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# DIGITAL TRANSFORMATION IN THE MILK PRODUCTION CHAIN

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**Abstract.** The use of digital technologies has spread to areas other than industry and has given rise to new areas such as smart cities, smart health, and education 4.0. The milk production chain is also benefiting from these digital innovations, but due to their characteristics, in a gradual and focused way. The objective of this research is to verify the use of digital technologies through digital transformation to improve the dairy production chain in the last 14 years. The methodology consisted of a longitudinal survey between 2008 and 2022. In 2008, we analyzed the digital technologies used in 3 large Brazilian dairy farms. In 2022, we look at the digital technologies that the XPTO company offers to dairy farms. We were able to verify that the use of digital technologies through digital transformation improved the production of the dairy chain. We can highlight that the main advances were in the automation of production with intelligent sensors such as IOT and digital platforms for online data processing with the use of AI, the evolution of computer network technologies and farm management systems.

**Keywords:** Digital transformation, digital technologies, AI, Dairy chain.

## 1 Introduction

Currently, there is a lot of discussion about the application of new digital technologies in the industrial production chain, the so-called Industry 4.0. It is also known as the Fourth Industrial Revolution. Strictly speaking, Industry 4.0 is a technological concept based on cyber-physical systems, the Internet of Things (IoT), which enables the factory of the future [1].

According to Portal da Industria [2], examples of technologies used in industry 4.0 are: artificial intelligence, cloud computing, big data, cyber security, internet of things, advanced robotics, digital manufacturing, additive manufacturing, systems integration, simulation and digitization systems.

The use of these digital technologies has spread to other areas and given rise to new areas like smart cities, smart health, education 4.0, etc. The milk production chain is also benefiting from these digital innovations, but due to its characteristics, in a gradual and focused way.

According to Pezzuolo et al. [3], dairy production is rapidly shifting in recent years towards intelligent livestock systems, driven by the rapid pace of technological advances such as the Internet of Things, big data, machine learning, augmented reality and robotics. These technologies are driving the collection, implementation, transmission and widespread use of digitized information on livestock farms.

In other areas, Creedon et al. [4] consider that new digital technologies providing veterinarians with immediate on-farm test results will allow for early clinical interventions, thus ensuring food safety and reducing losses.

Kochetkova & Shiryaeva [5] define that main reason for the low rate of dairy farming digitalization is that enterprise top executives are lacking clear understanding of how their organization should be transformed using modern information technologies.

Milk production in Brazil is an important activity of the agricultural sector has a vital role in the process of economic and social development of the country [6]. Digital technologies have contributed to improving dairy production in terms of control, measurement, analysis and cost reduction, in addition to making the entire chain reliable and safe.

The objective is to verify the use of digital technologies through digital transformation to improve the dairy production chain in the last 14 years.

## 2 Literature review

### 2.1 Digital transformation

According to Schwertner [7], digital transformation mainly involves production processes. This is particularly typical for manufacturing companies. Reducing costs by digitizing the development, testing and production processes of new products is of paramount importance. Mobile applications are most important for improving production processes and internal communications for employees who interact with customers that are mostly unusual. Large databases and information processing are more production focused. The digitalization of production processes opens opportunities to expand business and for its great internationalization/globalization.

Digital Transformation can be defined, according to Ebert and Duarte [8], as the adoption of disruptive technologies to increase productivity, value creation and social well-being. In this sense, Digital Transformation is enabling the development of the following types of technologies: collaborative equipment (drones and robots), 3D printing, digital interconnection of objects (IoT - Internet of Things), agile development, blockchain (trust protocol), APIs and Artificial Intelligence (AI). Finally, the authors highlight, in Table 1, that this Digital Transformation has objectives both in the social and economic fields.

**Table 1.** Objectives of Digital Transformation

| <b>Perspective</b> | <b>objective</b>  |
|--------------------|---|
| Social             | Promote the development of a more innovative and collaborative culture in industry and society. |

|          |  |
|----------|--|
|          | Change the education system to provide new skills and future guidance to people so that they can achieve excellence in digital work and society. |
|          | Create and maintain digital communication infrastructures and ensure their governance, accessibility, quality of service and accessibility.      |
|          | Strengthen digital data protection, transparency, autonomy and trust.  |
|          | Improve the accessibility and quality of digital services offered to the population.   |
|          | Implement innovative business models.  |
| Economic | Increase income generation, productivity and added value.  |
|          | Improve the regulatory framework and technical standards. <sup>1</sup> Introduction  |

Source: Adapted from Ebert and Duarte [8].

In this scenario, Bharadwaj et al. [9] highlight that, during the last decade, impressive improvements in information, communication and connectivity technologies have triggered new functionalities. Thus, the following external digital trends provided the foundation for the new business infrastructure in the digital age: pervasive connectivity, information abundance, global supply chains, better IT price/performance, growth of cloud computing, and the emergence of Big Data. Therefore, the expanded scope and scale of digital business can assist in executing the digital business strategy to create business differential and value creation, as the speed of decisions and actions are aligned with the speed of market conditions.

## 2.2 Milk production chains

The dairy chain is one of the most important activity of the agricultural sector and it plays a vital important role in the process of economic and social development of the country. After half a century of little change, largely explained by strong government intervention in the market sector, the milk production chain begins in the early 90s to experience profound changes as genetic control, artificial insemination, endemic controls, improvement of feeding and grazing, establishment of strict criteria for inspection, treatment, and sanitation, technological advances and product quality. These changes helped to increase the productivity of farms that were able to invest and to plan but impaired the dairy farms which were not able to keep up with changes, thus leading to dissatisfaction producers [10].

The milk production chain is one of the main economic activities in Brazil, with a strong effect on the generation of employment and income. Present in almost all Brazilian municipalities, milk production involves more than one million producers in the field, in addition to generating millions of jobs in other segments of the chain. In 2019, the gross value of primary milk production reached almost R\$35 billion and the net sales of dairy products reached R\$70.9 billion [11].

There is no consensus on the answer to the question whether technology adoption increases the cost of milk production. This question can be asked another way: Do more

technical milk production systems have a higher average cost? Some think so, others, no. Those who think so argue that the adoption of technology implies the use of more of this food, medicines, fertilizers, correctives, mineral salt and other inputs from nature. Thus, higher technological level implies higher average cost [12].

According to de Rocha et al. [11], due to the adoption of new technologies, it was possible to significantly increase the productivity of animals, land and labor and consequently the scale of production of farms. Thus, Brazil has become the third largest milk producer in the world, but still has great potential to be explored, mainly in terms of productivity gains, in order to also become one of the main players in the global milk market and derivatives.

On the other hand, those who don't argue that the main purpose of technology is to increase productivity and, by extension, reduce average cost. In addition, the more technified production systems, the production grows, or are the most technified, which have greater power of competition either because of the lower average cost [12].

### 3 Methodology

The methodology consisted of a longitudinal survey between 2008 and 2022, where the following variables were studied, according to Table 2, related to digital technologies used in dairy production.

**Table 2.** Variables and descriptions.

| Variable  | Description   |
|---|---|
| Automation and Robotics Systems                       | Applied at different levels of livestock production systems, for example Automatic Milking Systems (AMS), Automatic Feeding Systems (AFS) and Automatic Robotic Systems (ARS).  |
| Digital and Precision Livestock Farming sensors/tools | To increase the number of correct decisions per animal or per unit time. For example, the use of accelerometers for the monitoring, classification of behavior's, the use of NIR (Near-Infrared spectroscopy) technology during the preparation, mixing and distribution phases of the feed-ration.   |
| Farm Management Systems                               | Such as tools for data collection, processing, storing and disseminating data in specific form to carry out livestock operations, analysis and functions. Although the development of Farm Management Systems able to manage data deriving from multiple sources is in strong growth, today there are difficulties at farm level in the compatibility and data management between different technologies. |
| Data sources  | Represent the "sites" where the data are originally produced, stored or computed. For example: sensors technology for animals or livestock environment (dairy barn), remote animal monitoring (cow feeding, standing behavioral activities), feed ration analysis and monitoring of milking efficiency/parameters (e.g. Near Infrared Spectroscopy - NIR)   |

|                      |   |
|----------------------|---|
| Data users           | As the devices which receive data and provide a representation (results) or decision, such as management software's, plant/machine terminals (e.g. Automatic Milking Systems, mixer wagon, ...), smart devices (smartphones, tablet, etc.)  |
| Data repositories    | As the "places" where historical/new data or synthesis parameters and processed data are stored. Technologies for the storage of such data are represented by hard drive (conventional), farm server but the "Cloud" technology is increasingly widespread to facilitate access and sharing of data with other support figures for the livestock activity (e.g. veterinarian, agronomist, nutritionist) |
| Transmission systems | Constitute an enabling technology supporting data transfers   |

Source: Pezzuolo et al. [3]

In 2008, we analyzed the digital technologies used in 3 large Brazilian dairy farms. In 2022, we look at the digital technologies that the company XPTO offers to dairy farms.

## 4 Results and Analysis

Table 3 shows the results:

**Table 3.** Results

| Variable  | 2008   | 2022  |
|---|--|---|
| Automation and Robotics Systems                       | The three farms were the most modern in the country, the main systems Automatic Milking Systems (AMS), Automatic Feeding Systems (AFS) and Automatic Robotic Systems (ARS).  | XPTO has not developed a solution for AMS, but according to the Milkpoint website [13], Automatic Milking Systems simply have been present in the dairy industry for two decades. Currently more than 40,000 units are ordering cows and buffaloes in different production systems around the world.  |
| Digital and Precision Livestock Farming sensors/tools | The three farms used sensors for identification and traceability of cows, such as: the most used identification in dairy herds, kept in an intensive production system, was the use of electronic collars. Another type of electronic animal identification was microchip identification, also known as transponder and bar codes and RFID allow the automatic capture of the animal's identity. Another sensor used was the pedometer, which is an electronic | The sensors attached to the animals monitor temperature, steps, rumination, estrus potential and send the information to an artificial intelligence platform that indicates, according to XPTO, clearly and easily accessible information, reproductive cycles, health problems or any nonconformity in behavior of the animal. This data helps prevent possible diseases, with a direct impact on farm productivity. The tool makes it possible to follow the entire route, monitoring the temperature, number of times the tank was opened and if the milk was removed without authorization. |

|                         |  |  |
|-------------------------|--|--|
|                         | <p>equipment that continuously records the movement of animals by counting steps, is used for their identification and evaluation of their movement and the application is the detection of heat, as cows with hormonal changes, characteristic of the estrus period, walk more.</p>   | <p>The sensors located in the cooling tanks indicate if the product temperature is adequate to market standards or if it has undergone any variation above what is allowed. The technology also ensures that the volume sold with the dairy is the same as indicated in the tanks, ensuring operational efficiency and avoiding losses or contamination at the time of collection.</p> <p>The sensors also guarantee cheaper maintenance and less technical unavailability, as they follow the usage time and useful life of the tank cooling motors, predicting with the help of artificial intelligence, the need for replacement, repair and root cause of the problem.</p> |
| Farm Management Systems | <p>The existing systems in 2008 were very precarious compared to the current ones, the data was not collected online as they did not have networks or technologies that allowed covering the entire dairy farm, the data generated by the systems and sensors were manually updated on the farm's server. There were several types of data analysis for decision making, but only with manually collected data and this system helped the property management.</p> | <p>Currently, XPTO has created a system that combines the use of Artificial Intelligence, an Internet of Things network and monitoring and tracking sensors for monitoring the milk production chain, generating indicators for quality assurance, operational efficiency gains and agility in all the stages of the production process.</p>   |
| Data sources            | In 2008, data was not shared.  | In 2022, XPTO uses a digital platform that integrates IoT solutions  |
| Data users              | In 2008, it was not available.   | In 2022, several devices, mainly mobile.   |
| Data repositories       | In 2008, on server disks and backups.  | In 2022, in the clouds   |
| Transmission systems    | <p>The existing systems in 2008 were very precarious compared to the current ones, the data was not collected online as they did not have networks or technologies that allowed covering the entire dairy farm.</p>  | <p>According to XPTO, application eliminates the need for a robust technological infrastructure, such as connectivity and energy on the farms. Batteries with an average lifespan of ten years and specific communication networks for IoT are used, in addition to enabling a simple implementation, in a plug-and-play model.</p> <p>“Through Wi-Fi coverage, or other similar technology, the information captured is sent</p>  |



|  |  |  |
|--|--|--|
|  |  | to the cloud, where software can intelligently process and generate the data on screen”,<br>Words from XPTO's CTO. |
|--|--|--|

In 2008, automation represented the main advances in digital technologies applied in dairy production, the farms surveyed already used the AMS, AFS and ARS systems, but it was not the reality of most dairy farms. According to Pezzuolo et al. [3], automation has historically represented the first line of development in the livestock sector and is currently successfully developed for various commercial applications. XPTO chose not to develop a solution for automation, as competition is high in this area, and they preferred to focus on an area with fewer competitors.

The evolution of these automatic systems has shown an important reduction in the necessary manpower but, thanks to the growing equipment of sensors and intelligent technologies [3], in 2008, the sensors were already being used in a timid way and in 2022, we could verify that sensors are being used in all areas of dairy production, mainly for data collection for decision making.

The systems or programs used to manage the farms have evolved a lot in 14 years. In 2008, the systems were used for controls with little data collected online, because, due to the large extensions of the properties, there were no systems, sensors and networks that allowed the coverage of the entire area. In 2022, systems and programs are considered digital platforms that receive data instantly from an Internet of Things network and monitoring and tracking sensors and process with the use of Artificial Intelligence allowing to monitor the milk production chain.

The evolution of data, users and network are linked to advances in digital technologies that have provided new network technologies such as wireless networks and devices for the use of the internet in mobile devices such as cell phones, tablets and sensors and also the emergence of cloud computing. In 2008, networks were non-existent for dairy production areas, only the headquarters and some parts of the farm had quality internet, which had an impact on not having online data in real time. The advancement of digital technologies has allowed technological advances such as mobile applications that have improved production processes and internal employee communications [7], the use of IoT sensors in various parts of the dairy farm to collect data and have the data stored in the clouds (cloud computing).

## 5 Conclusion

The objective was achieved, we were able to verify that the use of digital technologies through digital transformation improved the production of the dairy chain. We can highlight that the main advances were in production automation because despite being the pioneer and the main focus in 2008, the AMS, AFS and ARS systems received several updates such as intelligent sensors such as IOT and digital platforms for online data processing. line with the use of AI, the evolution of computer networking technologies such as wireless networking, cloud computing and the Internet itself to obtain

data anywhere in dairy production and farm management systems that with online data line allow for better property management.

As future studies, research with production and economic indicators is suggested to measure the benefits obtained from the use of digital technologies and digital transformation.

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