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Maturity SCAN 4.0 - An Analysis And Discussion Of Results From The Scanning Of Digital Capabilities Adopted In Argentinian CPG Companies

Lourdes Perea Muñoz[1], Marcel Hagemann[2] , Lucila Palandella[1], Paz Cagliari[1]
[1]*Facultad de Ingeniería, LIDTUA-CIC-Centro de Industria 4.0 / Universidad Austral, Pilar, Argentina*
[2]*Industrie 4.0 Maturity Center Gmb/ RWTH University, Aachen, Germany*

Abstract

Industry 4.0 is a new dynamic paradigm for manufacturing companies, being studied by academia and evolving at the same time as companies are trying to leverage its potentials. Readiness and maturity models have been developed to assess Industry 4.0 adoption, diagnose the current state of companies regarding digital transformation and help them understand how to move from the current situation to a desirable future one. However, these models are generic, based on general principles of Industry 4.0 and do not consider the particular challenges and potentials of each industry and company. In practice, the success of Industry 4.0 implementation depends on how companies manage to match the concepts and technologies with specific potentials in the context of their strategy.

For this purpose, a study within companies of the same industrial sector is proposed. It serves as first step of "customization" of industry 4.0 concepts to help companies identify their specific benefits. The results of the study within 30 companies in the Consumer Packaged Goods sector in Argentina is presented. It combines the findings from surveys and self-assessments based on a proven maturity model with workshops and semi-structured interviews within a group of managers who are responsible for digital transformation, IT and Operations in their companies. In addition to an initial evaluation of the current Status quo, the analysis focusses on the main challenges and needs of the sector and possible actions to address them.

Keywords

Industry 4.0; Maturity Models; Readiness Assessment; Consumer Packaged Goods; Challenges

1. Introduction

Industry 4.0 (I4.0) is a new paradigm which is being adopted by companies around the world and has captured the interest of governments as an opportunity to make companies more competitive in today's highly changing environment. Since its first denomination as ‘Industry 4.0’ in Germany 2011[1], academic attention has evolved, from defining the term, settling its frontiers for different areas of application, and its technology enablers, to establish the implications from a company´s perspective. Therefore, the promising potentials of the fourth 'revolution' need to be translated to a realistic and affordable 'evolution' path.

For manufacturing companies, the ultimate goal of I4.0 is mostly based on transforming data into actionable knowledge, turning companies into agile, flexible and learning organizations, while enabling them to generate greater value. Thus, achieving digital maturity is a complex process; in which organizations must develop digital capabilities, not only from a technological point of view, but also from a holistic vision that takes into account people, culture and organizational structure [2].

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It is clear that such a complex process calling for the transformation of the company at all levels, in all processes and in the long term, requires specific tools to be sustained. This has given rise to prolific and still booming research on maturity models (MM), roadmaps and methodologies, which are aimed at helping companies, put the vision into action. MMs, in the context of I4.0, promise to guide the adoption of I4.0 technologies at the organization level [3]. MMs offer a generic, but detailed, step-by-step evolution, from early stages to full maturity of I4.0, allowing companies to diagnose their current situation and derive the actions to be taken to move forward in this process. Understanding at what stage organizations are, and what their pain points and challenges are, is the first step towards the structured pursuit of higher stages.

Despite the advances in the comprehension of what I4.0 stands for in a manufacturing company, and the common expectation of its general potential benefits, not all industries are adopting these enabling technologies at the same ease and it is necessary to understand what the reasons behind these differences are [1]. This demands a more specific approach, going to the practical arena to learn about the particular challenges related to the enterprise size [4], context of a geographic region or of an industrial sector.

In Argentina, the I4.0 concept started to develop around 2016. During 2018/19 relevant studies were published to show the initial situation of companies at the country, mainly focused on technological and context factors [5] [6] and based on surveys to executives regarding technology adoption and barriers to implementation, but, with neither a MM to support it nor a holistic understanding of the progress degree of companies. The results of these studies have been useful information for the strategic planning of productive development at a national level. Today, a different scenario can be observed, partly accelerated by the COVID-19 context, partly as result of governmental and institutional promotion, and partly because of the natural pressure from the international competitive scenario. Today many companies have a generalized understanding of the I4.0 concept and; the main concern is how to implement it.

The I4.0 implementation process is context dependent, and will be different for each company. It is necessary to examine each case to better define the company objectives. The need to measure the progress and success, as well as the need of benchmarking against competitors, is part of the industrial environments [1].

Two aspects are crucial: the motivation (to guarantee the movement) and the know how (to move in the correct direction). This study presents an analysis of the maturity state of companies in the Consumer Packaged Goods (CPG) sector in Argentina, with a dual purpose: i) to shed light on the potential that I4.0 can present to the sector and help companies understand where this specific potential lies (motivation) ii) to assess the internal development of digital capabilities in the companies in order to understand which actions should be taken to promote its development in an effective way (know how).

1.1 Maturity Models

As stated above, MMs help an individual or entity reach a more sophisticated maturity level in people/culture, processes/structures and/or objects/technologies following a step-by-step continuous improvement process. Roadmaps are plans that match short-term and long-term goals with specific technology solutions to help meet those goals [4].

Angreani et al [3] offers a systematic literature review of existing frameworks, indexes, roadmaps, readiness and maturity models for manufacturing and logistic sectors. They analysed 17 models as a result of a quality assessment selection that measures: i) research aims, method, and theoretical foundation, ii) structure accuracy and iii) practice orientation. They conclude: Almost all of the selected MMs have a perfect score in research aims, methods, and theoretical foundations. Regarding structure accuracy, most have good scores in modeling maturity levels, but there is a great dispersion in the scope of dimensions. Only five of the models, include the nine dimension categories in the review (strategy; leadership; customers; products; operations; culture; people; governance; technology). Practical orientation seems to be the main gap.

Different visions arise when referring to Industry 4.0, its specific requirements and the conditions to achieve the highest levels of maturity. Although, technology is always considered as an essential enabler of I4.0, there are differences in the relevance that authors assign to it. While some of them focus, even exclusively, on this aspect [7][8][9], others present a holistic approach that incorporates other organizational dimensions such as corporate strategy, structure, culture and human resources [2][10][11]. Schuh et al [2] manages to clearly translate their holistic vision to six "value based" development stages. This approach enables companies to plan and implement the road towards I4.0 maturity in a way that ensures continuous value creation throughout the transformation process. Another strength of this model is that it is based on a well-established management framework, enabling a deep understanding of the capabilities to develop in the main structural areas of an enterprise: Resources, Culture, Organization and Information Systems. Although [3] ranks it low in practical orientation, this tool has been successfully implemented in many projects around the world proving its usability [12]. For these reasons, the tool selected for this study is a simplified but detailed version of the "Industrie 4.0 Maturity Index" (Maturity SCAN 4.0).

1.2 Industry 4.0 in the CPG sector

No literature related to the I4.0 evolution in CPG industries, from our concern, has been found. However, there is some literature for associated industries like "food and beverage", one of the most representative of the CPG sector. The largest part relates to specific technology implementation. Hassoun et al [13] presents a complete state of the art in the Food Processing 4.0, highlighting the potential of the fourth industrial revolution technologies to improve quality and safety of processed food products, reduce production costs and time, save energy and resources, as well as diminish food loss and waste. They also highlights the value of the most promising technologies, such as the industry of robotics, smart sensors, artificial intelligence, the internet of things (IoT), and big Data, as the main enablers of the I4.0 in the sector, and its applications.

Konur et al. [14] presents the design, development and implementation of I4.0 in a traditional food manufacturing company as a case study, in which they have successfully utilized some emerging technologies, including IoT, big data analytics, machine learning and cyber-physical systems, and have reached some positive results on improving efficiency, productivity, and consistency. They also outlines some generic lessons useful to other similar SMEs, as the role of retrofitting in extending the life of current production facilities, and the cultural change in having academics and employees work together. The costs and benefits of this implementation are not shared.

In practice, the success of I4.0 implementation depends on how companies manage to match the concepts and technologies with specific potentials in the context of their strategy. Despite general benefits are shown in many publications and whitepapers, the majority of companies struggles in the identification of their own potentials, as this study proves. Our study is intentionally focused on companies of the same industrial sector. It allows taking a first step towards "customization" of I4.0 concepts, helping companies identify their specific benefits. It also provides them with a benchmark of the peer group.

2. Research Methodology

The research questions established for this study were:

- RQ1: What is the current maturity level of the companies in the CPG sector?
- RQ2: Which are the sector's current main pain points and challenges with respect to their Digital Transformation?
- RQ3: Which are the possible actions related to I4.0 implementation to overcome the pain points and address the challenges?

To answer these questions, a methodology for the identification of the sample and the definition of the project's phases was selected.

2.1 Sample identification

The CPG sector in Argentina is highly concentrated in a few companies. To give an order of magnitude, 74% of the turnover of gondola products corresponds to 20 companies. In order to guarantee the success of the project, not only the participation of a representative sample of the companies was required, but also the selection of the participants' profiles. Given the characteristics of the chosen tool, high seniority within the company, knowledge of the business and involvement in the planning or execution of the digital transformation were required. To ensure the validity of the answers only the following profiles were considered appropriate: digital transformation director (when existing), or both the operation and IT (Information Technology) director. For this reason, the consulting firm NUMAN (specialized in industrial recruiting) was invited to participate in the project. Out of a total base of 130 medium and large companies (more than 50 employees), the positive response rate was 30. From each enterprise, more than one participant with different roles signed up. Despite the fact that the study was conducted in Argentina, 66% of the enterprises were multinational and 34% were national. The number of employees gives an overview of the size of companies: 57% had more than 650 employees, 16% between 250 and 650, and the remaining 27% between 60 and 250 employees. With regard to the product portfolio, participants could be assigned as follows: Food and beverage 80%, Personal Care 13%, Baby Care 10%, Home Care 7% and Pest control 7%.

2.2 Phases of the methodology

A three-phase methodology was applied (Figure 1):

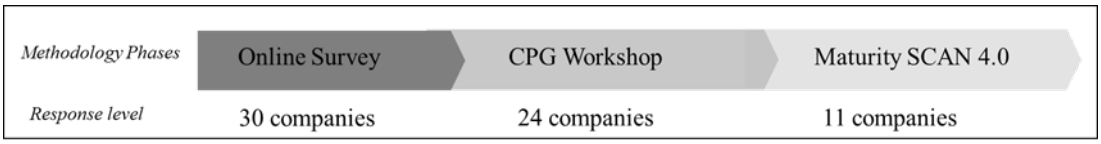

Figure 1- Three-phase methodology

- First Phase: consisting of an online survey, containing questions related to different aspects associated to I4.0: i) Importance and meaning, ii) Expectations and potentials, iii) Focus areas including pain points iv) Structural changes
- Second phase: A workshop with the leaders from the invited companies was conducted. The following topics were discussed: i) I4.0 Motivation and CPG Industry Challenges; ii) Digital Transformation Management and Description of "Maturity SCAN" tool. iii) Implementation challenges and practical experiences.
- Third phase: The "Maturity SCAN 4.0" was used to finish the first stage of the project, and to complete the diagnosis needed to answer the research question related to current maturity status.

2.3 Maturity SCAN 4.0

The "Maturity SCAN 4.0" is a tool specifically developed to assess the maturity level of manufacturing companies; based on the theoretical framework from ACATECH [1]. This framework outlines the evolution towards I4.0 in 6 maturity levels clearly defined and characterized (1. Computerization, 2. Connectivity, 3. Visibility, 4. Transparency, 5. Predictability, 6. Adaptability). In order to assure a holistic approach, the tool assesses the companies' maturity in four different structural forces, each of them includes two principles: Resources (Digital capability / Structured communication); Information Systems (Integration of IT systems / Information processing); Organizational Structure (Organic internal organization / Dynamic collaboration in value networks); Culture (Social collaboration / Willingness to change). The "Maturity SCAN 4.0", evaluates 77 capabilities which are assigned to three typical I4.0 development areas of manufacturing companies: Integrated Business Processes (33 capabilities), Agile Organization (22 capabilities) and Digital Shop Floor (22 capabilities). At the same time, each capability is associated with a company's process: overall process, production, production planning, quality, logistics and maintenance.

3. Results

In this section, we present the most significant results. The maturity status of a company (or area, or process) is expressed by a number between 1 and 6, corresponding to the maturity levels described above. This number represents an average of the scores obtained by each participating company for each capability, at the level of aggregation chosen for the analysis. Values presented as percentage are indicating the share of companies from the total sample that have given answers to a specific aspect.

3.1 Maturity SCAN 4.0

An answer to the first research question (RQ1) can be given based on the results of the Maturity Scan 4.0. A general analysis shows that the companies that completed the SCAN questionnaire are positioned, on average, between level "2. Connectivity" and "3. Visibility". This implies that companies are completing the last level of basic digitalization while taking the first steps towards I4.0 implementation. In order to better understand the development level of companies, results are analysed in three different directions and levels of aggregation of data: i) evolution level of structural forces and its principles; ii) maturity status regarding the three scenarios iii) analysis of individual capabilities. This analysis enables the identification of areas with opportunities for improvement. In order to best capitalize the value per of a maturity stage, a homogenous development of capabilities is needed.

3.1.1 Analysis of structural forces and its principles.

When analysing the four structural forces and its principles, the lowest scores must be noted for "Resources" and "Information systems" (see Figure 2). Average scores between 2,0 and 2,2 show that companies still face considerable gaps in the computerization of processes and the consistent connectivity of resources and IT systems. In consequence, they struggle in gathering and communicating data from equipment, employees and goods but also in exploiting the available data in a suitable way to support decision processes. All this is in alignment with the main challenges and pain points that companies selected in the previous online survey: 50% expressed difficulties in automatically generating data due to an aging equipment, and 37% admitted to have adopted different technologies along time, which made the integration difficult.

A more advanced maturity score, can be observed in the dimensions "organizational structure" and "culture". This seems natural for the principle of "dynamic collaboration in value network" (2.8), considering the key role of the supply chain coordination in the sector where the ultimate goal is to place the product in the latest consuming point and different collaborative planning techniques have been put into practise in the previous decades. The highest score of 3,0 with respect to the "Social Collaboration" [Fig. 2] indicates the increasing introduction of an open communication culture and a trained use of IT systems supported through appropriate incentives, that contributes to an agile exchange of information within the organization.

3.1.2 Analysis of Scenarios

Many participants showed a very narrowly constrained understanding of the term I4.0 as "digitalization of the shop floor" delimiting the digitalization of the factory from projects carried by the IT area. This matches with difficulties in integration between IT/OT (Operational Technology) which was expressed by 30% of the companies as one of their main pain points. Looking at the three scenarios helps connect technology-focused projects with the main principles behind I4.0: The digital shop floor, An agile organization, and the integration of business processes through IT.

The results in Fig. 2 show that companies are in average just completing the Connectivity level (2) with respect to the Digital shop floor scenario, which is characterized by the operational work on or with machines, where products are manufactured or assembled. The core challenge in this scenario is to replace manual information flows with automated information flows based on better data availability. Main pain

points mentioned in the survey are difficulties in automatically generating data due to aging equipment (50%) and a high manual effort in the planning and control of production processes (27%).

With regard to the scenarios "Agile Organization" and "Integrated Business Processes", companies are already on average already advancing towards visibility (2.7, and 2.3 respectively). The core challenge related to the Agile Organization scenario is the flexibilization of traditional organizational structures, which are generally rigid and hierarchical and the implementation of agile methods. Despite the higher score, still a 30% of companies mentioned the implementation of more agile methods as a pain point.

The core challenge related to the scenario of "Integrated Business Processes" is to reach a harmonized IT landscape in order to make information available across the company and therefore promote its value-adding use in decision processes. The main pain points that companies mentioned, associated to this scenario, are difficulties in IT/OT integration (30%); a low level of management integration between areas (27%), challenges of integrating machine control and information exchange (23%) and a low level of integration among clients and suppliers (20%).

Analysis of structural forces and its principles.

Structural Force	Principle	Average
Resources	Digital Capability	2,0
	Structured Communication	2,2
Organizational Structure	Organic Internal Organization	2,4
	Dynamic Collaboration in Value Networks	2,8
Culture	Social Collaboration	3,0
	Willingness to change	2,7
Information Systems	Integration of IT Systems	2,1
	Information Processing	2,1

Analysis of scenarios

Scenario	Average
Digital Shopfloor	2,0
Agile Organization	2,7
Integrated Business Proce	2,2

Analysis of processes

Process	Average
Overall Process	2,5
Production	2,3
Production Planning	2,2
Quality	2,2
Maintenance	2,2
Logistics	2,1

Figure 2- Current I4.0 Maturity Status of companies in the CPG sector (structural forces, scenarios and processes).

3.1.3 Analysis of Capabilities

As mentioned previously, the "Maturity SCAN 4.0" tool considers 77 capabilities to be assessed. The average results show that 56 capabilities were scored on average in the Connectivity level (2) aligned with the overall result. In order to achieve a homogenous development and advance to level 3, all capabilities should be at level 2 first.

From the organizational point of view, a greater progress can be stated; three capabilities have already reached the Visibility level [Fig.3]:

- Change Management in the Overall process; this means that changes (e.g., in processes, systems used, or organisational structure) are communicated openly and driven forward by a core team.
- Databased decision processes in the Overall process; this means that current and historical data are used to support the decision-making process.
- Communication Culture in the Overall process; this means that communication between areas and hierarchies is promoted through regular exchange (e.g., shop floor meetings at different levels).

It shall be mentioned, that aspects associated with the organizational structure are more difficult to measure and the higher scores may be biased through the participants perception. Another possible explanation is the previous rise of the Lean Manufacturing culture within the region.

Eighteen capabilities are on average still on the lowest maturity level of Computerization [see Fig. 3]; the majority of them are close to reaching the Connectivity level. Companies should focus on the following capabilities, which are hampering the maturity progress:

- Use of machine interface in the Quality process; this means that Interfaces of measurement equipment are not used. Quality data is documented manually.
- User interface in Quality and in Maintenance process; this means that in both processes there are only a few user interfaces dedicated to process-internal IT systems. Information is prepared to a very limited extent, e.g., paper-based information transmission.

The importance of these weaknesses is sustained by the outcome of the survey, since 31% of participants mentioned Quality Assurance as one of the main goals for the implementation of I4.0. Further capabilities that have not yet reached level 2, are associated with technology.

Analysis of capabilities

Capabilies Level 2.Connectivity	Process	Average
Data Storage	Overall	2,4
User interface	Logistics	2,0
Provision of information	Quality	2,1
Transparency of IT systems	Overall	2,1
Interdisciplinary skills of employees	Overall	2,2
Communication interface: Human/Human	Production	2,6
Project management	Overall	2,6
Incentive systems	Overall	2,7
Use of IT systems	Overall	2,9
Data analytics	Production	2,2
Decision Support (IT)	Maintenance	2,0
Target-oriented KPI	Production	2,3

Analysis of capabilities

Capabilities Level 3.Visibility	Process	Average
Change management	Overall	3,2
Databased decision processes	Overall	3,1
Communication culture	Overall	3,1

Capabilities Level 1.Computarization	Process	Average
Use of machine interface	Quality	1,4
	Logistics	1,8
	Production	1,9
User interface	Maintenance	1,7
	Quality	1,7
	Production	1,8
Communication interface: Human / Machine	Production	1,8
Provision of information	Production	1,8
IT competencies of employees	Production	1,8
	Quality	1,8
	Maintenance	1,9
	Production P	1,9
	Logistics	1,9
Identification of material	Quality	1,8
	Logistics	1,9
Decision support	Quality	1,8
	Production P	1,9
Resilience	Overall	1,9

Figure 3- Current I4.0 Maturity Status of companies in the CPG sector (results for selected capabilities)

3.2 Technology implementation

Regarding technologies, the ones with the highest level of implementation are Data Analytics (29%), Cloud Computing (29%), IoT solutions (21%) and Robotics (18%). These technologies are also the ones that are being assessed mostly in an experimental phase along with Artificial Intelligence (AI) [See Fig. 4]. This is consistent with the maturity level stated above: Sensors (IoT) allow connectivity and data collection specially in elderly machinery and connectivity; Cloud Computing allows data storage from different sources; Data Analytics allows data analysis and visualization. Moving a step forward, some companies (7%) are starting to work more intensively with AI.

3.3 Motivation and main challenges

The second research question (RQ2) can be mostly answered based on the previous survey, enriched with the results from the workshop.

The CPG sector faces the challenge of obtaining profitability from very short margins of the products. As the prices are commonly fixed by the market in a very competitive environment, companies need to work on their costs and expenses accounts. That is the main source for the companies to seek higher productivity. In parallel, markets are getting more complex, with higher degrees of specialization of customers' needs/ tastes, and required quality standards. When being asked about the motivation of implementing I4.0, 85% of the company's target efficiency, 54% speed & flexibility and 31% Quality Assurance.

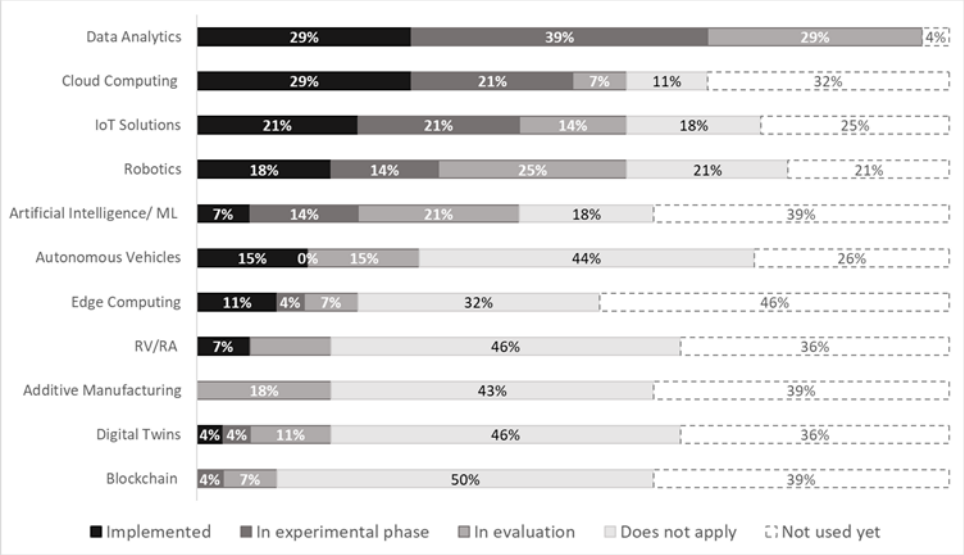

Figure 4 - Degree of adoption of different I4.0 technologies

I4.0 principles provide possible solutions to the before mentioned challenges. Nevertheless, in order to promote the digital transformation, a company needs to find a clear position with respect to the following three aspects: i) Motivation: why should companies adopt this new paradigm? ii) Management: how to adapt the organization, people and culture? and iii) Technology: which solutions are suitable?

Motivation: Companies of CPG sector are already aware of the general benefit of I4.0: 70% of the companies expect an essential impact on their P&L (profit and loss account) and consider it a competitive advantage. In contrast, only 37%, declare to have already identified the specific potential in the enterprise while 39% have begun only few I4.0 projects as they`re lacking a clear idea of its ROI in their own company. Specific challenges related to the identification of concrete potentials, and ROI approximation must be addressed.

Management: 43% of companies expressed challenges through immature management aspects hampering the digital transformation process. This involves the lack of standardization of processes and lack of understanding regarding information relevance to the business. Change management is another issue with 27% of participants remarking the need to change on employee mind-set and 27% the integration between various entities and teams. In addition, during the workshop, leaders of the sector highlighted the lack of support from the top management when it comes to investing in Digital Transformation projects, which is closely related to difficulties in estimating the ROI of interdependent projects that are generally evaluated in a separated manner.

Technology: Companies need to find an individually suitable set of technologies that make relevant information from all company areas and levels available during decision processes. Current challenges expressed by the participants refer mainly to the automated generation of data due to the age of the equipment (50%), achieving higher degrees of integration between IT and OT (37%) as well as the heterogeneity of the technologies in use (37%).

4. Conclusions

The results from the Maturity SCAN 4.0 indicate that Argentinian CPG companies are currently, in average between I4.0 maturity stage 2. Connectivity and 3.Visibility, which implies that they are moving from the most incipient stages of digitization to those where the potentials of I4.0 start to pay off. A large part of the challenges is related to the company's way of planning and managing their digital transformation. Some conclusions are presented regarding the current state of the companies, their challenges and possible actions. In Fig. 3, these aspects are summarized. The analysis presented indicates that:

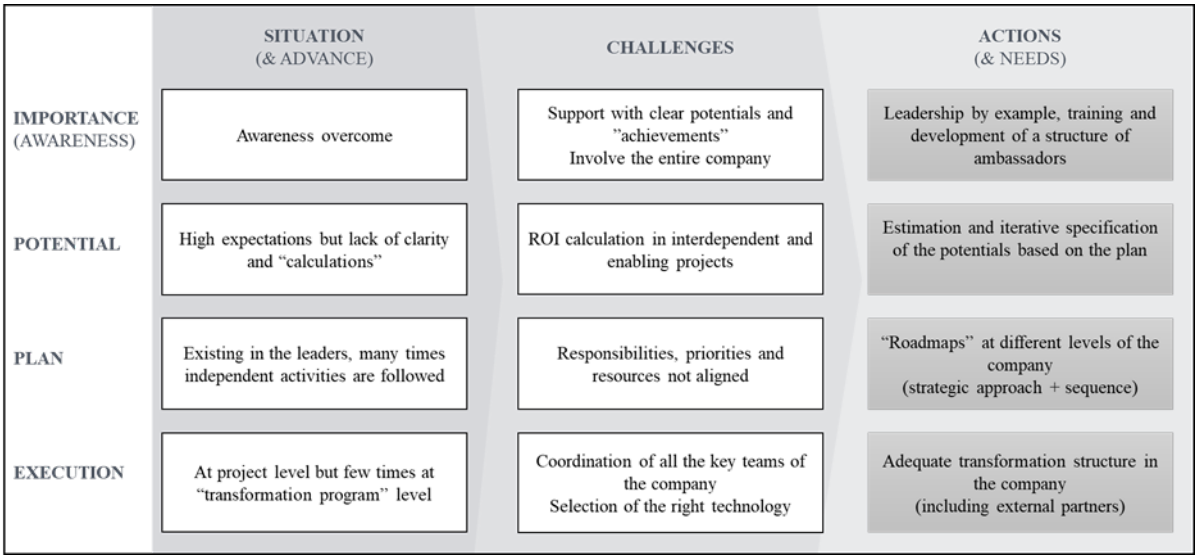

Figure 3: Summary of the current situation, main challenges and proposed actions for companies in the Argentinian CPG sector

A certain level of **awareness** is already reached; there is a good understanding of the importance and generic potentials of I4.0. However, awareness quickly drops when moving away from the personnel directly involved in the topic. The challenge is to increasingly involve the entire organization, which requires a strong leadership focus on a consistent up and down communication of application examples and success stories, the training of employees at all levels and organizational alignment between different departments and from shop floor to top floor.

High expectations on the **potentials** combined with a lack of a clear method for calculating ROI make it difficult to properly prioritize projects. The projects are not isolated but interdependent with each other, some of which have only a limited value on their own while enabling the implementation of other projects with a higher potential. The overarching calculation of the ROI for several projects together is only promising based on a consistent Roadmap that defines sequence and interdependencies of the projects. Although some leading companies declare to have a plan, the majority still lacks it and therefore promotes isolated activities driven by individual motivation from different areas of the company.

Changing this situation requires a holistic view on the ROI and the potentials on program instead of project level, raising awareness at all levels of the company and developing an organization that supports the development and execution of a centrally aligned **plan**, a "Digitalization Roadmap". In short, the roadmap as consistent, complete, global plan coordinates activities at different levels: corporate, production plant or process and needs to define how the projects are related to each other, in which sequence they are to be addressed and how they contribute to the strategic approach: the goals to be achieved.

Even less companies have found a satisfactory approach for the **execution** of their digital transformation programs. On application level, the execution is hampered through the before mentioned challenges such as eldery of machinery, different legacy technology regarding this machinery, different plant situations in different sites of the company, and difficulties of IT/OT integration. This underlines the need for better centralized alignment of activities based on the "Digitalization Roadmap". In order to use them successfully as steering tool, the establishment of responsibilities, priorities for certain projects, coordinated deadlines (start and end of a project) and a corresponding allocation of resources is required on the organizational level.

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Biography

Lourdes Perea Muñoz (*1981) is an associate professor and researcher at the Engineering Faculty in Austral University, Argentina. Dra. Ing. Perea Muñoz is co-founder of the Centre for Industry 4.0 at Austral University where she has coordinated research and outreach activities since 2020. She has lead the Digital Transformation Program for SMEs 4.0 carried out together with the National Government in 2019.

Marcel Hagemann (*1991) is Senior Consultant and responsible for LatAm at the Industrie 4.0 Maturity Center, Germany. He has led more than 25 Industry 4.0 maturity diagnosis and roadmap development projects at international level in different industries. He holds a Master's degree in Mechanical Engineering and Business Administration from RWTH Aachen University in Germany.

Lucila Palandella (*1982) Lucila Palandella is a member of the “Centre for Industry 4.0” of the Austral University; focused in investigation activities and transfer projects. She is also a specialist consultant in IT Project Management.

María Paz Cagliari Loyola (*1998) is a recent Industrial Engineering graduate and works at the Center for Industry 4.0 since April of 2022. She is also a graduate assistant in the subjects of Supply Chain, Operative Investigation and Operations at Austral University. Before that, she was an intern in General Motors.