The digital transformation in the upstream quality management as a technological and organizational agility mechanism in disruptive environments

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Abstract

The recent growing needs in the global food industry have been demanding an agile and resilient response to continue manufacturing products with the expected quality and food safety. A key element for this is the agility of the quality management of the supply chain, which has been achieved from using a correct quality management data digitization as well as its processing through business analytics and whose results are presented in this business case.

A prerequisite to be met was the global standardization of supplier performance evaluation criteria, whose efforts were achieved through the coordination of quality management professionals from France, Italy, the United States, Mexico, Brazil and Chile. With the standardized performance evaluation criteria, the calculation mechanisms were defined, which were later developed by the IT teams through Business Analytics solutions and represented in a visualization platform (Microsoft Power BI). This platform represents: a) the status of the certified supplier management system, b) its level of performance at a global level and by manufacturing site, c) the result of evaluation of the supplier management system, d) the result of the non- conformities identified at all reception sites and, e) the performance prediction of each supplier based on historical data.

As a result of this digital transformation, it was possible to obtain interconnected information in real time that facilitates showing compliance status of supplier quality management criteria, calculating the global performance level based on the contribution and weighting of each of the compliance criteria, facilitate decision-making based on the analysis of quality and food safety risks and determine the analytical prediction mechanisms (machine learning) that would warn of potential quality and food safety non-conformities. All this, in order to prevent deviations in the inputs used in the manufacture of food and to focus efforts for the improvement and innovation of the supply chain based on processed data and information.
Key words: quality performance indicators; data management; business analytics.

1. Introduction

Recently, the quality management function within many organizations has been facing the need to agile their control and decision-making processes to increase responsiveness to the raising need of food supply with the expected quality and food safety. Acceleration of this need was triggered during recent global disasters as the COVID-19 pandemic causing several problems and difficulties in the context of supply chain operations management (Tirkolaee et al., 2022).

This agility requires the establishment of prerequisites to develop the journey in digital transformation of the end-to-end upstream food quality management system. Hence, a digital quality management system seems to be showing multiple opportunities to create new approaches not only to solve the most basic tasks such as recording and digitalizing data obtained during the diverse quality management stages, but

also to analyze it and automate risk assessment for making quick optimal decisions in ambiguous situations, monitoring and process management.

However, it has become essential to consider the quality of data as an additional but of highest importance prerequisite by implementing the digital quality management system. As result of digital technologies, data availability has bloomed, and organizations have become inundated with large amounts of this resource. Although this is an expected outcome, increased data availability has also shown to create financial, time, and task completion burdens. As a result, experts estimate as much as 80% of project costs are often directed just toward data cleaning to convert it to a usable decision-making resource (Moore, Z., Harrison, D. E., & Hair, J., 2021). Hence data collection may become a double-edge knife and a burden for organizations if its quality is disdained.

On the other hand, the formalization of all management and production processes has created the prerequisites for the development of digital quality management technologies. The transition from a discrete approach in quality management of individual processes to an integrated management of all life cycle processes was the next stage of Quality Management System (QMS) development. The outcome, all data on products and their production processes become available for analysis. Complete information allows not only to effectively manage quality, but also to evaluate the effectiveness of preventive and corrective measures taken to eliminate non- conformities.

According to Aleksandrova, S. V., Vasiliev, V. A., & Letuchev, G. M. (2018) along with increasing the efficiency of the management system, digital transformation increases the productivity of processes and reduces the need for human resources. Also, these imply that digital technologies in quality management will allow the company to carry out quality control at all stages of the life cycle, including design, modeling, production, quality control of products and processes.

Based on the above, the present case study shows the highest importance of the digital transformation journey in the upstream quality management processes through the standardization of data generation and its classification in terms of criticality, the automated integration and calculation to facilitate risk assessment, and the optimization in the decision-making process to achieve and demonstrate compliance in quality and food safety. Finally, this case study highlights the importance of going through this path of digital transformation in an environment of continuous collaboration with IT teams, with those who define the business rules in terms of quality and food safety, and end users who make decisions through the use of information generated in the transformed data.

2. Reference framework

2.1. The digital transformation's journey

Digital transformation involves a significant organizational change, and it should be conceived as the strategy definition and implementation of current digital technologies addressed to improve operations within the organization. A digital strategy can be driven by the company's higher-level strategy, but it should always be aimed to improve efficiency, decision-making speed, foster innovation, etc. Despite the type of digital strategy pursued, the execution of that strategy changes how business is done and triggers a departure, sometimes radical, from "the old way of doing things".

According to Hess et al. (2016) the purpose of this journey is to benefit from digital technologies, such as productivity improvements, cost reductions and innovation. However, these authors report that traditional organizations struggle to effectively implement a digital strategy and deploy novel digital business

models. This might be caused as digital exploration capabilities represent the capacity to focus on radical innovation, generate new insights into unknown situations and explore uncharted territories. This involves, for instance, addressing new customer groups, identifying new needs for existing customers, training employees to perform a variety of tasks, empowering employees and engaging the organization in a process of dynamic change. In sum, in the context of the digital transformation phenomenon, exploration capabilities should enable an organization to innovate and transform the way of working.

Therefore, the digital strategy difficulties could circle around making changes on several interdependent factors simultaneously, including the organization's.

2.2. Digital transformation of the Quality Management System (QMS)

According to Vasiliev, V. (2022) the implementation of digital technologies begins with the choice of hardware and software determined by specific tasks. Also, automated workstations, servers, data warehouses and network equipment can be combined in different combinations if interfaces are available. As a rule, developers organize interfaces for the interaction of their software products, but rarely they can integrate with programs from other manufacturers, unless the software and the corresponding equipment come from the same manufacturer. Otherwise, it will be difficult to implement due to previously purchased equipment from different manufacturers.

The most obvious areas of application of QM and DT integration are the following:

- Data registration and analysis: This is one of the tasks in the quality system that requires a lot of labor. The emergence of high-speed data storage and processing systems can solve the problem of measuring and registering all kinds of data. Reducing the cost and increasing the speed of information storage and processing systems allows us to solve a task that previously seemed impossible – to measure and register everything that can affect the quality of the product. Software products and various types of sensors have been developed for new data sources. It has become possible to place sensors where it is necessary, and not where technology or product design allows it. The use of the "Internet of Things" to measure the functioning of processes, as well as products, is a prerequisite for the formation of big data sources. The use of sensors installed on products used by customers ensures that data on operating conditions, operation, failures, etc. are transmitted to the manufacturer throughout the entire product lifecycle. This makes it possible to continuously improve products, anticipate and prevent failures in their operation, and reduce maintenance costs. At the same time, Big Data can analyze data arrays of information coming from various sources.
- Control and monitoring of Digital Quality Management System (DQMS): Widely used in modern production statistical methods of quality control and management are easily integrated into the QMS. The next step towards smart manufacturing can be modern data processing methods. For example, neural networks trained according to appropriate algorithms can very quickly track dangerous trends in production processes and avoid the appearance of inappropriate products. Artificial intelligence can provide monitoring and control of QMS processes faster and better than a human. The accumulation of information about processes and algorithms for eliminating deviations and inconsistencies increases the efficiency of the system.
- Making decisions based on data (evidence) under conditions of uncertainty (ambiguity): State standards for quality management systems require the creation of sufficiently rigid algorithmized processes for the execution of procedures. The influence of the human factor is minimized.
- Decision-making in difficult situations: Any uncertainty can lead to an undesirable situation in the process. Thanks to predictive analytics tools, companies can analyze and predict processes occurring over

time, identify trends, anticipate changes and, consequently, plan more effectively. Digital transformation makes it possible to solve this problem with the help of reliable analytics. It is clear from the above that the creation of a DQMS effectively solves the problems of improving all processes of the product life cycle from development to production, and sometimes even to operation. Along with improving the quality and competitiveness of products, DQMS makes it possible to react quickly to any external and internal changes. At the same time, DQMS requires highly qualified employees, integration of the skills of engineers, programmers, and quality specialists. In addition to additional costs for the purchase of digital equipment, it is necessary to provide professional development of personnel structure (e.g., formality and decision-making), systems (e.g., processes, rules and procedures) and staff (e.g., morale, attitude, motivation and behavior) (Ponsignon, et al, 2019 cited in Vasiliev, V. 2022).

2.3. The role of Quality Managers in the Digital Transformation pathway

According to Ponsignon, et al, 2019, quality management (QM) involvement in the digital transformation is conceptualized as a road map encompassing four stages:

Stage 1: Plan the digital transformation

In this initial stage, QM participates in articulating the way in which the transformation is to be conducted. Organizations with a pragmatic and profound approach to digital transformation set up a cross-functional steering committee responsible for setting the transformation strategy and driving the transformation on the operational level. The specific role of QM in this committee is to support decision-making by identifying, prioritizing and responding to the needs and expectations of internal stakeholders. QM collects, analyses and formulates the digitalization needs of departments, processes and employees. Also, QM collaborates with IT to propose and select and/or participate in the development, testing and implementation of innovative digital tools, techniques and methods.

Stage 2: Conduct the digital transformation

This stage consists of coordinating collective effort, fostering employee engagement and enabling structured agility. First, QM helps to structure the transformation by playing the role of choreographer and catalyst in digitalization projects. For instance, quality managers are responsible for organizing and facilitating workshops and group assignments. They work to ensure the transformation program is inclusive, collaborative and co-constructed by all internal stakeholders.

Second, QM's role is to help, support and advise employees regarding the changes that are underway and explain the benefits of these changes. This includes reassuring, communicating, informing, explaining, coaching and motivating employees. In addition, QM develops and implements training mechanisms to raise employee skills and knowledge of digital tools and techniques and offers support to employees in using the technologies.

Third, participants emphasize the need for QM to maintain control over how processes are formalized whilst simultaneously allowing for a degree of flexibility and freedom in process execution. This reduces the risk that employees develop their own rules and ways of working, creating parallel processes, a phenomenon increasingly common in organizations. Enabling a degree of agility whilst retaining control over the existing process architecture is seen as a key challenge for QM. The danger otherwise could be is that

the organization could have two different ways of doing something at the same time: the structured digital processes and the ones that employees could design themselves based on the rigidness of the first ones.

Stage 3: evaluate the digital transformation

This stage is characterized by two activities. First, QM's role is to control and measure success by designing and implementing performance indicators, scorecards and audits to assess the impact of the digital transformation against predefined criteria (e.g., efficiency and speed; defects and problems; employee skills, satisfaction and engagement with digital solutions; environmental performance; partner, supplier and customer satisfaction). Performance information is then shared and communicated to relevant stakeholders.

Second, QM is responsible for centralizing and valorizing data. This involves gathering, sorting, classifying and consolidating a wide range of data from business processes and functional departments. QM also evaluates the validity, reliability and relevance of internal data with a view to avoiding the 'data graveyard' syndrome (e.g., accumulation of unexploited and unexploitable data that are stored but cannot be used). In a world in which nearly 80% of information is unstructured, the ability to evaluate data – that is, to analyze its relevance, reliability, availability and uniqueness – is crucial. An issue and managerial challenge for quality is: how do you consolidate and lend value to information and data?

Stage 4: adjust the digital transformation

The final stage consists of two main activities: capitalizing on newly acquired knowledge and driving collaborative continuous improvements. QM is entrusted with the responsibility to develop, feed and keep up to date a centralized knowledge base on performance and excellence. This involves searching, capturing and formalizing best practices as well as tacit know-how that is embedded in individuals. Several quality managers noted the importance of setting up benchmarking groups for sharing practices linked to digitalization.

Moreover, QM shares and spreads a continuous improvement culture across the organization. Specifically, QM's role is to organize, facilitate and coordinate a continuous process of collaborative improvement through digitally enabled groups and collectives. Hence, quality management's continuous improvement approach helps to ensure the transformation process continually achieves its many goals'. In addition, QM plays a key role in diagnosing and resolving, or in supporting the resolution, of problems arising from the use of digital tools and solutions (Ponsignon, et al, 2019).

2.4. Changing the supplier management process into digital transformation

As indicated by Fortner, Z. A. (2021) an effective supplier quality management process is a critical component for ensuring a high level of brand equity, customer satisfaction, and patient safety. Manually managing suppliers results in process gaps due to siloed systems, incomplete risk assessments, inefficient means of reporting, and an increase in product deviations and recall as well as an inability to provide reliable data on supplier performance. Nevertheless, Fortner, Z. A. (2021) indicates that organizations can start taking steps toward transforming the supplier management process by taking the following measures:

Automating supplier quality management

Using an automated supplier management system provides visibility into the supply chain, so external issues can be found before they escalate. With all supplier data hosted in a central system where it can be accessed by authorized parties, quality events can be managed consistently and efficiently. All third par-

ties are managed from a single point, making for easy comparison, with automated scorecards that reflect both current data and historical track records. This capability enables organizations to respond efficiently to quality events, and better equips them to deal with audits. Reducing the time to respond to quality events translates to cost savings for the manufacturer.

Managing quality across the supply chain poses a lot of complexity. An automated solution alleviates this by enabling traceability and making each third party accountable for its role in the supply chain. Integrated functionality of an automated system can provide continuous and clear risk assessments on low-, medium-, and high-risk suppliers. It will also enable documentation of collaboration with suppliers directly within the system.

Breaking down silos

Silos hinder communication could disrupt supply chains, causing surprises and business delays, result in duplicate effort across various departments, and slow down the time it takes to respond to quality events. An integrated approach to supplier management tightly connects an organization with its supplier ecosystem. In doing so, it provides the insight needed to help organizations reduce surprises, meet compliance, and respond faster to risk events.

Be proactive about supplier management

The ability to act proactively is critical for preventing incidents due to poor supplier quality. Organizations can start taking steps to proactively manage suppliers by following these best practices:

Provide suppliers with key performance indicators (KPIs)

Often, organizations focus on the efficiency and effectiveness of internal operations, but do not apply the same approach to third parties. Organizations can ensure that suppliers are meeting performance expectations by providing clear KPIs that measure supplier quality performance.

Communicate effectively

Communication is key for driving collaboration with third parties. Organizations should engage suppliers and provide routine feedback on the quality of goods and services and have a clear understanding of supplier capabilities.

Maintain an approved supplier list

Know upfront which suppliers are approved to do business with by keeping and maintaining an approved supplier list. This will limit risks by ensuring you're only engaged with the best suppliers for your business.

Leverage cross-functional data

An organization's quality management efforts must be interconnected among cross-functional teams to truly understand the impact of risks across the enterprise.

Build a culture of quality with suppliers

Cloud-based quality management systems (QMS) can help ensure an integrated quality network across suppliers. Internal quality management processes connect with third parties, streamlining communication

and delivering comprehensive visibility into issues from raw material through manufacturing to the customer experience. Organizations can use QMS solutions to successfully identify vulnerabilities, gain visibility over supplier tiers and into quality processes. It helps increase supplier accountability, ensuring that suppliers are aligned with resolution requirements and gives insight into which suppliers are top performers.

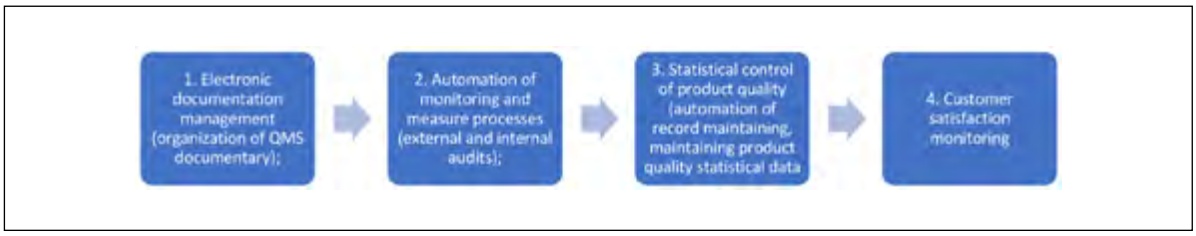
The result is a collaborative supplier management process that allows visibility into the process so you can identify potential issues before they escalate. Organizations that implement an integrated supplier quality management solution will have the tools to start tackling supplier risk proactively and ensure only safe, quality products reach the market (Fortner, Z. A., 2021).

2.5. Quality Management System (QMS) automation

As indicated by Menshikova, M. (2019), a way to continuously improve the quality management system at an enterprise is based on its automation. This ensures a clear informational or fata interaction of the involved functions and areas to which the QMS applies. Currently there are available experiences with respect to introducing modern IT technologies into the quality management system, which allow achieving the goal of improving business efficiency while reducing risk. Nevertheless, these technologies still use (in a varying degree) people's knowledge and abilities to ensure normal operation in the enterprise.

Therefore, QMS automation involves the transfer of manual operations quality management into digital form. This is because there are several tasks in the quality management day-to-day activities that require significant human resource efforts. For example, collecting and analyzing data on products, processes and organization systems, monitoring and management, making evidence-based decisions, scaling quality system requirements to evolving processes, risks identification and analysis etc. Thus, a proposal by Menshikova, M. (2019) regarding the main functions of the QMS that need to be automated are shown in Figure 1. Automated QMS functions, as follows:

FIGURE 1. Automated QMS functions



Source: Adapted from Menshikova (2019)

3. Objective

This research is aimed to design an upstream quality management integrated digitalization collaborative strategy in a globally operating food industry to foster agility and resources efficiency in the risk assessment and decision-making process to ensure quality and food safety compliance as well as focused improvement actions and programs.

4. Methodological design

The approach we determined for this case study involves 5 higher-level stages explained as follows:

a. Identification of quality and food safety digitalized & manual data: This stage involved the identifi-

cation of all existing data recorded in a global Enterprise Resource Planning (ERP) at using factory, country and corporate levels affecting both quality and food safety results.

b. Supplier performance standardization: This approach considered the categorization and weighting of supplier quality/food safety data through the participation of quality upstream expert professionals to propose a calculation of a globally standardized supplier performance indicator.

c. Automation of supplier performance & risk assessment: This stage comprises the collaboration with both Quality Management (QM) and Information Technologies (IT) teams to develop the automation methodology within the ERP on supplier performance calculation and risk assessment.

d. Dashboard creation and Quality professionals training: Once automation was achieved, the supplier performance dashboards were created and integrated through a cloud connector and Power BI platform. As a second step, Quality and Purchasing professionals were trained to interpretate and use the information provided by the supplier performance indicators.

e. Improve and focalize actions to improve supplier performance: Quality professionals used the supplier quality & food safety performance indicators to improve monitoring activities at using factories as well as to focus audit requirements upon performance results.

5. Results

To describe this case study, the assessed enterprise belongs to the food industry with global operations. It manufactures several food product categories and procures both ingredient and packaging materials from small to big size enterprise suppliers. Supplied materials come from primary (e.g., agriculture, forestry, animal husbandry, fishing, poultry farming, and mining) and secondary sectors (e.g., manufacturing or industrialized products). Results obtained according to the methodological design are explained as follows.

5.1. Identification of quality and food safety digitalized & manual data

During this stage, we identified 5 main sources of data recorded within a global Enterprise Resource Planning (ERP) at various levels that were affecting compliance on both quality and food safety, as shown below.

Supplier quality & food safety audits

Suppliers are regularly audited to ensure that manufacturing processes in their production sites are executed in accordance with the enterprise required quality and food safety standards. Decision upon this process will be determined as: “Qualified” or “Not Qualified”.

The audit results are entered manually in an ERP platform and final reports are extracted so those are sent manually to the audited supplier. It is relevant to highlight that audit reports were found to be structured in a way that requisite fields are not mandatory to be filled out except for the final decision status (e.g., “Qualified” or “Not Qualified”). Hence, an audit report could show decision status, but empty in the detail section per audit findings that could foster data analysis. Although external information was found attached within each audit record (e.g., food safety or quality verification reports, pest control trends, etc.), that information is unstructured and out-of-the-ERP “processable”. Hence, it was not part of the digitalized raw data used to assess performance.

Once suppliers receive audit reports over e-mail, they shall respond on the same via with a corrective action plan that will be entered back manually by the auditor in the ERP in each non-conformity identified (if any was recorded).

To reduce manual actions (e.g., communication with suppliers on audit reports and corrective actions), and additional IT integration development to connect the ERP with a Digital Platform (DP) created for suppliers to access and share information required by the company (their customer). This integration automated the exchange of audit reports upon completion by the auditor in the ERP and automatically notifying suppliers once reports were sent to them. Also, this integration supported the digitalized exchange of supplier corrective action response in the platform. Should the response be validated by the auditor, it would then be automatically transmitted to the ERP to have the process recorded and completed. After that, audit information will be part of the supplier performance calculation and risk assessment automation.

Third Party Complaints (TPCs) (understood as complaints made to suppliers by using factories)

This information is created by any using factory that found deviations in the ingredients or packaging materials received. A complaint is triggered in the ERP at batch number level and deviations are: 1) classified through a defect mode list and) briefly described so that suppliers better understand the deviation and respond accordingly with a root-cause analysis (RCA) and a corrective action plan. There were several opportunities identified in the complaint process including:

- Complaint classification was limited to a 2-levels defect mode list that was insufficient for the factory users to have the deviation accurately classified. Also, the list was incomplete per the existing deviations that have been reported in the last 5 years.
- Complaints are sent over e-mail and RCA and corrective action plan are received through the same via. Nevertheless, neither RCA nor corrective action plans although assessed by the QM professionals, those are not recorded anywhere.

Based on this, an immediate action was to update the classification defect mode list by extending the detail level up to 5 levels as well as the defect mode accuracy options. This new classification also considered if the complaint affected quality or food safety.

To reduce manual actions (e.g., communication with suppliers on 1) RCA and 2) corrective actions, additional fields were created in the ERP solution so that these 2 fields were also part of the complaint data. Then and additional IT integration process was developed to connect the ERP solution with the Digital Platform (DP) created for suppliers (as explained above in "Supplier quality & food safety audits ") to exchange complaints upon their creation by the using factory in the ERP. This integration automatically notified and sent complaints to suppliers as soon as they are created. Also, this integration supported the exchange of RCA and corrective action response in the Digital Platform (DP). If validated by the complaint creator, it would be automatically transmitted to the ERP to have the process recorded and completed, so it would be also part of the supplier performance calculation and risk assessment automation.

Regional/global complaint impact

When complaints were classified as food safety deviations and suppliers sourced factories located in more than one country, this triggered a communication to all supplier users so that preventive measures were assessed and implemented as needed.

Laboratory analytical results

This information is recorded in the ERP based on the monitoring activities defined by each QM team at using factory level. Even though the analytical test type and outcome is recorded, there is not a quality or food safety criticality established to better classified.

Status of quality & food safety certification through international standards

As part of the quality and food safety requirements requested to suppliers, more than 80% are already certified under a standard recognized by the food industry including the Global Food Safety Initiative, Good Manufacturing Practices certification and other local certifications required by some authorities. Data recorded is the status of "Certified" / "Not certified·" status.

5.2. Supplier performance standardization and automation of supplier performance & risk assessment

From the 5 main source of data identified above, we categorized and weighted each one based on their impact on supplier quality performance. This was achieved with a collaborative approach gathering quality upstream expert professionals from Europe, North and Latin America, and Asia (including China). The initial outcome of this focus group used a ponderation classification scale 1-5 of the 5 data sources where 1 is the lowest critical contributor and 5 as the highest, as follows:

TABLE 1. Weighted data impacting Supplier Performance

Data source	*Weighting*
Supplier quality & food safety audits	2
Third Party Complaints (TPCs)	4
Regional/global complaint impact	5
Laboratory analytical results	3
Status of quality & food safety certification	1

Source: Self-made (2023).

This proposal was used by the collaborative team to verify its accuracy with 200 well-known suppliers that were considered "subjectively" low or high performing in their country of responsibility. The classification was then adjusted to have a global agreement.

After criteria standardization for supplier performance was reached as above, the IT teams developed within the ERP an automatic performance calculation by crossing the proposed weighting with the results historically obtained by each supplier on the 5 data sources in the past 18 months. The outcome generated a performance rate measured in percentage with a threshold established to classify globally if a supplier was low or high performing.

Upon the standardized and automated performance indicator calculation, a manual risk assessment process created by the organization was also automated within the ERP using not only supplier performance but also highlighting the status of certification as mentioned above. At the end, this provided real-time proposal for upstream quality management professionals, on the type (e.g., off-site or physical-in person) and the standard extent (complete standard or focused requisites assessment) for the audits planned and executed for each supplier based on their a fixed- frequency calendar. This reduced ca. 50% complete assessments done physically and increased the audit focus where it really mattered, increasing human resources efficiency and preventing potential non-conformities in materials supplied to using factories.

5.3. Supplier performance dashboard creation, QM professionals training and improvement actions

In order to provide visibility on supplier performance and risk assessment in an integrated platform, supplier performance dashboards were created through the integration of the ERP data into a cloud connector that stored massive amount of data of over 9000 suppliers sourcing worldwide. Data was then connected to a Microsoft Power BI platform. It showed not only the overall and individual compliance percentage status from all 5 data sources mentioned above, but also the details and raw data of each calculation so that upstream quality professionals could better address and adjust the automated calculation and risk assessment proposal. It is important to highlight this initial piece of data shown in the dashboards showed "actual" performance based on historically existing data and represented the current state of each supplier in terms of compliance.

A second of piece of data was developed through a predictive analytics mechanism. This process involved a correlation analysis among the 5 data sources to determine statistical significancy to build a model that would provide more accurate result on future non-conformities as a "predicted information". Despite the large amount of data globally, it however determined only two data sources showed as statistically significant including: "Third Party Complaints (TPCs)" and "Laboratory analytical results". This was due to their large amount of data and existing structured details in the last 5 years that supported statistical correlation and therefore, the supplier performance indicator.

The other 3 data sources were found to be sparse, hence showing no significant correlation to supplier performance calculation. Whilst a supplier site, TPCs and Laboratory data could include dozens of records within last 5 years, the Supplier Audit and Certifications status data are limited as those activities may occur only once within 2 to 3 years and therefore, supplier performance could not show impact. It is also important to consider that data from both audit and certification are used as attributes (e.g., qualified/not qualified or certified/not certified) with no additional detailed data to have analyzed.

Then, statistically significant data was integrated in a computer programming language (Python) to have it programed to analyze through an algorithm package to determine a 90-day supplier performance forecast or predicted result for each supplier. Information was validated by both IT and QM professionals, and it was then included in the dashboard to visualize both "Actual Supplier Performance" and "Forecasted Performance". The later showed in what data source predicted performance would change in the future.

In parallel, both Quality and Purchasing professionals were trained to interpretate and use the information provided by the actual supplier performance and predicted performance indicators outcome shown in the Power BI dashboards.

6. Discussion

As presented in results, the digital journey transformed data into valuable and usable information for a decision-making process. The supplier performance indicators contributed significantly to reduce redundant efforts changing the old "ways of working" based on fixed standards, into a more effective and focused actions addressed to reduce and prevent supplier deviations. This is supported by Fortner, Z. A. (2021) who indicates that when all third parties are managed from a single point, making for easy comparison, with automated scorecards that reflect both current data and historical track records, this enables organizations to respond efficiently to quality events, and better equips them to deal with audits, translating into cost savings for the manufacturer. However, we came across with several challenges that may limit the data analytics and therefore the integration effectiveness.

6.1. Quality of data

One of these challenges considers the need to increase the quality of data generated in the supplier audit reports to strengthen the analytics process. This then means that a future possibility shall also include in the predictive digital assessment the audit details (e.g., non-conforming type, criticality, affected quality and the food safety requisite, etc.). To achieve this, an improvement project was proposed to modify the audit reporting process in the ERP in order to: 1) creating a minimum mandatory set of audit requisites that would force auditors to fill then out and provide further structured data. These sets of requisites would be defined by concentration areas (e.g., microbiology, allergen management, foreign matter prevention, chemical contamination, adulteration, etc.); 2) automatically triggering a mandatory set of requisites auditor selection as the automated risk assessment resulted in a physical audit. Then auditors must select the most appropriate set based on raw data provided in the supplier performance dashboard.

Another area to improve when it comes to quality of data is the laboratory results fields. As mentioned above, even though the type of analysis is performed with an In/out result is recorded in the ERP, criticality for both quality or food safety is not classified, limiting the ability to integrate this into a separate weighting and set it up in the analytics process to better predict future performance based on what laboratory results actually show.

With regards to TPCs, data has an opportunity for improvement in the RCA field. Today, detailed information even though is uploaded as evidence for QM professionals' revision and approval, there are not structured fields in the ERP where the complaint cause can be standardized and entered. With this, data could be better processed, and preventive improvement projects could be better focused and triggered by both QM and purchasing professional on suppliers responding to specific characteristics (e.g., geographical location, type and category of materials sourced, etc.).

6.2. Automated communication with suppliers

Communication triggered automatically to suppliers through the digital platform created to access and exchange information required for either audit results or TPCs represents was a very well-accepted approach by QM professionals as this increased efficiency in the efforts to request and remind suppliers on information to be provided on their side. Fortner, Z. A. (2021) supports our approach as referring that an integrated functionality of an automated system will enable documentation of collaboration with suppliers directly within the system.

However, as opposed to the ERP where not only the 5 data sources but also administrative information of suppliers is stored, this Digital Platform is an external portal that does not entirely mirror all supplier information existing in the ERP. Hence, if suppliers are not onboarded to the Digital Platform, then even though the communication automation is triggered from the ERP, there will be "no one" on other side of the Digital Platform to receive and respond to the automated request communication for either audits or TPCs.

6.3. Standardizing supplier performance & risk assessment

The standardization process resulted as a satisfactory outcome that showed not only a globally aligned and recognized calculation but also, it helped focusing efforts where "it mattered" showing the "real pains" of the management system that should be addressed with suppliers through the coordination of improvement actions and activities by the QM and purchasing professionals. As indicated in the results, reducing up to ca. 50% on audits to be executed physically (on-site), this allowed QM professionals to focus not only

on relevant audits, but also to improve resources efficiency for improvement activities, to prevent potential non-conformities in materials supplied to using factories.

It was clear that this digital transformation journey helped to "break down the silos". As in explained by Fortner, Z. A. (2021), silos can disrupt supply chains by hindering communication, causing business delays, duplicating effort cross-functionally, and slowing down the time it takes to respond to quality events. Our integrated approach to supplier management through this digital journey connected the organization with our suppliers´ data ecosystem.

6.4. The collaborative role of Quality Management and IT professionals

This digital transformation journey was only possible with the collaborative contributions of the expert upstream Quality Management team. This team created the actual framework on the business needs with regards to supplier quality and performance management. Additionally, it was paramount to integrate the geographically diverse contributions from the different countries and regions as differences in experiences and quality culture needed to impregnate the globally standardized result. As authors refer in their publications, QM professionals' collaboration shall ensure the transformation program is inclusive, collaborative and co-constructed by all internal stakeholders (Ponsignon, et al, 2019).

Another key role of the collaborative team was their participation in the implementation verification activities. As indicated by Ponsignon, *et al* (2019), QM professionals shall collaborate with IT to propose and select and/or participate in the development, testing and implementation of innovative digital tools, techniques and methods. In the frame of this digital journey, the collaborative team was paramount not only in the definition of the business rules, but also in the testing phase that was determinant for success in the big data validation upon development.

In addition to the collaborative QM team, the wider QM organization needed to know and understand the ongoing digital project being underlined, developed and implemented. For this, QM's team leader role was also paramount to underline the way forward. Ponsignon, *et al* (2019) confirms this by stating that the role of QM lead is to help, support and advise employees regarding the changes that are underway and explain the benefits of these changes, including reassuring, communicating, informing, explaining, coaching and motivating employees. In addition, QM lead shall develop and implement training mechanisms to raise employee skills and knowledge of digital tools and techniques and offers support to employees in using the technologies.

In the context of this case study, the supplier performance and forecast implementation journey required key activities related control and measure success. Although, this stage was achieved by having supplier performance indicators, a relevant learning of this end-to-end approach included also to design and implement performance indicators, scorecards and audits related to assess the effectiveness of the digital transformation project against predefined the criteria, fact that is supported by Ponsignon, *et al* (2019). Hence, a recommendation resulting of this digital journey was to also establish and implement IT indicators that would determine effectiveness and efficiency of the implementation itself, in addition to the ones already described for the technical QM supplier topic. This may become as the most importance, as this can reduce time-consume tasks of diagnosis and resolution of problems arising from the use of digital tools and solutions that may not work as planned.

7. Conclusions

In the context of this case study, the digital journey transformed data resulted a valuable and usable data decision-making process, fostering the information analysis by QM professionals and reducing redundant or duplicated activities that changed the company's *status quo* in regards of upstream quality management. This also promoted awareness on the old pathway that intended to control, to a new one mostly aimed to prevent and predict to reduce and prevent supplier deviations.

The digital "standardization" journey also helped focusing efforts on actual potential deviations based on information showing the "real pains" of the upstream quality management system. The final goal of this is not reducing the need of human resources but allowing the existing ones to better invest their actions on relevant actions (e.g., audits) as well as improvement activities, to prevent potential non-conformities in materials supplied to using factories.

With respect to the integration approach, we also conclude that this digital transformation journey "breaks down the silos" by connecting the organization suppliers´ QM data ecosystem and supporting the agility needed, speeding up the decision-making process when quality or food safety events arise, or to prevent potential ones. However, a challenge of the outmost importance within the digital transformation approach is to always bear in mind the need to ensure and (if applicable) increase the quality of data to be processed and integrated in analytics approach.

The integrated communication with third parties using automated digital IT solutions seem to be very well-accepted approaches by QM professionals, increasing efficiency in the various actions involved in the day-to-day communication with suppliers. This integrated functionality enabled the information and documentation collaboration with suppliers directly within the digital ecosystem. However, it must be ensured that connecting separate platforms must prevent process disruption by ensuring that triggers from platform, will continue its end-to-end path on the other platform.

Finally, the digital transformation journey can only be possible with the cross-functional collaborative participation of experts (e.g., upstream Quality Management), IT team, purchasing professionals and other parties interested in improving the upstream QM performance using a digital solution approach.

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