, the factor was named "External factors". The question from the construct "Competitors" loaded in the same factor, but the Cronbach's alpha was smaller than 0.7; therefore, the construct "Competitors" was eliminated for the subsequent analysis.

Table 18. *EFA results for constructs in "External Factors"*

Questions	***External factors***	***Competitors***
Cronbach's α	0.874	0.555
Competitors 1		0.780
Competitors 2		0.586
Competitors 3		0.710
External Support 1	0.453	
External Support 2	0.610	
External Support 3		
Integration of Supply Chain 1	0.833	
Integration of Supply Chain 2	0.871	

5.2.3 Regression Results

The model remains like shown in Figure 10. A regression analysis was performed to determine the contribution of each construct to the dependent construct, the "Adoption of technologies."

Before carrying out the regression models, we tested the collinearity of the constructs. The results can be found in Table 19. There are two pairs "Expected benefits – Challenges" and "Technostress – Culture" with a coefficient greater than 0.6; which could mean moderate collinearity between the constructs. However, the VIF in Table 20 shows values below 5; indicating that the multicollinearity between the constructs could be disregarded (Belsey et al., 2005)

Table 19. *Correlation coefficients*

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1 -Adoption of technologies	1								
2 - Training	0.565*	1							
3 – Top Management Support	0.480*	0.397*	1						
4 – Change Management	0.593*	0.574*	0.437*	1					
5 – Techno stress	-0.065	-0.114	0.151	0.041	1				
6 – Culture	0.467*	0.369*	0.647*	0.461*	0.258*	1			
7 – Expected benefits	0.064	-0.022	0.131	-0.034	0.065	0.086	1		
8 – Challenges	0.182	0.034	0.140	0.033	-0.001	0.102	0.702*	1	
9 – External factors	0.550*	0.488*	0.340*	0.453*	0.040	0.311*	0.147	0.067	1

Correlation is significant at the 0.01 level (2-tailed)

A regression analysis was performed to validate the model of the survey. In the first step it was assessed the direct effect of the five organizational constructs in the adoption of technologies. In the second model, we included the constructs “Expected Benefits” and “Challenges”. In the third step we included as well the “External Factor” construct with the variables of External Support and Integration of Supply Chain. Finally, in the fourth model, we assessed the moderating effect that the “External Factors” have in the “Expected Benefits” and “Challenges” for the adoption of Digital technologies.

The results of the regression analysis (see Table 20) shows a significant direct relationship between the constructs of organization and the adoption of technologies. Adding the constructs “Expected Benefits” and “Challenges” slightly improved the predictive power of the model. In the third step, when the “External factors” were included, the R^2 improved again significantly, proving that the “External factors” also contributed to the adoption of the technologies. Finally, the interaction of the external factors within the “Expected challenges” and “Challenges” were also included. The R^2 remained almost unaltered and the significance of the model is remarkably reduced.

We could conclude that model 3 (represented in Figure 10) is the model that better represented the model for the survey, where all constructs (except “Culture”) contribute to the adoption of technologies.

Table 20. *Regression results for Adoption of technologies*

Model	*Dependent variables*	*Beta*	*t*	R^2	*F*	ΔR^2	*VIF*
1	*(Constant)*		-0.242	0.473	24.194***		
	Training	0.240	3.065**				1.573
	Top Management Support	0.176	2.078**				1.827
	Change Management	0.309	3.785***				1.709
	Technostress	-0.129	-1.942*				1.128
	Culture	0.151	1.743*				1.934
2	*(Constant)*		-0.237	0.491	2.411*	0.018	
	Training	0.247	3.175**				1.578
	Top Management Support	0.169	2.015**				1.844
	Change Management	0.307	3.780***				1.724
	Technostress	-0.122	-1.845*				1.135
	Culture	0.139	1.606				1.944
	Expected Benefits	-0.063	-0.731				1.913
	Challenges	0.172	2.018**				1.888
3	*(Constant)*		-4.368***	0.556	19.145***	0.065	
	Training	0.133	1.712*				1.780
	Top Management Support	0.143	1.814*				1.855
	Change Management	0.240	3.091**				1.793
	Technostress	-0.131	-2.117**				1.136
	Culture	0.127	1.568				1.947
	Expected Benefits	-0.138	-1.684*				2.001
	Challenges	0.206	2.567*				1.906
	External factors	0.315	4.376***				1.543
4	(Constant)		-4.208***	0.558	0.378	0.002	
	Training	0.122	1.537				1.849
	Top Management Support	0.145	1.824*				1.871
	Change Management	0.234	2.979**				1.814
	Technostress	-0.130	-2.081**				1.114
	Culture	0.137	1.656				2.023

Expected Benefits	-0.121	-1.377	2.266
Challenges	0.202	2.404**	2.082
External factors	0.307	4.189***	1.578
Expected Benefits*External Factors	0.052	0.519	2.988
Challenges*External Factors	0.005	0.055	2.775

Significant at p < 0.10 **Significant at p<0.05 ***Significant at p<0.001

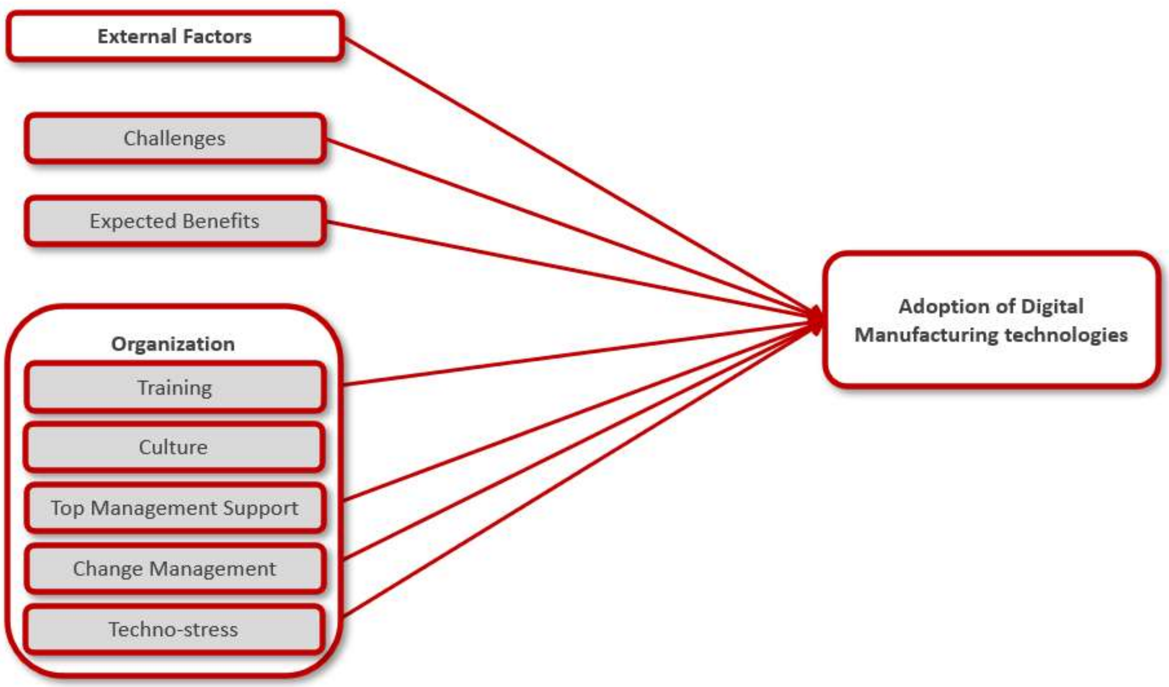

Figure 10. *Representation of survey constructions*

Finally, we checked if the assessment of the plants belonging to different clusters had some statistical differences (details in Table 21). Since cluster 2 was an outlier, it was not considered in this analysis. In general, there were minor or no differences between the assessment of the different clusters. However, we could conclude that people working at plants in clusters 3 and 4 assess different 6 out of 9 constructs in the model.

Table 21. *Differences between clusters*

Construct	1-3	1-4	1-5	3-4	3-5	4-5
	t	t	t	t	t	t
Expected Benefits	-0.931	1.031	-3.631**	1.830*	-2.726**	-4.207**
Challenges	-0.959	1.241	-1.293	2.038**	-0.807	-1.920
Adoption of technologies	-0.973	1.274	-0.250	2.269**	0.312	-1.084
Training	-1.773	0.030	0.124	1.673	1.051	0.104
Top Management Support	-1.031	1.415	-0.672	2.241**	-0.155	-1.428
Change Management	0.286	1.271	0.163	1.032	0.061	-0.351
Technostress	0.511	0.428	-0.977	-0.103	-1.229	-1.190
Culture	-1.799	1.276	-0.680	2.906**	1.131	-1.903*
External factors	-1.313	1.571	-1.346	2.505**	-0.271	-2.411**

****Significant at p < 0.10 **Significant at p<0.05***

5.2.4 Survey Analysis

The survey was sent to 245 employees of BeverageCo working in 10 different countries and we obtained 149 complete responses; what made a response rate of 60%. Most of the respondents worked in a Manager or Leader position (78%) and more than 80% of the respondents have been working for the company more than 5 years as could be seen in Table 9. Therefore, we could consider that the results of the survey reflected a deep knowledge of the company and the FMCG industry.

However, the assessment is not consistent for all group of employees. As shown in Table 12, the perception of Digital Manufacturing for people working at a more operative level is different than the perception of people working in the central departments of the country or even region. This finding could be especially relevant when the new Digital Manufacturing strategy is designed.

In general terms, BeverageCo employees are familiar with most of the technologies related with Digital Manufacturing (see Table 10). The technologies they considered would be more beneficial in BeverageCo are Automation, Cloud Computing and Data Analytics. More than 80% of the employees agree or totally agree with the statement that the implementation of these technologies would be beneficial for the company. The more unknown technologies are Blockchain and Digital Twin. This finding provides a guidance of which technologies could be “easier” to implement and for which technologies a deeper training and analysis is necessary.

As it was mentioned in Section 5.2.2, after performing EFA analysis and calculating the Cronbach’s Alpha, only 9 constructs remained statistically relevant. The resulting model and the results per clusters were used to build the Digital Manufacturing strategy recommendations in Section 6.1.1.

6 MANAGERIAL RECOMMENDATIONS

This chapter discusses the results of clustering the BeverageCo plants and survey analyses and offers managerial recommendations that the company should consider for the creation of their Manufacturing Digital Transformation strategy.

This capstone project is based on the premise that BeverageCo is already involved in a Digital Transformation journey. Therefore, the company already has a holistic vision for the manufacturing digital transformation. For this reason, the recommendations described in this chapter are not starting with the creation of digital transformation vision and objectives as the literature suggests (Albukhitan, 2020). However, it relies on the vision already created by BeverageCo executives.

Following the framework used along throughout this document, TOE (Technology – Organization – External factors), the recommendations in this chapter will be structured using these three factors. These three factors were evaluated through the survey and the Scorecard data. The recommendations considered results from both Scorecard data and survey.

6.1.1 General Recommendations

In general, according to the survey results, the way BeverageCo employees perceived Digital Manufacturing and its benefits is satisfactory. As seen in Figure 11, for the questions related to the expected benefits of Digital Manufacturing, most employees agree with the statements that Digital Manufacturing will provide cost reduction, better use of resources, and increase the flexibility at production. However, there are some improvement opportunities that BeverageCo should consider if the company aims to pursue a successful Digital Manufacturing Transformation.

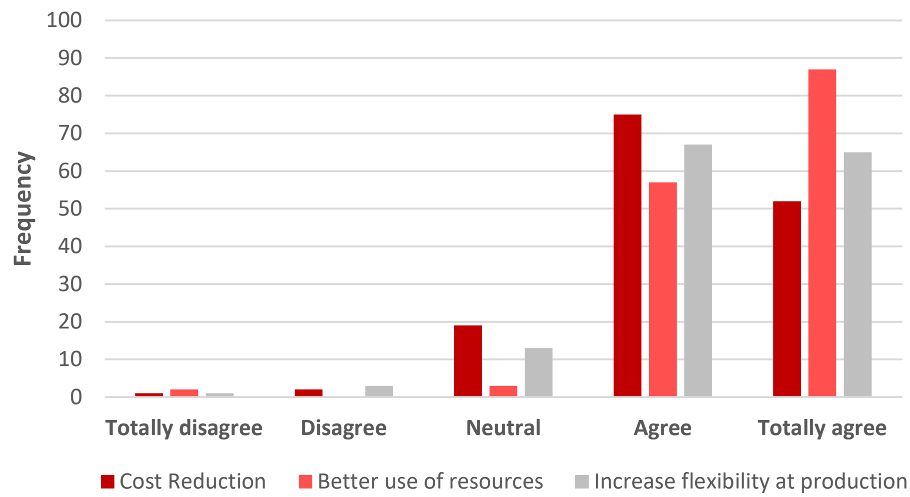

Figure 11. *Results expected benefits of Digital Manufacturing*

Organization

For the organization factor, one of the biggest improvement opportunities in Digital Manufacturing, that is common for all clusters, is training. As mentioned in Section 5.2, the construct "training" was composed of three questions to measure employee's perception of BeverageCo training programs for Digital Manufacturing. According to the results on the training construct (see Figure 12), only 27% of employees totally agree or agree with the statement that the company has training programs for Digital Manufacturing. Moreover, the percentage of people that consider that they are getting the effective training they need is further reduced to 22%.

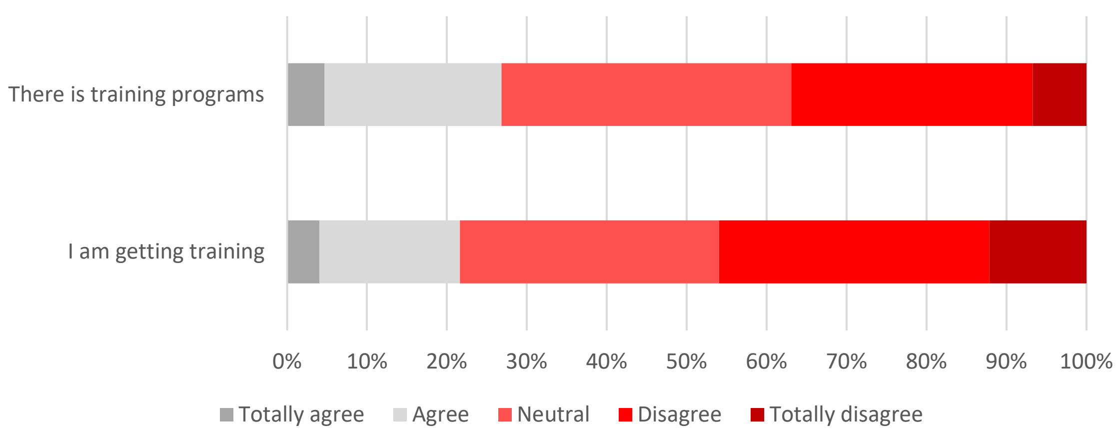

Figure 12. *Results of training questions*

Based on interviews with BeverageCo executives, this finding is aligned with the initial strategy that BeverageCo had for Manufacturing Digital Transformation, where only the employees that were going to use new technology were trained. The training programs were not for all the employees; thus, the Digital Manufacturing capabilities are not built yet. For this reason, BeverageCo should consider first create a training program for all their manufacturing employees with the basic concepts of Digital Manufacturing, making faster the adoption of new processes and technologies in the future. According to Albukhitan (2020), without relevant knowledge, the introduction of new technology alone is not enough to make it work. Therefore, the enhancement of employee's knowledge is a key element for the integration of Digital Manufacturing technologies.

Another improvement opportunity found through the survey was related to the "techno-stress" construct. Although employees stated that the use of Digital Manufacturing technologies fits their organization culture and that top management supports the adoption of Digital Manufacturing, they also think they are forced to change their work habits to adopt to Digital Manufacturing technologies. This is not what Manufacturing Digital Transformation aims to achieve. A core benefit of Digital Manufacturing is to ease employees' work so that people can invest their time in activities that add value to the company. This finding is also related to past Digital Manufacturing experiences. Previous Digital Manufacturing technologies implemented in BeverageCo were not simple to implement, where employees stuck with the idea that Digital Manufacturing technologies are not easy to adopt. Therefore, BeverageCo should consider a change management program (with successful internal examples) for its employees to show that Digital Manufacturing technologies are convenient to use. It is normal that people have resistance to change. However, once BeverageCo can reset and retest their employees, it could create an opportunity to improve employee status and cost savings.

External Factors

From BeverageCo employees' general perspective, the construct "Integration with Supply Chain Partners" should be improved. Employees think that the company should be working more closely with both customers and suppliers for the implementation of technologies of Digital Manufacturing. This should also be pursued in the Digital Manufacturing Transformation strategy that the company aims to create.

Additionally, it is important to mention that the external factors were also considered in the cluster analysis, using the official statistics published by government agencies for each country where BeverageCo has presence, so the resulting clusters have already included the weight of this factor.

Technology

From the survey results, there are two main improvement opportunities for the implementation of Digital Manufacturing technologies that are common to all clusters: IT infrastructure and Digital Manufacturing physical integration. Only 30% of the employees believe that the company has built an IT infrastructure that supports the implementation of Digital Manufacturing and the percentage of employees that consider that the physical integration of Digital Manufacturing would be straightforward is barely 17%.

For these reasons, Digital Manufacturing Transformation strategy should analyze first the current IT infrastructure of the plants and, depending on the case, try to leverage it in the facilities where it is needed. According to Albukhitan (2020), this step should be done by a dedicated group of digitally qualified experts and a specialized leadership to ensure a successful transformation.

Nevertheless, the responsibility for digital technologies introduction should be a shared goal by the whole organization and not limited to few employees or departments. This is important to mention because in previous implementations, the responsibility was exclusively of one department (Center of Excellence of Manufacturing); therefore, employees did not develop accountability for the technologies implemented.

It is important to remark that some digital technologies are already implemented in certain bottling plants. We described the maturity of these digital technologies with the variable Digitalization as it was described in Section 4.2.2. However, this Digitalization level has yet no impact on the Efficiency of the plants. As it is shown in Table 8 there is no statistical difference on efficiency independently on the Digitalization level of the plants. This unexpected result confirmed that previously efforts in the implementation of digital technologies did not provide the expected results.

6.1.2 Recommendations by Cluster

Although, Digital Transformation is driven by the advent of digital technologies, if the organization is not ready, the Digital transformation will fail. In order to prevent this, the current strengths and weaknesses for each cluster were analyzed. The recommended focus and technologies proposed are based on our literature research, understanding of Digital Transformation efforts and knowledge of BeverageCo.

As shown in Table 22, the proposed strategy for Clusters 1, 3 and 5 is focused on digital technologies that could help the bottling plants to improve their capabilities and achieve their digital vision. However, for Cluster 4, the main focus we proposed should concentrate on the organization factor, specifically in the “culture” construct.

As it was mentioned previously, Cluster 2 was considered as an outliner and it represented only two bottling plants, its statistical results were not conclusive and therefore, was not included in this analysis.

A detailed description of the different Clusters and their main characteristics was provided in Section 5.1.3. Taking into consideration these business characteristics, the Scorecard data and the results of the surveys specific managerial recommendations are proposed for each cluster.

Cluster 1 – Intermediate complexity and expenses

Cluster 1 strengths are “ambidexterity”, “compatibility” (included in “adoption of technologies”) and “change management”. Plants from Cluster 1 consider that 1) the company is working for the identification, exploring and implementation of Digital Manufacturing technologies, 2) the physical integration of Digital Manufacturing will be straightforward, and 3) they have available change managers, documentation and support once a new Digital Manufacturing technology is introduced. However, employees also feel threatened of losing their job because of the adoption of new technologies (“techno-stress”). According to this, BeverageCo strategy for this cluster must be based on a transparent and effective communication so that they can get employees motivated about the potential of new technologies. Knowing that managers in this cluster are engaged with Digital Manufacturing, they can pass high commitment onto employees as part of the digital transformation process.

Likewise, Cluster 1 plants believe that the adoption of Digital Manufacturing technologies will increase production flexibility. As mentioned previously, Cluster 1 has an intermediate complexity, therefore, the implementation of technologies that could help them reduce complexity and increase flexibility must be the main objective for them. Cluster 1 could start implementing Automation and Internet of Things (IoT), therefore, they can have more data available, and start using big data analytics for their processes.

Cluster 3 – High Complexity

Cluster 3 is prepared for more advanced Digital Manufacturing technologies due to its levels of automation and people readiness. Plants from Cluster 3 have strengths such as “top management support” and “culture” that show that they are ready for biggest challenges. For example, they believe that the use of Digital Manufacturing technologies is consistent with business practices, as well as fitting the organizational culture (DNA KOF). They also consider that the adoption of Digital Manufacturing will help them attain their competitive advantage and that top management is willing to take risks in this topic. Although they think that the physical integration of Digital Manufacturing would not be straightforward, this can be managed in the Digital Manufacturing strategy.

Plants in Cluster 3 have already implemented some digital technologies (higher values for Digitalization in the Scorecard data). Thus, they should start working with more advanced Digital Manufacturing technologies such as Machine Learning as part of predictive maintenance and Additive Manufacturing for spare parts. These technologies could help them mitigate the high complexity that plants of this cluster have. In terms of the organization, the most challenging task to achieve is to develop a digital culture. Considering that those plants already have their own digital cultures, this should be used as an advantage for the implementation of technologies of Digital Manufacturing.

Plants in Cluster 3 have a high Digitalization score due to their ongoing implementation of some digital tools. To continue the Manufacturing Digital Transformation journey, these plants will need to invest. However, these investments could not just follow the latest trends in digital technologies. Proper planning for the investment process is essential for the success of the Manufacturing Digital Transformation. Additionally, digital technologies solutions must be selected if they have a solid ROI (return of investment) and proof-of-concept (POC) that can be developed.

Cluster 4– High Expenses

Cluster 4 differs from the others because they should focus first on the organizational aspect instead of technologies that they could implement. These plants showed that they are not prepared for a Digital Manufacturing Transformation due to several reasons: 1) they do not expect major benefits from the adoption of Digital Manufacturing technologies, 2) they do not view that top management is willing to invest in Digital Manufacturing, 3) they do not believe that Digital Manufacturing technologies are consistent with their business practices and part of their supply chain strategy, or fits the organization culture, 4) they do not think that company is identifying and exploring Digital Manufacturing technologies, and 5) they consider they do not have change management.

Therefore, before BeverageCo starts implementing Digital Manufacturing technologies, they should evaluate what can be done to change the mindset of the people. In case they try to implement something before this is improved, the probability of failure is going to be higher.

This cluster requires systematic change management. This process must start with the communication of the manufacturing digital transformation vision to all employees. Also, it should have an action plan with concrete milestones for digital transformation. This plan must be communicated comprehensively and should ensure coordinated and targeted actions. Finally, commitment across all levels is needed. From top management to the “last” employee, they should feel committed. Once all elements are equally considered, change can most likely be achieved. If one element is neglected, it probably fails (Kreutzer et al., 2018).

Cluster 5 – Low complexity, Low expenses

Plants in cluster 5 associate the Digital Manufacturing adoption with cost reduction, increased resource efficiency and internal communication and coordination among departments and locations. They believe that top management supports Digital Manufacturing with funds and they are willing to take risks. Also, they perceive that Digital Manufacturing is part of the supply chain strategy and, above all, they do not think that Digital Manufacturing technologies threat their job security nor are too complex nor they are forced to change their work habits to adopt to Digital Manufacturing technologies. This is very important because it shows that Cluster 5 employees are non-resistant to changes, and therefore, BeverageCo can implement new technologies easily.

Although they do not consider that BeverageCo is implementing Digital Manufacturing technologies (ambidexterity) and that IT infrastructure that they have is going to support the implementation of Digital Manufacturing, the culture for a Digital Transformation can be noticed.

Plants for Cluster 5 have low budgets so that BeverageCo should start implementing lower cost digital solutions that replace repetitive, redundant and time-consuming tasks that are performed manually by a task force that consumes a huge number of man-hours.

Also, Cluster 5 could start with the implementation of the Internet of Things sensors and Automation in the processes that have high variability only (e.g., higher CpK). It is not necessary to do it for the whole plant since they already have good performance. They need to generate digital data, so it can be analyzed to create initiatives for improvement.

Table 22 summarized the strengths and weaknesses of each clusters, as well as the proposals for each group of plants.

Table 22. *Strengths and weaknesses per cluster*

Cluster	Strengths	Weaknesses	Strategy	Focus
Cluster 1 – Intermediate Complexity and Expenses	Compatibility Ambidexterity Change Management	Techno-stress	Technologies	Automation – IoT Big Data Analytics
Cluster 3 – High Complexity	Top Management Support Culture	Compatibility	Technologies	Machine Learning Additive Manufacturing
Cluster 4 – High Expenses	Competitors	Expected Benefits and Challenges Change Management Ambidexterity Techno-stress Culture	Organization	Culture
Cluster 5 – Low Complexity and Expenses	Expected Benefits and Challenges Top Management Support Culture Techno-Stress	Compatibility Ambidexterity	Technologies	Sensors for IoT Analytics

During this project, the clusters for the companies were defined based on the information from the Scorecard data from 2018. However, since the methodology was already created and the necessary variables were discovered, this clustering could be dynamic. To incorporate new acquisitions or even bottling plants that did not have information in the ERP system at the moment of this analysis could remain the same and will not demand a significant effort for BeverageCo.

One of the possible improvements of the methodology for Beverage would be the incorporation of new variables into the model. At the time of the modeling, only production fixed costs were available for all the bottling plants. We believe that the inclusion of the cost-to-make variable per plant could also add relevant information on the performance of the bottling plants.

7 CONCLUSIONS

The present study had the objective of creating a Digital Transformation strategy for BeverageCo's manufacturing plants that considers the current situation and readiness of each bottling plant as well as their main characteristics from both the operational and organizational perspectives. To achieve this, a multiple research methodology approach was used to analyze data from two different sources: BeverageCo's ERP system (Scorecard data) and a survey administered to all the plants. The aim is to close the gap found in the literature, where most scholars address technological aspects of the implementation of smart systems without taking into account external and organizational aspects like employees' training or change management.

For Scorecard data analysis, an Exploratory Factor Analysis (EFA) was conducted to reduce the number of variables and linear combinations of the original set. Following this, a clustering analysis was performed to define the number of possible groups of plants with similar characteristics according to their performance (Manufacturing KPIs).

The results of the Scorecard data show that even though each plant has certain particularities, they can be classified in groups that can be used in the industry and are statistically valid. For this reason, BeverageCo plants can be grouped into 5 clusters. The first cluster, Cluster 1, with 14 plants, is characterized by intermediate levels of complexity and expenses. Cluster 2 is composed of only 2 plants that have a strong negative correlation with the External Factor. For this reason, this cluster is away from the others, indicating that this cluster is an outlier. Cluster 3, with 10 plants, is characterized by the highest levels of complexity, while Cluster 4, composed of 11 plants, is characterized by the highest levels of expenses. Finally, Cluster 5, with 8 plants, is characterized by the lowest levels both in complexity and expenses.

For the survey analysis, a TOE framework was designed. This framework incorporates not only a technologic approach but also the organizational and external factors that could affect the adoption of Digital Manufacturing. The survey was designed based on the existing literature about digital technologies and how organizations prepare themselves to embrace the new changes. Although the constructs were already proven by other scholars, we found the construct “External Support” that included external support and integration with Supply Chain, was not statistically relevant for the BeverageCo model.

The main conclusion that can be drawn from the survey is that employees from BeverageCo have a fair knowledge of what are the Digital Manufacturing technologies. However, it is important to remark that people working in corporative positions and the people working directly at the bottling plants have a different assessment of the benefits and challenges that a Digital Manufacturing Transformation requires. Although the Digital Manufacturing should be an initiative initially driven by a corporate department, to align all efforts, the understanding of Digital Manufacturing for employees involved in the design and implementation phase should be common.

According to most employees of BeverageCo, the two fields where the company had the most room for improvement are the adaptability and compatibility of IT Systems. This provides the company with the ability of a smooth transition to the new technologies and the change management & training processes when new processes or technologies are implemented.

For the overall strategy, BeverageCo should work in three main aspects to improve the adoption and effectiveness of the Manufacturing Digital Transformation:

Create a framework to train employees in Digital Manufacturing. The training should not be based only on digital technologies, but also to create a company environment that increases the benefits and goals of the Manufacturing Digital Transformation.

Analyze IT infrastructure and physical integration with legacy systems already in BeverageCo. The first step is to identify if the current IT infrastructure and organization could handle the implementation of new technologies. Moreover, if new technologies are to be implemented, it is crucial to define if these new technologies could be integrated with the legacy systems already implemented in the bottling plants in order to avoid duplicate or even incompatible systems.

Improve the integration of Supply Chain stakeholders. Although the Manufacturing Digital Transformation is driven by and implemented in Operations, the initiative must be aligned with the rest of players in the Supply Chain; like Distribution, Procurement, and even Sales. A Digital Transformation aims to reduce the silos within a company; thus, also other departments should be integrated (or at least informed) about the roadmap that manufacturing creates.

7.1 Opportunities for future research

One possible opportunity that would enrich the analysis would be the incorporation of new variables into the model. During the construction of the model, only production fixed costs were available to measure the financial performance of BeverageCo bottling plants. Considering that the variable "Cost-to-Make" would be a better indicator to measure manufacturing's financial results, we believe that its inclusion could reflect the actual cost structure of the plants.

In addition, BeverageCo's new acquisitions could be considered in the clustering analysis if the data is available. In the Methodology chapter, it was mentioned that some plants did not have information available in the ERP system. Therefore, they were not considered in the analyses. In case where this situation changes, the methodology used in this study could be readily performed for these new acquisitions. Focusing on this, BeverageCo could consider the managerial recommendations described in this document to these plants.

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APPENDIX

Appendix A. Semi structured interview BeverageCo executives

Interview goal:

- To understand the Digitalization strategy of the company, specially related to the whole Supply Chain and Manufacturing.
- To define the expectations and scope of the project.

Structure of the interview:

- Strategy of the company
    - What is the vision of the company?
    - How do you visualize the company in the next 10 years?
    - What are the necessary changes and the biggest challenges to achieve the vision in the future?

- Strategy of the Supply Chain:
    - How does Supply Chain contribute to the strategy of the company?
    - Why did you decide to digitalize Supply Chain / Manufacturing?
    - Is there a roadmap for the digitalization of the Supply Chain / Manufacturing?

- Current status of the Supply Chain:
    - Is the Supply Chain standardized along the different countries where the company operates?
    - What is the role of the Supply Chain Center of Excellence?

- Experience with Digitalization in the Supply Chain/ Manufacturing:
    - Did the company implement some digitalization technologies?
    - How was the experience with these implementations?
    - How would be the ideal digitalized organization looks like?
    - What do you expect from the implementation of Manufacturing Digital technologies?

- Current Performance Indicators in Manufacturing
    - How do you measure the performance of the different processes?
    - What are the KPIs in daily/ weekly/ monthly basis?

- Expectations of the projects
    - What are your expectations for this project?
    - What is the scope of the project? Manufacturing? Supplier integration?

Appendix B. Survey for employees in BeverageCo

Hola Equipo KOF!

Queremos saber tu percepción sobre Manufactura Digital. Todas las plantas de la familia KOF están invitadas a participar en la encuesta sobre Manufactura Digital.

Las respuestas obtenidas serán completamente confidenciales. Si tienes alguna pregunta, no dudes en ponerte en contacto con las personas encargadas de la encuesta en los siguientes correos electrónicos: sgallo@mit.edu o anaisoc@mit.edu

Te llevará aproximadamente unos 20 minutos. No hay respuestas incorrectas; solo responde lo que piensas.

Muchas gracias por tu tiempo.

Indica en qué país trabajas:

- ○ Argentina
- ○ Brasil
- ○ Colombia
- ○ Costa Rica
- ○ Guatemala
- ○ México
- ○ Nicaragua
- ○ Panamá
- ○ Terracota (Corporativo)
- ○ Uruguay
- ○ Venezuela

Escribe el nombre de la planta en la que trabajas:

Indica tu posición en la organización:

- ○ Director
- ○ Gerente
- ○ Jefe
- ○ Otro

Escribe los años que llevas trabajando en KOF:

Para tu información:
En esta encuesta **Manufactura Digital** se define como una iniciativa tecnológica que busca crear nuevas oportunidades que transformen el rol de la manufactura.

Las siguientes tecnologías forman parte de la Manufactura Digital.
Si estás familiarizado con ella, señala si estás de acuerdo en que la implementación de dicha tecnología en KOF sería beneficiosa. En caso de no conocerla, selecciona la columna "No conozco esta tecnología".

	Totalmente en desacuerdo	En desacuerdo	Neutral	De acuerdo	Totalmente de acuerdo	**No conozco esta tecnología**
Impresión en 3D (Additive Manufacturing)						
Inteligencia Artificial (AI)						
Realidad Aumentada (Augmented Reality)						
Automatización (Aumotation)						
Blockchain						
Computación en la nube (Cloud Computing)						
Análisis de Datos (Data Analytics)						
Gemelo Digital (Simulation - Digital Twin)						
Internet de las cosas (Internet of Things)						
Machine Learning						
Robótica (Robotics)						
Ciber seguridad (Cybersecurity)						

Resultados

	Totalmente en desacuerdo	En desacuerdo	Neutral	De acuerdo	Totalmente de acuerdo
La adopción de tecnologías de Manufactura Digital está asociada con reducción de costos.					
La adopción de tecnologías de Manufactura Digital está asociada con un mejor aprovechamiento de los recursos.					
La adopción de tecnologías de Manufactura Digital está asociada con un incremento de la flexibilidad en producción.					
La adopción de tecnologías de Manufactura Digital está asociada con la capacitación de la mano de obra.					
La adopción de tecnologías de Manufactura Digital está asociada a ajustes del modelo de negocio.					
La adopción de tecnologías de Manufactura Digital está asociada con una permanente comunicación con otros elementos de la cadena de suministro.					
La adopción de tecnologías de Manufactura Digital está asociada con el establecimiento de estándares.					

Adopción de Tecnologías

	Totalmente en desacuerdo	En desacuerdo	Neutral	De acuerdo	Totalmente de acuerdo
Nuestra compañía ha construido una infraestructura IT que soporta la implementación de Manufactura Digital.	○	○	○	○	○
La infraestructura actual de IT puede ser actualizada para integrar las tecnologías de Manufactura Digital.	○	○	○	○	○
La integración física de las tecnologías de Manufactura Digital será sencilla.	○	○	○	○	○
Nuestra compañía identifica e investiga el uso de tecnologías de Manufactura Digital.	○	○	○	○	○
Nuestra compañía implementa tecnologías de Manufactura Digital.	○	○	○	○	○
Nuestra compañía es consciente de los riesgos relacionados con la ciberseguridad.	○	○	○	○	○
Nuestra compañía dispone de planes de acciones para prevenir ciber ataques.	○	○	○	○	○

Organización I

	Totalmente en desacuerdo	En desacuerdo	Neutral	De acuerdo	Totalmente de acuerdo
La adopción de tecnologías de Manufactura Digital hará más fácil el trabajo de los colaboradores.	○	○	○	○	○
Nuestra compañía dispone de programas de entrenamiento para el uso de tecnologías de Manufactura Digital.	○	○	○	○	○
Estoy recibiendo el entrenamiento que necesito para el uso efectivo de las tecnologías de Manufactura Digital .	○	○	○	○	○
Nuestros gerentes y directores apoyan la adopción de Manufactura Digital y la consideran una estrategia importante.	○	○	○	○	○
Según nuestros gerentes y directores, la adopción de Manufactura Digital permite que mantengamos una ventaja competitiva.	○	○	○	○	○
Nuestros gerentes y directores están dispuestos a invertir en Manufactura Digital.	○	○	○	○	○
Nuestros gerentes y directores están dispuestos a asumir riesgos asociados con la adopción de Manufactura Digital.	○	○	○	○	○
Cuando se presentan nuevas tecnologías de Manufactura Digital hay gestores de cambio disponibles	○	○	○	○	○
Cuando se presentan nuevas tecnologías de Manufactura Digital la documentación necesaria está disponible y la recibo a tiempo.	○	○	○	○	○

Organización II

	Totalmente en desacuerdo	En desacuerdo	Neutral	De acuerdo	Totalmente de acuerdo
Cuando necesito utilizar nuevas tecnologías de Manufactura Digital tengo el apoyo de otros empleados.	○	○	○	○	○
Me veo obligado a cambiar mis hábitos de trabajo para adaptarme a las tecnologías de Manufactura Digital.	○	○	○	○	○
A menudo encuentro demasiado difícil entender y utilizar las tecnologías de Manufactura Digital.	○	○	○	○	○
Siento que no se comparte el conocimiento entre compañeros por miedo a ser reemplazado.	○	○	○	○	○
Siento que mi puesto de trabajo está constantemente amenazado debido a las tecnologías de Manufactura Digital.	○	○	○	○	○
El uso de tecnologías de Manufactura Digital es coherente con nuestras prácticas de negocio.	○	○	○	○	○
La implementación de Manufactura Digital forma parte de la estrategia de Cadena de Suministro.	○	○	○	○	○
El uso de tecnologías de Manufactura Digital se adapta a nuestra cultura corporativa (ADN KOF).	○	○	○	○	○

Factores Externos

	Totalmente en desacuerdo	En desacuerdo	Neutral	De acuerdo	Totalmente de acuerdo
La competencia en nuestro sector es despiadada.	○	○	○	○	○
Somos conscientes de la utilización de Manufactura Digital por parte de nuestros competidores.	○	○	○	○	○
Nuestra compañía estaría más presionada a la hora de implementar Manufactura Digital si el sector también la implementara.	○	○	○	○	○
Existe un número suficiente de expertos externos que podrían ayudarnos a implementar tecnologías de Manufactura Digital.	○	○	○	○	○
En nuestra compañía hay un grupo en el corporativo que está disponible para resolver problemas con tecnologías de Manufactura Digital.	○	○	○	○	○
El gobierno ha dispuesto incentivos para la implementación y el uso de tecnologías de Manufactura Digital.	○	○	○	○	○
Nuestra compañía trabaja estrechamente con nuestros clientes más importantes en la implementación de tecnologías de Manufactura Digital.	○	○	○	○	○
Nuestra compañía trabaja estrechamente con nuestros proveedores en la implementación de tecnologías de Manufactura Digital.	○	○	○	○	○

Muchas gracias por completar la encuesta!